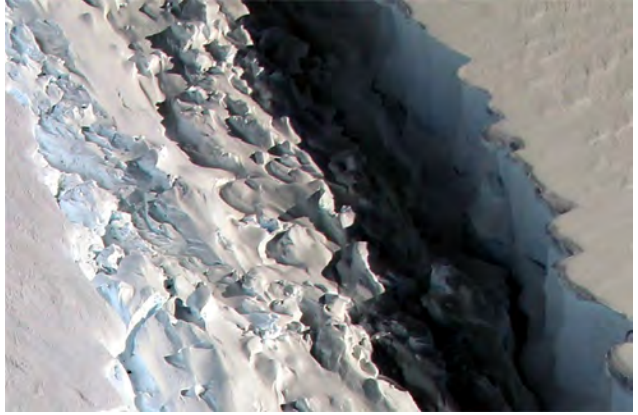





NASA's SAR/Geodetic Imaging Program

Dr. Gerald Bawden

Program Scientist

Geodetic Imaging

NISAR/SDC/UAVSAR/OPERA/ASF

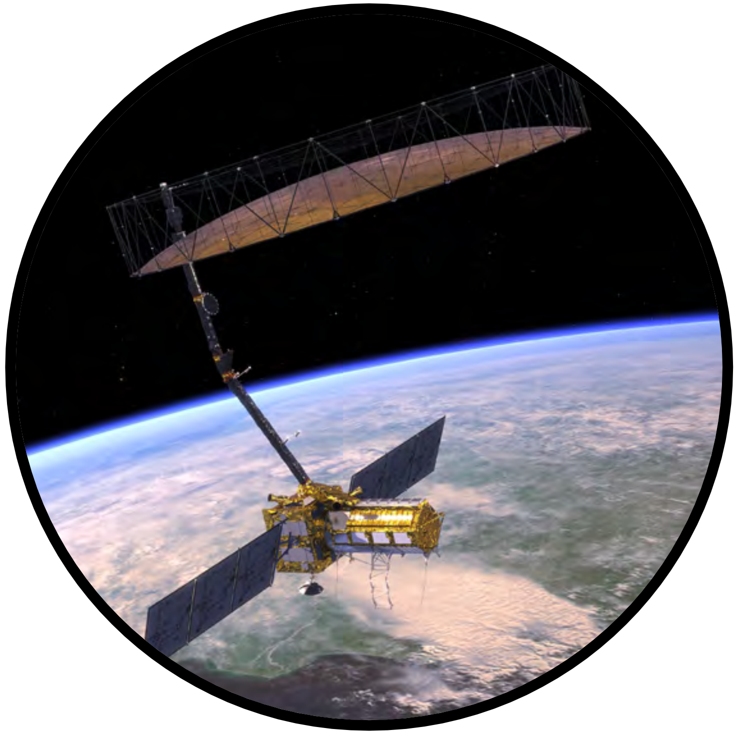
NASA Headquarters

Second Workshop on International Coordination for Spaceborne Synthetic Aperture Radar

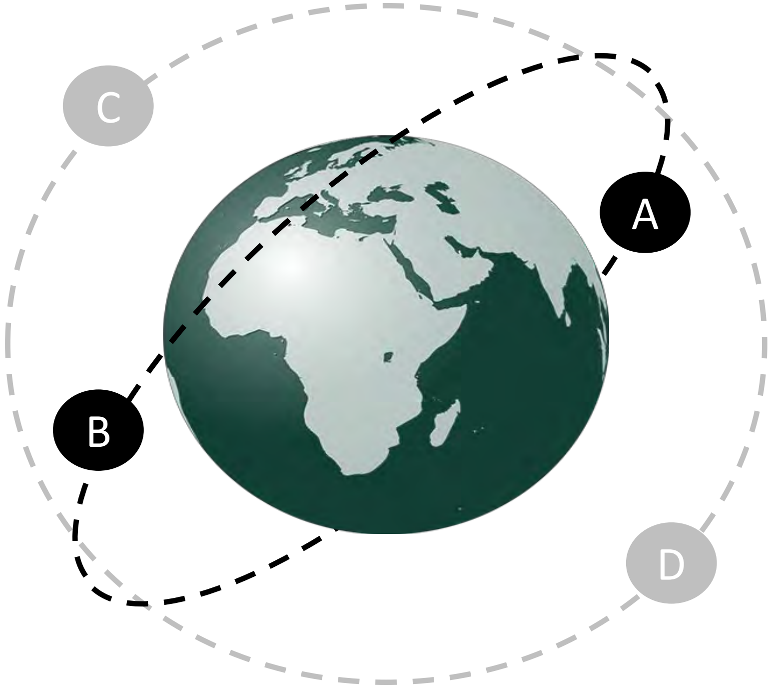
28-30 September 2022

ESRIN: Frascati, Italy

NASA’s Earth Observing SAR-InSAR-Geodetic Imaging Program Overview



NISAR



SDC

Surface Deformation And Change

UAVSAR- NextGen

OPERA

Multi-Mission Products

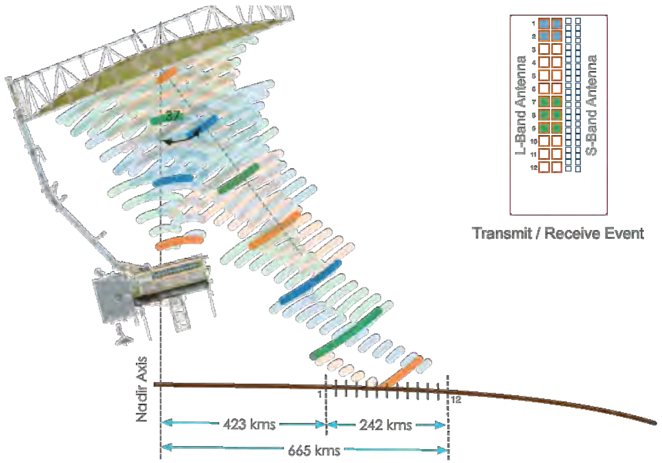
NISAR Status and Upcoming Activities

- All payload electrical & mechanical integration is complete; dynamic testing is underway
- Mission Scenario Tests in April demonstrated end-to-end system functional performance
- 3 of 4 NISAR Ka-band ground stations are operational, 4th will be operational by end of year
- Next Steps:
  - Aug 2022 – Jan 2023: Thermal/Vacuum Testing
  - Jan 2023 – Feb 2023: Pack and ship from JPL to India
  - Mar 2023 – Dec 2023: Integrate with spacecraft
- **January 29, 2024: Launch Window Opens**
  - **16 months + 1 day**

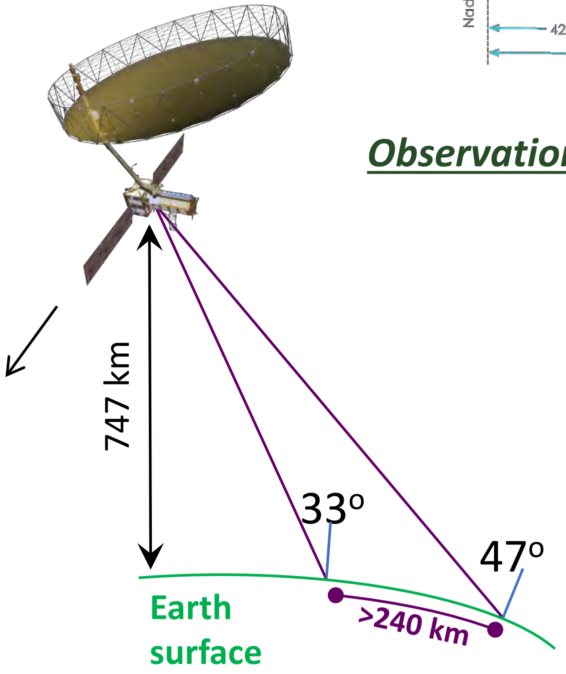
NISAR Observation Summary

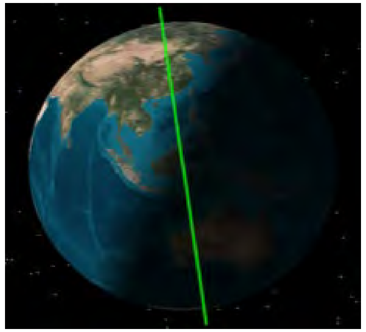
NISAR Characteristic:	Would Enable:
L-band (24 cm wavelength)	Low temporal decorrelation and foliage penetration
S-band (9.4 cm wavelength)	Sensitivity to light vegetation
SweepSAR technique with Imaging Swath > 240 km	Global data collection
Polarimetry (Single/Dual/Quad)	Surface characterization and 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

SweepSAR



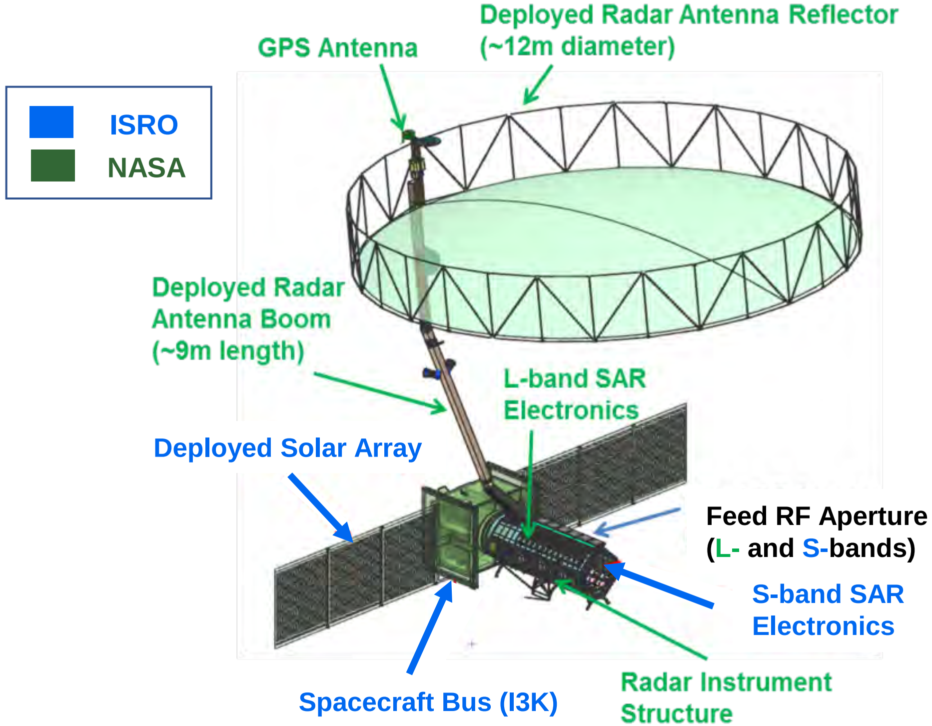
Observation Geometry





6 AM / 6 PM

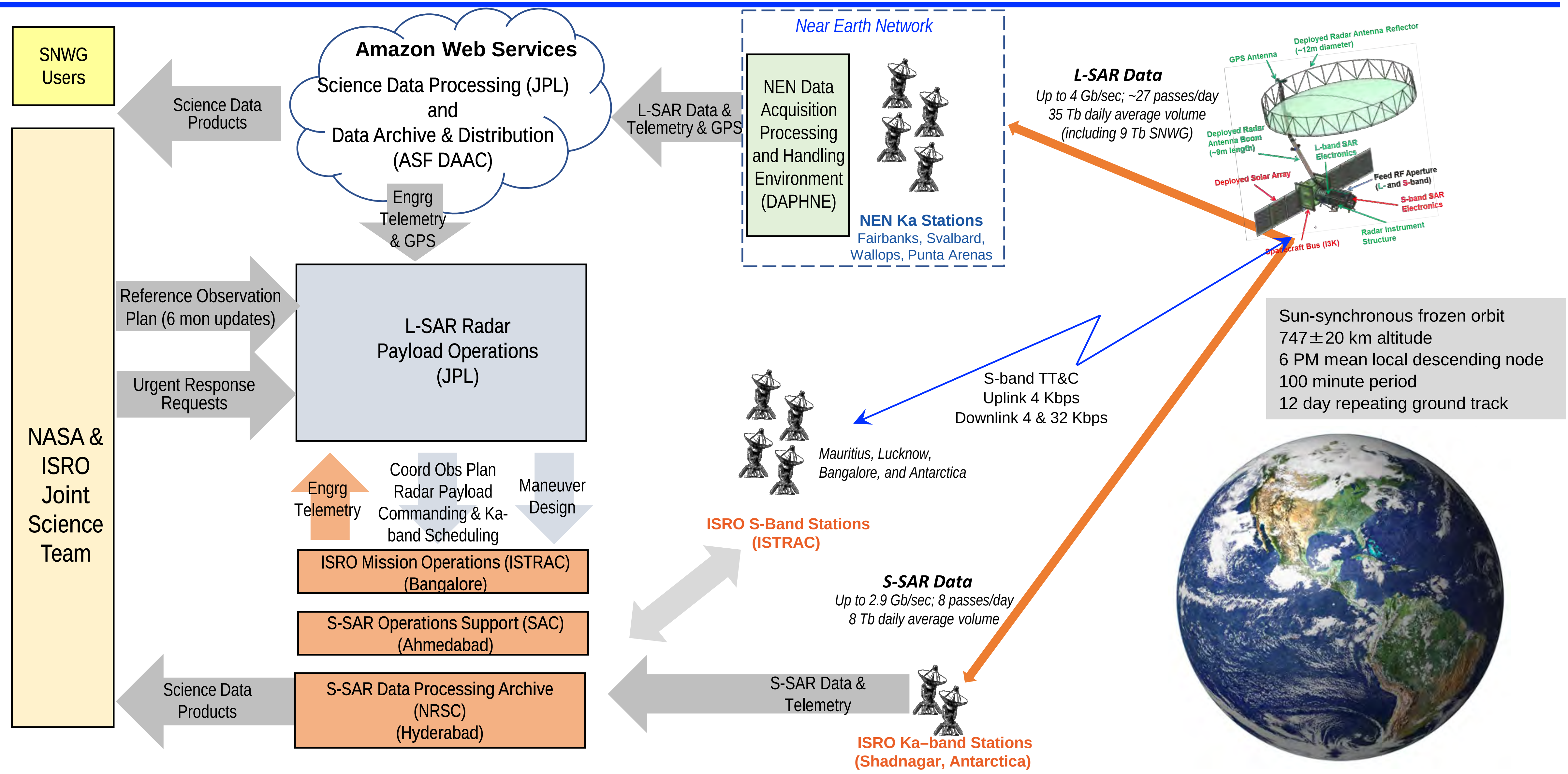
NISAR Mission Hardware
Close integration between ISRO and NASA



	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 Mission Operations
Close integration between ISRO and NASA

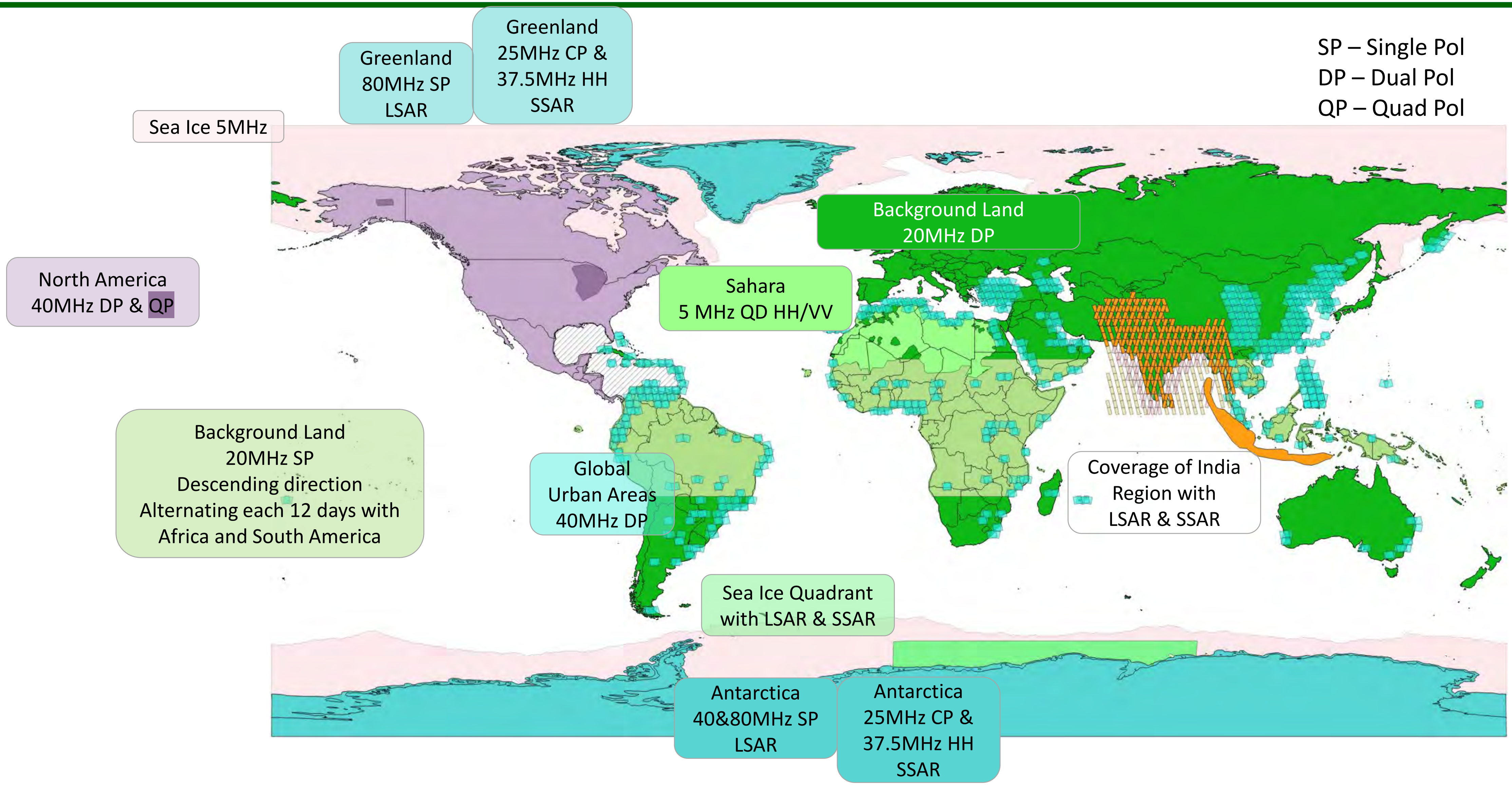


Dec2017 pre-CDR Baseline

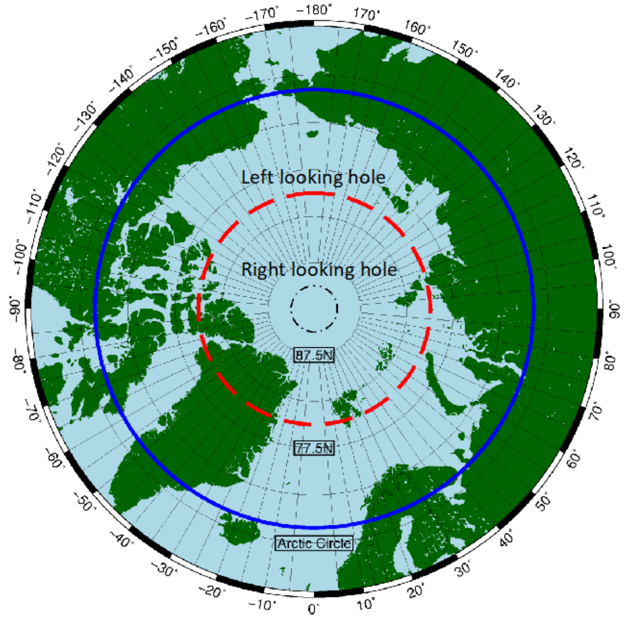
Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Current Observation Plan Revised every 6 months

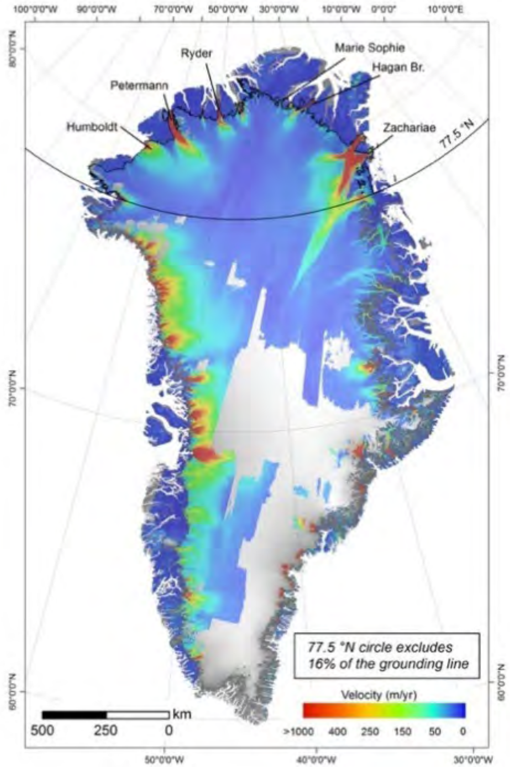
SP – Single Pol
DP – Dual Pol
QP – Quad Pol



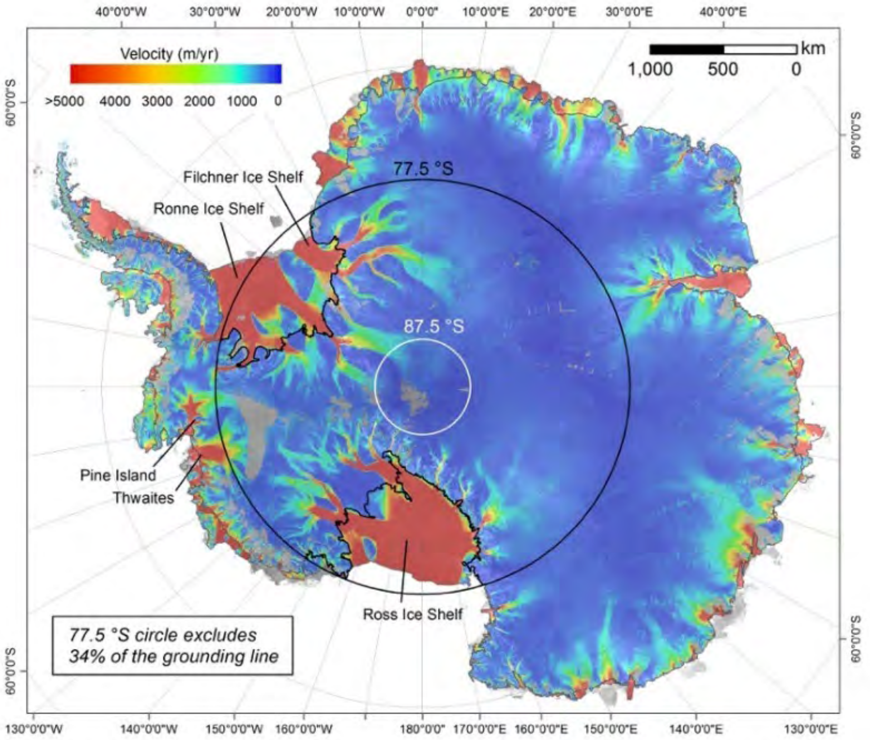
- For right-looking mission, NISAR covers up to 87.5 N and 77.5 S
- **For left-looking mission, NISAR covers up to 77.5 N and 87.5 S**



Arctic Sea Ice coverage much reduced for left-looking mission



North Greenland coverage is reduced for left-looking mission



Antarctica coverage is greatly increased for left-looking mission

ESA Sentinel-1 C-band radar will mitigate Arctic coverage loss

NISAR Level 0, 1, & 2 Product Overview

Level 0 | Level 1 | Level 2

Level 0, Level 1, Level 2, Level 3-4 Validation, Browse Products, and Catalog delivered to DAAC

Ancillary Data (Meteo, DEM, etc.)

Radar Reformatted Raw Data

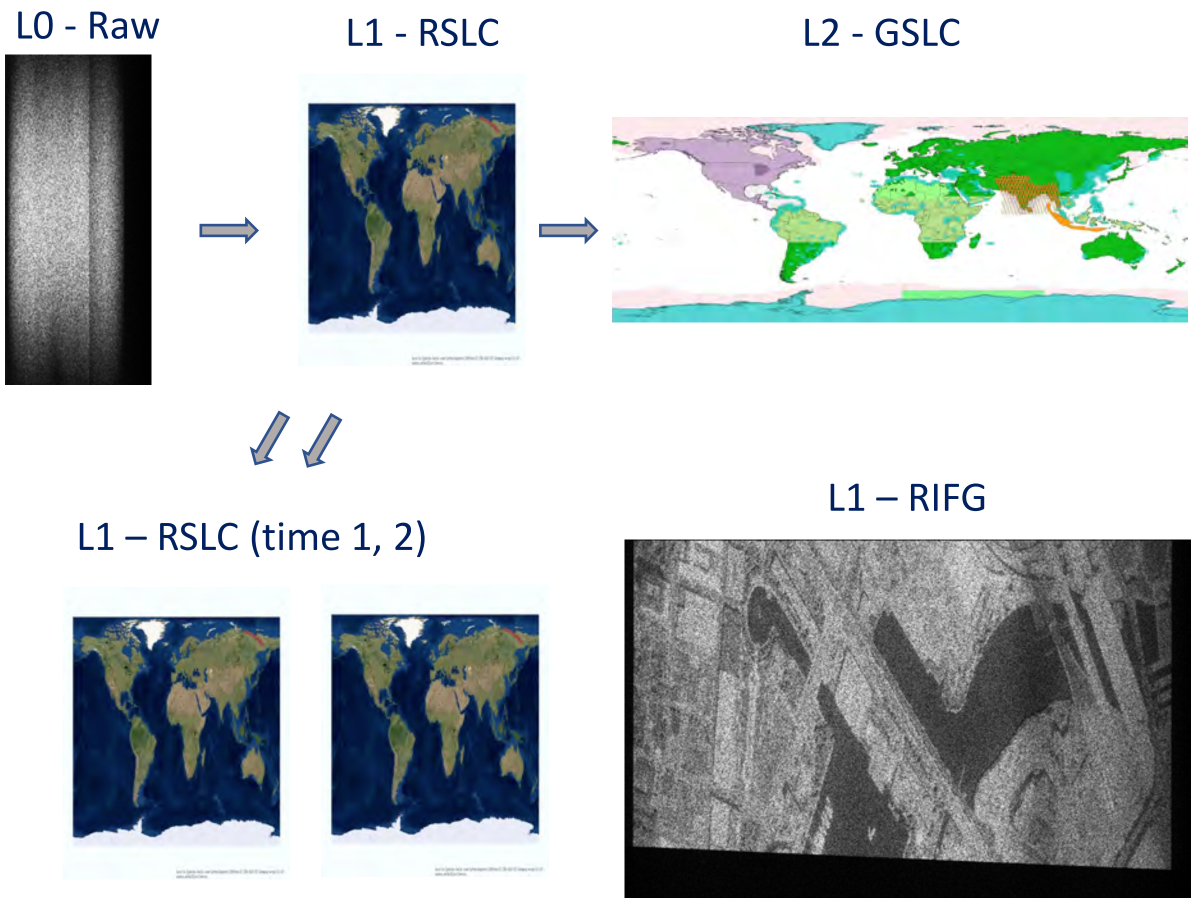
Time Varying Parameter Files

→ Calibrated Single Look Complex Images in Radar Coordinates

(multiple modes)

→ SLC & Multi-looked & Geocoded polarimetric images

→ Multi-looked & Geocoded Interferograms and Images



NISAR's DAAC:
[Alaska Satellite Facility]

NISAR L2 SAR Products

Level 0	Level 1	Level 2

Level 0, Level 1, Level 2, Level 3-4 Validation, Browse Products, and Catalog delivered to DAAC

Ancillary Data
(Meteo, DEM, etc.)

Radar Reformatted Raw Data

Time Varying Parameter Files

→ Calibrated Single Look Complex Images in Radar Coordinates

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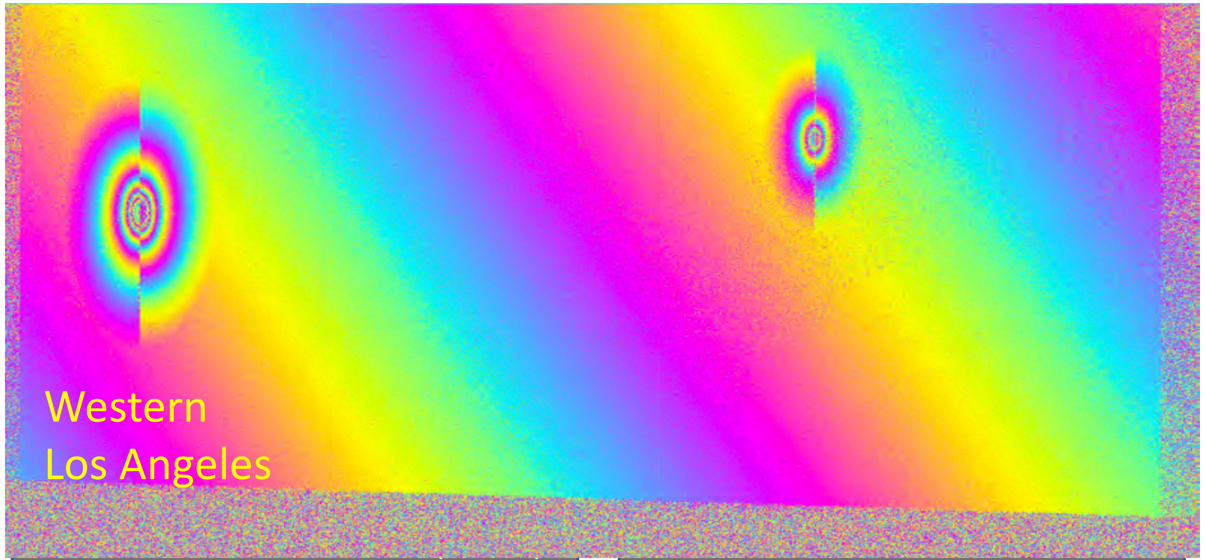
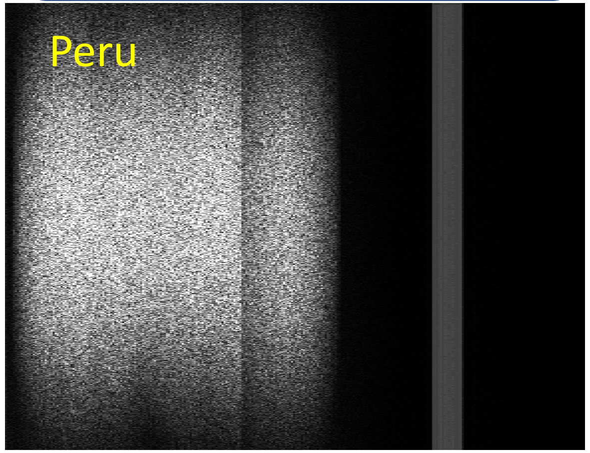
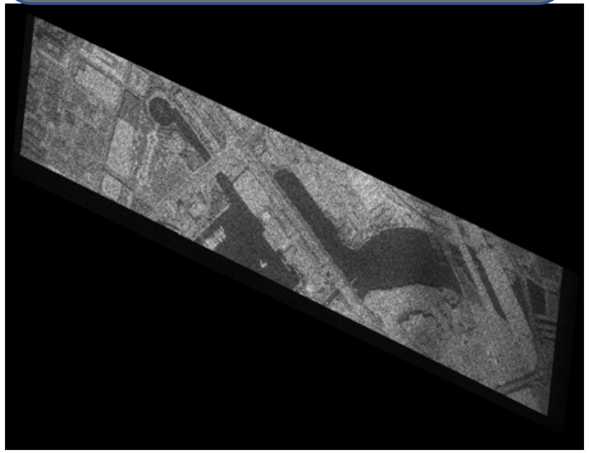
→ SLC & Multi-looked & Geocoded polarimetric images →



Simulated NISAR from Sentinel-1 data

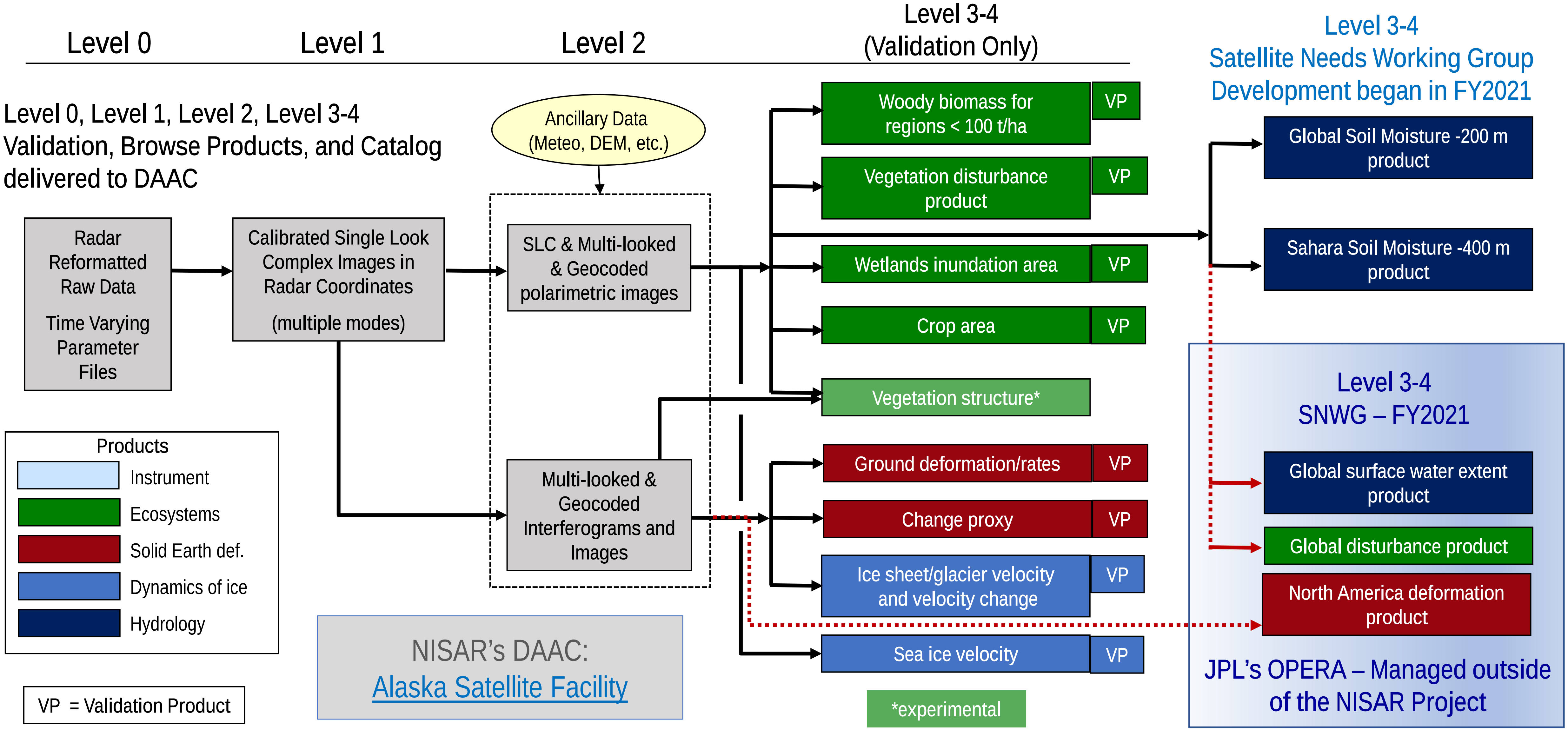
terrain correction (RTC: GSLC) collected Sentinel-1 data





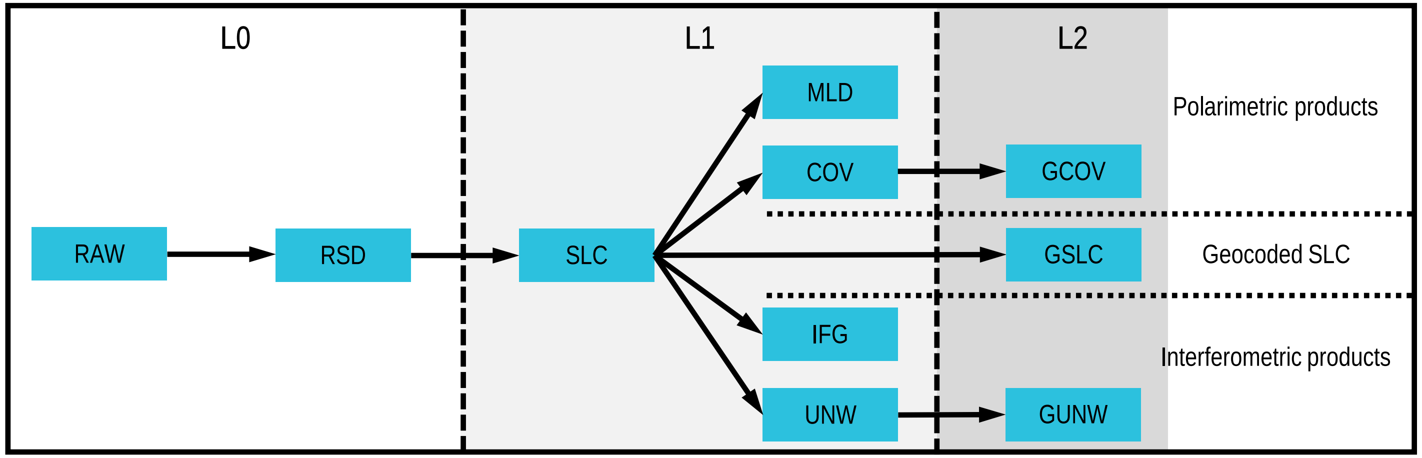
NISAR’s DAAC:
Alaska Satellite Facility

NISAR Science Data Analysis and Archive Approach

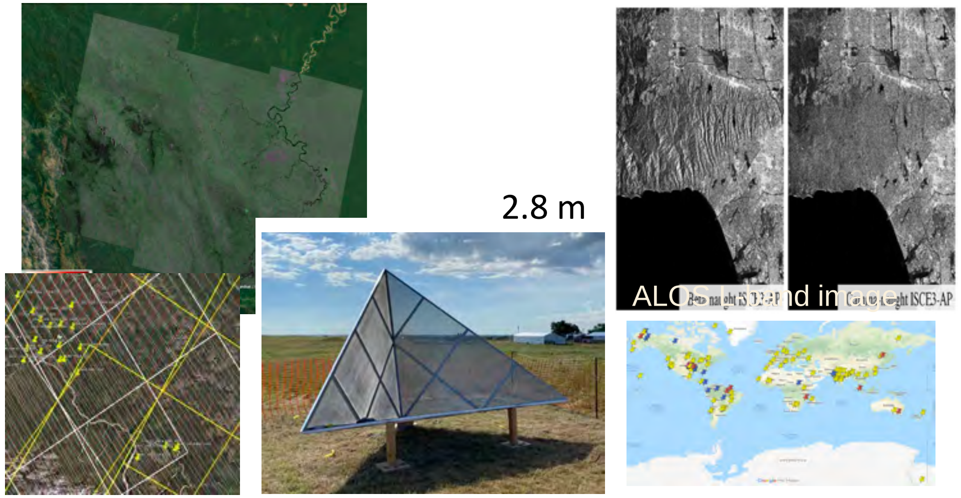


Science Data System Summary

- 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



NISAR Cal/Val Overview



Instrument

- Image calibration schedule during service 'commissioning' phase and the first 5 months of operation
- Corner Reflector Sites in Oklahoma, Alaska, & India
- UAVSAR phase calibration

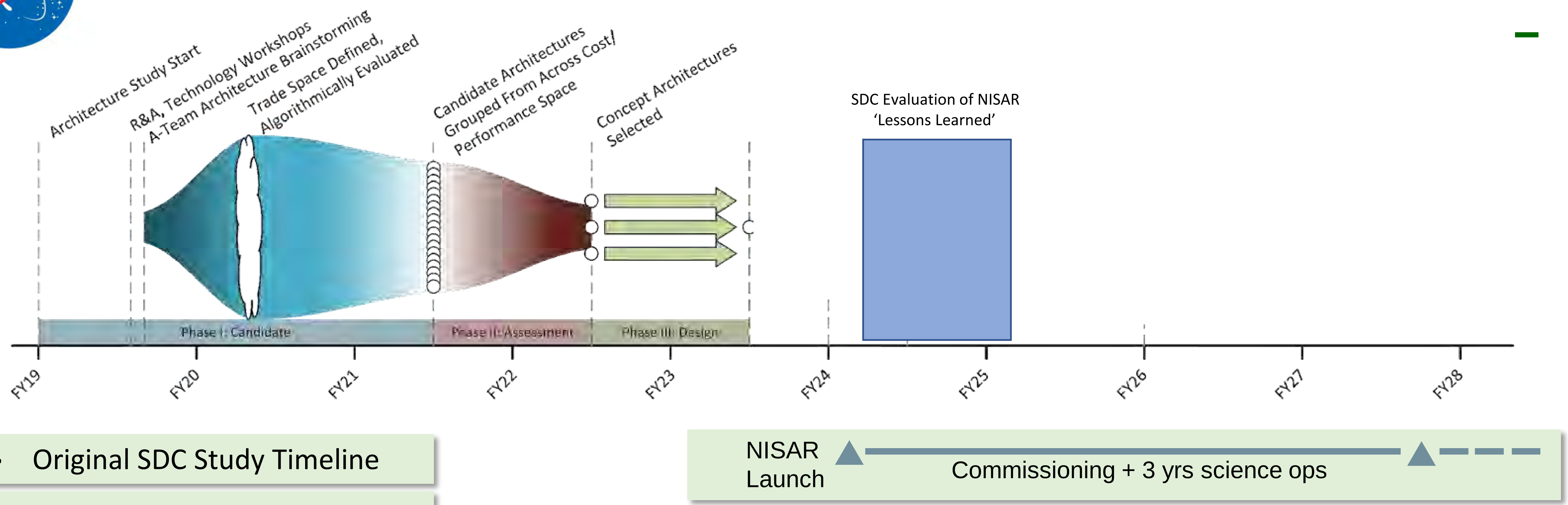
Science Cal/Val

- Each Science Disciplin developed a Cal/Val plan for their Level 3,4 validation activities.
- Ecosystems: there are >100 Cal/Val sites globally and include collaborations with ISRO, NASA ABoVE, NSF NEON, University of Oklahoma, Alaska Satellite Facility, UNAVCO, NSF GAGE, University of Nevada Reno, JECAM, ESA Biomass, US Dept of Ag.
- *Validation scientific requirements workflow will be availabe in Jupyter notebooks*

Launch Window Opens
January 29, 2024

Satellite Dhawan Space Center, India

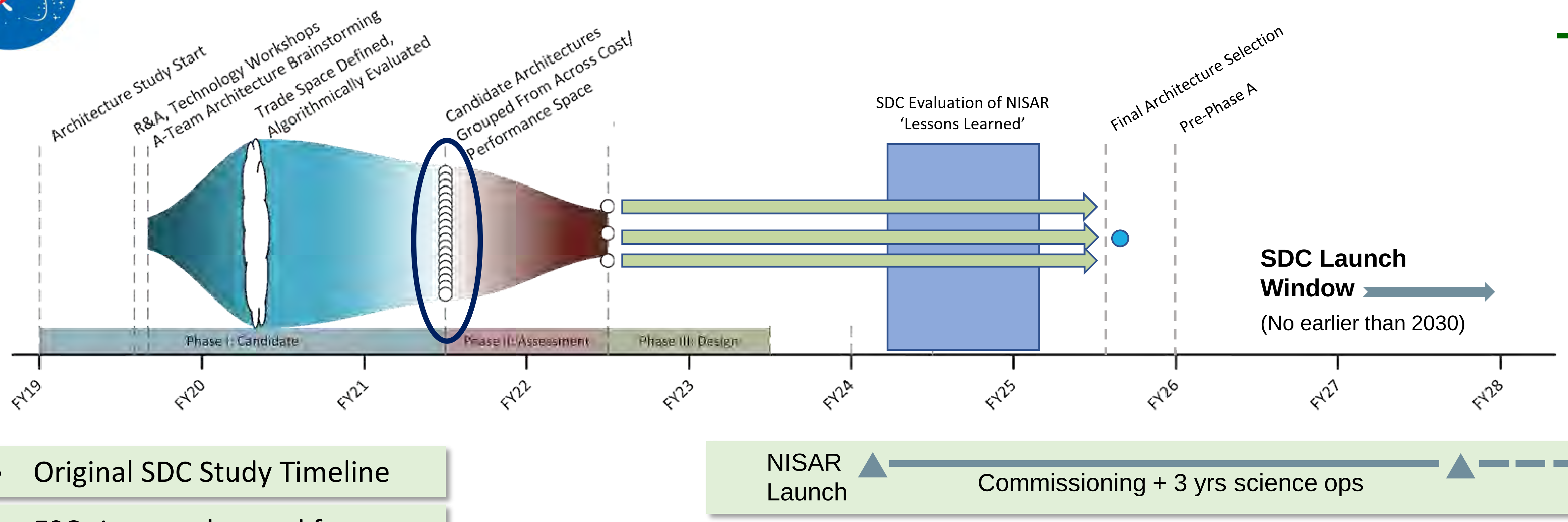
Surface Deformation and Change Timeline



- Original SDC Study Timeline

- ESO: Lessons learned from NISAR will guide the SDC architecture development and selection

Surface Deformation and Change Timeline



- Original SDC Study Timeline

- ESO: Lessons learned from NISAR will guide the SDC architecture development and selection

- Final SDC selection will likely be mid-2025

- The SDC Study Team completed the initial downselect in Spring 2022

Selected SDC Architectures - Deformation Science Perspective

Architecture	Characteristic	Continuity	Improved accuracy	Rapid repeat sampling
L1C	*NISAR w/PWV inst.*			
L4A	*2x NISAR w/ROSE-L*			
L5A	*NISAR via 5 Small Sats.*			
L6C	*ROSE-L Active Multi-Squint Co-fliers*			
L6E	*ROSE-L Passive Multi-Squint Co-fliers*			
L8A	*Sub-Daily Repeat*			
L9A	*NISAR via Multi-Squint Co-fliers*			
L12B	*Multi-Baseline Helical Orbit*			
L12C	*Fast Revisit Low Cost per Sat.*			
L18A	*Multi-Squint Low Cost per Sat.*			

Level of Improvement From NISAR

Large

Medium

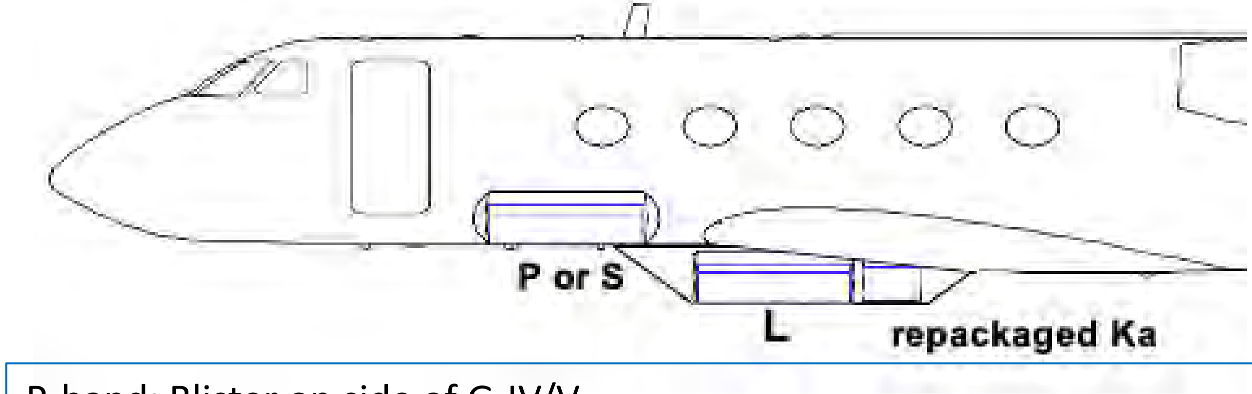
Small

NISAR-like

UAVSAR NextGen Modernization Plan

Phase 1:Underway

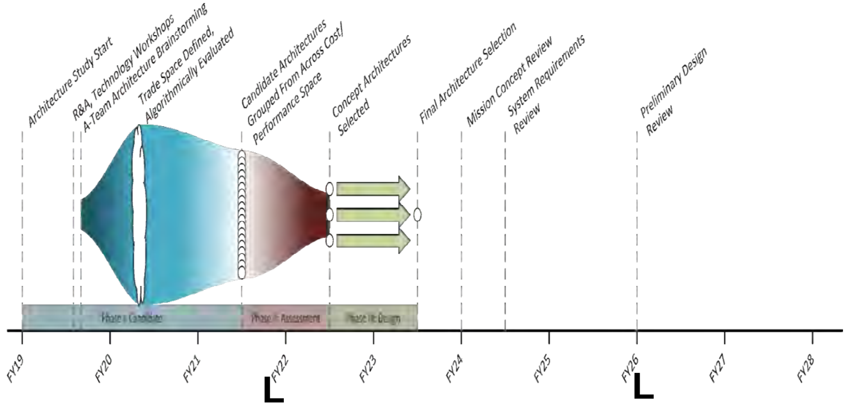
Ensure uninterrupted facility capability (P-, L-, and Ka bands)
Full modernization of the backend will enable multifrequency science



P-band: Blister on side of G-IV/V
L band and Ka band together in a canoe mount in the belly of the aircraft
Migrate operations to a newer G-IV aircraft

Phase 2

Develop S-band hardware
Develop bistatic/single pass interferometry
L- and S-band for topography/vegetation structure

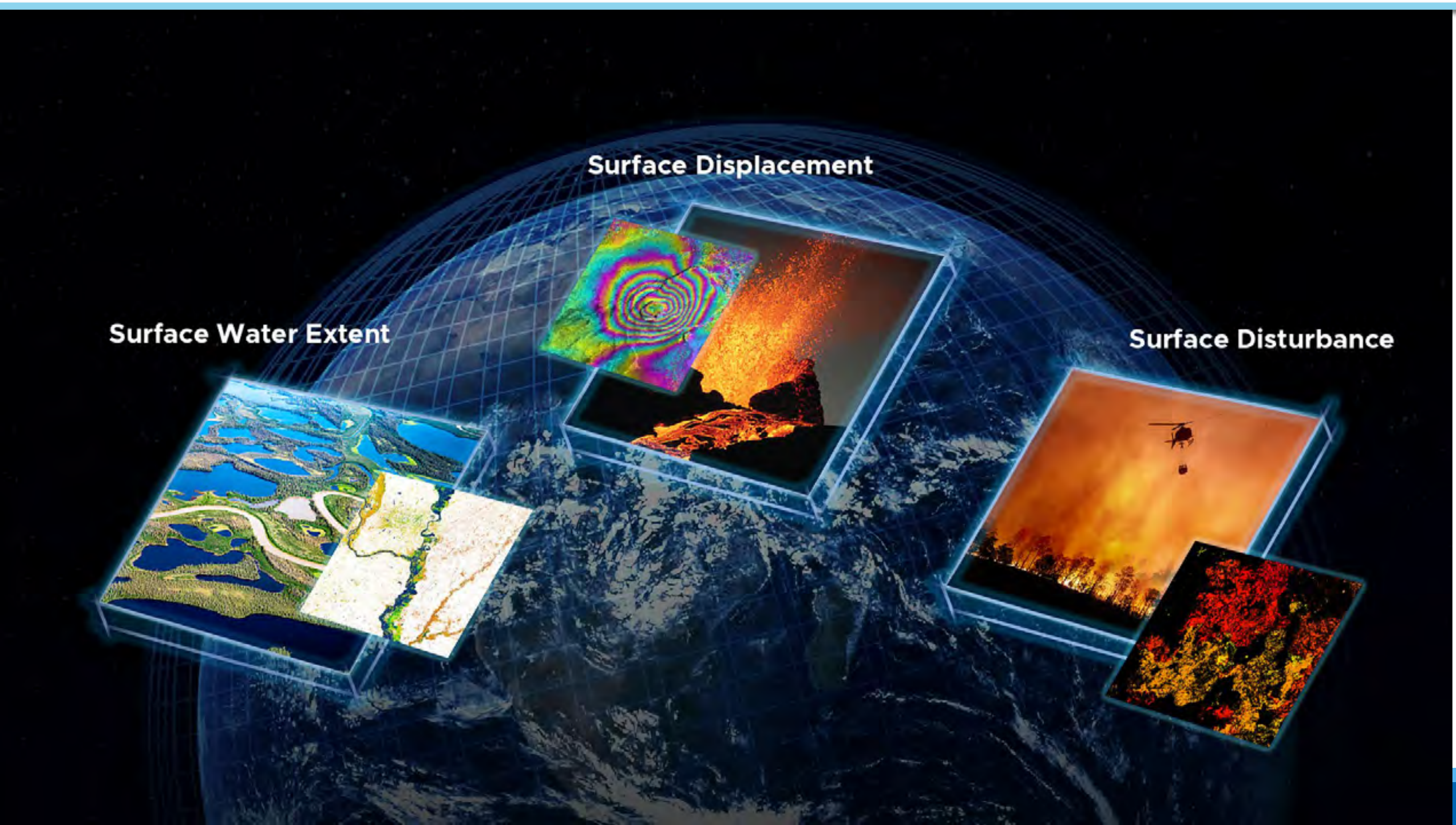


Develop wing-pod capabilities for long wavelength single pass

OPERA

Observational Products for End-Users from Remote Sensing Analysis

A suite of new NASA products that were identified and enabled through the US Government's Satellite Needs Working Group



Global Surface Water Extent

Landsat, Sentinel-2, Sentinel-1
NISAR, SWOT

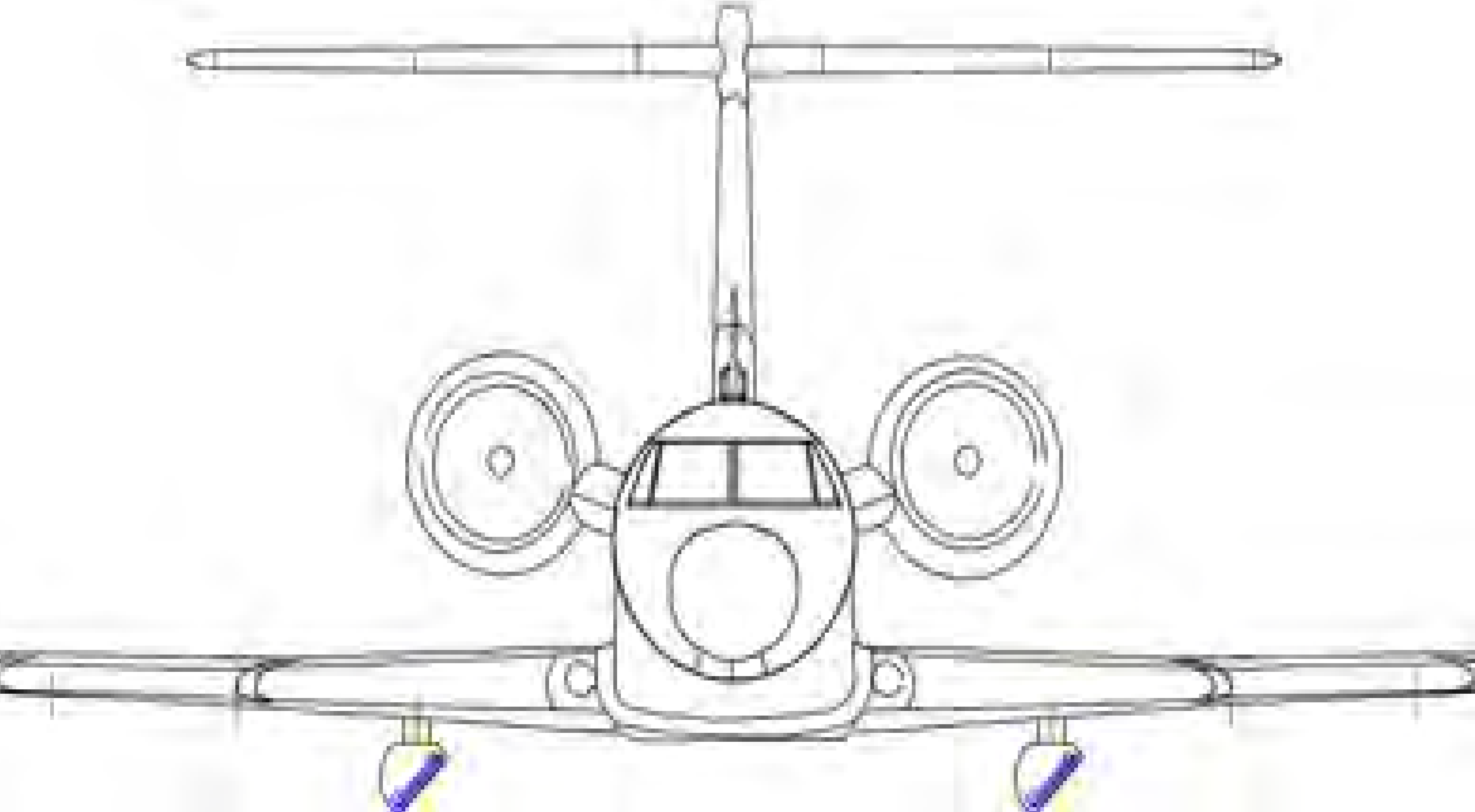
Surface Disturbance Products

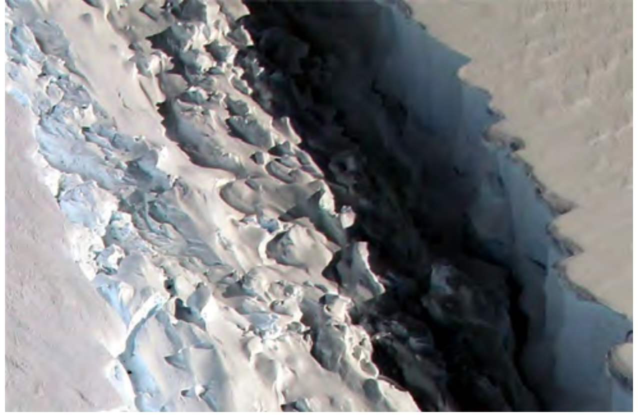
Landsat, Sentinel-2

North America Deformation

PSInSAR (S1, NISAR): 200 km inside Canada to Panama, AK, HI, US territories

Global RTC Sentinel-1 Products
North America Coregistered SLC for Sentinel-1



Thank You

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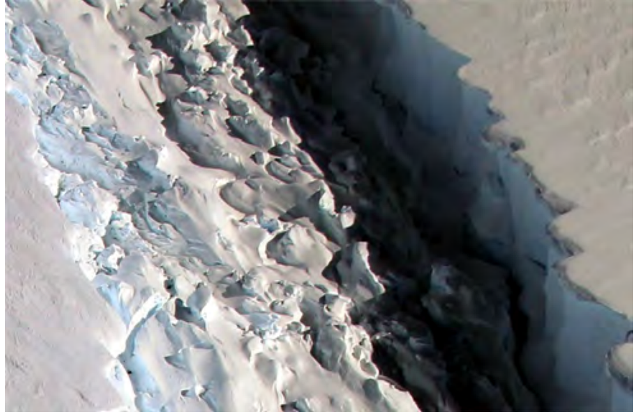


Backup

NISAR Science Observing/Operations Modes
Blanket Land and Ice Coverage Every 12 Days

NASA - ISRO SAR Mission

- Observation strategy employs a small subset of possible modes*

Observation Strategy	L-band		S-band		Culling Approach	
Science Target	Mode+	Resolution	Mode	Resol.	Sampling	Desc Asc
Background Land	DP HH/HV	12 m x 8 m			cull by lat	↙ ↖
Land Ice	SP HH	3 m x 8 m			cull by lat	↙ ↖
Sea Ice Dynamics	SP VV	48 m x 8 m			s = 1 p	↙ ↖
Urban Areas		6 m x 8 m			s = 1 p	↙ ↖
US Hi-Res					s = 1 p	↙ ↖
Himalayas			CP RH/RV		s = 1 p	↙ ↖
India Agriculture	QP				s = 1 p	↙
India Coastal Ocean			DP HH/HV or VV/VH		s = 1 p	↖
Sea Ice Types	DP VV/VH				s = 3 p	↙

*Example – actual modes in current plan vary geographically and seasonally