Jet Propulsion Laboratory
California Institute of Technology

NASA-ISRO SAR (NISAR) Mission Science and Development Status

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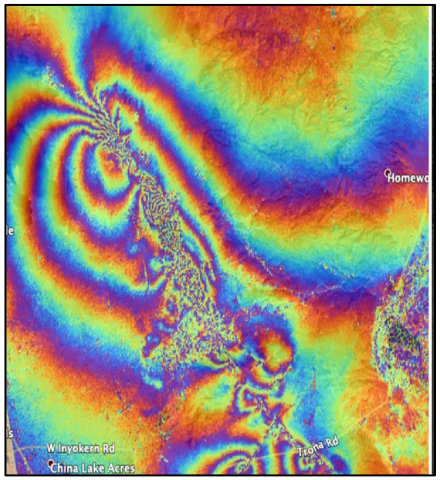
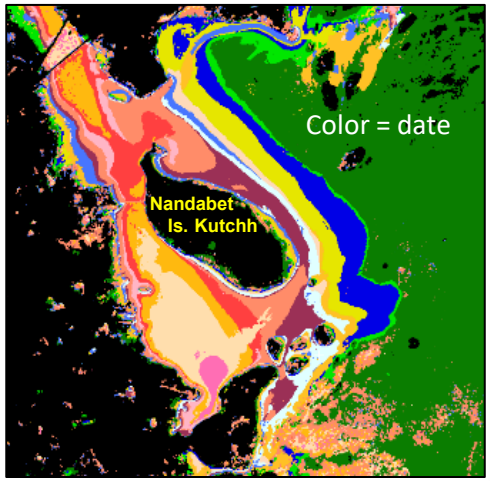
NISAR Project Team

2022 Living Planet Symposium
May 26 2022

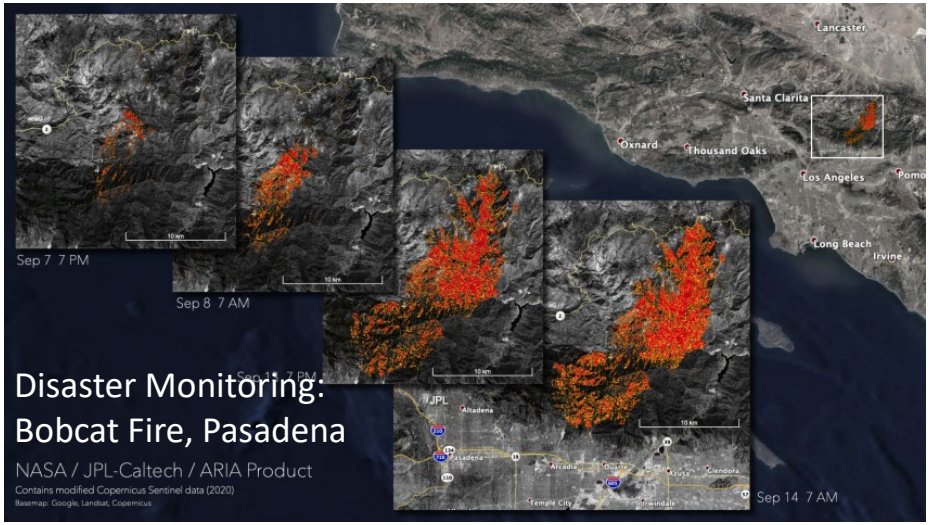
NISAR Science Capturing a Dynamic Earth



Earthquake Dynamics, Ridgecrest



Wetland Inundation, India



Disaster Monitoring: Bobcat Fire, Pasadena

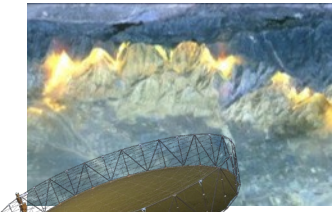
- **Dynamics of Ice: Ice sheets, Glaciers, and Sea Level**
  - *Will there be catastrophic collapse of the major ice sheets, including Greenland and West Antarctic and, if so, how rapidly will this occur?*
  - *What will be the resulting time patterns of sea-level rise?*
  - *How are alpine glaciers changing in relation to climate?*
- **Ecosystems and Biomass Change**
  - *How do changing climate and land use in forests, wetlands, and agricultural regions affect the carbon cycle and species habitats?*
  - *What are the effects of disturbance on ecosystem functions and services?*
- **Solid Earth Deformation: Hazard Response**
  - *Which major fault systems are nearing release of stress via strong earthquakes?*
  - *Can we predict future eruptions of volcanoes?*
  - *What are optimal remote sensing strategies to mitigate disasters and monitor/manage water and hydrocarbon extraction and use*
- **Coastal Processes: India**
  - *What is the state of important mangroves?*
  - *How are Indian coastlines changing?*
  - *What is the shallow bathymetry around India?*
  - *What is the variation of winds in India's coastal waters?*

NISAR Science Observation Overview

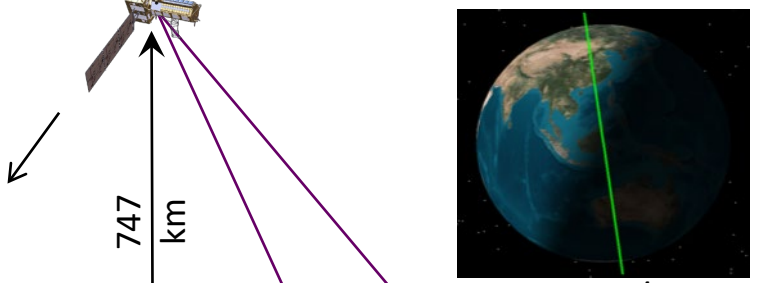
NISAR Characteristic:	Would Enable:
L-band (24 cm wavelength)	Low temporal decorrelation and foliage penetration
S-band (9.4 cm wavelength)	Sensitivity to light vegetation
SweepSAR technique with Imaging Swath > 240 km	Global data collection
Polarimetry (Single/Dual/Quad)	Surface characterization and biomass estimation
12-day exact repeat	Rapid Sampling
3 – 10 meters mode-dependent SAR resolution	Small-scale observations
3 yrs (NASA) / 5 yrs (ISRO) science operations	Time-series analysis
Pointing control < 273 arcseconds	Deformation interferometry
Orbit control < 500 meters	Deformation interferometry
> 10% (S) / 50% (L) observation duty cycle	Complete land/ice coverage
Left-only pointing (Left/Right capability)	Uninterrupted time-series Rely on Sentinel-1 for Arctic

NISAR Will Uniquely Capture the Earth in Motion





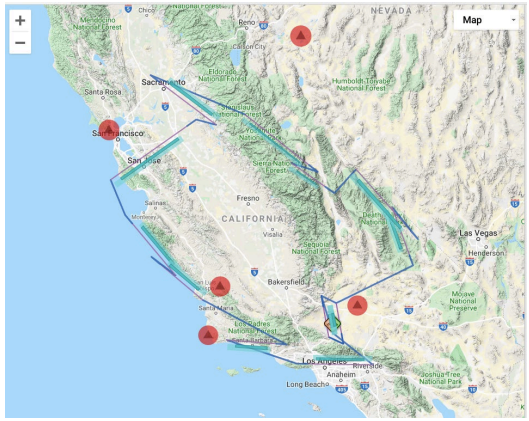

Observation Geometry

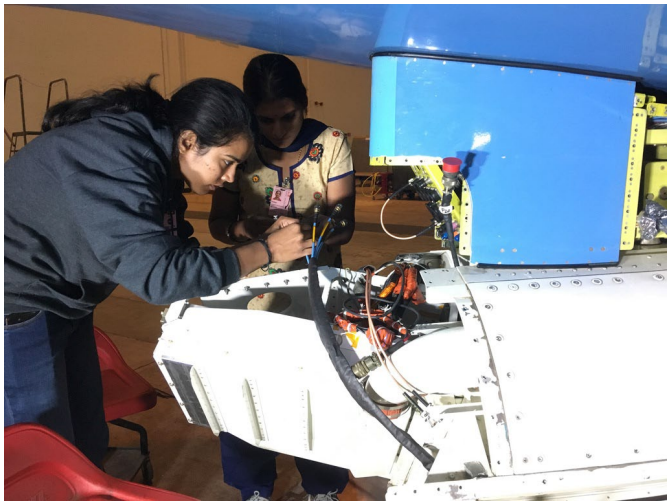


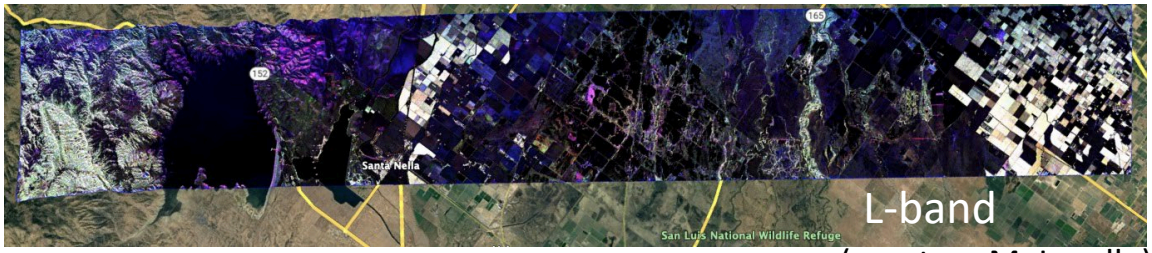
6 AM / 6 PM

ISRO ASAR L+S Band Airborne Testbed on UAVSAR Platform

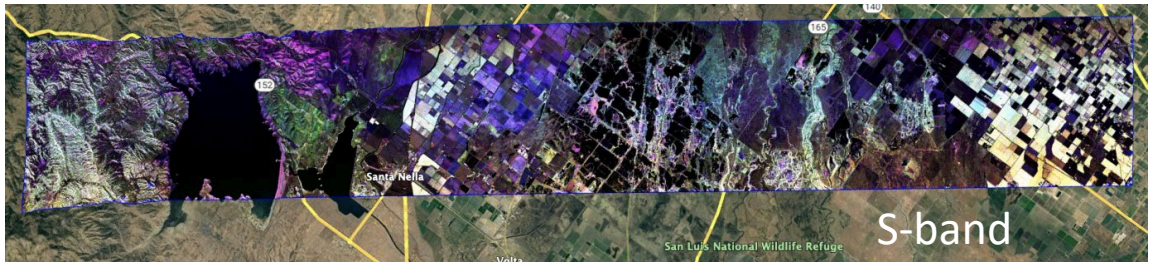
- 150+ L+S band polarimetric data sets from US ASAR Airborne campaigns over a range of NISAR science-related targets: Agriculture, Soil Moisture, Forests, Glaciers, Sea-ice, landslides
- 2019 Western Campaign
- 2021 East Coast Campaign
- Data Sets available at ASF DAAC







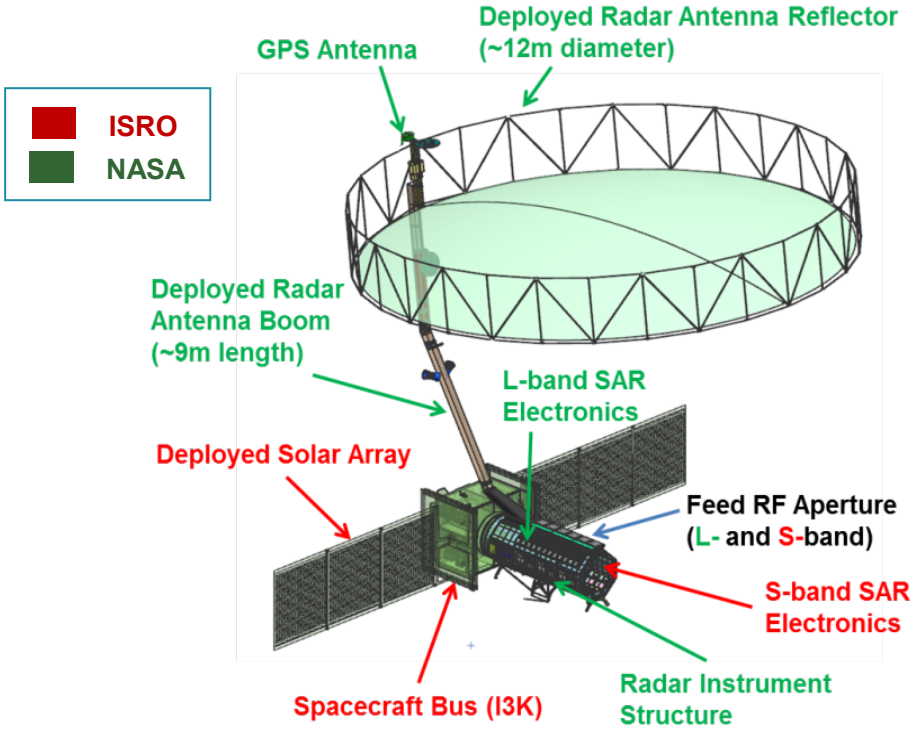
(courtesy M. Lavalle)



ASAR geocoded products generated through NISAR L2 processor

NASA-ISRO SAR Mission

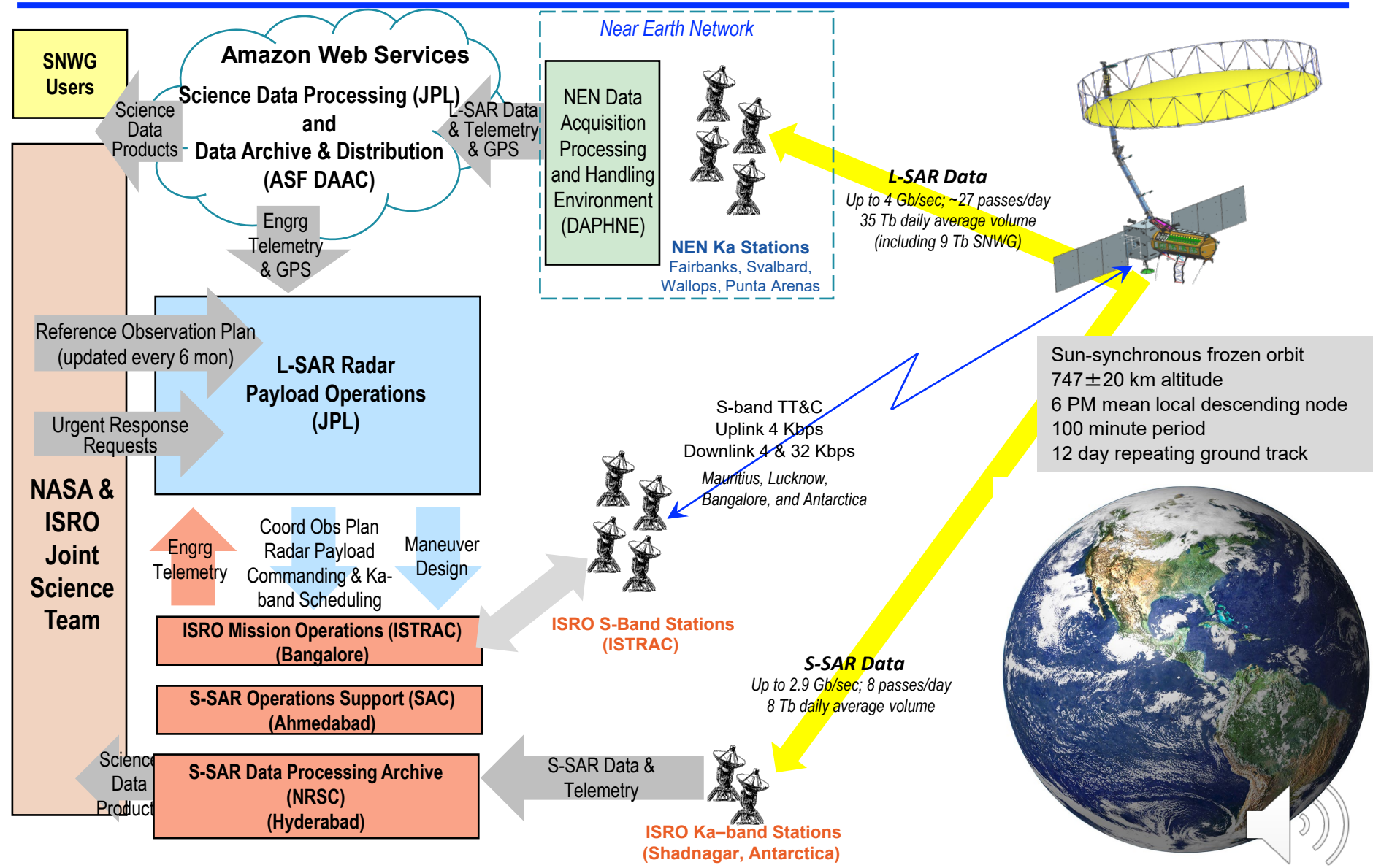
Close integration with international partner



	Mass (kg)	Power (W)
Spacecraft Mainframe	920	1312
Engineering Payload	134	640
L-SAR	283	1515
S-SAR	314	2757
Common Instrument Structure	466	
Reflector and Boom	292	
Propellant	269	
Total	**2678**	**6224**

NASA Provides	ISRO Provides
• L-band SAR • Shared P/L structure & 12m reflector and boom	• S-band SAR • S-SAR baseband data handling (BDH)
• Engineering payload - GPS, Power & Pyro - Payload Data System with 12 Tb recorder - NEN-compatible high rate Ka-band system	• Spacecraft Bus (I3K) • ISRO-compatible high rate Ka-band system • Observatory I&T • GSLV Launch Vehicle
Integrated radar observation planning and operations	Spacecraft operations (command uplink, telemetry and tracking)
L-SAR data downlink to NEN Ka-band stations	S-SAR, select L-SAR data downlink to ISRO stations
L-band science data processing and distribution	S-band science data processing and distribution
NASA Science Team	ISRO Science Team

NISAR Operations Overview



NISAR Development Status

L-SAR I&T (JPL)
April 2019-Jan 2021

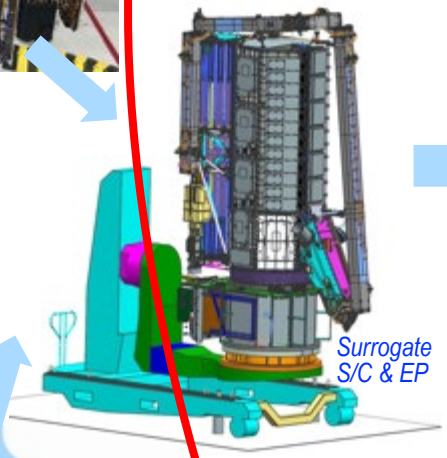
Engineering Payload Buildup (JPL)
June 2020 – June 2021

Surrogate S/C with Engineering Payload Elements Integrated

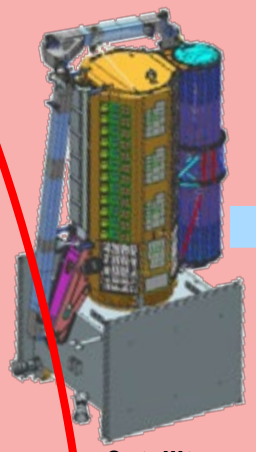
SIT-2 & 3 (JPL)
Radar Payload I&T
Feb '21- Feb '23

We are Here

Radar Payload (with BDH, GPS & SSR



SIT-4 (URSC)
Observatory I&T
Mar '23-Jan '24



Launch Operations
(SHAR) & Launch
Jan 2024

Geosynchronous Launch Vehicle (GSLV) Mark II

Satish Dhawan Space Centre

Sriharikota

RIS "Clamshell" Delivered to SAC for S-SAR Integration (June 2019)

DTM I&T (JPL)
Dec '20

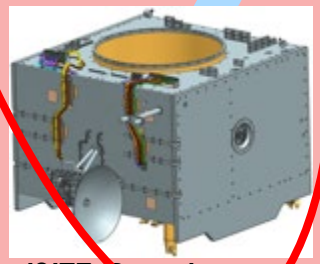
March '21

August '21

S-SAR I&T (SAC)

Baseband Data Handler (BDH) (URSC)

Satellite Mainframe I&T
Mar '21-Feb '22

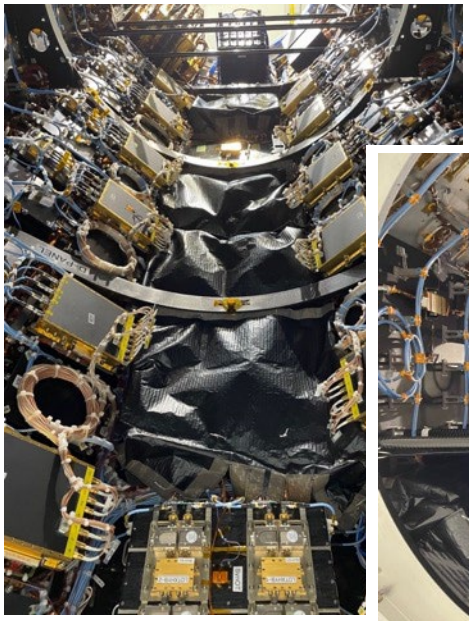


ISITE, Bangalore

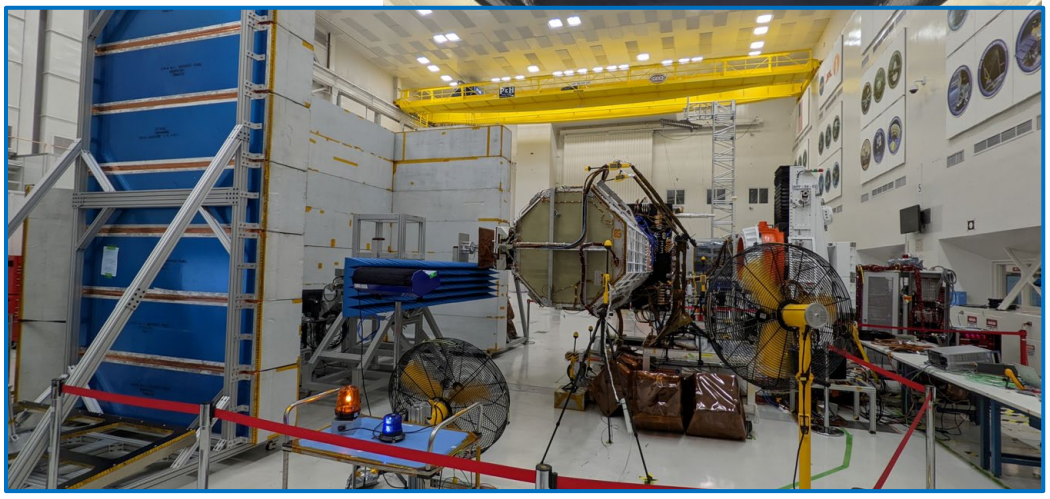
Satellite Integration & Test Establishment (ISITE) Bangalore

NISAR Fun with RF Fields

JPL tech working on EMI Mitigations



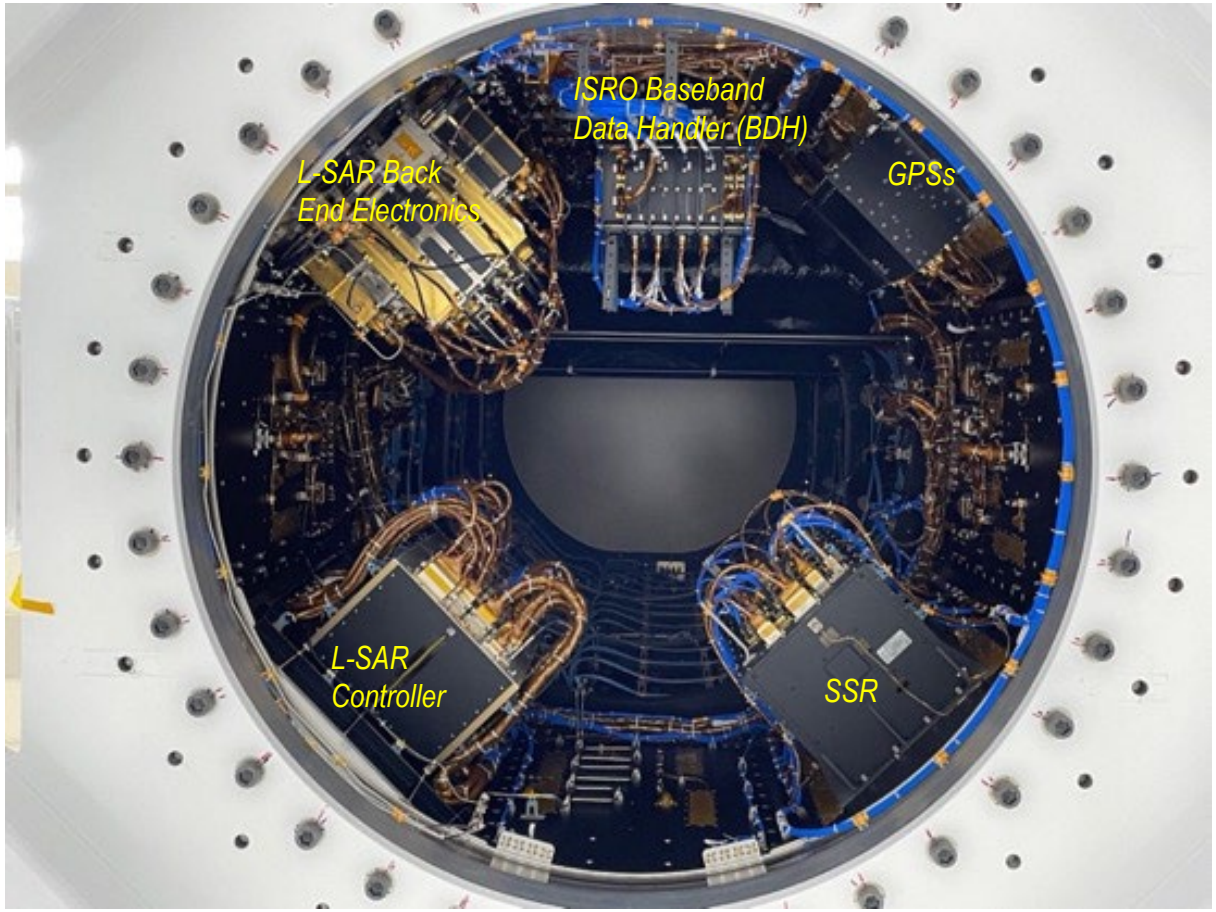
Flight EMI blankets installed in Jan-Feb



Radar Payload Self Compatibility EMI Testing (March)

Radar Instrument Structure Integration Completed and Closed Out

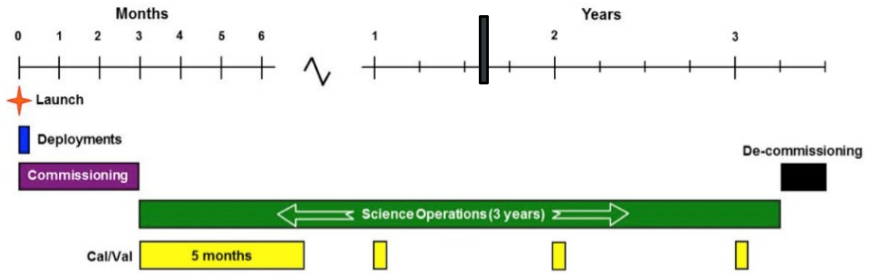
Radar Instrument Structure Mechanically Installed onto Spacecraft Simulator/Engineering Payload (Feb)



Interior View of Closed out Radar Instrument Structure before mating with S/C Simulator (Feb 8)

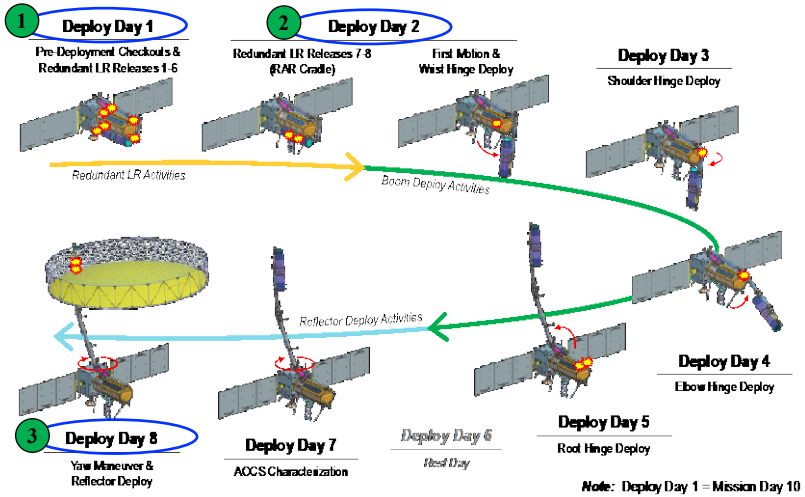
Mission Scenario Tests Successful

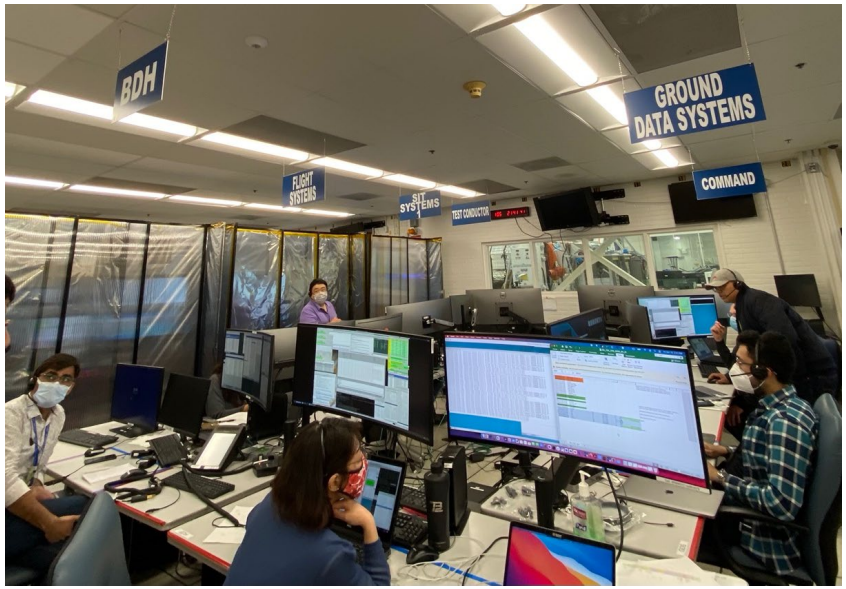
"Day In The Life"



1. Conducted a slice of a typical "Day in the Life" of science operations during the SIT-03 MST-1 Day-in-the-Life run – including 10-hr ROSTs with background sequences, concurrent science (L-SAR only) data record and dual-channel Ka-band playback scenarios on April 12th and a single joint datatake using packaged commanding for S-SAR/BDH as a pathfinder for MST-2 executed on April 15th.

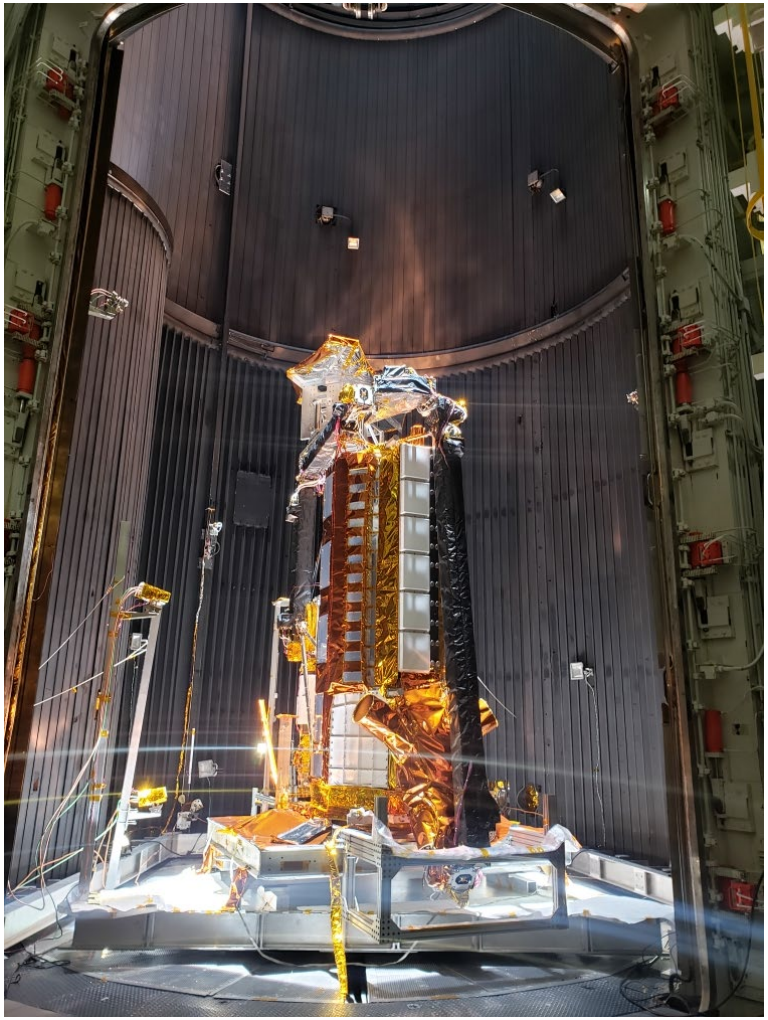
Nominal Deployment



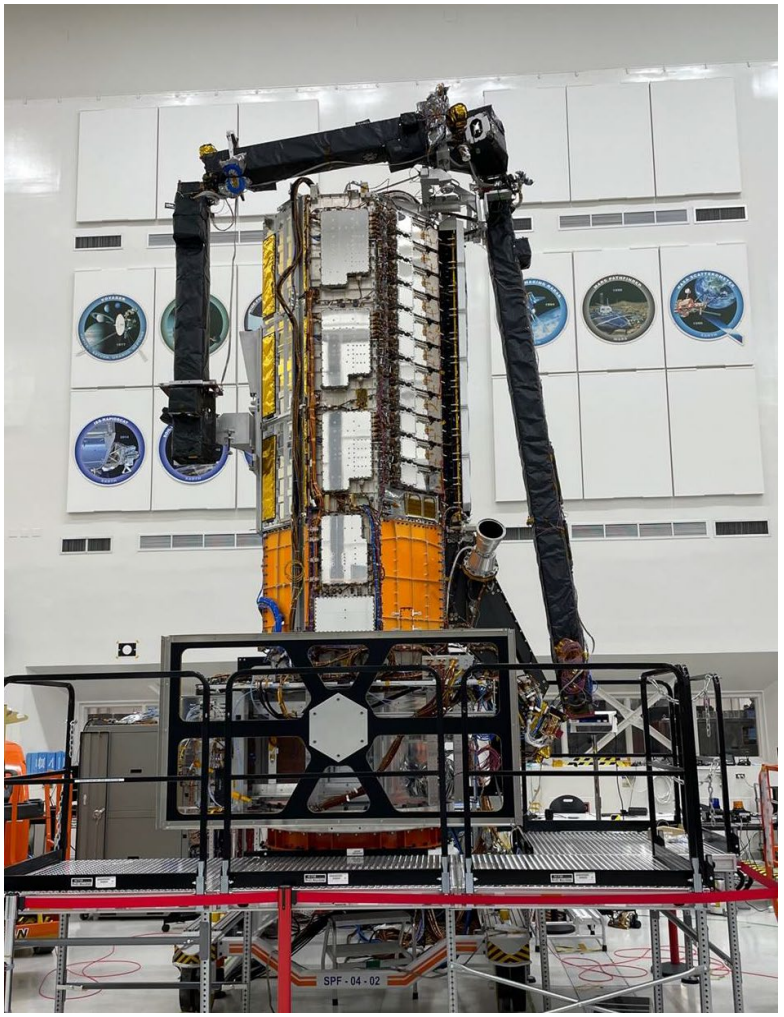


Commissioning

Boom/Reflector Integration

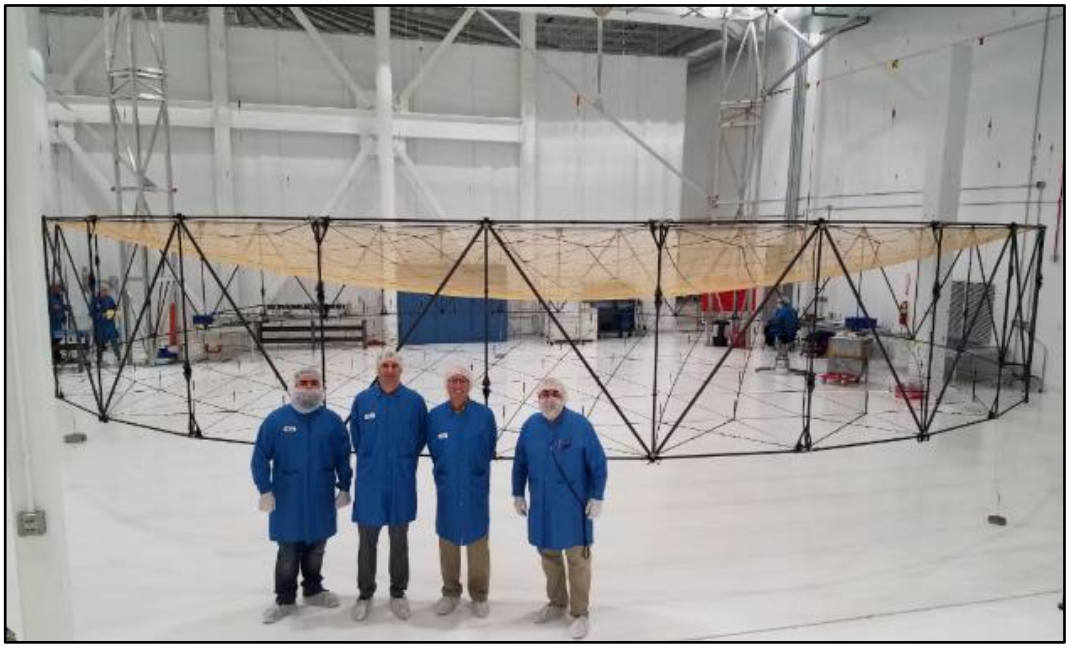


Flight Boom & Reflector were previously integrated & environmentally tested on flight spare structure in 2020

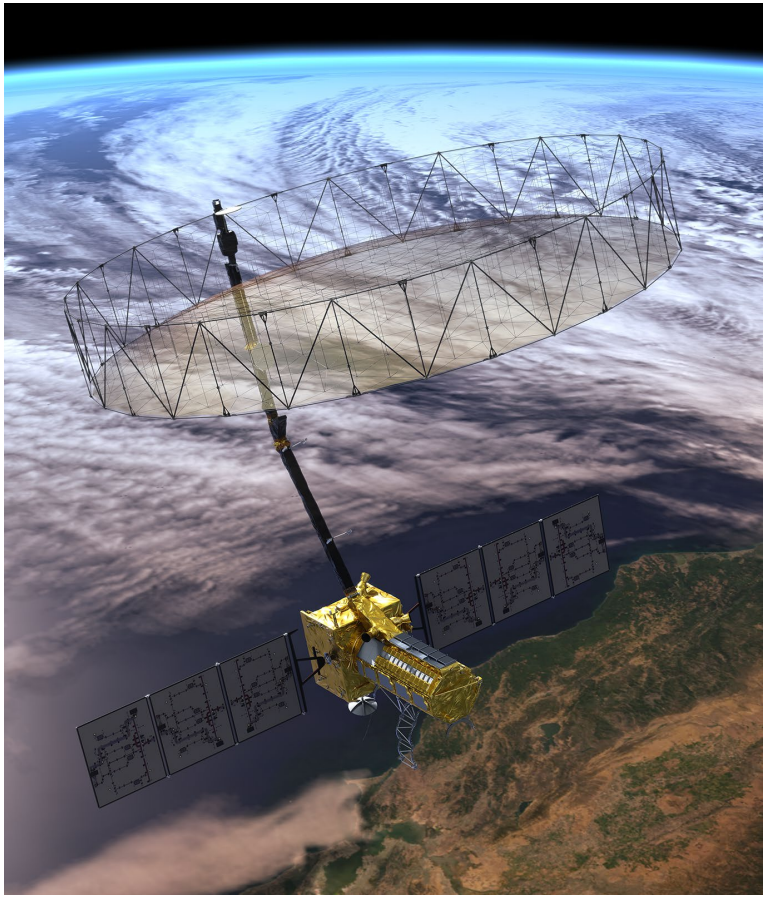


Flight Boom currently being integrated with flight model radar structure; Flight Reflector integration late May 2022

Boom/Reflector Integration



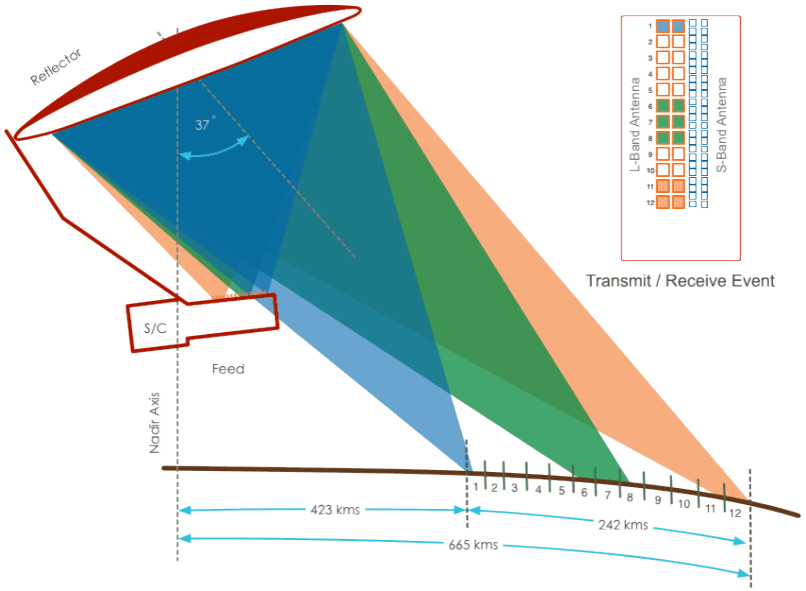
Reflector was completed in 2019

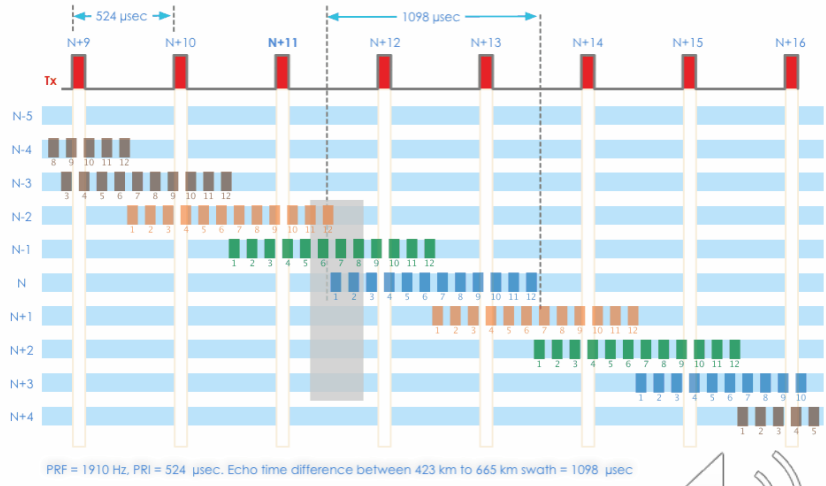


Flight Configuration of NISAR

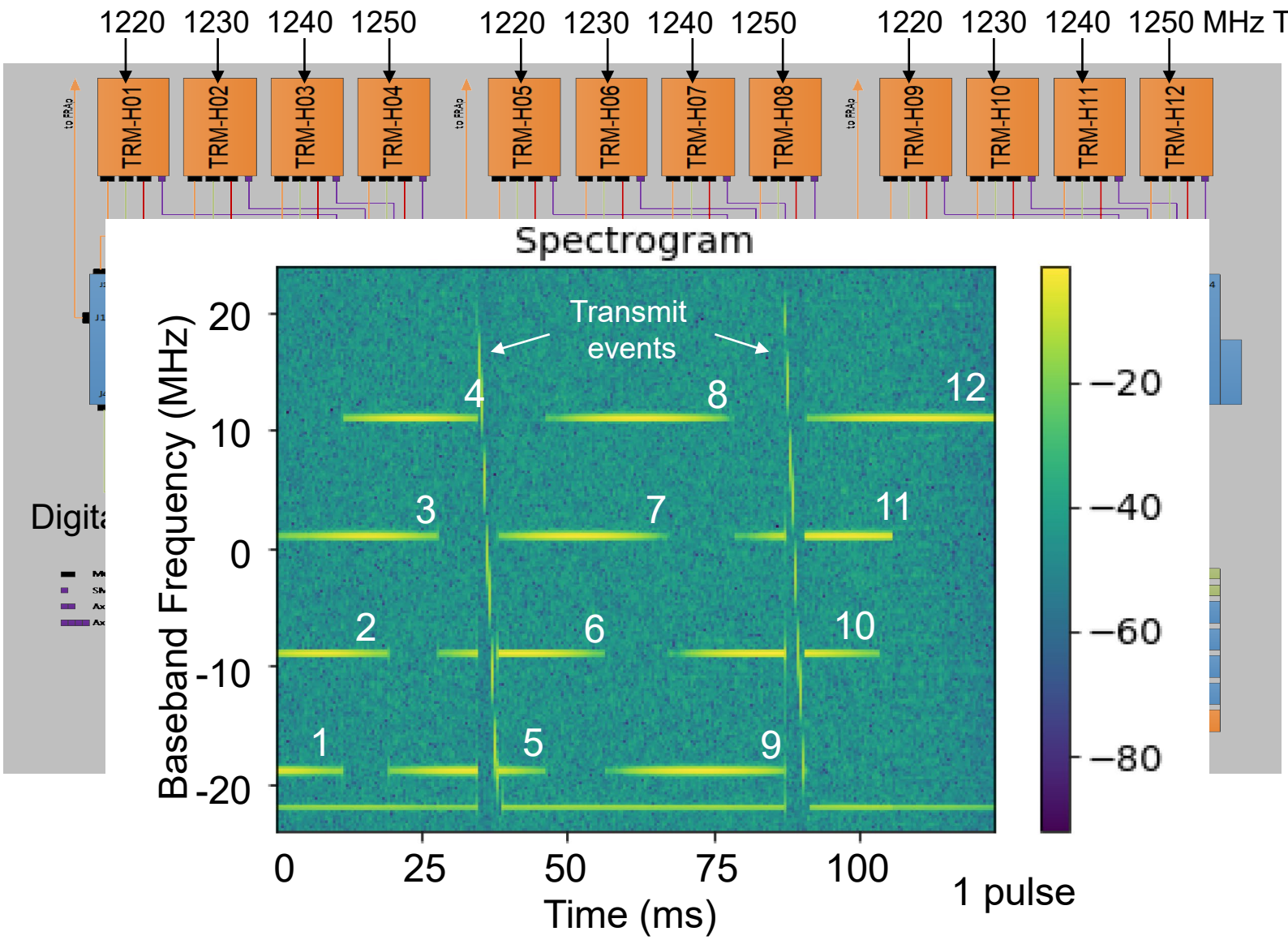
SweepSAR Measurement Technique

- **SweepSAR Basics**
  - On Transmit, illuminate the entire swath of interest (red beam)
  - On Receive, steer the beam in fast time to follow the angle of the echo coming back to maximize the SNR of the signal and reject range ambiguities
  - Allows echo to span more than 1 Inter Pulse Period (IPP)
- **Consequences**
  - 4 echoes can be simultaneously returning to the radar from 4 different angles in 4 different groups of antenna beams
  - Each echo needs to be sampled, filtered, Beam-formed, further filtered, and compressed
  - On-Board processing is not reversible – Requires on-board calibration before data is combined to achieve optimum performance

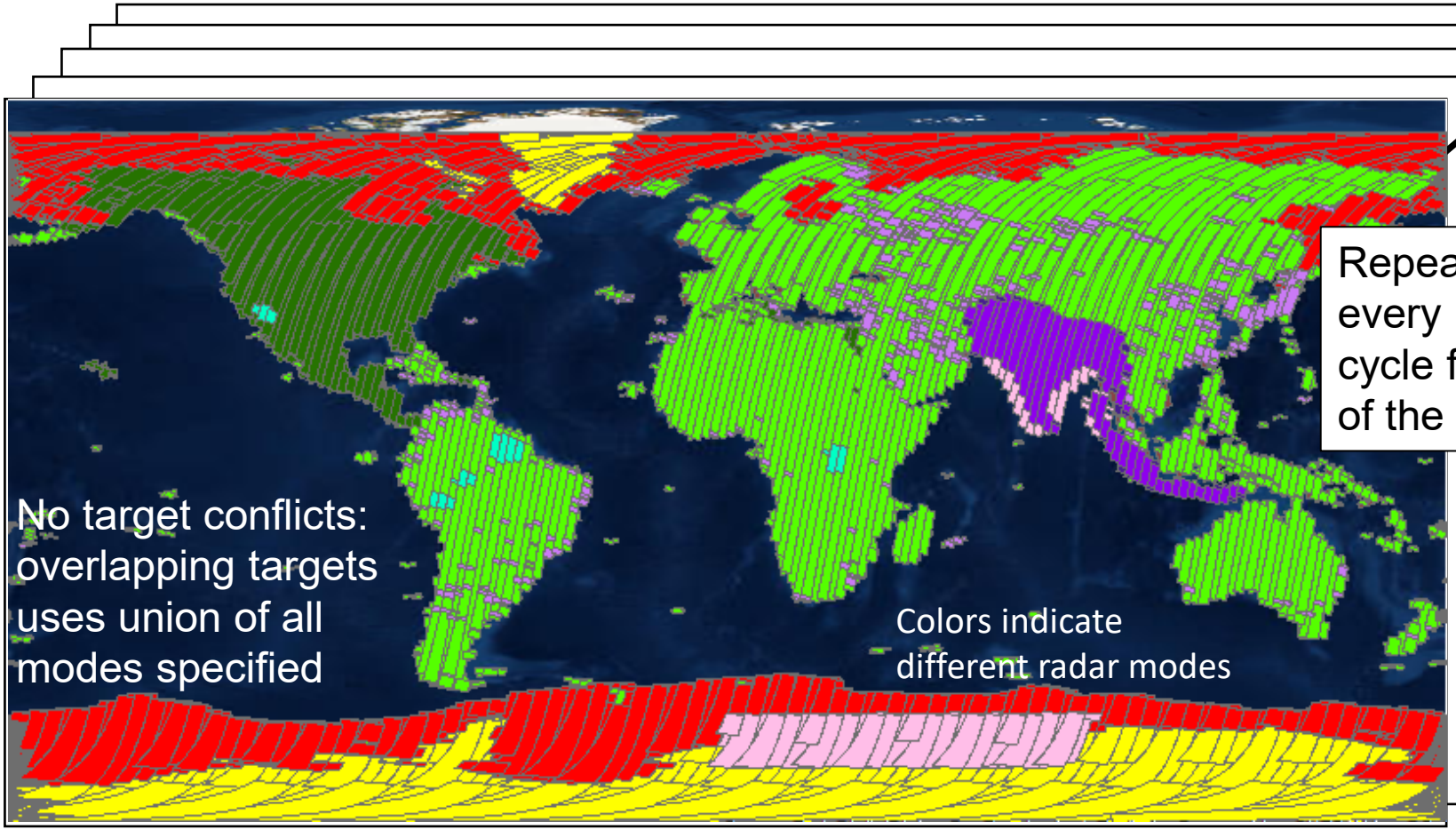




L-SAR Architecture
(Only Horizontal Polarization Shown)



NISAR Systematic Observations

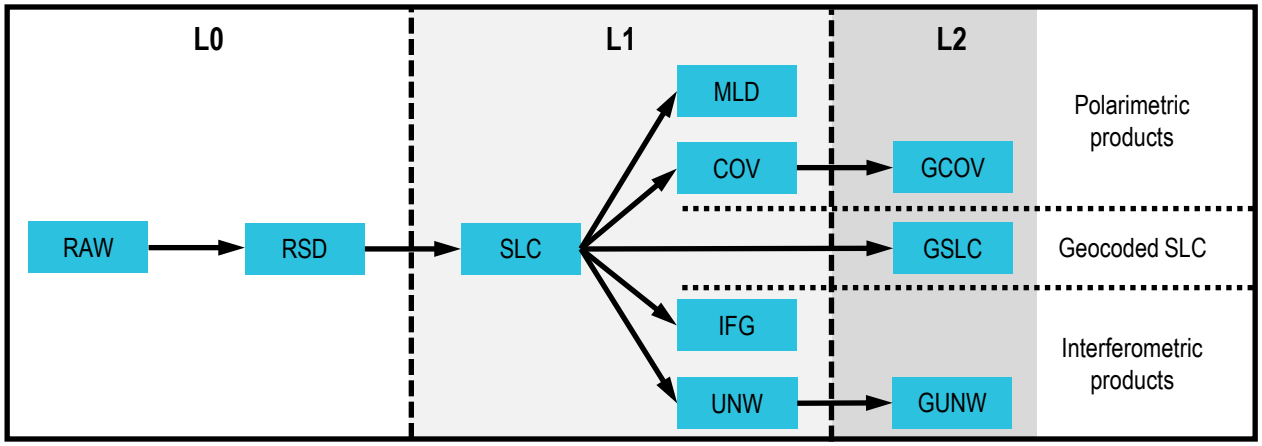


J. Doubleday
P. Sharma, JPL

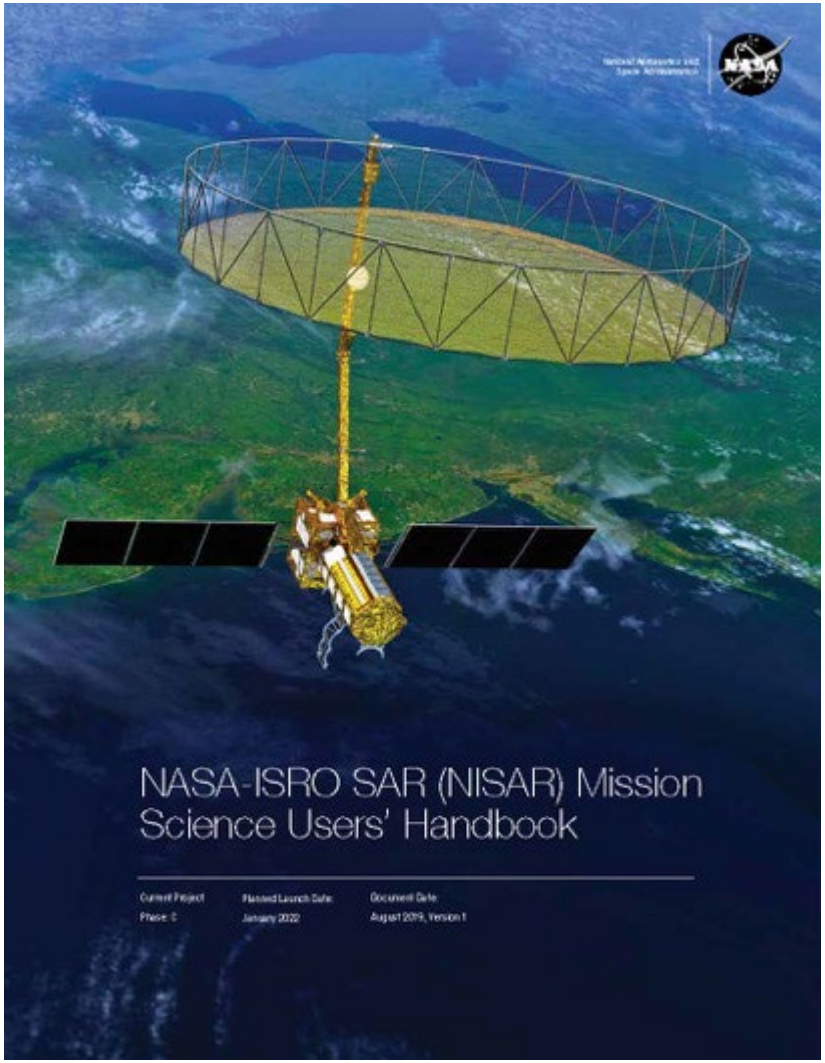
Persistent updated measurements of Earth 1.6 PB raw data per year
Level-2 global products

Science Data System Summary

- Ingest 35 Tbits (4.4 TB) of raw data per day on average
- Automatically generate L-SAR L0a, L0b, L1, and L2 science products (> 70TB/day)
  - Generate S-SAR L0 science product for data downlinked through NASA Ka-band
- Perform bulk reprocessing twice during mission
  - 8 months of data after L2 product validation at 4x rate
  - 12 months of data at end of mission at 3x rate
  - Anticipate assessing additional processing / reprocessing options before launch
- Sample products derived from UAVSAR data, processed like NISAR, are available
  - https://uavsar.jpl.nasa.gov/science/documents/nisar-sample-products.html
- Open source (github) ISCE3 software already available, support these workflows and products



Summary



- NISAR Instrument and Engineering Payload Integration and Test rapidly proceeding
- Integration with spacecraft planned to begin early 2023
- Global products to Level 2 fully and openly available to the global community
- Cloud-based data, tools and services to facilitate access and use
- Anticipated launch of NISAR in 2023/2024

For more information: ***https://nisar.jpl.nasa.gov***

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