DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

UNISEC University Space Engineering Consortium

CROSSEYE: a CubeSat LEO constellation for plastic litter detection in open sea

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Introduction

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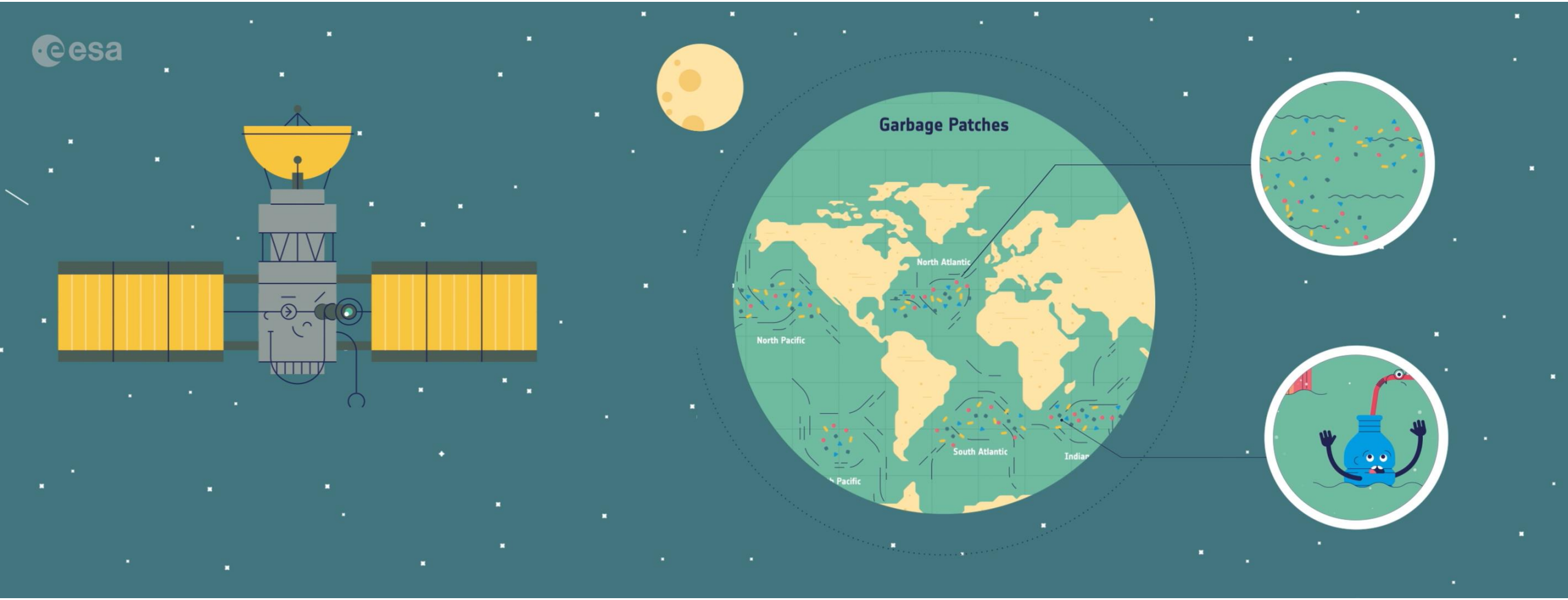
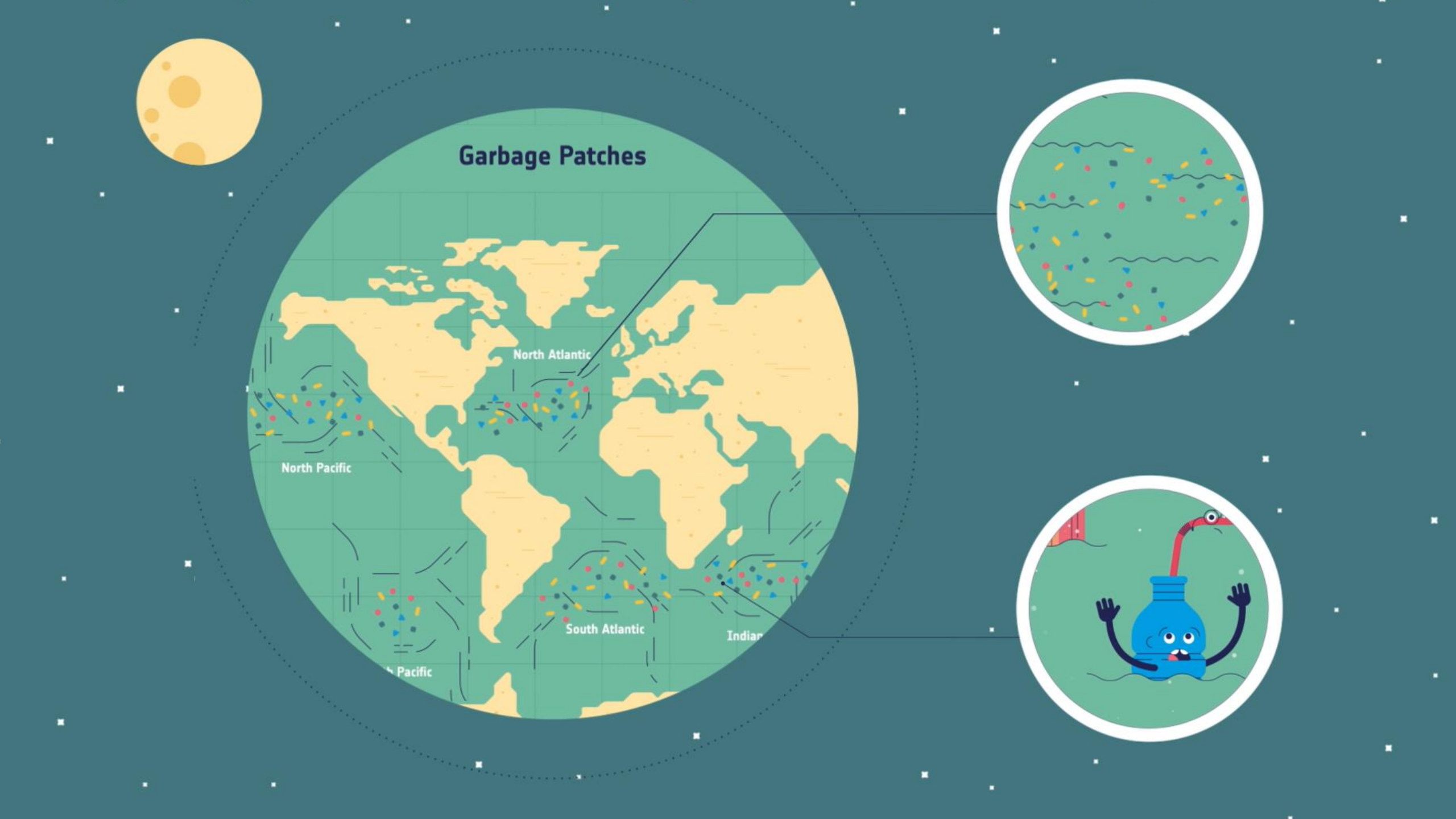
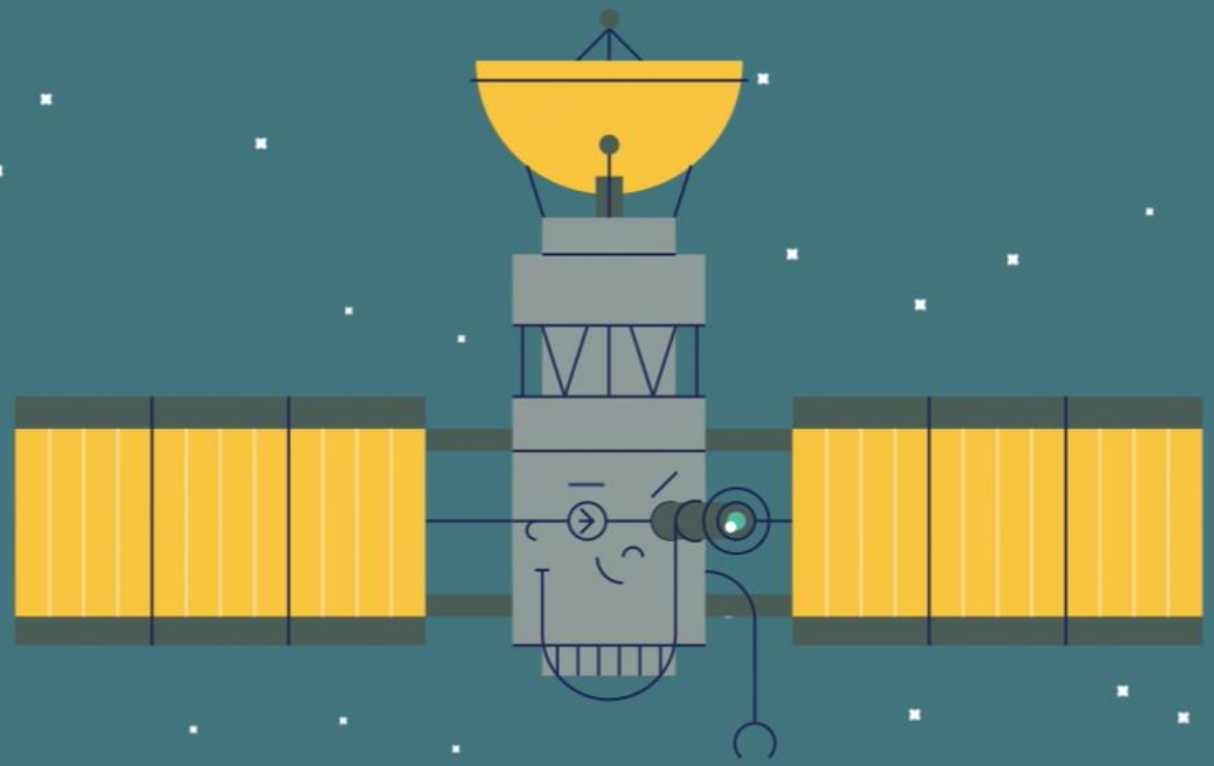



Garbage Patches
North Atlantic
North Pacific
South Atlantic
Indian
Pacific




Garbage Patches
North Atlantic
North Pacific
South Atlantic

Introduction

Plastic detection from space

- Multi-spectral imagery
- Hyperspectral sensing
- GNSS reflectometry

- SAR imagery

✓ Good capabilities demonstrated in this field

✘ No operational system for global monitoring and detection of plastics with sufficient temporal and spatial coverage

✓ Would allow global monitoring of plastic litter at sea

✘ Robust approaches for SAR-based plastic detection at sea not available due to the lack of assessed datasets to train and test new procedures on large scales

Introduction

Plastic detection from space

- Multi-spectral imagery

- SAR imagery

✓ Good capabilities demonstrated in this field

✓ Would allow global monitoring of plastic litter at sea

CROSSEYE

(Combined in pendulum Remote Observation cubeSat System for icEYE) mission

Mission Objectives

OB1:

- Macroplastic detection in open sea through EO acquisitions

OB2:

- EO/SAR - based innovative measurement principle validation

OB3:

- Development of a database of collected plastic data

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Key Parameters

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OB1:

- Macroplastic detection in open sea through EO acquisitions

OB2:

- EO/SAR - based innovative measurement principle validation

OB3:

- Development of a database of collected plastic data

KP1:

- 20 m spatial resolution

KP2:

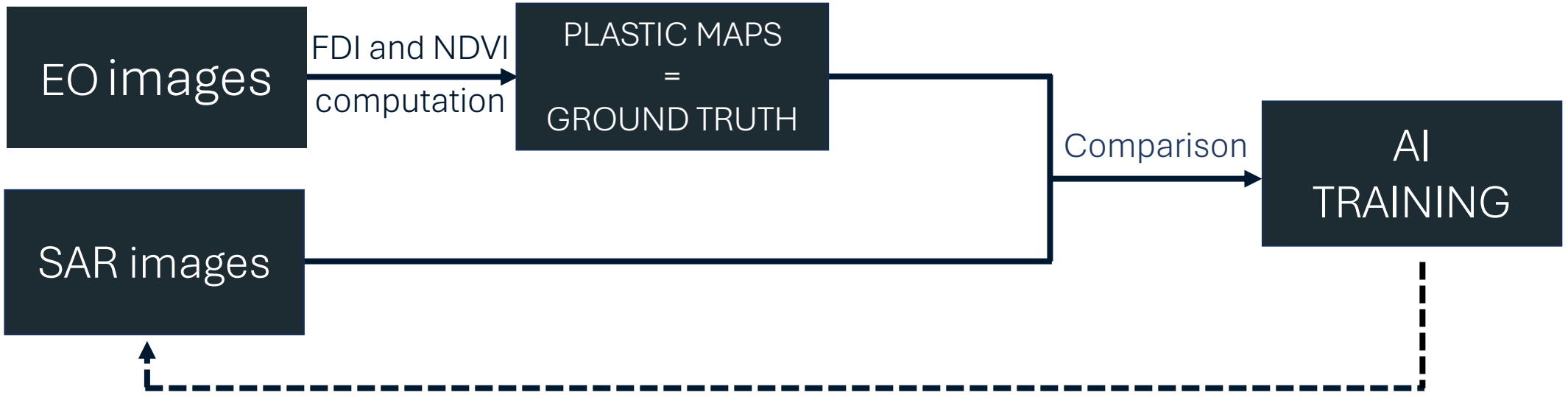
- 6 bands (NDVI, FDI, FAI)

KP3:

- Simultaneous acquisitions (time lag +/- 4 h)

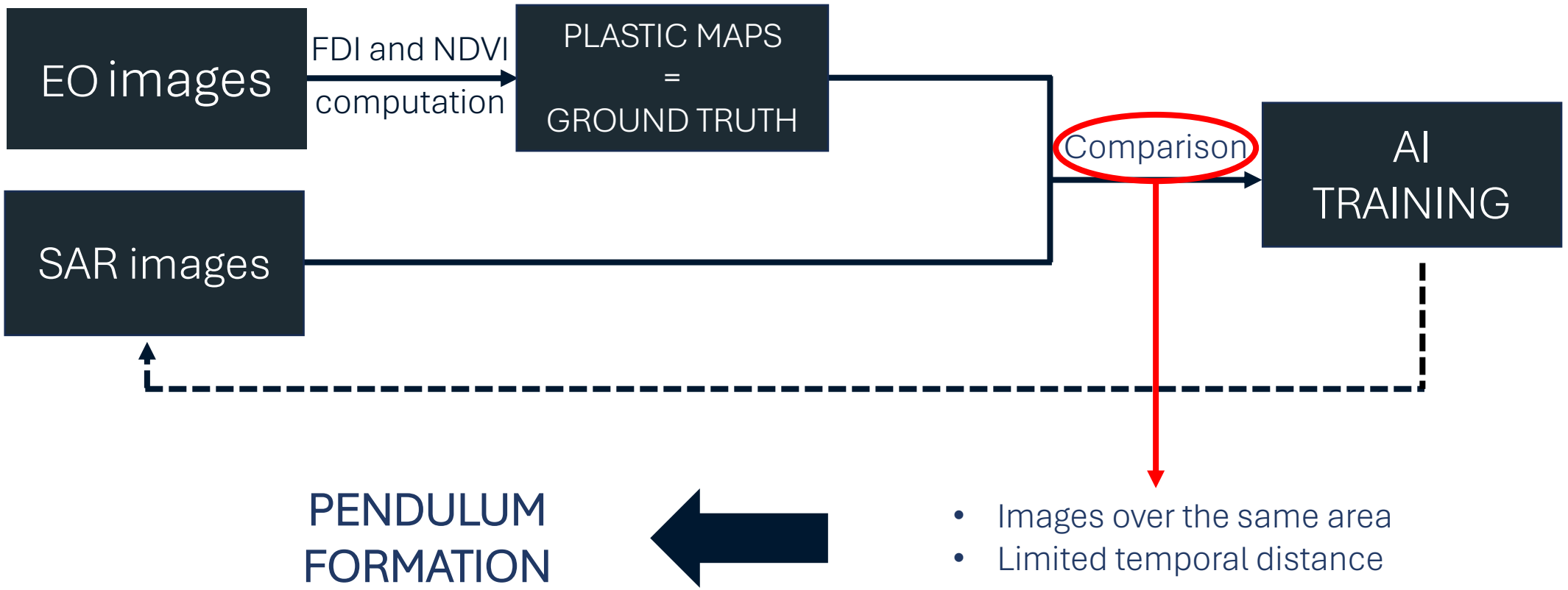
Mission Concept

AI detection of marine litter in SAR images – Measurement principle

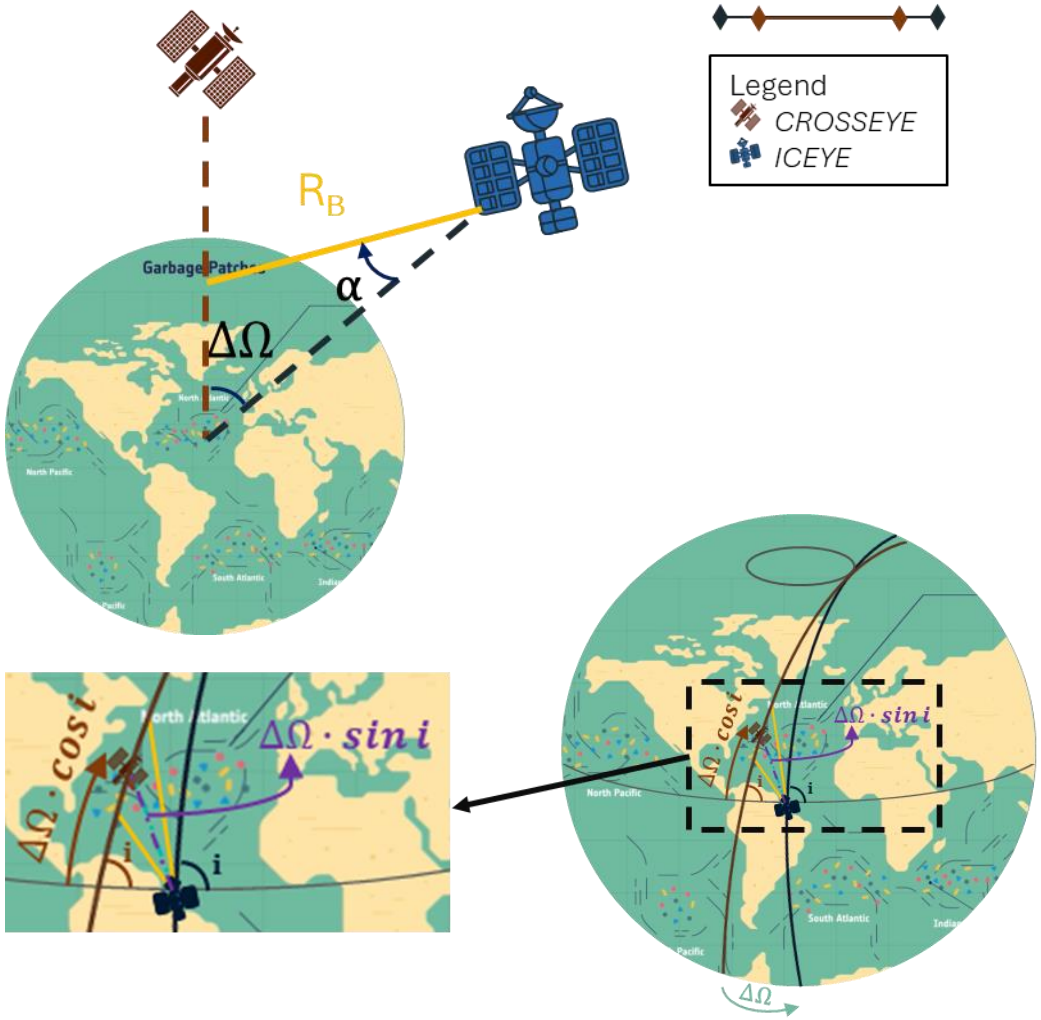


Mission Concept

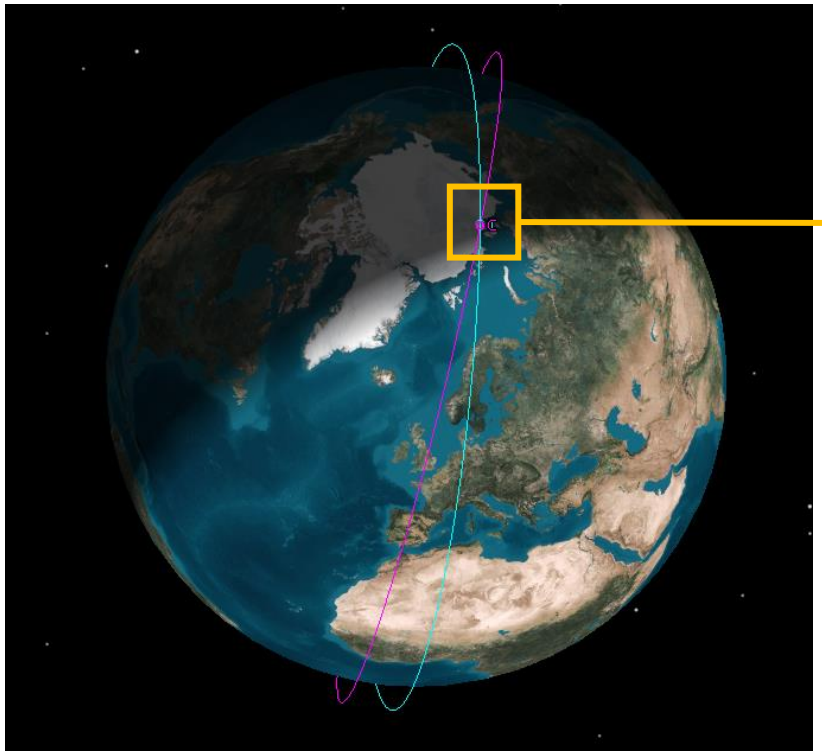
AI detection of marine litter in SAR images – Measurement principle

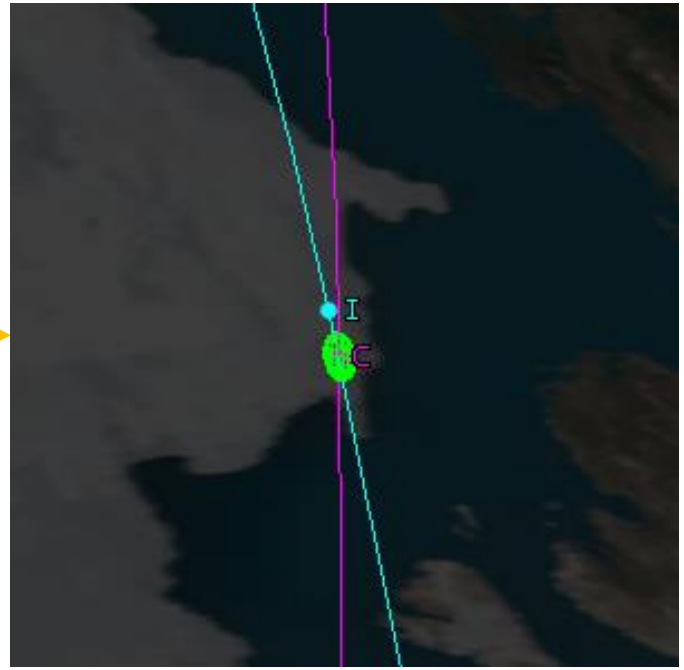


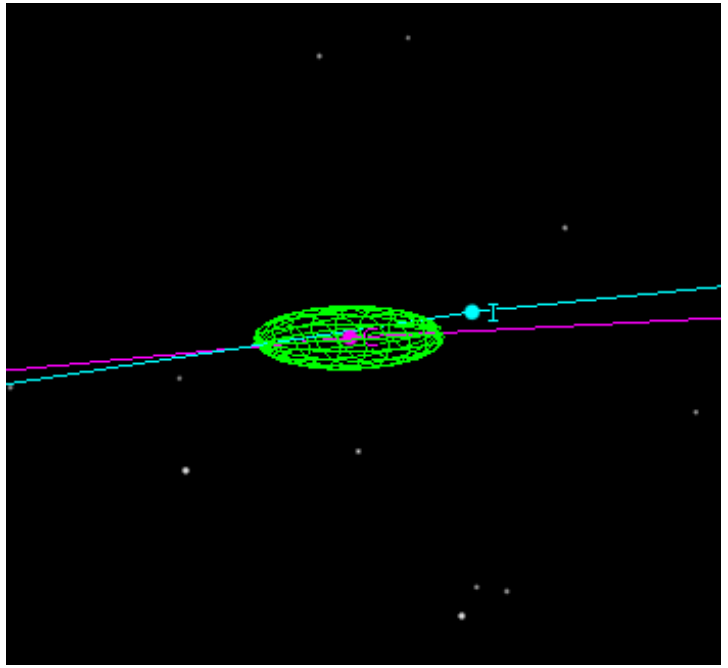
Pendulum


Legend
CROSSEYE
ICEYE
R_B
α
ΔΩ
$\Delta\Omega \cdot cos\, i$
$\Delta\Omega \cdot sin\, i$
i
North Pacific
South Atlantic

Safety distance







- Δe provides radial and cross-track separation
- $\Delta \nu$ provides along-track separation (~ 16 Km)

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Constellation

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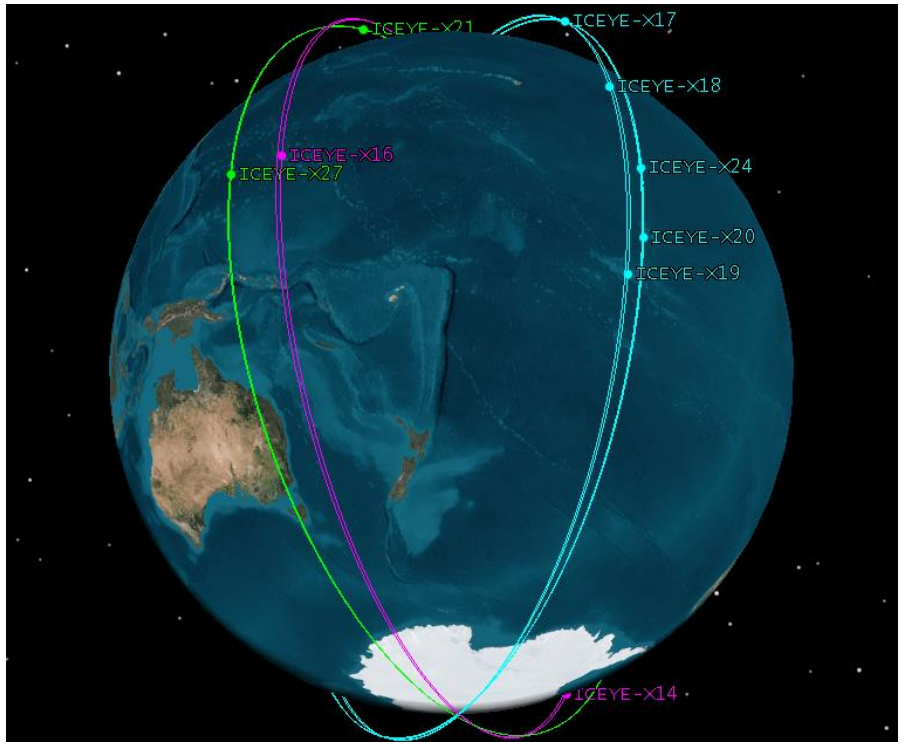
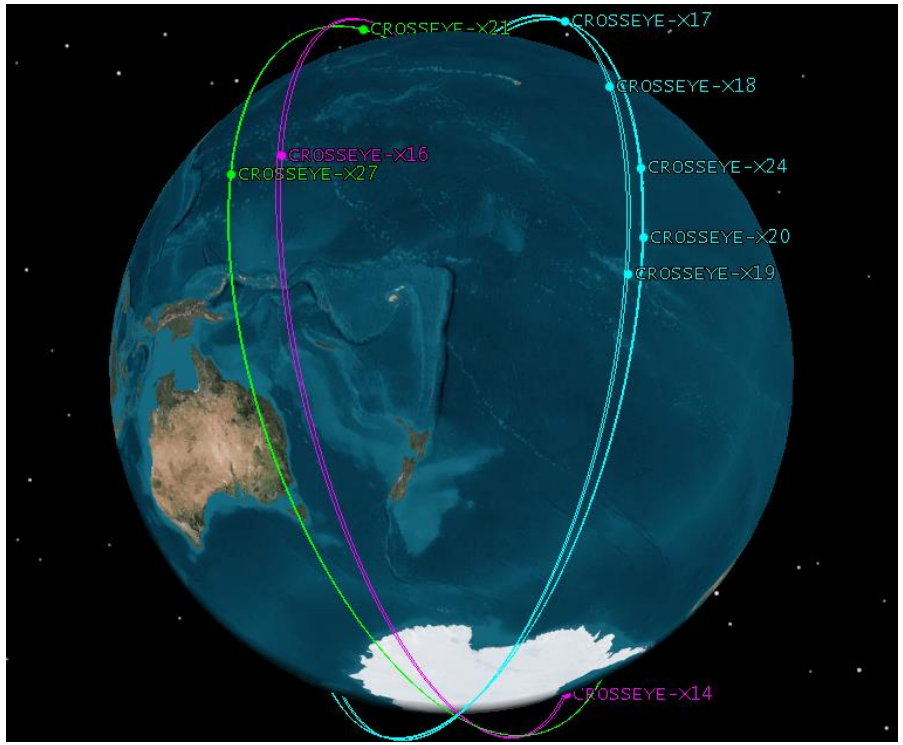
ICEYE



$\Delta\Omega, \Delta\nu, \Delta e$

CROSSEYE



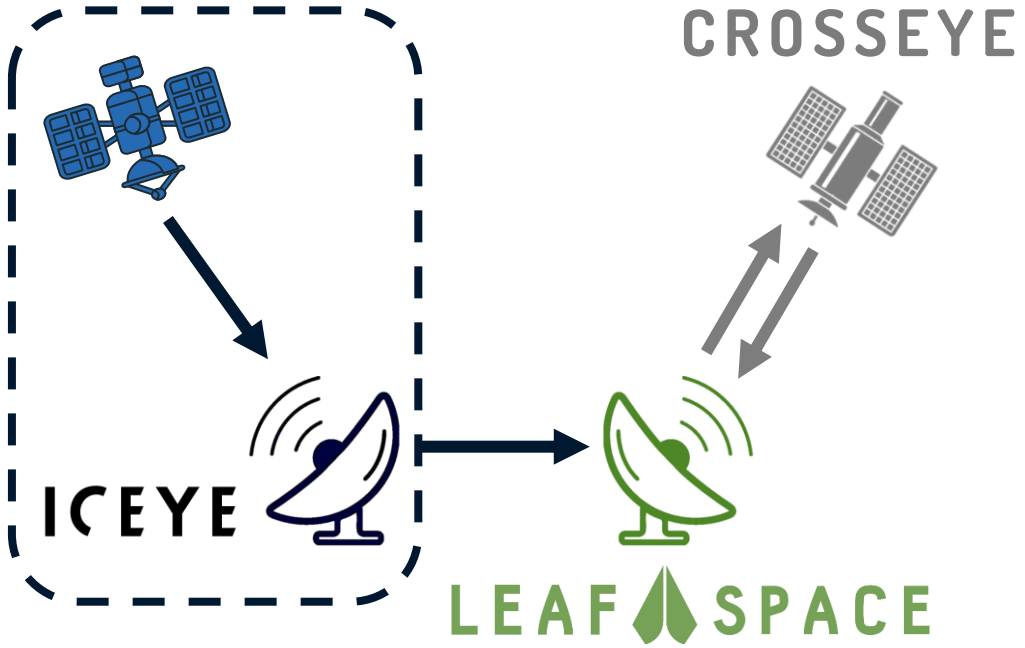
LTAN
10:00 PM | 1:15 AM | 9:30 PM

ALTITUDE
490 ÷ 520 Km

INC
97.40 ÷ 97.55 °

Ground Segment

- 11 of 17 active Leaf Space ground stations placed at middle latitudes
- Link between the two missions at ground segment level



Payload

Plastic detection requirements

- 20 m minimum resolution
- VNIR, SWIR bands to compute FDI, NDVI, FAI indexes

6U CubeSat Standard compatibility

- Mass and Power constraints

Custom electro-optical payload

	VNIR	SWIR
Focal length (mm)	400	400
Aperture (mm)	96.0	96.0
F/#	4.17	4.17
FOV across track (deg)	1.76	2.20
Swath width (km)	16.0	20.0
Ground sampling distance (m)	15.6	9.80
MTF @32.5 lin/mm	0.66	0.66
Number of pixel (H x V)	1024 x 25	2048 x 1
Pixel size (μm)	12 x 12	7.5 x 7.5
Number of bands	5	1
Pixel depth (bits per pixel)	8	8
Mass (kg)	4.09	
Volume (mm^3)	1.5×10^6 (< 2U)	
Data rate (Mbps)	473	
Power consumption (Standby-On) (W)	1.00 – 35.0	

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Platform

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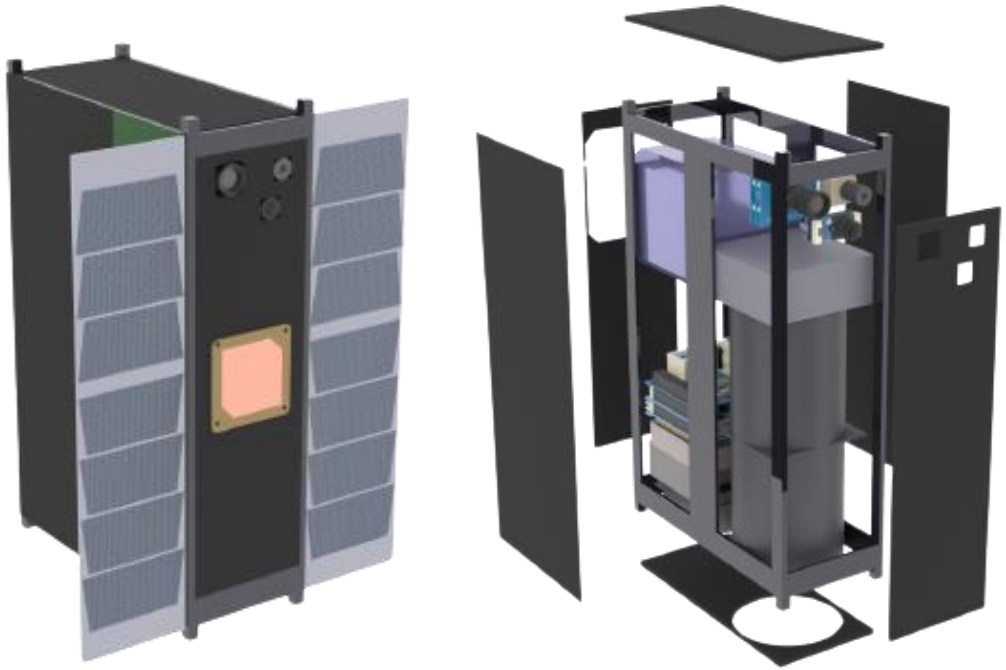
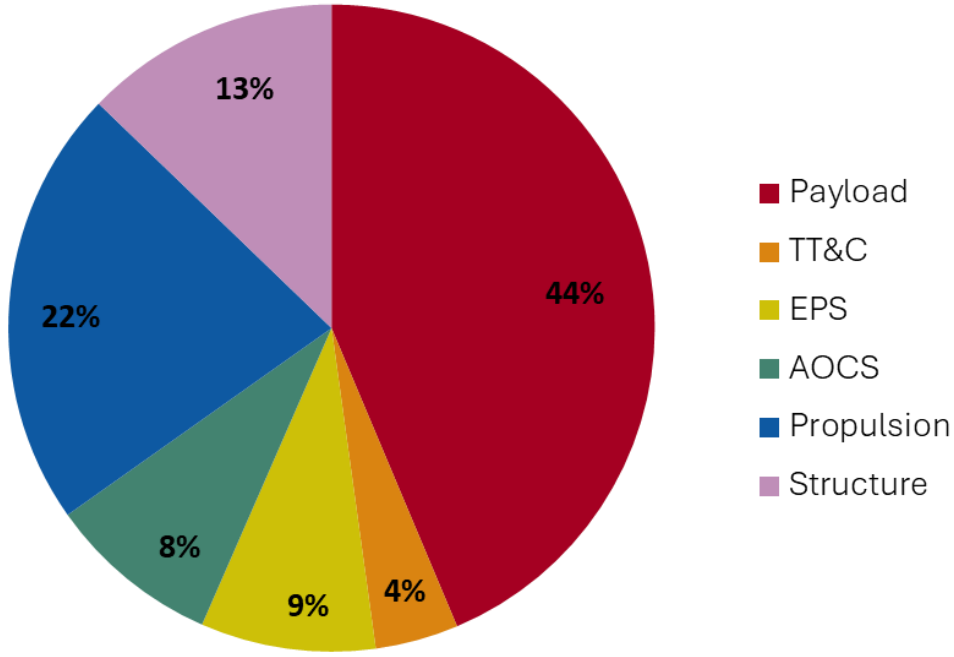
Preliminary design shows the compatilibity with a standard 6U CubeSat platform



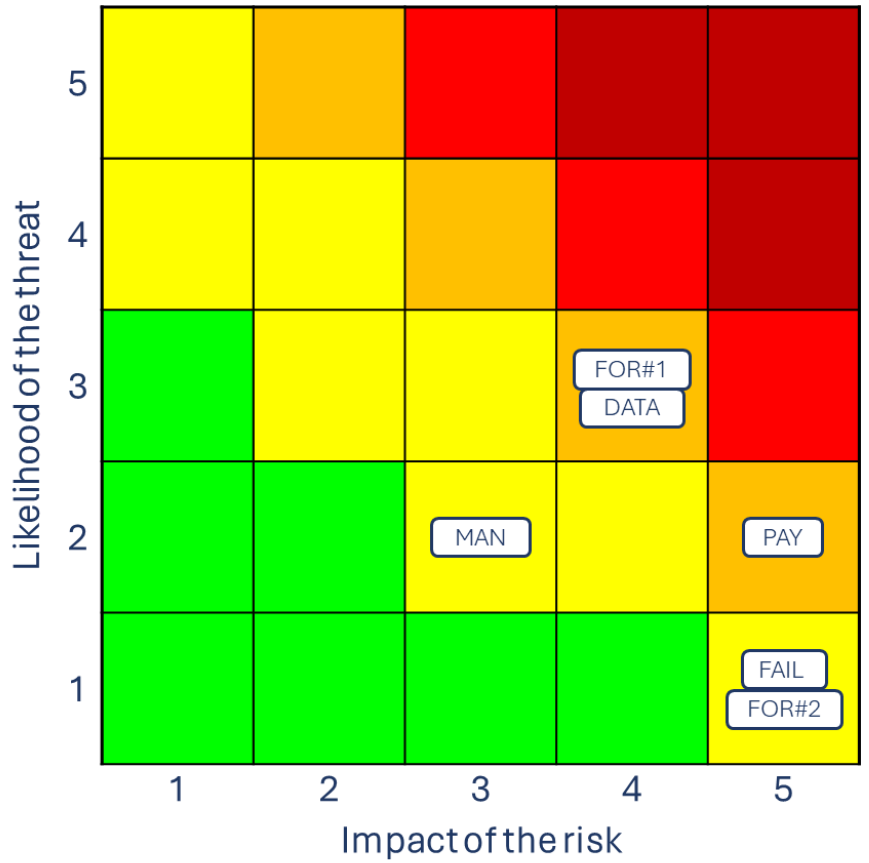
Mass Budget



TOTAL MASS	10.9 kg
TOTAL AVERAGE POWER CONSUMPTION	7.82 W

Mission Risks

Risk	Description	L	I
PAY	Custom payload not feasible or integrable	2	5
FOR#1	Pendulum formation with ICEYE not reached	3	4
FOR#2	Collision risk	1	5
DATA	EO/SAR database building technique not implementable	3	4
FAIL	Not mature subsystems parts cause unexpected failures	1	5
MAN	Lack of handover, schedule delay, loss of information	2	3



Conclusions

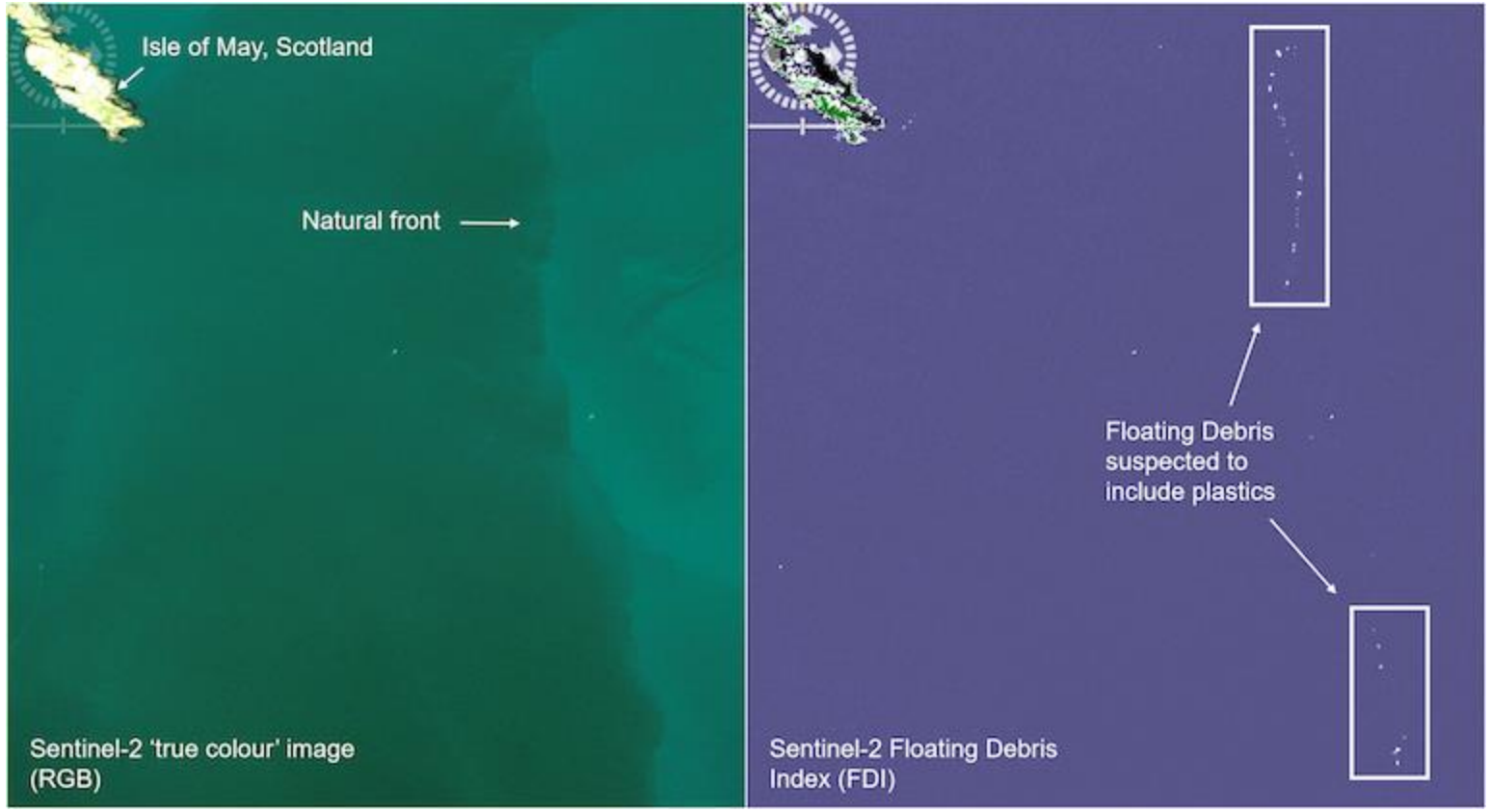
- CROSSEYE platform design feasible integrating COTS components except for the payload
- Design easily adaptable to other SAR-equipped platforms
- Incremental strategy of CROSSEYE mission to widen the quantity and quality of collected data
- Capability to build a database tailored to fit the customer's demands (i.e., wildfire, coastal erosion, plastics)
- Contribution to plastic litter detection from space, promoting sustainability and furthering the understanding of Earth's ecosystem.

Conclusions

Thank you for the attention!

Q&A

EO PLASTIC DETECTION



Satellite imagery showing plastic pollution off the coast of Scotland. Image by Lauren Biermann

Mission Timeline