The 14th CanSat / CubeSat Leader Training Program (CLTP14) – *Mission Design*

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Nihon University

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Contents

1. Background

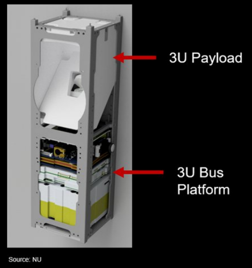
- **Bio:**
  Derrick Tebusweke
  Space Systems Engineering Researcher
  Uganda

- **Education:**
  Msc. Electrical and Space Systems Engineering | Kyutech | Japan | BIRDS5 Project
  Bsc. Electrical Engineering | Makerere University | Uganda

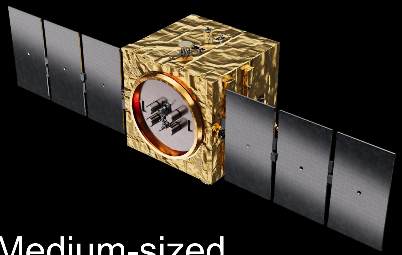
- **Position:**
  2025 – Research Associate in CubeSats | Northumbria University | UK | ALIGN Mission
  2022 – Power System Engineer | Astroscale Limited | UK | ELSA-M Mission

- **Research Interests:**
  Nanosatellites, Spacecraft Power Systems, Attitude Determination & Control and Space Environmental Testing

1U (Two) and 2U
© BIRDS5 Project



6U (Two)
© NU



Medium-sized
© Astroscale

2. Introduction

- CLTP Overview:
  - Full cycle satellite development training: initial design – launch and operation - utilizing a HeptaSat kit
  - Hands-on

Lab#1 Development environment setup: Mbed's Keil Studio Cloud, Tera Term,…

Lab#2 Electrical Power Subsystem Design

Lab#3 Command & Data Handling subsystem design

Lab#4 Sensor subsystem design

Lab#5 Communication subsystem and Ground station subsystem design

Lab#6 Structural system design

Lab#7 Mission Design and Implementation

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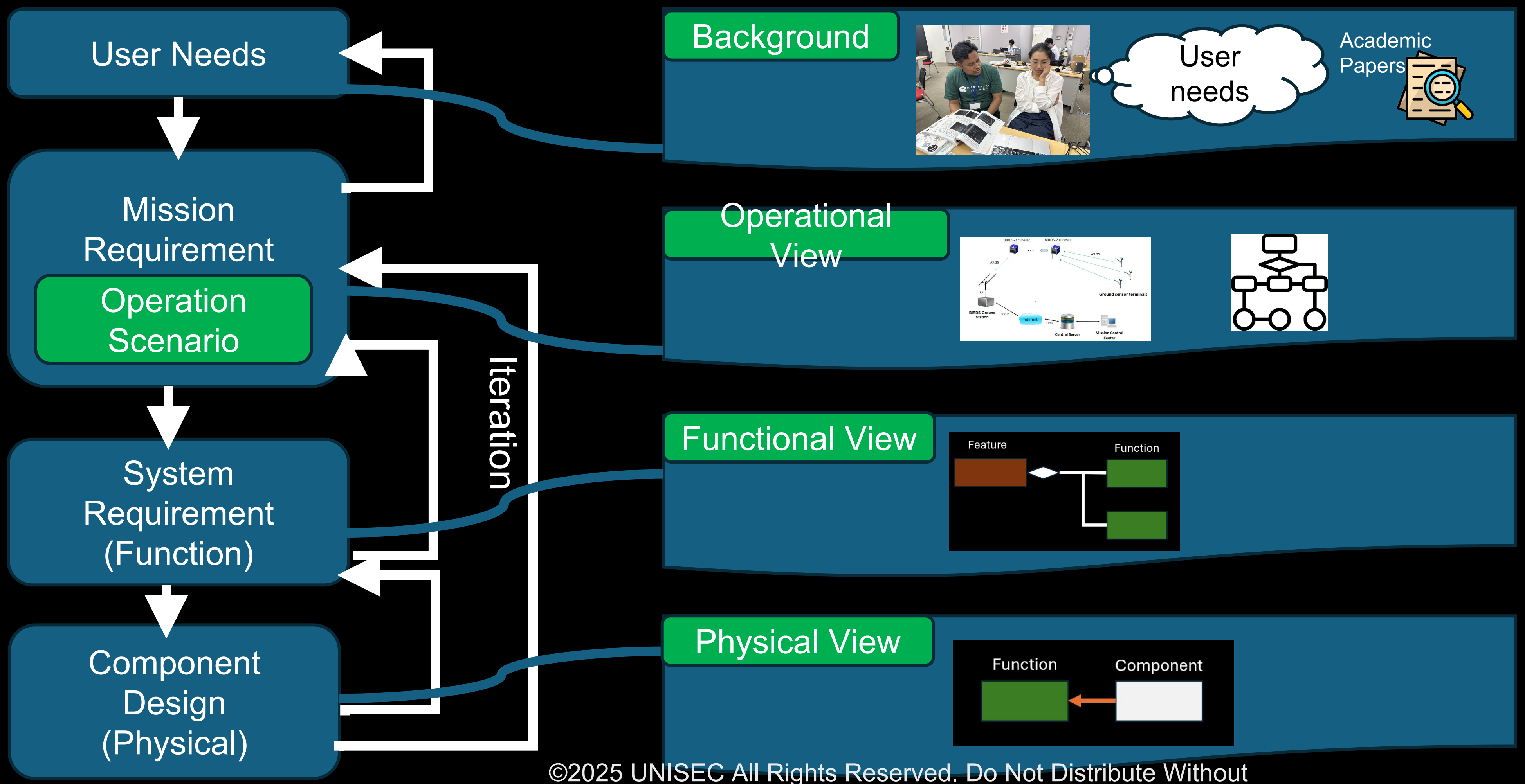
3. Mission Design

3.0 Step 0: Overview of Systems Design



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Feature Example:
Communicate with satellite

Function Example:
Transmit Command

Component Example:
Transceiver

3. Mission Design
3.0 Step 0: Overview of Systems Design

Model-Based System Engineering Design

View	Definition	Model Diagram	
		Static (Structure)	Dynamic (Behavioural)
Operational	How to use / operate system	Use case diagram	Use case scenario
Functional	Functions required in system	Block definition diagram	State machine diagram
Physical	HW & SW required in system	Internal block definition diagram	Sequence diagram

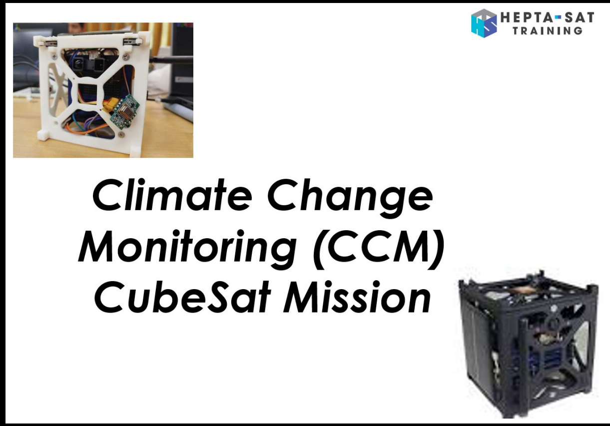
What?

How?

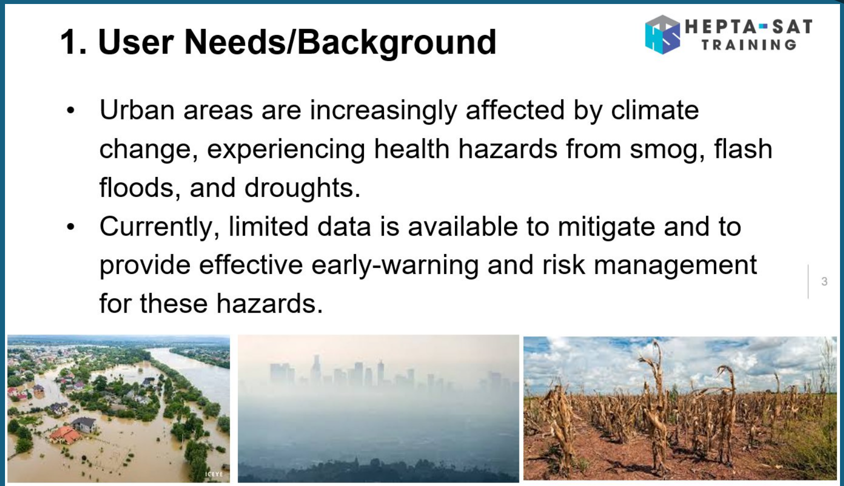
3 Important Views In Mission Design

2. Mission Design
2.1 Step 1: Requirement Development Example

Example of our group project mission idea



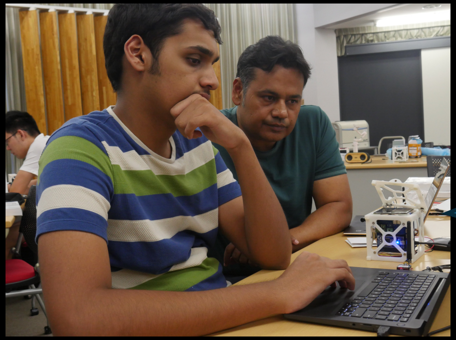
1 Obtain User Needs



User needs:

- Crude and obscure

3. Mission Design
3.1 Step 1: Requirement Development Example…



How can we achieve such a mission?

A
Use ground sensors and terrestrial networks for monitoring?

B
Launch satellite, get data and send it back?

C
Launch a drone, get data and send it back?

3. Mission Design
3.1 Step 1: Requirement Development

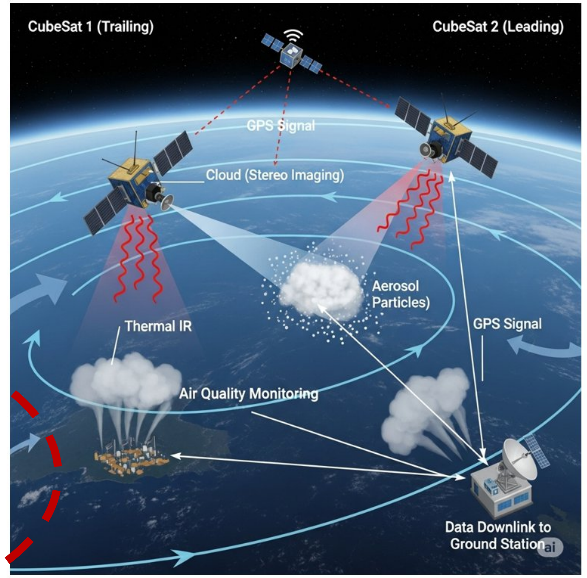
2 Conduct an **Operation Scenario** tradeoff

- A: Terrestrial networks are costly in terms of internet data
  → X
- B: Satellite orbit is very high, cloud mapping possible, higher resolution, many revisit times
  → ✓
- C: Limited coverage
  → X

Note the functional and physical elements (HW , SW) needed

The CCM mission is a coordinated 2-satellite CubeSat mission designed to provide valuable atmospheric and environmental observations, with a focus on urban smog, cloud formation (especially cloud bursts), and flood-related weather events.

Each 1U CubeSat carries sensors chosen to measure key parameters for smog and extreme weather, enabling classification and early-warning capabilities:



3. Mission Design

3.2 Step 2: System Design from Operational View

3 Create Mission Goal / Objective

Mission Goal Statement Template

[MG-1] To __________ By ___________ Using _______

- To: [Overall intent statement]
- By: [Process statement]
- Using [Methodology statement]

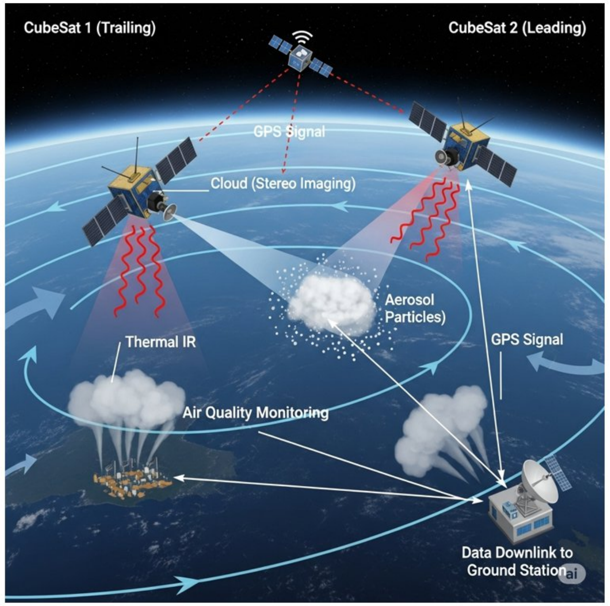
To keep traceability

Example: CCM CubeSat Mission

HEPTA-SAT TRAINING

2.1 Mission Goal/Objective

- MG1. Demonstrate multisensor fusion in a CubeSat for climate monitoring
- MG2. Measure temperature of clouds and urban surfaces
- MG3. Demonstrate Intersatellite link for integrated sensing.

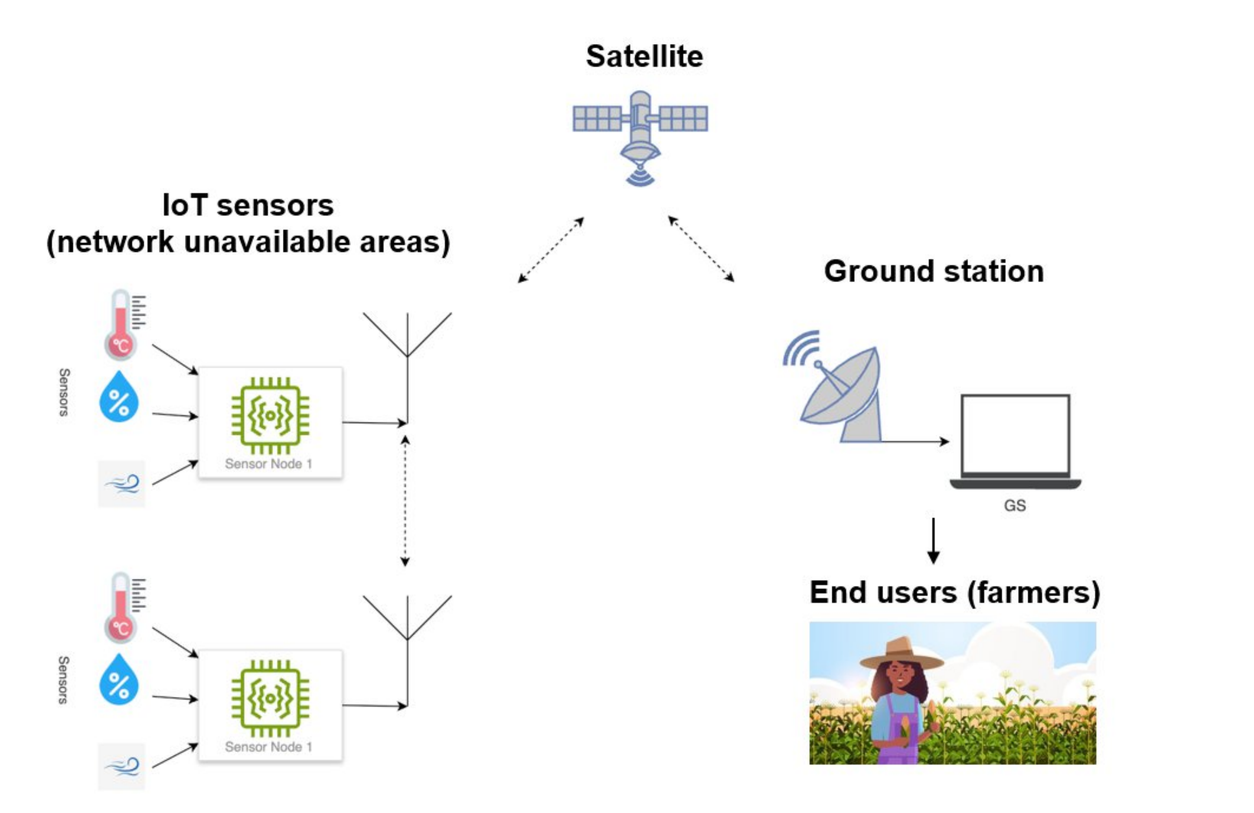


3. Mission Design

3.2 Step 2: System Design from Operational View

4 Create A Concept Sketch:

MIZU Mission (Monitoring of Irrigation Zones Using satellites & IoT)



Purpose:

- Shows interrelationships between the systems:
  - Launcher, satellite, ground station, operator, etc
- Derives necessary functions:
  - E.g Data uplink/downlink

3. Mission Design

3.2 Step 2: System Design from Operational View

5 Create Success Criteria:

Example: CCM CubeSat Mission

3. Success Criteria HEPTA-SAT TRAINING

Success Level	No.	Mission Success Criteria	Verification Method
Minimum Success	MG-1	Successfully connect the sensors	Compare satellite data to ground sensors and existing satellite platforms.
	MG-2	Measure temperature of clouds and urban surfaces	
	MG-3	Measure distance between fixed satellites	
Full Success	MG-1	Gather data for distance and thermal sensors	Compare satellite data to ground sensors and existing satellite platforms.
	MG-2	Classify smog vs. dense cloud	
	MG-3	Measure relative distance between CubeSats	
Advanced Success	MG-1	Demonstrate data fusion from both satellites	Compare satellite data to ground sensors and existing satellite platforms.
	MG-2	Detect extreme cloud events (cloud bursts)	
	MG-3	Cross-validate measurements from both satellites	

To keep traceability

Key:

- Minimum Success: must achieve condition to admit mission success
- Full Success: condition you can admit the mission is success
- Advanced Success: condition which you want to do but might be difficult due to cost, time, skill, etc
- Verification Method: How to verify mission success

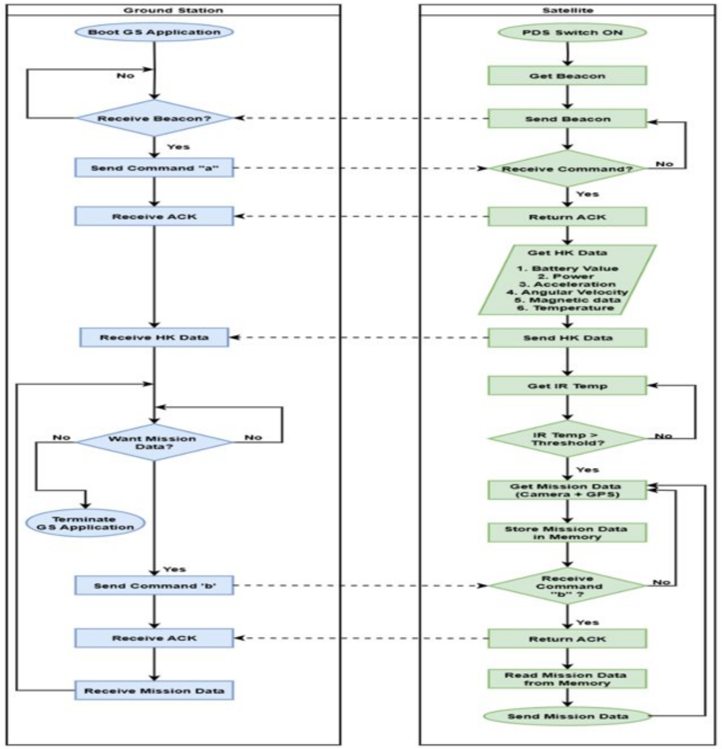
3. Mission Design

3.2 Step 2: System Design from Operational View

6 **Create A Flowchart / Sequence Diagram of The Sequence Between Satellite and Ground Station:**

Example: CCM CubeSat Mission

- Get HK Data (Health, battery, temperature).
- Acquire IR Distance from sensor.
- Get IR Thermal Image from sensor.
- Get Camera and GPS data.
- Downlink Mission Data via Xbee (2.4 GHz, 250 kbps)

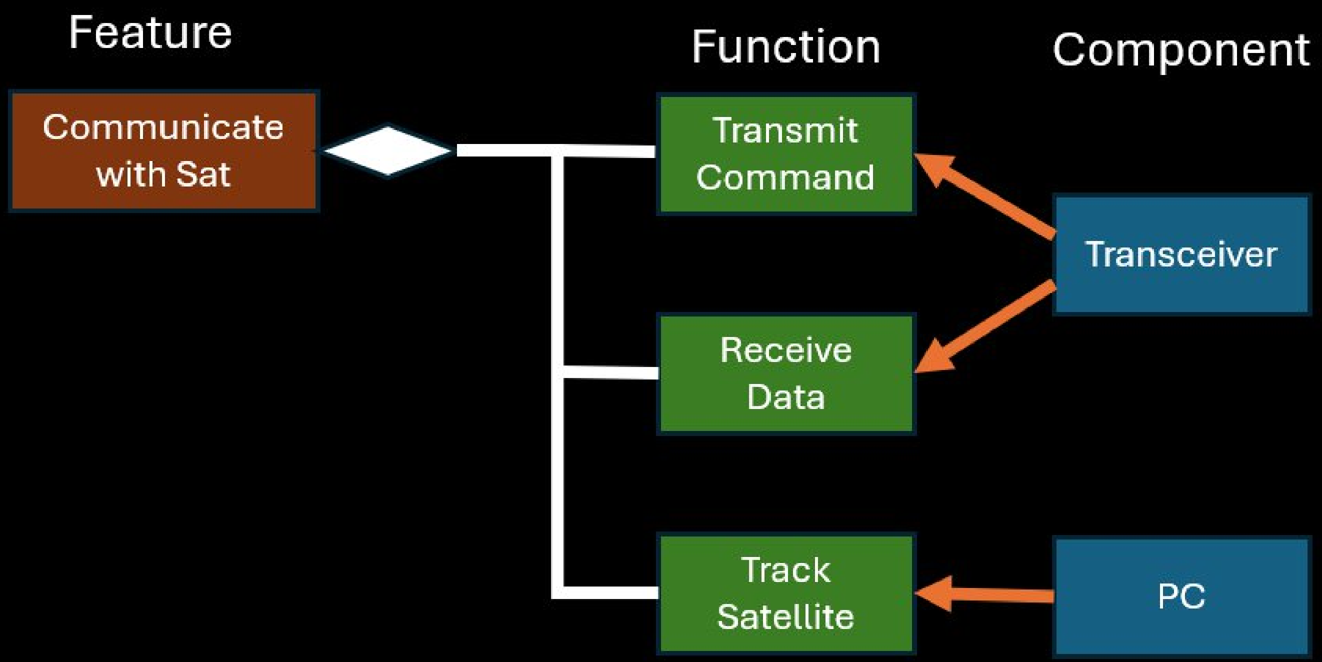


Sensor Description:

- IR Distance Sensor:
  - Detects thick clouds
- IR Thermal Imager Sensor:
  - Cloud temperature
- Camera and GPS:
  - Visual and geotagging

3. Mission Design
3.3 Step 3: System Design from Functional View

7 **Create A Function Decomposition Diagram:**

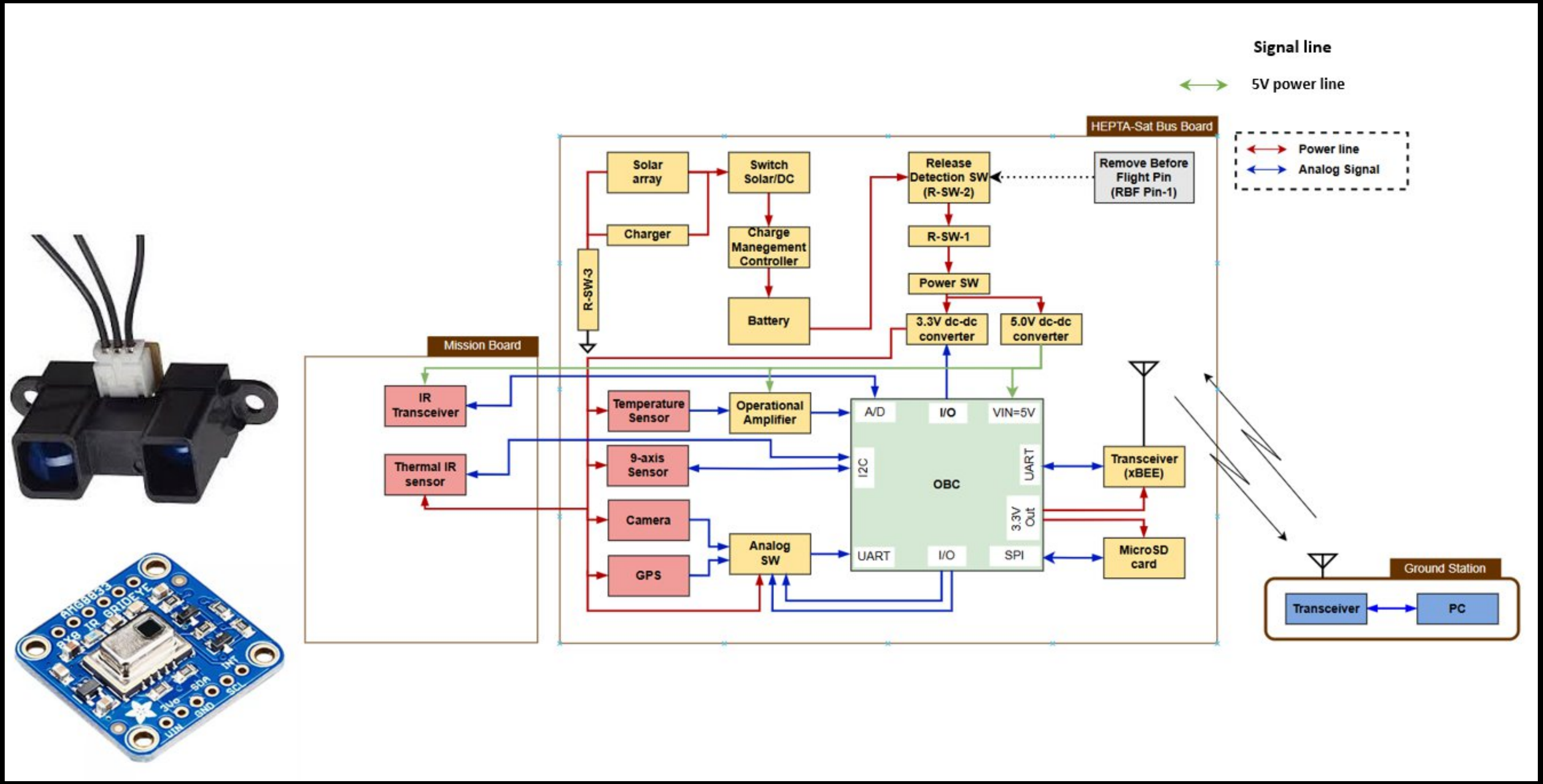


Purpose:

- Identifies functions and components from features.
  - Operational Requirement -> Feature
  - System Requirements -> Function, Component
- Easy to understand relationship between features, functions and components.

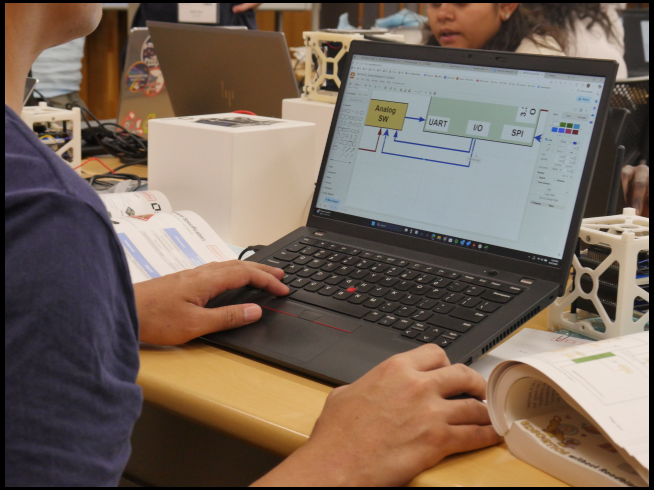
3. Mission Design
3.4 Step 4: System Design from Physical View

8 **Create A Block System Diagram:**
Example: CCM CubeSat Mission



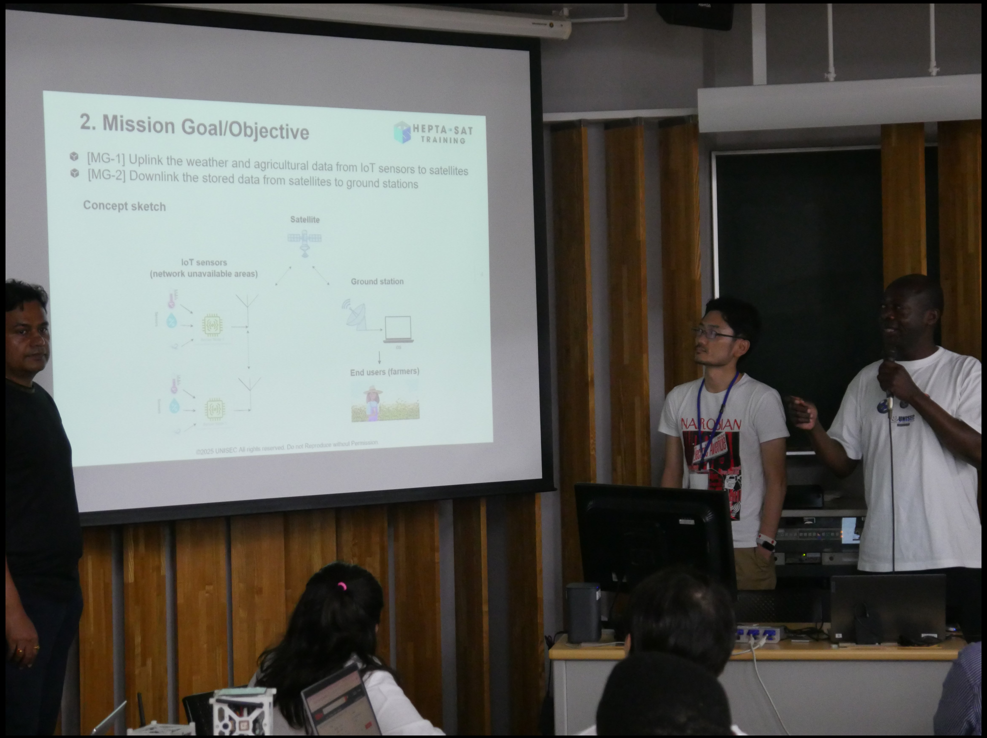
Purpose:

- Represent how components are connected to each other and with other interfaces in a model diagram



3. Mission Design
3.5 Step 5: Mission Design Review (MDR)

9 **Presentation of Mission Feasibility**



3. Mission Design

3.6 Step 6: Component Selection

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Create a Components List:

Example: CCM CubeSat Mission Components List

No.	Components	Model	URL	Where to Get	Qty	Unit Price	Total
1	IR Thermal Sensor	AMG8833	https://akizukidenshi.com/catalog/g/g116737/	Akihabara Market	1	3980	¥ 3,980.0
2	IR Distance Sensor	GP2Y0A02YK	https://akizukidenshi.com/catalog/g/g103158/	Akihabara Market	1	980	¥ 980.0
3	Air Humidifier	GB/T23332-2009		Akihabara Market	1	2980	¥ 2,980.0
4	Jumper Wires				1	0	¥ -
	TOTAL (JPY)						**¥ 7,940.0**

Key parameters from Components Datasheets:

Level	No.	Parameter	Point
Selection	1	Operating Voltage	Voltage input range
	2	Interface	Communication interface
	3	Power Consumption	Power draw
	4	Circuit	Elements necessary for operation
Implementation	5	Circuit & Pin arrangement	Pin Interface
	6	Package	Parts size

3. Mission Design

3.7 Step 7: Experimental Setup / Breadboarding

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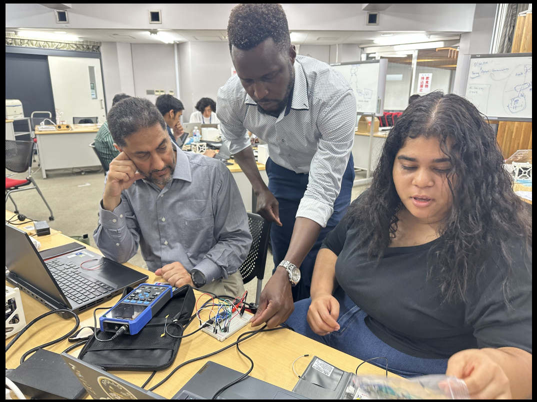
Connect procured components to achieve the mission:

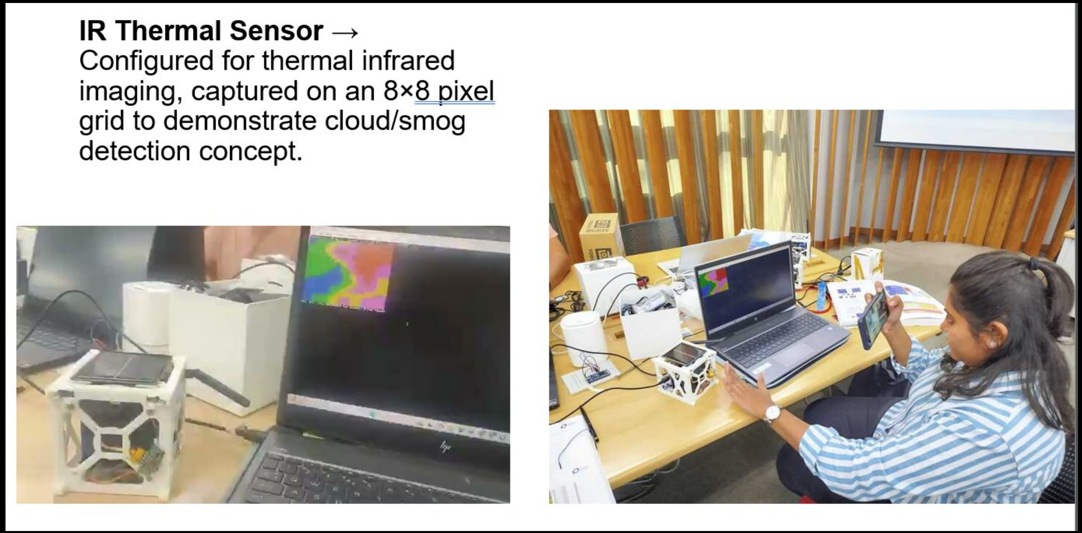
Example: CCM CubeSat Mission IR Thermal Sensor Integration Test

Integration Methodology:

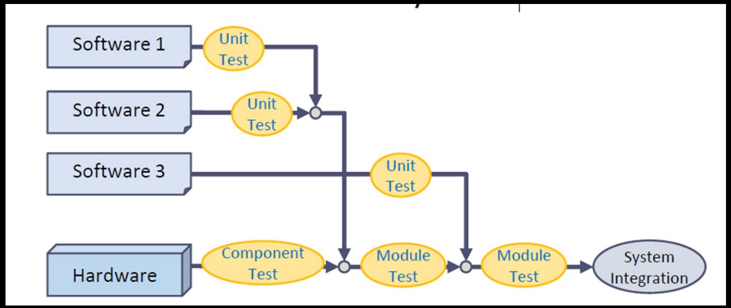
- Keep and add components systematically.



Example: TerraQuak CubeSat Mission Breadboarding



Example: CCM CubeSat Mission IR Thermal Sensor Integration Test



3. Mission Design
3.8 Step 8: Experimental Source Code

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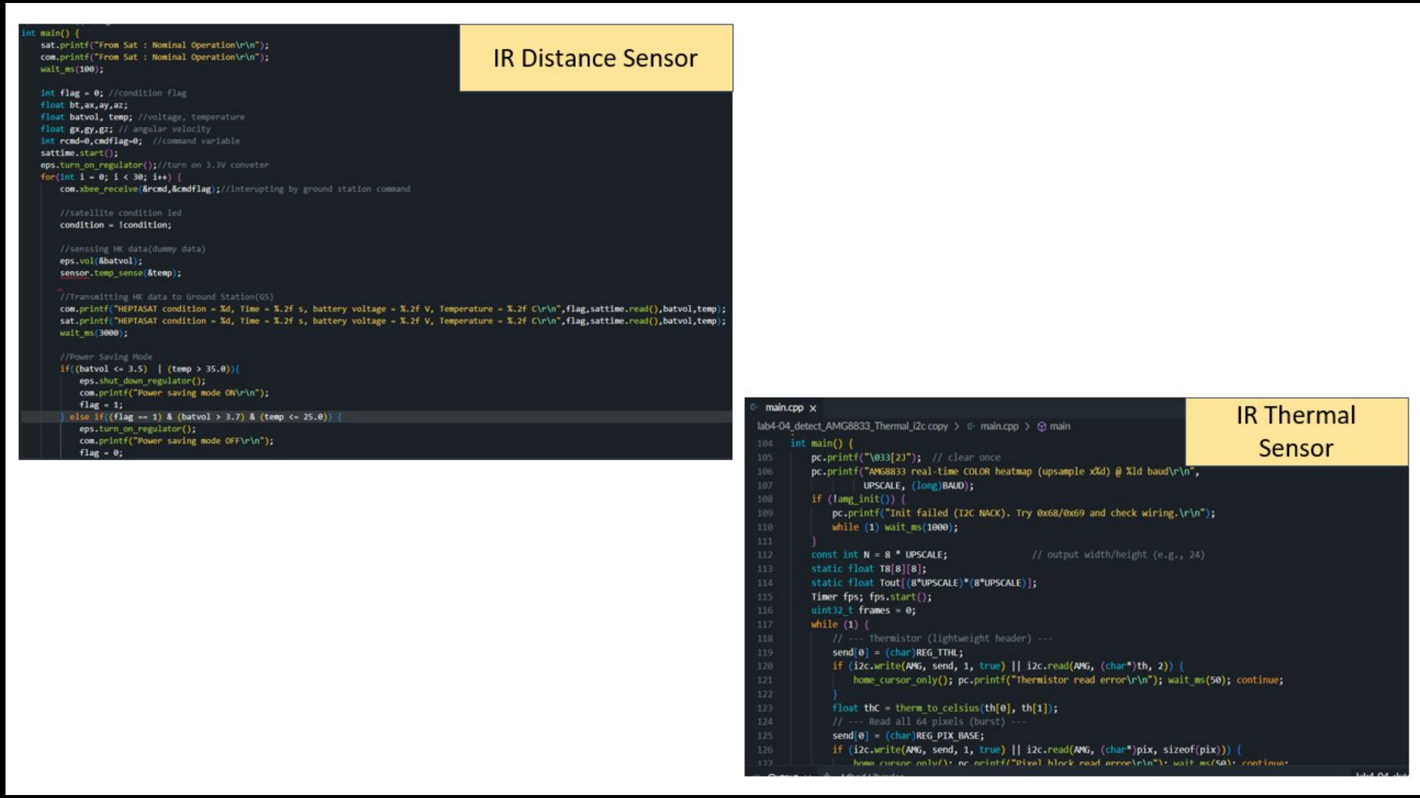
Use version control software like GitHub



Integration Methodology:

- Keep and test software systematically.

3. Mission Design

3.9 Step 9: Preliminary Design Review (PDR)

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Final Project Presentation and Graduation to Teaching Assistants (Green T-shirts)

Purpose:

- Validate the system-level design against requirements.

Example: CCM CubeSat Mission IR Distance Sensor Integration Test

3. Mission Design

3.10 Step 10: Schedule Management

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Create a Schedule:

Example: CCM CubeSat Mission Scedule

Action Item	Person in charge	22/08/2025				26/08/2025			
		9	12	15	18	9	12	15	18
Mission Feasibility	All	■	■						
Sensor Selection	Derrick, Bansi		■	■	■	■			
System Modeling	Marloun, Derrick				■	■			
System integration	All					■	■		
System verification	Rizwan							■	■
Prepare final presentation	All						■	■	■

Important:

- Should be a living document drafted at the project start

3. Mission Design
3.11 Final Projects Overview

No.	Mission	Mission Overview	Members	Teaching Assistants
1	AtmoHEPTA	In-Situ Atmospheric Mass Density Detection	**Mohammed, Essien, Yang**	Nan, Yuto, Nagisa
2	Climate Change Monitoring (CCM) CubeSat Mission	To provide valuable atmospheric and environmental observations, with a focus on urban smog, cloud formation, and flood-related weather events.	**Rizwan, Marloun, Bansi, Derrick**	Aki, Yusuke
3	MIZU	Monitoring of Irrigation Zones Using satellites & IoT)	**Phanish, Ojas, Shohei, Joseph**	Debrupa, Yuzuki
4	TerraQuak	To detect post-earthquake affected buildings susceptible to collapsing due to structural damage using satellite IoT technology.	**Samir, Bonny, Marian, Selma**	Nicki Leon Broichhausen
		Teaching Practice		
1	Heat stroke alert System - Sat	To save people from heat strokes	Shinichi, Hiroshi. Akiko and Shizuka	**Selma, Joseph, Ojas**
2	Thermal - Sat	Surface Thermal Environment Mapping Satellite	Ito, Sakai , Tsukuda, Kyue	**Yang, Shohei, Marloun, Marian**
3	Bare Naked Bear - Sat	Bear monitoring	Mayu, Kazuma, Yuya, Tmoaki	**Bonny, Rizwan, Derrick**
4	Flood - Sat	Water level measurement to Flood detection	Emily, Sakura, Makiko, Iwasaki, Mizusaki	**Essien, Samir, Bansi, Phanish, Mohammed**

4. Lessons Learned

- During breadboarding, ensure component pins are fully inserted in breadboard.
- Easy to learn with an extra mission
- Have a dedicated mission board to handle missions.

Thank You!
Any Question?