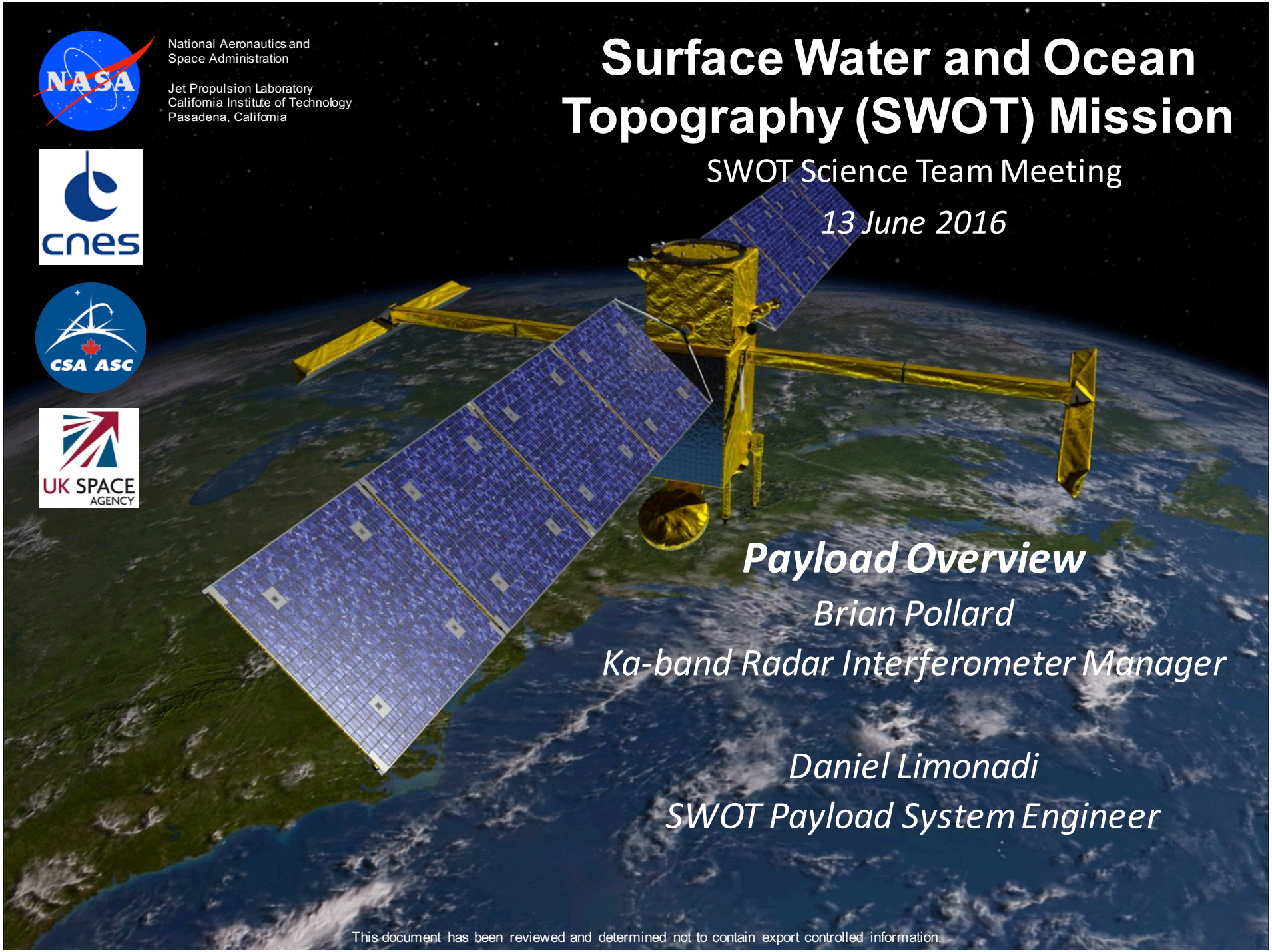
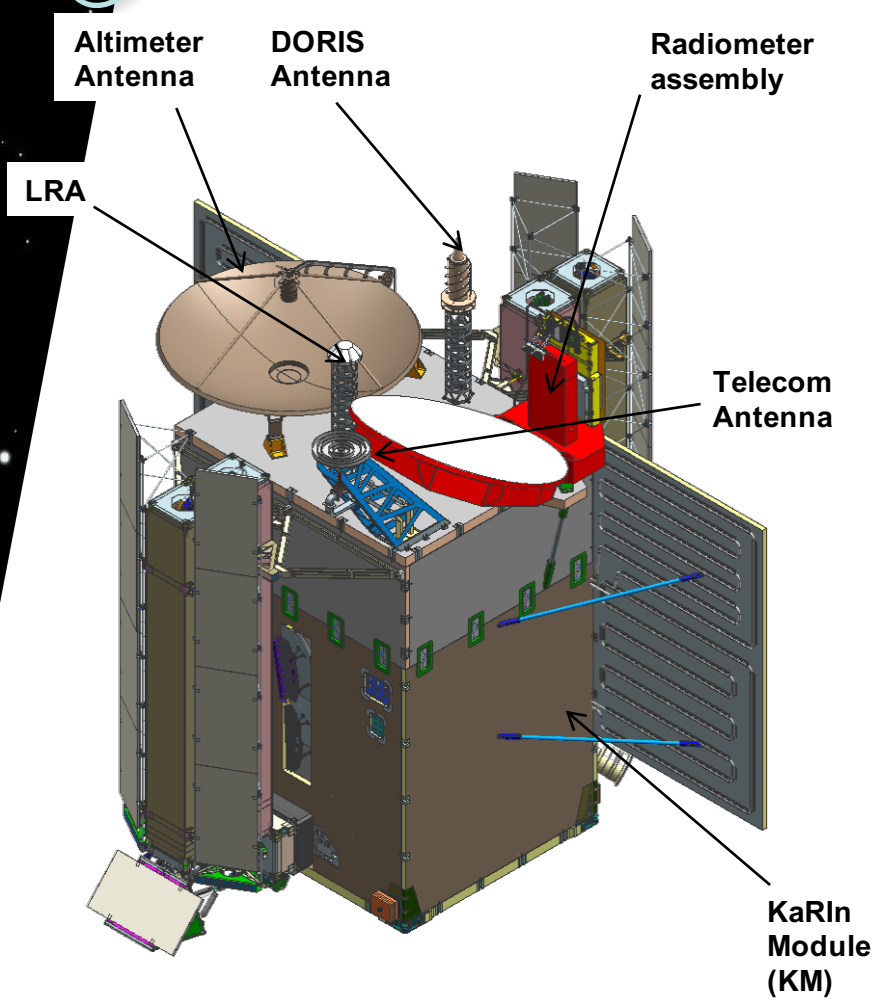
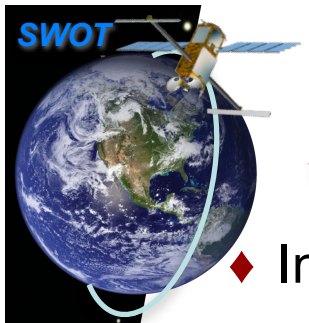

National Aeronautics and
Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California
Surface Water and Ocean Topography (SWOT) Mission
SWOT Science Team Meeting
13 June 2016
Payload Overview
Brian Pollard
Ka-band Radar Interferometer Manager
Daniel Limonadi
SWOT Payload System Engineer
This document has been reviewed and determined not to contain export controlled information.

Payload Composition

Payload (PL)



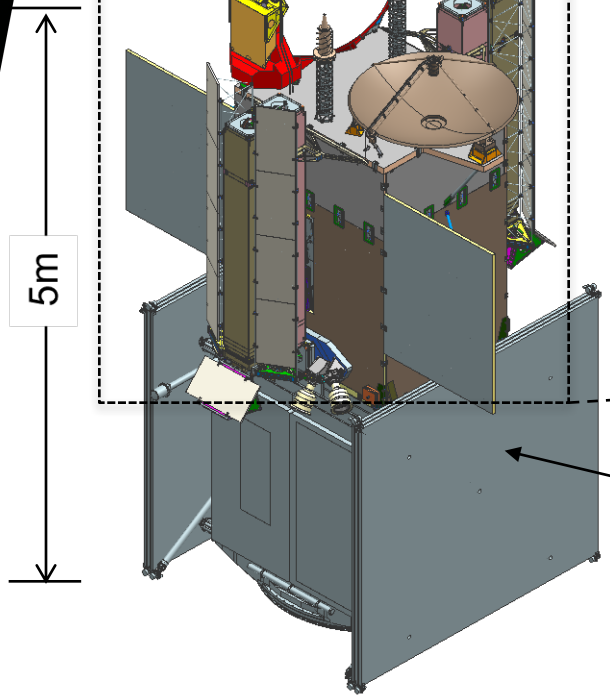
- X-band Telecom (JPL)
  - *For high rate downlink of P/L data*
  - *All systems under consideration have flight heritage*
  - *dual active channel*
- Ka-band Radar Interferometer - (JPL) - KaRIn
  - *The primary instrument, to measure a swath of surface elevations*
  - *CNES-provided RF subsystem*
  - *CSA-provided EIKs (part of high power assembly)*
- Nadir Altimeter (CNES) - NA
  - *To measure absolute height, calibration at cross-overs, ionospheric delay*
  - *Ku/C-band, nadir looking*
  - *Significant heritage from Jason series*
- Cross-Track Advanced Microwave radiometer (JPL) - AMR
  - *To measure wet tropospheric delay*
  - *3-frequency design with significant heritage from Jason series*
  - *Dual active channels*
- Instruments for Orbit Determination
  - *GPSP (JPL)*
  - *DORIS (CNES)*
  - *Laser Reflector Array - LRA (JPL)*



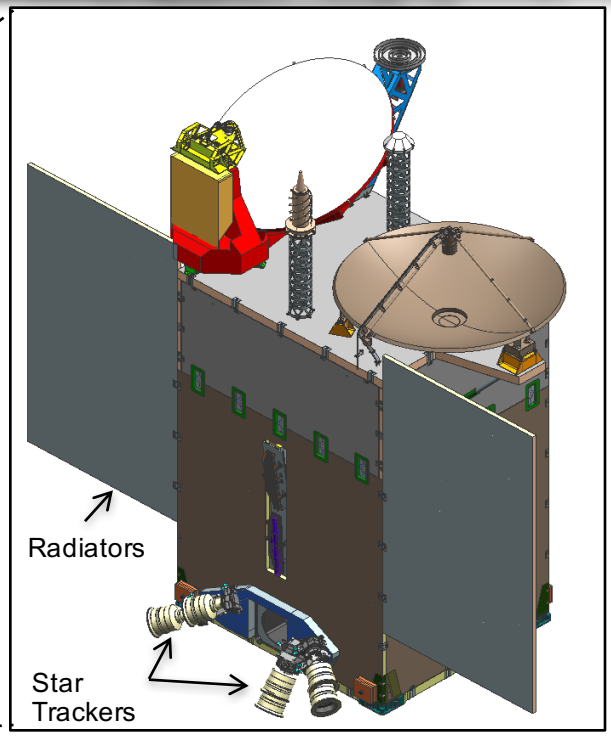
Payload System Architectural Drivers

- Interferometric Precision
  - *High precision for oceanography feature resolution drives largest possible power / aperture product (peak & average power, antenna size) & interferometric baseline length*
- Stability
  - *KaRIn electronics thermal stability requirement, together with significant power dissipation, drive the loop heat pipe architecture*
  - *Pointing stability drives the need for a composite metering structure and composite antenna masts for KaRIn*
  - *Eliminate moving parts needed during science operations on payload in order to support KaRIn stability -> use low gain antenna and high power amplifier for the X-band telecom system*
- Continuous Data Coverage
  - *Drives need for substantial on-board processing of KaRIn ocean data*
  - *Drives observatory data flow architecture (KaRIn -> spacecraft solid state recorder -> telecom -> ground stations)*

Payload Configuration (1 of 2)



Observatory

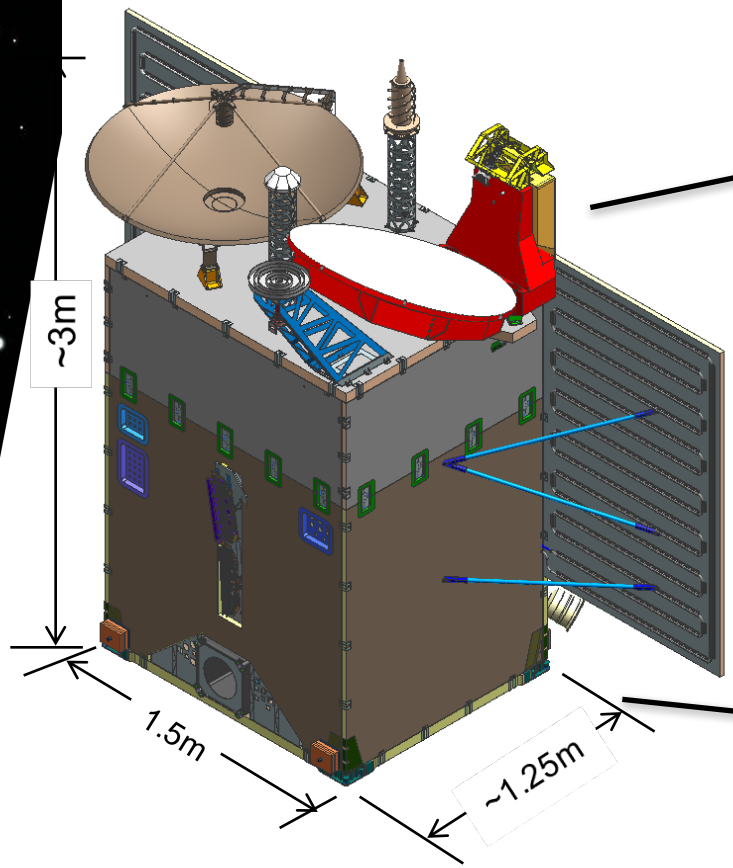


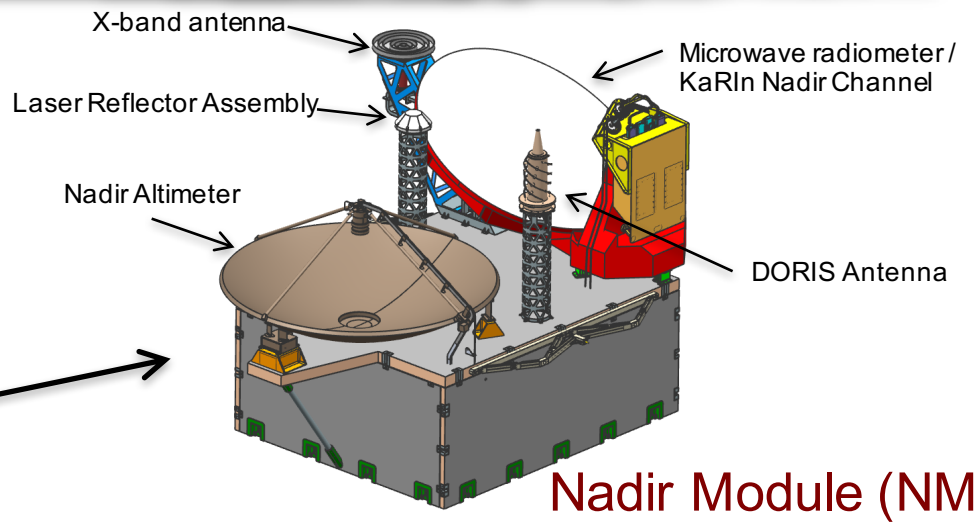
Payload - PL
(masts
removed)

Platform - PF

- Hosts NASA GPS-P receiver, with zenith pointing antenna

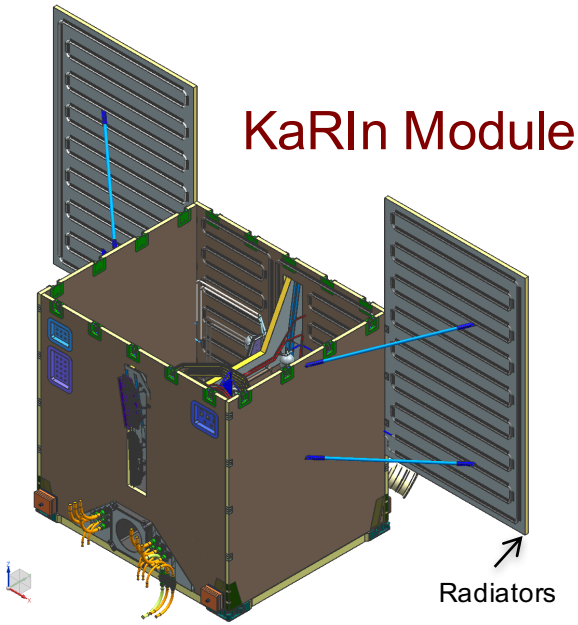
Payload Configuration (2 of 2)



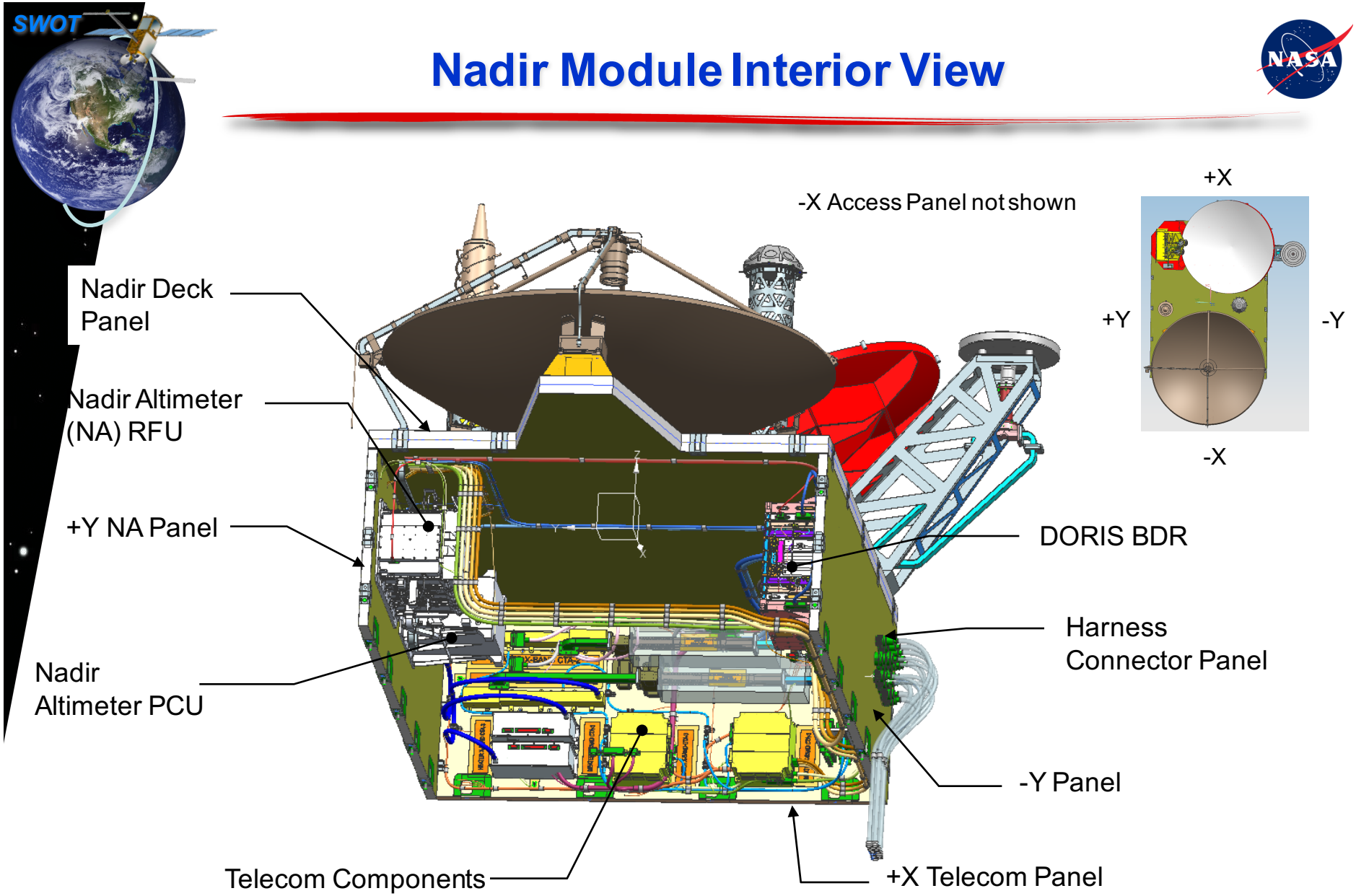


Nadir Module (NM)

KaRIn Module (KM)



Nadir Module Interior View



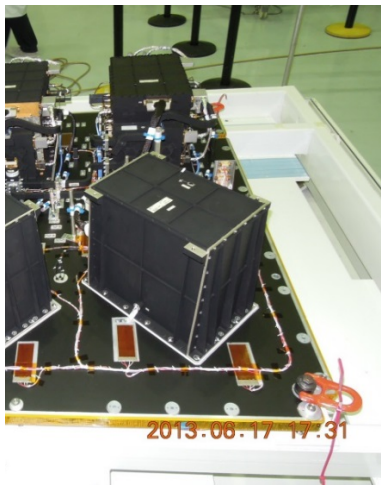
Nadir Altimeter Instrument Overview

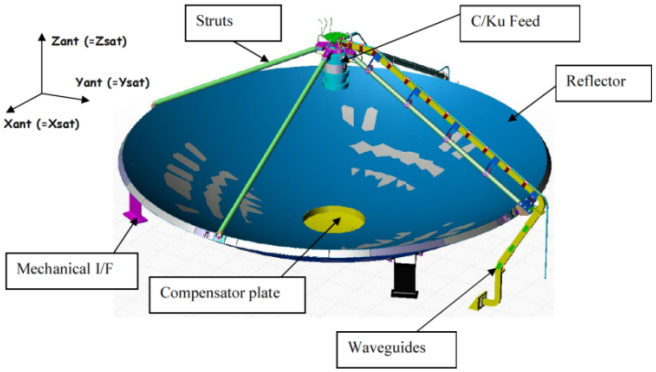
- Nadir Altimeter Hardware
  - *Dual-Frequency Ku/C nadir altimeter*
  - *RFU, PCU and interbox harness integrated on Flight +Y panel at TAS-T*

  - *Nadir Altimeter Characteristics*
    - *Range measurement between satellite and sea surface*
    - *Calibration at cross-overs*
    - *Autonomous transition*
    - *Autonomous tracking vs DIODE/DEM mode*
    - *Autonomous restart*

  - *Nadir Altimeter Heritage*
    - *The design is mature thanks to a long flying heritage from various programs: Jason 1,2,3, Cryosat,, SARAL*
    - *On board Sentinel 3A and 3B*
    - *Baseline for SWOT: Recurrent from Jason-2, Jason-3…*
    - *Changes limited to replacement of obsolete parts and SWOT specificities (orbit, I/F…)*

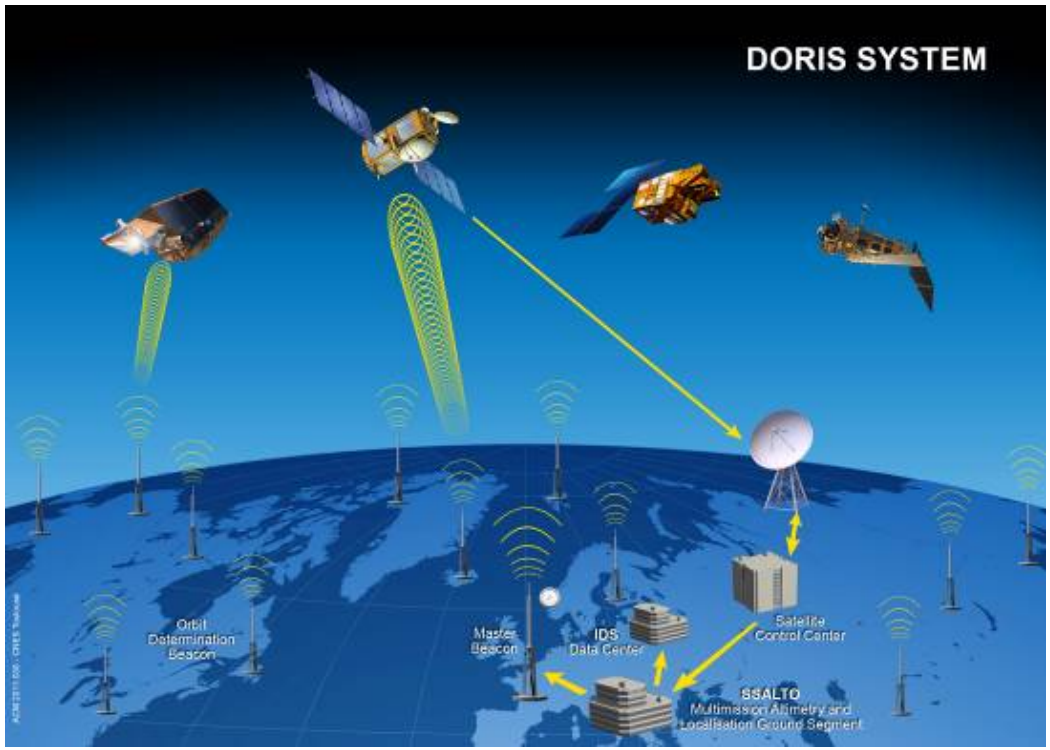
Image Jason 3 Nadir Altimeter (one side)





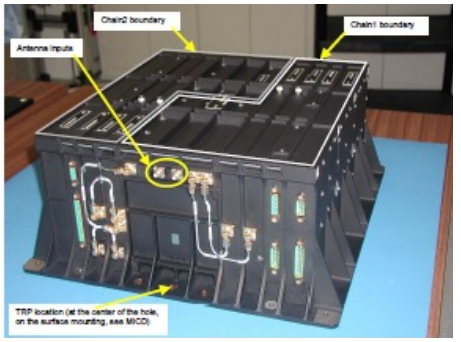
DORIS System: General Concept

- Designed in early eighties for precise orbit determination of ocean altimetry missions
- Based on Doppler shifts measurements of RF signals transmitted by a world wide beacons network (one way thanks to stability of on board and beacons USOs)
- Use of about 56 DORIS Beacon on Ground
- Dedicated existing Ground Segment (SSALTO) to collect and process DORIS data
- 17 DORIS receivers launched, 10 DORIS in operation



DORIS Overview and Heritage

- DORIS Hardware:
  - *DORIS electronic box (BDR, including USOs): Internal redundancy*
  - *DORIS Antenna (dual frequency): FM #23*
- DORIS Characteristics:
  - *High-precision Doppler measurements (accuracy better than 0.3 mm/s)*
  - *Tracking capability of 7 beacons simultaneously*
  - *Autonomous operation (set it and forget it)*
  - *10 MHz distribution*
  - *Onboard time-tagging wrt to International Atomic Time*
  - *Possibility of pps distribution (not used on SWOT)*
  - *Onboard orbit determination (DIODE software) and distribution to KaRIn and Nadir Altimeter*
- DORIS Heritage
  - *The design is mature thanks to a long flying heritage from various programs: Jason 1,2,3, Spot 2,3,4,5, Envisat, Cryosat, Pléiades, SARAL, HY2 …*
  - *Baseline for SWOT: recurrent DORIS from Jason 3, Sentinel-3, Jason CS (DGXX-S version, improved from Jason-2 version including change of processor to allow higher accuracy of Diode SW)*
  - *Cumulative on-orbit life: over 130 years!!!*

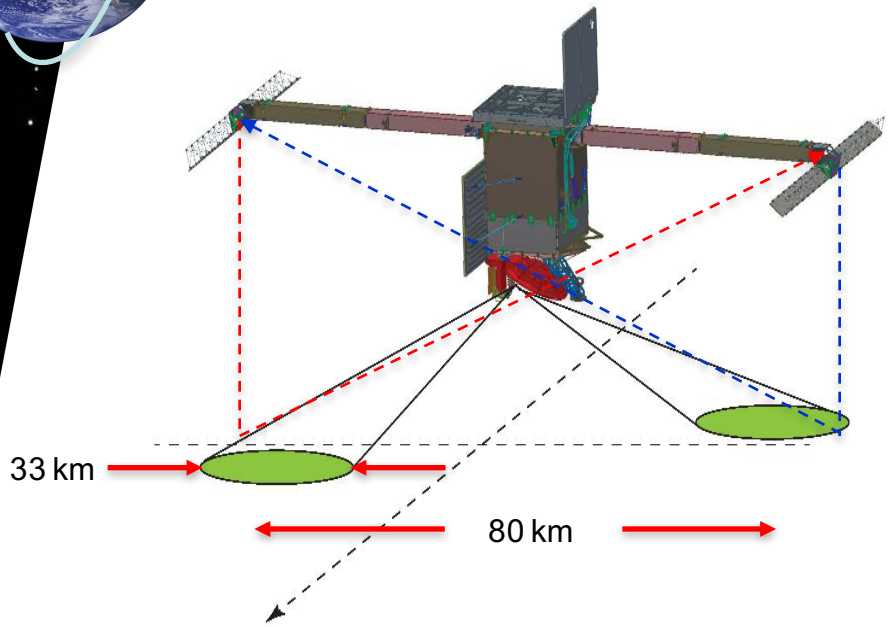


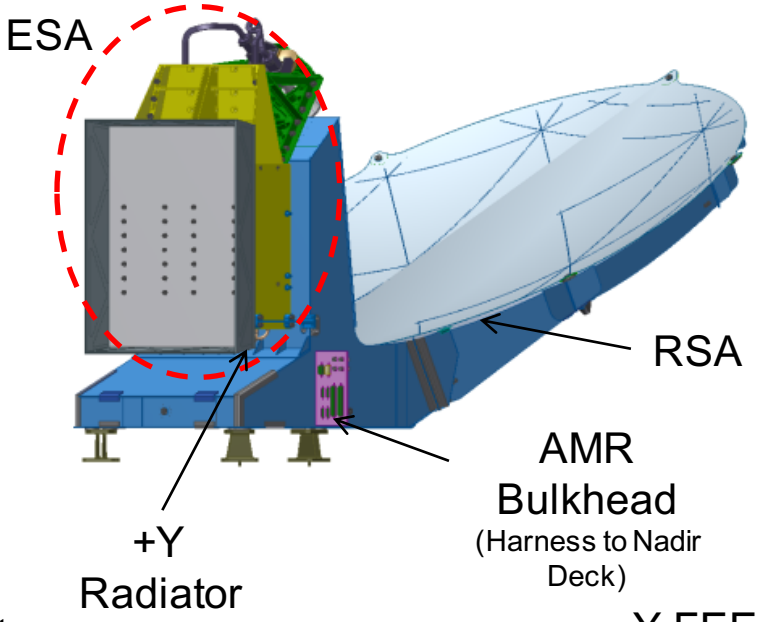
Receiver and Processing Unit (BDR)

Antenna

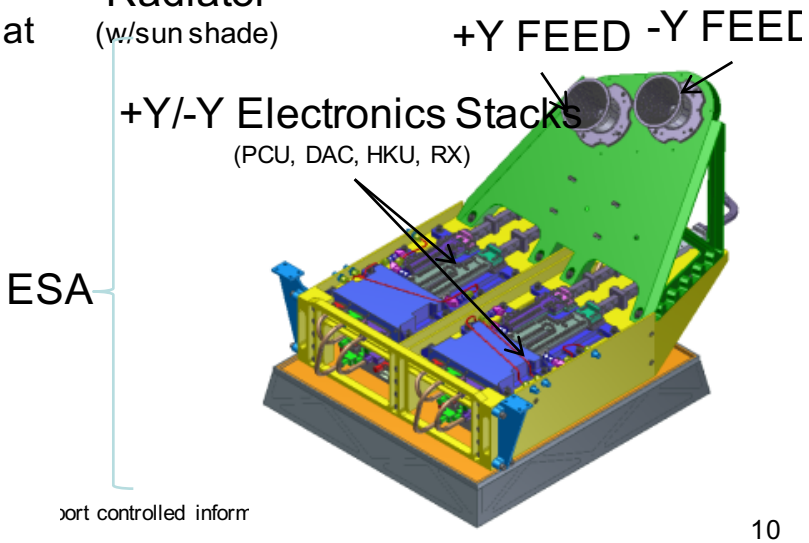
AMR Instrument Overview

Instrument baseline is the cross-track implementation





- Two independent instrument chains measure wet path delay at the center of each KaRIn swath.
- Heritage reflector design with two AMRs feed horns to meet baseline requirements.
- Thermal design and mechanical layout of electronics accommodates operating two chains simultaneously
- Heavily leverages OSTM, Jason-3, and COWVR electronics designs and spare hardware
- Status:
  - New electronics have been prototyped and functionally tested.
  - RSA contract is in place and vendor design review held



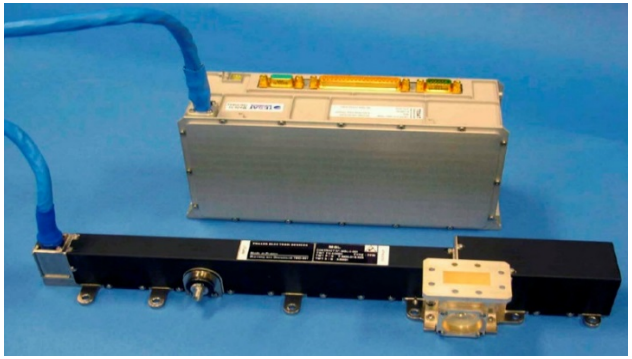
ort controlled inform

X-Band Telecom Development Status

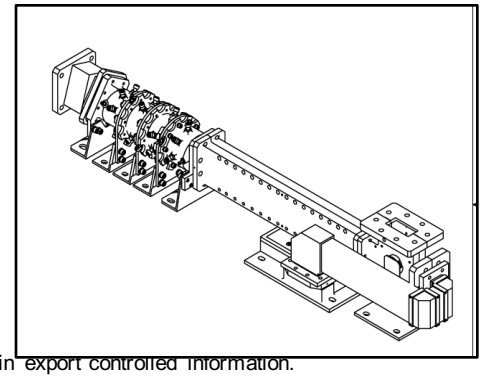
- Design supports project requirement for ~8 Tb/day of data downlink of science and payload housekeeping data to transmit two signals simultaneously to CNES ground stations
  - *Each of two polarizations receives 310 Mbps information bits from SSR*
  - *Operates in Earth Exploration Satellite Service (EESS) X-Band, 8025-8400 MHz*
- High-heritage hardware assemblies procured from industry: modulators, TWTAs, filters, isolators.
  - *LGA is in-house custom design – prototype fabricated and tested.*

L3/CE Modulator
(SMAP heritage)

Tesat/Thales TWTA
(MSL, JUNO & commercial heritage)



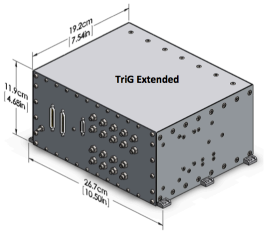
FMC Filter/Isolator
(Landsat heritage)



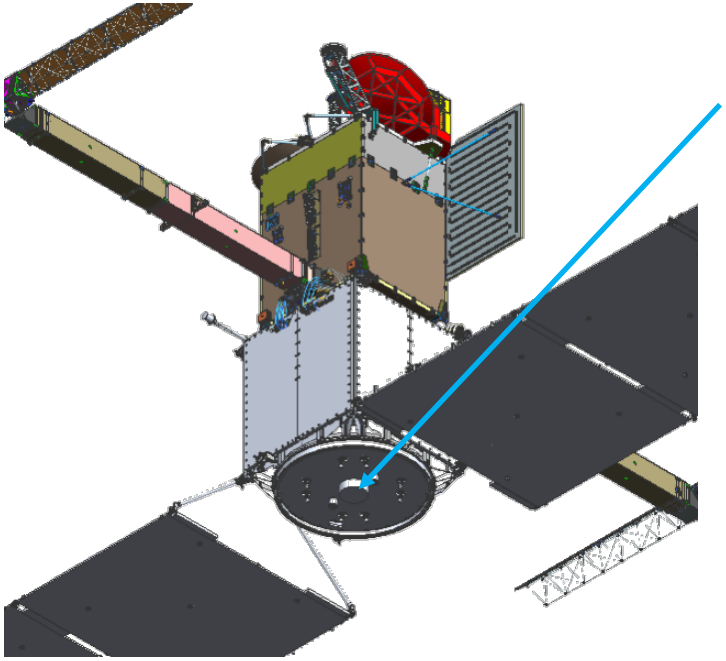
LGA and Polarizer
(in house design)

GPSP Overview and Heritage

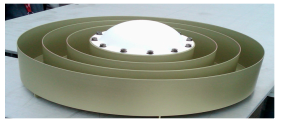
- The GPSP instrument is part of the Precise Orbit Determination suite together with DORIS to meet baseline mission requirements.
- Performance requirements are based on heritage Jason 3 capabilities.
- Hardware design inherited from COSMIC 2 and DSAC
- Current status: final preparations for flight receiver build



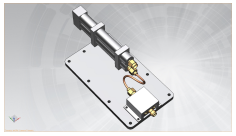
TriG Electronics



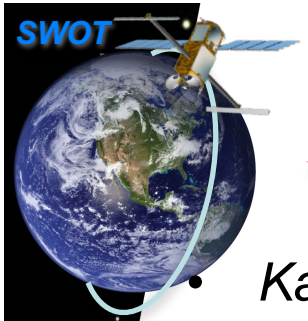
GPSP Antenna
- minus Z facing boresite



POD antennas

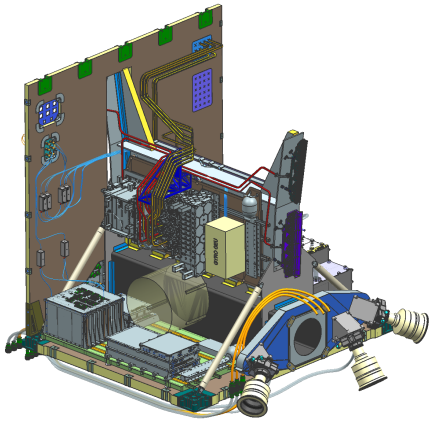


BPF/LNA

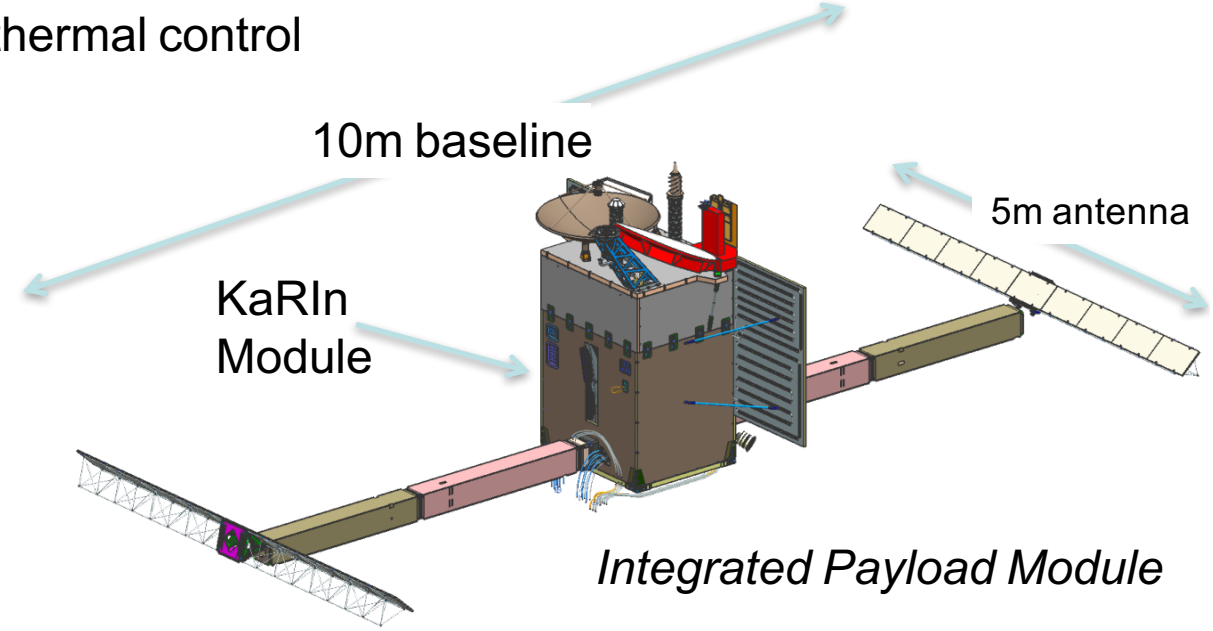


KaRIn Instrument Overview

- *KaRIn is the prime instrument for the measurement of water elevation & extent*
- *Ka-band interferometric SAR:*
  - ~600 Kg, ~1100 W
  - 1500W RF transmit power
  - High precision, deployable antenna structure
  - Loop Heat-Pipe thermal control

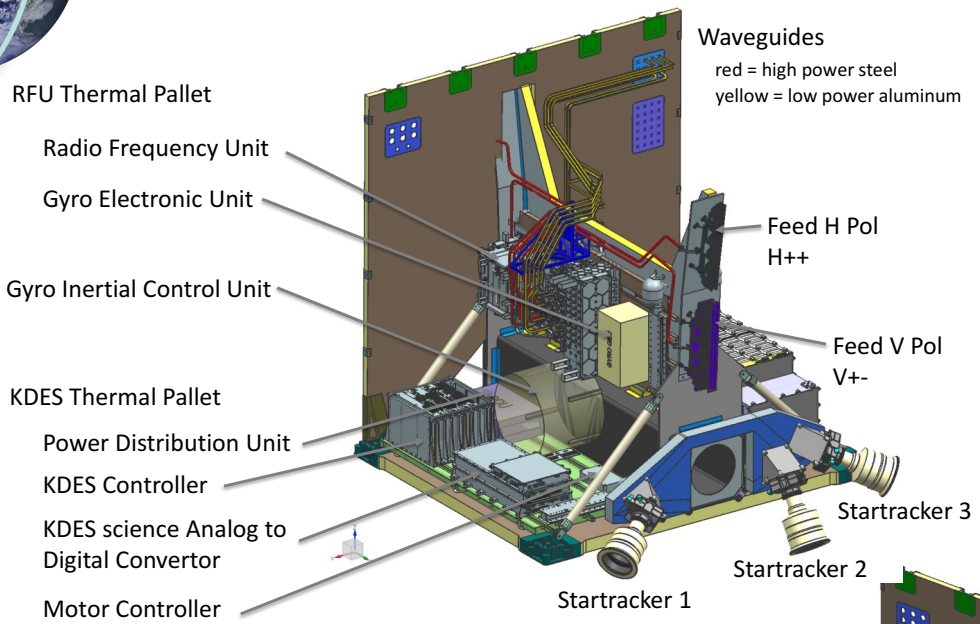


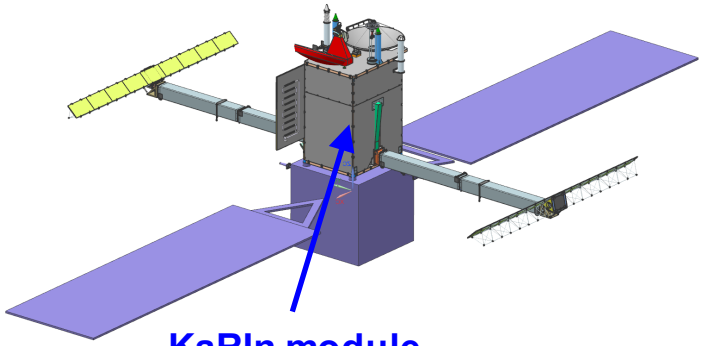
Internal view of KaRIn electronics

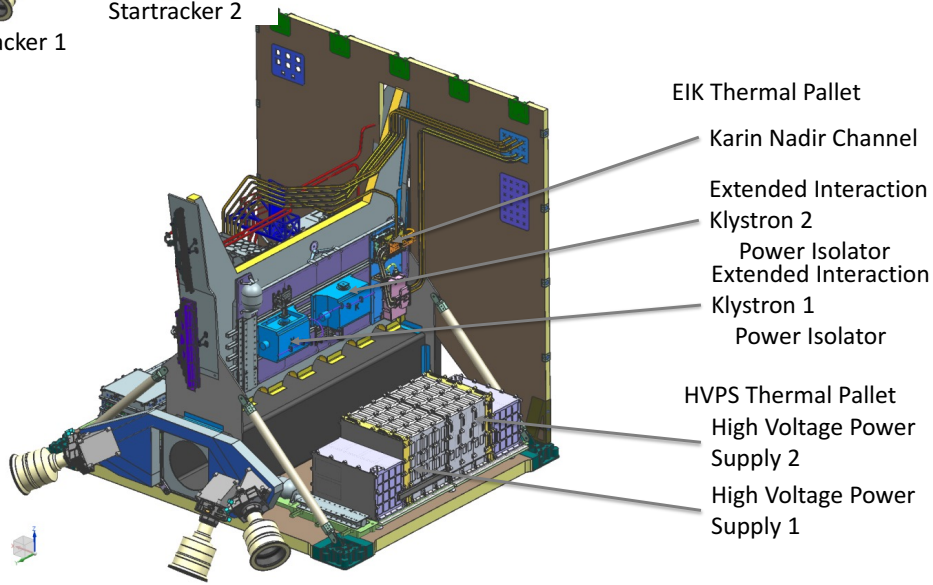


Integrated Payload Module

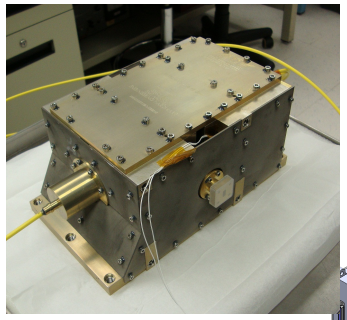
KaRIn Physical Module Configuration





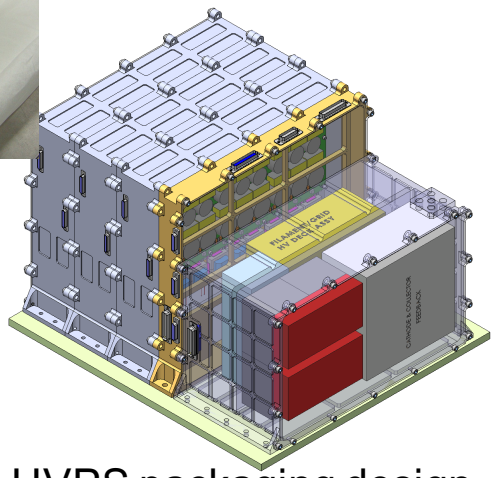


KaRIn Implementation Status (1)



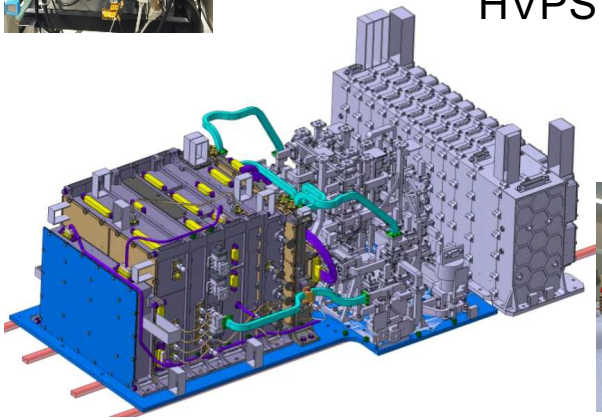
EIK EM1

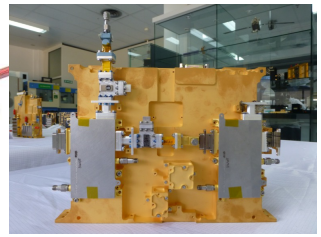
HVPS breadboard



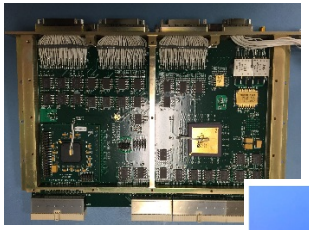
HVPS packaging design

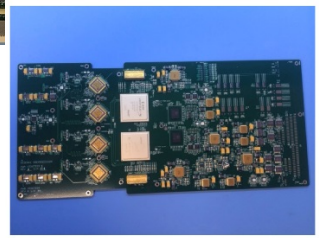
- KaRIn hardware follows a three cycle build process:
  - ✓ *Breadboard or prototyping of key functions prior to PDR.*
    - ✓ Basis for compliance assessment. Other than iso-filter, no major technical problems uncovered
    - ✓ Successful PDR held October 2015
  - *Engineering Models at assembly, subsystem, and instrument level*
    - Now in development
  - *PFM hardware, fully tested and delivered to payload I&T in the KaRIn module configuration*





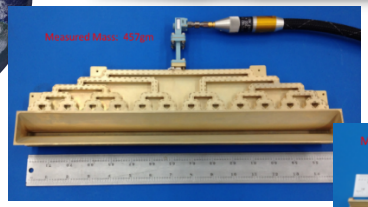
RFU packaging design, & EM receiver slice





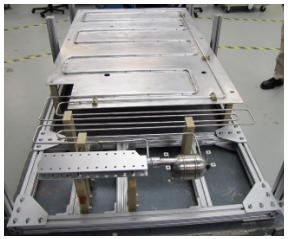
KDES SSRI & sADC EDU boards

KaRIn Implementation Status (2)



Full sized feed breadboards

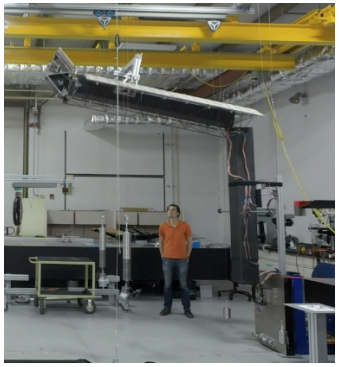
- *KaRIn deployable antenna assembly prototyping all key functions & requirements in phase B*
- *Partial or full EMs built in phase C*
- *PFM DAA is assembled, including antenna panels, for functional deployment, RF testing, alignment, environmental qualification, and other key tests prior to delivery to Payload I&T*

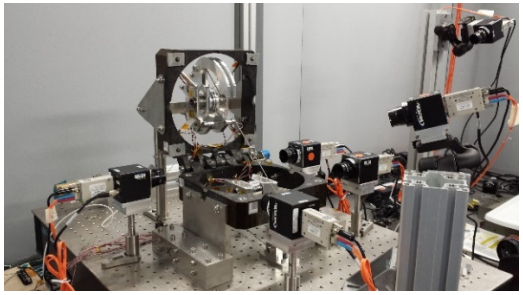


LHP / CCHP testbed

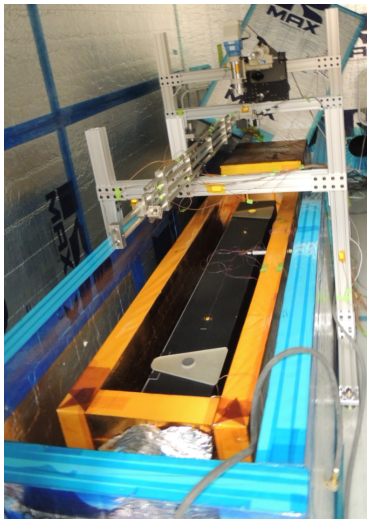
IRA deployment / latching mechanism testbed

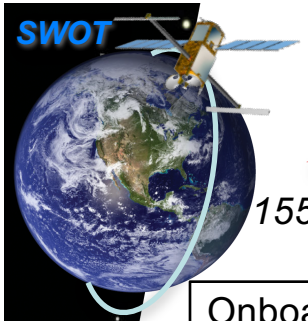
Full-sized mast deployment



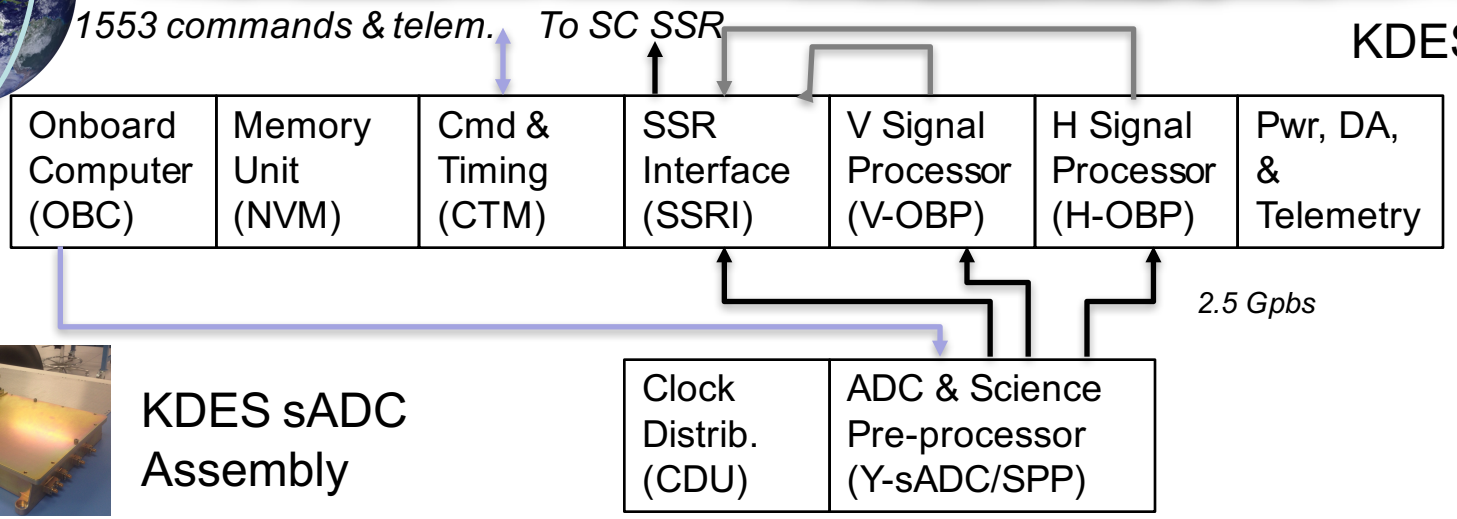


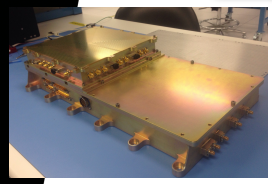
Prototype hinge and boom tube testing





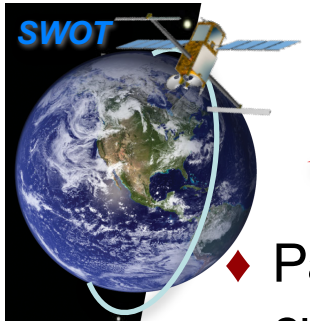
KaRIn Onboard Processor





KDES sADC Assembly

- The On-Board Processor (OBP) implements both the Land and Ocean processing modes in a combination of firmware and software.
- The OBP is spread across 4 different custom boards + a central computer with a micro-processor
- All Engineering Model boards have been fabricated and are through preliminary testing. Firmware & software development is ongoing.
  - After EM integration and test we will be committing to the flight design.
  - To mitigate risks and have a high probability of success, the algorithm must be locked down in advance of the EM integration and test. *This was a significant focus of the SDT and your help was greatly appreciated!*
  - Next key milestones: *All final bit-true-models will be completed by end of July, final coding of the last OBP algorithms begins early August, and testing completes in October 2016*



Summary

- Payload team has completed a rigorous set of reviews culminating in the Payload PDR (February), and the Project PDR (April)
- Team is actively building / testing Engineering Model hardware for new designs, and, for heritage designs, has begun flight procurements
- Present design is compliant with all performance requirements with adequate margin.
  - *The design has minor technical / functional non-compliances that are expected to be worked successfully in the lead-up to the Critical Design Review season (Summer 2016-Spring 2017)*
- Team has a strong focus on maintaining careful change control & minimizing mission and implementation risk, while maximizing science return