

SCIntillation and IONosphere – eXtended (SCION-X) – A Small Satellite for Ionospheric and Atmospheric Science

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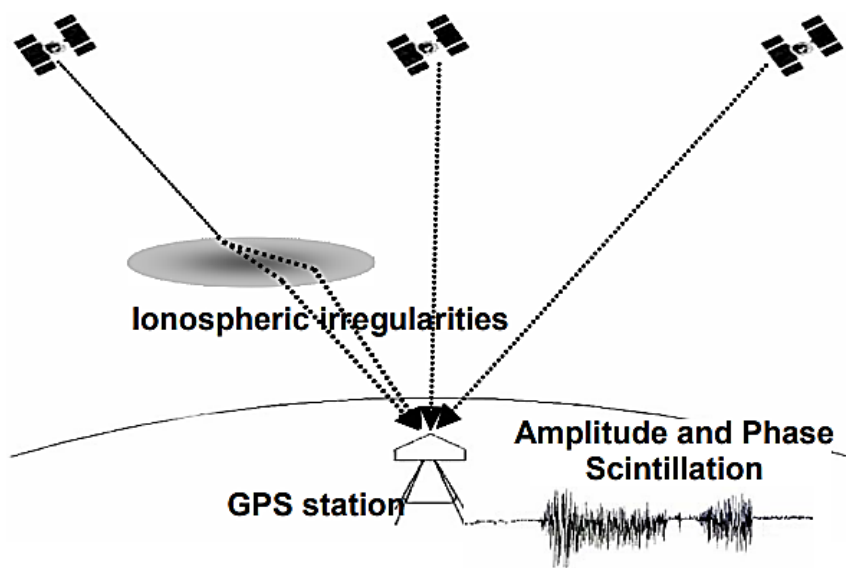
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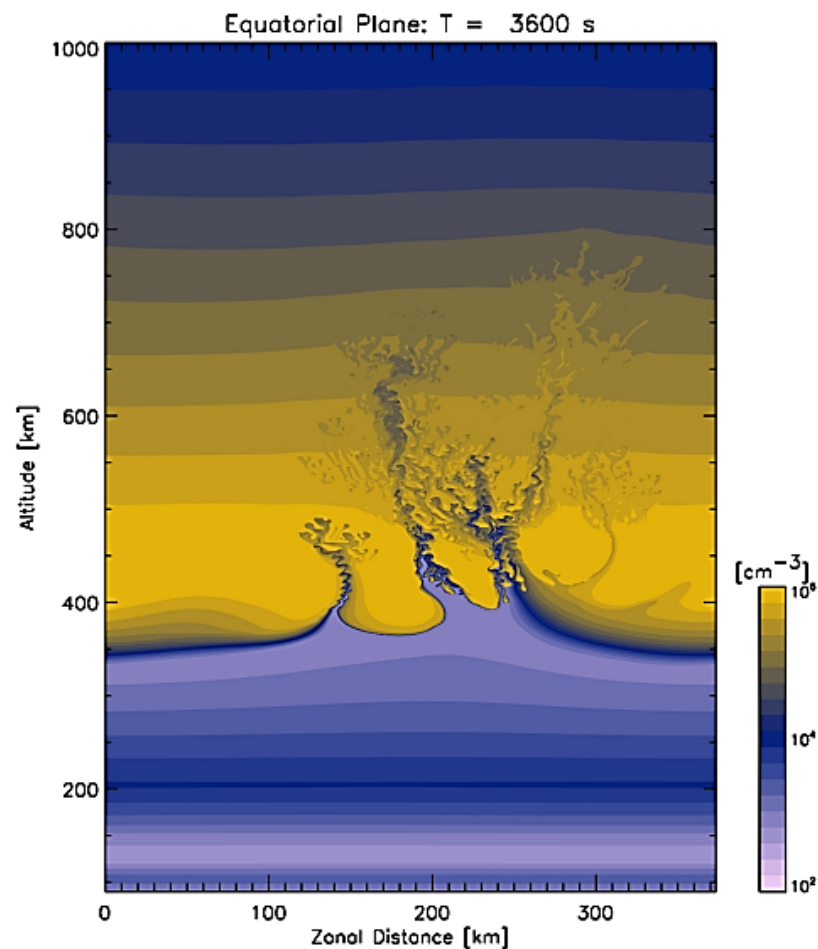
Date: 2020.10.13



What is the ionospheric morphology in the F region and its associated anomalous phenomena?

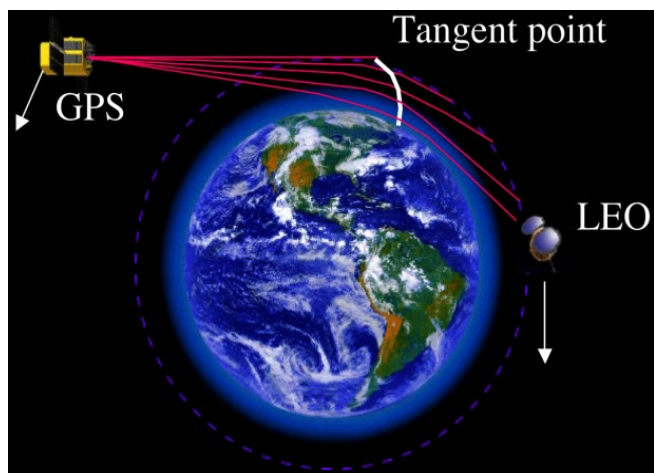


Theerapatpaiboon et al., 2005

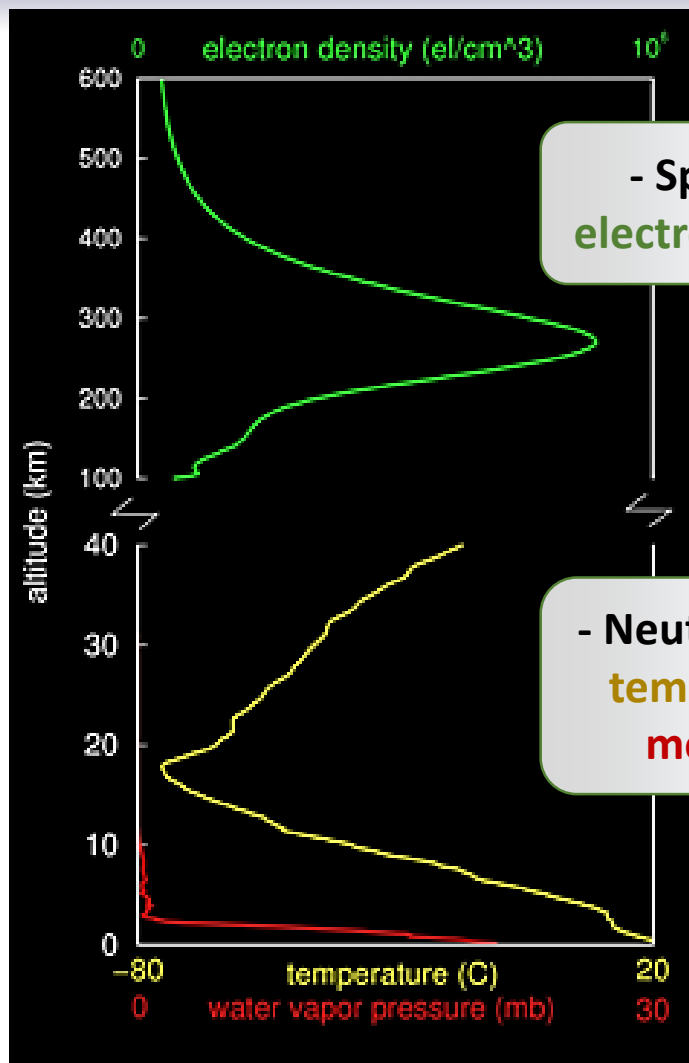


Yokoyama et al., 2013

What is the effect of assimilating GNSS Radio Occultation (RO) and Reflectometry (R) data on precipitation and aerosol forecasting?



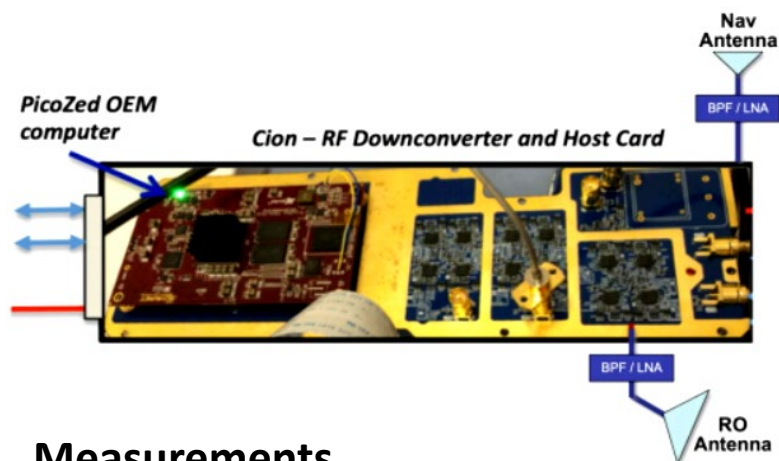
Anthes, 2011



- Space Weather -
 electron density profile

- Neutral Atmosphere -
 temperature profile
 moisture profile

GeoOptics Cion-R GNSS RO / Reflectometry (R) Receiver



Space weather monitoring & Weather forecast

Measurements

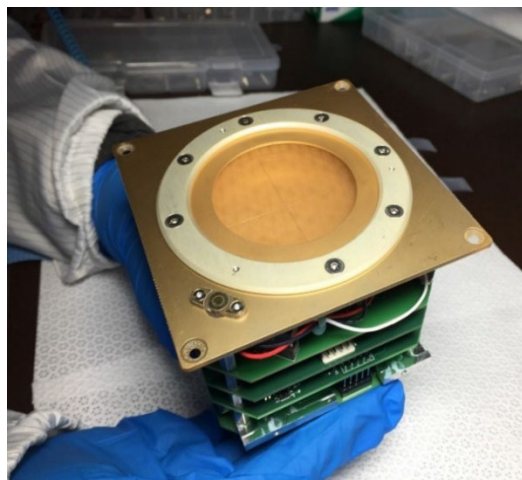
- Scintillation S4 index
- Signal-to-Noise ratio
- Ionosphere electron density
- Atmospheric pressure
- Dry temperature and water vapor in the troposphere and stratosphere

GeoOptics Cion-R	
Volume	1 U
Power Consumption	12 W
GNSS Signal	GPS L1, L2
RO / R Antenna Size (Ideal)	10 cm x 30 cm patch array



Mission Objectives and Payloads (2)

Compact Ionospheric Probe (CIP)



Measurements

- Electron and ion temperature
- Light to Heavy Ion ratio
- Ion drift velocity
- Ion density

CIP is the miniaturized version of AIP (Advanced Ionospheric Probe) aboard FORMOSAT-5.

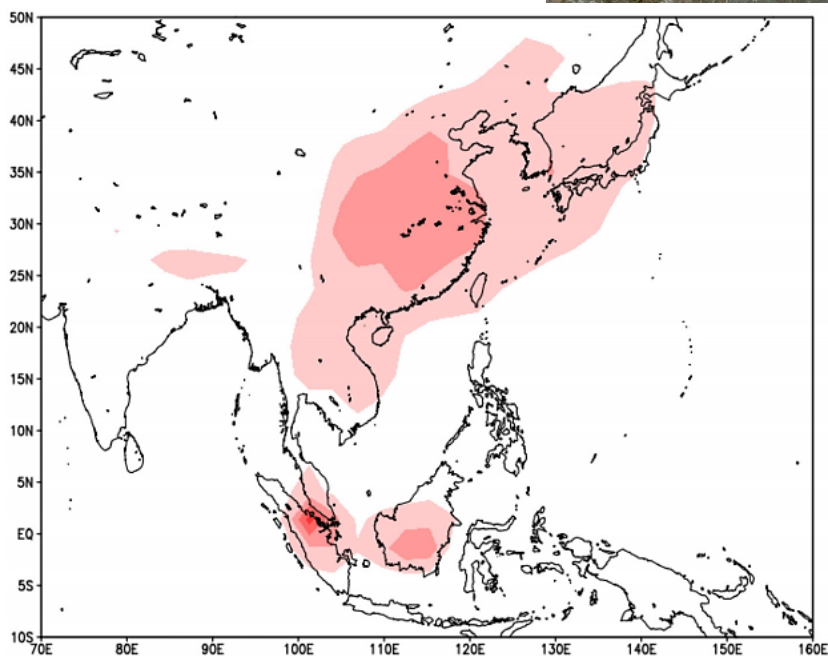
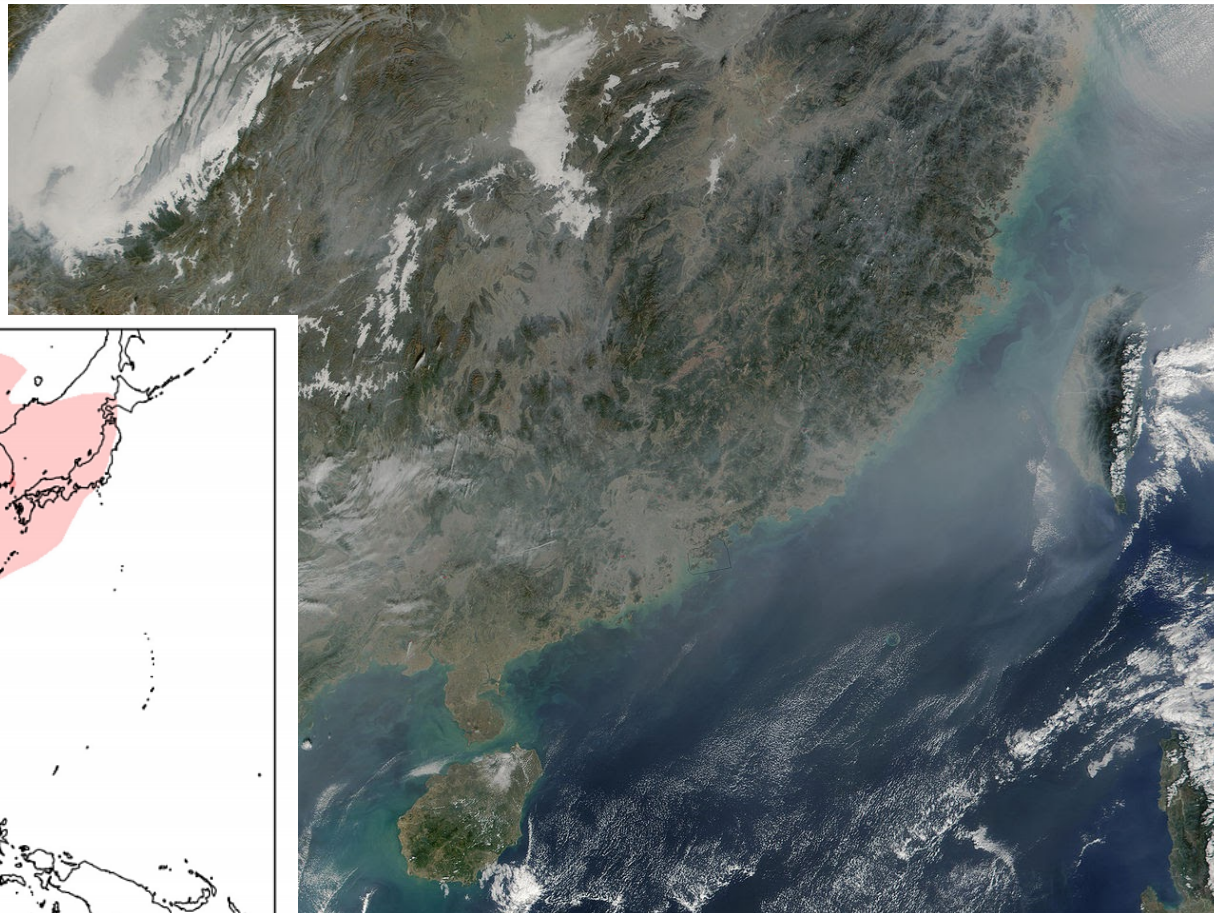
Space weather monitoring

CIP	
Mass & Volume	0.4 kg, 0.7 U
Power Consumption	4.32 W
Data Rate	Normal mode: 280 B/s Fast mode: 2240 B/s
FOV	90°



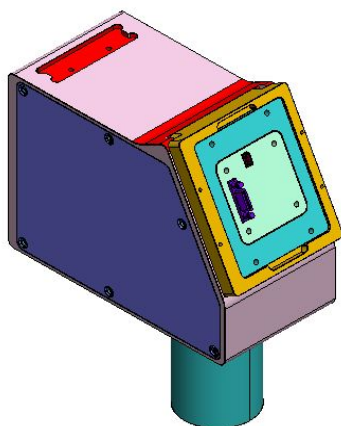
Scientific Significance

What is the distribution of air pollution around the Southeast Asian region and Taiwan ?



http://visibleearth.nasa.gov/view_rec.php?id=2361

Hyper-Spectral Camera ANalyzer (Hyper-SCAN)



Hyper-SCAN is utilized to capture geographical images and air-borne features to quantify PM2.5 pollution distribution and locate its source origins.

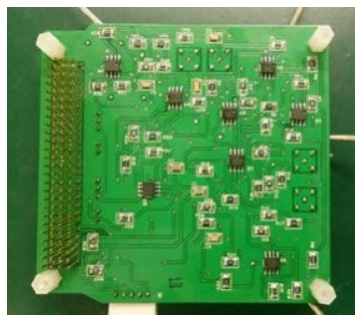
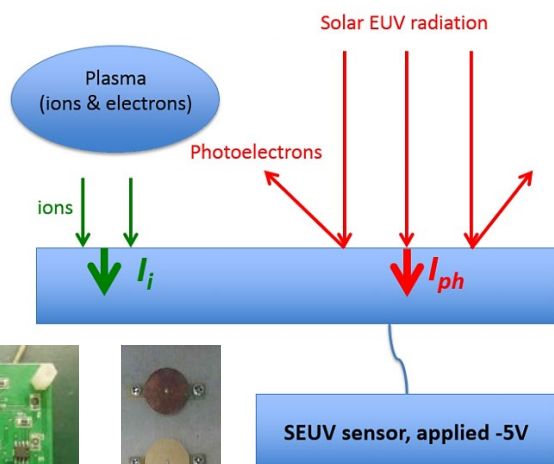
Measurements

Spatial spectrum data for air pollution remote sensing

PM2.5 observation

Hyper-SCAN	
Mass & Volume	< 2 kg, 4 U
sensor	CMOS or CCD
FOV	4.58° cross-track 0.057° along track
Spectral Range	380 – 1020 nm
Data Rate	4 MB/s
Spatial Resolution	100 m @ 500 km Alt

Solar Extreme Ultraviolet Probe (SEUV Probe)



SEUV sensor, applied -5V

Measurements

- Photoelectric current
- Ionosphere Plasma current

Atmospheric photochemistry observation

SEUV Probe	
Mass & PCB Size	90 g, 95 mm x 90 mm
Measured λ	< 280 nm
Probe Type	4 circular electrodes ($\phi=1$ cm), gold & tin
Sampling Mode	240 or 15 sps
Power Consumption	0.8 W



Orbit Definition

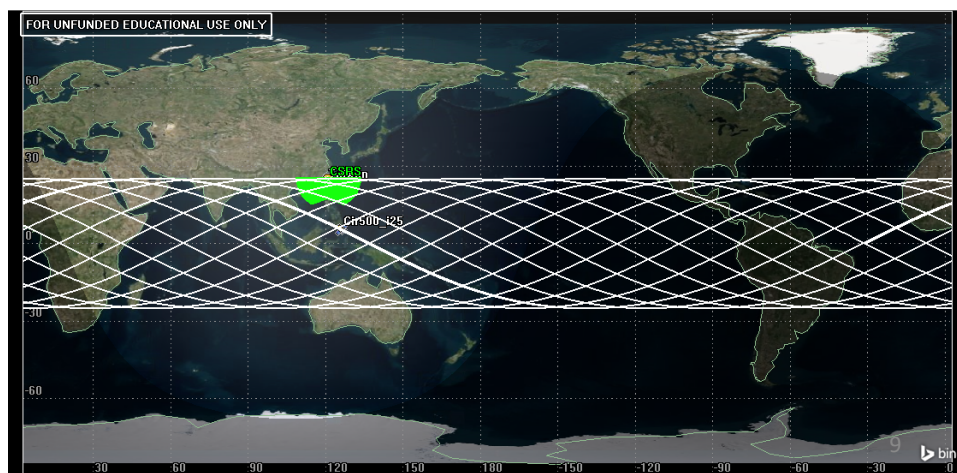
Operational Constraints

- Lifetime
- Communication time
- Observation time
- Finances

Payloads	Orbit Requirements
CIP	Altitude in F-region of ionosphere Latitude: at least $\pm 25^\circ$
Cion-R	Altitude: higher altitude \rightarrow more comprehensive data Latitude: at least $\pm 25^\circ$
Hyper-SCAN	Altitude: lower altitude \rightarrow higher resolution image Latitude: at least $\pm 25^\circ$

Altitude	500 km
Eccentricity	0
Inclination	25°
RAAN	279.26°
Argument of Periapsis	0°
True Anomaly	0°

Duration 04:00 UTCG 1 Jun, 2022 - 2023





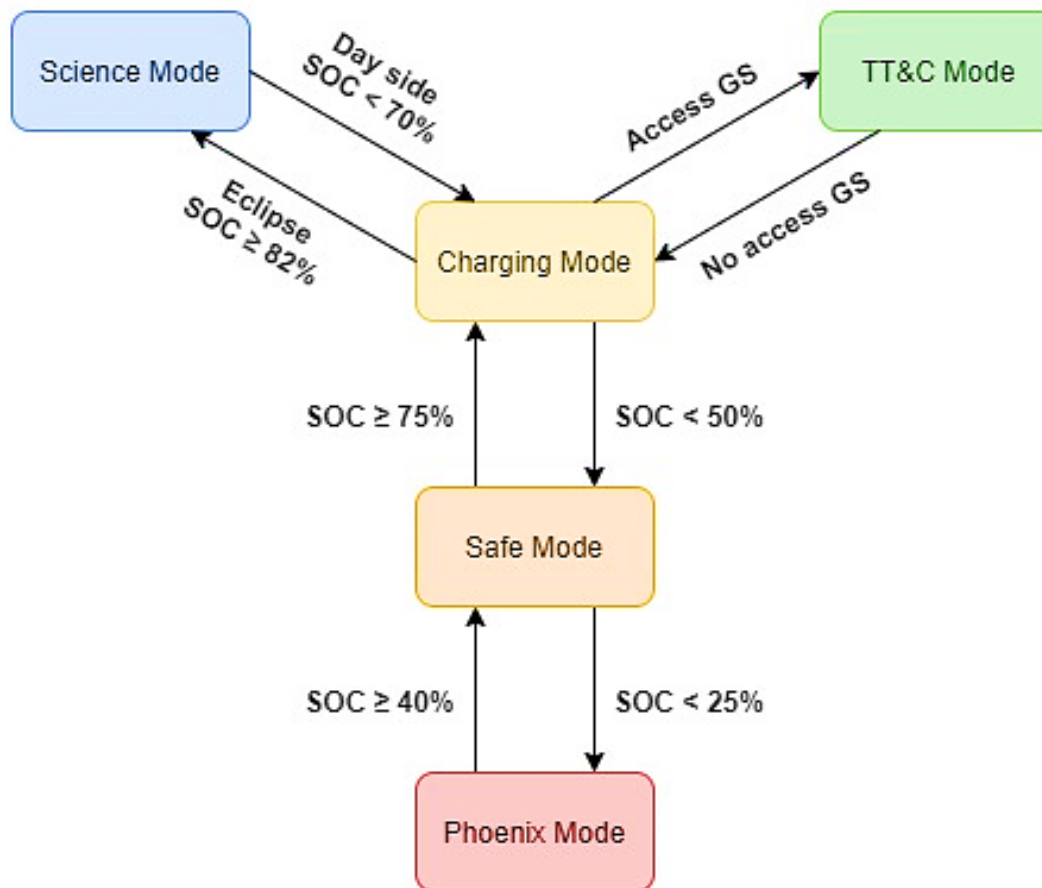
Mission Concept and Operations

Operational modes of SCION-X

Subsystem	EMERGENCY		NOMINAL				
	Phoenix	Safe	Charging	TT&C	Science_RO	Science_R	Science_CIP
CDH	ON	ON	ON	ON	ON	ON	ON
EPS	ON	ON	ON	ON	ON	ON	ON
ADCS	OFF	Coarse Sun Point	Fine Sun Pointing	Surface pointing	LVLH	LVLH	LVLH
UHF Tx	Beacon	Beacon	Beacon	Beacon	Beacon	Beacon	Beacon
UHF Rx	ON	ON	ON	ON	ON	ON	ON
X-Band	OFF	OFF	OFF	ON	OFF	OFF	OFF
Cion-R	OFF	OFF	OFF	OFF	As required	As required	As required
CIP	OFF	OFF	OFF	OFF	As required	As required	As required
Hyper-SCAN	OFF	OFF	OFF	OFF (Night)	OFF	OFF	OFF
				ON (Sunlight)			
SEUV	OFF	OFF	As required	OFF	OFF	OFF	OFF



Mission Concept and Operations



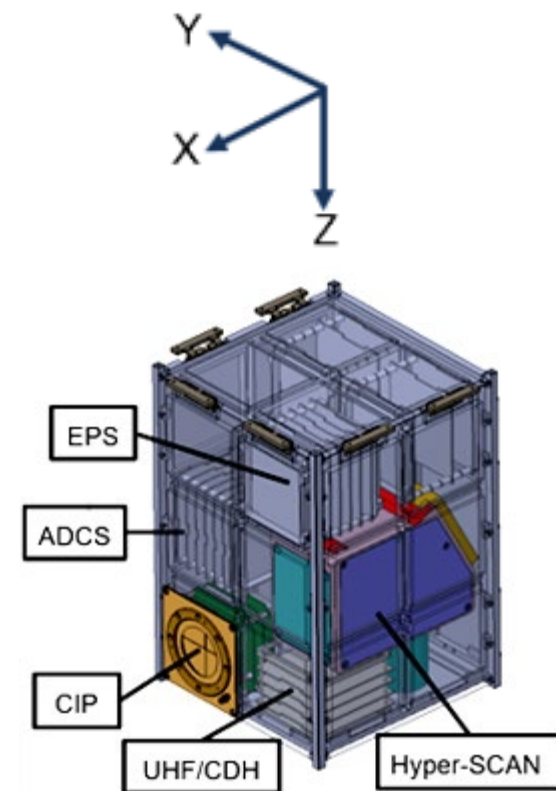
Flow chart of operational mode



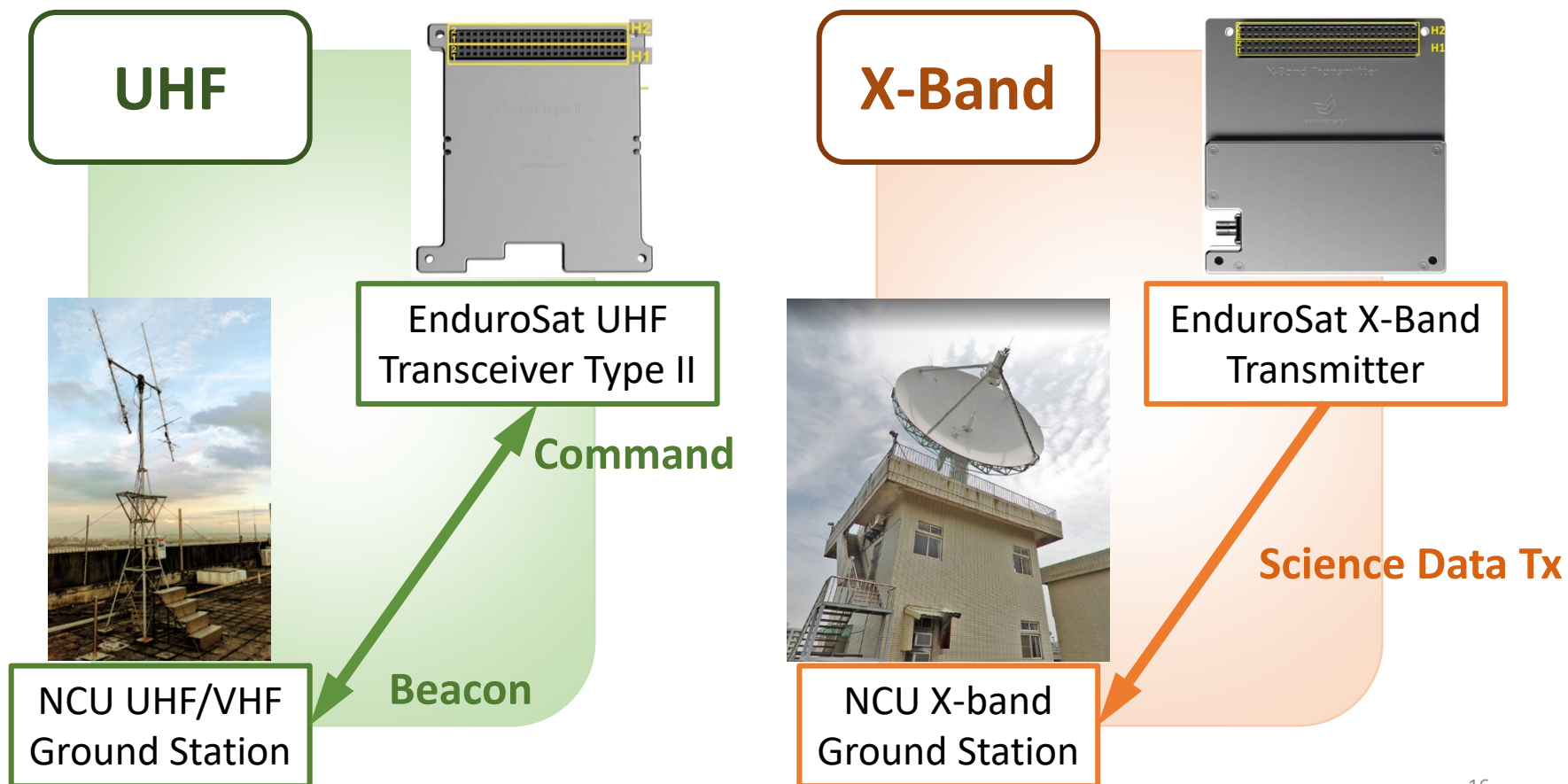
Spacecraft System Definition

SCION-X System Architecture

Subsystem	Notes	TRL
Cion-R	GeoOptics Cion-R	2
	Tallysman TW3872E GNSS Antenna x2	6
CIP	Compact Ionosphere Probe (CIP)	8
Hyper-SCAN	Hyperspectral Imager	4
SEUV	Solar Extreme Ultraviolet Probe	9
EPS	Modified IDEASSat EPS Control Board	6
COMM (UHF)	EnduroSat UHF Transceiver Type II	9
	Tape measure monopole antenna	2
COMM (X-band)	EnduroSat X-band Transmitter	6
	EnduroSat X-Band Single Element Antenna	6
ADCS	CubeSpace CubeADCS	7
C&DH	Microsemi SmartFusion 2	7



Communication Subsystem (COMM)





Spacecraft System Definition

Communication Subsystem (COMM)

One Year Data Volume Estimation

	data rate	total time	total data size	one day data size	Descriptions
	(Bytes/sec)	(hr)	(GB)	(MB / day)	
CIP (Normal)	280.00	0.00	0.00	0.00	0.00%
CIP (Fast)	2240.00	3315.66	24.90	69.86	37.85%
Cion-R	37000.00	2601.72	322.75	905.47	29.70%
Hyper-SCAN	4194304.00	0.47	6.59	18.50	8 pass
Total science data	-	-	354.24	975.33	
Downlink	7864320.00	11.23	296.04	830.54	30 Mbps, QPSK
Margin	-	-	-58.20	-163.28	
			-16.43%		



Spacecraft System Definition

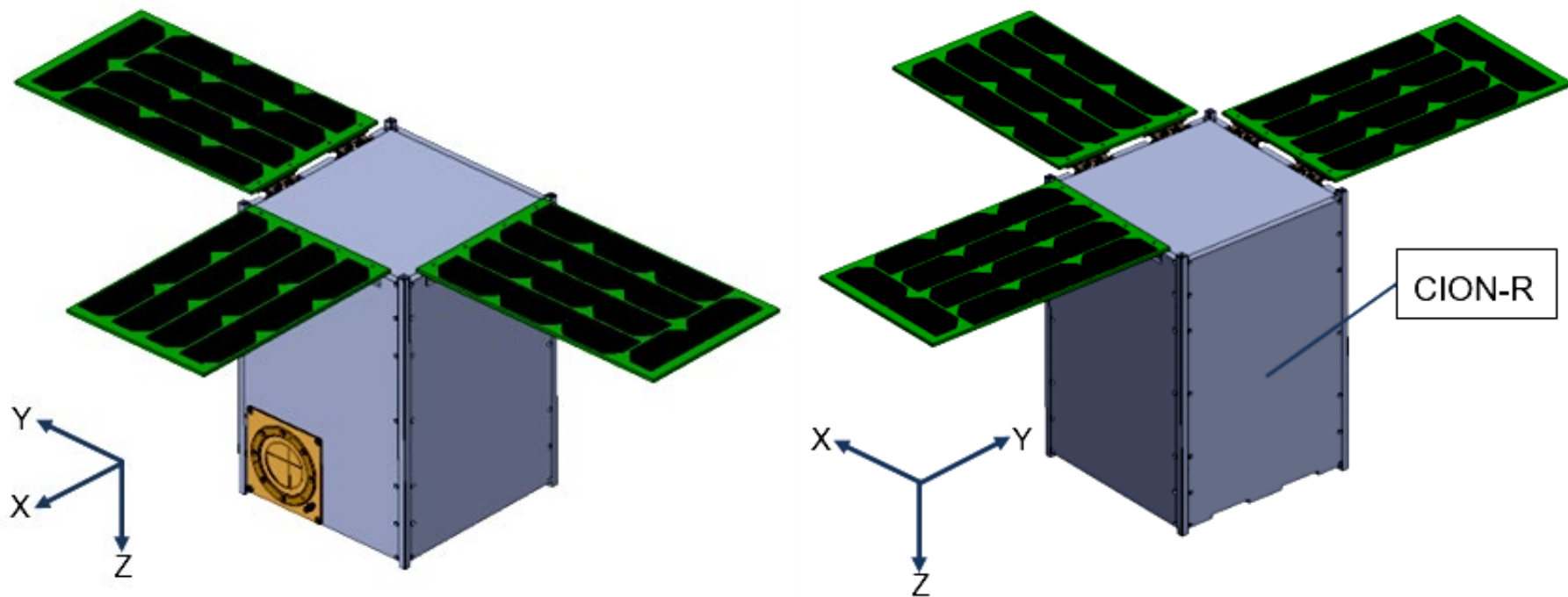
Electrical Power Subsystem (EPS)

Science Mode				
		Peak (W)	Duty Cycle (%)	Peak (W)
	Battery heater	6.1	25.00%	1.53
	EPS	3	100.00%	3
Cube ADCS	ADCS	6.58	100.00%	6.58
	Cion-R	15	29.70%	4.46
POD	GNSS	0	0.00%	0
TW3872E	Patch Antenna (x6)	0.50	29.70%	0.15
	CDH	1.4	100.00%	1.4
	UHF (Tx)	2.07	6.37%	0.13
	UHF (Rx)	0.15	93.63%	0.14
	Xband (Tx)	12	5.30%	0.64
DAY	Hyper-SCAN	5	0.50%	0.03
	CIP	4.8	37.85%	1.82
			Total	19.85
	Solar Panels power	43.47	62.15%	27.02
No. of cells	40		Margin	(36.08%) 7.16



Spacecraft System Definition

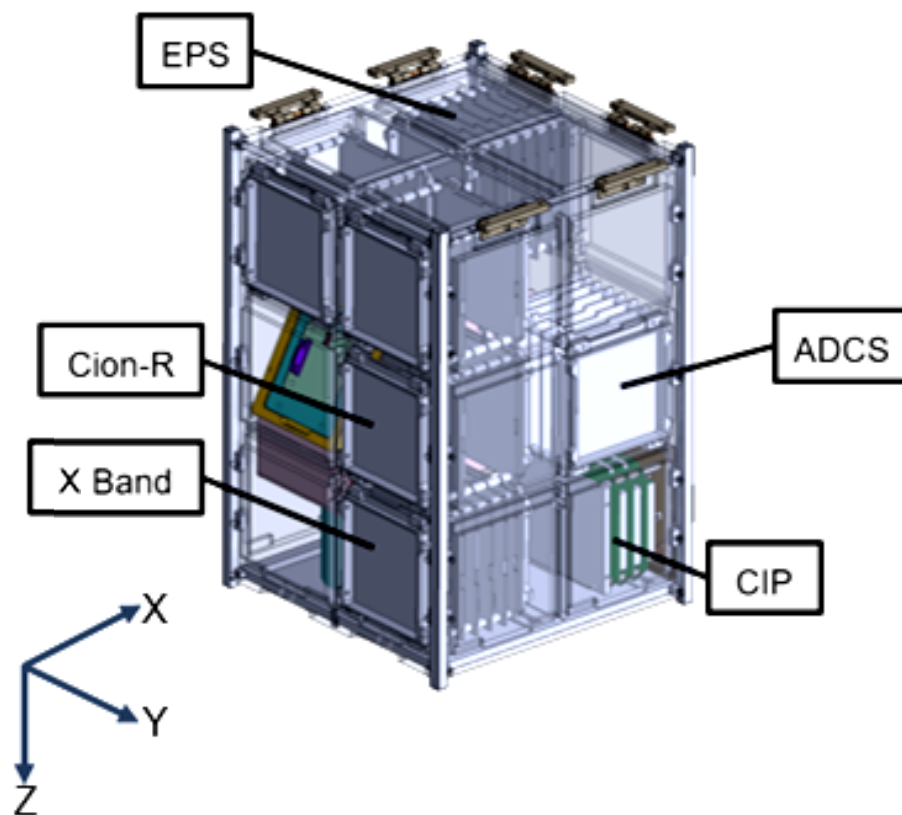
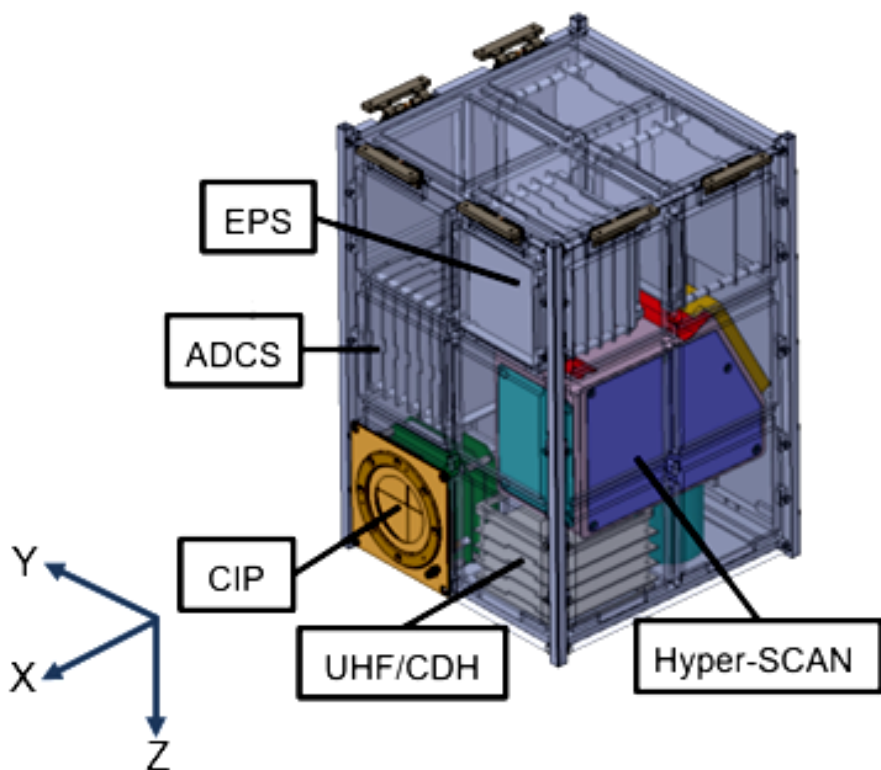
Structure Subsystem (STR)





Spacecraft System Definition

Structure Subsystem (STR)





Conclusions

CubeSats platform for scientific missions

- A 12U CubeSat in the preliminary design stage
- Expected to be launched in 2023

SCION-X Mission Objectives and Payloads

- Space weather monitoring & Weather forecast → Cion-R
- Ionospheric studies → CIP
- PM2.5 air pollution → Hyper-SCAN
- Atmospheric photochemistry observation → SEUV Probe

Analysis

- STK Simulation for the orbit
- NCU UHF and X-Band Ground Station
- Requirements for each subsystem
- Trade off between power and data volume estimation



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Question?