



Earth Observation & Small Satellite Systems

UIM 2015

**PRESENTATION TO USER MEET, NRSC
JANUARY 2015**

EO Missions - Program Profile (2014-18)



	2015-16	2016-17	2017-18	2018 and Beyond
High Resolution Mapping Missions	CARTO-2C (Mar' 16)	CARTO-2D (JAN' 17) MICROSAT (OCT' 16)	CARTOSAT-2E (SEP' 17) CARTOSAT-3 (SEP' 17)	CARTO-3A CARTO-3B
Ocean and Atmosphere Observation Missions	SCATSAT (NOV' 15)	UIM 2015	OCEANSAT-3 (AUG' 17)	
Resource Monitoring (Land & Water) and Microwave missions		RESOURCESAT-2A (APR' 16) HYSIS (DEC' 16)		<ul style="list-style-type: none"> RESOURCESAT-3 Sampler RESOURCESAT-4 Mx RISAT-2A RISAT-1A NISAR

Future HIGH Resolution Cartography Missions



2015-16

2016-17

2017-18

2018 and Beyond

CARTO-2C
(Mar' 16)

CARTO-2D
(Jan' 17)

CARTOSAT-2E (Sep' 17)
CARTOSAT-3 (SEP' 17)

CARTO-3A
Carto-3B

2016 2017 2018 2019 2020 2021 2022 2023

Carto-2C

Carto-2D

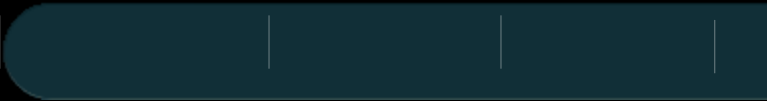
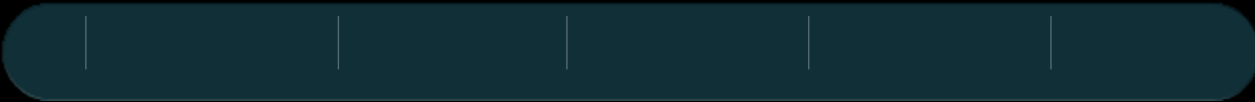
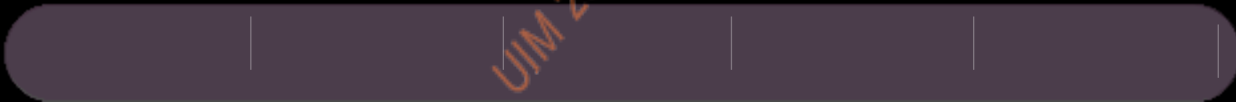
Carto-2E

Carto-3

Carto-3A

Carto-3B

UIM 2015



Ocean and Atmospheric Study Missions



2015-16

2016-17

2017-18

2018 and Beyond

SCATSAT(NOV' 15)

OCEANSAT-3(AUG' 17)

2015 2016 2017 2018 2019 2020 2021 2022

Oceansat-2

Scatsat-1

Oceansat-3A

Oceansat-3B

Oceansat-3C

UIM-2015

Resource Monitoring (Land & Water) Missions



2015-16

2016-17

2017-18

2018 and Beyond

RES -2A (APR' 16)
MICROSAT (OCT' 16)
HYSIS (DEC' 16)

RISAT-1A / RISAT-2A
Resourcesat-4 Mx / Resourcesat-3 Sampler
NISAR

2016

2017

2018

2019

2020

2021

2022

2023

RES-2A

Microsat

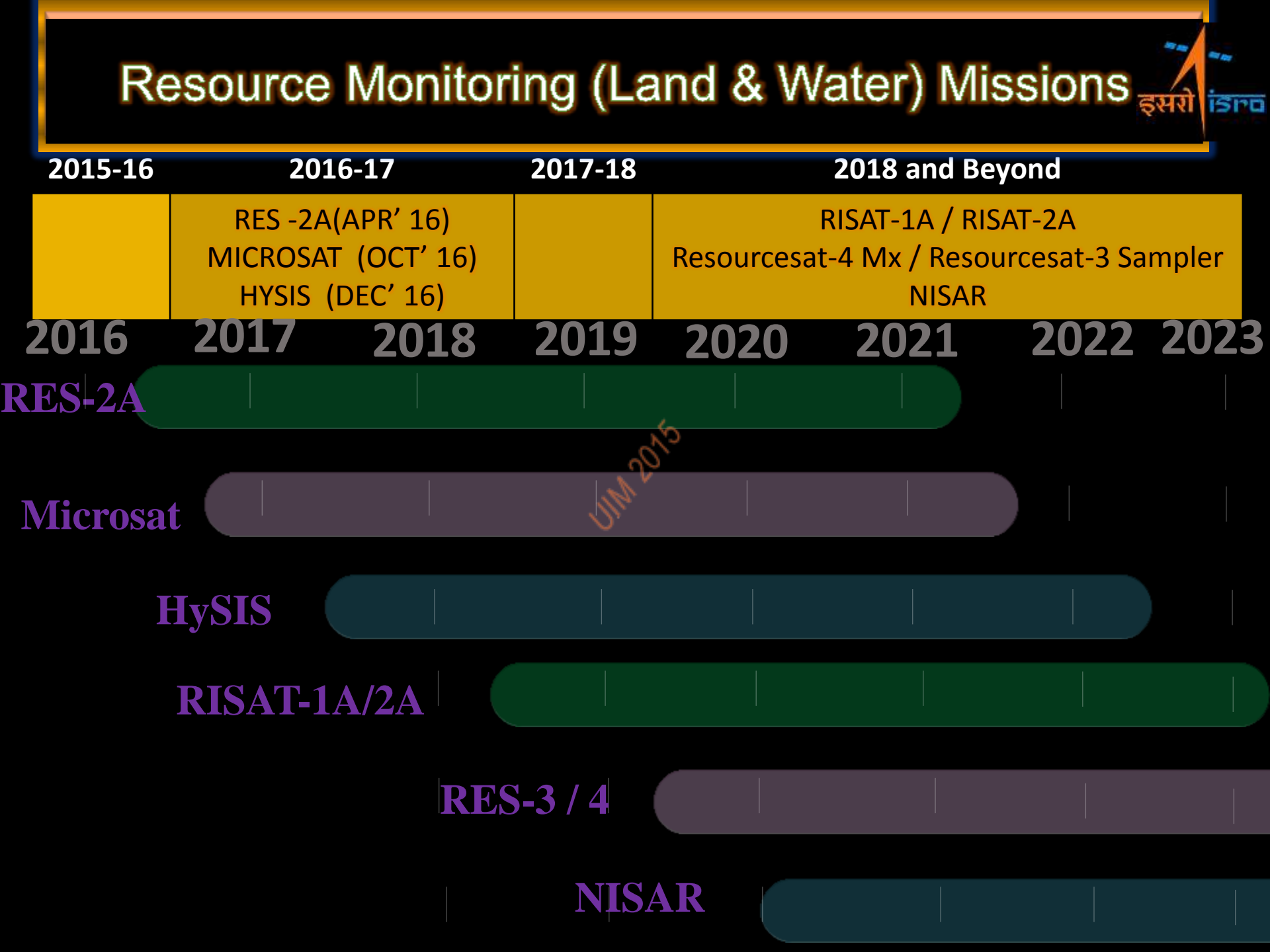
HySIS

RISAT-1A/2A

RES-3 / 4

NISAR

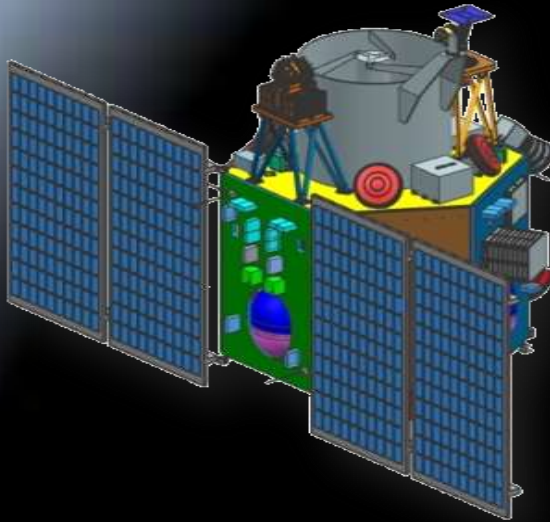
UIM 2015





ISRO FUTURE EO PROJECTS

July 2015



Cartosat-2C/2D/2E

Payloads:

- Panchromatic with 0.64 mtr resolution
- Multispectral with 4 Band with 2 mtr resolution

Challenges

- Employing Detectors with Time Delayed Integration
- Dual Star sensor based attitude processing
- Wavelet based Compression

Milestones

- Space and Ground Segment PDR completed.
- Payload thermal design completed. Development and testing of representative payload chain completed.

S/C Readiness :

Cartosat-2C : MAR'16

Cartosat-2D : JAN'17

Cartosat-2E : SEP'17

Cartosat-2C/2D/2E: Payload Highlights

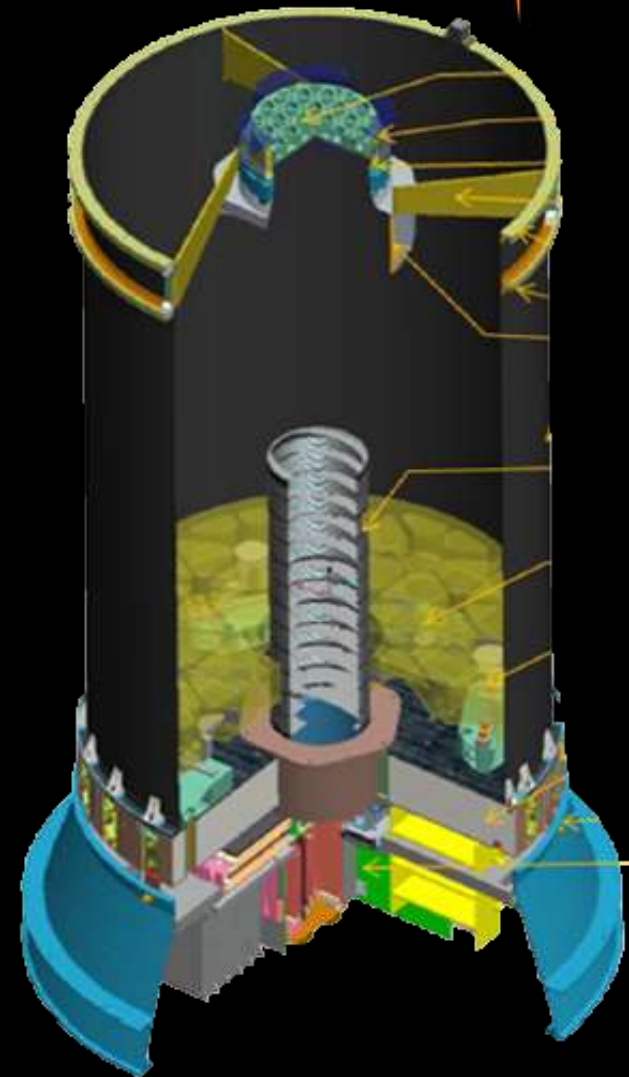


PANCHROMATIC CAMERA

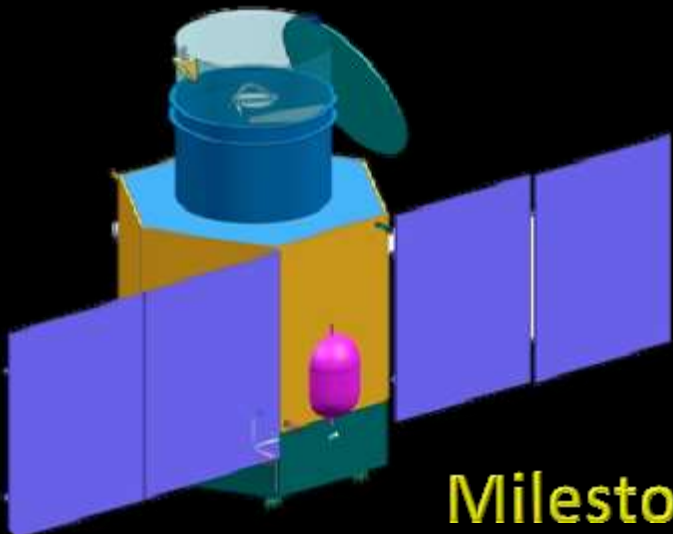
Resolution	: 0.64m
Swath	: 10 km
Spectral Band	: 0.45 - 0.90 μm
Detector	: 8k TDI -Two Nos.
Total data rate	: 2342 Mbps

MULTISPECTRAL CAMERA

Resolution	: 2.0 m
Swath	: 10 km
Spectral band	Band-1: 0.45 - 0.52 μm Band-2: 0.52 - 0.59 μm Band-3: 0.62 - 0.68 μm Band-4: 0.77 - 0.86 μm
Detector	: 1.3k TDI CCD - 5 nos.
Total data rate	: 1464 Mbps



Cartosat-3/3A/3B Series



Orbit Parameters (Mean)

- Type : Polar Sun Synchronous Orbit
- Altitude : 450 km
- Inclination : 97.2 deg
- ECT (Local Time): 10.30 hrs
- Period : 93.6 min

Milestones:

- Approved by Standing Projects Appraisal Committee (SPAC)
- Baseline Design Review Completed
- Major Actions completed with refinement in configuration
- Advance actions for procurement of long lead items.
- Realization of new specific subsystems through Advanced Technology plan.
- PDR Planned in May 2015

S/C Readiness :

Cartosat-3 : 2018

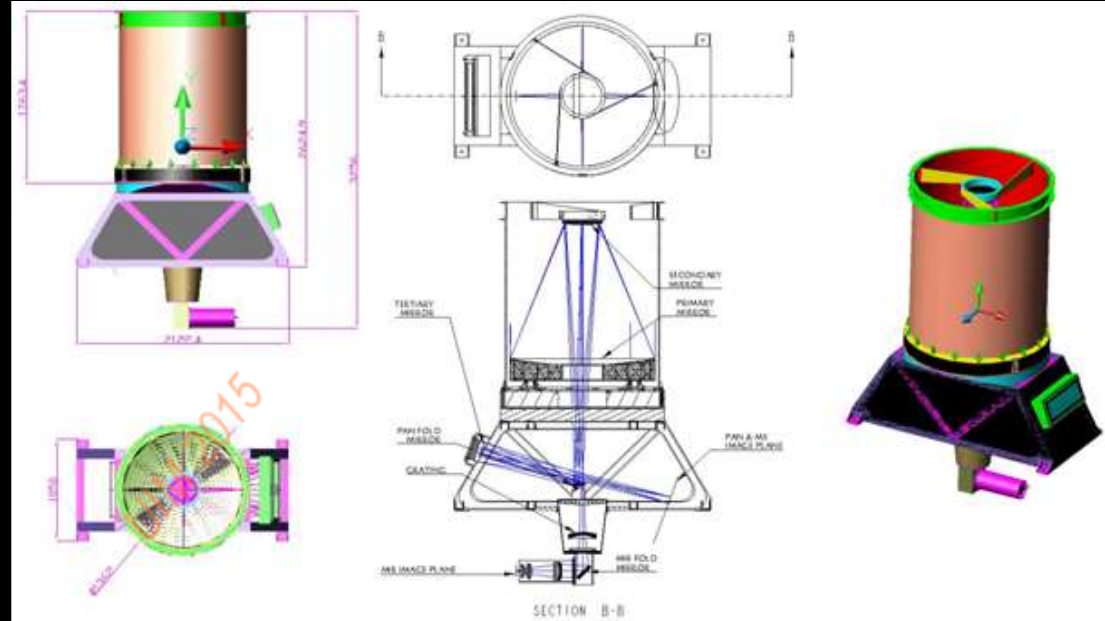
Cartosat-3A : 2019

Cartosat-3B : 2020

Cartosat-3/3A/3B Payload Highlights

Payloads

- High resolution PAN with 0.25m resolution
- High resolution Multispectral VNIR with 1m resolution
- Hyper spectral SWIR and VNIR with 12m resolution (or) 5m MIR



Telescope Structure of Payload

EO System Salient Capabilities

- ~0.25 m GSD (nadir), >15 Km Swath Panchromatic (0.45 to 0.9um)
- ~ 1 m GSD (nadir), > 15 Km Swath 4 -bands visible Multi-spectral
- ~5m GSD (nadir) MWIR (3 to 5 microns)

Coverage Capability per Day By Carto-3

Ground stations	Spot mode (Km ²)	Strip mode (Km ²)	Limitation
NRSC X-Band only	5824 x 4 =23,296	6160 x4=24,640	Download time (8 min)
NRSC Ka Band only	9000 x 4=36,000	18832 x 4=75,328 (385x16x3)	20 spots
NRSC X Band + Antarctica X Band	9000 x 4 =36000** 5824 x 11 = 64064 = 100,064	12320 x 4 = 49280** 6160 x11=67760 = 117,040	** Download at NRSC + Antarctica
NRSC Ka band + Antarctica X band	9000 x 4=36000 5824 x 11 = 64064 =100,064	4 x 24992=99968** 11 x 6160=67,760 =167,728	** Download at NRSC + Antarctica

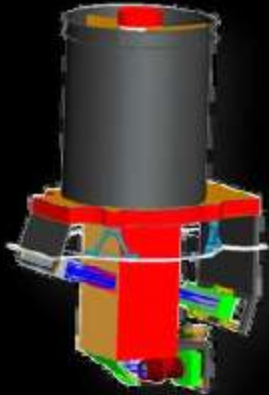
Cartosat-3/3A/3B



NEW DEVELOPMENTS/CHALLENGES

Payload

- Telescope Structure
- Optics
- Detectors
- Payload Electronics
- Thermal – Cryo-coolers, Heat Pipes



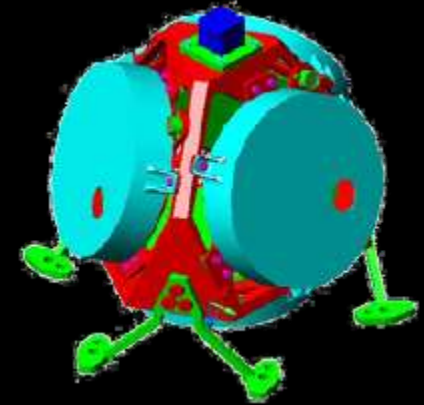
Data Handling & Transmission

Compression – Variable, upto 5

- SSR - >2 TB
- Format: CCSDS, Encryption (H/W, S/W)
- 8PSK Modulation
- X-band/Ka band transmission, with PAA/DGA

AOCS

- High accuracy Star Sensors
- Fibre Optics Gyros
- Control Momentum Gyros
- 12 channel Dual frequency SPS



Platform Electronics

- New Advanced-OBC
- New Power Electronics



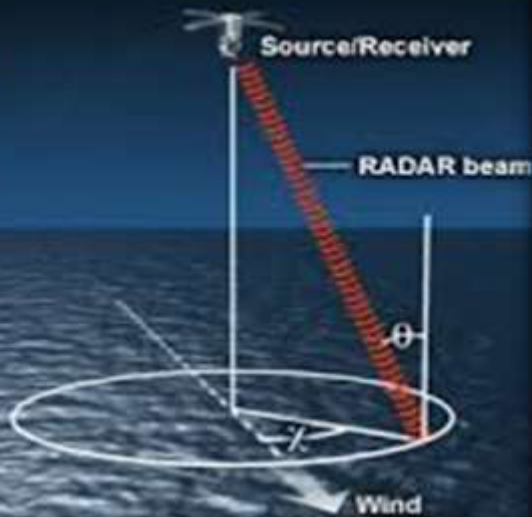
Mech Systems:

- Platform Structure
- Payload shutter
- New DGA
- Mission management

Scatsat-1

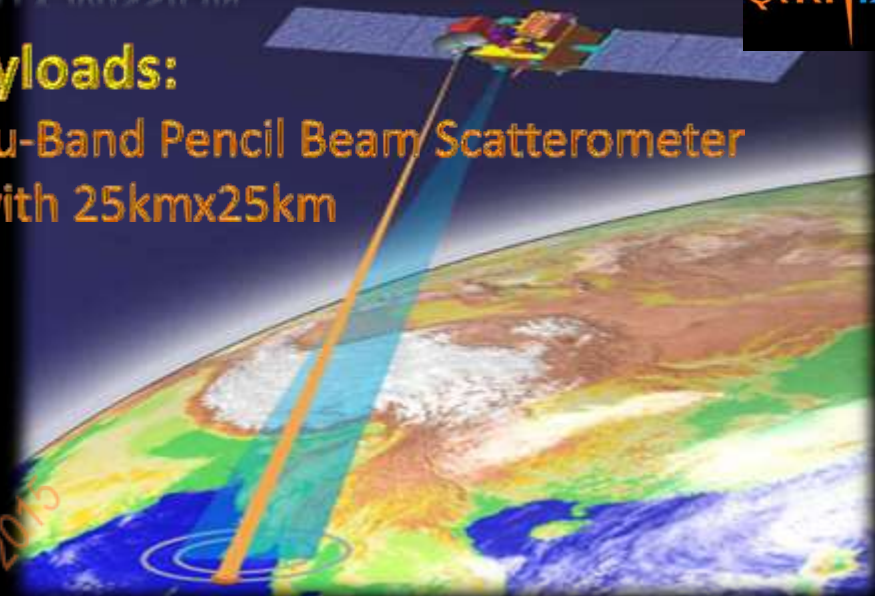
OSCAT CONTINUITY MISSION

Satellite Viewing Geometry



Payloads:

- Ku-Band Pencil Beam Scatterometer with 25kmx25km



Challenges

- Payload accommodation in IMS-2 BUS
- Improvement with respect to OSCAT observations

Milestones

- Configuration Finalized
- Space and Ground segment PDR completed
- Realization of Flight Model Sub-systems in Progress



S/C Readiness : NOV'15

Resourcesat-2A

(Repeat mission of RS-2)



Payloads:

- LISS-4 Multispectral with 5.8 mtr
- LISS-3 Multispectral with 23.5 mtr
- AWiFS Multispectral with 56 mtr

Improvements

- Improved SWIR Detectors for AWiFS
- Implementation of changes based on Resourcesat-2 experience

Milestones

- Primary Structure(MPL) Delivered to Integration
- Propulsion System Integration completed except Tank & Thrusters
- Mainframe Systems T&E In-Progress
- Payloads Assembly & Testing In-Progress

S/C Readiness :
APR '16

OCEANSAT 3

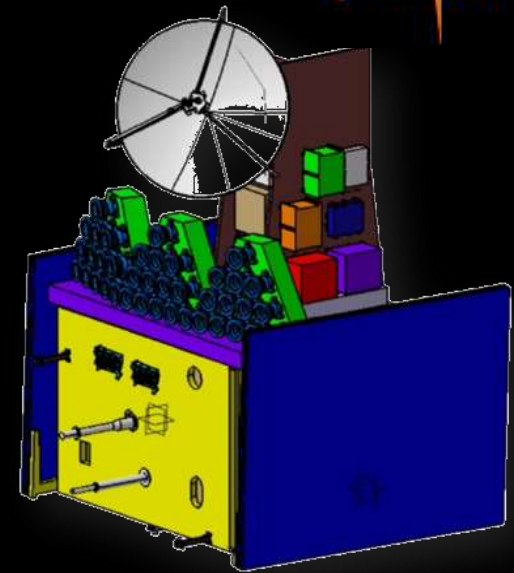


Payloads:

- Scatterometer-3
- OCM -3
- Sea Surface Temperature Measurement (2 TIR Bands)-1

Challenges:

- SNR better than 1000 at ocean radiance
- Narrow spectral bands 10nm (Optics)
- Development of 4K CCD detector at SCL
- Accommodation of payloads on IRS bus



**S/C Readiness :
AUG 2017**

Milestones:

- Project Clearance by SPAC (Budget revision is under review)
- Configuration Finalized
- BDR for optical payloads completed
- Study to accommodate ARGOS is being carried out

OCEANSAT-3 Payload Highlights

Improvements over Earlier missions



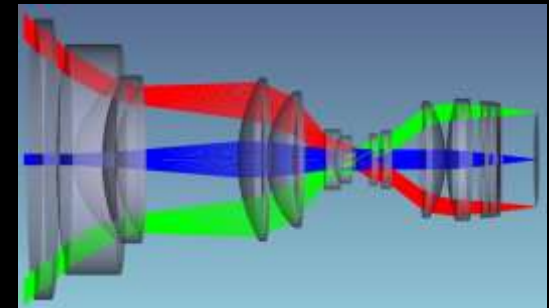
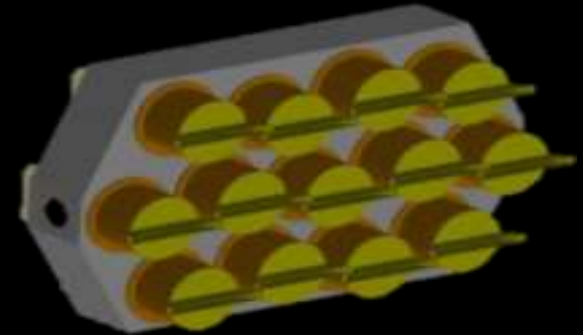
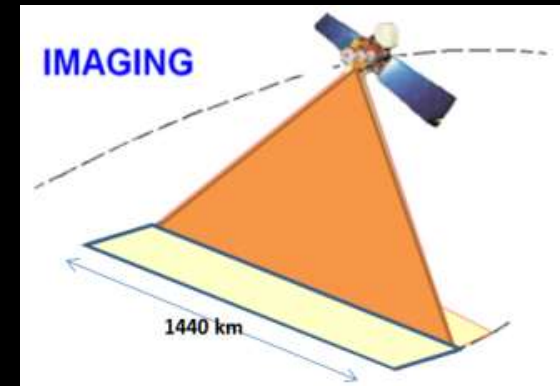
Parameter	Earlier	Present
Ocean Color Monitor		
No. of OCM Bands	8	13
OCM Coverage	Lat 45N,45S	Full sunlit duration
Swath	1440Kms	1440Kms
Tilt of OCM	$\pm 20^\circ$	$\pm 20^\circ$
Digitization-OCM	12 bits	14/16 bits
Resolution	LAC 360mtrs/GAC 1km	LAC 360mtrs/GAC 1km
SNR	360	Min 1000
Sea Surface Temperature Monitoring		
No of SST bands	-----	2(TWO)
Coverage	-----	continuous
Scatterometer		
Scatterometer Frequency	13.515 GHz (Ku Band)	13.515 GHz (Ku band)
Resolution of Scatterometer	25 x 46 km	25 x 46 km
Swath width of Scatt.	1400 km / 1800 km	1400 km / 1800 km

OCEANSAT-3 Payload Highlights



Ocean Color Monitor-3 Payload

- ✓ Payload for Ocean & Land Appl.
- ✓ Thirteen Spectral Bands in the Visible & Near Infra-red region (407 to 1020 nm)
- ✓ Narrow band width spectral bands
- ✓ Large Coverage with good Spatial Res.
 - Swath : 1440 km.
 - Repeativity : 2 days
 - IGFOV : 360 m (B1 to B10);
1080 m (B11 to B13)
- ✓ High radiometric performance at low radiance – SNR >1000 at Sea Ref Radiance
- ✓ Provision for along track tilt ($\pm 20^\circ$) to avoid Sun glint



OCEANSAT-3 Payload Highlights



Scatterometer Payload



Scatt. Applications

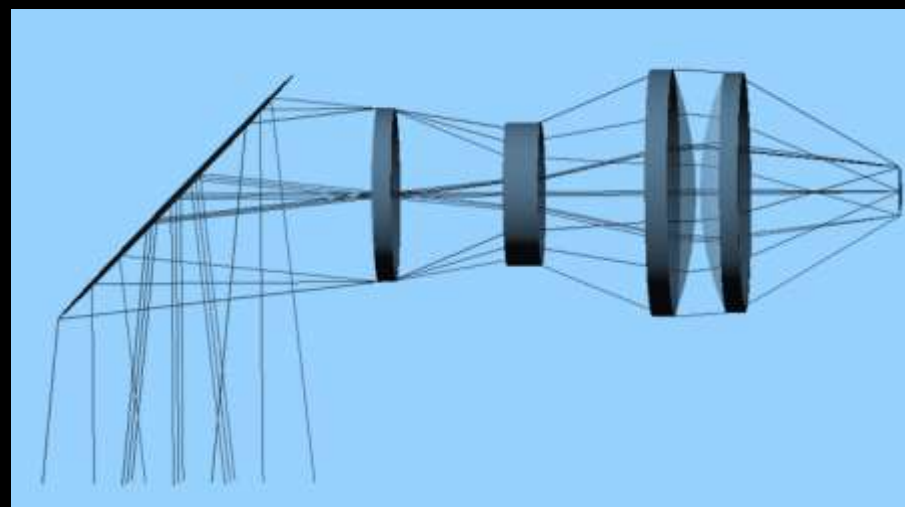
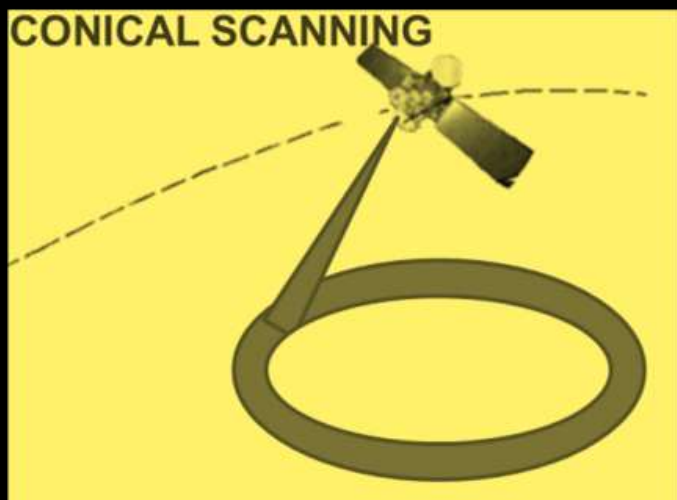
- Numerical weather prediction / forecasting and Nowcasting
- Identification of Cyclo-genesis and hurricanes and monitoring of their trajectory
- Improvement of PFZ identification by assimilation of Wind information with Chlorophyll concentration & SST data
- Monitoring of Polar Sea Ice changes
- Ocean state forecasting

OCEANSAT-3 Payload Highlights



Sea Surface Temperature Monitoring

SR. NO.	DESIGNATION	BAND DEFINITION (um)	IGFOV AT NADIR (m)	SATURATION TEMPERATURE (K)	NEdT @ 300K
1	TIR-1 (0° & 45°)	10.75-11.25	1080	340	150mK
2	TIR-2 (0° & 45°)	11.75-12.25	1080	340	150mK



Scanner based design, 1 Camera Head (2 Views)

NASA-ISRO Synthetic Aperture RADAR (NISAR)

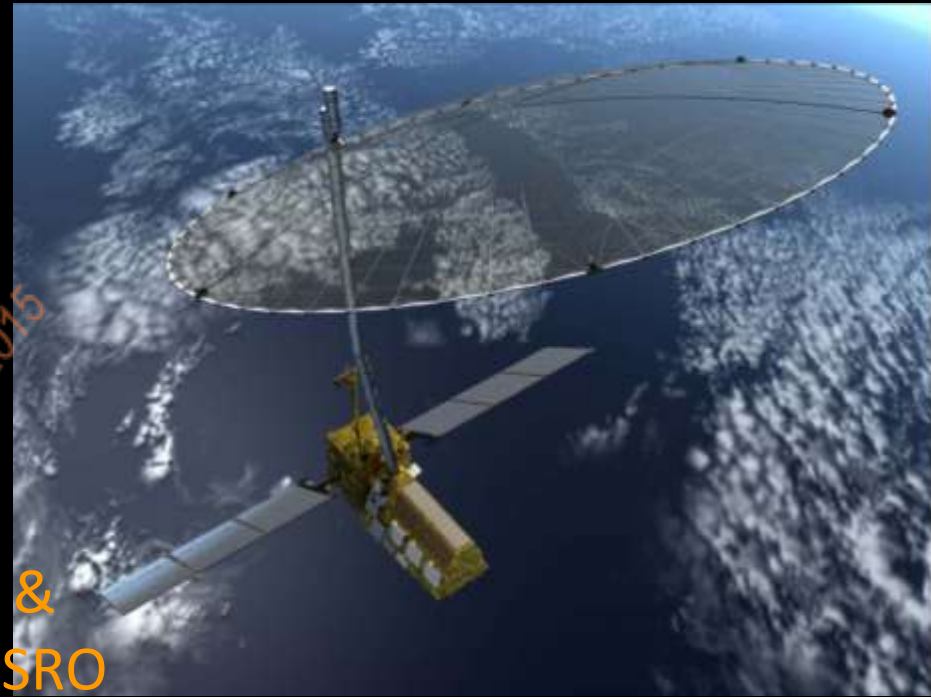


Payloads:

- Dual Band (L&S) Synthetic Aperture RADAR

Highlights:

- Collaborative global mission between NASA/JPL & ISRO
- New Sweep SAR Tech. with 12m unfurlable reflector
- L-Band SAR payload, SSR & GPS provided by NASA/JPL
- S-Band SAR payload, S/C bus & Launch by GSLV provided by ISRO

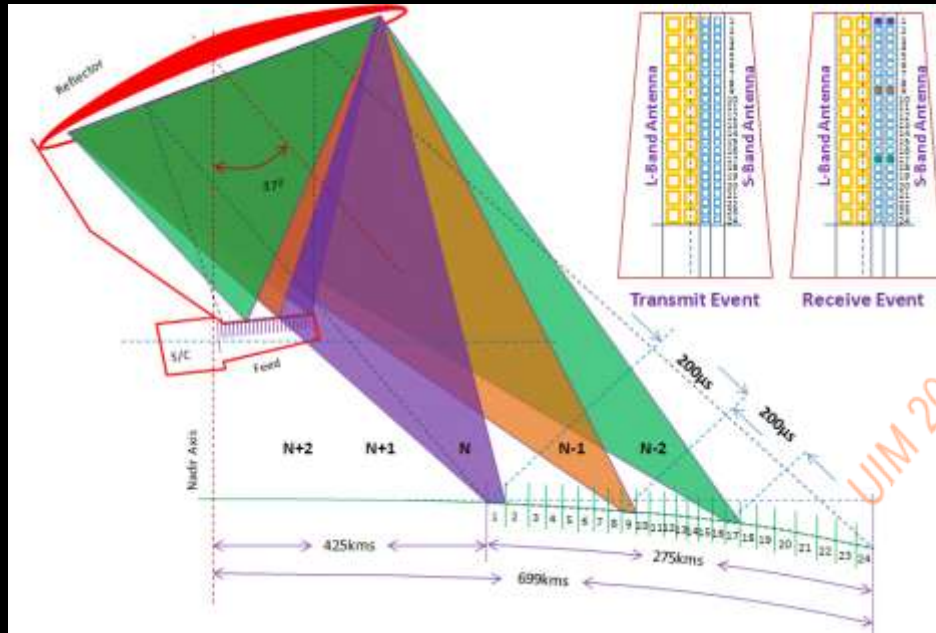


Milestones:

- TAA (Technical Assistance Agreement) and IA (Implementing Arrangement) signed between NASA /JPL & ISRO
- BDR of subsystems completed

S/C Readiness : By 2020

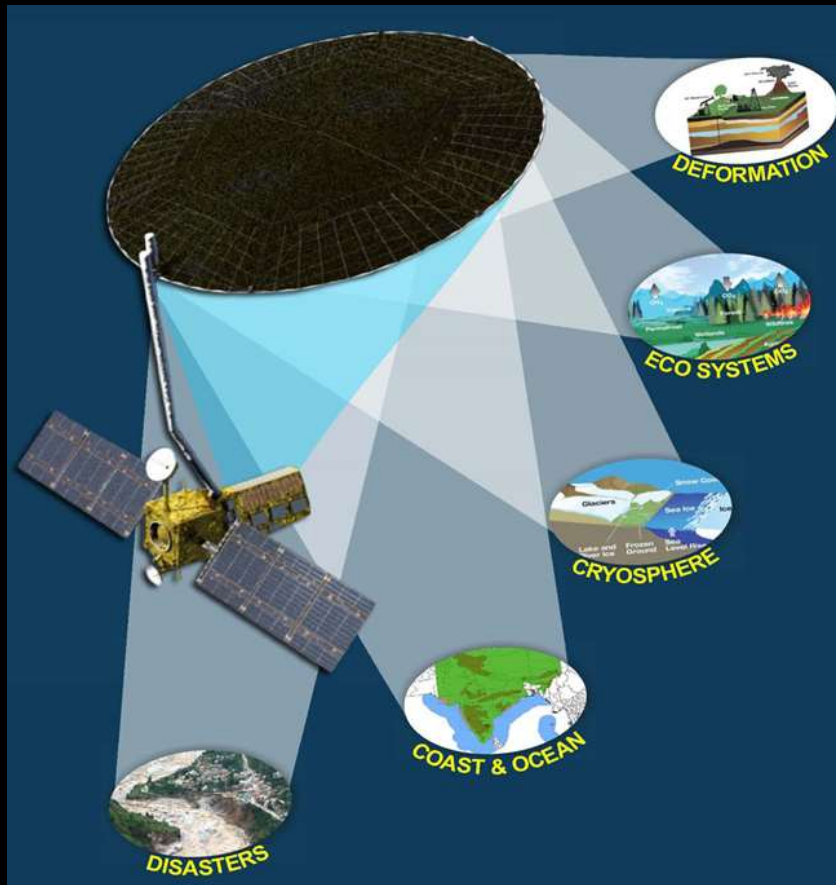
NASA-ISRO Synthetic Aperture RADAR Payload Highlights



- Range Resolution: 3 – 10m
 - Sub-pixel Geolocation
- Azimuth Res : 8(L) x 5(S)m
- Less than -20dB NESO

- Sweep SAR Technology
- Single Reflector for S & L band - 12m dia
- Synchronized Elec. for simultaneous S & L band operation
- Can operate in single / dual / quad / compact / split-band dual pol.

NASA-ISRO Syn. Aperture Radar: Applications



• Disasters

- ✓ Flood
- ✓ Oil slick
- ✓ Forest fire

• Ocean

- ✓ Bathymetry
- ✓ Wave spectra
- ✓ Coastal wind Speed

• Cryosphere

- ✓ Ice sheet Dynamics
- ✓ Ice shelf Dynamics
- ✓ Sea ice Dynamics & thickness
- ✓ Mountain glacier Dynamics

• Deformation

- ✓ Inter Seismic Strain
- ✓ Co-seismic deformation
- ✓ Volcanic deformation
- ✓ Land Subsidence
- ✓ Land Slide

• Coast

- ✓ Coastal Erosion
- ✓ High Tide Lines

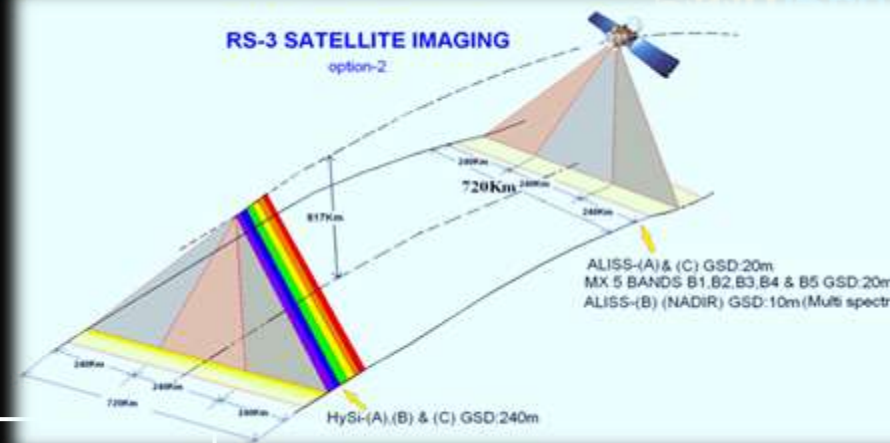
• Eco systems

- ✓ Forest Biomass
- ✓ Biomass change

Resourcesat-4 Mx

Mission Objective

To provide the assured continuity of Data services to the user community on an operational basis of Land and Water resources management with improved spatial resolution, spectral resolution and better revisit frequency



Challenges PAYLOAD related

- Optics design
- Design and development of spectral defining elements_(filters)
- Procurement of detectors
- Design and Development of Payload electronics and Data Formatter
- X-Band 8-PSK data downlink system

Bus related

- Dual Gimbal Gyro/ Fiber Optic Gyro
- Meeting Platform stability



Milestones

- Project Report is ready

**S/C Readiness :
By 2020**

Resourcesat-4 Mx : choice of spectrum

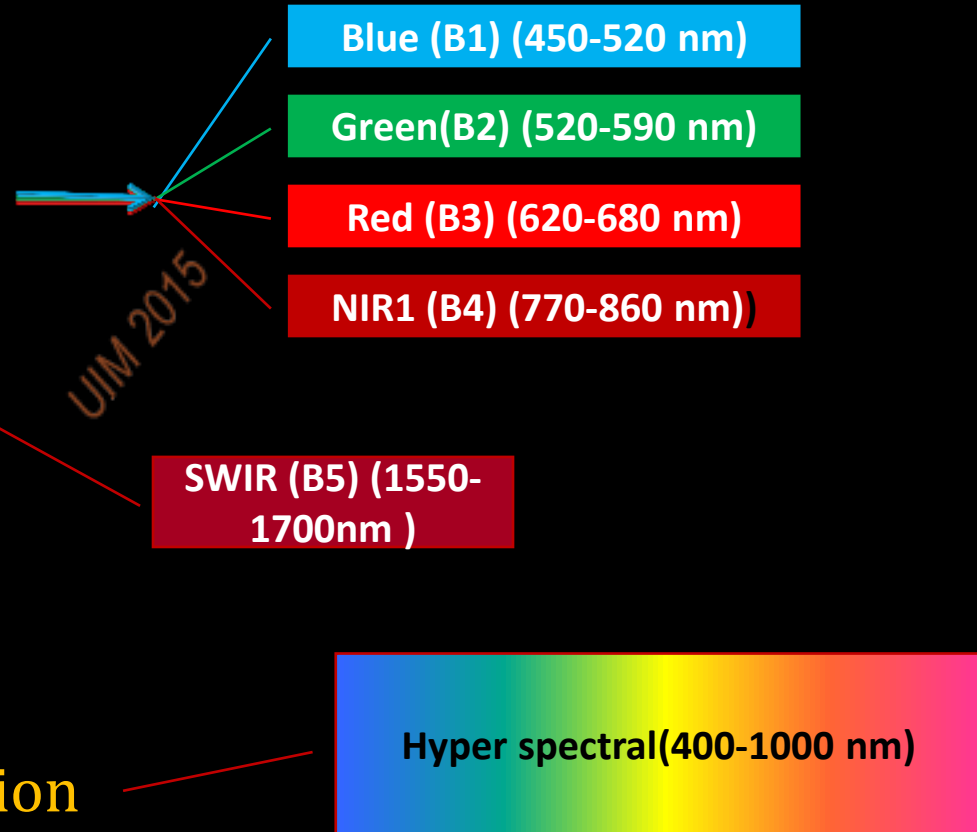


• The payloads operate in 5 bands+ ATCOR

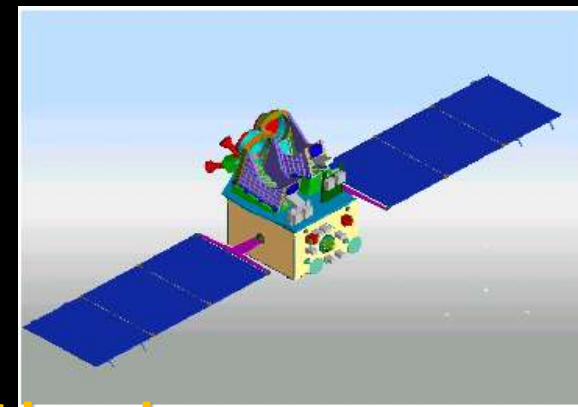
• VNIR - 4 bands

• SWIR - 1 bands

• Atmospheric correction



Resourcesat-3 Sampler



PAN band

Spectral range	450-900nm
Foot print at nadir (IGFOV)	2.5m
Ground sampling distance (GSD)	1.25m
Swath	60km per telescope

MX bands

Number of bands	3
Spectral definition	B2: 520-590nm B3: 620-680nm B4: 770-860nm
Foot print at nadir (IGFOV)	2.5m
Swath	60km

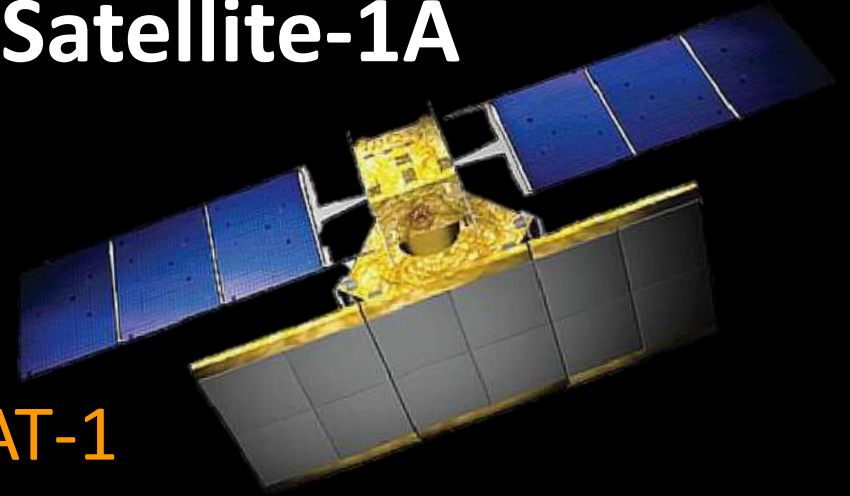
Number of bands	60
Spectral range & BW	400-1000nm, 10 nm
Foot print at nadir (IGFOV)	30m
Swath	60km

HyS-VNIR

Number of bands	160
Spectral range	900-2500nm
Spectral bandwidth	10nm
Foot print at nadir (IGFOV)	30m
Swath	60km

HyS-SWIR

Radar Imaging Satellite-1A



Mission Objective

- Continuity Mission of RISAT-1

Payload

- Operating in C-band (5.35 GHz), which enables imaging of the surface features during both day and night under all weather conditions.

Project Status

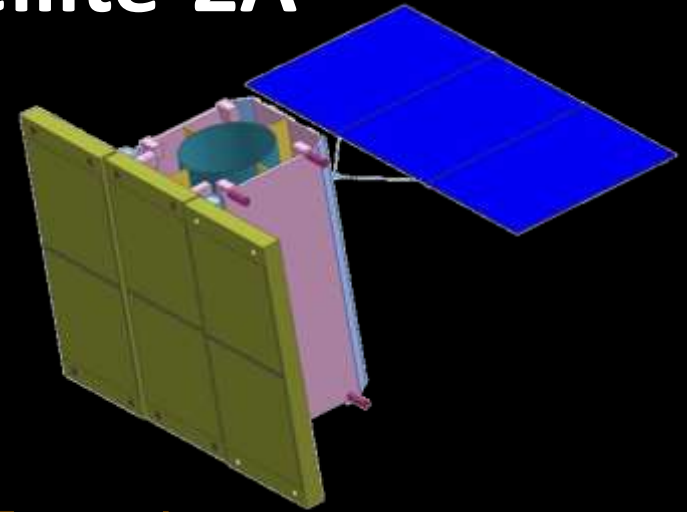
- Project Report is ready

**S/C Readiness
: By 2020**

Radar Imaging Satellite-2A

Mission Highlights

- Continuity Mission of RISAT-2
- X-Band SAR



Major Developments & Challenges

- X-band SAR Payload miniaturized Elec. development.
- Conflicting requirement : High agility Vs high payload mass.
- Suitable BUS structure to accommodate Large payload ant
- New bus systems for high resolution payload
- Deployment Mechanisms for payload.

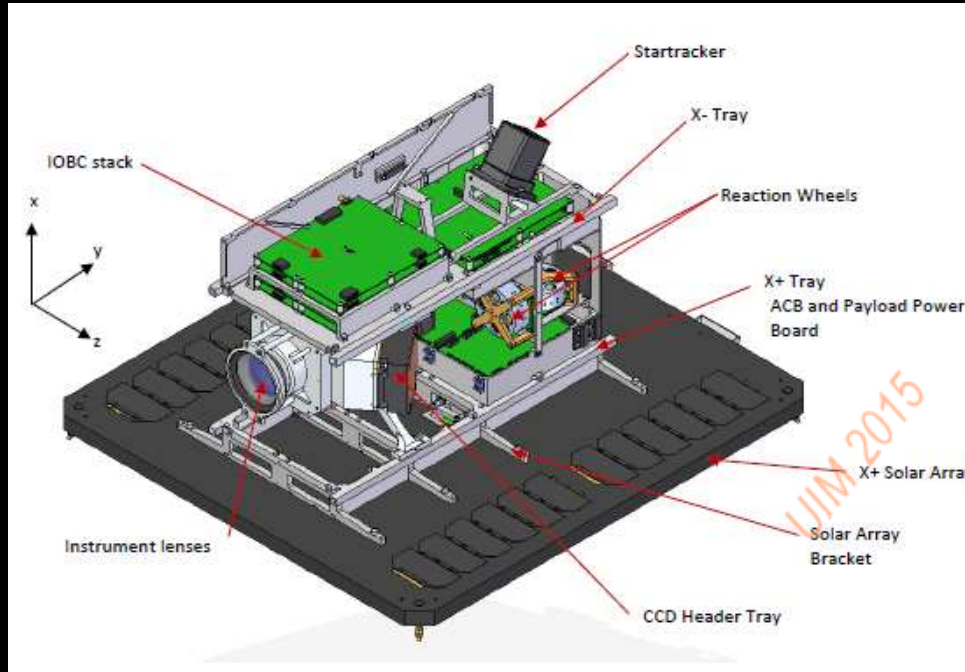
Project Status

- Project Report is ready
- Baseline configuration finalized

**S/C Readiness :
SEP 2018**

NEMO-AM : Nano sat for Earth Monitoring and Observation – Aerosol Monitoring

Salient Features



- ✓ Mass: 15kg(27Kg with ejection system)
- ✓ Volume: 70X60X30 cm³
- ✓ 3 VNIR bands (480-500 nm, 660-680nm and 860-880nm), dual polarization, multiple look angle
- ✓ SFL's generic Nano satellite Bus architecture
- ✓ Sub-degree pointing accr'cy
- ✓ 50W peak power gen.
- ✓ S-band uplink and downlink
- ✓ 2-Mbps data link capability

Project Status

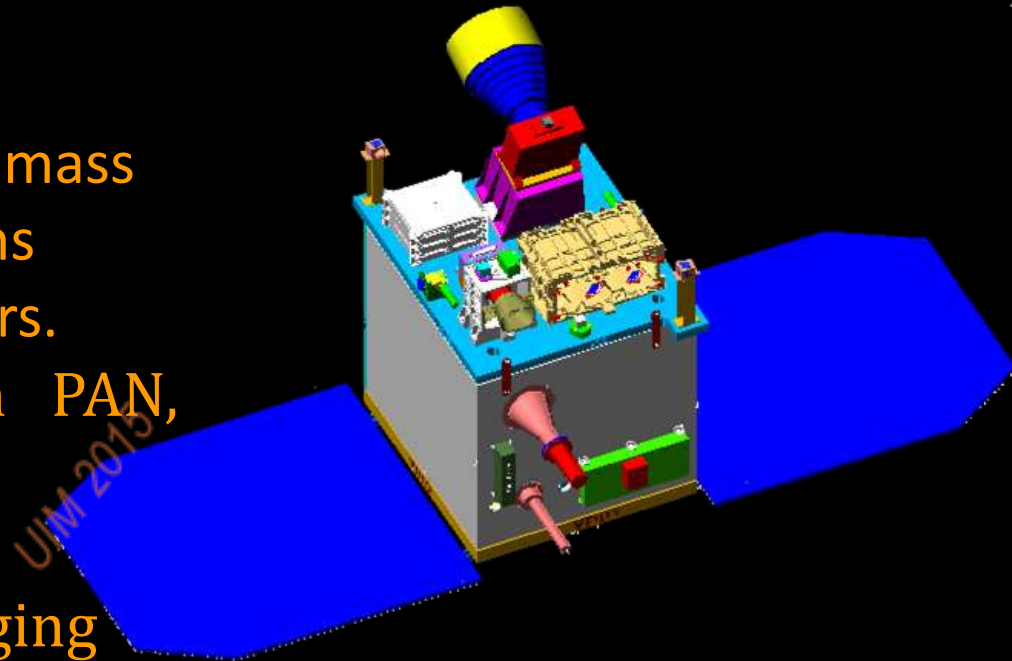
- Instrument ready for T&E.
- Instrument Calibration at SAC : June 2015.

**S/C Readiness :
By July 2015**

MICROSAT-1

Mission Highlights

- IMS-1 class : 120kg mass
- Orbit : 300kms
- Local time : 0930hrs.
- Will carry payloads in PAN, MIR & LWIR bands.
- PAN for day imaging;
- MIR/LWIR for night imaging

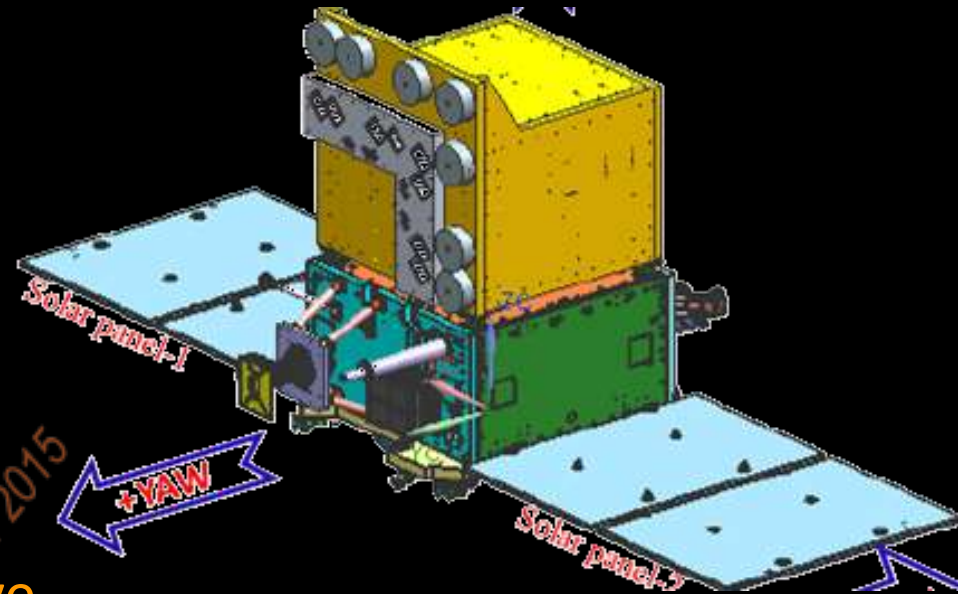


PAN	Resolution	Band	Swath	SNS	Data rate
	0.7mts	0.5 -0.85um	3.2kms	1:7	52Mbps
IR	Resolution	Band	Swath	SNS	Data rate
	6 m	3.7 – 4.8um 8-12 um	2 kms	1:10	1Mbps

HySIS: Hyper Spectral Imaging satellite

Mission Highlights

- IMS-2 BUS : 400kg Class
- Sun Synchronous Orbit
- 630km Altitude
- Global coverage on a repetitive basis
- High resolution observations
- Mission life – 5 Years



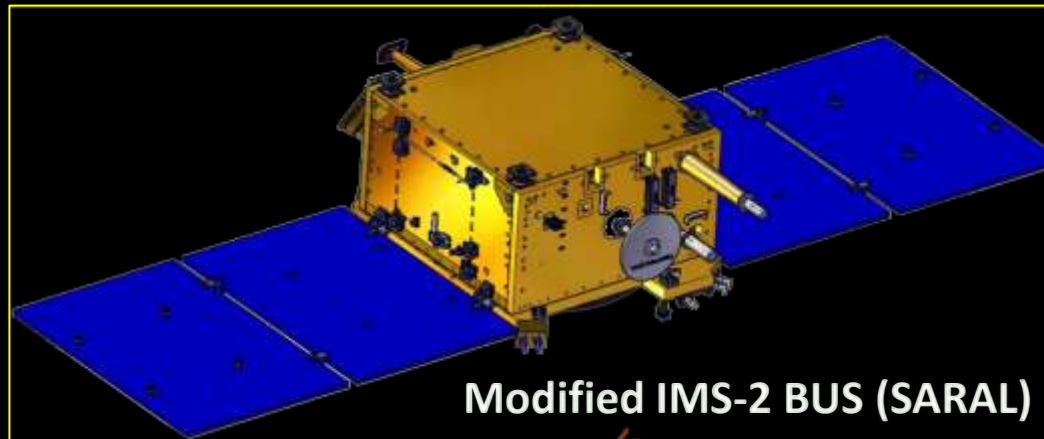
HYSI Payload

- Push broom Imaging with Area Array detectors
- Step and stare imaging
- Spatial & spectral Binning
- Wavelength: 0.4 – 2.4 μ m
- Contiguous 10nm spectral bands

HySIS: Payload Highlights

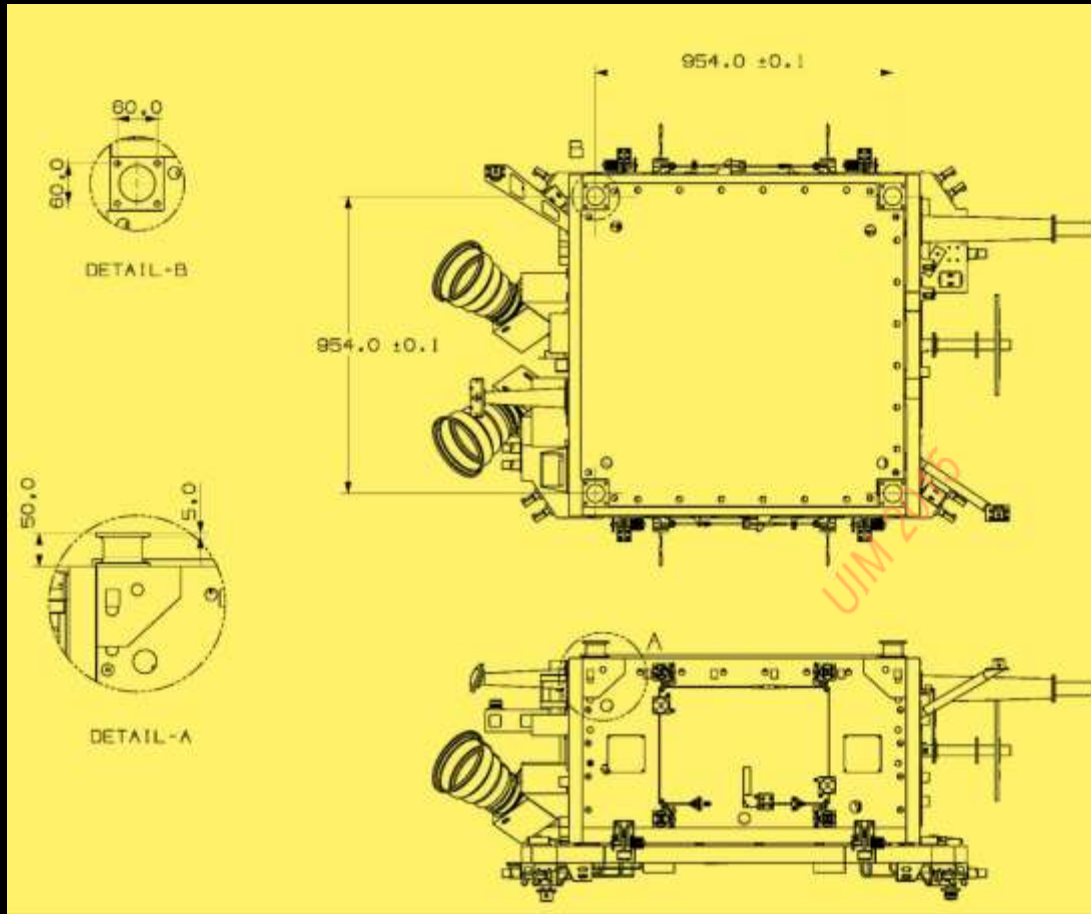
Parameter	Specification
IGFOV	48 μ rad
Spatial Resolution (GSD)	30 m
SWATH	30 Km
Spectral Range	VNIR: 400 – 900nm, SWIR: 850-2400nm
Spectral Resolution	Better than 10nm
Number of Bands	VNIR: 66 , SWIR: 256
SNR	VNIR: > 500; SWIR: >150
Step and Stare ratio 1: 5	
SWR(@Nyquist)	>20%
Operating Modes	Raw, Spatial and Spectral
Overall Payload size	1.0 x1.0 x0.8 m ³
Mass / Power	100 Kg / 120 watts average

Small Satellite BUS (IMS-3)



- Spacecraft Mass : 450kg
- Main Bus Size : 1118 x 1087 x 615 mm
- Power Generation : 850w (BOL)
- Raw Bus Supply : 28-42V
- TC/TM Rate : 4Kbps
- Data Tx Rate : 32/64/160Mbps
- Storage : 32Gb(SDRAM) / 256Gb(Flash mem.)
- Pointing Accuracy : $\pm 0.1^\circ$ all axis
- Drift Rate : 1×10^{-4} deg/sec

Small Satellite BUS (IMS-3)...Payload Interfaces



- P/I Mass : 200kg(max)
- P/I Volume : 1118 x 1087 x 550/750mm
- P/I Mounting I/f:
4 Pods at 4 corners
- Payload CG :
>400mm Longitudinal
(from Sep. Plane)
± 5mm Lateral

Stiffness Const - 1st Natural Freq.(with rigid I/F) : >100 Hz (Long.)
>70 Hz (Lateral)

Thermal Environment : Isolated from Main bus

Small Satellite BUS (IMS-3) Payload Interfaces..contd



- P/I Power Consumption : 400w max.(10 min /orbit operatn)
250w max (cont ON in 6am or 6pm)
- BUS I/f : MIL-STD-1553 B Bus
Actuator line for deployment
Analog TM / Digital & RF bit monit.
Temp. Monit. & Heater Control
- Data Handling I/f : Data down link rate – 16 / 160 Mbps
LVDS Interface

Thank You...

for your kind attention