NASA-ISRO SAR (NISAR) Mission
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California Institute of Technology

2021 CEOS LPV Plenary
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NISAR Science
Capturing a Dynamic Earth

- **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:

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

### NISAR Will Uniquely Capture the Earth in Motion

**Observation Geometry**

- 747 km
- 6 AM / 6 PM
- 33°
- 47°
- 240 km
NISAR will produce Level 3 science measurement products over Cal/Val sites to validate those measurement requirements.

- Algorithms for producing the level-3 products may have parameters that must be calibrated as well.

NISAR is also supporting the production of a validated global soil moisture product, that will be produced for every collected image over land.

NISAR must also demonstrate the capability to change the observation plan and achieve reduced processing latency for urgent response.
Ice sheet time-varying velocity sampling at 500 m resolution near weekly

Ice sheet/glacier fast deformation rates (> 50 m/year) at 250 m resolution during cold season

Ice sheet/glacier/ice cap slow deformation rates (<50 m/year) at 100 m resolution during cold season

And: sea ice velocity at 100 m/day accuracy on a 5 km grid every 3-days

Validated with deployed GPS on ice
Co-seismic displacement and Vertical displacement of Ice annually and monthly of floating ice shelves and ice tongues at 100 m resolution

Permafrost deformation rate (semi-monthly at 100 m resolution during snow free months over any 90 day interval)

Secular deformation rate (per year)

Transient deformation rate at 100 m resolution over 12 days

Validated with GNSS networks or deployed GPS
Ecosystem Measurement Requirements

Detection of Forest disturbance

Accuracy: 80% for disturbances > 50% at ha scale **annually**

Active agricultural crop area

Accuracy: 80% at 1 ha resolution **every 3 months**

Wetland inundation Extent

Accuracy: 80% at 1 ha resolution **every 12 days**

Biomass

0 Mg/ha

100 Mg/ha

Validity: 20 Mg/ha **annually**

Over 1 hectare

Validated with field measurements and/or other remote sensing data
Sample Mission Plan

Persistent updated measurements of Earth

- Science Performance Tool now using as-built instrument measurements
- Performance metrics have been stable throughout Phase C
  - **Solid Earth** and **Biomass** metrics shown at right
  - Also metrics for Glacier velocity and disturbance
- Science will participate in V&V by interactive process with Radar and Mission Systems engineering to update instrument performance with mission plan in performance tool estimates.

### Solid Earth Performance

<table>
<thead>
<tr>
<th>Metric</th>
<th>Coverage Req.</th>
<th>Coverage Est.</th>
<th>Uncertainty Est.</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 in mm</td>
<td>70%</td>
<td>82.5%</td>
<td>3.5 * (1+sqrt(L))</td>
<td>OK - OK</td>
</tr>
<tr>
<td>Coseismic (660) in mm</td>
<td>70%</td>
<td>81.0%</td>
<td>4 * (1+sqrt(L))</td>
<td>OK - OK</td>
</tr>
<tr>
<td>Transients (663) in mm</td>
<td>70%</td>
<td>86.6%</td>
<td>3 * (1+sqrt(L))</td>
<td>OK - OK</td>
</tr>
<tr>
<td>Active (658) in mm/yr</td>
<td>70%</td>
<td>93.7%</td>
<td>2</td>
<td>OK - OK</td>
</tr>
<tr>
<td>PermaFrost in mm</td>
<td>80%</td>
<td>84.9%</td>
<td>4 * (1+sqrt(L))</td>
<td>MARGIN-OK</td>
</tr>
</tbody>
</table>

0.1 km < L < 50 km) Meets requirements with ≥ 10% margin / < 10% margin

### Sample Biomass Metrics

- Requirement is 80%, 20 Mg/Ha

- **Sample Biomass Metrics**
NISAR Operations Overview

L-SAR Data
- Up to 4 Gb/sec; ~27 passes/day
- 35 Tb daily average volume
  (including 9 Tb SNWG)

S-SAR Data
- Up to 2.9 Gb/sec; 8 passes/day
- 8 Tb daily average volume

Near Earth Network

SNWG Users
Science Data Processing (JPL)
and Data Archive & Distribution (ASF DAAC)

Engr Telemetry & GPS

Coord Obs Plan
Radar Payload Commanding & Ka-band Scheduling

Sun-synchronous frozen orbit
747 ± 20 km altitude
6 PM mean local descending node
100 minute period
12 day repeating ground track

L-SAR Radar Payload Operations (JPL)

Engr Telemetry

NASA & ISRO Joint Science Team

Reference Observation Plan
(updated every 6 mon)

Urgent Response Requests

L-SAR Data Acquisition Processing and Handling Environment (DAPHNE)

NEN Data
Acquisition
Processing
and Handling

NEN Ka Stations
Fairbanks, Svalbard, Wallops, Punta Arenas

Mauritius, Lucknow, Bangalore, and Antarctica

ISRO Mission Operations (ISTRAC)
(Bangalore)

S-band TT&C
Uplink 4 Kbps
Downlink 4 & 32 Kbps

ISRO S-Band Stations (ISTRAC)

S-SAR Data & Telemetry

S-SAR Operations Support (SAC)
(Ahmedabad)

ISRO S-Band Stations (Shadnagar, Antarctica)

S-SAR Data Processing Archive (NRSC)
(Hyderabad)

ISRO Mission Operations (ISTRAC)
(Bangalore)

Amazon Web Services
Science Data Processing (JPL)
and Data Archive & Distribution (ASF DAAC)

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(Hyderabad)
NISAR Systematic Observations

Persistent updated measurements of Earth resulting in 1.6 PB raw data per year

Repeated every 12 day cycle for the life of the mission

No target conflicts: overlapping targets uses union of all modes specified

Colors indicate different radar modes

J. Doubleday
P. Sharma, JPL
• 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
  • Anticipate assessing additional processing / reprocessing options before launch

• SDS makes data available to NASA/ISRO project users and DAAC

• Sample products derived from UAVSAR data, processed like NISAR, are available

• Open source (github) ISCE3 software already available and is beginning to support these workflows and products
A new design for L-Band Trihedral Reflectors has been implemented to optimize manufacturing and assembling requirements and to accommodate the new 2.8 m size.

- The L-Band reflectors are to be manufactured to be light enough to carry by 1-2 people and easy to assemble on-site.
- The reflector is propped up flat on the surfaces of three wooden bases, two in the front and one at the vertex (with variable tilts just be using different front bases).
- At the end of each corner is an eyebolt screw for wiring and attaching down to the stakes on the ground.

Leonard Ortiz, JPL
• NISAR will have 12 sub-beams
• An onboard digital beamforming algorithm will be used to form the NISAR 240 km range swath

13 reflectors will be deployed at the edge of each sub-beam in beam overlap areas

12 reflectors will be deployed at the middle of each sub-beam

Bright distributed targets will be also used to evaluate the calibration across the sub-beam overlap areas
ALOS-1 L-HH image mosaic of Oklahoma

Reflectors to be deployed in Oklahoma and Alaska
Also will utilize the existing reflector array in California
Launch Date – Oct 2022 to Jan 2023

- NASA/JPL & ISRO have agreed to a new schedule plan that realistically results in a launch not later than late January 2023
  - Engineering delays and COVID-19 impacts have both contributed to delays
- L-SAR is fully integrated and in test;
- S-SAR is fully integrated and delivered to JPL for integration with L-SAR
- S-SAR is on a parallel I&T path with L-SAR – delivered to JPL in March 2021 and now being jointly integrated