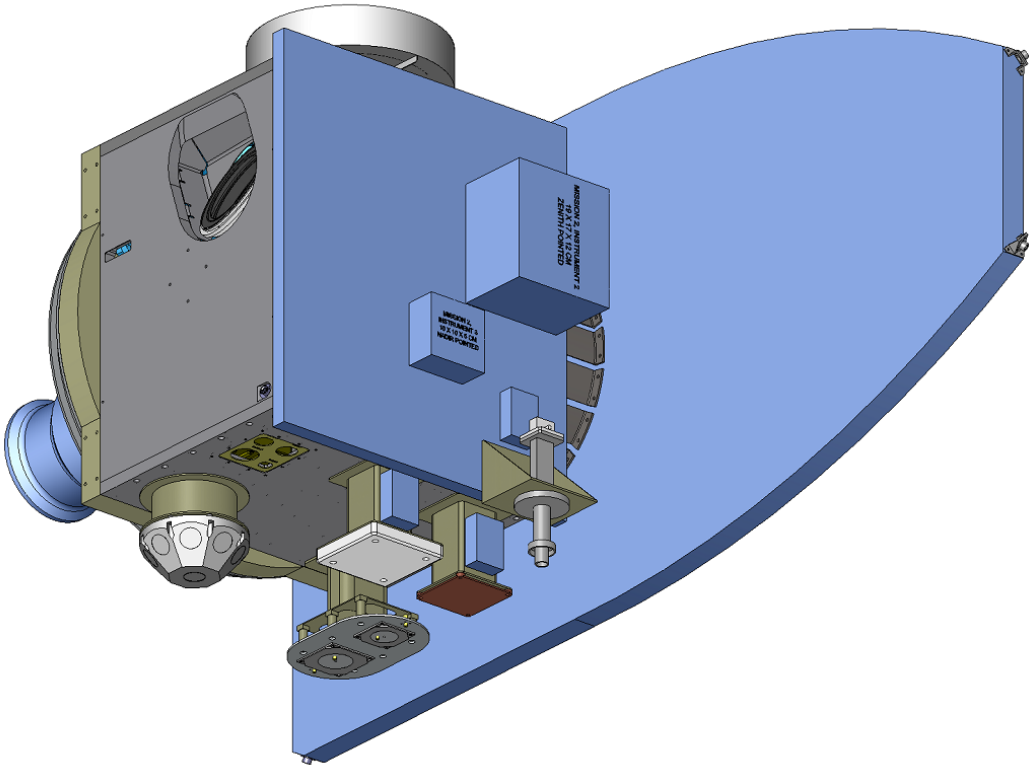
The Geodetic Reference Antenna in Space (GRASP): A Mission to Enhance the Terrestrial Reference Frame

Venture EV-2

Mission Concepts



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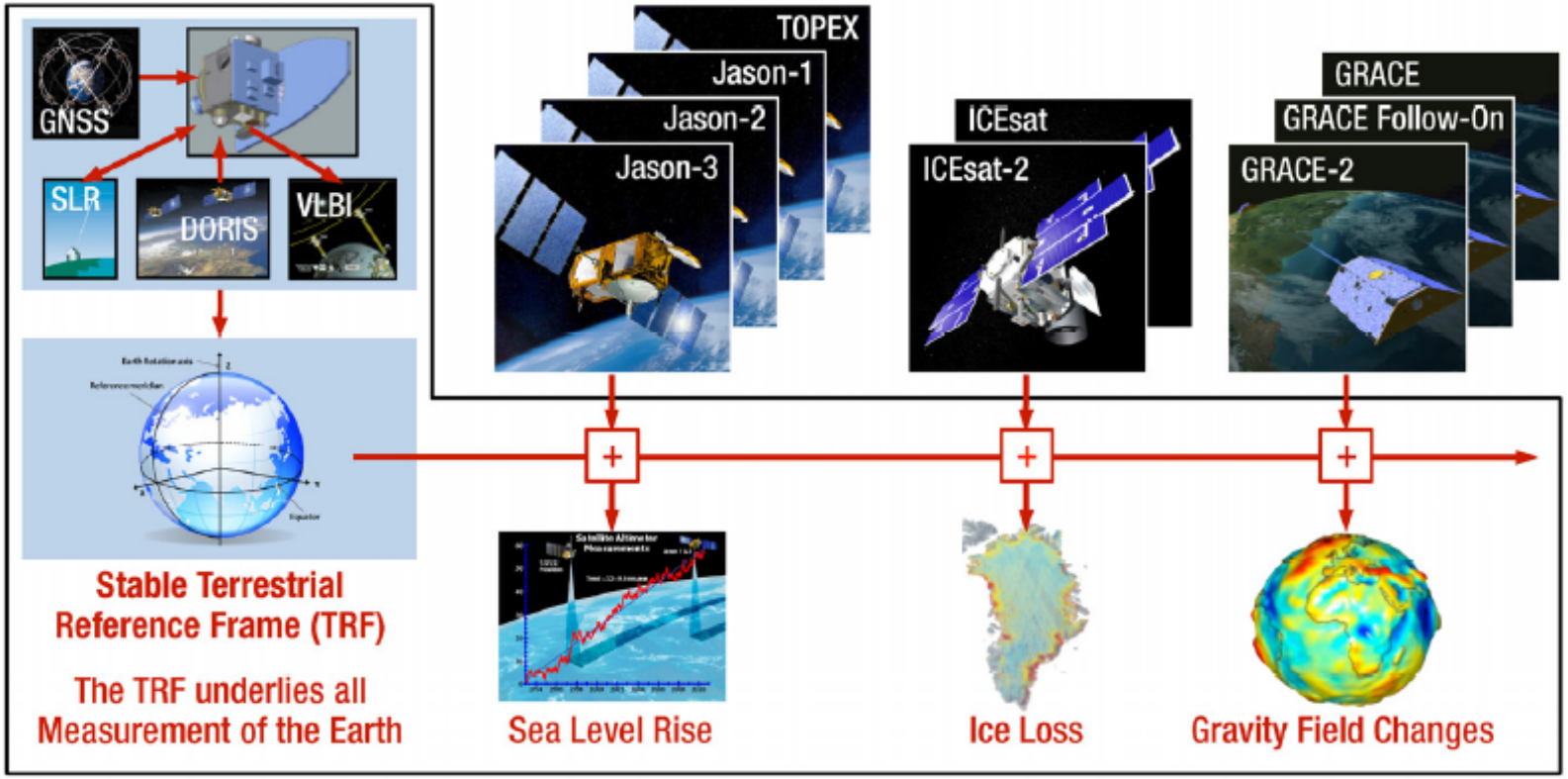
JPL

The Most Complete Geodesy Mission

Collocate all the geodetic technique on a supremely calibrated satellite

- Use as reference for all GNSS antennas (space and ground)
- Determine ground collocation at arbitrary baselines

GRASP enhances science from past and future Earth science missions; ~30 year impact from a 3 year mission

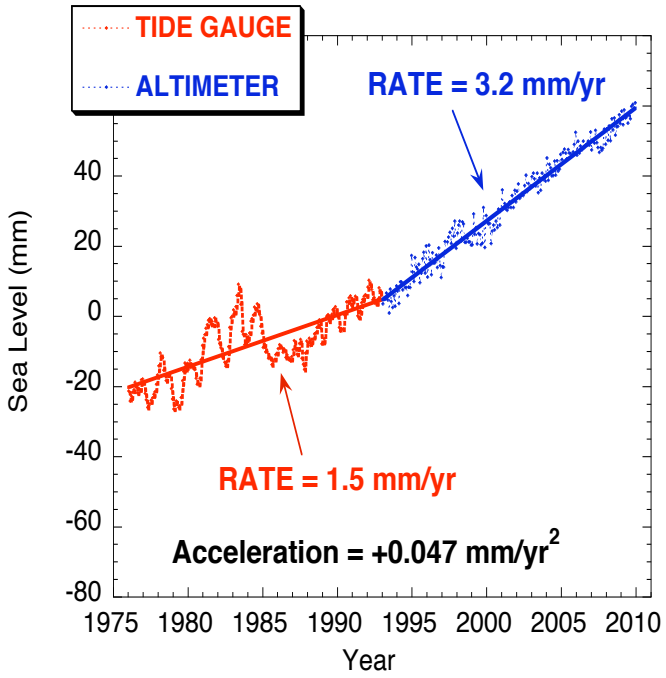


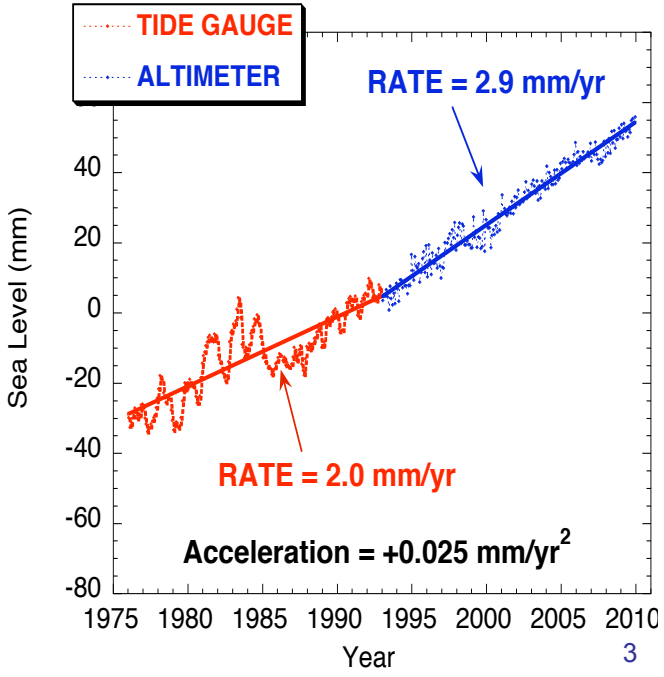
Key Science Goals

- **Meet GGOS goals** for the TRF: ~1 mm accuracy, 0.1 mm/yr stability
- Enable the accurate dissemination of the TRF with GNSS and DORIS to any location on Earth and low Earth orbit
- Measure the long-wavelength variability in the Earth gravity field that are either not observed (degree 1) or poorly observed (J_2) by GRACE
- Reinterpret satellite altimetry and tide gauge records to determine global mean sea level rise relative to the GRASP-based TRF – how is sea level accelerating
- Reinterpret satellite ICESat and GRACE data records to determine ice mass loss relative to the GRASP-based TRF – how is ice mass loss accelerating

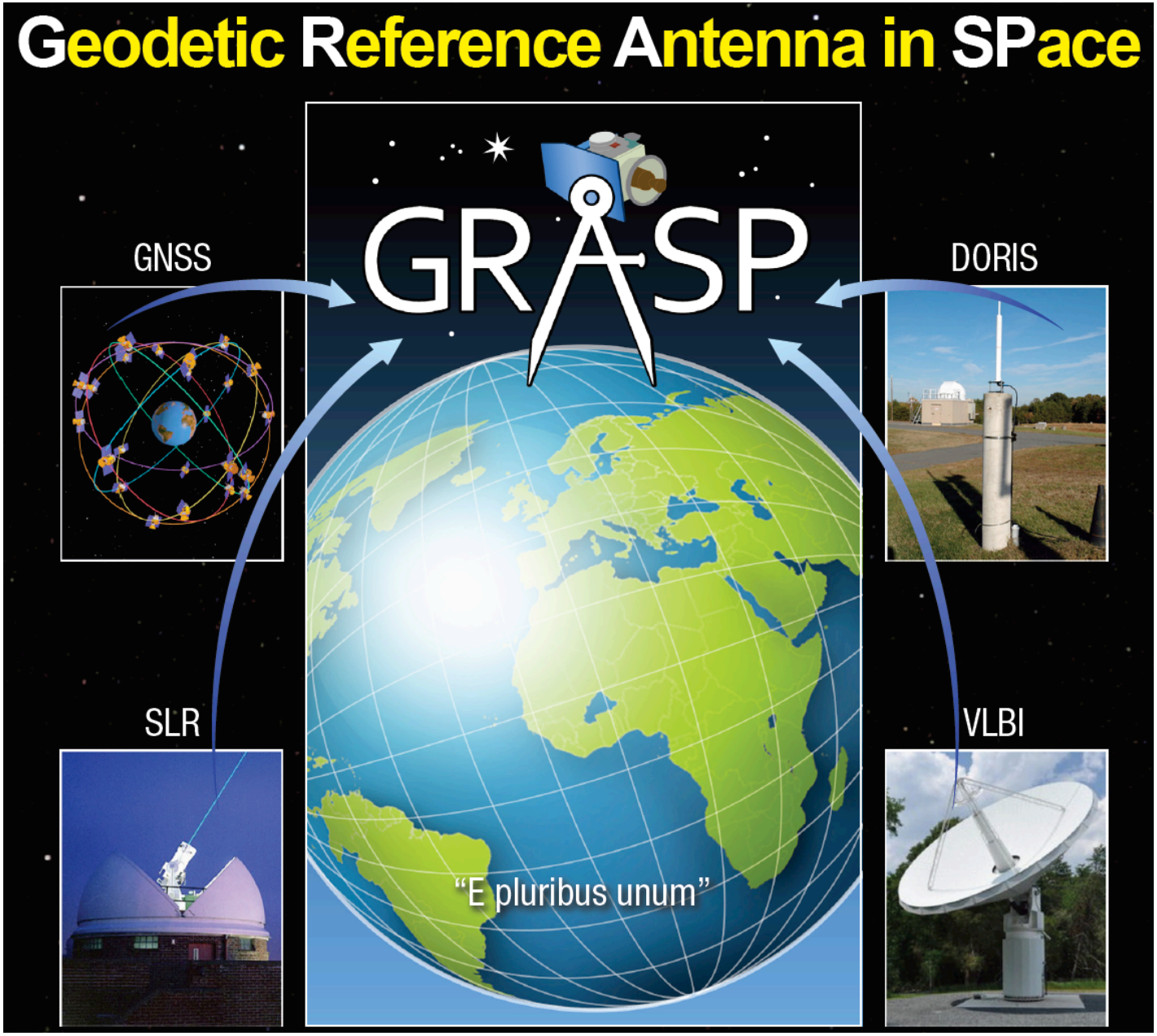
TRF errors readily manifest as spurious sea level rise accelerations

Left: ITRF2005
(based on Church and White, 2011)
Right: ITRF2000
(simulated into the Church and White records)





Geodetic Reference Antenna in SPace



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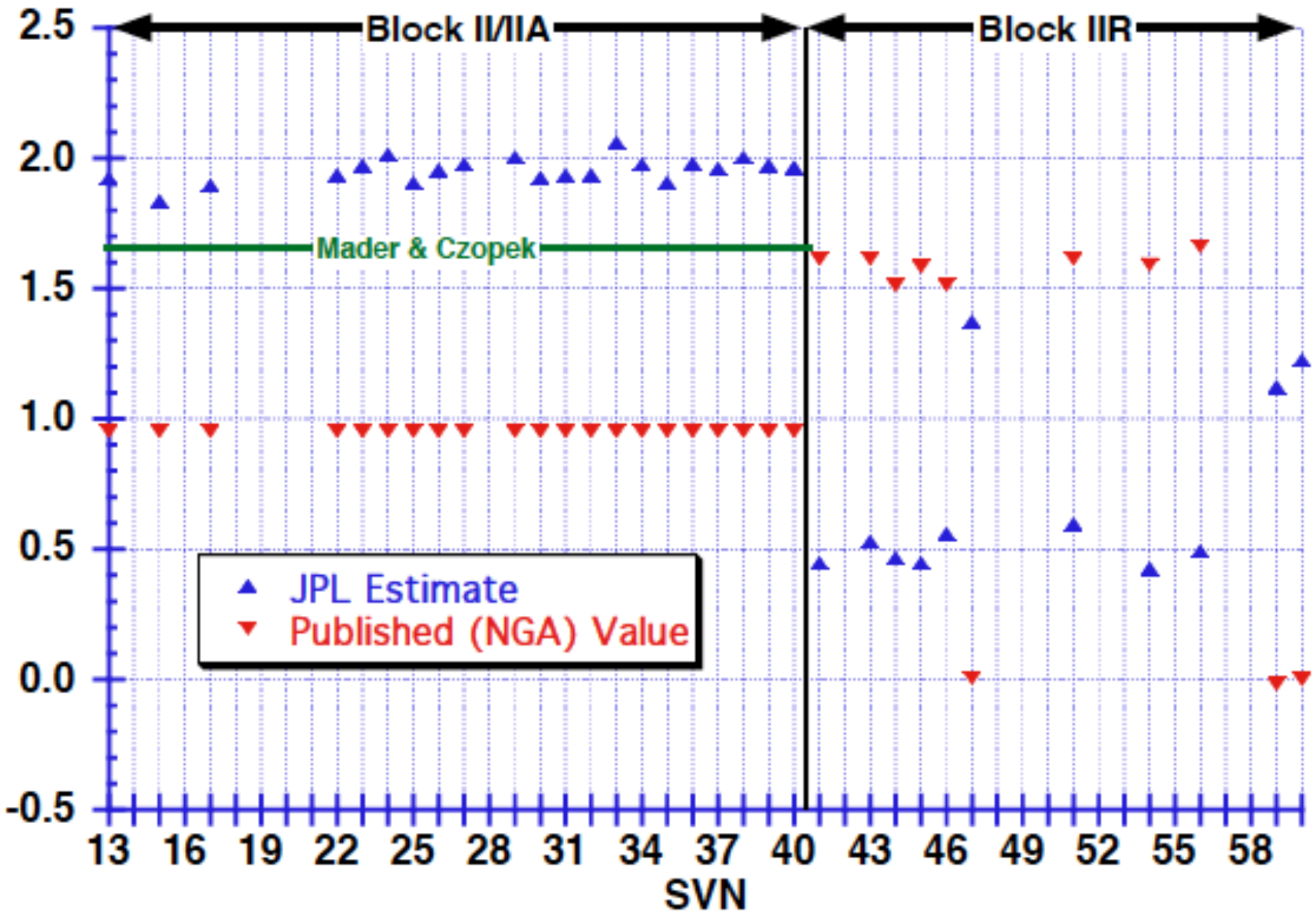
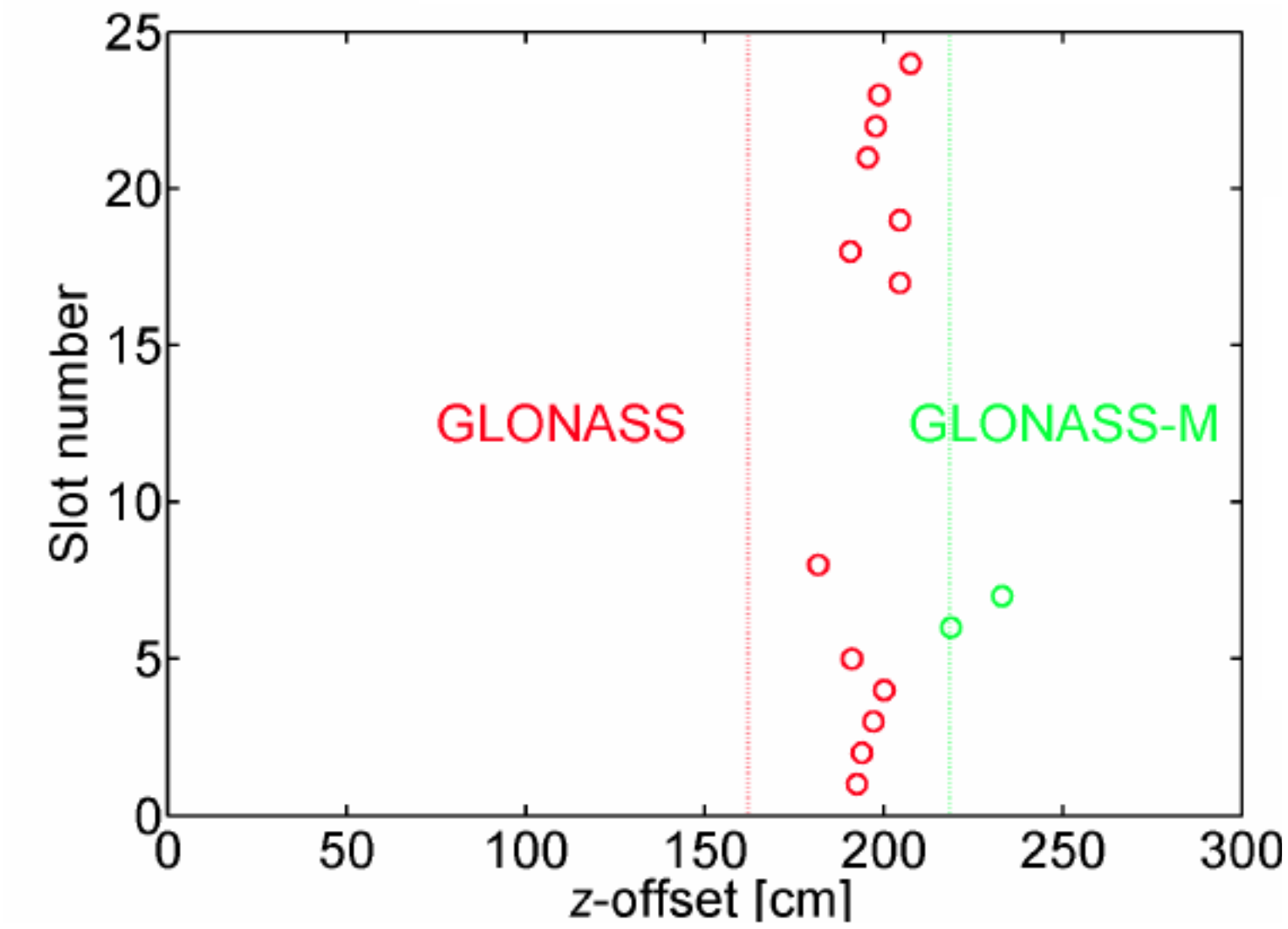
GPS Nadir (+Z) Phase Center Offsets



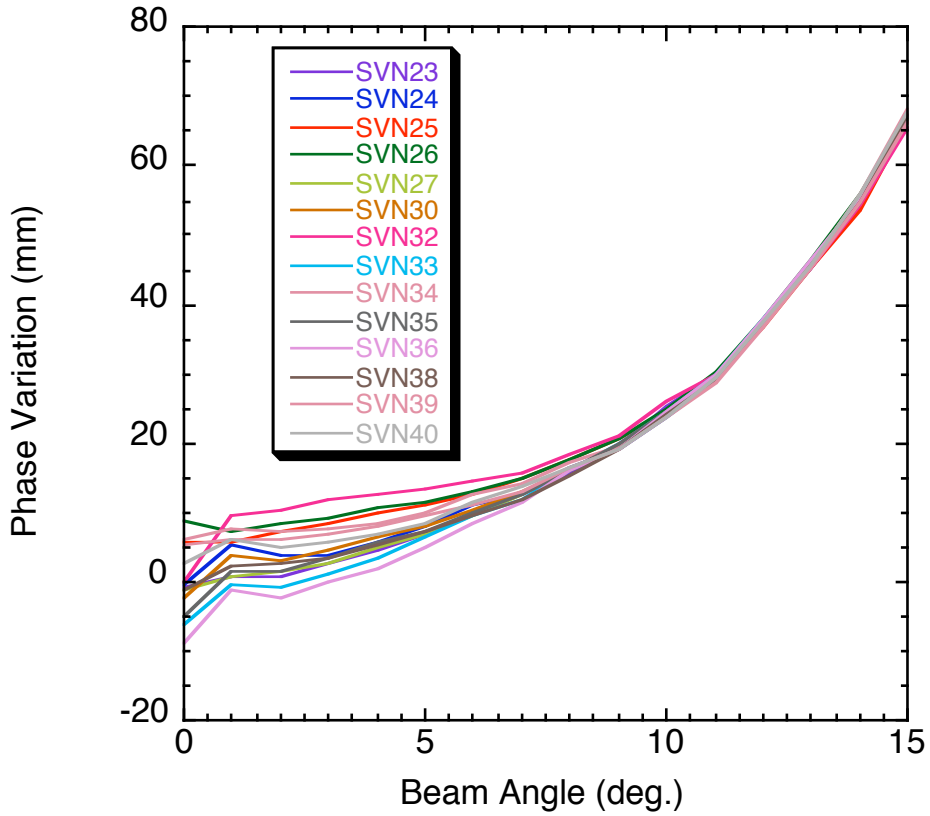
GLONASS Nadir Phase Center Offsets



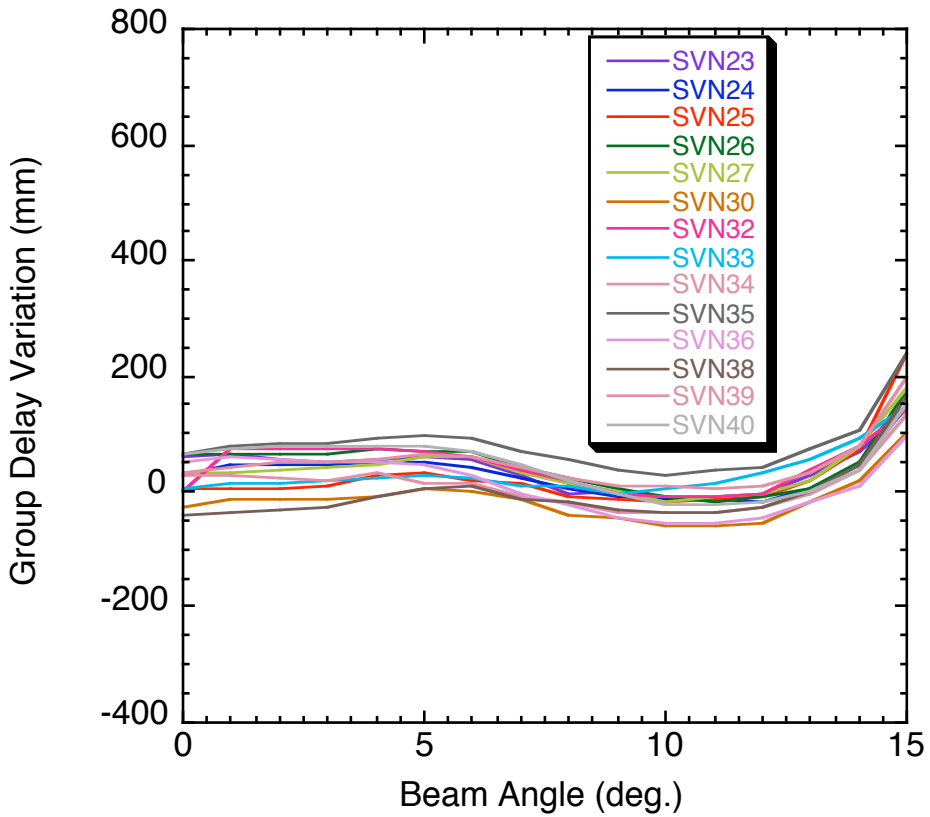
From Schmid et al., 2006

Legacy (Block IIA) Antennas
Total Variation Relative to S/C Center of Mass

PHASE (LC)

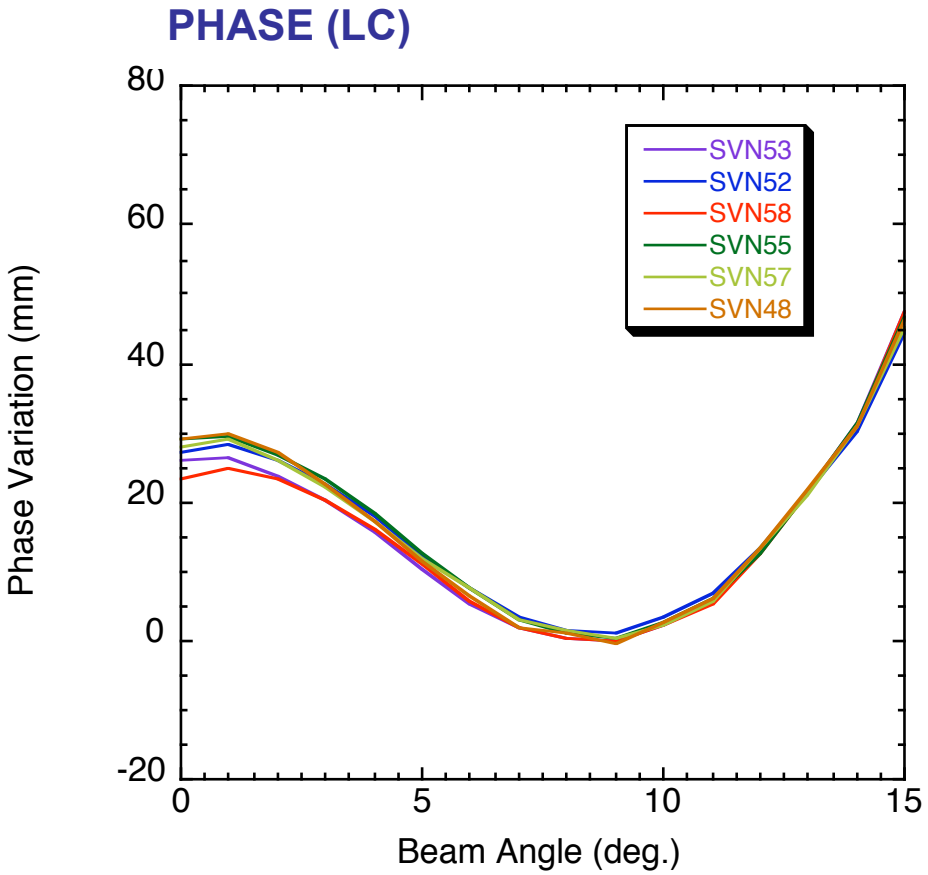


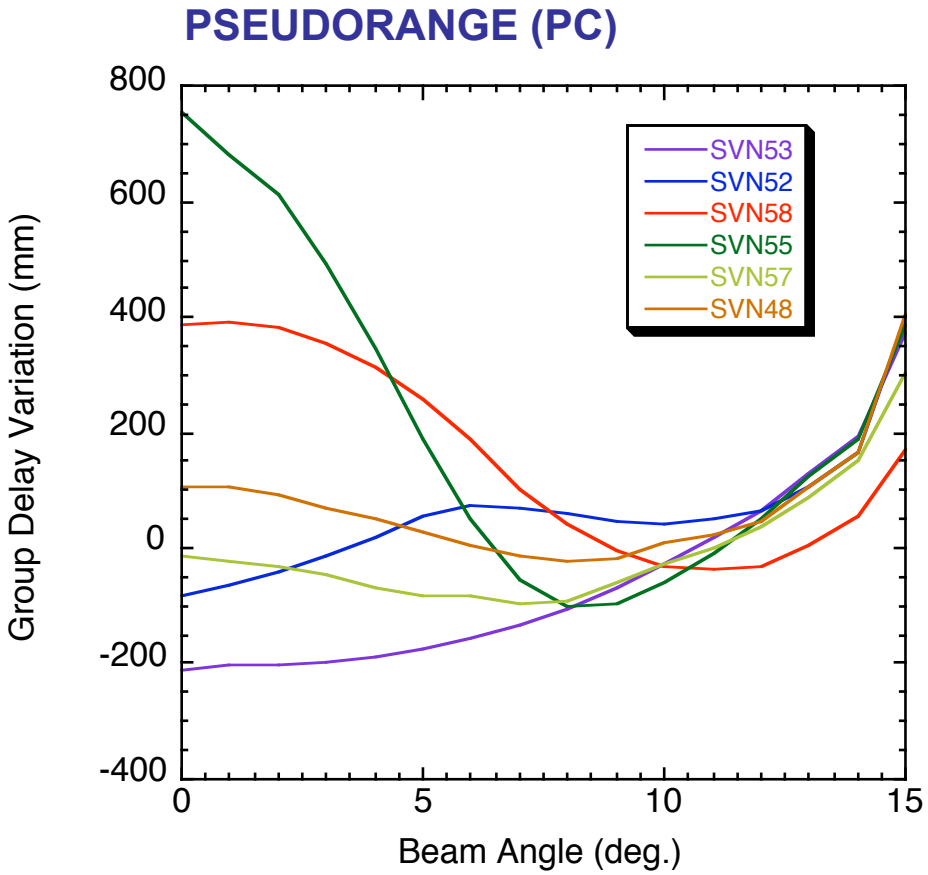
PSEUDORANGE (PC)



- Good consistency among individual PRNs for both phase and group delay
- LC map consistent with a spherical waveform with offset R: *R* (*1 – cos el*); PC is not consistent with a spherical waveform

Modernized (Block IIR-M) Antennas
Total Variation Relative to S/C Center of Mass

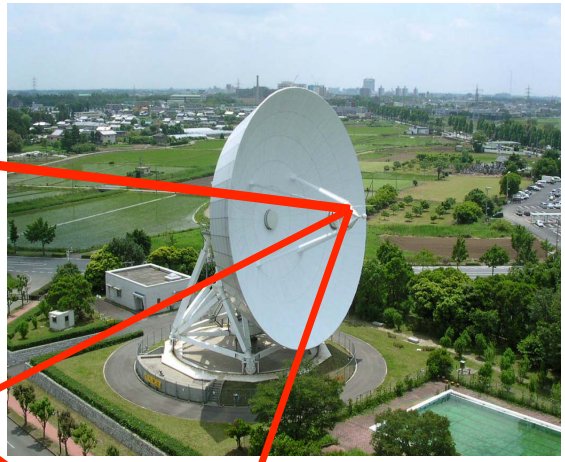




- Significant inter-spacecraft discrepancies for group delay (right)
- Similar-sized discrepancies observed for Legacy Block IIR (IIR-A) and IIR-B
- Neither phase nor group delay maps are consistent with a spherical waveform

Ground Site Ties Between Techniques

SLR/LLR



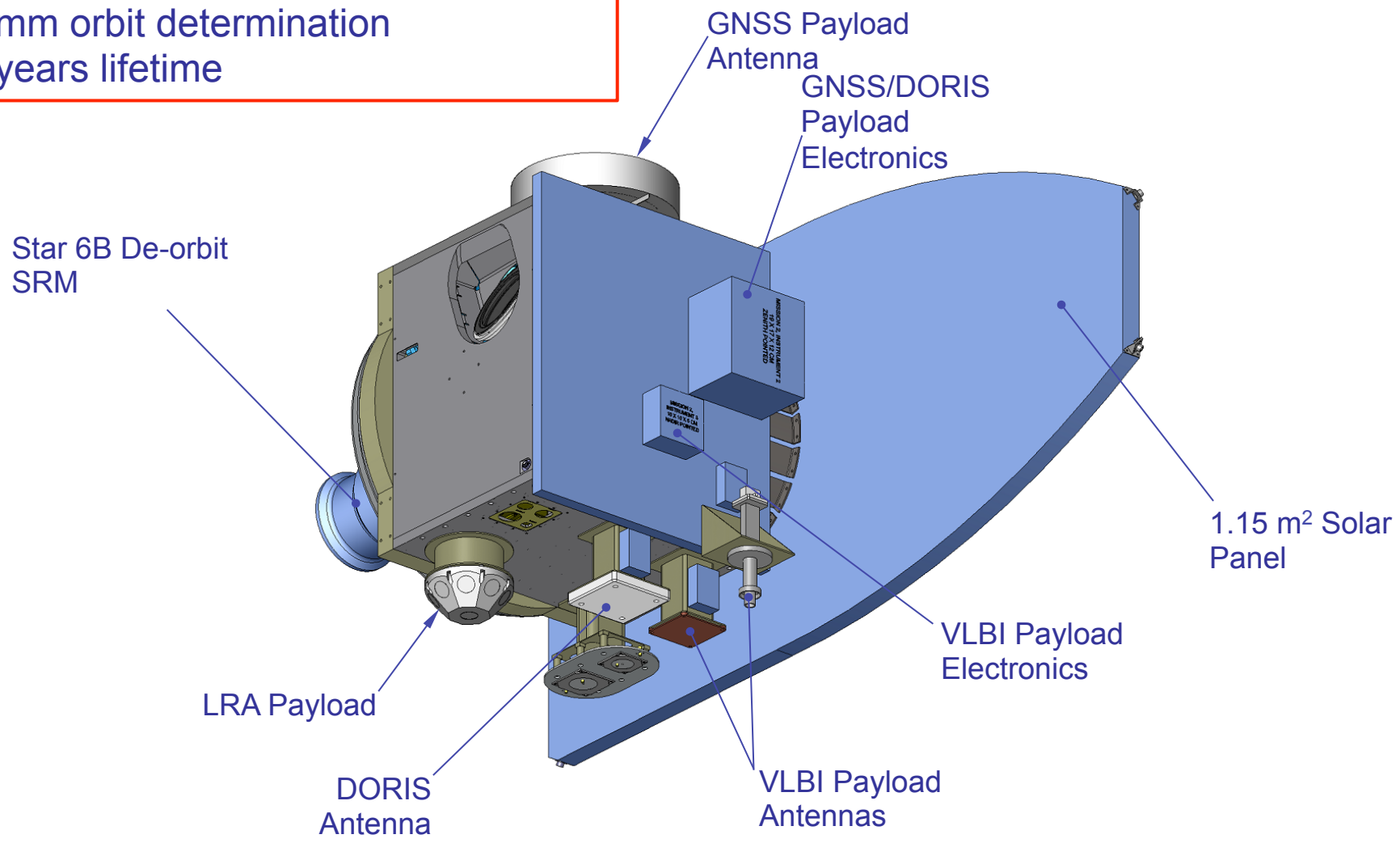
VLBI

GNSS

DORIS

The GRASP Spacecraft

Orbit: 850x1350 Sun-synch
Collocate sensors and CM to 1 mm
1 mm orbit determination
3 years lifetime



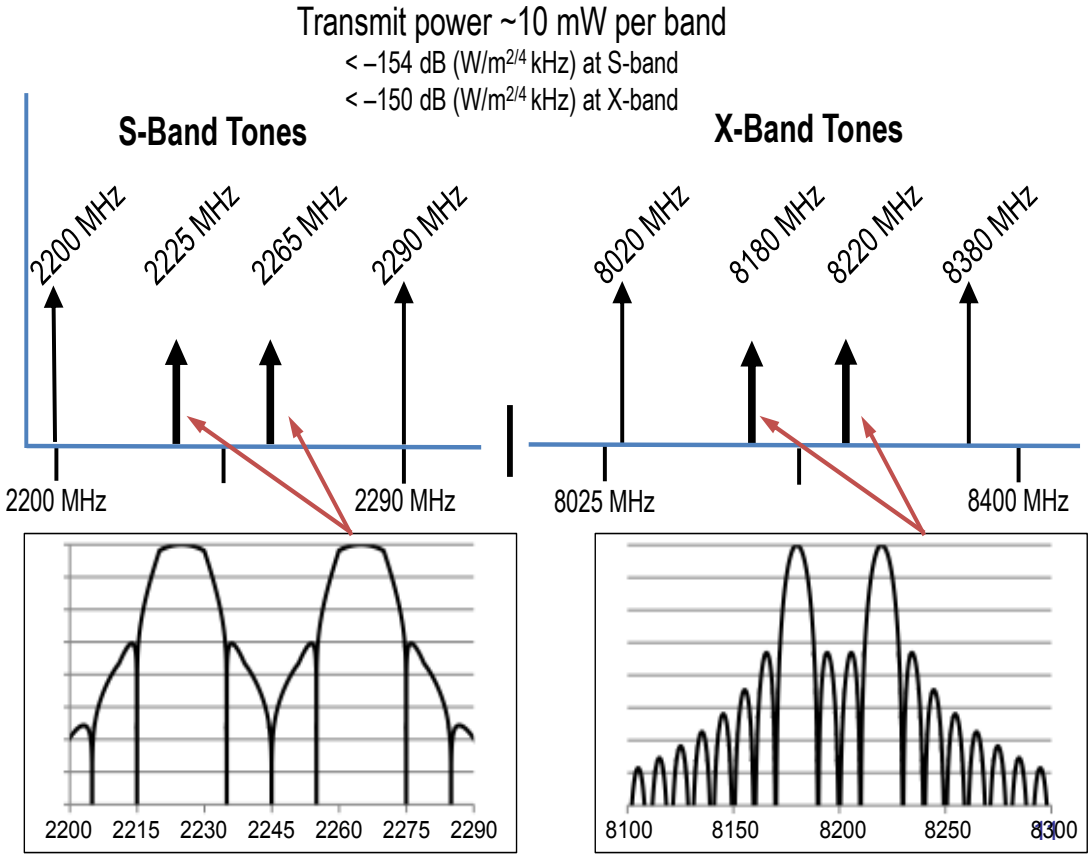
Novel Instruments on GRASP

DORIS: New receiver capability incorporated into the JPL's *TriG* GNSS receiver (next generation BlackJack, with GPS, GLONASS, and Galileo all-in-view capability)

- DORIS *phase* measurements from up to 7 beacons
- Common time tags with GNSS measurements
- CNES already provided ICD; may ultimately contribute the standard DORIS receiver

VLBI Tone Transmitter (VTT): A new instrument with heritage in several GRAIL sub-systems

- Signal is compliant with NTIA regulations while compatible with both present-day VLBI and VLBI2010
- High precision ionospheric-free observables (1-σ, 1-sec)
  - 0.2 mm pseudorange (1 sec)
  - 0.01 mm phase (1 sec)
- JPL will write ground software to extract Level-1 (phase and pseudorange) observables from the broadband VLBI data; publish in RINEX-like format



Next Step: Looking for Partnerships

- We have a well-reviewed, complete mission concept
- We have a very strong and broad support from the geodetic community
- We have a broad base international scientific and technical leadership
- We aim to unify and calibrate all GNSS to enhance science inter-operability
- We have an open data policy

We are soliciting partnerships with agencies that are able to provide cost sharing or in-kind services, for example:

- Launch services
- Payload components
- Bus
- Ground system

Estimated total mission cost: $100M over 6 years.