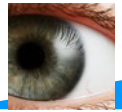
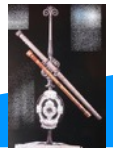
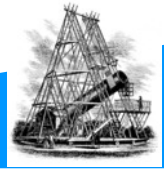
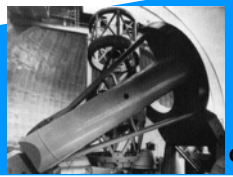
Project PETREL: Platform for Extra&Terrestrial Remote Examination with LCTF

Yoichi YATSU@Tokyo Institute of Technology
on behalf of the PETREL Team

Time Domain Astronomy

- Traditional Astronomy is driven by Telescopes

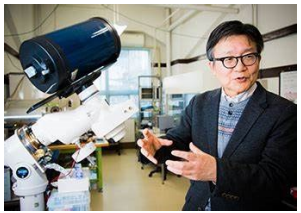

Φ7mm

Φ4cm

Φ50cm

Φ5m

Φ30m

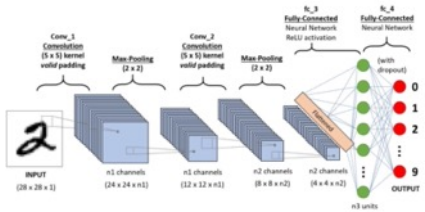
DIAMETER was EVERYTHING!!

- New discovery space opened up by IoT technologies

Earlier observations are important


Robotic Telescopes

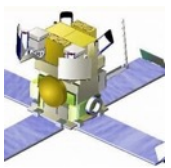
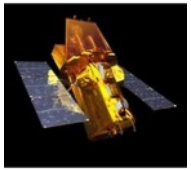

Internet



Computer Science


Super Computers

And we need Agile and autonomous Astronomical satellites.

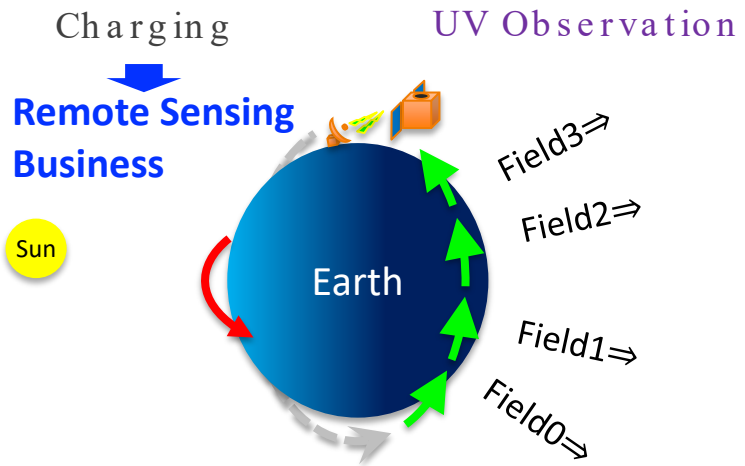
Consideration of Financial Plan

I need more than $3M for my own astronomical satellite, **BUT**

- JAXA is NOT interested in smallsats for Science.
- Smallsats are still expensive for a poor astronomer(me).

And I found that

- UV sky in day-side is too noisy for astronomy.
- Day-side should be used more effectively.



SATELLITE SHARING Concept

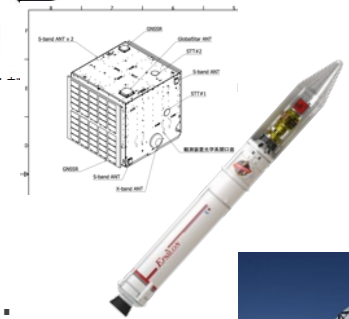
I concieved a beautiful concept

"**SATELLITE SHARING**" with industrial guys

- Night: Astronomy
- Day: Remote Sensing

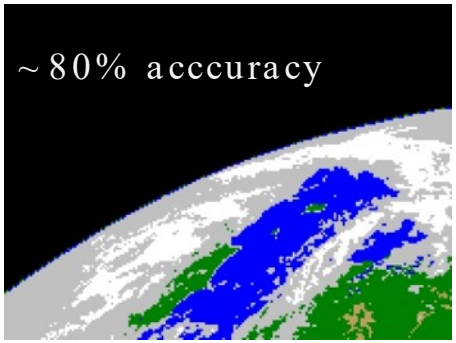
And we got:

- Space Telescopes from ***Genesia Corp***.
- System design support from ***inet Corp***.
- Epsilon rocket from ***JAXA.***
- Antennas from ***inet Corp.*** and ***Goonhilly.***
- Support in data analysis from the other collaborators.



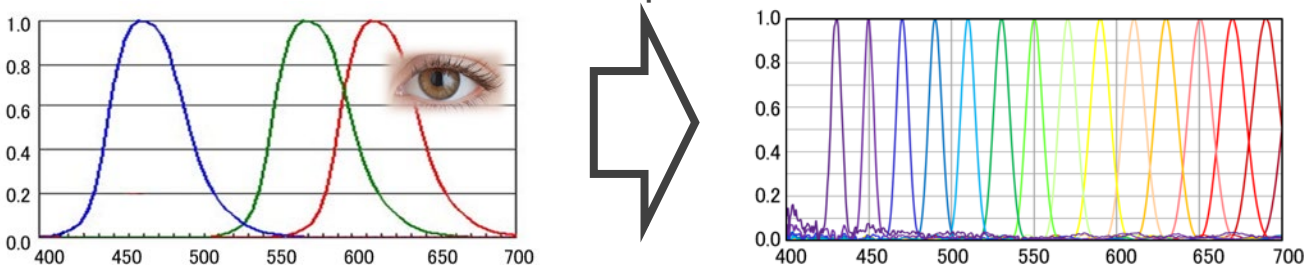
What do we observe in Day time???

- ***DLAS/RAPIS-I*** demonstrated in-orbit realtime Image recognition using color information(2019)

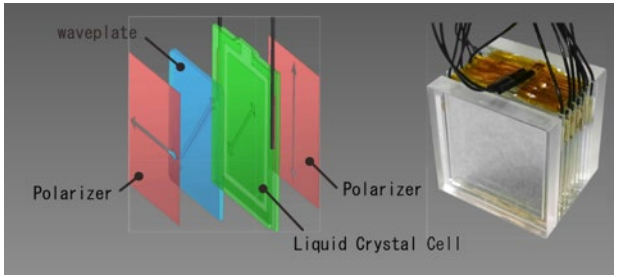


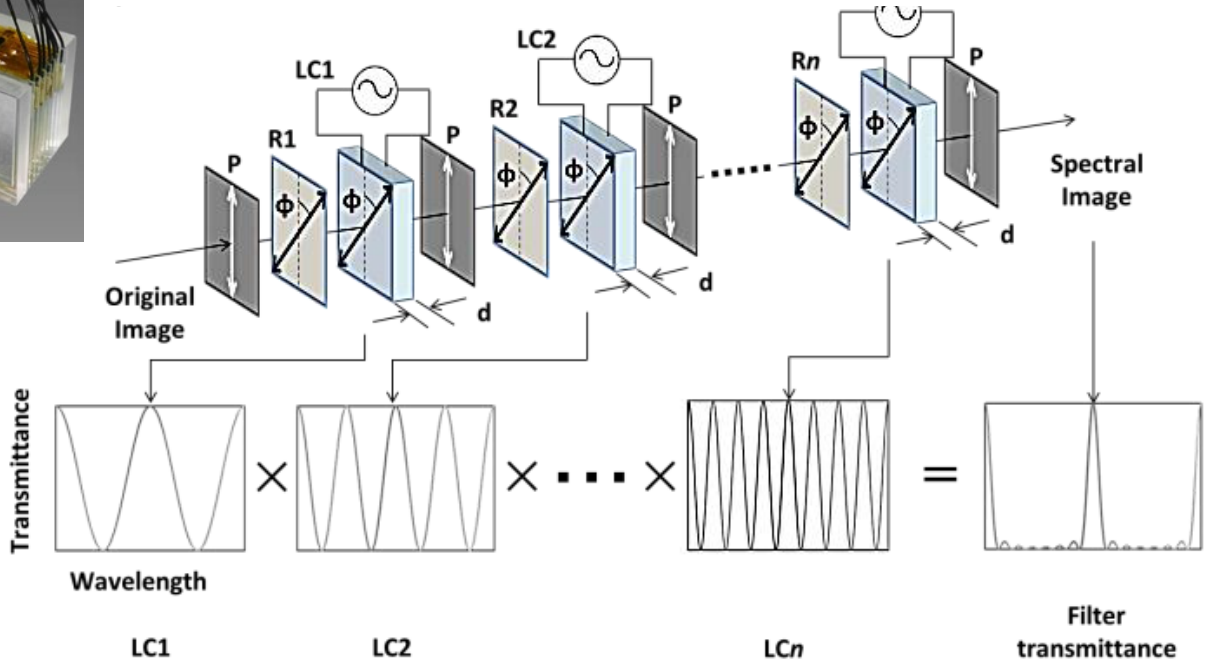
Thick Cloud
Thin Cloud
Ocean
Forest
Desert
Rocky Desert1
Rocky Desert2
Space

- Then we are interested in multi-spectral camera



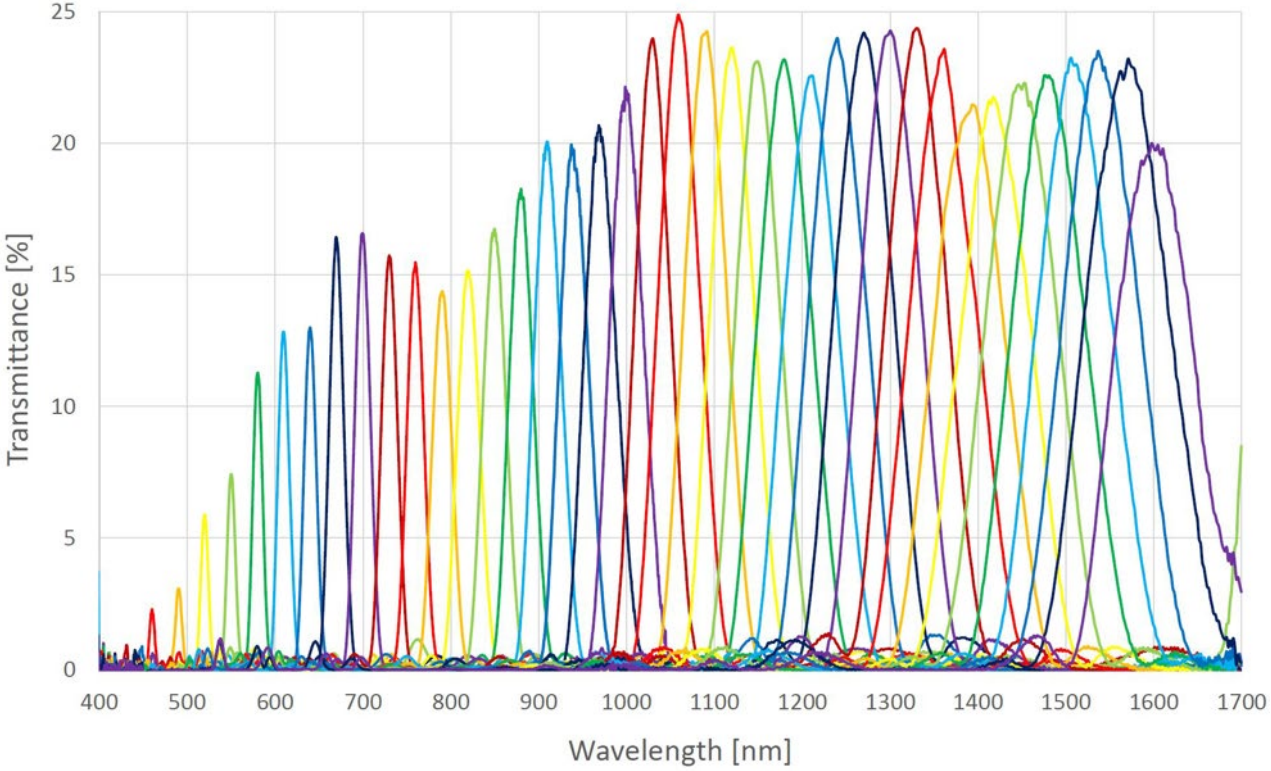
Key device: Liquid Crystal Tunable Filters (LCTFs)





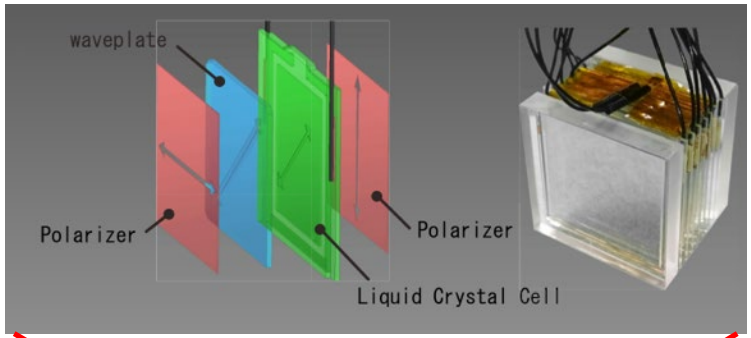
from Terashima+ 18

We can choose any 512 colors from 400~1800nm



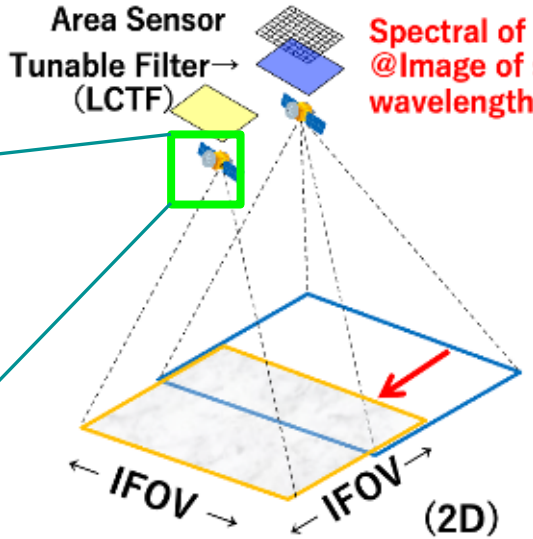
Tunable multi-spectral Camera

See Terashima&Wako+18 and references therein.



LCTF spectroscopic imager

Record a [2D] monochromatic image (Acquire spectrum information by switching wavelength on filter)



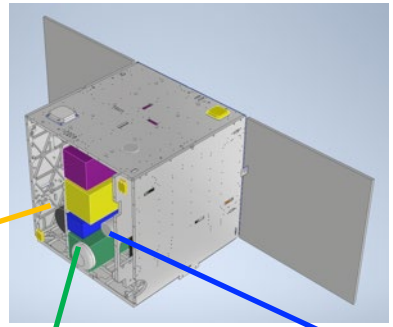
Targets: Blue Carbon

- Blue Carbon: Biological carbon captured by coastal-marine organisms through photosynthetic process of...

From Prof. Nadaoka's slide

55□ of total organic carbon stock on the globe is owned by marine organisms! (Pendlenton et al. 2012)

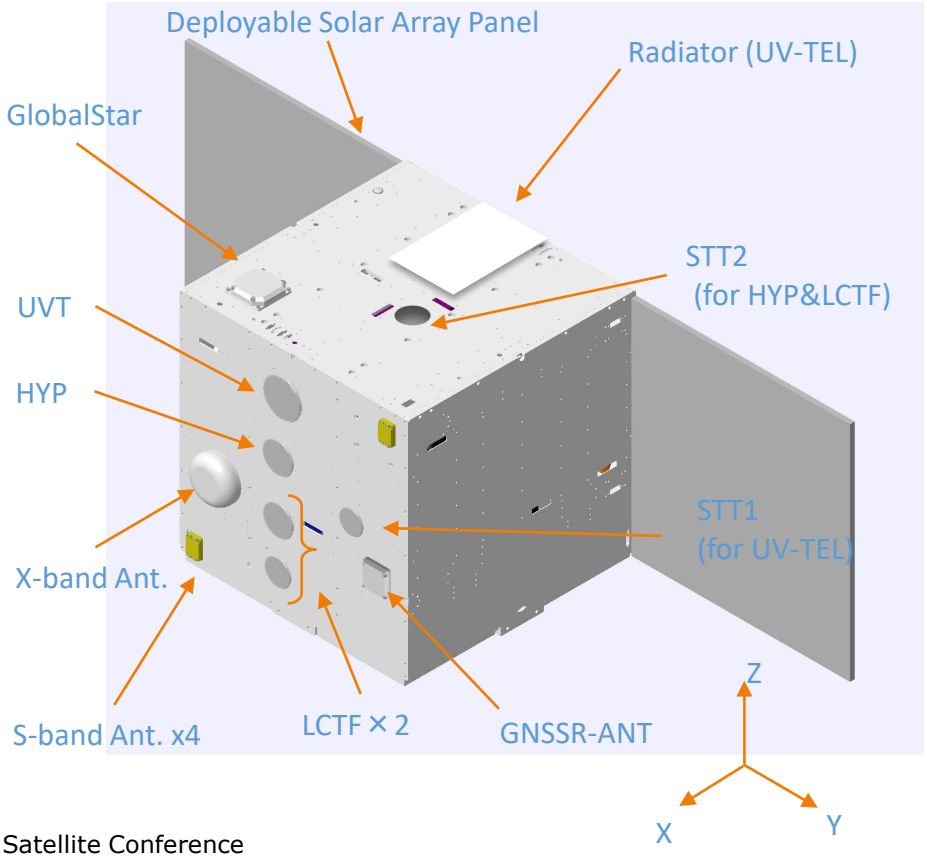
Specifications of mission instruments



CAMERAS / PARAMETERS	LCTF-HR	LCTF-VIS	HYPER
PAYLOAD	3 U / 4.5kg	3 U / 2.0kg	1 U / 1.7kg
POWER CONS.	3 W@max	3 W@max	3 W @max
GSDS	10 m	30 m	30 m
Swath	15 km	100 km	60 km
Wave band (λ)	400-800 nm		
Spectral res. (Δλ)	15 nm	15 nm	10 nm
Channel	512	512	40
DATA RATE	750 MByte / day	750 MByte / day	750 MByte / day
OBS DURATION	<3min/orbit	<3min/orbit	<3min/orbit

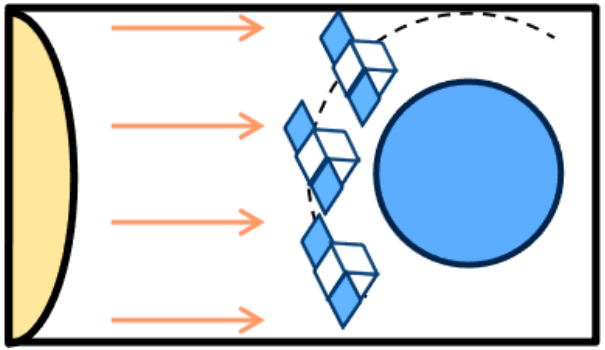
Specifications of Satellite system

Parameters	Values
Mission	□ Spectral Imaging of Land & Sea □ UV Astronomy
Geometry	470× 1300× 480 □ Paddle Deployed
Mass	□ 65Kg
Power	□ Power Generation□ 150.7 W □ Battery Capacitance□ 9600 mAh
Attitude	STT based zero-momentum 3-axis
Comm	□ S-band up□ 1 Kbps □ S-band down□ 10 K□ 100 Kbps □ X-band down□ 40 Mbps □ Globalstar TX for Alert message
Data Strage	□ Mission Telemetry□ 32 GBytex2 □ HK data□ 2 GByte
Mission Life	□ years□ TBD)

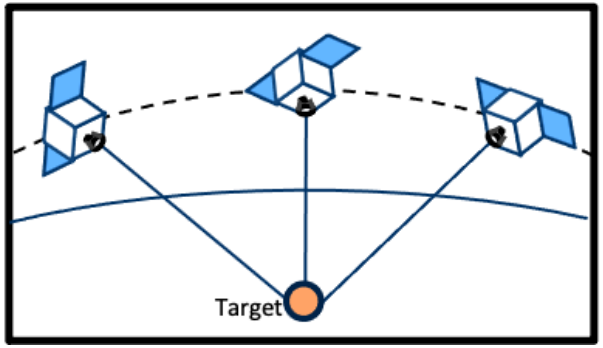


Operation Modes

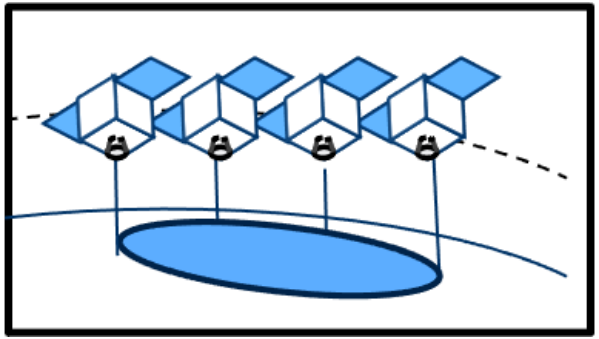
(1) Standby Mode
Sun-oriented (Charging)



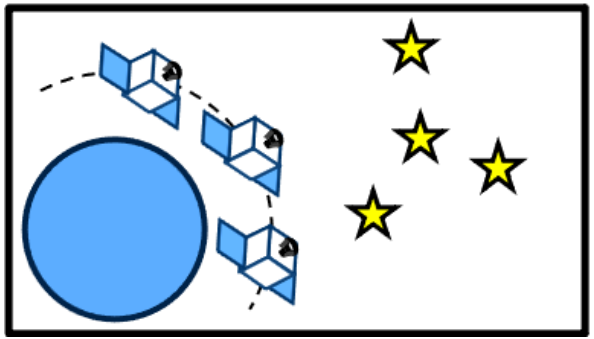
(3) Target pointing Mode
For High-SN observations and TLM downlink



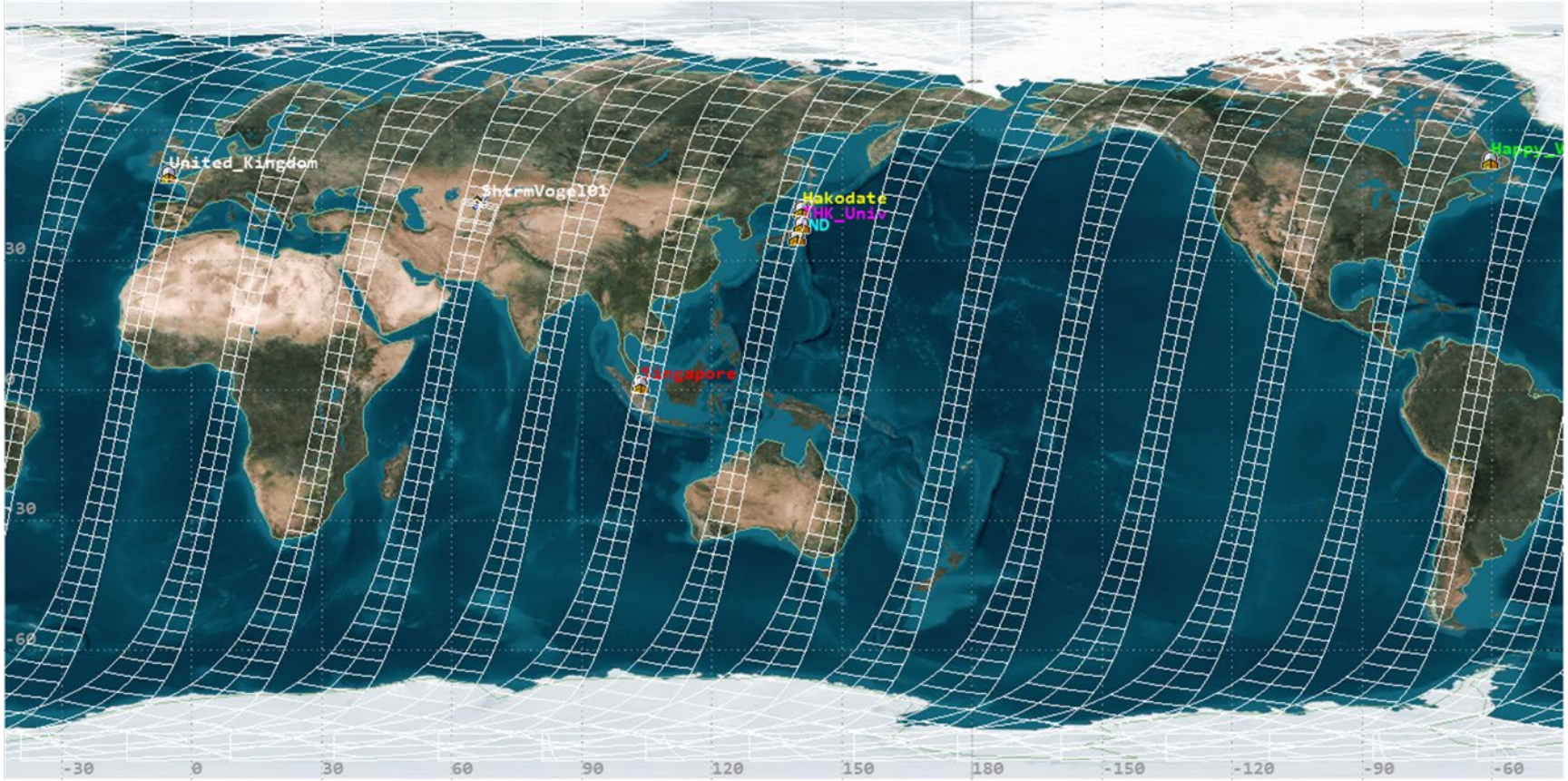
(2) Push Bloom Mode
LVLH for earth observations



(4) Astro Mode
Inertia pointing for astronomy



Coverage of PETREL a day



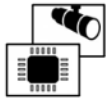
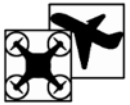
Summary

- PETREL: a multi-purpose satellite developed by an academic-industrial alliance
  - Night-time mission: **UV Astronomy**
  - Day-time mission: **Spectral imaging with LCTF tunable multi-spec Cams**

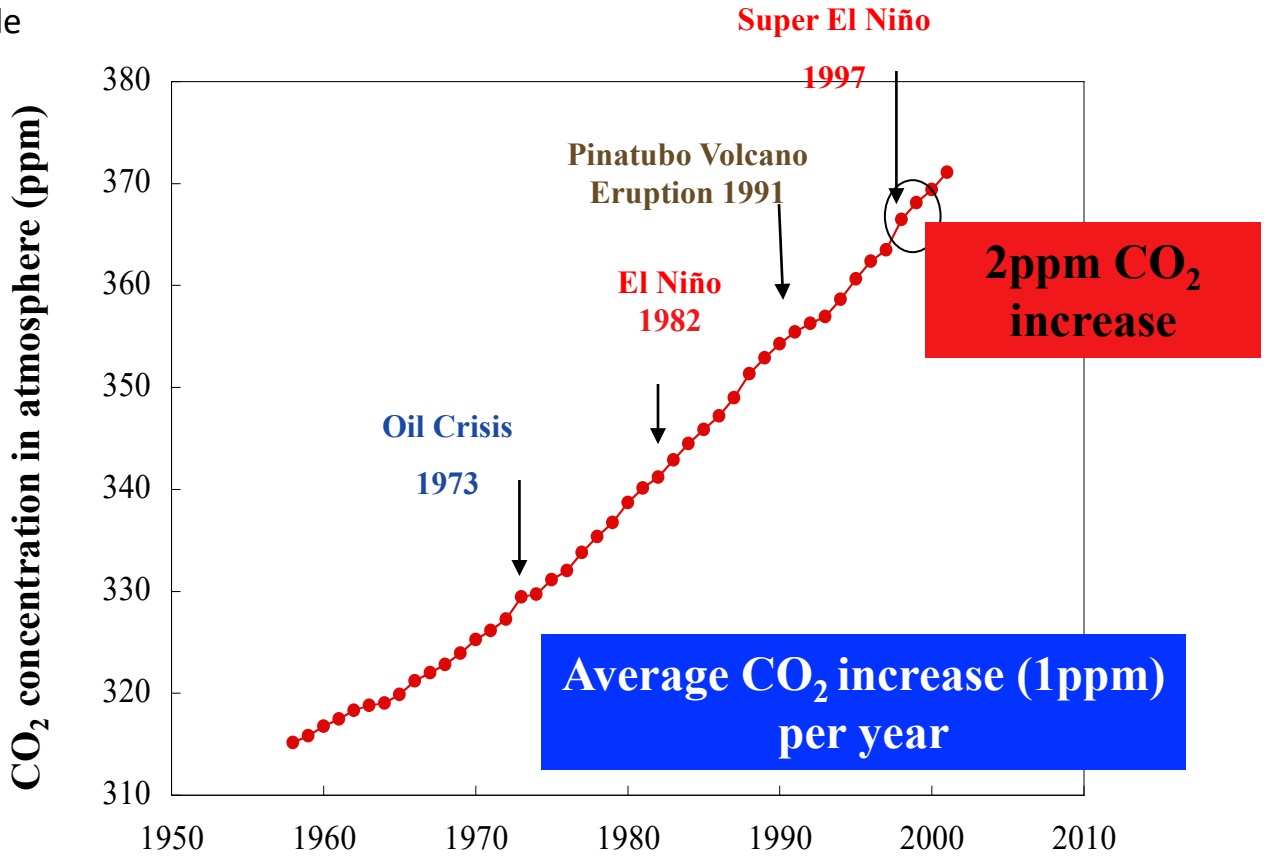
- Satellite bus System
  - 60 kg micro-satellite based on Tokyo Tech's Hibari satellite.
  - 3 attitude modes are supported with zero-momentum 3-axis att control
- Schedule
  - June-2021: Preliminary Design Review
  - Dec-2021: Critical Design Review
  - Feb-2022: Final Integration/Environmental Tests
  - May-2022: Shipping to JAXA
  - July-2022: Launch!?

Project Members

From the earth to Space

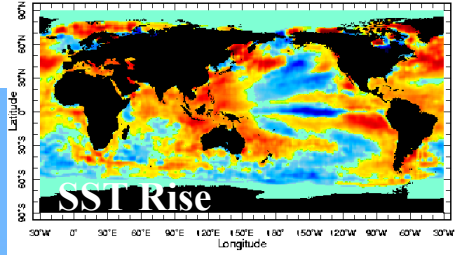
Service area	Academic organization	Company
 Satellite Component	UNIVERSITY OF FUKUI; SCHOOL OF SCIENCE THE UNIVERSITY OF TOKYO	GENESIA
 Satellite Bus	National Institute of Technology Sendai College	I-NET Corp.
 Ground Stations, Operations	Tokyo Tech; TOHOKU UNIVERSITY	GOONHILLY
 Drone & Airplane		EDICS
 Data Center & Software	INFORMATION TECHNOLOGY CENTER THE UNIVERSITY OF TOKYO; YNU YOKOHAMA National University; HOKKAIDO UNIVERSITY	M·SOFT 伝わる 画像技術
 Applications -Oceanology -Argonomy -Environmentrogy -Astrophysics -Space Science	NAGOYA UNIVERSITY; TOHOKU UNIVERSITY; Tokyo Tech; NAOJ National Astronomical Observatory of Japan; Caltech; KAVLI IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE; SCHOOL OF SCIENCE THE UNIVERSITY OF TOKYO	Happiness Grows from Trees SUMITOMO FORESTRY; UMITRON; JSpacesystems

From Prof. Osaki's slide



Annual average of CO_2 concentration in atmosphere at Mauna Loa, Hawaii from 1958. (Cited from "The State of Hawaii Data Book 2001)")

Multiple Environmental stresses



Unsustainable Tourism development

Mangroves

Watershed

Over/illegal fishing

Ocean acidification

Ocean

SLR

Seagrass Bed

Coral Reef

Outbreak of COTS

Annually its 0.5-3□ has been lost due to degradation of coastal environment (Pendleton et al. 2012).

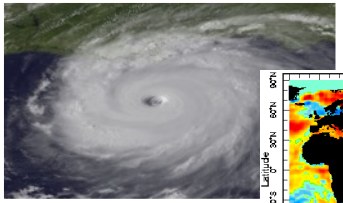
From Prof. Nadaoka's Slide

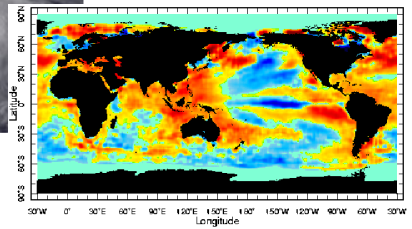
From Prof. Nadaoka's Slide

Negative chain reaction

Rapid declining of coastal ecosystems

Carbon release back to atmosphere





Coral Triangle as world richest area in biodiversity

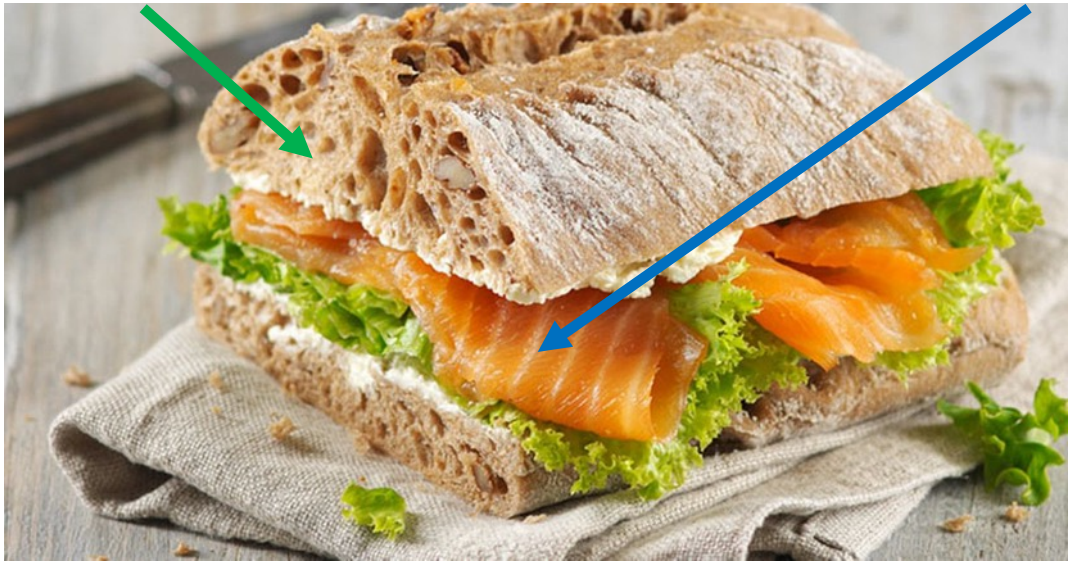
We'd like to eliminate the negative chain utilizing our technology

Man can't live on bread

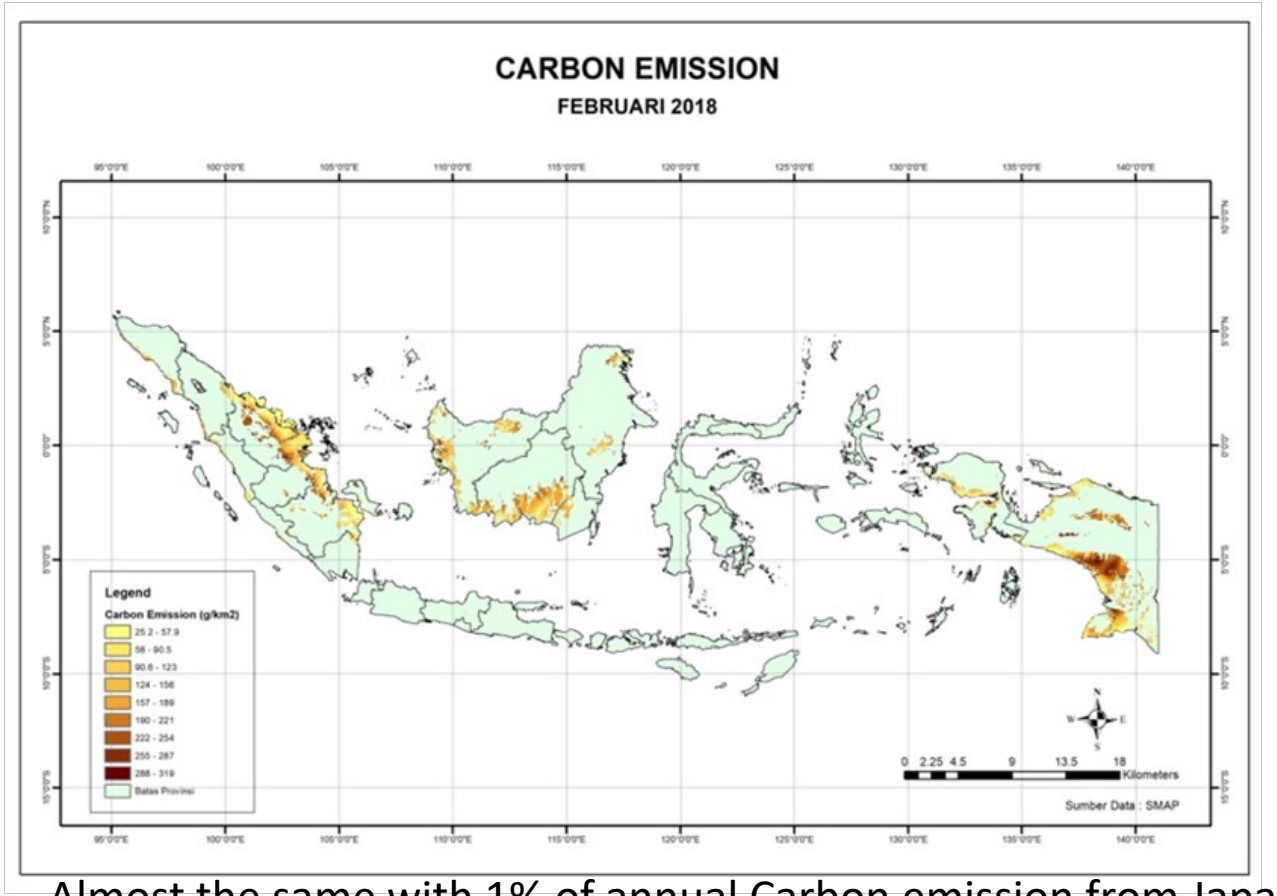
Matthew 4-4

Agriculture

Aquaculture



Climate issue



Almost the same with 1% of annual Carbon emission from Japan