NIHON UNIVERSITY
College of Science and Technology

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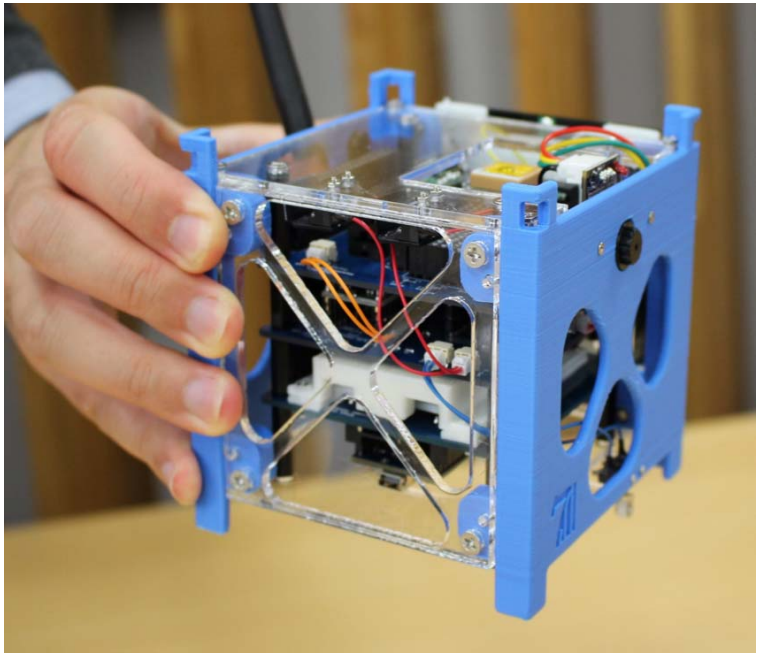
University Space Engineering Consortium

Pico-Satellite Training Kit HEPTA-Sat:

Hands-on Practices for Space Engineering

Masahiko Yamazaki(Nihon University)



Pre-Symposium Hands-on Workshop at Stellenbosch University(Dec. 9-10)

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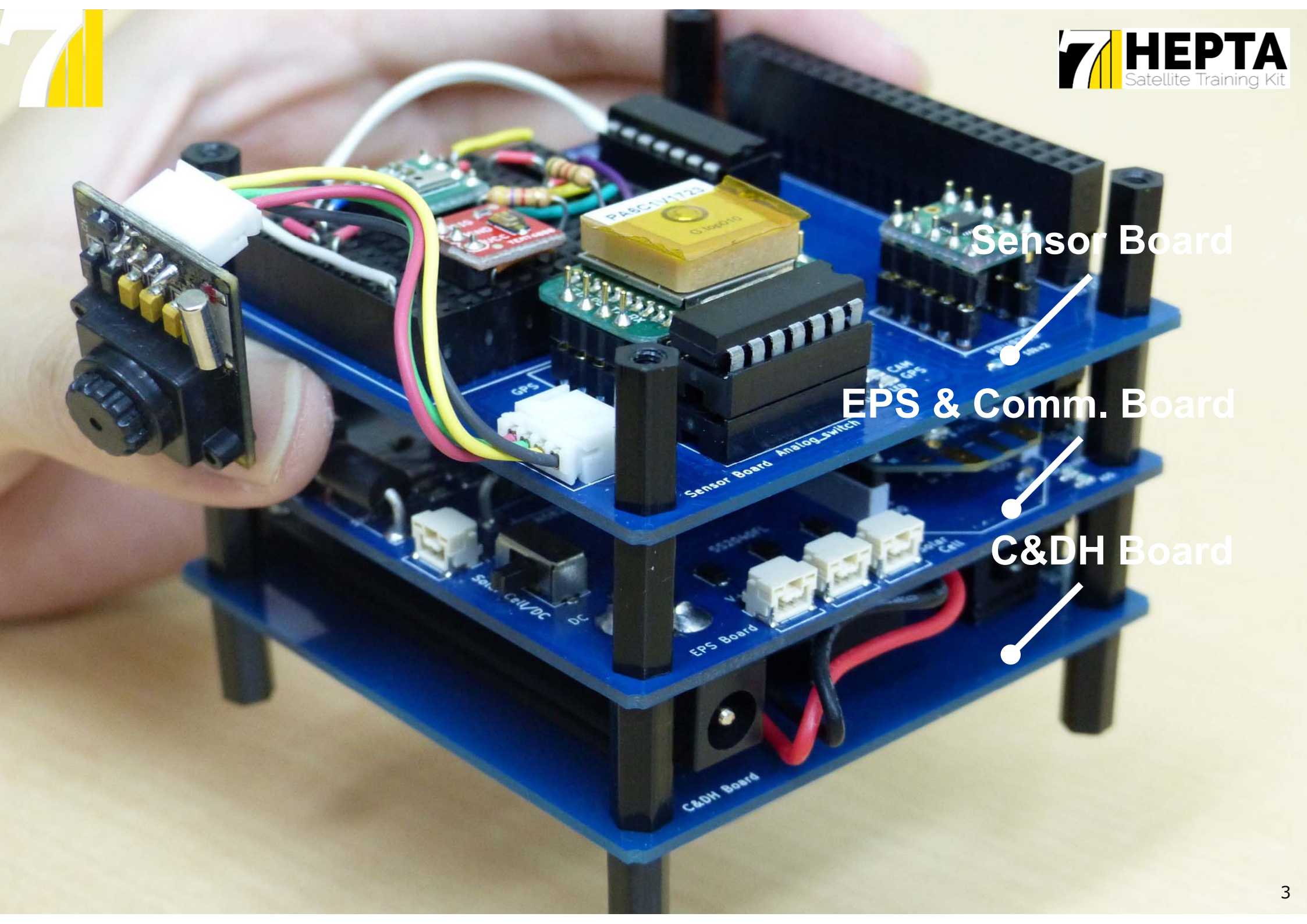
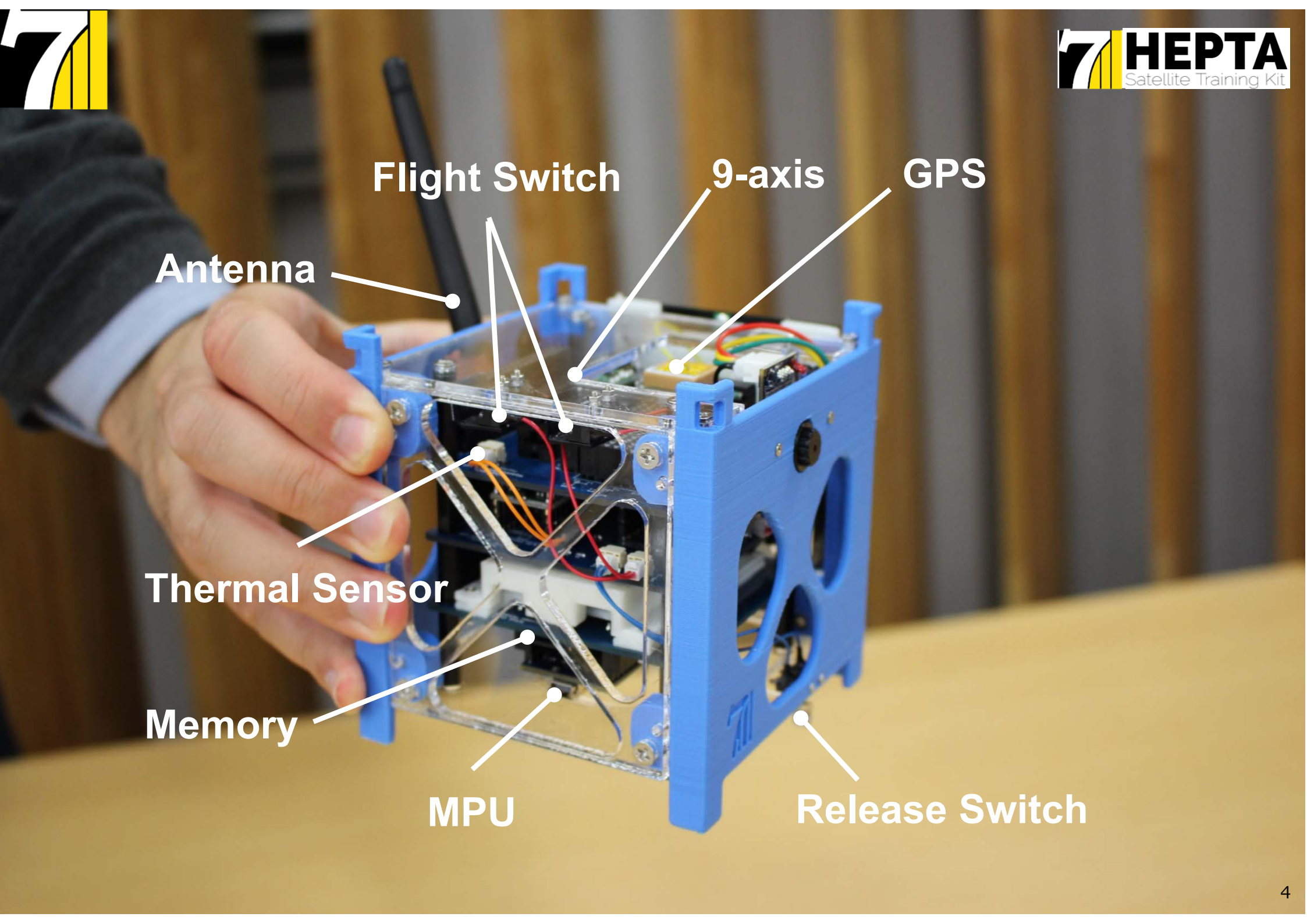
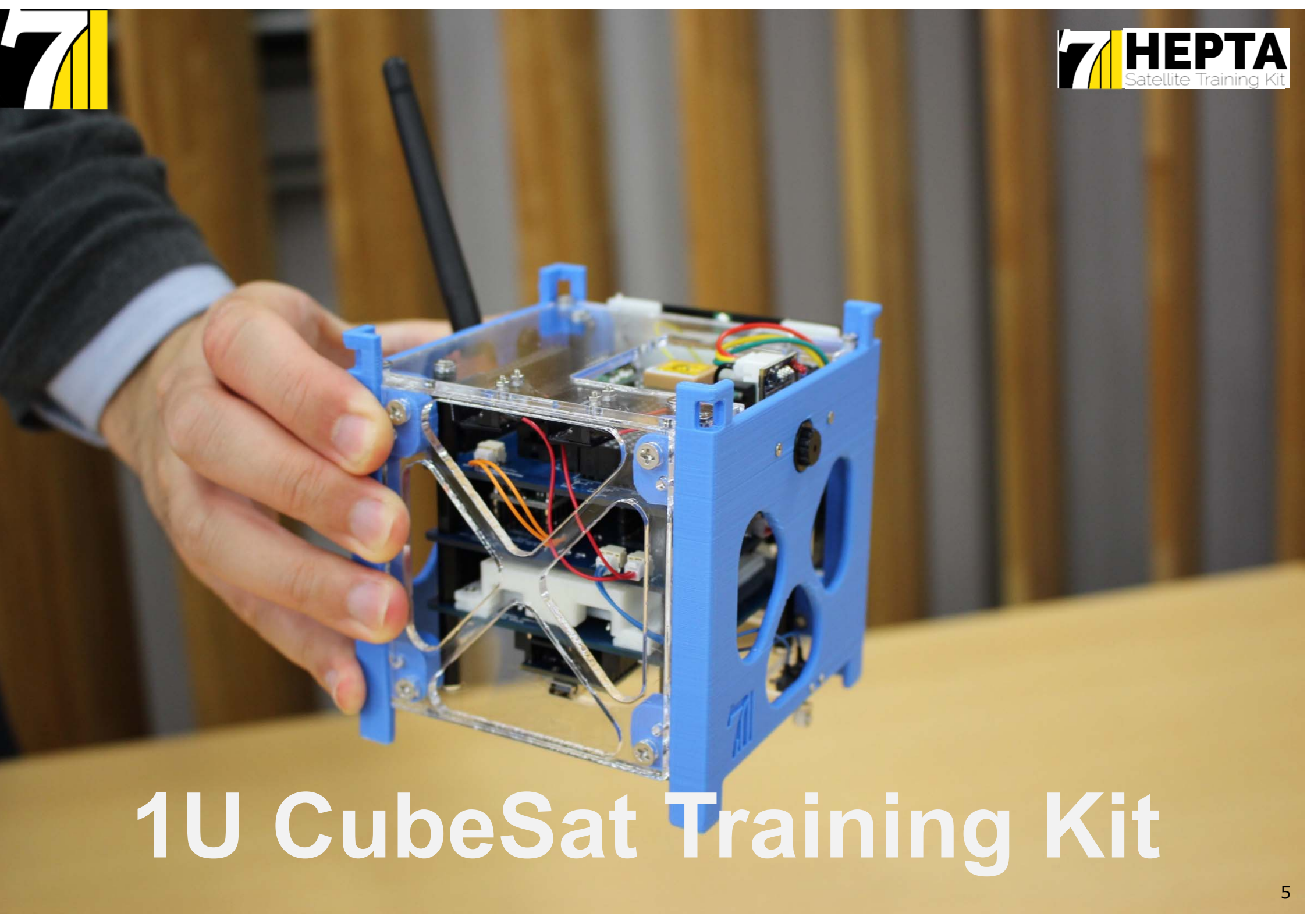
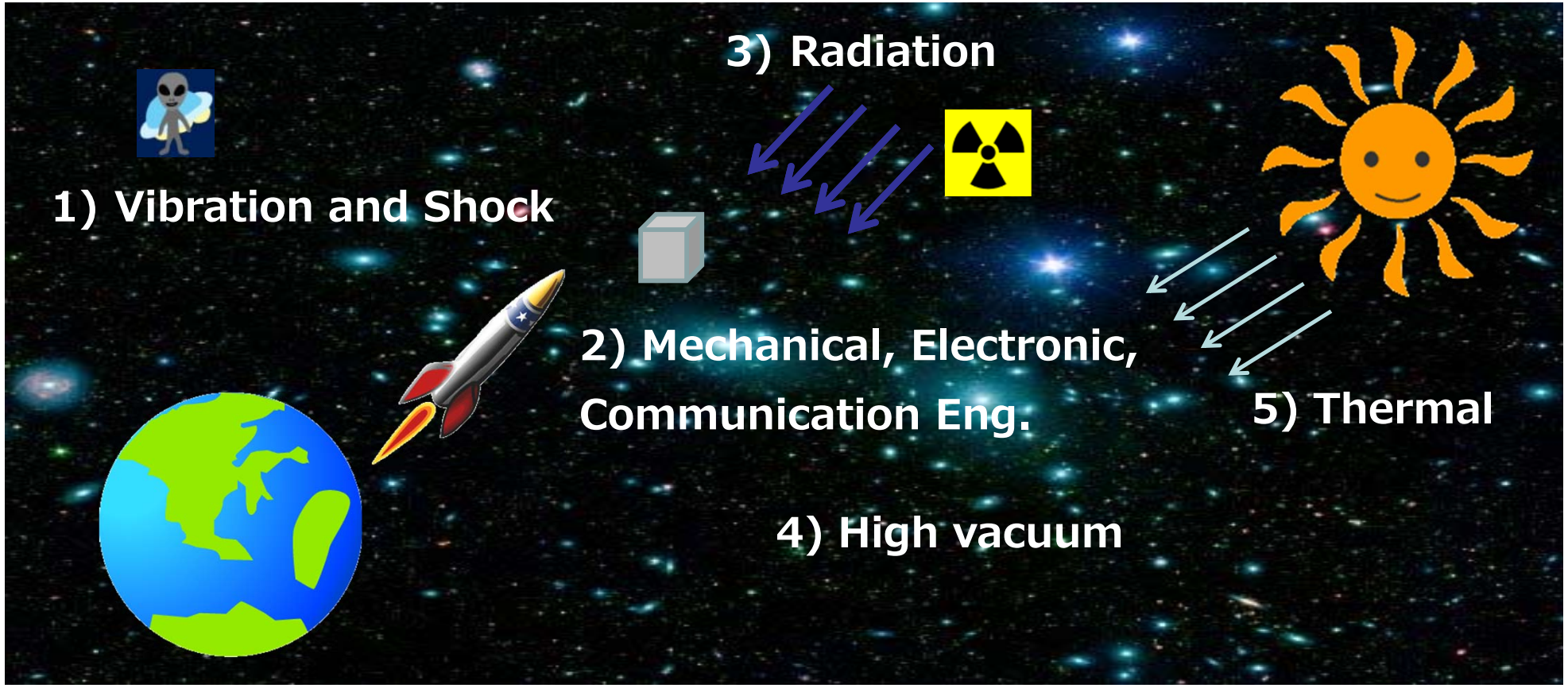

Sensor Board
EPS & Comm. Board
C&DH Board


Flight Switch
9-axis
GPS
Antenna
Thermal Sensor
Memory
MPU
Release Switch


HEPTA
Satellite Training Kit
1U CubeSat Training Kit

Why CubeSat Training Kit?

- Satellite is possible to learn **variety of elemental technologies**
  - Mechanical engineering, electronic engineering and communication engineering and it's system integration. (Multi-disciplinary)
  - To learn the space systems engineering, CubeSat development project based learning is a very effective training way.



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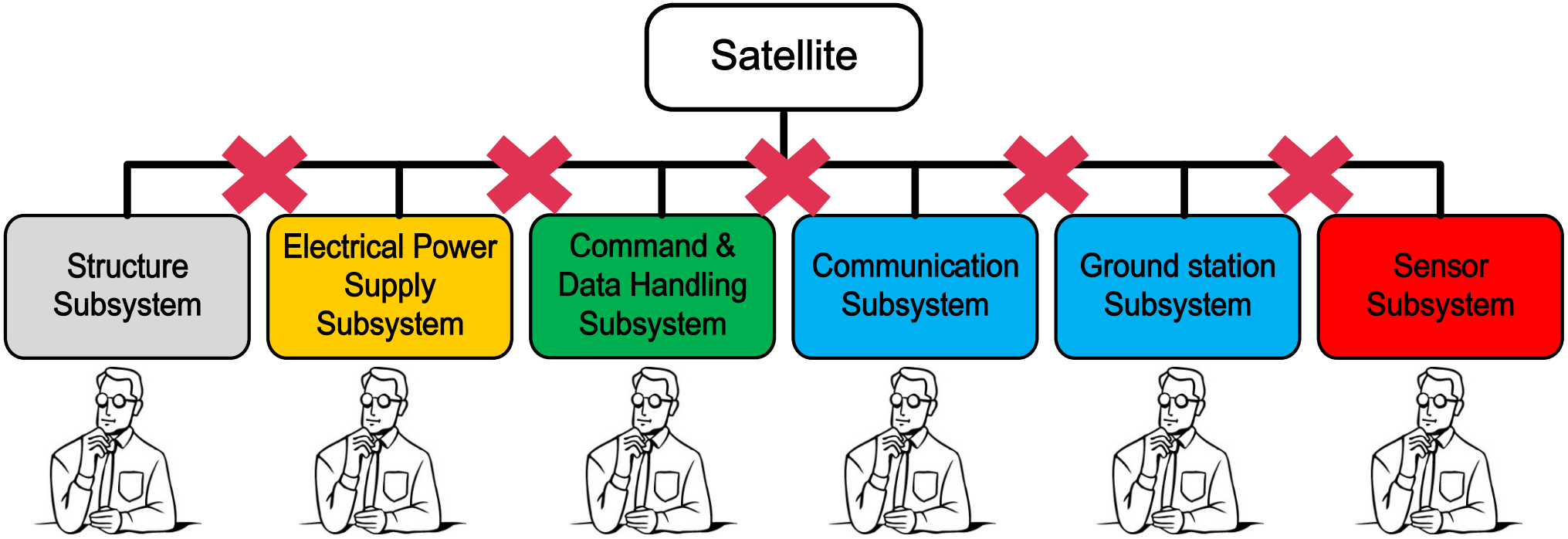
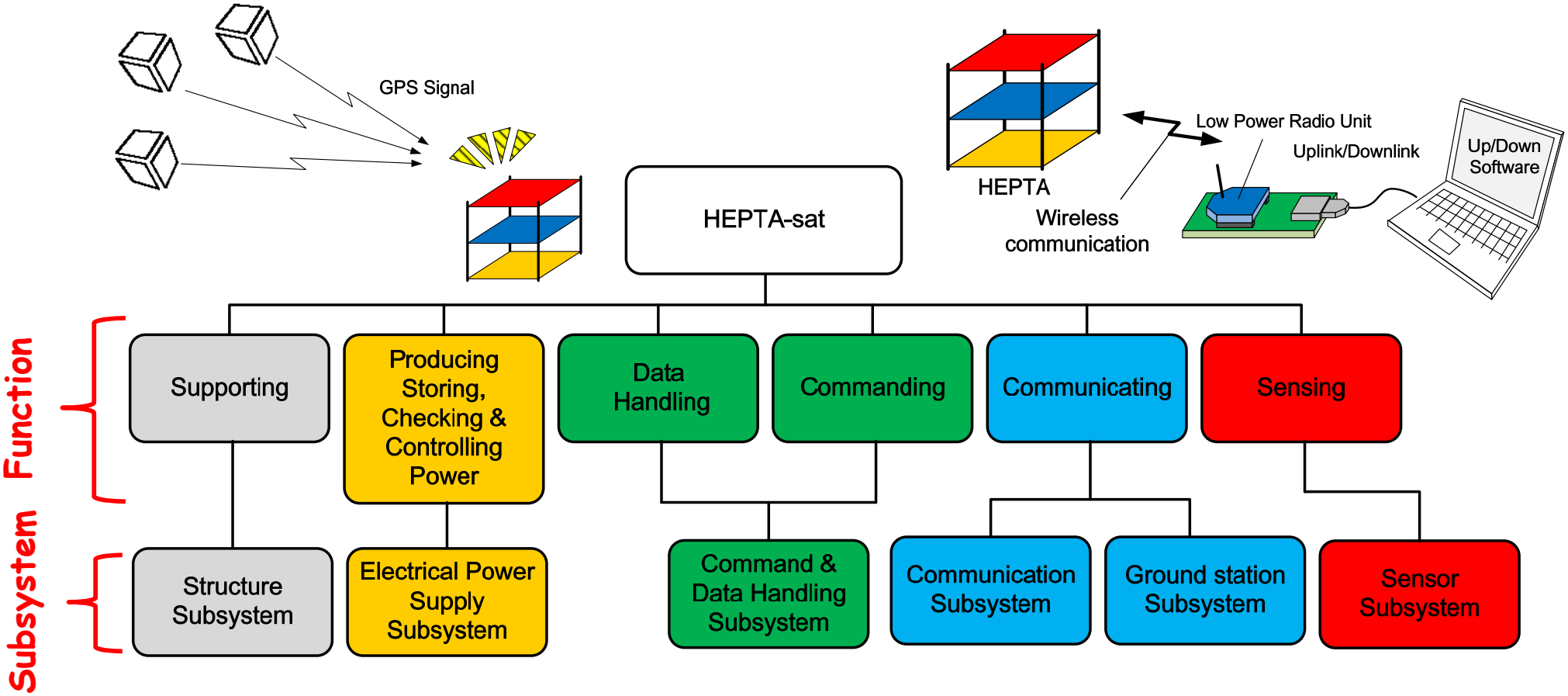
  - To learn the space systems engineering, CubeSat development project based learning is a very effective training way.
- It is sometimes **hard to gain knowledge or experience** of the **whole development process** because the roles are divided into team members.



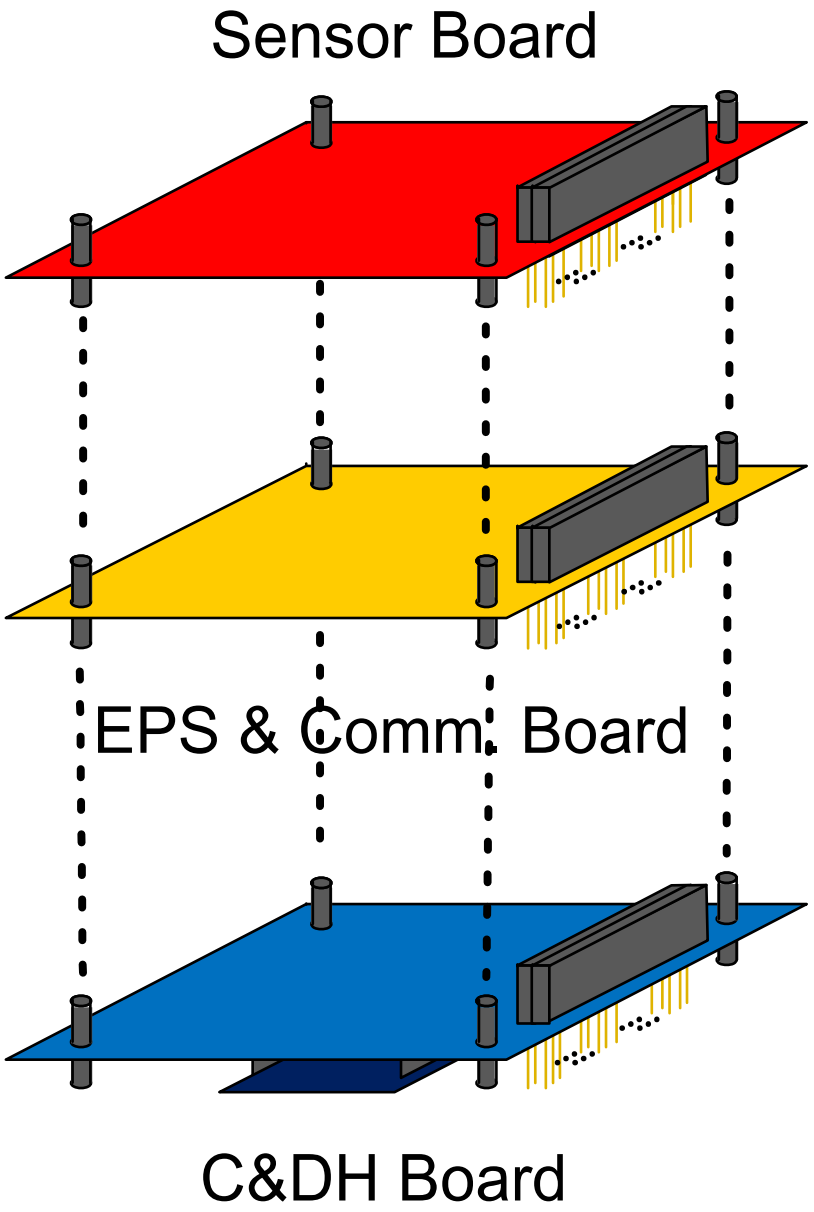
HEPTA-Sat Kit

- 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



Pin socket

- Electrically connected through pin-sockets. Every board has same electrical interface.

Spacer

- Physically connected and fixed with spacer.

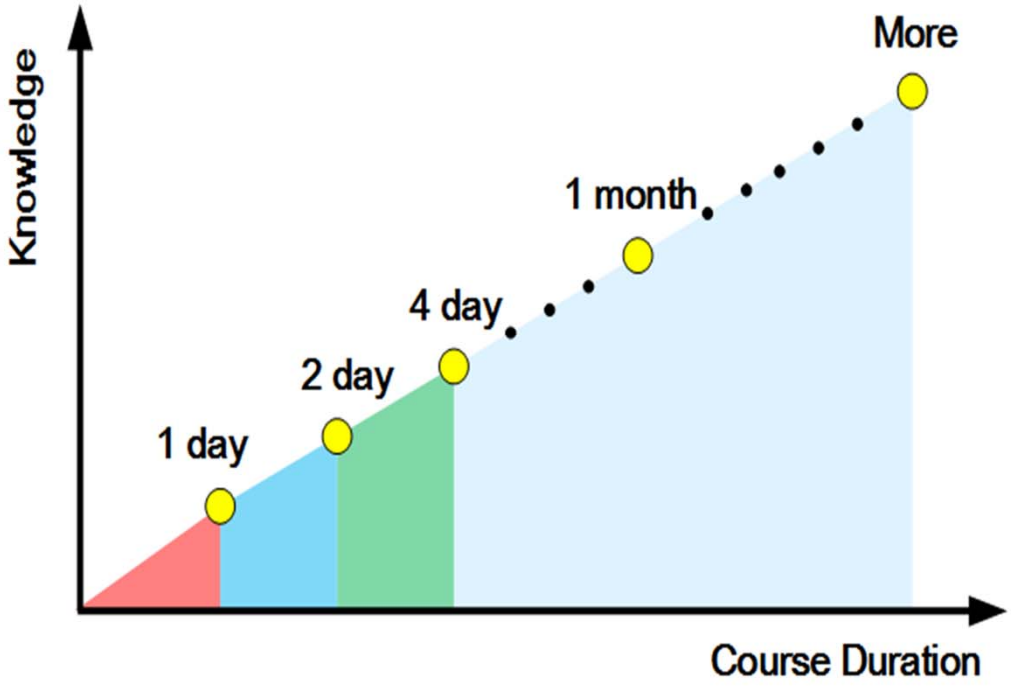
Electrical Interface

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Upper Surface	GND	VIN	VB	nR	I/O	I/O	I/O	I/O	tx	rx	mosi	miso	sck	rx	I/O	ADC	I/O	I/O	I/O	I/O
Lower Surface	GND	VIN	VB	nR	I/O	I/O	I/O	I/O	tx	rx	mosi	miso	sck	rx	I/O	ADC	I/O	I/O	I/O	I/O

	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21
Upper Surface	VOut	VU	IF-	IF+	RD-	RD+	TD-	TD+	D-	D+	I/O	I/O	sda	scl	I/O	I/O	I/O	I/O	I/O	I/O
Lower Surface	VOut	VU	IF-	IF+	RD-	RD+	TD-	TD+	D-	D+	I/O	I/O	sda	scl	I/O	I/O	I/O	I/O	I/O	I/O

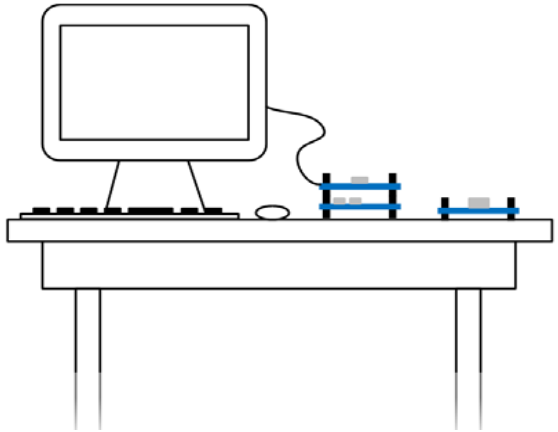
HEPTA-Sat Kit

- Effective and low-cost tool over a short amount of time by oneself or by team.
- Almost all major equipment is removable and can be integrated repeatedly.
- The textbook allows beginners to study the software, hardware, and ultra-small satellites efficiently and systematically on their own.
- Users can design, manufacture and integrate their own circuit board to run an original mission. (User board)




Self-education


Group-education



HEPTA-Sat Training Program

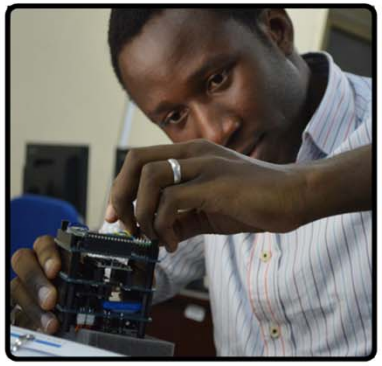
HEPTA Satellite Training Kit

Concept of Training: "Understanding basic satellite system architecture & Experiencing the pico-satellite development process"

Goal of Training: "Experiencing the development process of ultra-small satellites in a short time and acquiring the basic knowledge of space engineering"

Step 1:
Lecture

Step 2:
Hardware Assembly

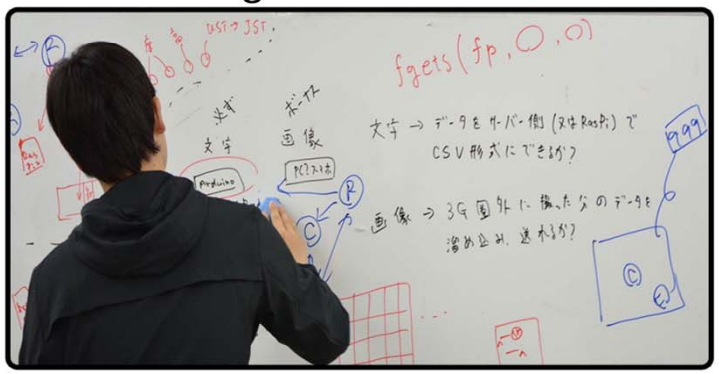


Step 5:
Field test

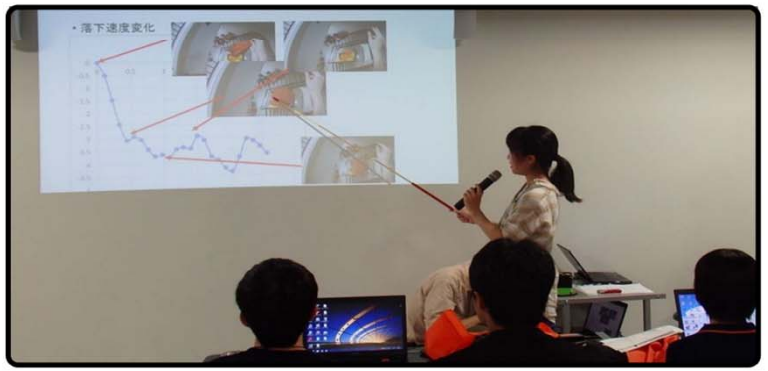
Congratulations!

Step 3:
Hardware & Software Integration

Step 4:
Mission Design



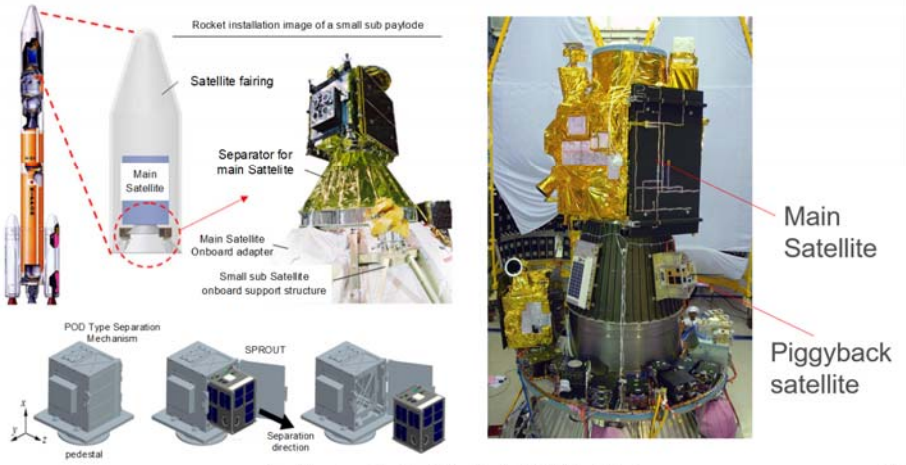
Step 6:
Review & Presentation



HEPTA-Sat Training Program

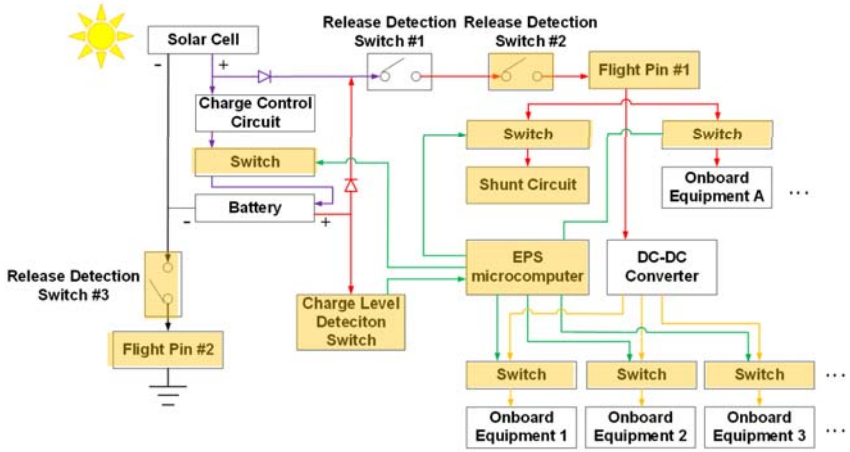
Introduction to pico-satellite

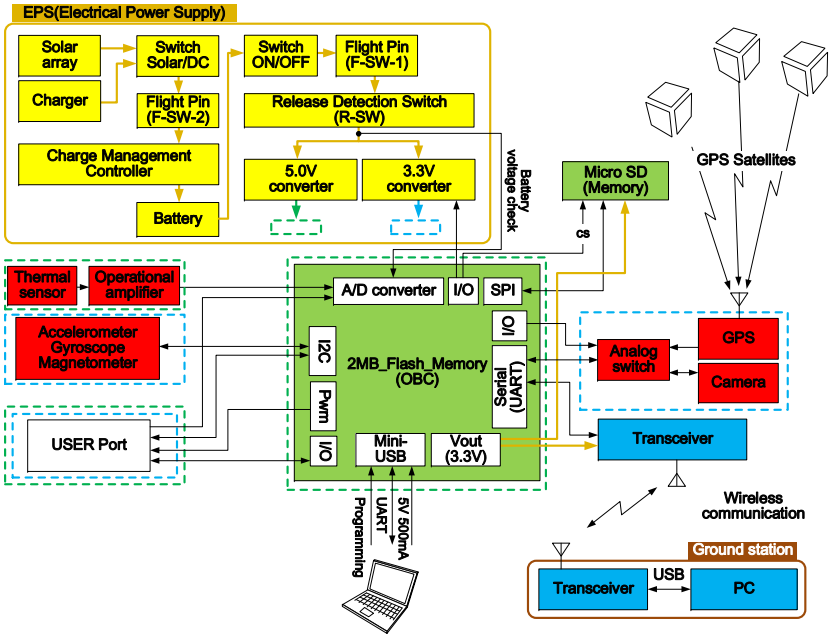
- Satellite needs a separation system that deploys the satellite from the launch vehicle to the orbit.



1. Check Function and architecture of EPS Subsystem

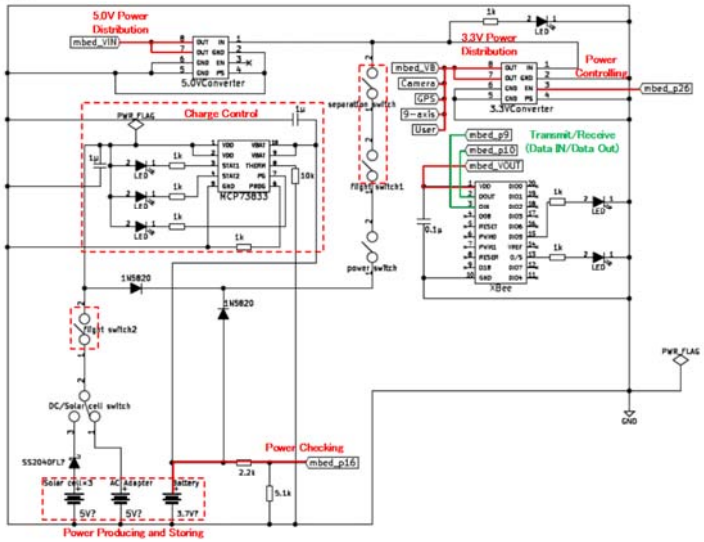
- An example of EPS subsystem that considers reliable and secure electric power supply, management of proper power supply, and safety assurance.





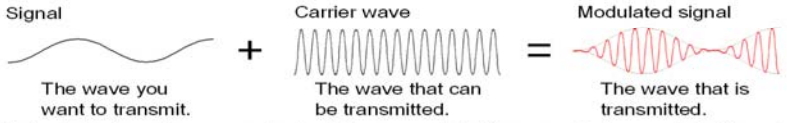
1. Check Function and architecture of EPS Subsystem

- The circuit diagram of HEPTA-Sat's EPS and communication board.

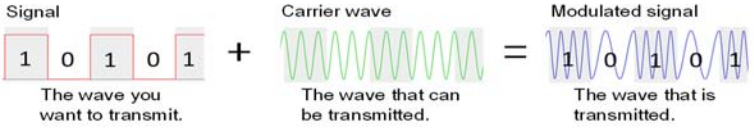


2. Check of function and architecture of Communication Subsystem

- There are variations in the modulation and demodulation scheme.
- Amplitude Modulation (AM) or Frequency Modulation (FM) are ways of broadcasting radio signals. Both transmit the information in the form of electromagnetic waves.
- AM works by modulating (varying) the amplitude of the signal or the carrier to be transmitted according to the information being sent, while the frequency remains constant.



- Digital data is also conducted by modulation and demodulation. The following figure is the schematic diagram of frequency modulation of digital data.



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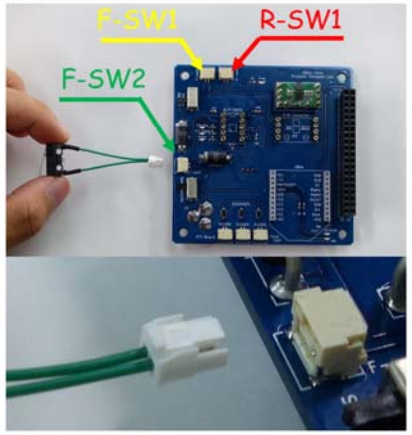
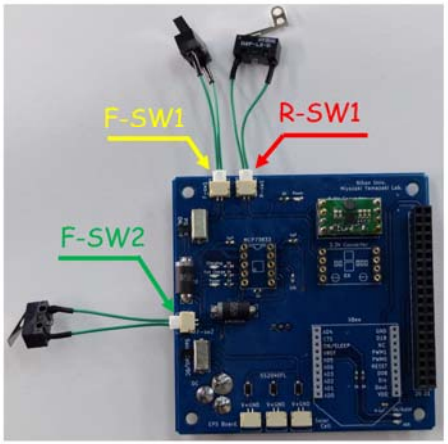
5. Installation of Release Detection and Flight Switches

- To install the release detection switch and flight switch, in HEPTA-Sat, a roller type switch and a hinge lever type switch are attached as release detection switch and flight switch, respectively. F-SW1 is shorter than F-SW2.



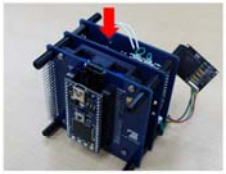


10. Software & Hardware Integration: Detect acceleration by using 9-axis Sensor

- Software and hardware integration of EPS & communication board and C&DH board are conducted
- Acquire the acceleration sensor data.

File name : Detect_Acceleration

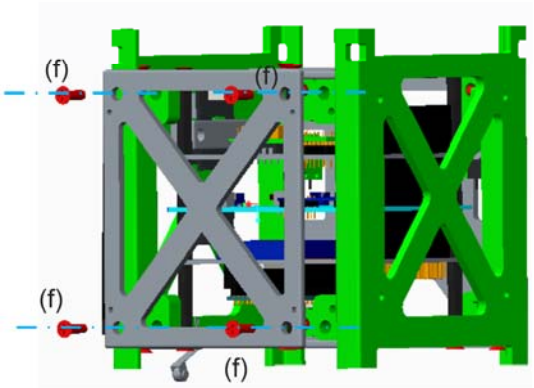
```
#include "mbed.h"                                   include mbed library
#include "Hepta9axis.h"                             include Hepta9axis library

Serial pc(USBTX,USBRX);                             serial class declaration
Hepta9axis n_axis(p28,p27,0xD0,0x18);               Hepta9axis class declaration

int main()                                          main loop start
{
   pc.baud(9600);                                   set communication rate
   float ax,ay,az;                                  variable definition
   pc.printf("Accel Sensor Mode\r\n");              display "Accel Sensor Mode" on PC
   for(int i = 0; i<50; i++) {                      loop 50 times
      n_axis.sen_acc(&ax,&ay,&az);                  get Accel value
      pc.printf("%f,%f,%f\r\n",ax,ay,az);          display "Accel value" on PC
      wait(1.0);                                    1.0 second wait
   }                                                loop end
}                                                   main loop end
```

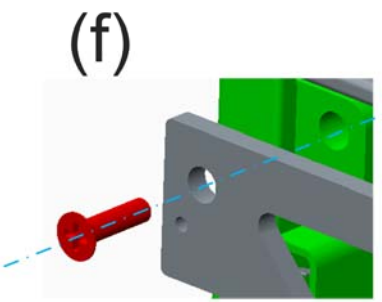


3. The structure of HEPTA-Sat

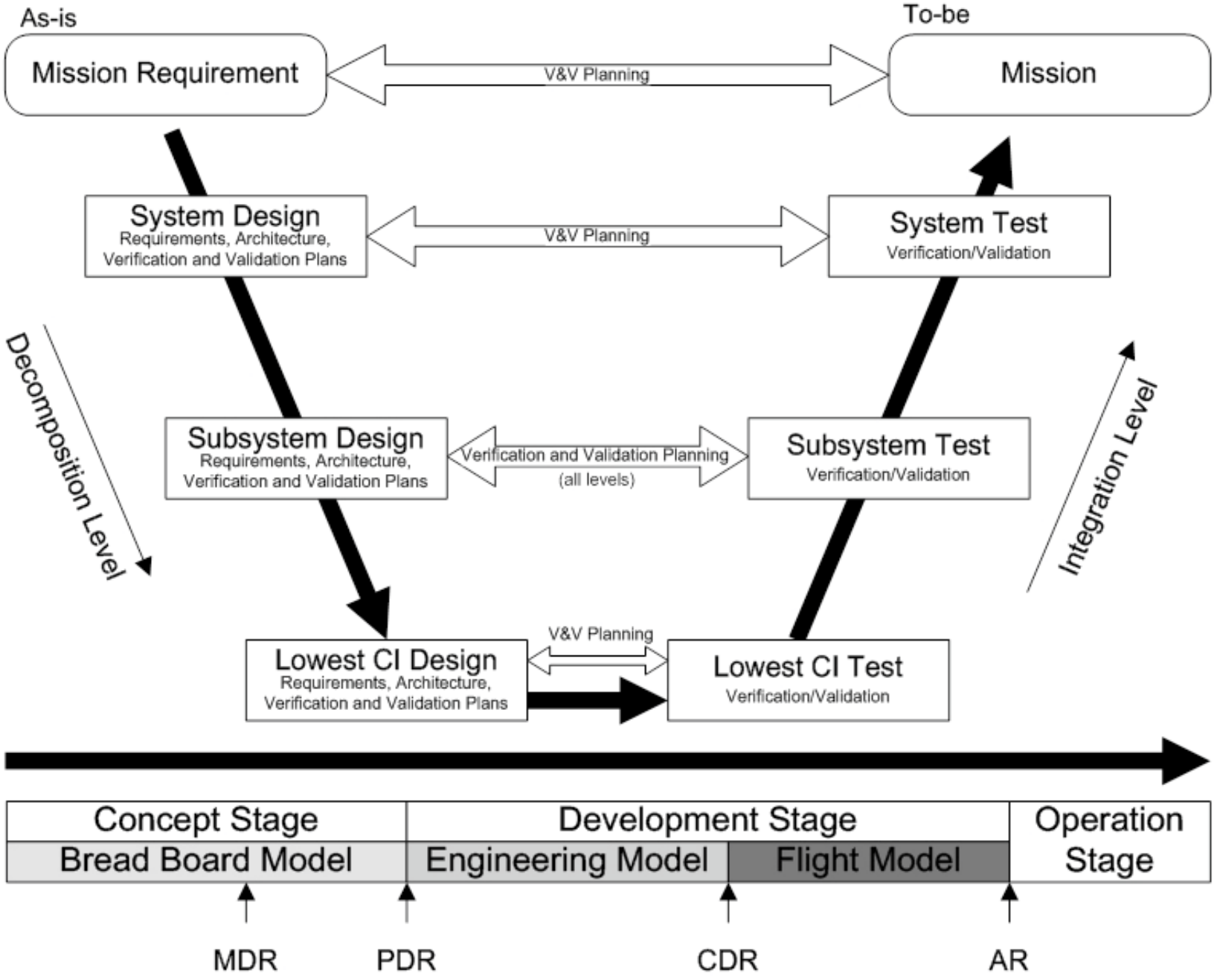
Fabrication and Assembly of the structure subsystem of HEPTA-Sat

- Next, assemble the trusses.





HEPTA-Sat Training Program



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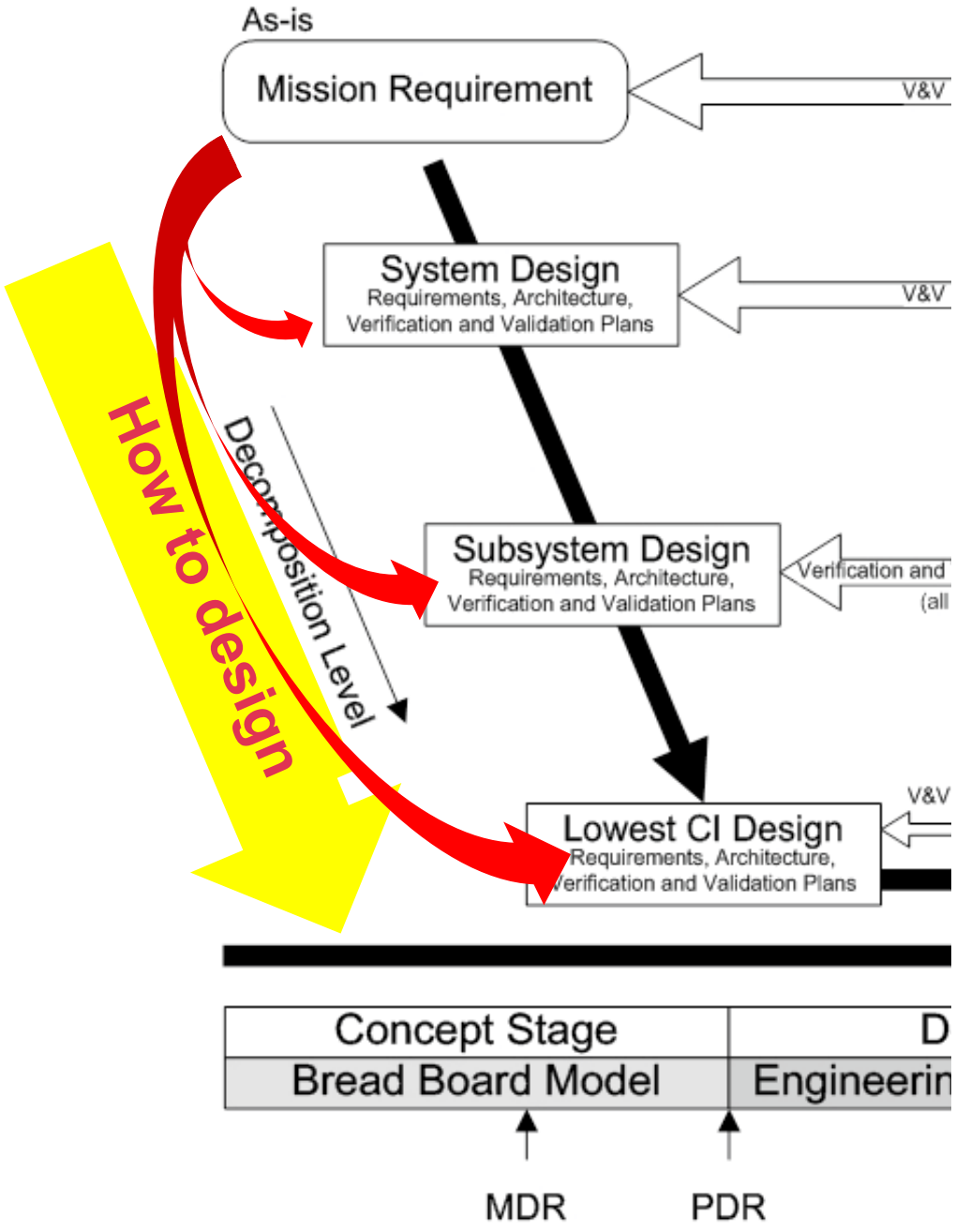

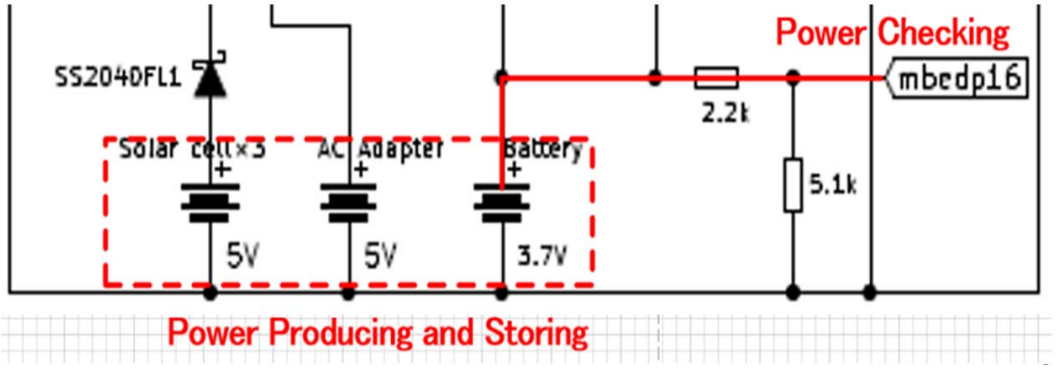

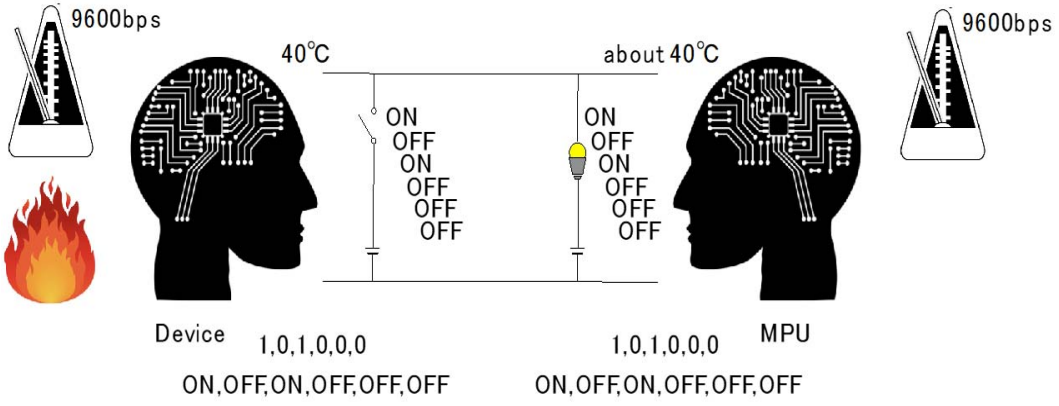

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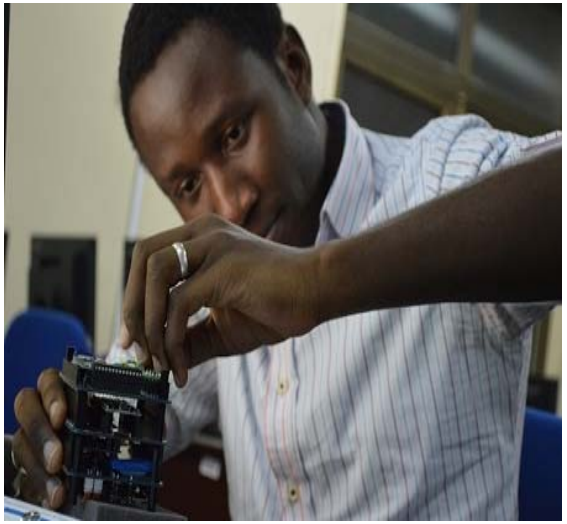
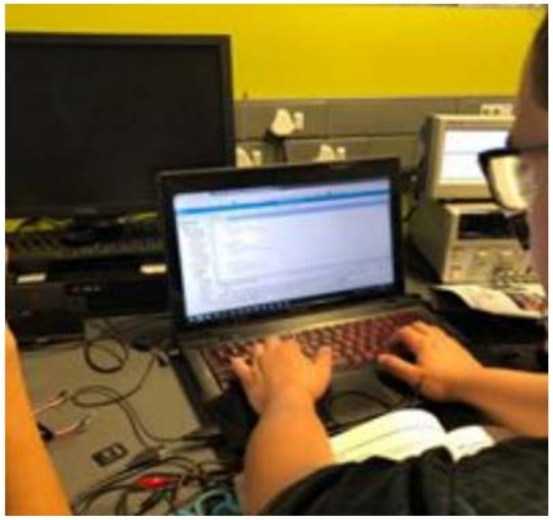
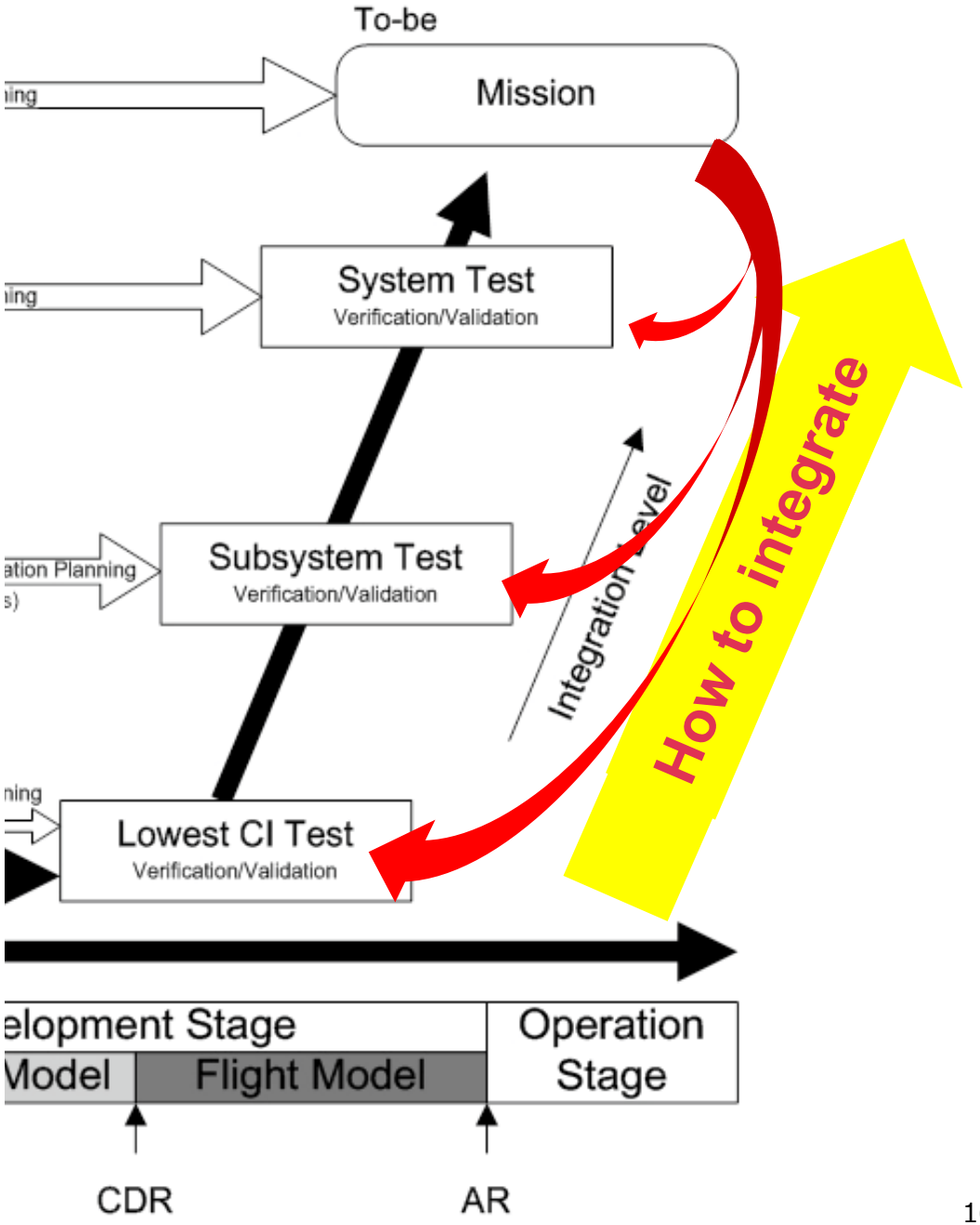




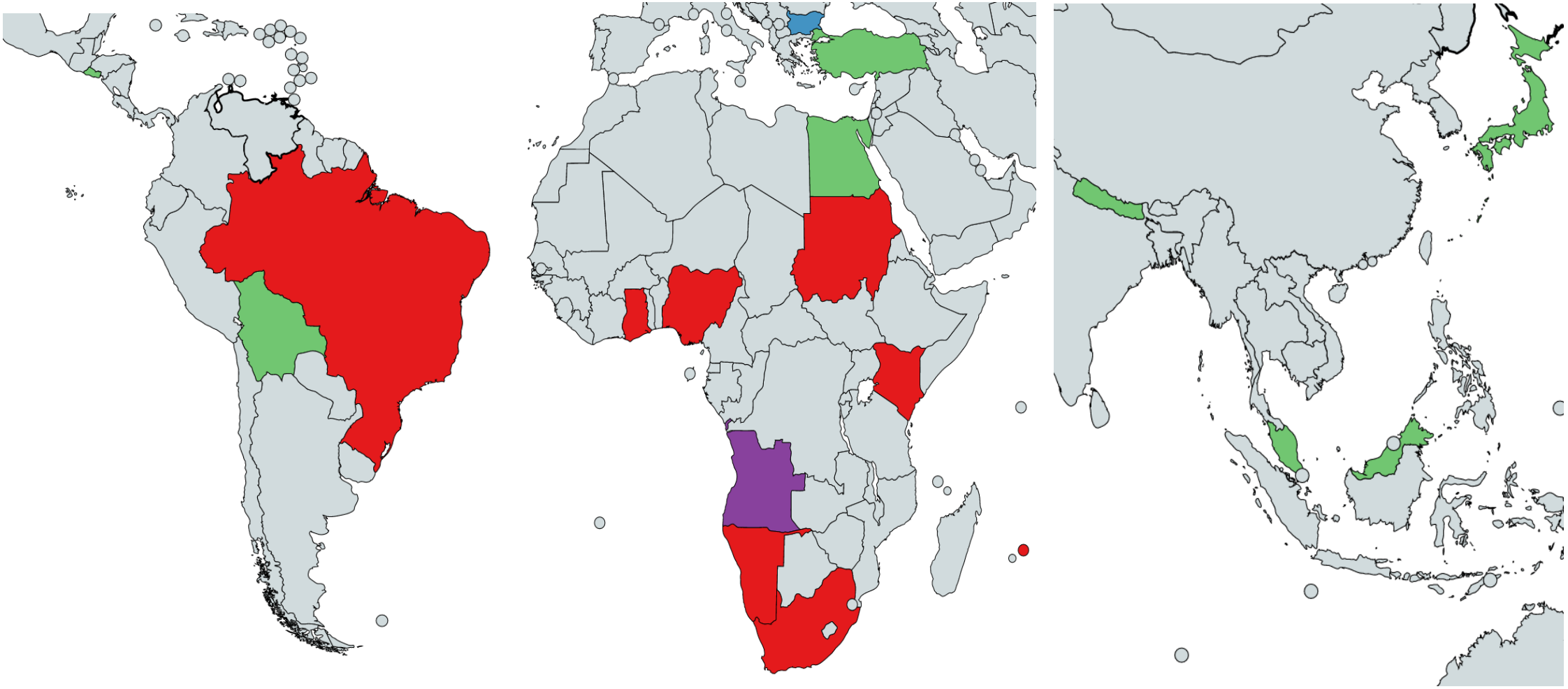
```
int main(){
    pc.baud(9600);
    float bt;
    for(int i=0;i<10;i++){
        battery.vol(&bt);
```

main loop start
set communication rate
variable definition
loop 10 times
get battery voltage



Recent Activities

- A hands-on class of about one day to a week was held for domestic and overseas Engineer, Researcher, University and High school students.



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- It held in Japan in September, Nepal in October, Bulgaria in November and South Africa in December 2017.

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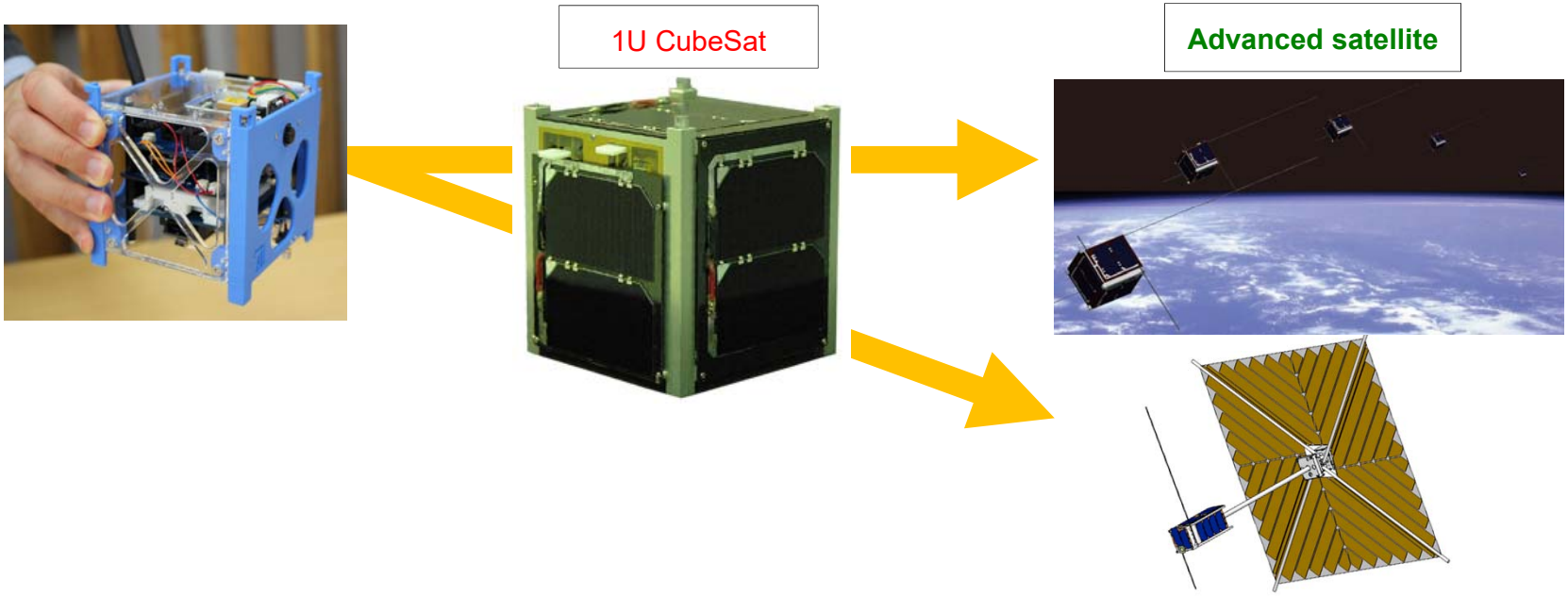
Conclusion



- Benefits of a hands-on education based on small satellite are…
  - Experience the whole system construction. Create ideas out of nothing and integrate and accomplish the system to work correctly.
  - Learn time and cost management, how to deal with risks, and how to work in a team.
  - Be given feedback from the real world, not a desk study but a real experience through developing an actual spacecraft.
- These learning experiences can create opportunities for in-depth study of the mission plan, specialized theory, design, development and experiment, also for students who wish to learn fields other than space.