NarSha Project: The First Korean Near Real-time Methane Monitoring Microsatellite Constellation Mission

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Oct. 24th, 2023

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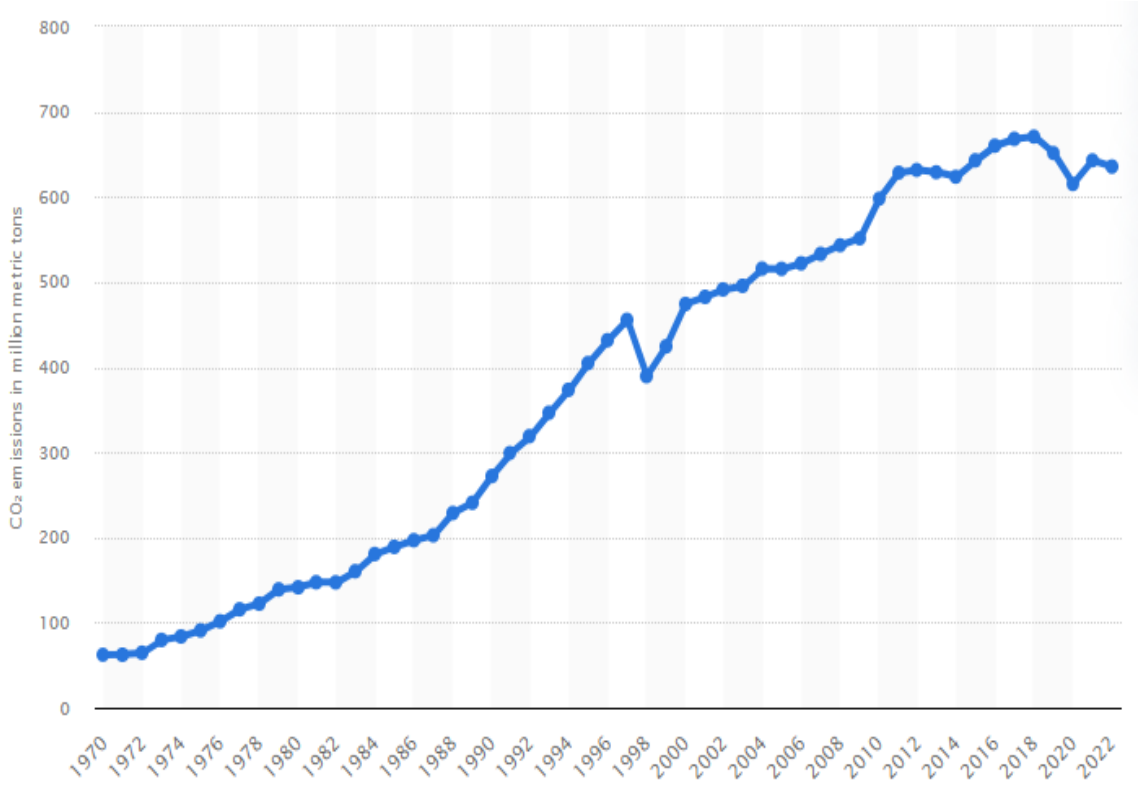
Overview

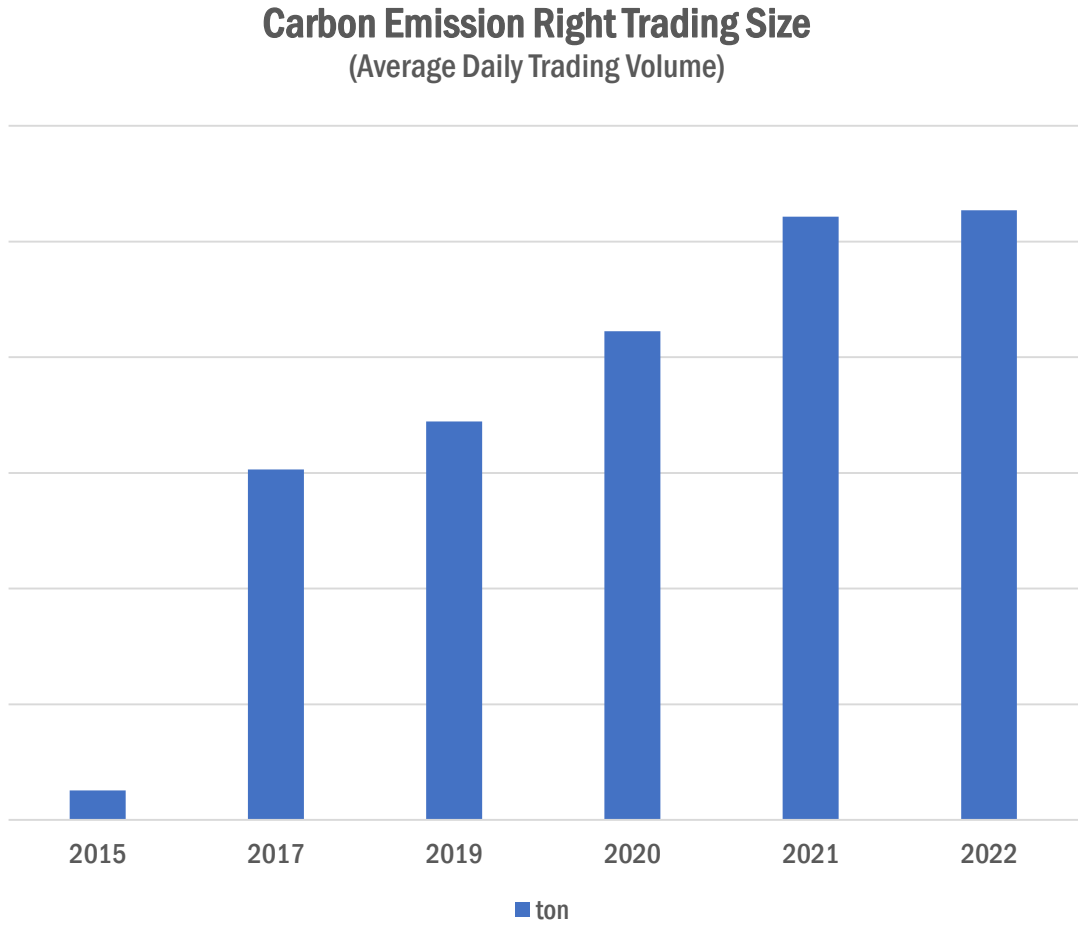
- **The industry structure of S. Korea**

Carbon dioxide (CO_2) emissions from fossil fuel and industrial purposes in South Korea from 1970 to 2022



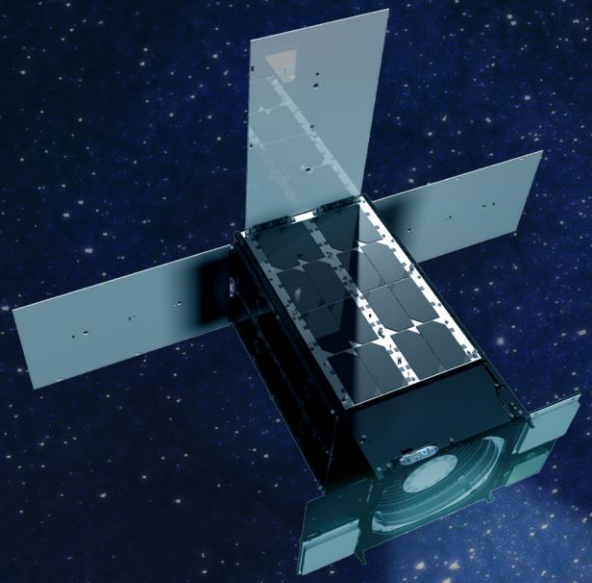
Ref. : Statista

- **The carbon market of S. Korea**



Ref. : Financial Services Commission of Korea

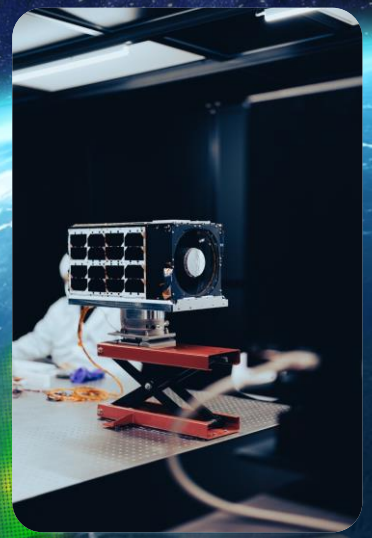
NARA SPACE | Climate Lab Seoul National University | 서울대학교 SEOUL NATIONAL UNIVERSITY | KASI 한국천문연구원

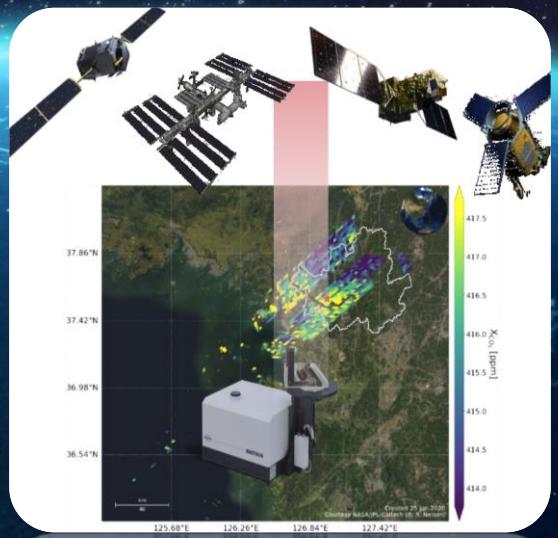


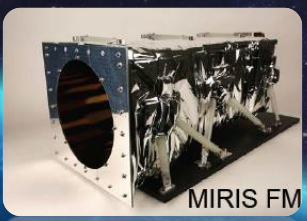
Constellation Mission : NarSha

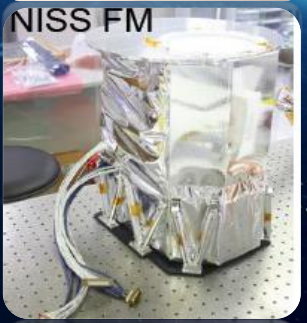
The First Satellite of NarSha : K3M
(Korea Methane Monitoring Microsatellite)

Target of First Launch : 2026 Q4





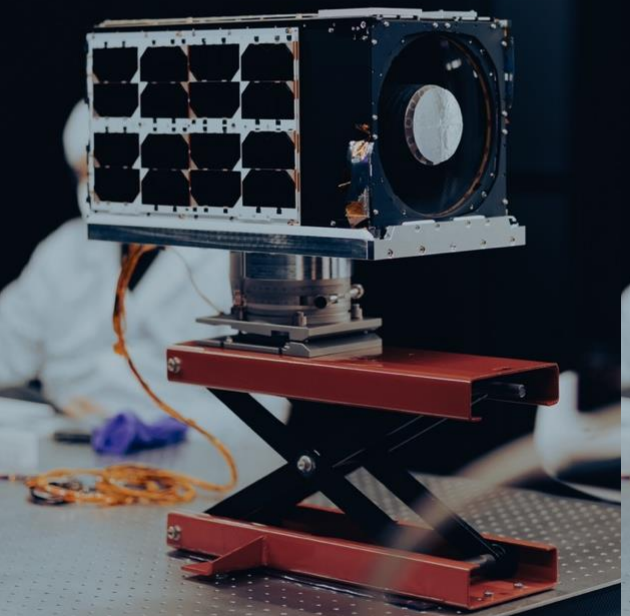




About Us

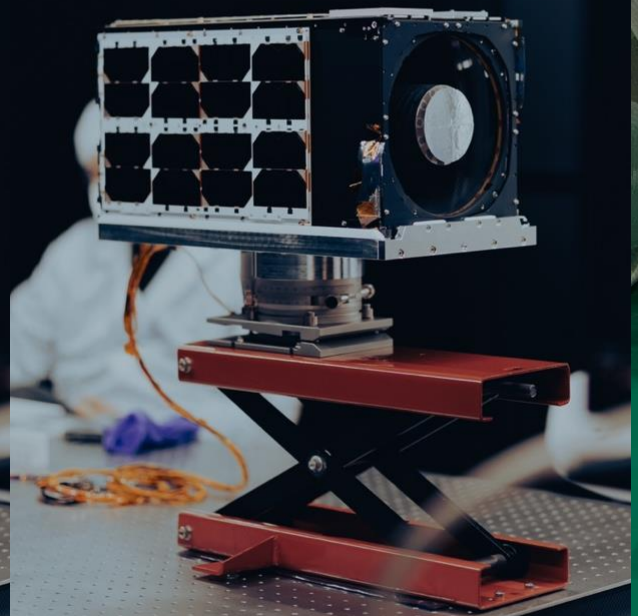
2023.11.

Observer-1A
(Vegetation Index)



2024.06.

Observer-1B
(Vegetation Index)

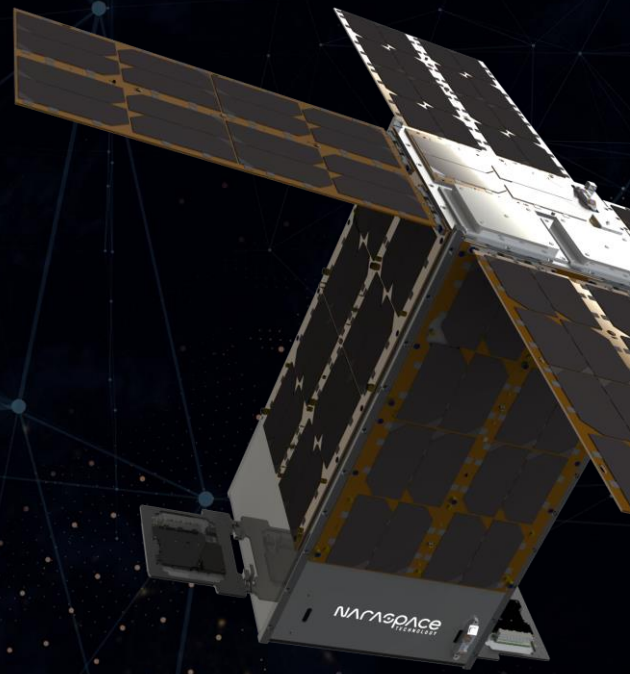


2024.Q4.

BusanSat
(Fine Dust)

2025.Q4.

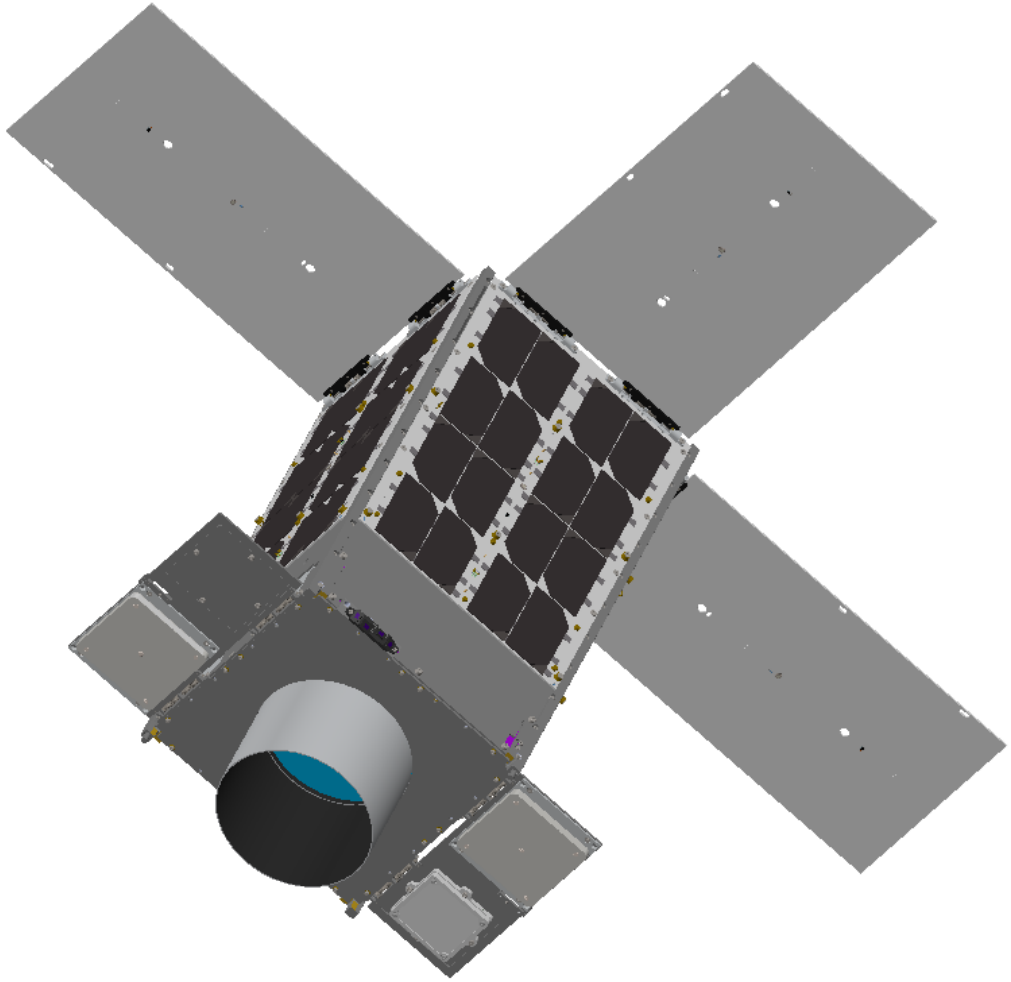
Oracle
(Wildfire Monitoring w/ Video)



- Ready to launch
- Now Developing

Satellite System

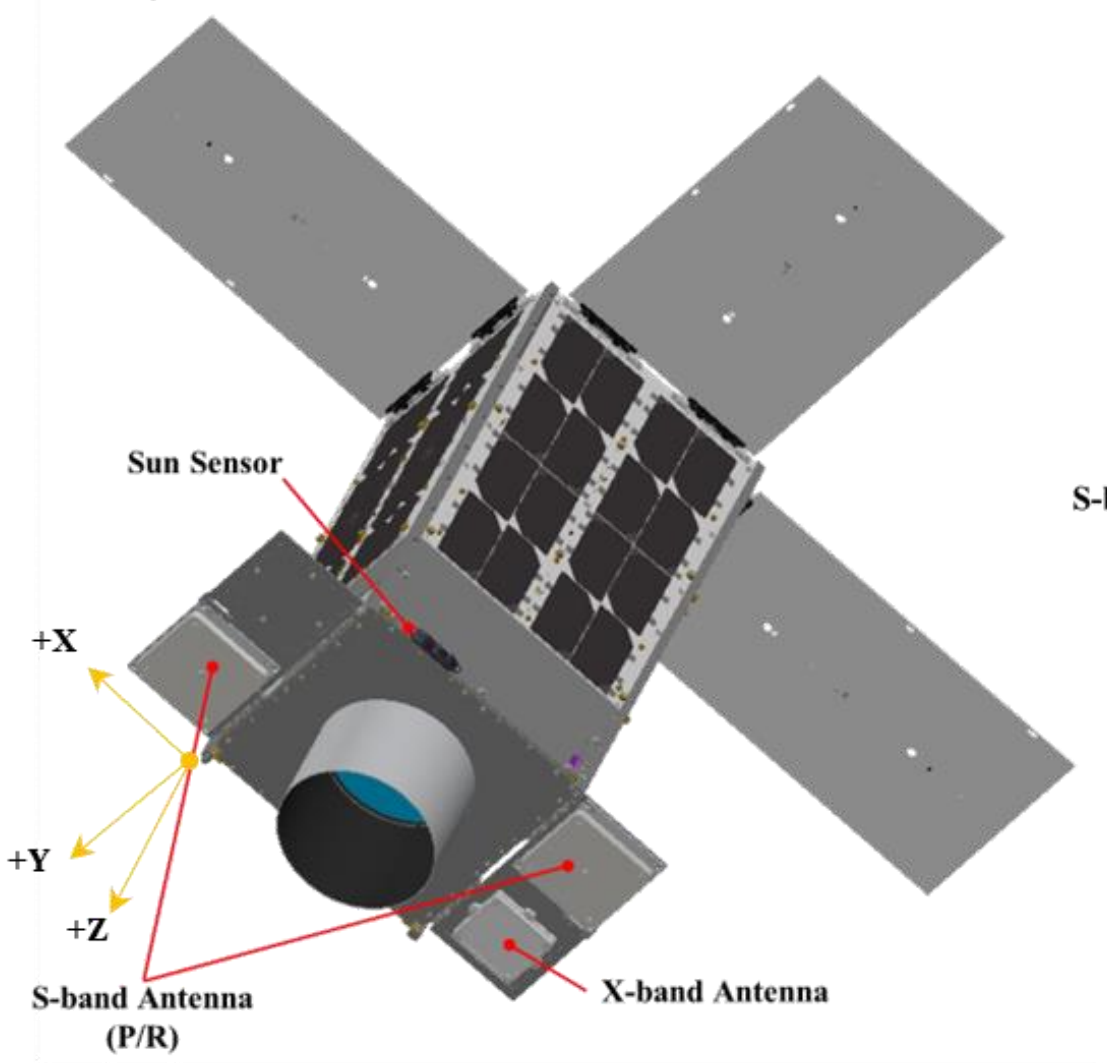
- **Specification of K3M**

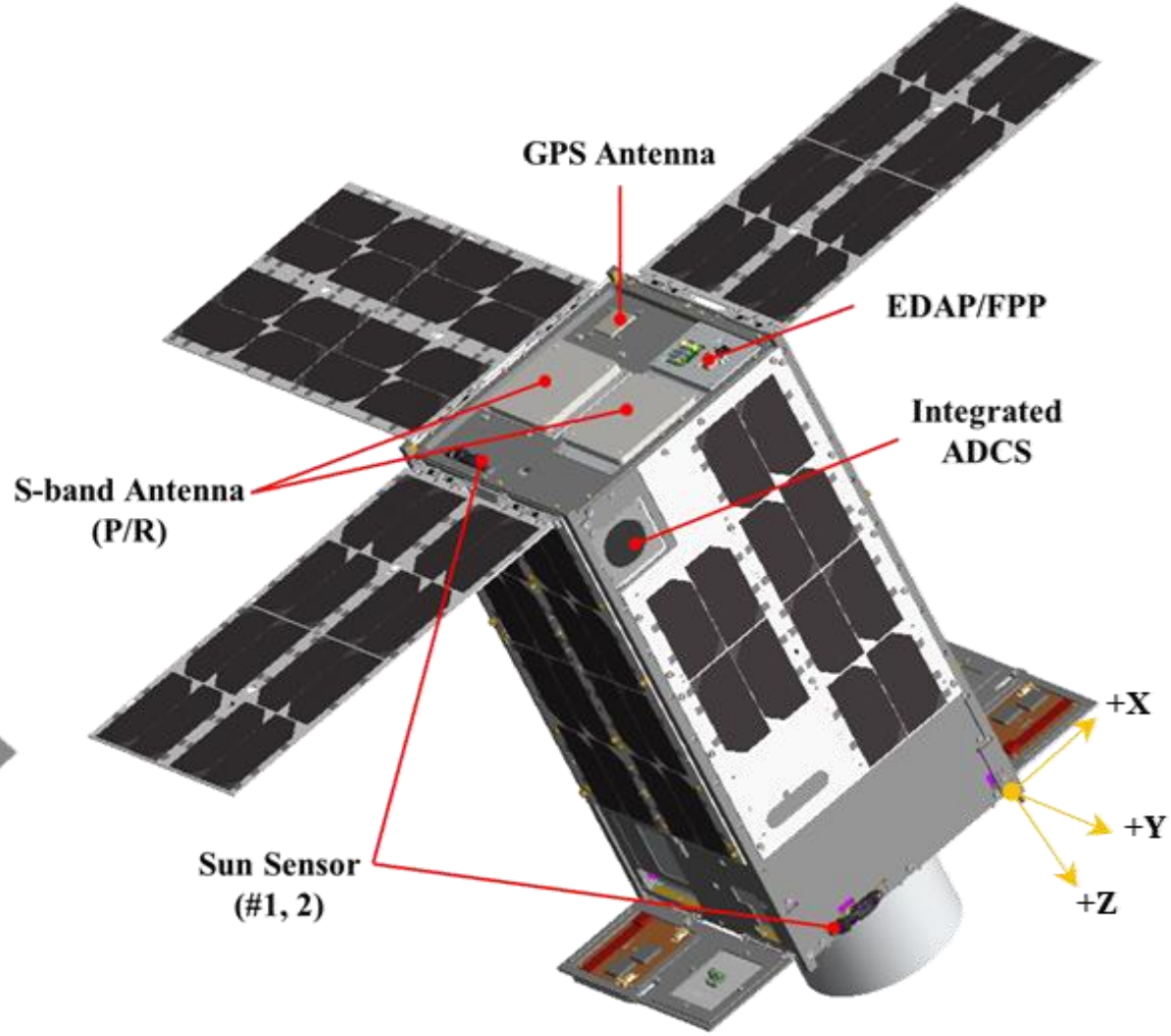


Contents		Performance
Mission	**Lifetime**	>2 yr
	Orbit	500 km SSO
Payload (Fabry-Perot)	**Dimension & Mass**	12U+ / 10 kg
	Power Consumption	< 20 W (max. @processing)
	Spectrum	1600~1700 nm (SWIR)
	FOV	1.3 deg x 1.3 deg
	GSD	< 50 m
	Spectrum Resolution	~ 0.1nm
Bus (16U)	**Pointing Accuracy**	+/-0.02 deg
	Off-Nadir Pointing (Tilting)	+/-10 deg
	Data I/F	CAN, RS-422, SpW
	Power Generation	53. 377 W @ Sun-pointing & EOL
	Battery	172 W (@ BOL)
	TC/TM	33.4 kbps / 83.52 kbps (S-band)
	Data Downlink	43 Mbps (X-band)

Satellite System

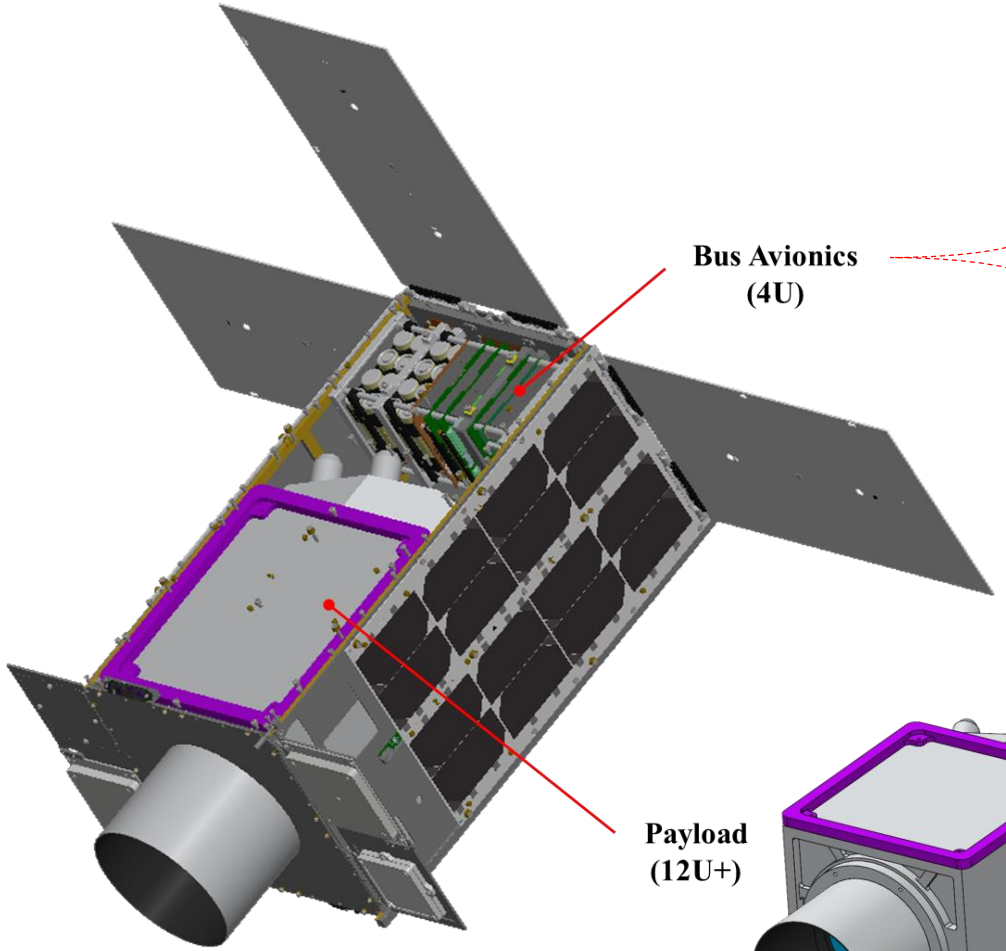
- **Configuration: External**

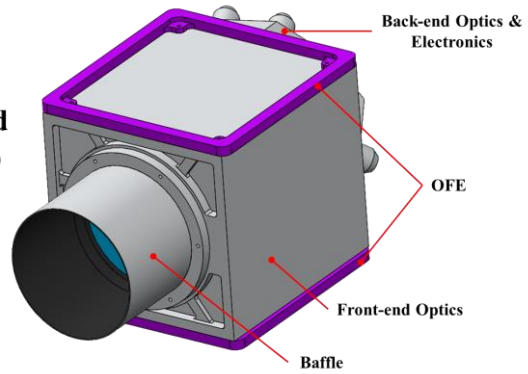


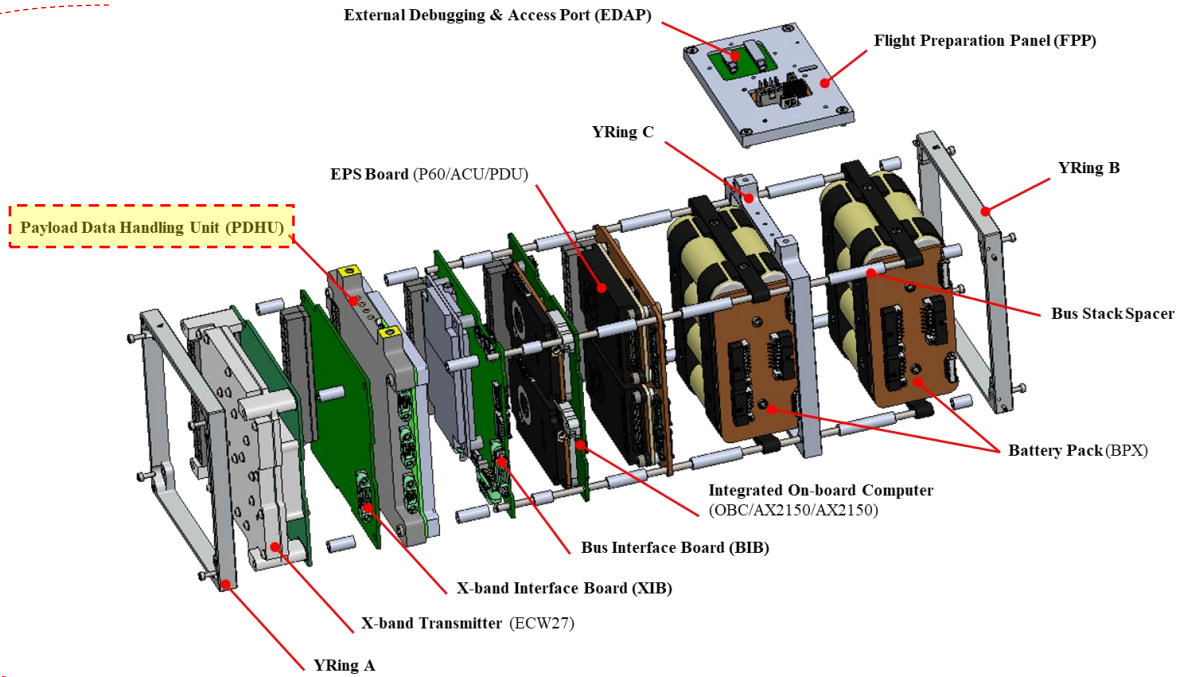


Satellite System

- **Configuration: Internal**



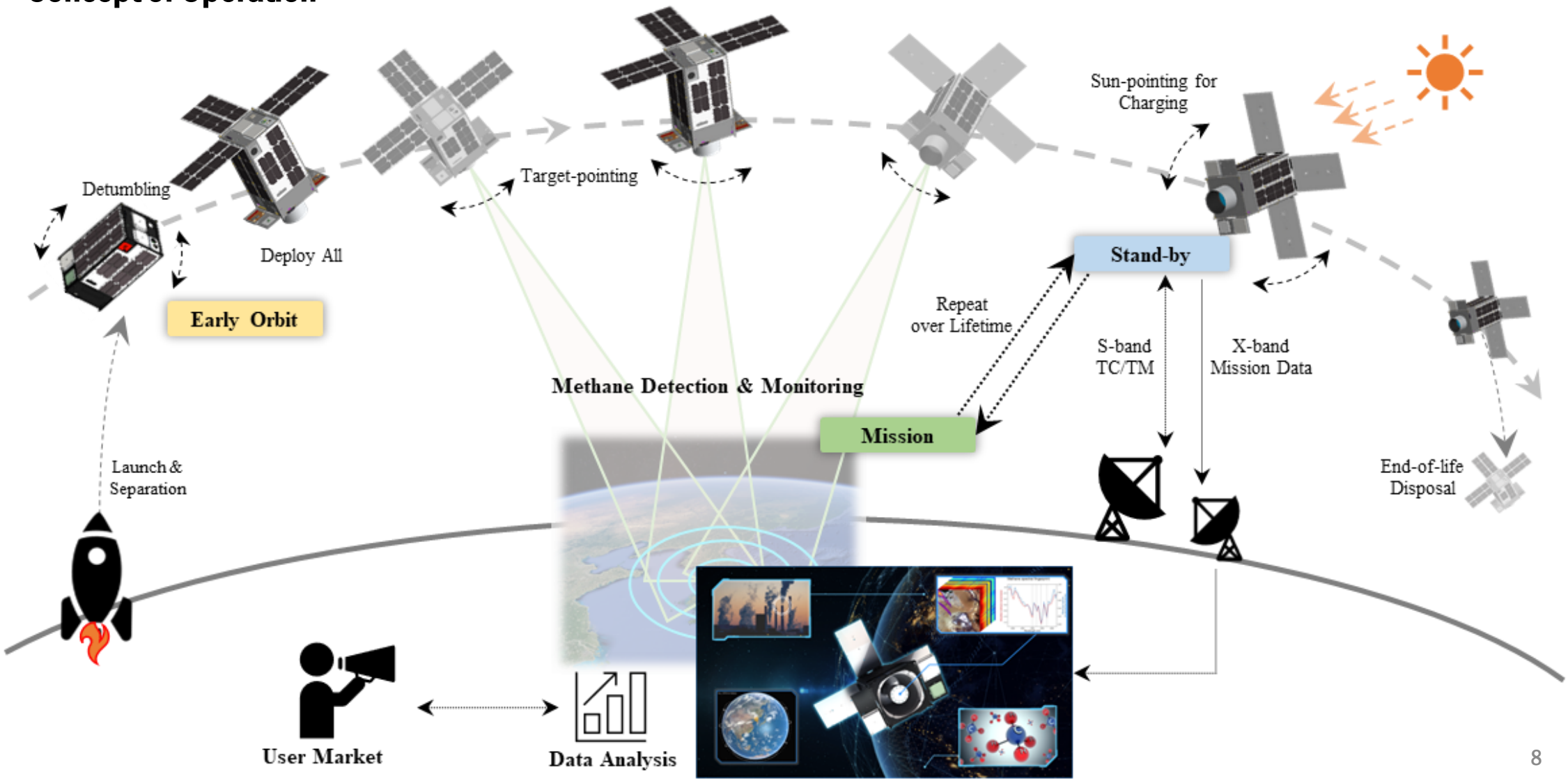




Parameter	Specification	
Electronics		
FPGA	Xlinx FPGA (COTS heritage)	
Memory	DDR SDRAM (1 GByte)	
Storage	NAND flash data storage (32 GB)	
Power Consumption	Max. 5 W	
Mass	160 g ± 10 g	
Size	90.17 x 95.88 x 11.7 mm (w/ Case)	
Interface		**Speed**
C&DHS TM/TC	CAN	1 Mbps
C&DHS Data	RS-422	115.2 Kbps
Payload data	SpaceWire	100 Mbps
Payload PPS	GPIO	-
X-band Tx Data	LVDS	up to 50 Mbps

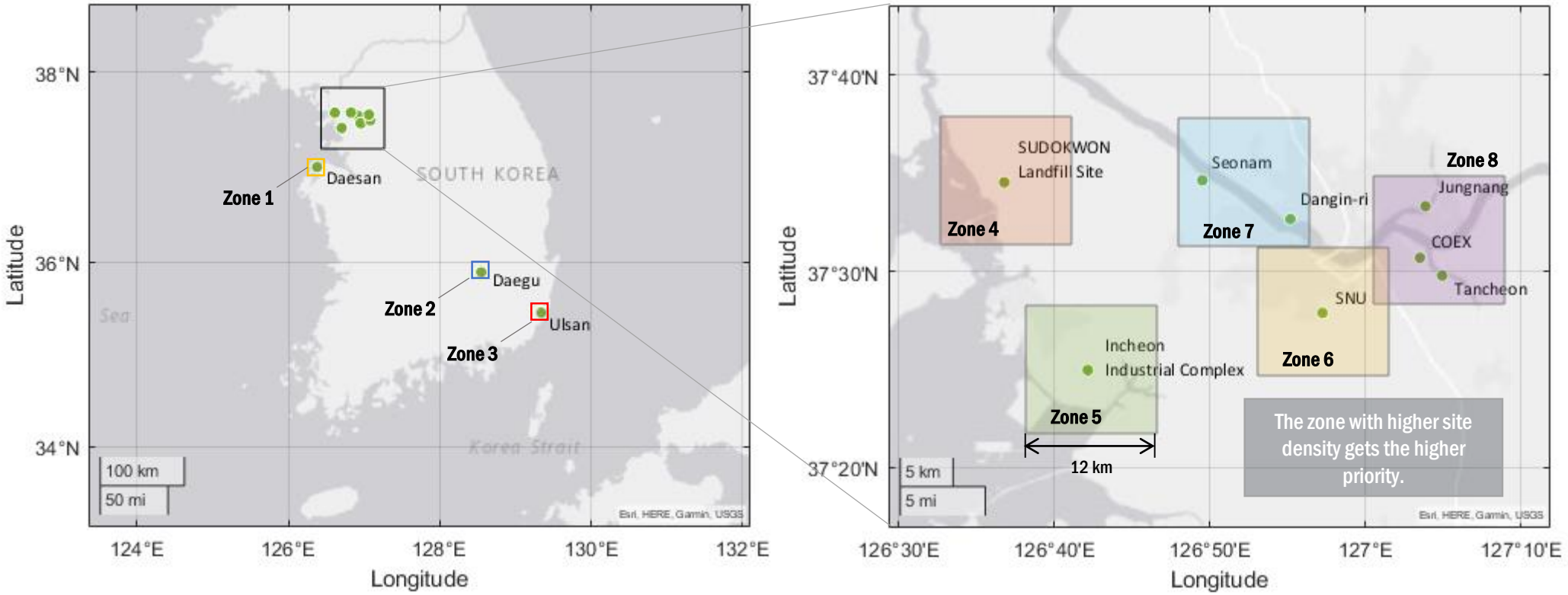
Mission Operation

- **Concept of Operation**



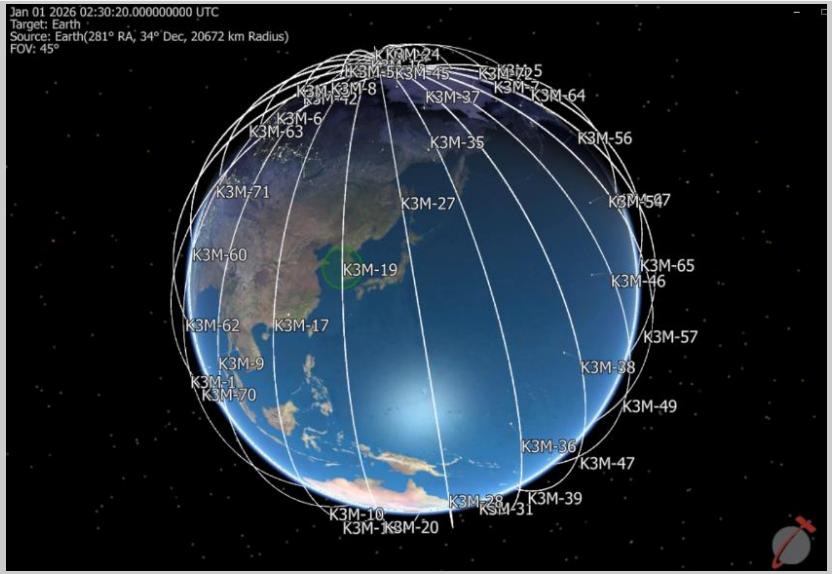
Mission Operation

- **Mission Design & Analysis**
  - **8 zones for shots** from 11 sites of interest
    - Define 8 subgroups (zones) considering 12 km x 12 km of ground projected area of a shot
    - One spacecraft shoots 1 zone every shooting window*

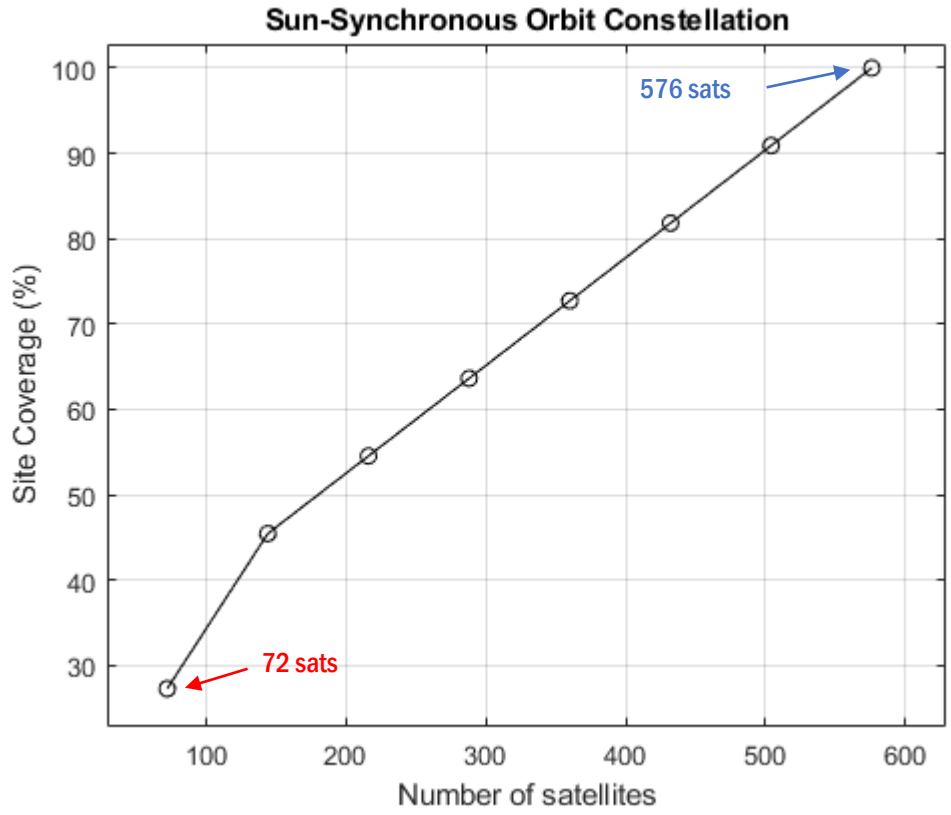


Mission Operation

- **Mission Design & Analysis**
  - Constellation design for 1-hour-gap* observation – SSO case

Type	Sun-Synchronous Orbit
Configuration	
Total # of Spacecraft	72 (27%; 3 sites) ~ 576 (100%; 11 sites)
Total # of Planes	12
Altitude, Inclination	510 km, 97.444° (91/6 revs per day)
LTAN	6h ~ 18h (ΔLTAN = 1h)
ΔM_0 **	132.5°

*Observation gap and site coverage have a trade-off relationship. E.g., 72-sat constellation can achieve 54 % of site coverage if the observation gap is set to 2 hours.



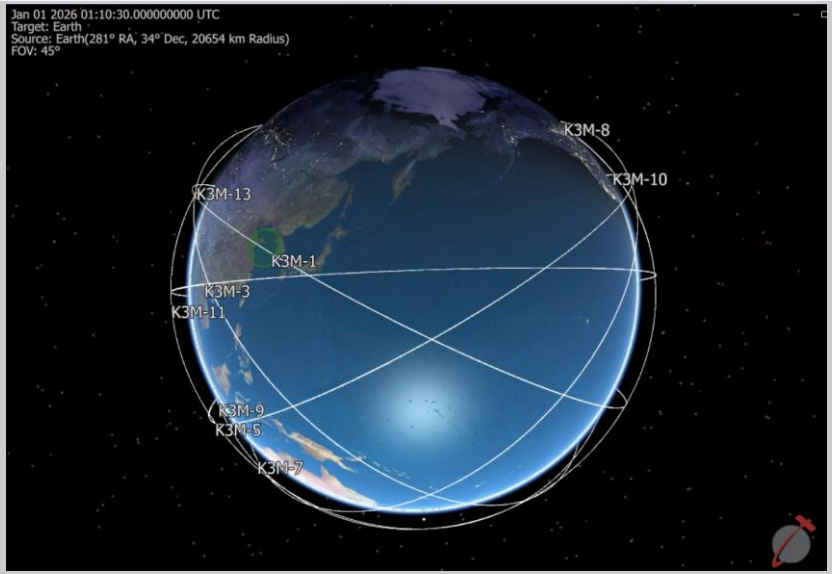
Expected coverage trend over constellation size (SSO)

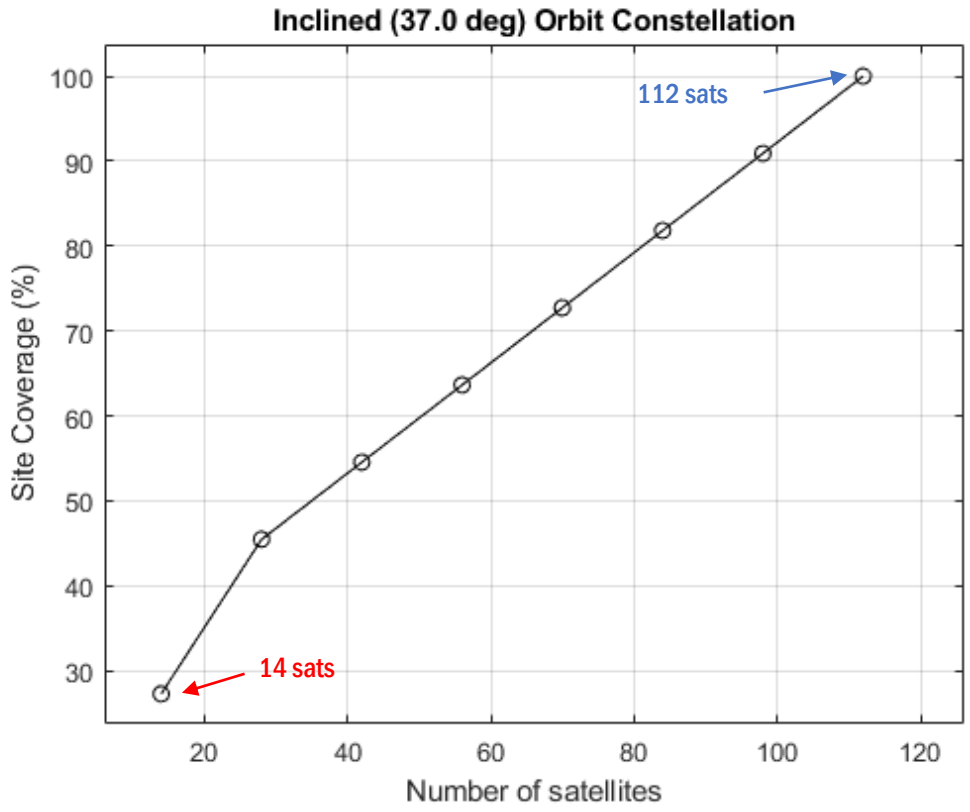
** ΔM_0: Mean anomaly offset b/w planes

Mission Operation

- **Mission Design & Analysis**
  - Constellation design for 1-hour-gap* observation – inclined orbit case

*Observation gap and site coverage have a trade-off relationship. E.g., 14-sat constellation can achieve 54 % of site coverage if the observation gap is set to 2 hours.

Type	Inclined Orbit
Configuration	
Total # of Spacecraft	14 (27%; 3 sites) ~ 112 (100%; 11 sites)
Total # of Planes	7
Altitude, Inclination	510 km, 37.0°
LTAN	51.4°
ΔM_0 **	-59.15°



Expected coverage trend over constellation size (Inclined)

** ΔM_0: Mean anomaly offset b/w planes

Summary

- The industrial background and carbon market of South Korea need satellite based methane monitoring
- The target of the mission is to detect methane emission of industry complex of South Korea and Asia
- Using 16U based nano-satellite system for near real-time methane point source constellation
- NarSha will contribute tracking and quantifying global methane emissions

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Mission Operation

- **Mission Design & Analysis**
  - Constellation revisit-time analysis – SSO case (576 spacecraft)
    - Epoch: Dec 31, 2025, 23:30:00.000 UTCG (3 days, 5-sec time step)

Site	# of revisits / 3 days	Duration (second)		
		Min.	Avg.	Max.*
Daesan	60	30	47.8	70
Ulsan	32	15	55.9	70
COEX	32	55	66.4	70
SUDOKWON	51	5	42.9	70
Dangin-ri	32	55	65.3	70
SNU	31	55	66.0	70
Daegu	35	5	62.6	70
Incheon	36	5	55.8	70
Tancheon	30	55	66.7	70
Jungnang	32	55	66.2	70
Seonam	31	55	65.5	70

* Assuming the maximum spacecraft's tilting angle should be less than 25° to Nadir

Mission Operation

- **Mission Design & Analysis**
  - Constellation revisit-time analysis – inclined orbit case (112 spacecraft)
    - Epoch: Dec 31, 2025, 23:30:00.000 UTCG (3 days, 5-sec time step)

Site	# of revisits / 3 days	Duration (second)		
		Min.	Avg.	Max.*
Daesan	75	5	56.8	75
Ulsan	80	5	56.4	75
COEX	54	10	55.6	75
SUDOKWON	41	5	54.6	75
Dangin-ri	49	5	54.8	75
SNU	56	10	54.1	75
Daegu	83	5	58.8	75
Incheon	58	10	55.2	75
Tancheon	55	10	55.0	75
Jungnang	53	5	55.2	75
Seonam	53	10	55.5	75

* Assuming the maximum spacecraft's tilting angle should be less than 25° to Nadir