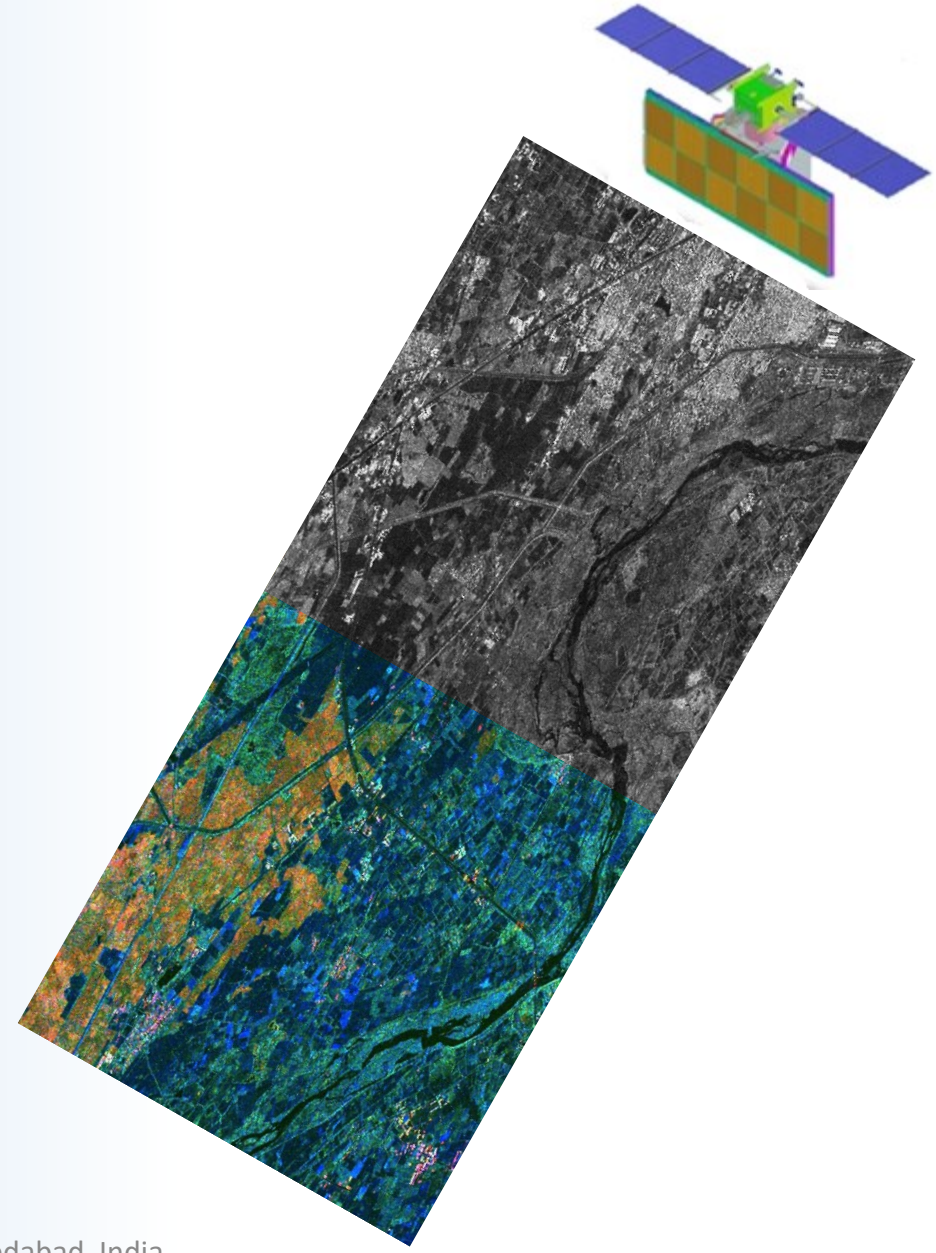
Establishment of In-House ‘L’ and ‘S’ band calibration facility for NISAR Mission



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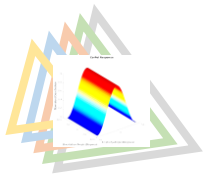
Back Ground & Aim of the Study

In-House Integrated Calibration facility was established and operationalized in 2015 for Optical & SAR Data Calibration.

- **The site back ground and passive Calibration Targets (designed CRs) are tested well for ‘C’ band ‘ X’ band for different modes and polarizations.**
- **As part of readiness for NISAR Data Calibration – envisaged ‘L’ and ‘S’ band data feasibility is studied using NOVASAR and ALOS-PALSAR.**
- **The obtained imagery and derived calibration parameters – provides good confidence for the upcoming NISAR data calibration.**



Input Data Sets

1. The Advanced Land Observing Satellite (ALOS)-2, Phased Array L-band Synthetic Aperture Radar (PALSAR) was chosen to image the Shadnagar calibration site in Stripmap, Quadpol mode on 27-Dec-2023.

2. NovaSAR-1 imaging over Shadnagar calibration site in strip map mode on 30-Mar-2021, 13-Apr-2021, 25- Jul-2021 and 01-Nov - 2024.

Parameter	Value
Frequency	1.2365 Ghz
Look	Right
Node	Ascending
Polarization	HH+HV+VH+VV
Incidence Angle	31 Deg

Parameter	Value
Frequency	3.2 Ghz
Look	Left
Node	Descending
Polarization	HH (30th Mar 21, 25th Jul 21) VV(13th Apr 21) HH, VV (1st Nov 2024)
Incidence Angle	17.03 (30th Mar 21), 28.92 (25th Jul 21) 28.46 (1st Nov 2024)

Corner Reflectors for L & S-Band SAR data calibration

- **Towards Calibration and Validation of upcoming NISAR Mission, the following Corner Reflectors (CRs) suitable for L and S band frequencies are deployed at IMGEOS Cal-Val site.**

Type of Corner Reflector	Size	Theoretical RCS (dBsm)	
		S-Band	L-Band
Square Trihedral	125 cm	40.2	32.087
Square Trihedral	150 cm	43.37	35.25
Dihedral	100 cm	34.563	26.45

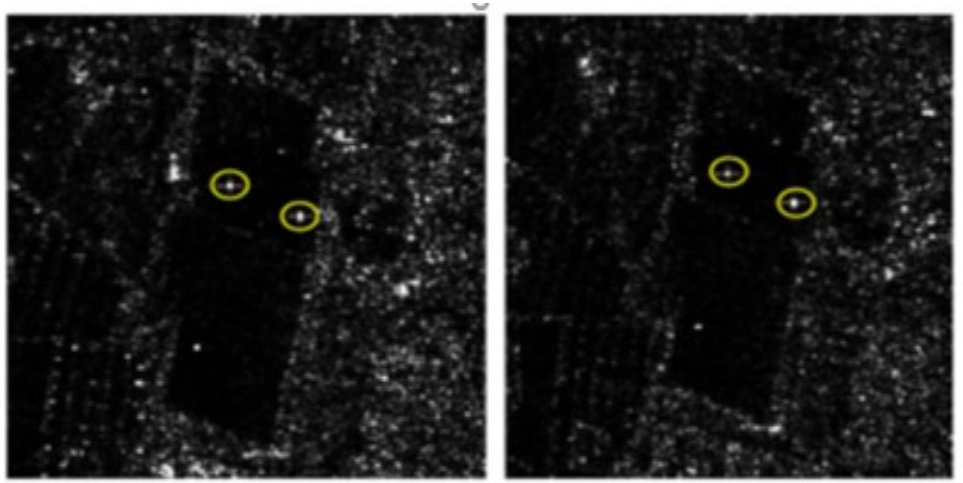
125 cm Square Trihedral

150 cm Square Trihedral

Targets Deployed

Corner Reflector Type	Size (m)	RCS (dBsm)	Qty	Identification
Square Trihedral	1.25	31.947	02	STH
Square Dihedral	1.0	26.309	02	SDH

Spatial deployment of Targets in the CAL site

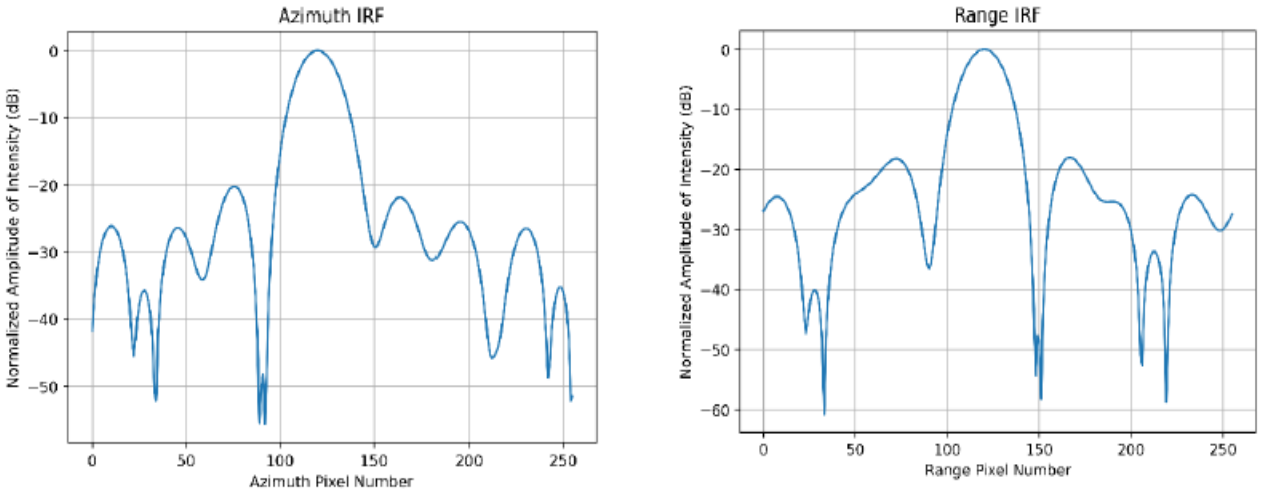


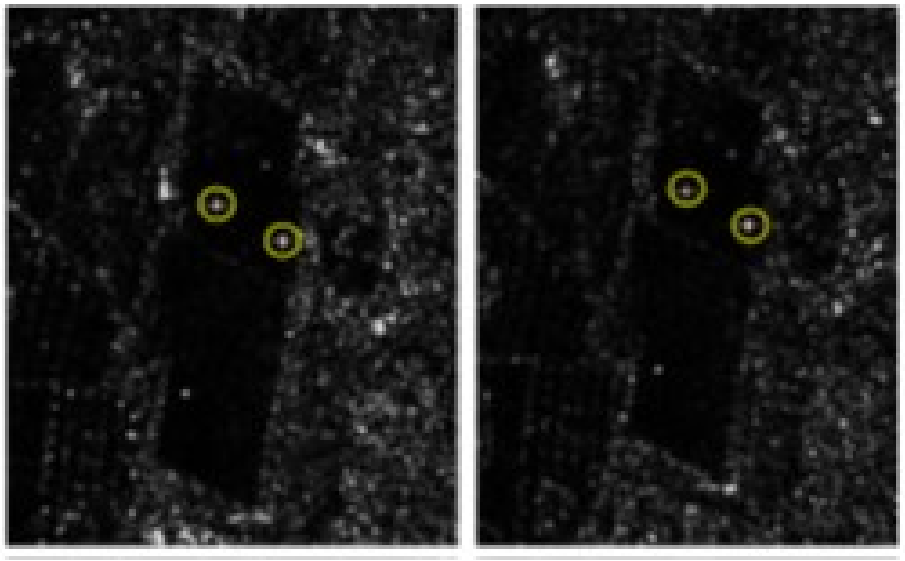
Acquisition of the deployed targets in the image

L band data calibration results

Data Collection: ALOS-2,PALSAR: Stripmap Mode, QUADPOL on 27th Dec 2023 over IMGEOS Calibration site.

Deployed Calibration Targets: 1.25m Sq. Trihedral & 1.0m Sq.Dihedral





HH Profile

Obtained relatively good IRF for HH & VV profile

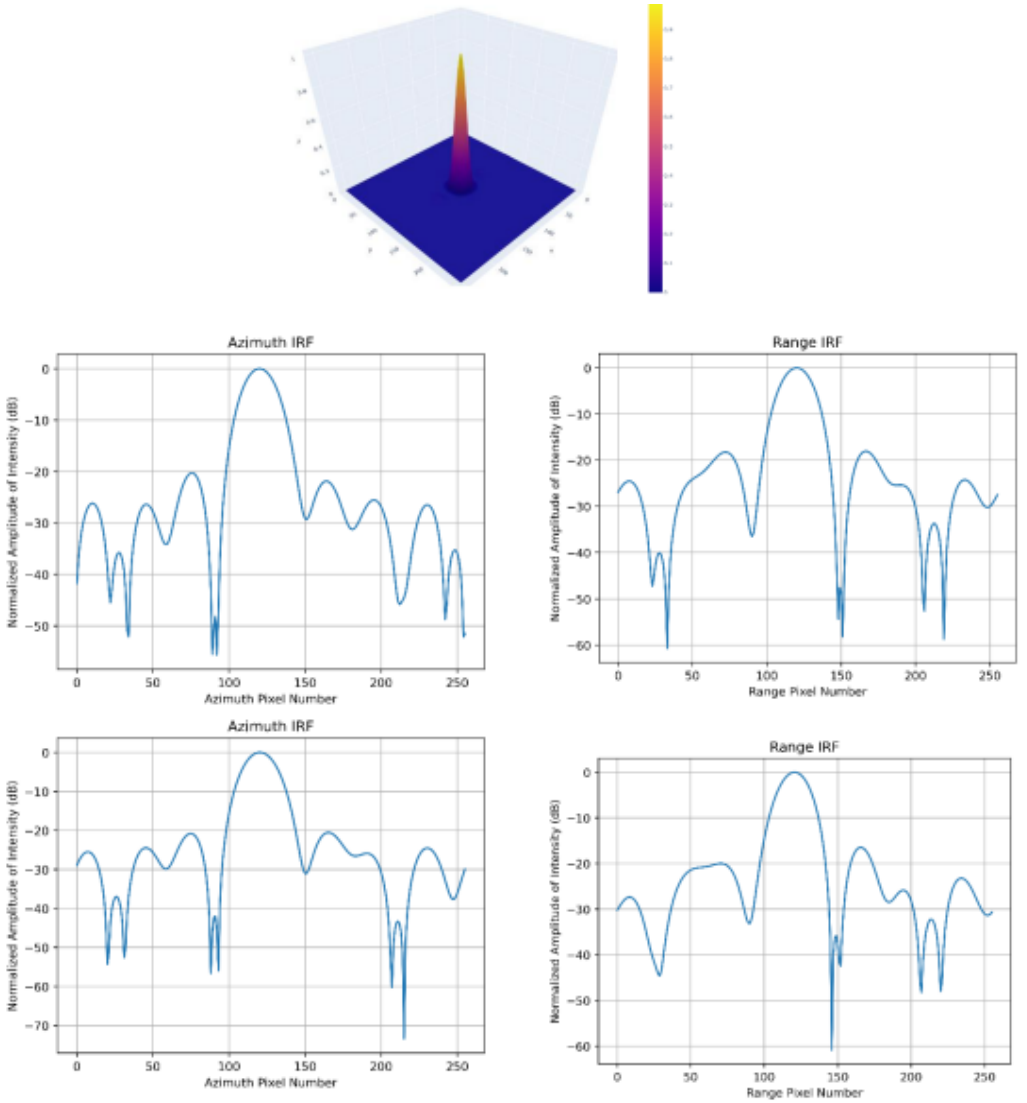
- ✓ Experiment demonstrated the suitability of site, methodology and deployed CR for the ‘L’ band data.
- ✓ Good back ground ratio is also Observed, better than 30dB.

L band data calibration results cont..

Parameter	Value
PSLR (dB)	≤-13.26+2 dB
ISLR (dB)	≤-10.16+2 dB
Resolution (m)	4.125 (az), 3.57 (rn)
VV/HH amplitude ratio	≤1±0.047
Phase diff. VV & HH (deg)	≤5

Observed Response in ALOS Full POL data				
Polarisation	STH-1	STH-2	SDH-1	Background
		Intensity in dB		
HH	126.83	127.55	106.15	
HV	…	….	104.13	
VH	…	….	105.19	
VV	127.42	127.6	102.7	85±5.47

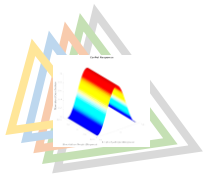
- Good response observed for STH in Co-Pol data.
- Poor response observed for SDH in both the co-pol and cross-pol.



Intensity profiles on the STH-1. Top row:3D profile, middle row: HH pol profile, last row:VV pol profile.

L band data calibration results cont..

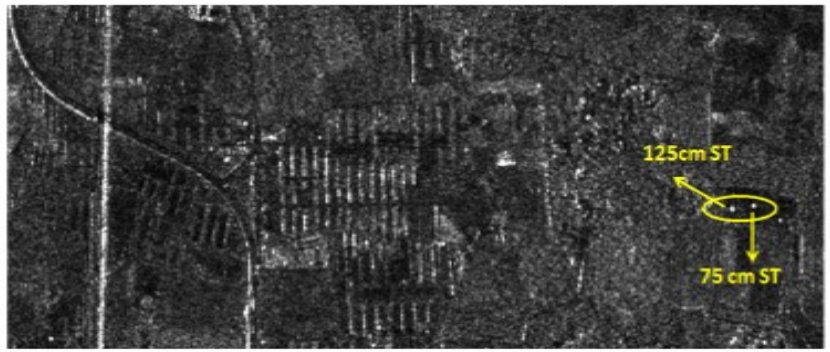
CR ID.	Polarization	Background to peak ratio (dB)	Range Dirn.		Azimuth Dirn.		Theoretical RCS (dBsm)	Measured RCS (dBsm) (Integration Method)	Resolution (m)	
			PSLR (dB)	ISLR (dB)	PSLR (dB)	ISLR (dB)			Range	Azimuth
STH-1	HH	-31.27	-18.05	-14.31	-20.27	-17.56	31.94	27.68	3.4	3.72
STH-1	VV	-33.56	-16.47	-13.96	-20.54	-16.53	31.94	27.90	3.58	3.91
STH-2	HH	-30.88	-15.16	-14.03	-18.53	-18.88	31.94	27.00	3.40	3.91
STH-2	VV	-31.31	-16.02	-14.29	-18.47	-18.62	31.94	26.96	3.58	3.91



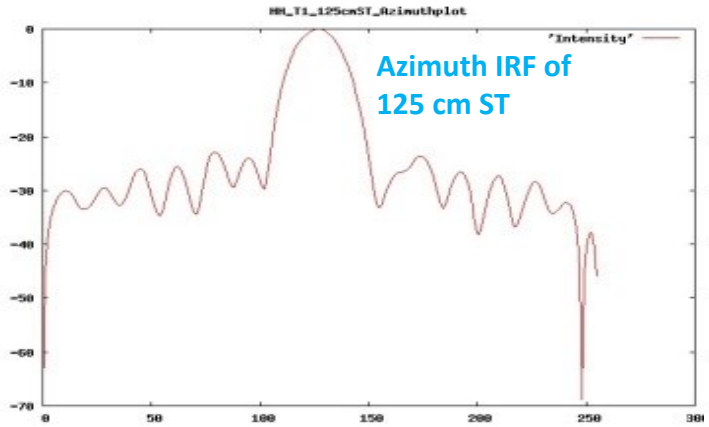
Point Target Analysis over NovaSAR S-Band Data

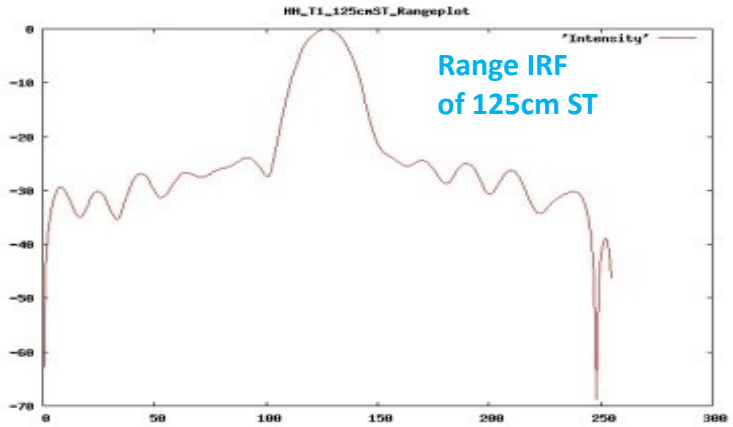
- Point Target Data Analysis was performed using in-house developed software on NovaSAR S-Band SAR data acquired in 6m stripmap mode over IMGEOS Cal-Val site and derived the image quality parameters in both azimuth and range directions.
  - ✓ Peak Side Lobe Ratio(PSLR); Integrated Side Lobe Ratio(ISLR) ; Spatial Resolution or Impulse Response Width(IRW)

Date of Pass	Target Type	Background to Peak Ratio (BGPR) (dB)	Azimuth			Range		
			PSLR (dB)	ISLR (dB)	Resolution (Mts)	PSLR (dB)	ISLR (dB)	Resolution (Mts)
30-03-2021	125cm Square Trihedral	-34.64	-22.87	-18.54	5.94	-23.94	-18.25	5.94
13-04-2021	125cm Square Trihedral	-30.02	-22.84	-19.09	7.5	-22.93	-17.11	6.25
	75cm Square Trihedral	-26.42	-21.52	-16.75	7.81	-19.58	-14.3	6.25
25-07-2021	125cm Square Trihedral	-32.74	-22.24	-18.63	6.88	-21.95	-18.02	6.25



NovaSAR data over NRSC Cal-Val Site acquired on 13-04-2021





Calibration of NovaSAR S-Band SAR data

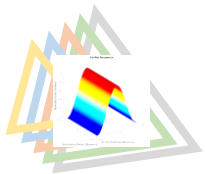
Derivation of Radar Cross Section (RCS) Using Corner Reflector

Date of Pass	Target	Polarization	Peak DN value	Background to Peak Ratio (dB)	Energy (dB)	Theoretical RCS (dBsm)	Measured RCS (dBsm)	Diff RCS (dBsm)
30-03-2021	125cm Square Trihedral	HH	4858	-33.63	89.31	40.2	39.31	0.89
25-07-2021	125cm Square Trihedral	HH	4243	-32.85	88.56	40.2	38.56	1.64

Estimation of Geometric Accuracy

Date of Pass	Target	Lat Error (m)	Lon Error (m)	Radial Error(m)
13-04-2021	125cm Square Trihedral	2.125	39.03	39.09
25-07-2021	125cm Square Trihedral	2.75	-19.4	19.6

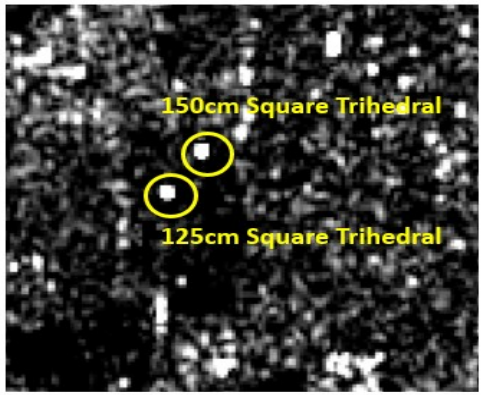
- *Image quality parameters derived for NovaSAR S-Band SAR are as per the specifications.*
- *The geometric accuracy of Level-2A products (with precise DEM Registration) is observed to be within 50m.*



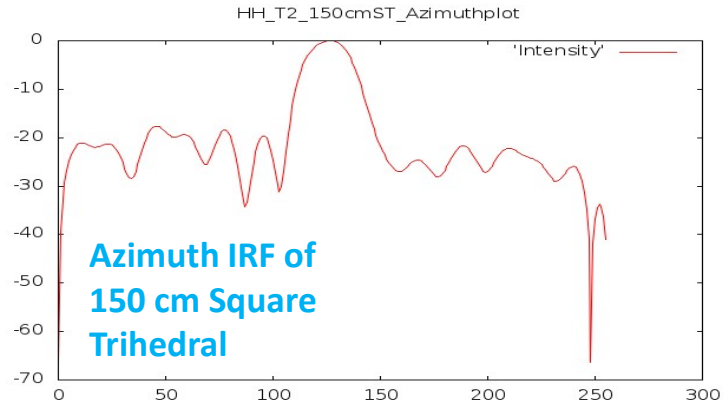
S-Band Data Calibration Results Cont..

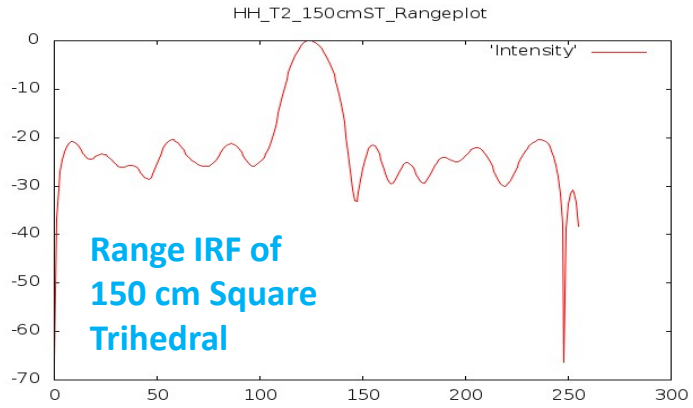
Point Target Analysis Results of NovaSAR 20m ScanSAR mode (VV, HH) data acquired on 01-11-2024

Target Type	Polarization	Azimuth			Range			Theoretical RCS (dBsm)	Measured RCS (dBsm)
		PSLR (dB)	ISLR (dB)	Resolution (m)	PSLR (dB)	ISLR (dB)	Resolution (m)		
125cm Square Trihedral	VV	-19.57	-13.99	22.31	-21.35	-12.26	15.94	40.2	39.78
125cm Square Trihedral	HH	-18.16	-13.75	21.25	-21.68	-13.14	17	40.2	38.57
150cm Square Trihedral	VV	-19.12	-14.52	22.31	-19.54	-13.2	17	43.37	40.82
150cm Square Trihedral	HH	-17.62	-12.91	21.25	-20.47	-13.03	17	43.37	39.49



NovaSAR data (HH) over IMGEOS Cal-Val Site on 01-11-2021





Outcome of the study

1. The deployed Square Trihedral CRs are meeting the Point Target Analysis requirements for the envisaged ‘L’ and ‘S’ band frequencies.
2. Calibration parameter assessment are close to the expected values.
3. Computation methodology is working well for the ‘L’ and ‘S’ band frequencies.
4. The suitability of Site and Background is established.

To Continue the study further

- ❑ Few more experiments to be carried out for concurrent observations for co-pol.
- ❑ Cross – Pol: SDH orientation and size suitability to be studied.