24th UNISEC-Global Meeting
Space Synergy: Opening avenues for the academe, industry, and local and international partnerships

Towards development of satellite payloads in the Philippines

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Philippine Space Agency

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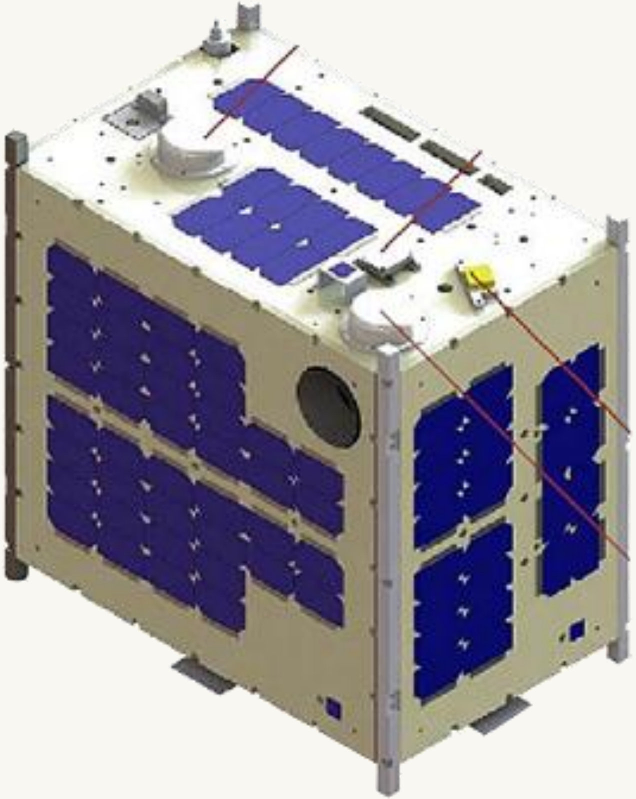
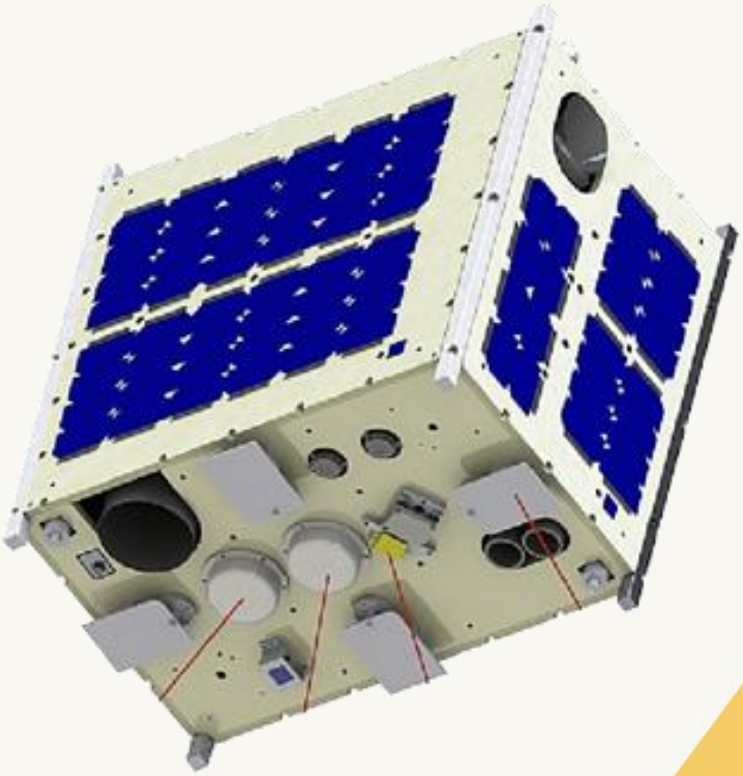
What is this about?

- Story of payload development in the Philippines
  - The story of DIWATA cameras
  - Inspiration in building cameras locally
  - Role of the industry
- Lessons learned
- Moving forward

Philippine’s first earth observation microsatellite





Philippine's first earth observation microsatellite

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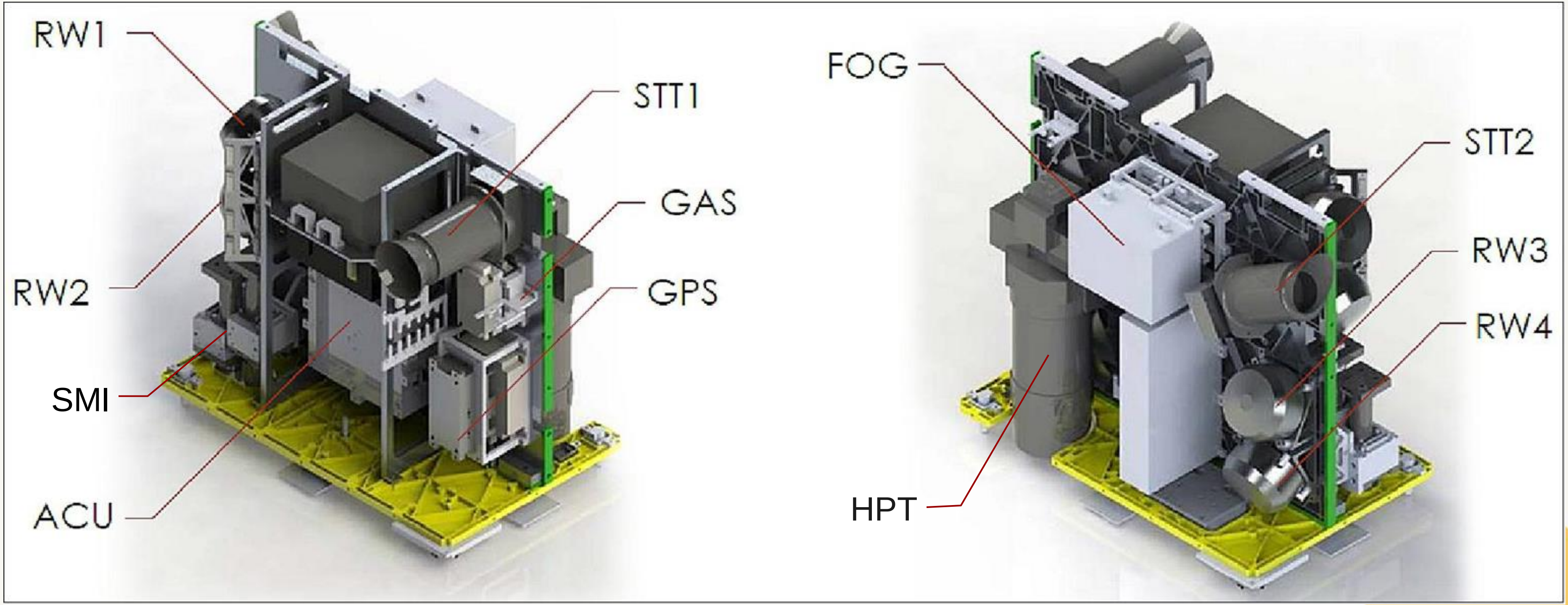
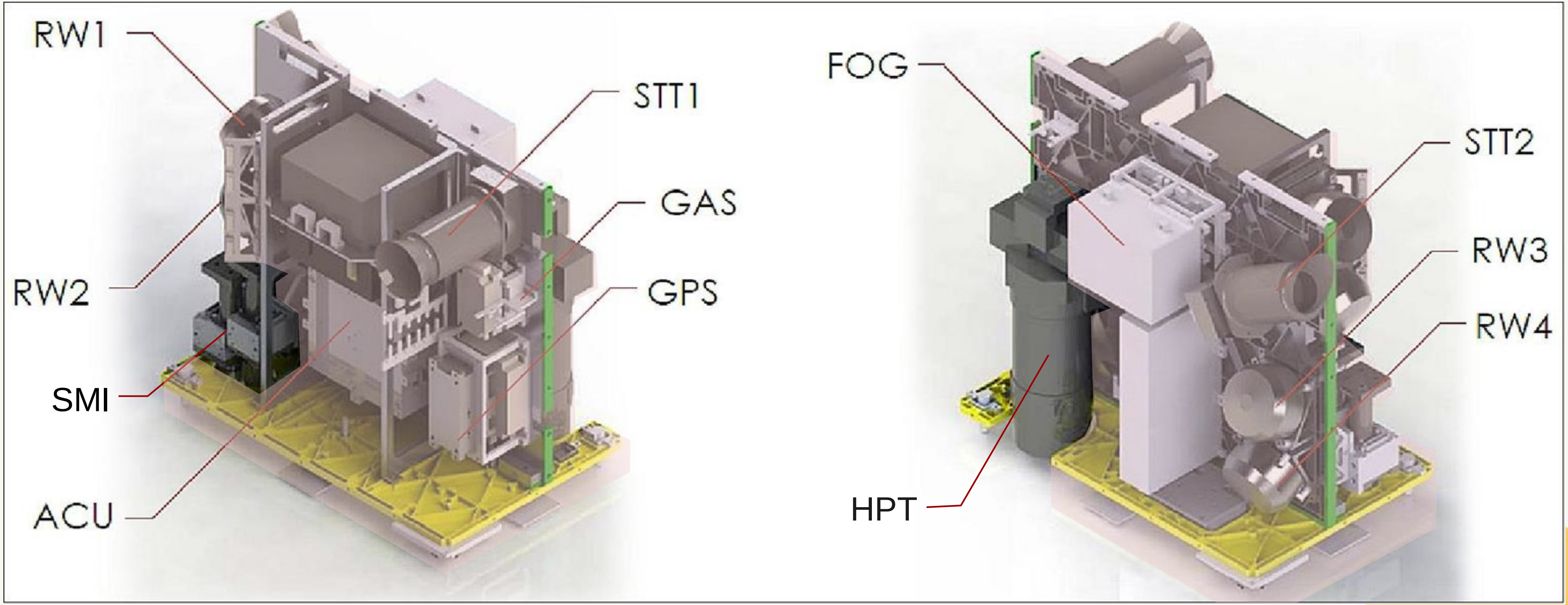


The payload is one of the two main components of a satellite



- Payloads enable the satellite to perform it’s mission

Payloads are components of the spacecraft that enable it to perform its mission

- Payloads vary depending on the needs of the mission
  - Telecommunications: transceivers
  - Earth observation: optoelectronic/radar
  - Technology demonstration: test models
  - Rocket test launch: dummy mass
- Must be carefully crafted to avoid under- and/or overdesigning
  - Mission Requirements
  - Constraints (Technical and logistical)
  - Dependencies

DIWATA payloads

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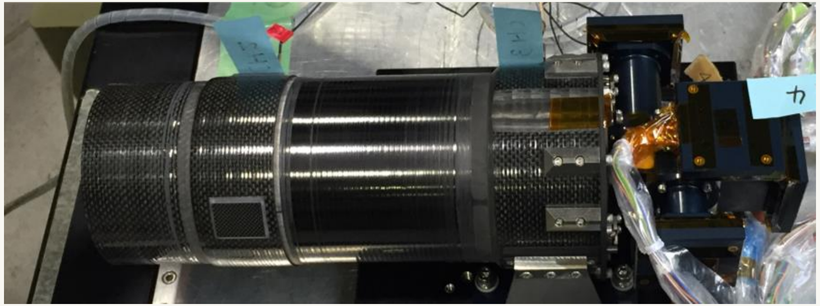

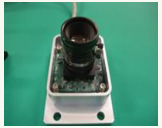

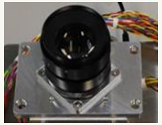

DIWATA optoelectronic payloads

Callsign	DW4TA-1
Downlink Frequency (APRS,VR,beacon)	145.9 MHz
Uplink Frequency (APRS,VR)	437.5 MHz

DIWATA Communication payloads

DIWATA is an optical earth observation microsatellite

- Payloads are optoelectronic cameras (aka digital cameras)
- Uses the visible (VIS), ultraviolet (UV), and infrared wavelengths (IR) of the electromagnetic spectrum
- Designed to capture spatial and spectral information about the earth

ISO 20473:2007
https://standards.iteh.ai/catalog/standards/sist/0a6dd55b-b551-427c-8ce1-047430554dee/iso-20473-2007

Table 1 — Spectral bands for optics and photonics

Designation of the radiation		Short designation			Spectral bands[a] Wavelength λ nm	Frequency ν THz	Wavenumber σ cm^{-1}	Photon energy Q_e eV
Ultraviolet radiation	extreme UV	UV		EUV	1 to 100	3×10^5 to 3 000	10^7 to 10^5	1 240 to 12,4
	vacuum UV		UV-C	VUV	100 to 190	3 000 to 1 580	10^5 to 53 000	12,4 to 6,5
	deep UV			DUV	190 to 280	1 580 to 1 070	53 000 to 36 000	6,5 to 4,4
	mid UV		UV-B		280 to 315	1 070 to 950	36 000 to 32 000	4,4 to 3,9
	near UV		UV-A[b]		315 to 380	950 to 790	32 000 to 26 000	3,9 to 3,3
Visible radiation, light		VIS			380 to 780	790 to 385	26 000 to 13 000	3,3 to 1,6
Infrared radiation	near IR	IR	IR-A	NIR	780 to 1400	385 to 215	13 000 to 7 000	1,6 to 0,9
			IR-B		1 400 to 3 000	215 to 100	7 000 to 3 300	0,9 to 0,4
	mid IR		IR-C	MIR	3 000 to 50 000	100 to 6	3 300 to 200	0,4 to 0,025
	far IR			FIR	50 000 to 10^6	6 to 0,3	200 to 10	0,025 to 0,001

[a] The wavelength values are valid for delimitation of the spectral bands. The values for frequencies, wave numbers and photon energies are approximate values given for convenience.

[b] For other fields of application, which are excluded from the scope of this International Standard, there may be different definitions. For example, IEC 60050-845:1987, identical with CIE Publication No 17.4, for its purpose, defines the upper limit of the UV-A band as 400 nm (see also Annex A).

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ISO 20473:2007 “Optics and Photonics - Spectral Band”

An image records light-matter interaction

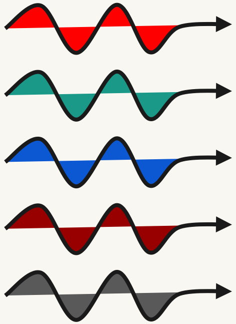
Red

Green

Blue

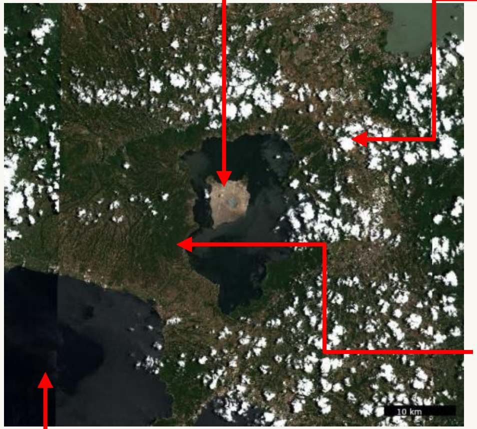
NIR

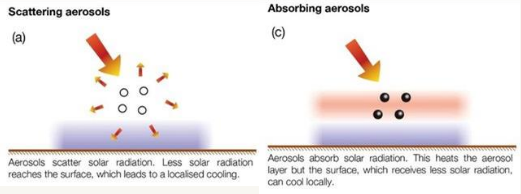
SWIR



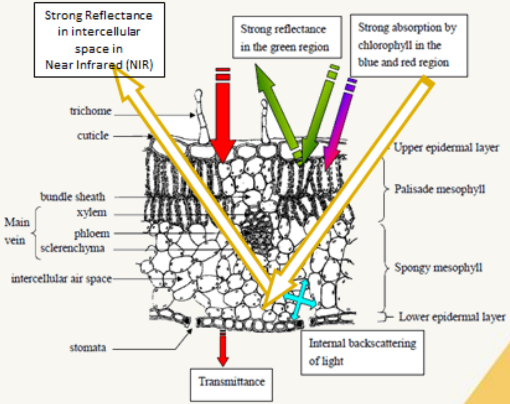
Soil
(Reflection)

Aerosol
(Scattering)

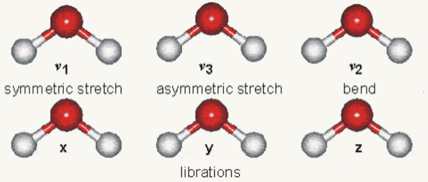




Foliage
(Absorption and
Interference)



Water
(Absorption)



http://www.senteksystems.com/wp-content/uploads/2015/12/plant-strucuture-detail_tr.png
Mollard, James. (2017). Improving the Simulation of Carbonaceous Aerosol in HadGEM3-UKCA. 10.13140/RG.2.2.28820.55682.
http://www.acamedia.info/sciences/J_G/envrad/microwaves/v1.gif

What are we trying to detect?

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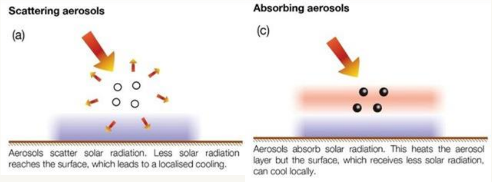
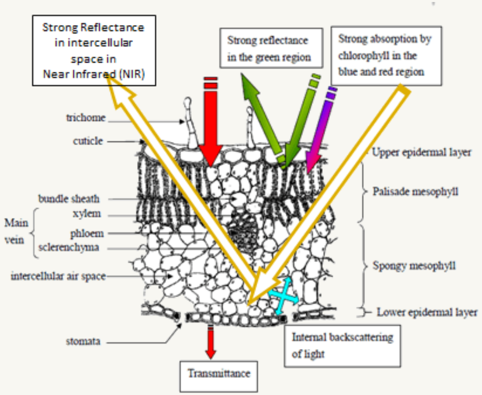
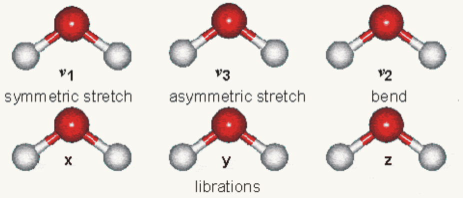
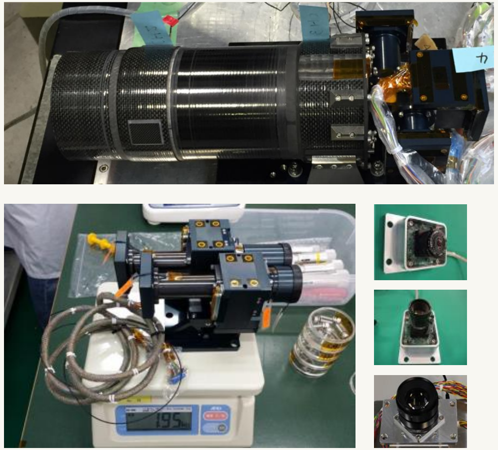


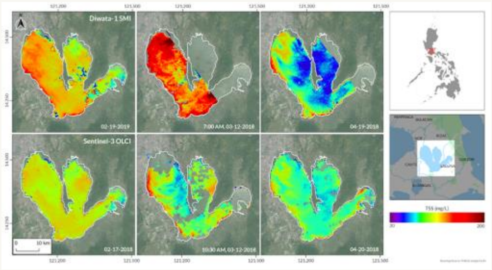


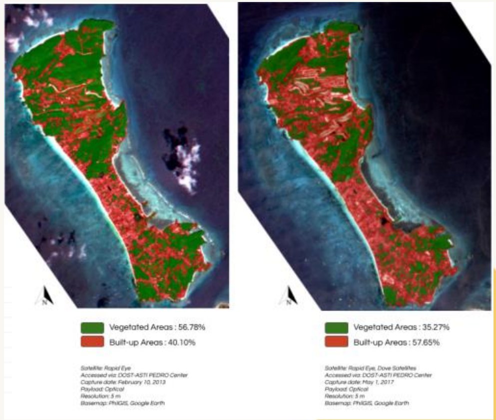


Geophysical phenomena



Remote sensing instrument





RS data products

http://www.senteksystems.com/wp-content/uploads/2015/12/plant-strucuture-detail_tr.png
Mollard, James. (2017). Improving the Simulation of Carbonaceous Aerosol in HadGEM3-UKCA. 10.13140/RG.2.2.28820.55682.
http://www.acamedia.info/sciences/J_G/envrad/microwaves/v1.gif

How did we start developing satellites?

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- Started in September 2014 with the Sakura Science Plan
- A series of activities:
  - Satellite Application lectures
  - Lab tours in Hokkaido and Tohoku Universities
  - Industry tours (Mitsubishi Heavy Industries)
- A mission planning session
  - Identified the requirements
  - Identified the main features of the payload
  - Discussion on possible launch opportunities for the satellite

For us it is something new and we are very eager to try

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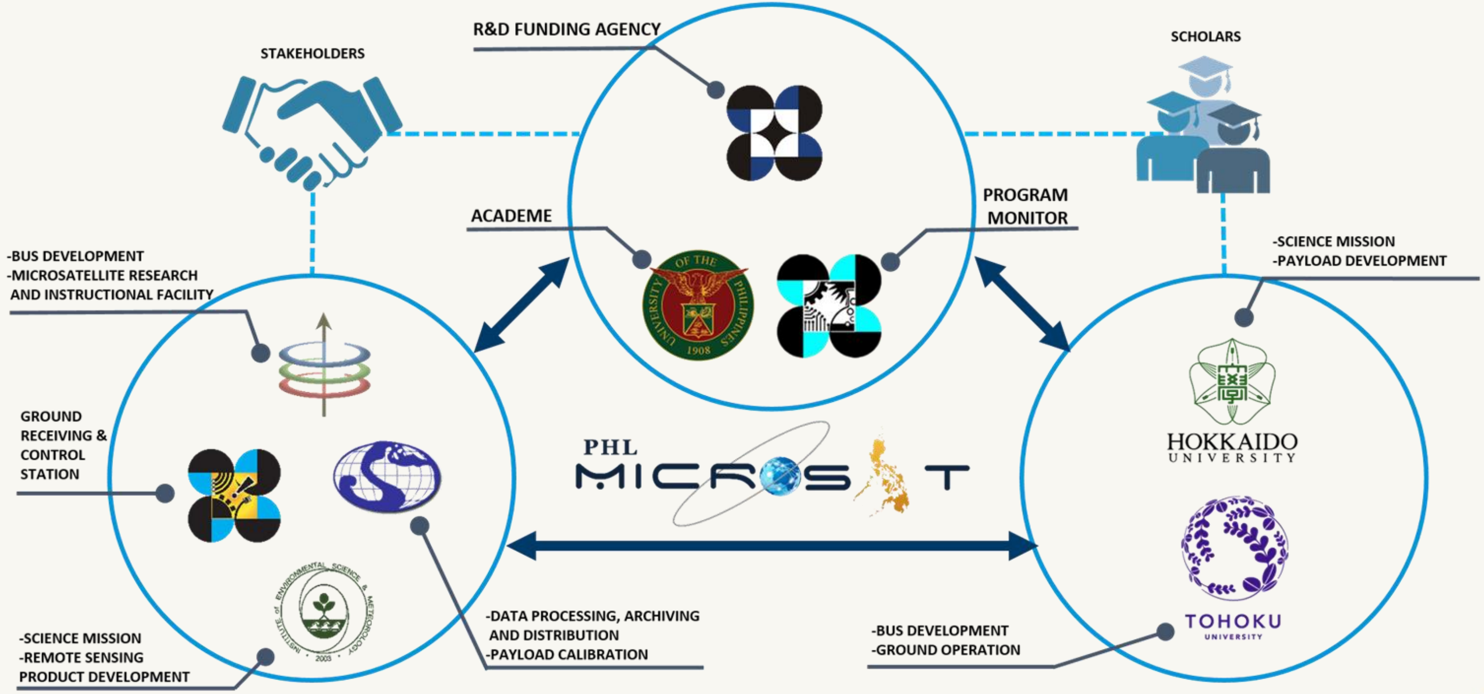
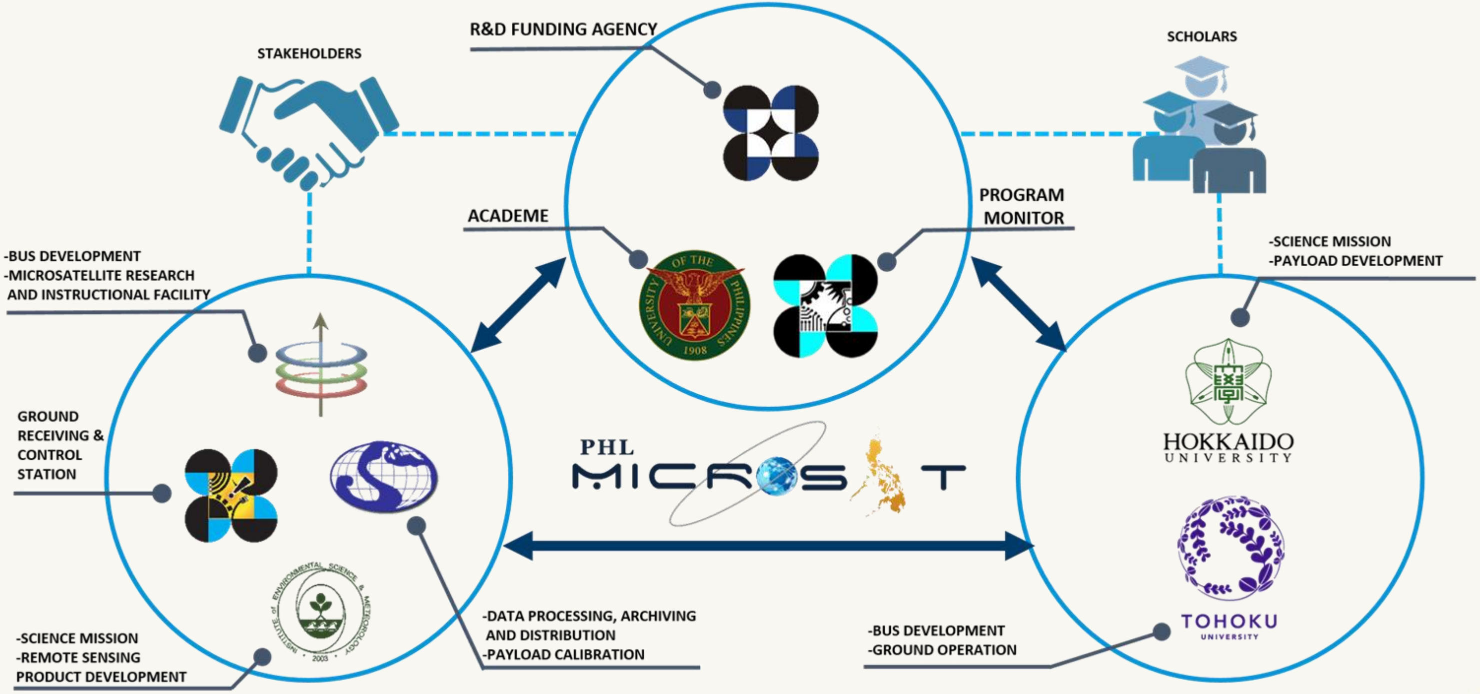
- PH delegates consists of a very diverse team of scientists and engineers
  - Electronics and communication engineers
  - Mechanical Engineers
  - Geodetic engineer
  - Environmental scientist
  - Physicists
- No PH delegate has experience in developing space technologies

PHL-Microsat is a collaborative R&D endeavor



However there is a limitation to PHL-Microsat



A noticeable gap in the previous phase is the lack of a component project that focuses on payload development

STAMINA4Space took over PHL-Microsat

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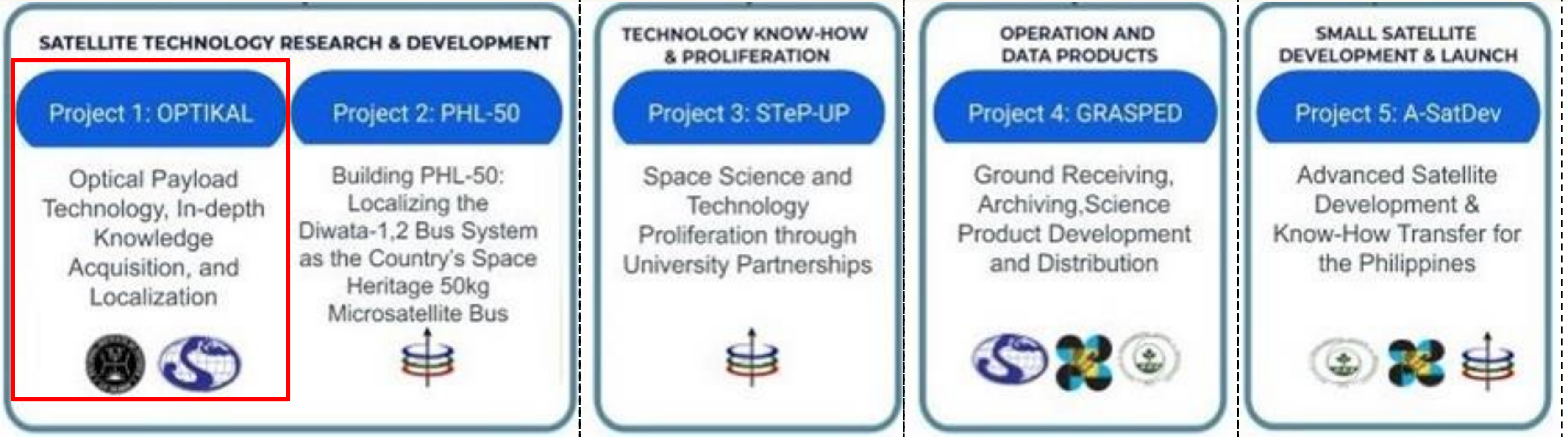
UPSTREAM	CAPACITY BUILDING	DOWNSTREAM	UPSTREAM



Microsatellite (~50 kg) *Industry Partnerships*	*Nanosatellite (~1 Kg)* *Academic Partnerships*	*Data Products & Services* *Government/End-users*	*Microsatellite (~100 kg)* *Know-how advancement*

Payload development became a focus of satellite development in the Philippines

Objectives of Project OPTIKAL

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Research and Development

R1.
Define mission and technical specification of the primary payload

R2.
Collaborate with International partners in the design, development, and testing of a multispectral payload

R3.
Locally design, develop, and test optical payload for aircraft or satellite platform

R4.
Calibrate and validate the developed optical payloads

Capacity Building

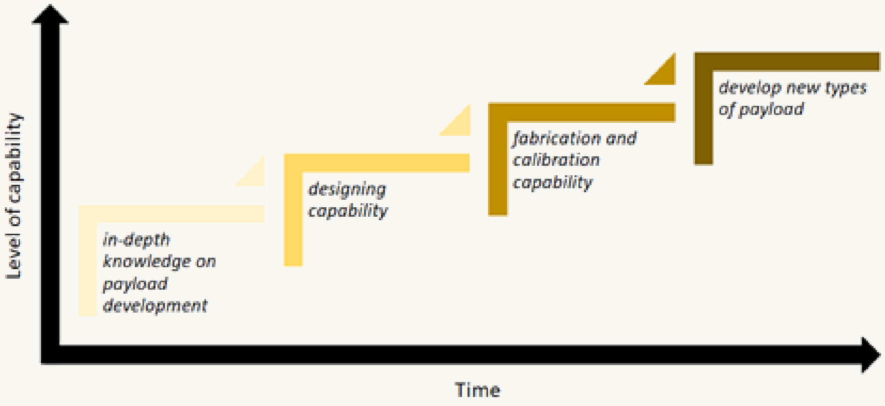
C1.
Establish an optical payload laboratory

C2.
Produce highly trained personnel in optical payload design and development

C3.
Knowledge proliferation in optical design and development

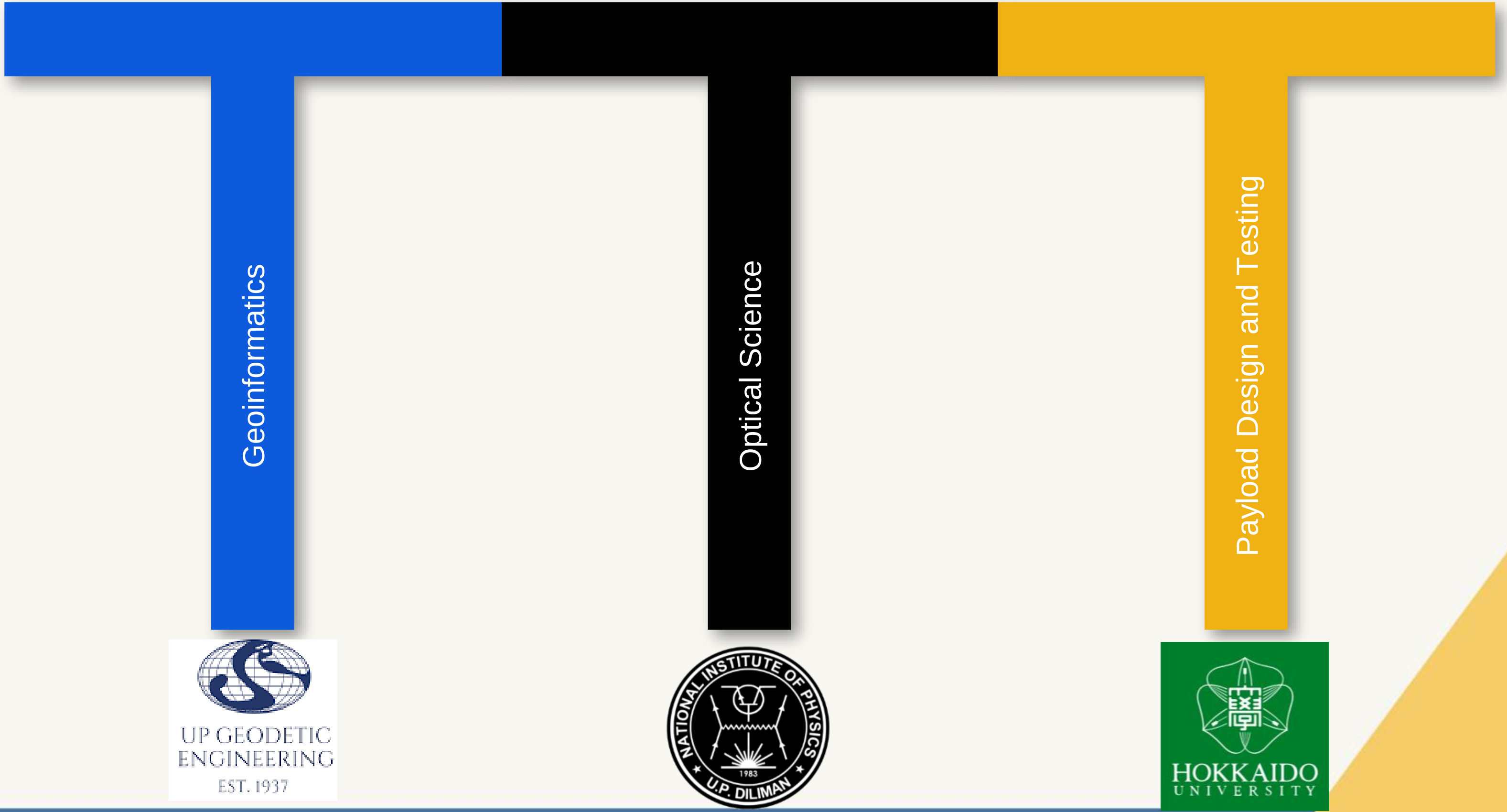
Payload development is identified as a critical component of satellite development

OPTIKAL will be spearheading the satellite payload development in the country and will follow a roadmap towards a *payload development-capable nation.*

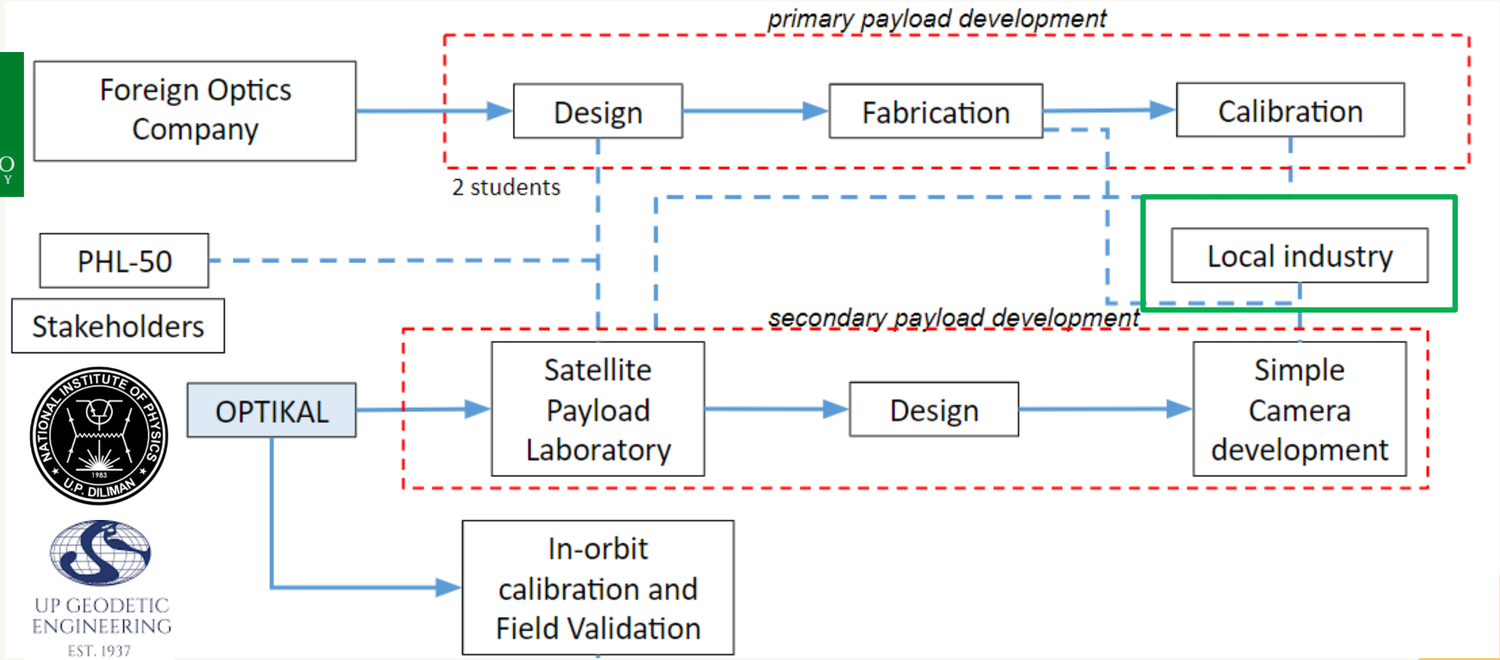


A good collaborator is T-shaped

A good collaborator is T-shaped



Activities of OPTIKAL



We realized that the industry is an important player of development

International Collaboration Activities

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Mission and concept of design	Design and design review	Assembly and Integration	Testing and Qualification
HOKKAIDO UNIVERSITY	Japanese Companies HOKKAIDO UNIVERSITY	Japanese Companies HOKKAIDO UNIVERSITY	HOKKAIDO UNIVERSITY

Development process is iterative

Mission Definition and Technical Specification

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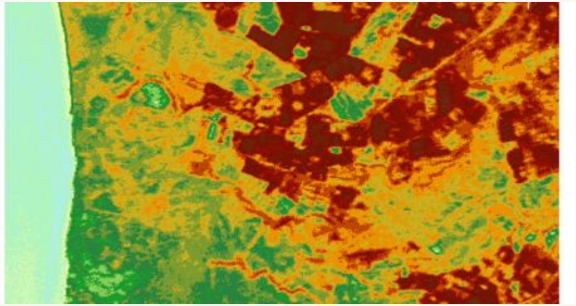
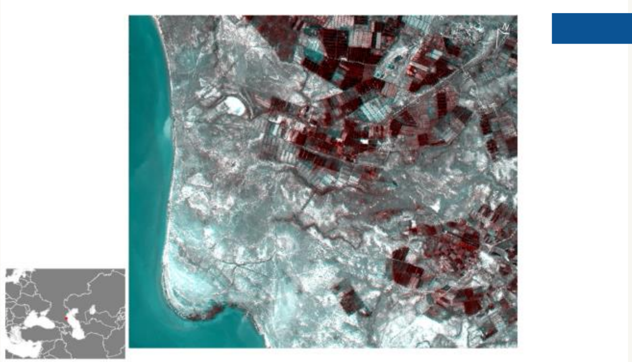
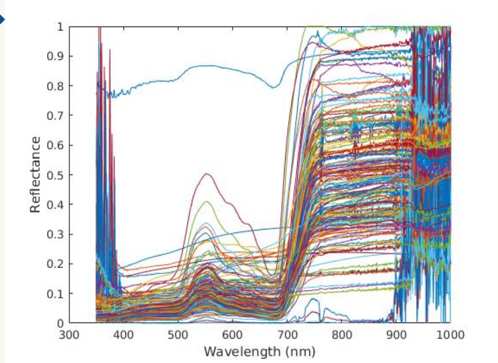
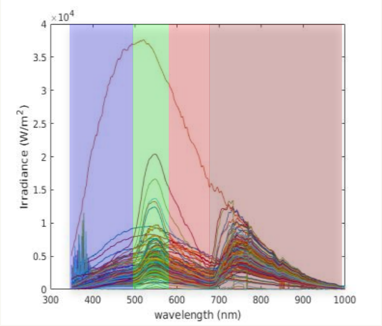




Defining the mission of the primary payload

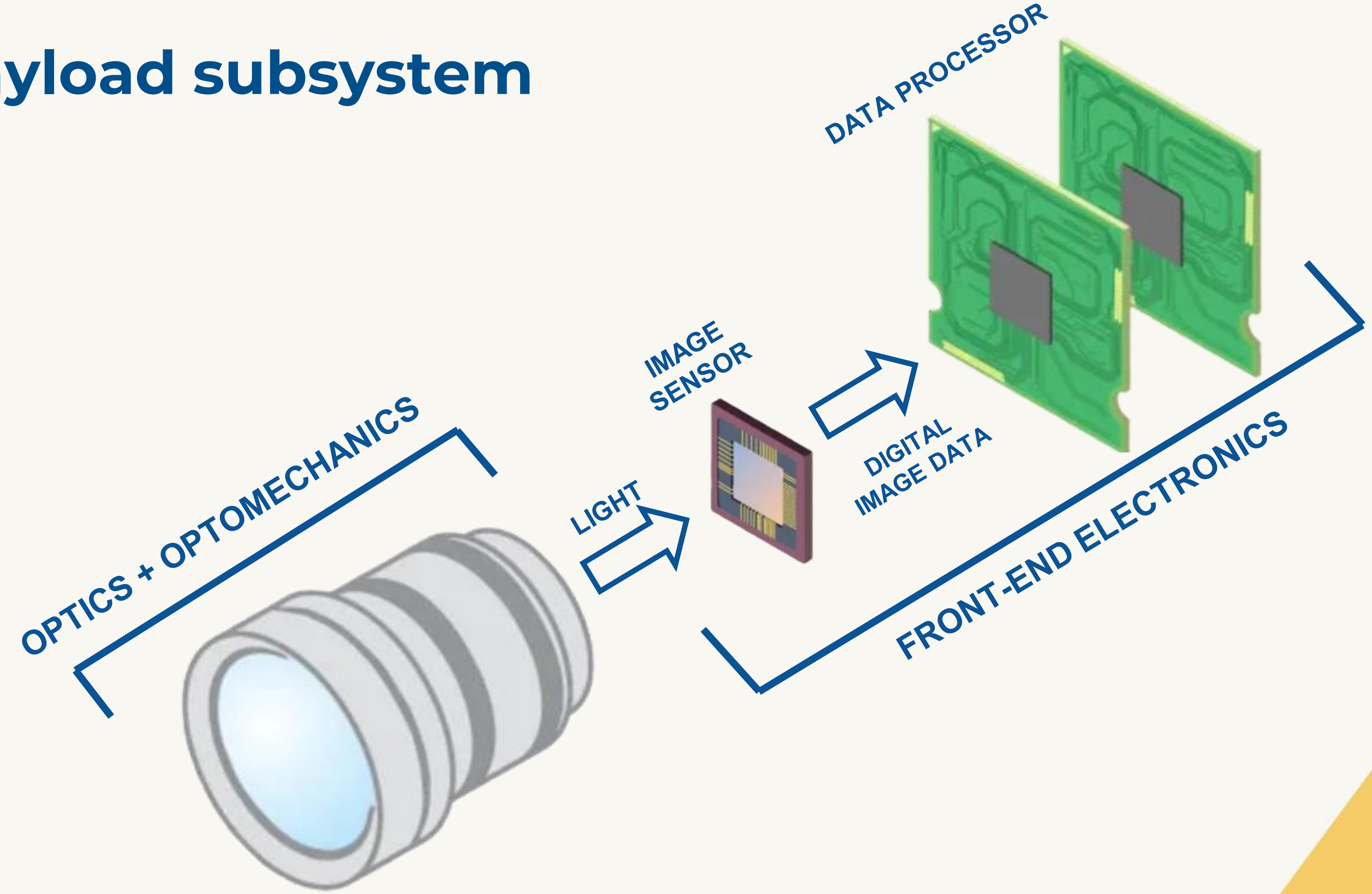


Data gathering and building of spectral library



Designation of band edges and imaging simulation

Payload subsystem



Summary of local activities

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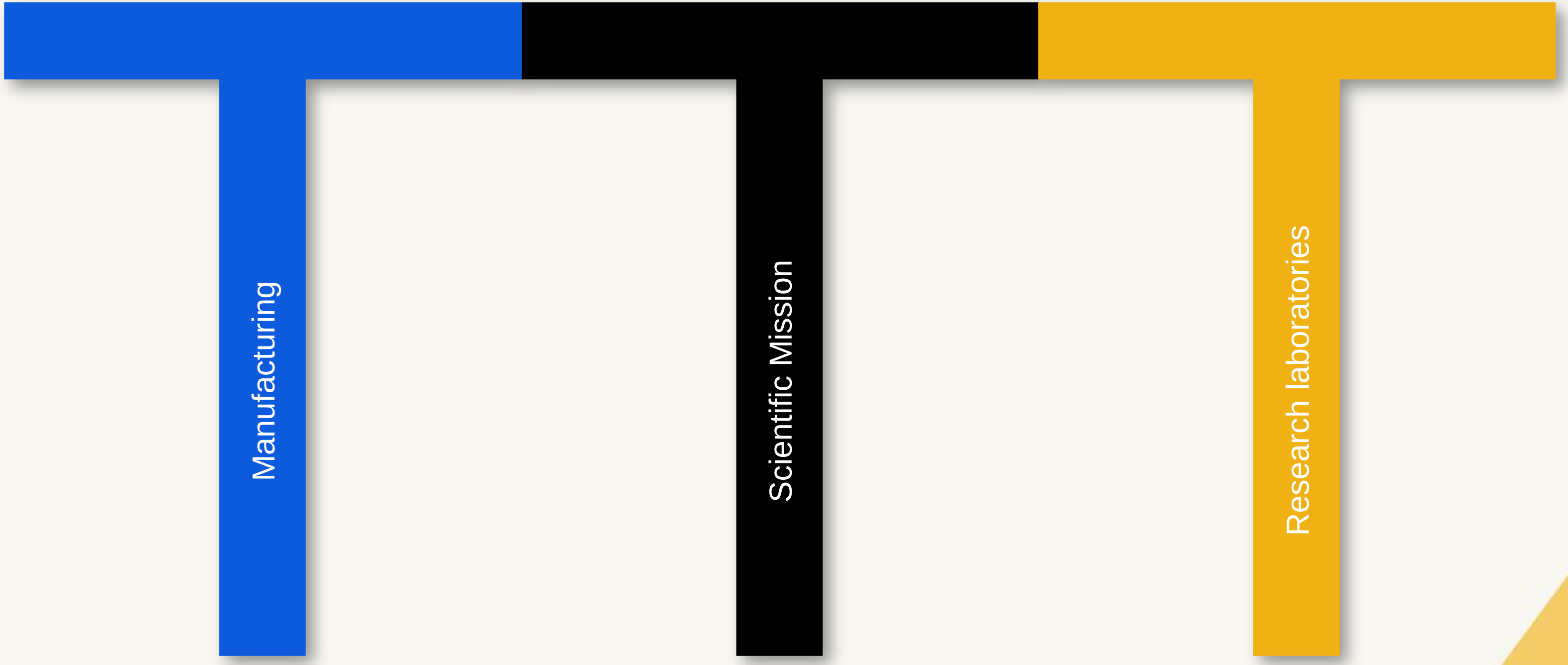
Mission and concept of design	Design and design review	Assembly and Integration	Testing and Qualification
	Local PH Companies	Local PH Companies	HOKKAIDO UNIVERSITY

Development process is iterative

What is the role of the industry?



Industry

Academe

Some challenges

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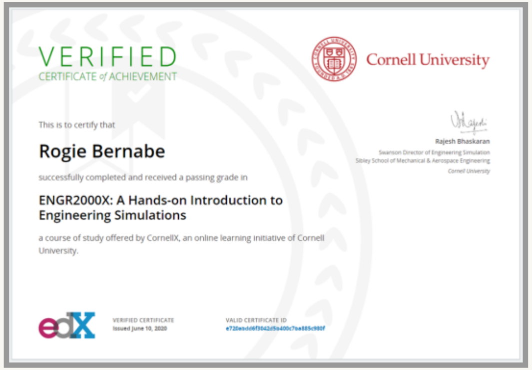
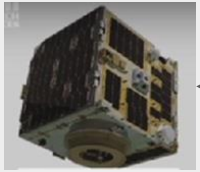
- There are no optical design companies in the Philippines
- Philippine universities are good in optical science but we have no experience is optical engineering
- Resolution: We learned optical engineering from trainings online


VERIFIED
CERTIFICATE of ACHIEVEMENT
Cornell University
This is to certify that
Rogie Bernabe
successfully completed and received a passing grade in
ENGR2000X: A Hands-on Introduction to Engineering Simulations
a course of study offered by CornellX, an online learning initiative of Cornell University.
Rajesh Bhaskaran
Swanson Director of Engineering Simulation
Sibley School of Mechanical & Aerospace Engineering
Cornell University
edX
VERIFIED CERTIFICATE
Issued June 10, 2020
VALID CERTIFICATE ID

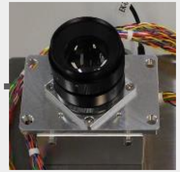

SPIE.
IACET
CERTIFICATE of COMPLETION
This is to certify that
Andrew Rafael Bañas
has successfully completed the course
Introduction to Lens Design and Aberration Theory
Julie Bentley, Instructor
Continuing Education Units (CEUs): 0.8
20 January 2020
Krisinda Plenkovich, Director
Education and Community Services


SPIE.
IACET
CERTIFICATE of COMPLETION
This is to certify that
Micah Jibril Alampay
has successfully completed the course
Introduction to Optomechanical Design
Daniel Vukobratovich, Instructor
Continuing Education Units (CEUs): 2.4
10 February 2020
Krisinda Plenkovich, Director
Education and Community Services

Our development strategies

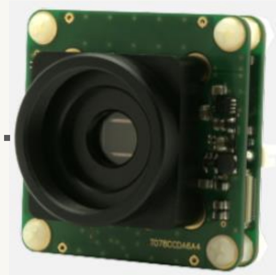


DIWATA-
2B

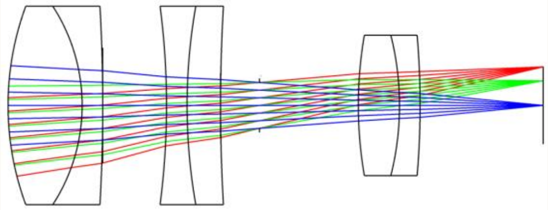


Enhanced
Resolution
Camera

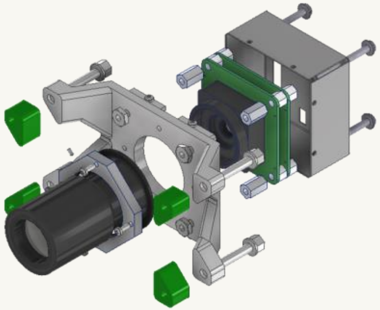
Space heritage optoelectronics



WAT-078H
(Watec)



COTS lenses



Optomechanical assembly
(built in PH)

Spaceborne panchromatic camera

Occena, D. J.; Bernabe, R.; Alampay, M. J.; Hernandez, A.; Madalipay, J. C.; Hilario, P. L.; Soriano, M.: 'A localized spaceborne camera for nano- and micro-satellite platforms', IET Conference Proceedings, 2021, p. 253-257, DOI: 10.1049/icp.2022.0581IET Digital Library, https://digital-library.theiet.org/content/conferences/10.1049/icp.2022.0581

After working hard...

Multi-Application Linear Camera Monochromatic and Tri-linear Array (MALICMATA)

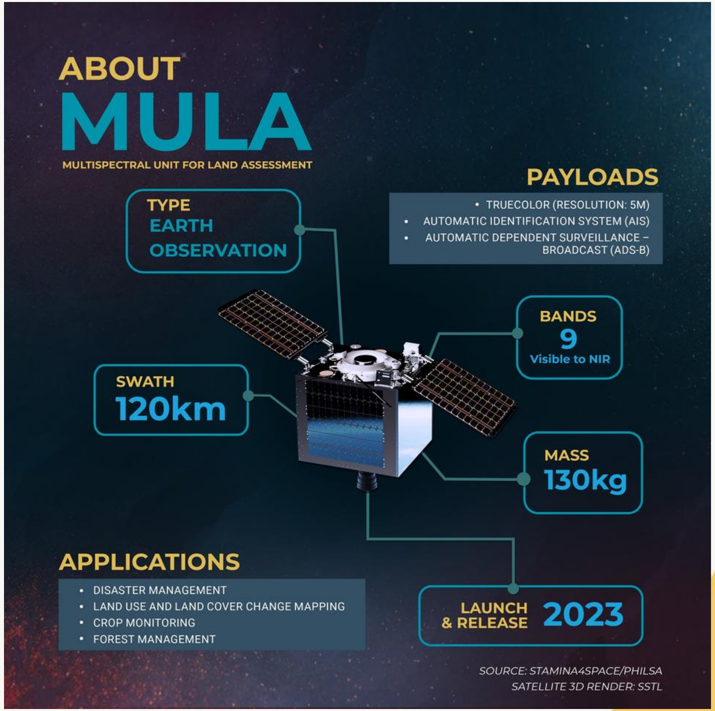
Panchromatic Camera

Some notes

- Industry has practices
  - Fixed schedules
  - Profit oriented
  - Documentations like Scopes of works, etc.
- We needed to adopt our procurement process
- We also needed to communicate them the needs very clearly
  - Apply the scientific method
  - Practice good scientific communication
  - Constant discussions and communications
- Academe can absorb some risks

Payloads under development

- Multispectral Unit for Land Assessment
- Operational Earth Observation
- Payloads
    - 9 band multispectral imager
    - Automatic Identification System - (AIS)
    - Automatic Dependent Surveillance - Broadcast (ADS-B)



Summary

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- Payload development is a collaborative process
- For the Philippines:
  - Payload being developed completely abroad
  - Partial developed operations payload
    - Specs from Philippines
    - Development in Japan
  - Fully developed small cameras through OPTIKAL
- We are at an early phase we are gaining more experience as we go about our satellite development programs
- We recognize that developing the Philippine’s local space capability will be made possible by the synergy between government, academe, and industry

Acknowledgement

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The Space Technology Acquisition, Mastery, Innovation and Applications (STAMINA4Space) Program's Optical Payload Technology In-Depth Knowledge Acquisition and Localization (OPTIKAL) is funded by the Department of Science and Technology (DOST) through the DOST Grants-in-Aid (GIA).

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Thank you.