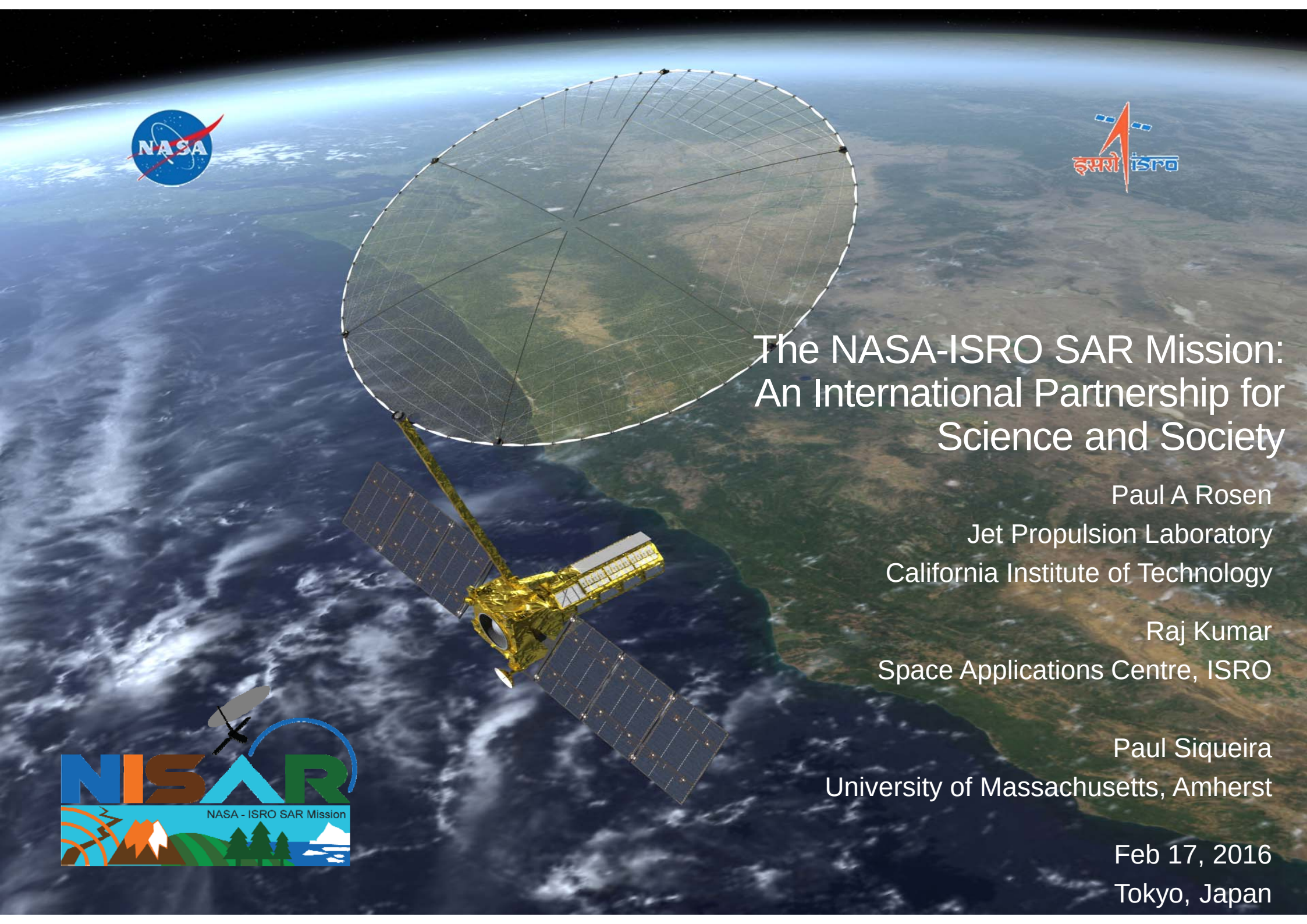

The NASA-ISRO SAR Mission: An International Partnership for Science and Society

Paul A Rosen
Jet Propulsion Laboratory
California Institute of Technology

Raj Kumar
Space Applications Centre, ISRO

Paul Siqueira
University of Massachusetts, Amherst

Feb 17, 2016
Tokyo, Japan

Level-1 Science Requirements in Plain English

For a minimum of 3 years:

a) *Measure ground movements in areas of expected solid earth deformation every 12 days from two directions to understand the processes causing earthquakes, volcanic eruptions, landslides, aquifer and reservoir variations , etc.*

b) *Measure flow of Earth's ice sheets and glaciers every 12 days from two directions to understand their interaction with global climate*

c) *Measure sea ice movements in both the Arctic and Antarctic to understand their interaction with global climate*

d) *Measure the dynamics of global woody aboveground biomass*

e) *Measure the dynamics of major wetlands and agricultural systems*

f) *In the event of a major natural or anthropogenic disaster anywhere in the world, task observations and downlinks rapidly on a best efforts basis*

NISAR Ecosystems Science Drivers*

- Biomass Estimation
- Disturbance Monitoring
- Inundation Extent
- Agricultural Area Mapping





NISAR Ecosystems Science Drivers*

- Biomass Estimation
- Disturbance Monitoring
- Inundation Extent
- Agricultural Area Mapping

Aboveground woody vegetation biomass annually at the hectare scale (1 ha) to an RMS accuracy of 20 Mg/ha for 80% of areas of biomass less than 100 Mg/ha.





NISAR Ecosystems Science Drivers*

- Biomass Estimation
- Disturbance Monitoring
- Inundation Extent
- Agricultural Area Mapping

NISAR will detect, annually, changes in Vegetation Canopy Cover (VCF) of 0.5 or greater at the hectare scale (1 ha) with a classification accuracy of 80%





NISAR Ecosystems Science Drivers*

- Biomass Estimation
- Disturbance Monitoring
- Inundation Extent
- Agricultural Area Mapping

Inundation extent within inland and coastal wetlands areas at a resolution of 1 hectare every 12 days





NISAR Ecosystems Science Drivers*

- Biomass Estimation
- Disturbance Monitoring
- Inundation Extent
- Agricultural Area Mapping

Classification of active agriculture area at 1 ha resolution of staple crops will be reported every three months.





NISAR Ecosystems Science Drivers*

- Biomass Estimation
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Classification of active agriculture area at 1 ha resolution of staple crops will be reported every three months.



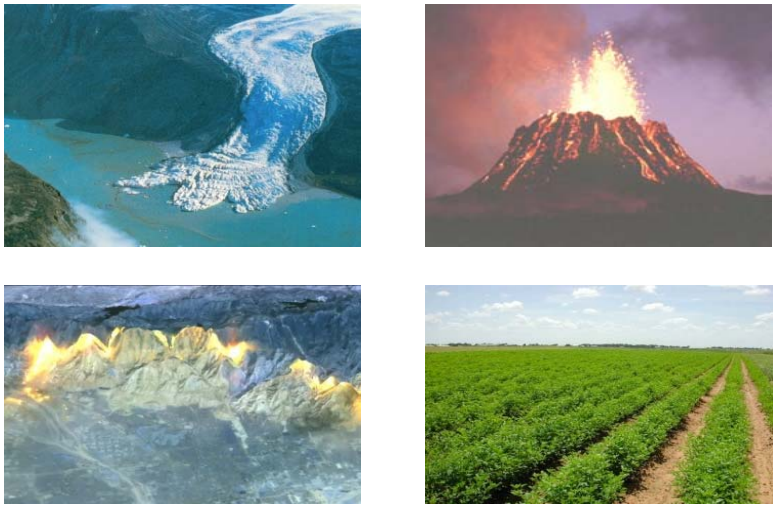


- * Science drivers are different than the many uses of NISAR for Ecosystems Applications

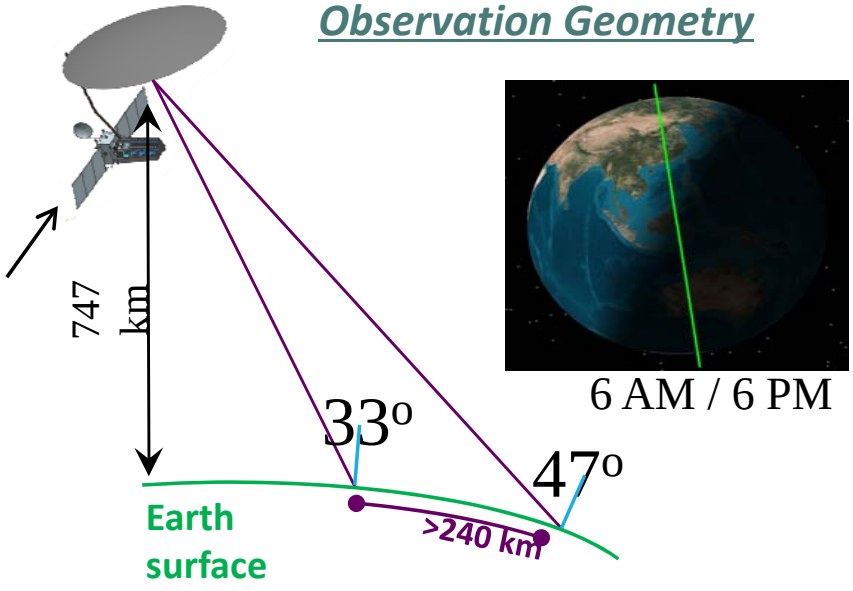
NISAR Science Observation Overview

NISAR Characteristic:	Would Enable:
L-band (24 cm wavelength)	Low temporal decorrelation and foliage penetration
S-band (12 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 years science operations (5 years consumables)	Time-series analysis
Pointing control < 273 arcseconds	Deformation interferometry
Orbit control < 500 meters	Deformation interferometry
> 30% observation duty cycle	Complete land/ice coverage
Left/Right pointing capability	Polar coverage, north and south

NISAR Would Uniquely Capture the Earth in Motion



Observation Geometry



NISAR Observation Concept

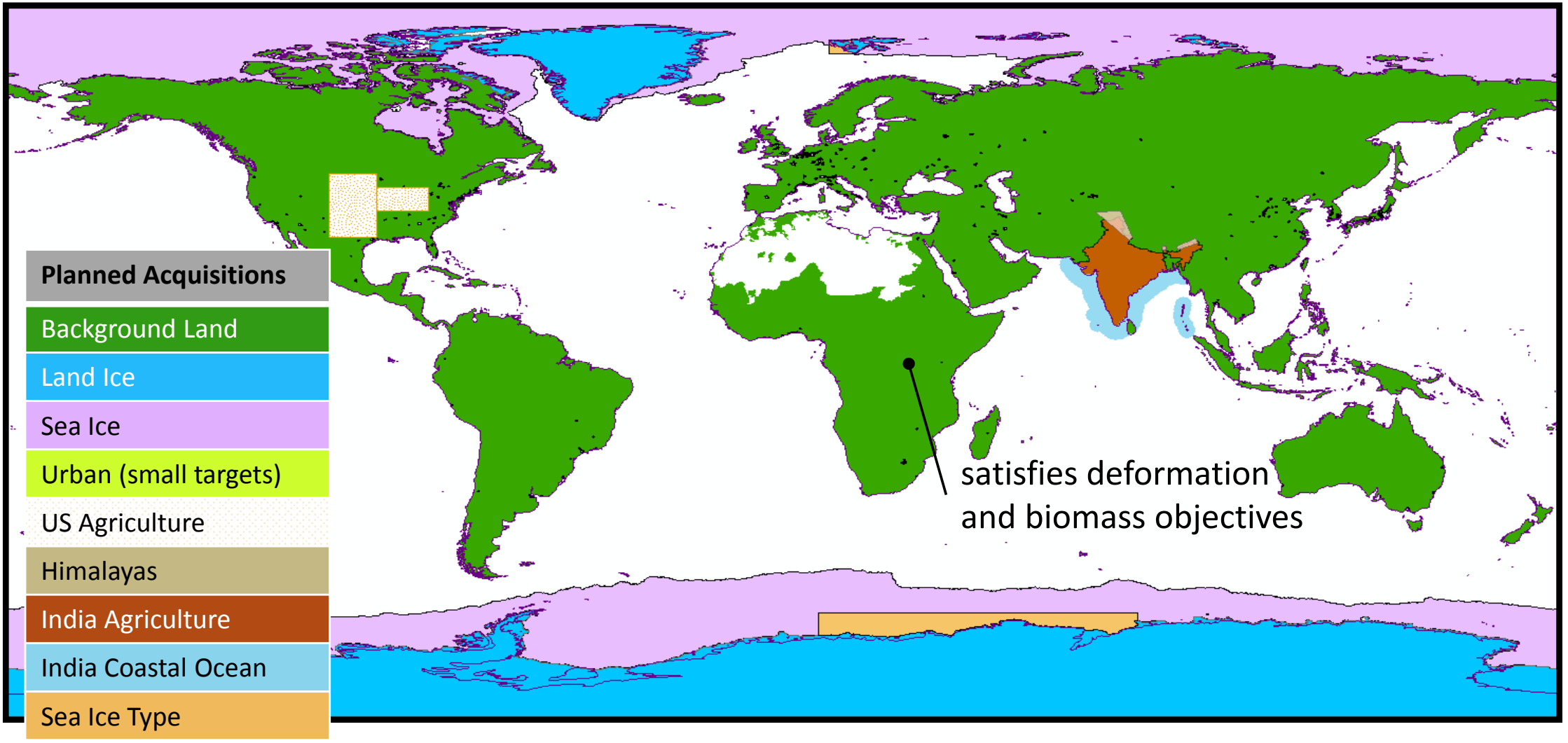
NISAR* Science Definition Team has adopted an observation strategy to accommodate three major science disciplines with nominally different needs:

- Minimize radar mode contention
- Apply fixed observation plan over each 12-day repeat cycle**
- Cull excessive overlap by thinning observations over the cycle
- Allow for urgent request

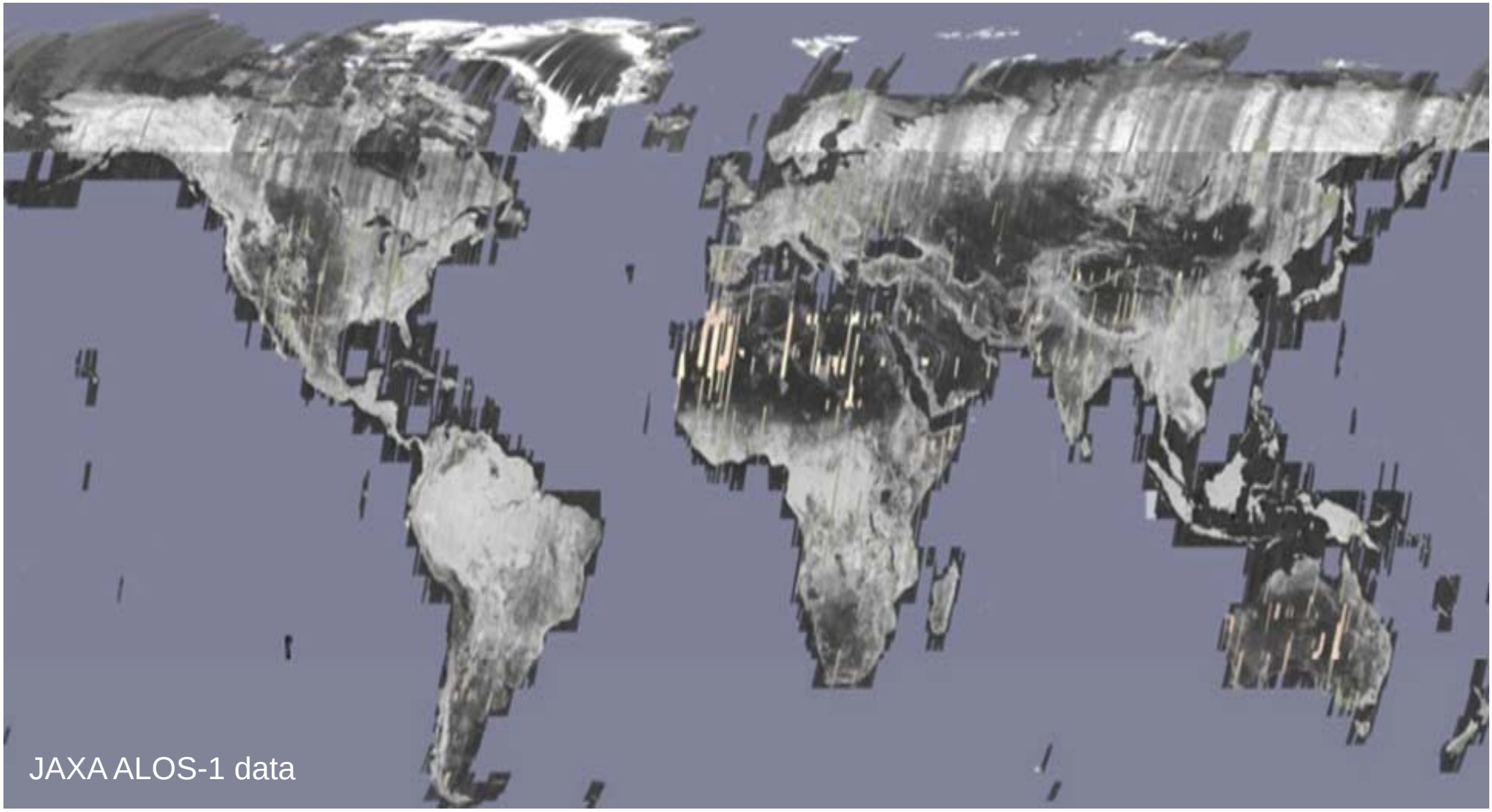
** To the extent possible

NISAR Simplified Target Masks

- Each colored region represents a single radar mode set tailored to that science target



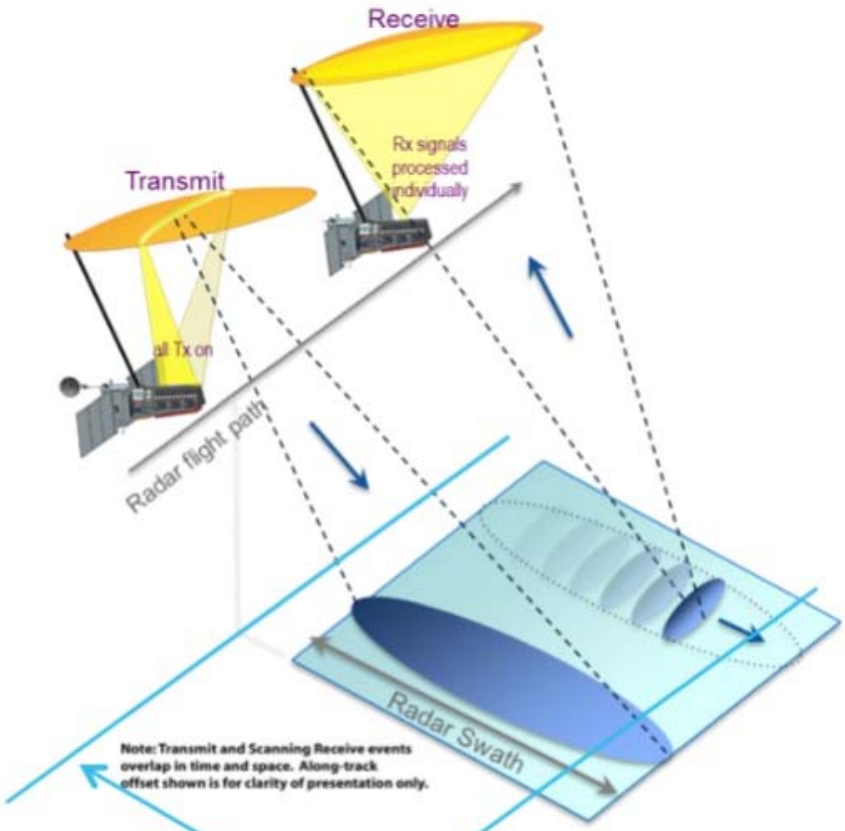
Repeat Coverage Every 12 days (Revisit every 6 days)



NISAR Swath Coverage
240 km SweepSAR

- All science disciplines require frequent coverage over global targets
- NISAR approach would acquire sufficient swath to cover equatorial ground track extent

  ➔ Global access at desired time sampling and imaging characteristics



~236 km Earth-fixed ground track spacing at equator for 12-day repeat orbit

NISAR Observation Concept

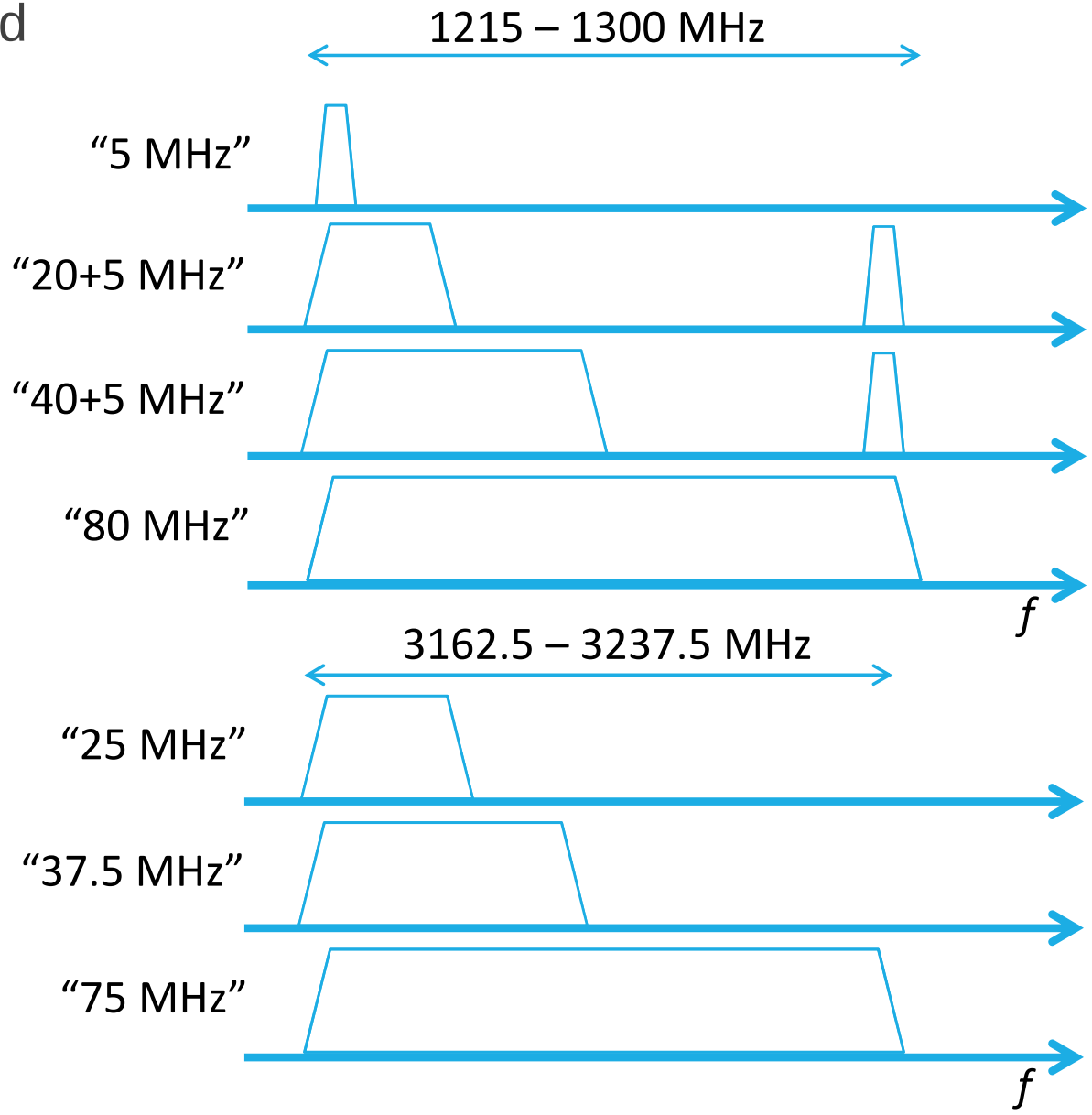
- Science targets are observed in specific fixed modes, with culling at high latitudes to reduce overlapped data takes
- "Background Land" satisfies deformation and biomass objectives

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 Agriculture	QP HH/HV VV/VH				s = 1 p	
Himalayas			CP RH/RV		s = 1 p	
India Agriculture					s = 1 p	
India Coastal Ocean			QQP HH/VV f_{c1} f_{c2}		s = 1 p	
Sea Ice Types	DP VV/VH				s = 3 p	

⁺ Main-band mode; split band is narrower bandwidth and can be like (DP) or orthogonal (QQP) polarizations

NISAR Radar Mode Bandwidth Options

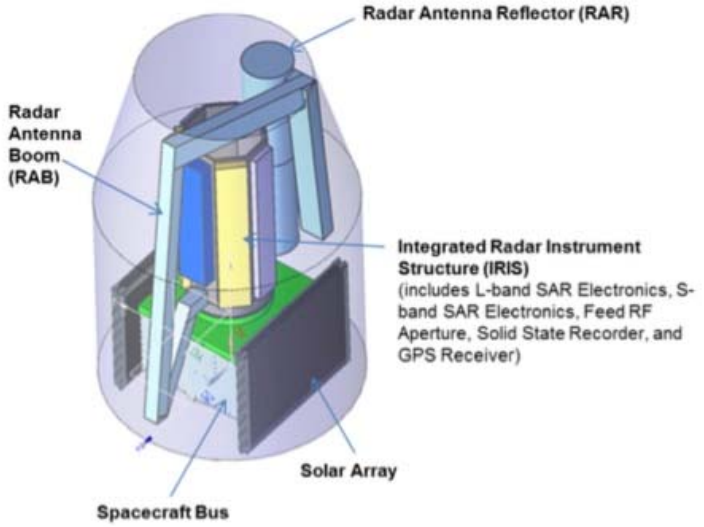
- L-band modes used for land and land-ice imaging include 5 MHz sideband
  - Useful for ionospheric correction
  - Used for all L-band polarization modes
  - Ensures interferometric compatibility independent of bandwidth and polarization



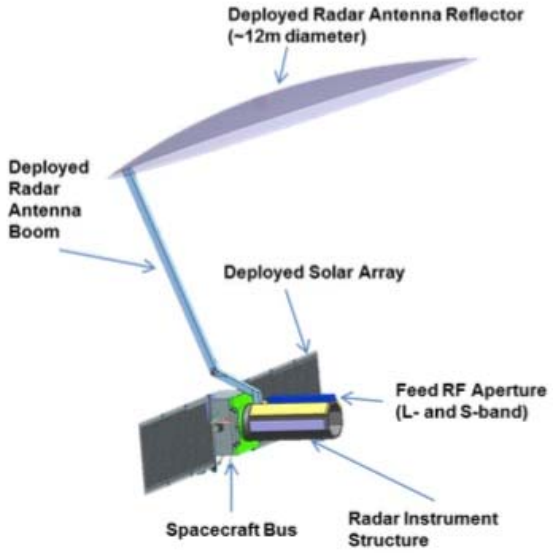
- S-band modes have three available bandwidths:

NISAR Flight System Summary – 1

Launch Configuration



On-Orbit Configuration

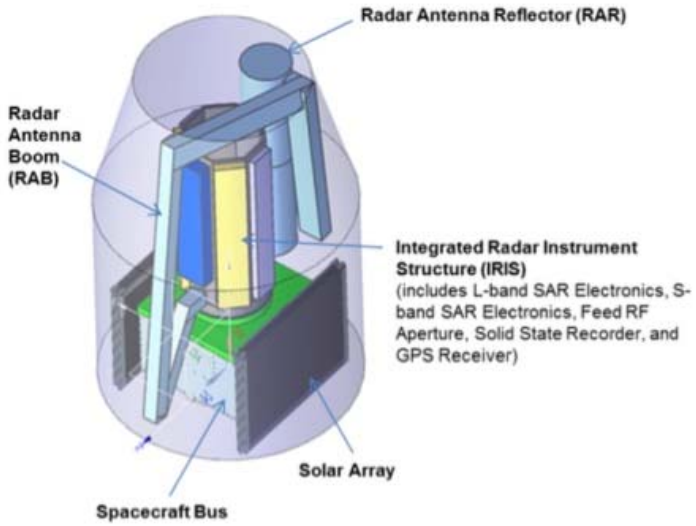


- **Spacecraft bus (ISRO)**
  - ISRO I3K heritage bus with several modifications (structure, power switches and reaction wheels)
- **L-band SAR (JPL)**
  - L-band SAR Electronics
  - L-band Feed RF Aperture
  - Radar Instrument Structure (RIS)
  - Radar Antenna Boom (RAB)
  - Radar Antenna Reflector (RAR)
- **S-band SAR (ISRO)**
  - S-band SAR Electronics
  - S-band Feed RF Aperture

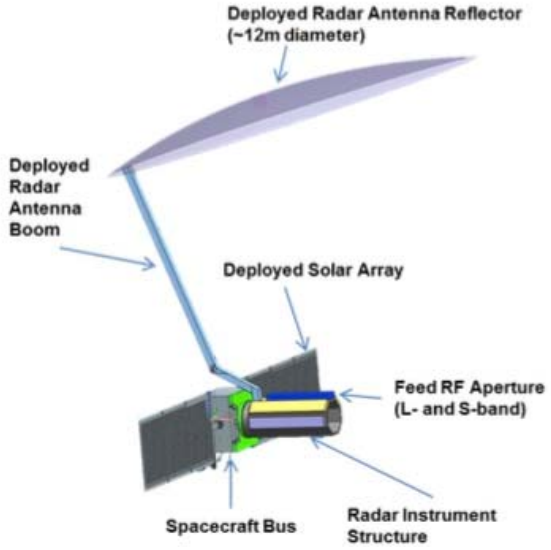
ISRO
JPL

NISAR Flight System Summary – 2

Launch Configuration



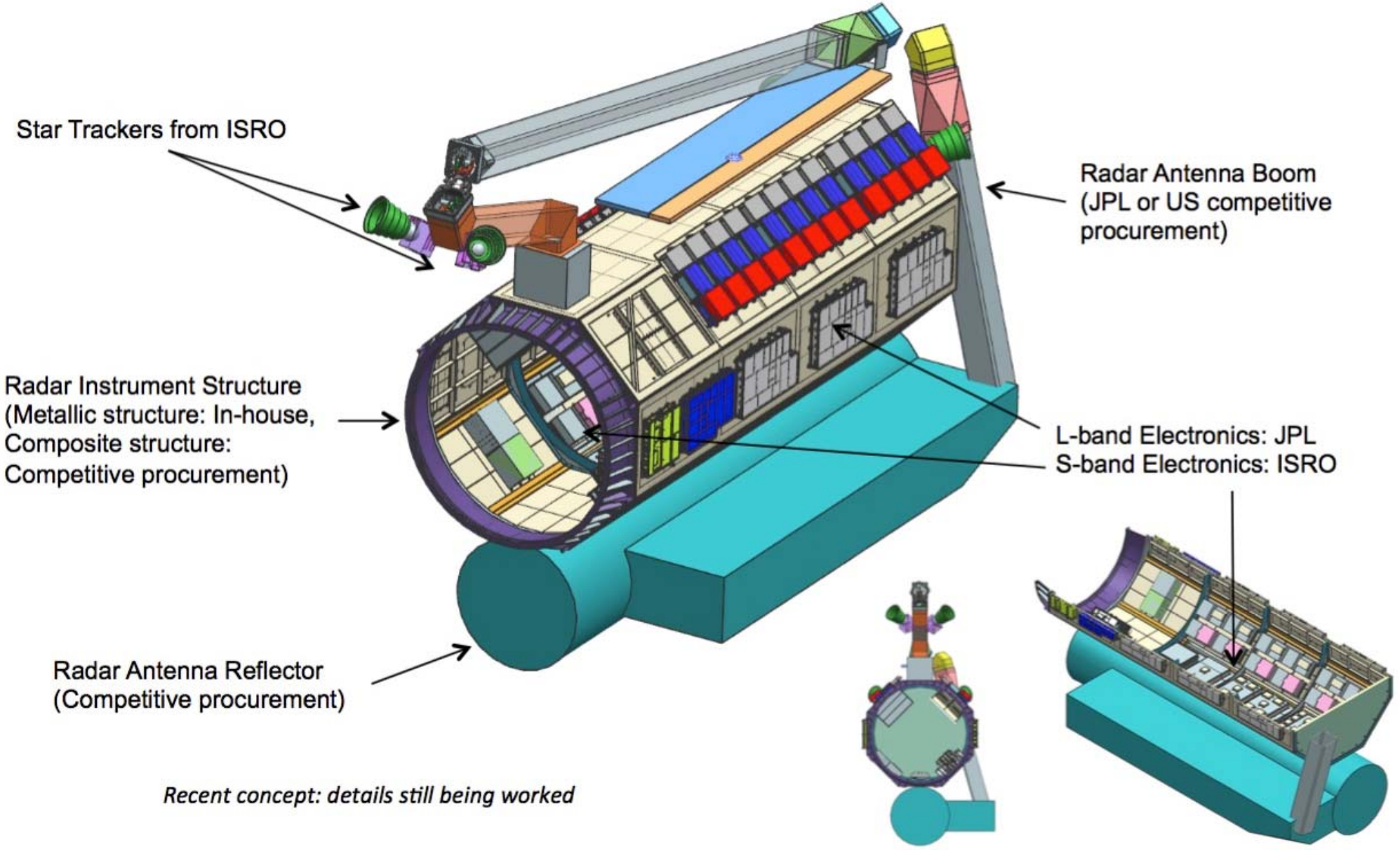
On-Orbit Configuration



- Engineering Payload (JPL)
  - Payload Communication Subsystem (PCS)
    - Ka-band high rate transmitter
  - GPS Payload (GPSP)
    - GPS receiver
  - Solid State Recorder (SSR)
  - Payload Data Subsystem (PDS)
  - Power Distribution Unit (PDU)
- Launch Vehicle (ISRO)
  - Geosynchronous Satellite Launch Vehicle (GSLV) Mark-II

ISRO
JPL

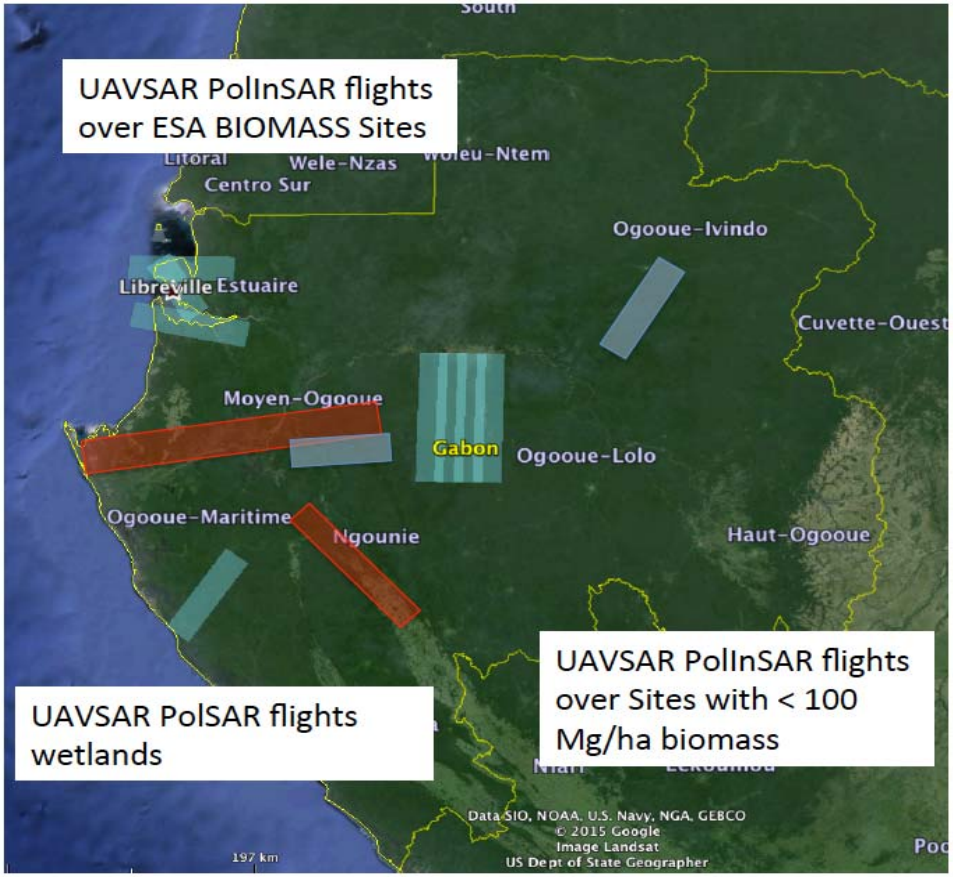
NISAR Stowed Configuration



NISAR Instrument Housing

AfriSAR CAL/VAL Campaign in Tropical Forests

- NASA deploying UAVSAR & LVIS in February
  - ONERA deployed Sethi on Falcon-20
  - DLR currently deployed in Gabon (SAR and Tandem-X acquisitions



AfriSAR: Collaboration with ESA on Cal/Val for Geodetic Imaging Missions

- Both ESA and NASA have upcoming missions with a focus on Ecosystem dynamics and above-ground biomass:
  - NISAR (NASA-ISRO Synthetic Aperture Radar) is an L-band S-band spaceborne SAR (JPL-launch 2020)
  - GEDI (NASA Global Ecosystem Dynamics Initiative) is a spaceborne Lidar on the International Space Station (UMD, GSFC- launch 2019)
  - BIOMASS (ESA) is a P-band spaceborne SAR (CNES-launch 2020)

BIOMASS

NISAR
NASA - ISRO SAR Mission

NISAR Programmatic Status

- Mission Concept Review completed successfully in Oct 2013
- Phase A started May 2014 (Key Decision Point A in Mar 2014)
- Implementing Arrangement between NASA and ISRO signed Sep 2014
- System Requirements Review/Mission Definition Review completed successfully in Dec 2014
- Phase B started Mar 2015 (Key Decision Point B in Feb 2015)
- ASF Selected as Data Node: January 2016
- Science peer review completed April 2016
- BIOMASS/ICESAT-2/GEDI/NISAR Joint Cal/Val Workshop in May 2016
- NASA PDR in June 2016
- NASA Applications workshop held annually (October)
- ISRO Applications workshop held annually (November)
- Launch late 2020