Technology Demonstration of the Geodetic Reference Instrument Transponder for Small Satellites (GRITSS)

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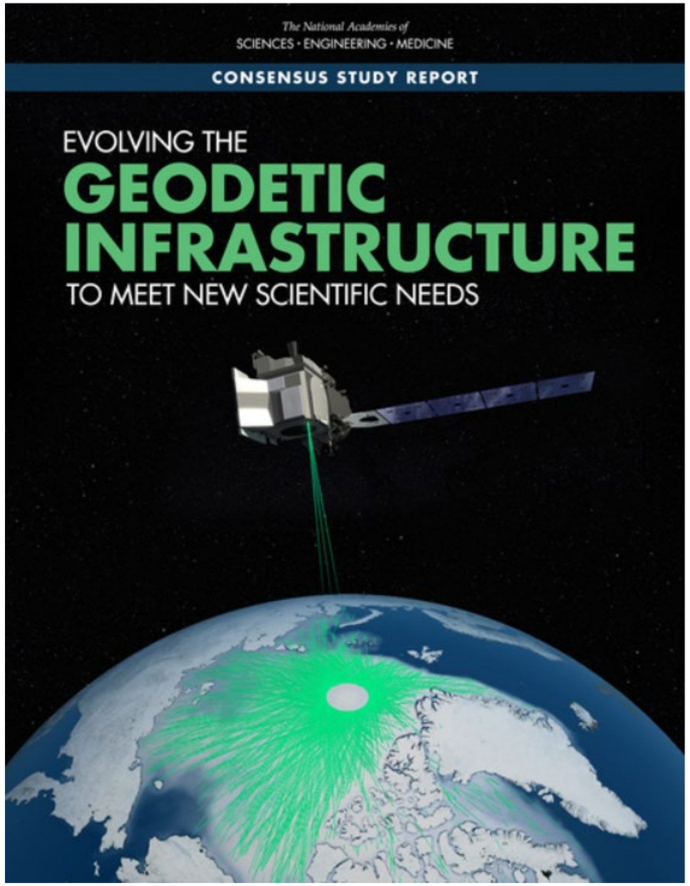
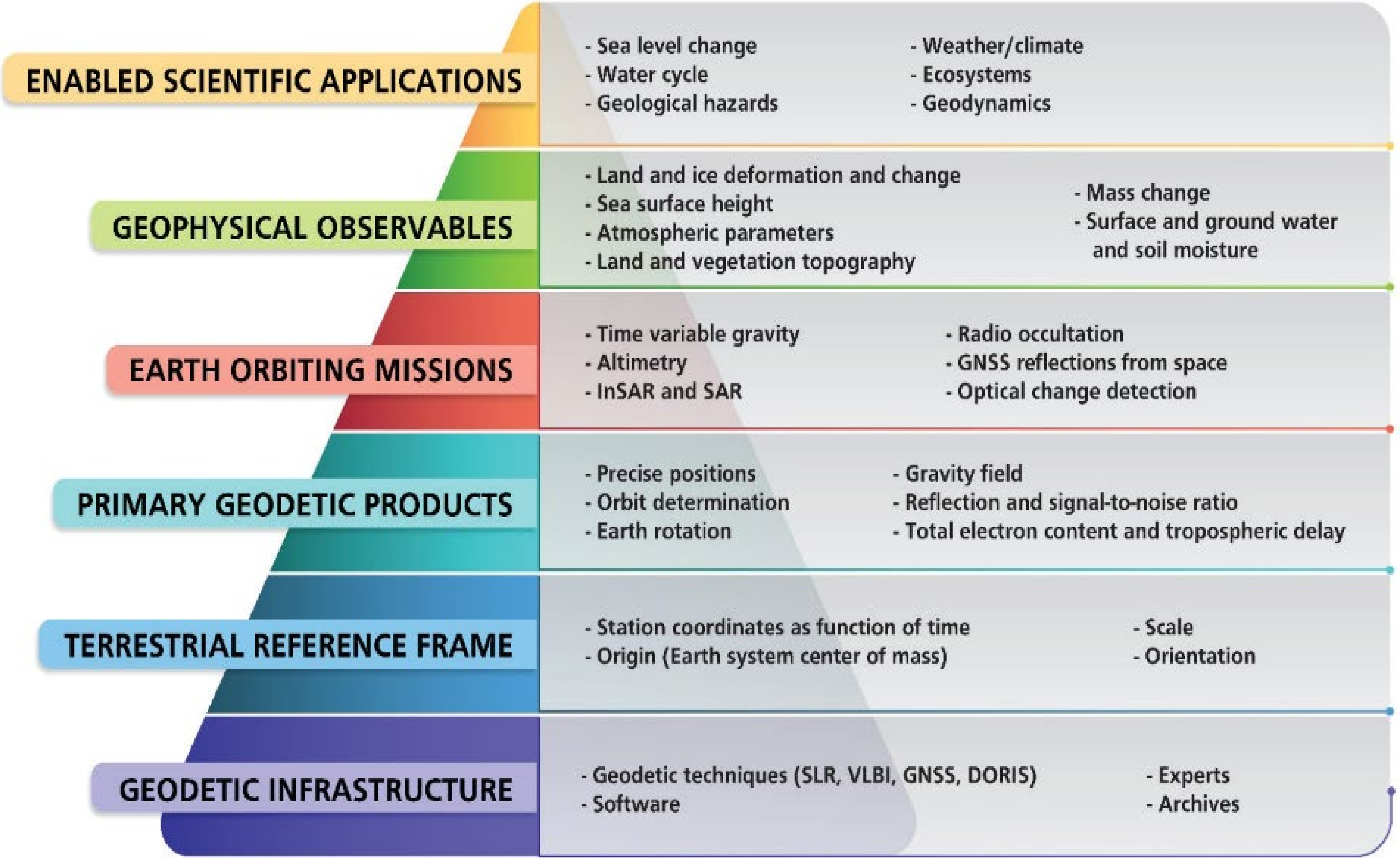
Geodetic Infrastructure is the Foundation for Enabling Many Scientific Applications





National Academies: Evolving the Geodetic Infrastructure to Meet New Scientific Needs https://doi.org/10.17226/25579

The Geodetic Measurement System

VLBI
- Orientation of ITRF with respect to ICRF
- ITRF Scale

SLR
- Origin of ITRF (Earth's CM)
- ITRF Scale
- Position spacecraft in ITRF ("Orbits")

GNSS
- Precise monitoring of Polar Motion and Rotation Rate
- Position spacecraft in ITRF ("Orbits")
- Position instruments on Land and Sea (Tide Gauges and Buoys, Geodetic Instruments)

DORIS
- Position spacecraft in ITRF ("Orbits")
- Enhances global distribution of ITRF Station positions and velocities

Technique Connectivity (Station Co-Location)

Fully Define ITRF

VTS: ITRF Performance Improvement

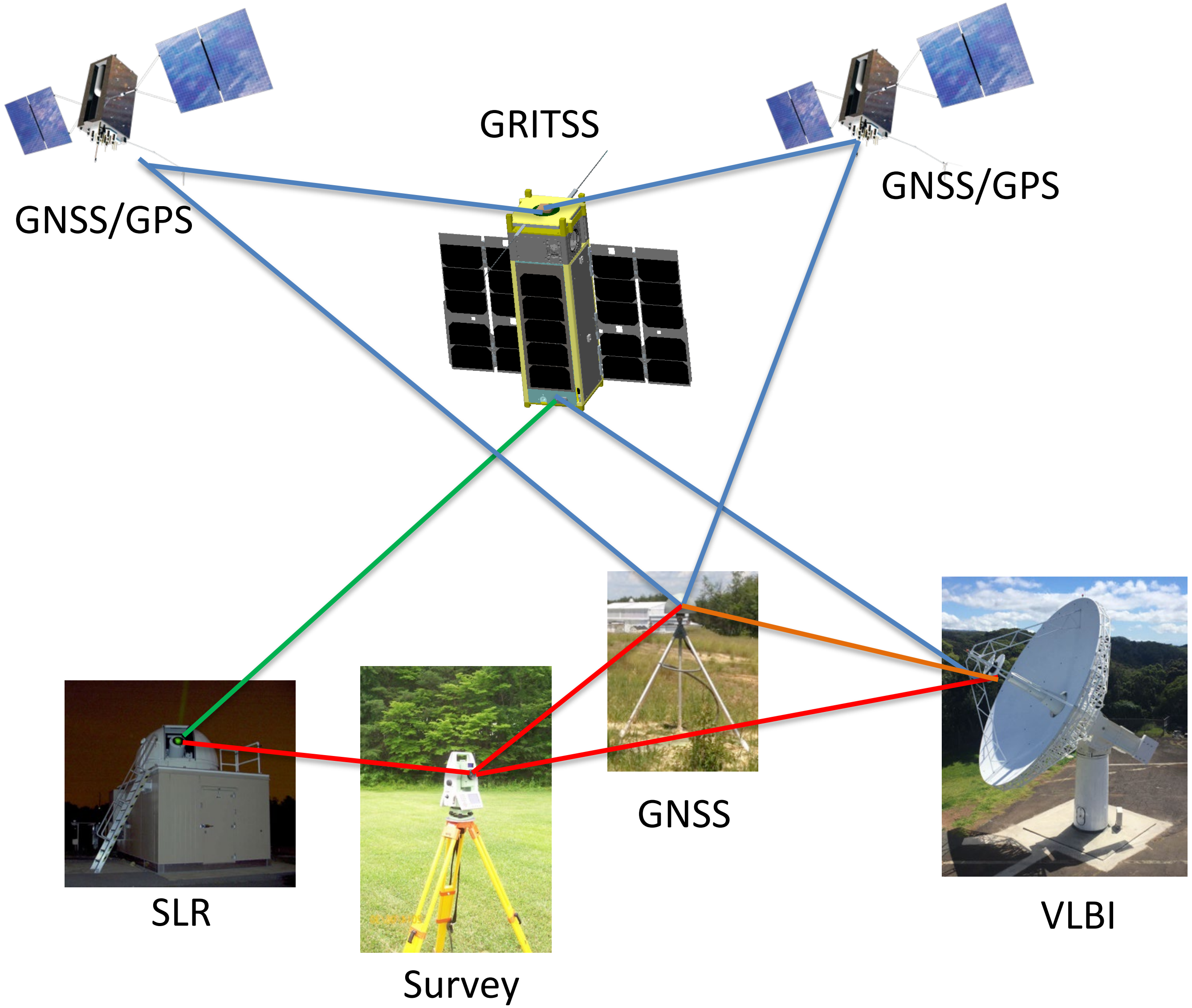
Origin, Scale, Orientation

Low-Density Global Distribution

High-Density Global Distribution

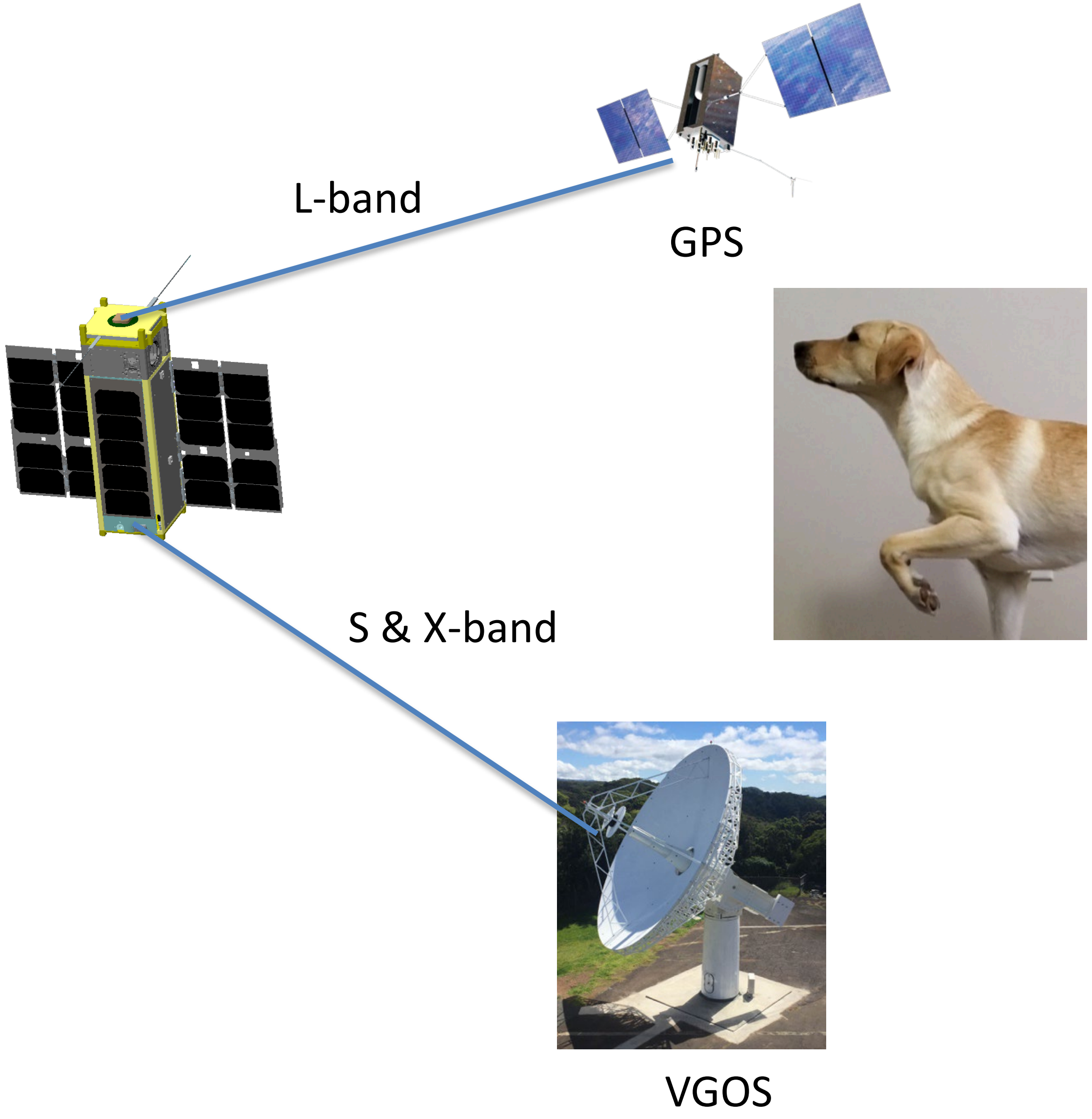
Geodetic Colocation In Space

Observations of a common space-based reference has the potential for reducing the uncertainty in the local-ties to the mm level thus improving the ITRF combination.



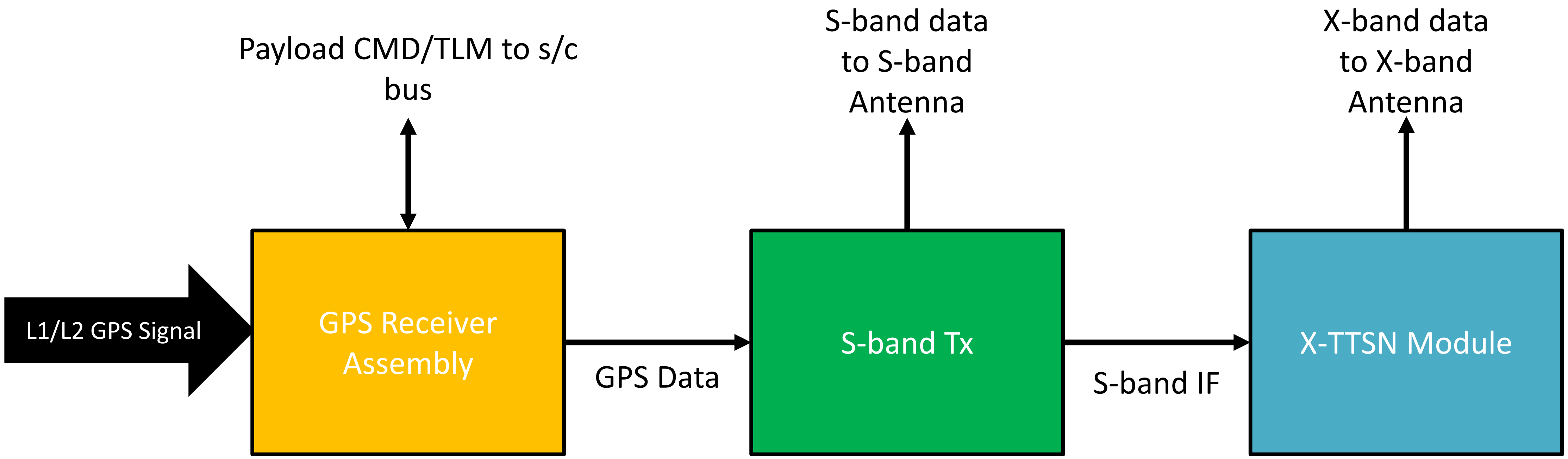
The GRITSS Dog-Leg

GRITSS upconverts and transponds GPS signals to individual VGOS ground stations.



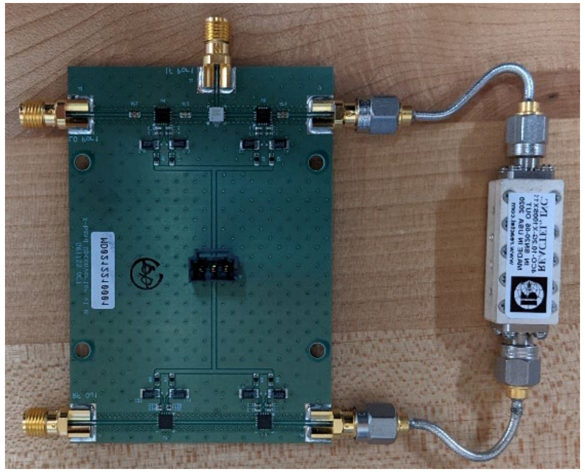
GRITSS Instrument Subsystems

- GPS Receiver Assembly
- Ultra-Stable Oscillator (USO)
- S-band Transmitter - 3.2 GHz
- X-band Transmitter and Timing extension (X-TTSN) Module - 10.2 GHz
- Antennas (L1/L2 GPS, X-band, and S-band)
- Laser Retro-Reflector



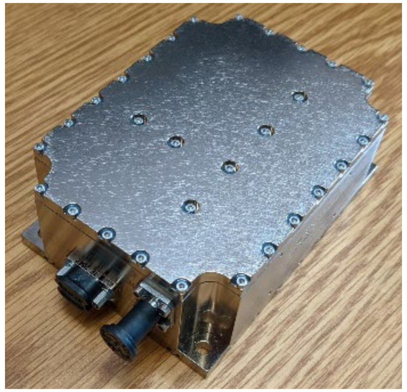
Completed Technology Readiness Level 5 Development

S-band Transmitter



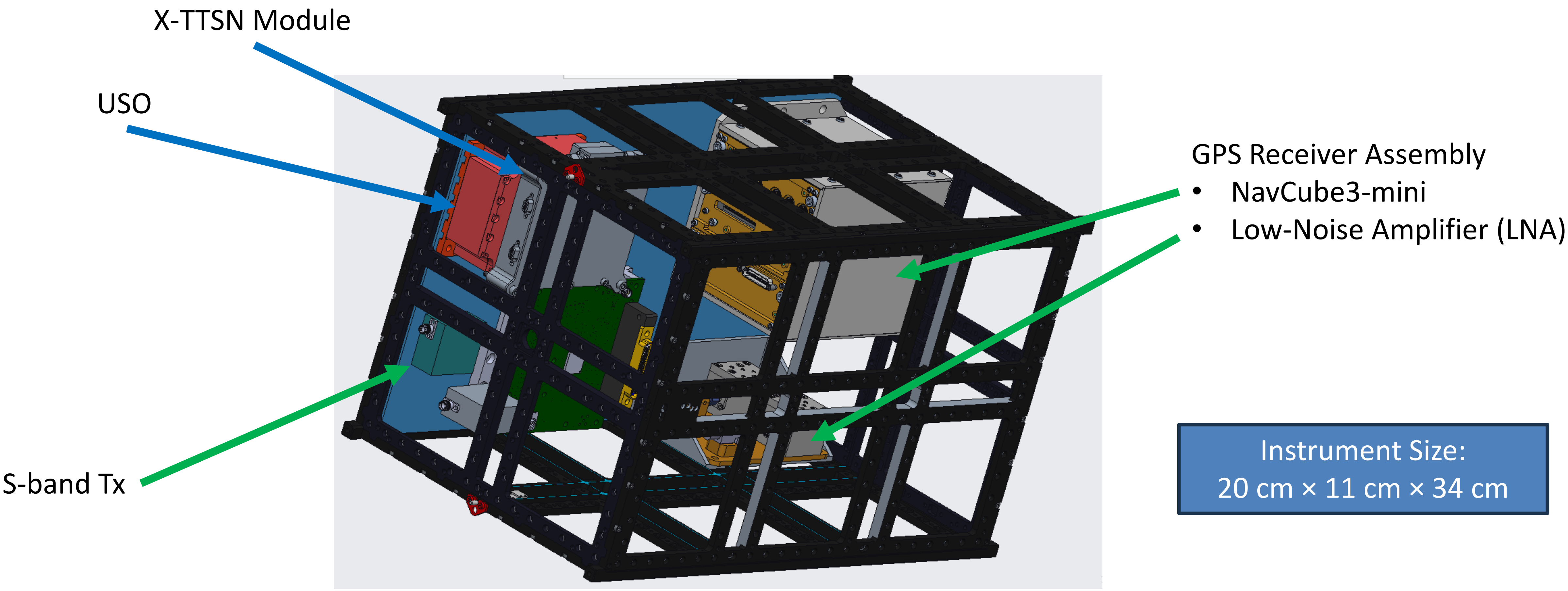
X-band Transmitter

GPS Receiver Assembly



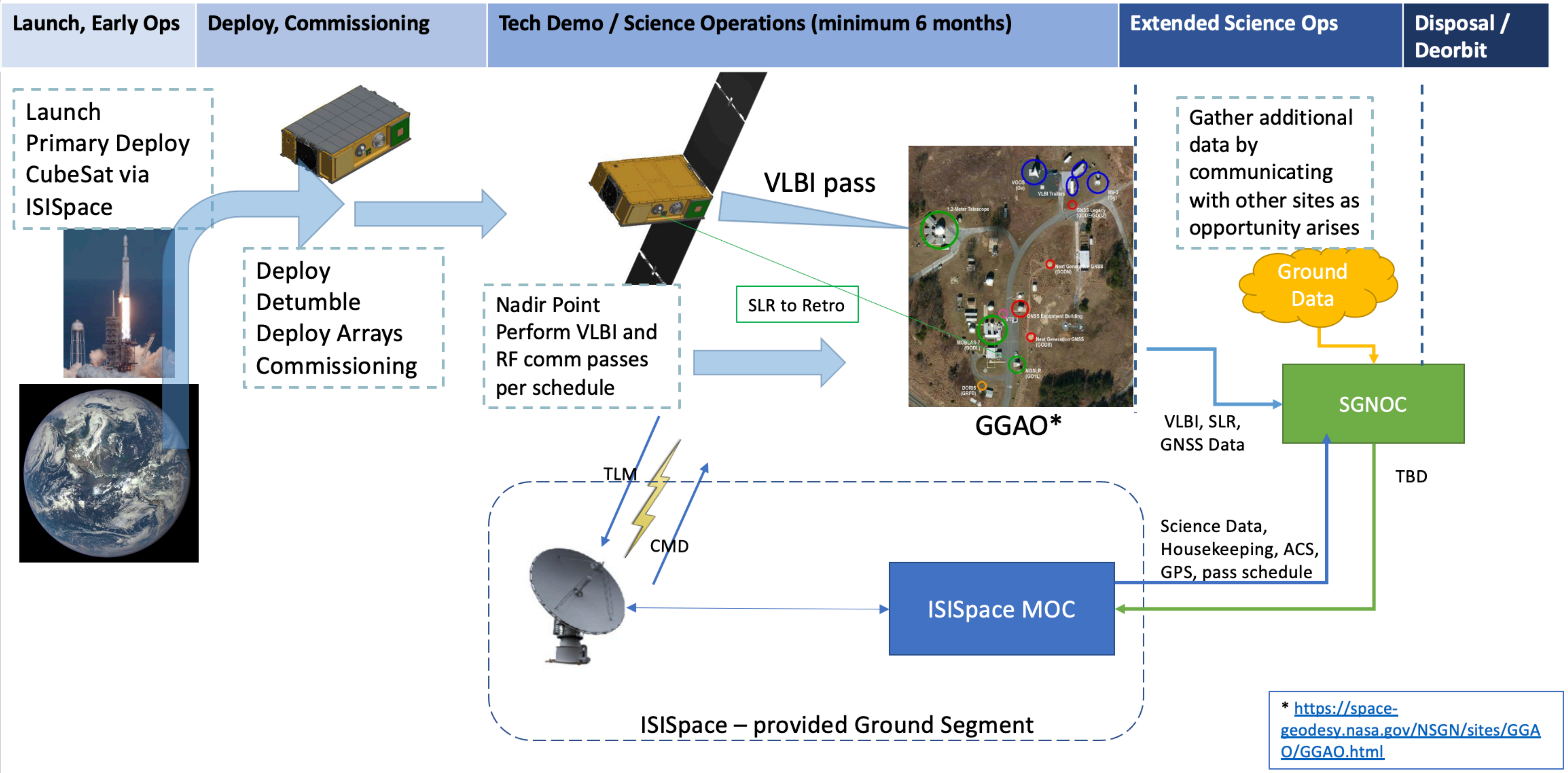
Wenzel USO

GRITSS Instrument Fits Within 6U Volume



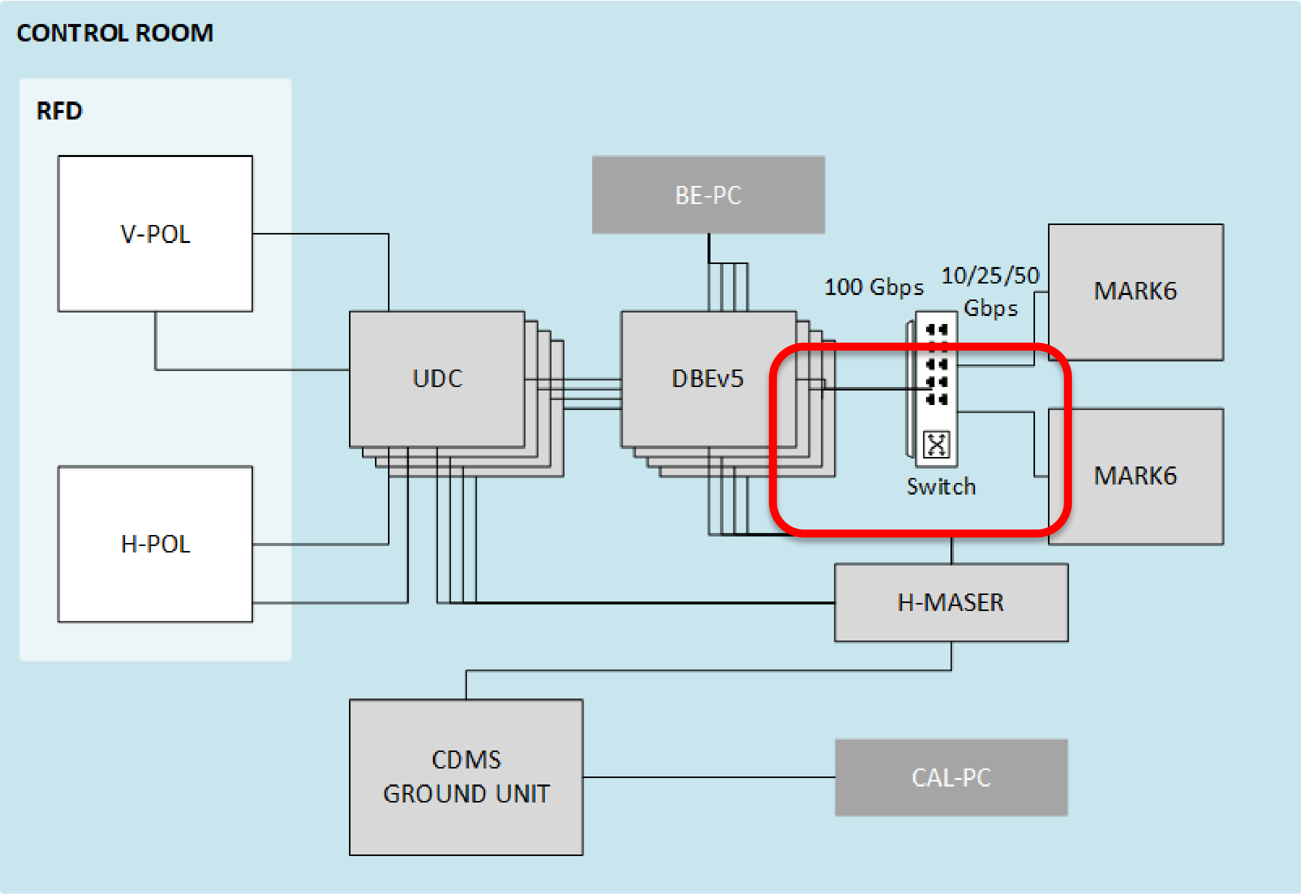
Instrument Size:
20 cm × 11 cm × 34 cm

Concept of Operations



High-level VGOS Signal-Chain Architecture: DBEv5

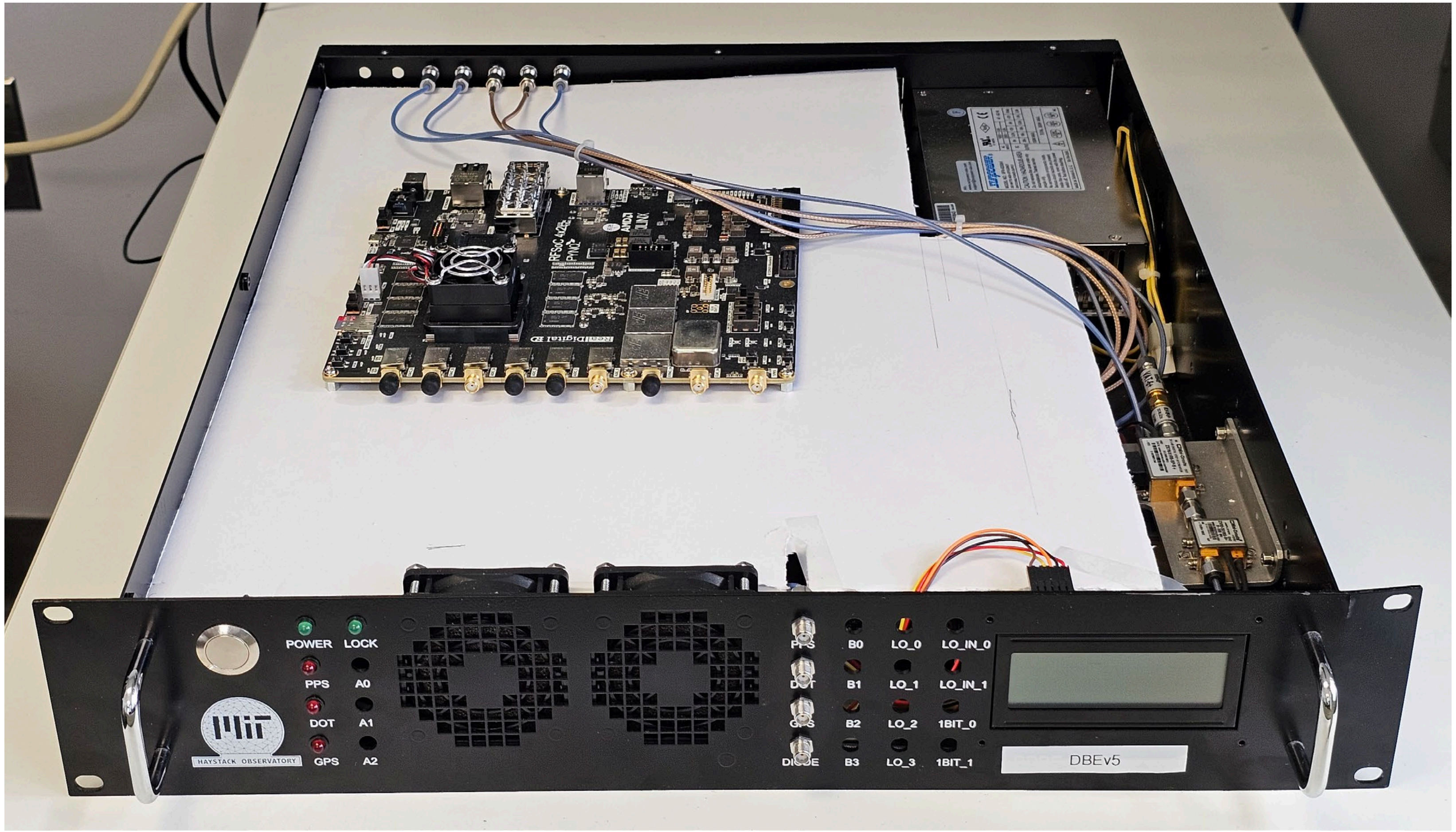
- GRITSS ground segment is based on VGOS signal chain by MIT
- R2DBE (v4) upgraded to a drop-in DBEv5 replacement, an RFSoC-based DBE that also includes a GRITSS personality
- DBEv5 outputs to 100 GbE switch, then 10/25/50 GbE to Mark6



VGOS/DBEv5 architecture

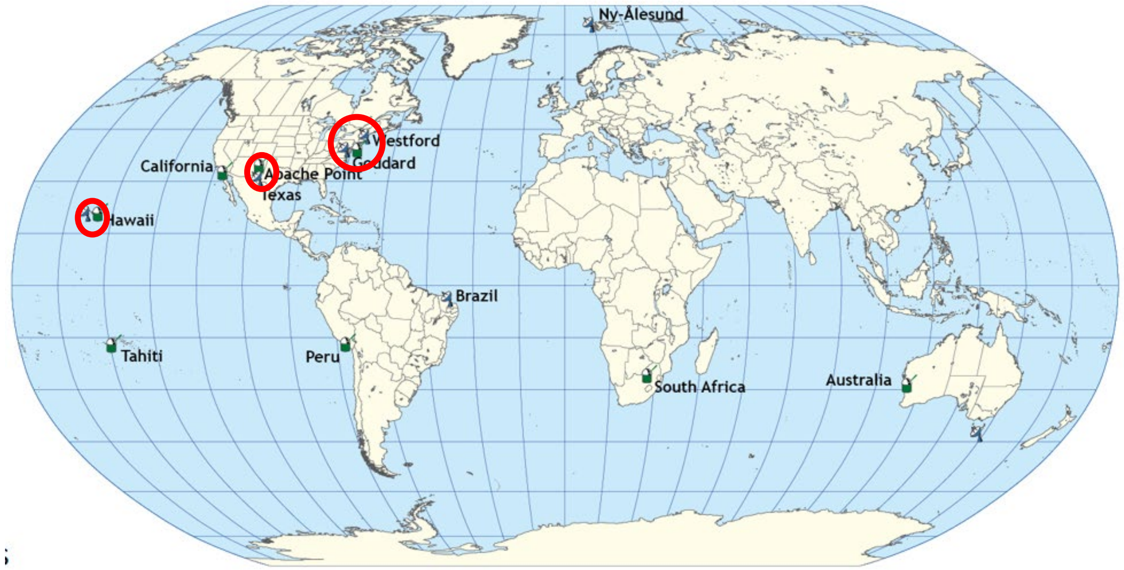
Digital Backend version-5 (DBEv5): GRITSS personality

- DBEv5 replaces the R2DBE (DBEv4) with a smaller-footprint RFSoC 4x2
- For GRITSS, DBEv5 outputs a single 32-MHz channel from PFB, full-bit depth, VDIF complex format
- Supports PPS-triggered capture of raw 32-MHz ADC samples



The GRITSS Demonstration Mission

- A NASA Earth Science and Technology Office sub-class D technology demonstration mission
- Jointly developed by the University of Massachusetts, Lowell and NASA GSFC
- 12UXL CubeSat, launch, and operations services provided by ISISpace in the Netherlands.
- Nominal operations: 1 year (extendable)
- Orbit: 550-km sun-synchronous, Nadir pointing
- Only broadcasts GRITSS signals over VGOS stations as spacecraft power permits



Initially targeting US NASA VGOS stations and will invite other VGOS stations to participate after successful first phase

Station Compatibility

- ✓ Custom VGOS-GPS receiver developed for Technology Readiness Level 5 testing that can be used instead of VGOS Digital Back End if necessary.
- ✓ Tested compatibility of GRITSS-like signals with VGOS signal chain at Westford.
- ✓ Measured VGOS signal-chain electrical delays at GGAO.
- ✓ Demonstrated ability to track satellites by three NASA VGOS antennas.
- ✓ Verified Septentrio PolaRx5TR GNSS receiver meets GRITSS timing requirements.
- ◆ Migrate Digital Back End to RFSoC-based architecture and develop GRITSS personality
- ◆ Modify the VGOS VDIF and Mark6 recording mode for GRITSS

Project Status

- ✓ 2022 - Demonstrated Technology Readiness Level 5
- ✓ July 2023 - Payload Preliminary Design Review
- ✓ Feb 2024 - Spacecraft Design Review
- ✓ Apr 2024 - Payload Final Design Review
- ◆ Oct 2024 - Spacecraft Final Design Review
- ◆ May 2025 - Instrument-Spacecraft Integration and Test
- Oct 2025 - Launch

Summary

- GRITSS will demonstrate a space-tie using the novel approach of transponding the GPS signals to a VGOS antenna.
- GRITSS is on a fast-track for launch and operations in 2025.
- We look forward to working with other international VGOS stations as part of an extended mission!