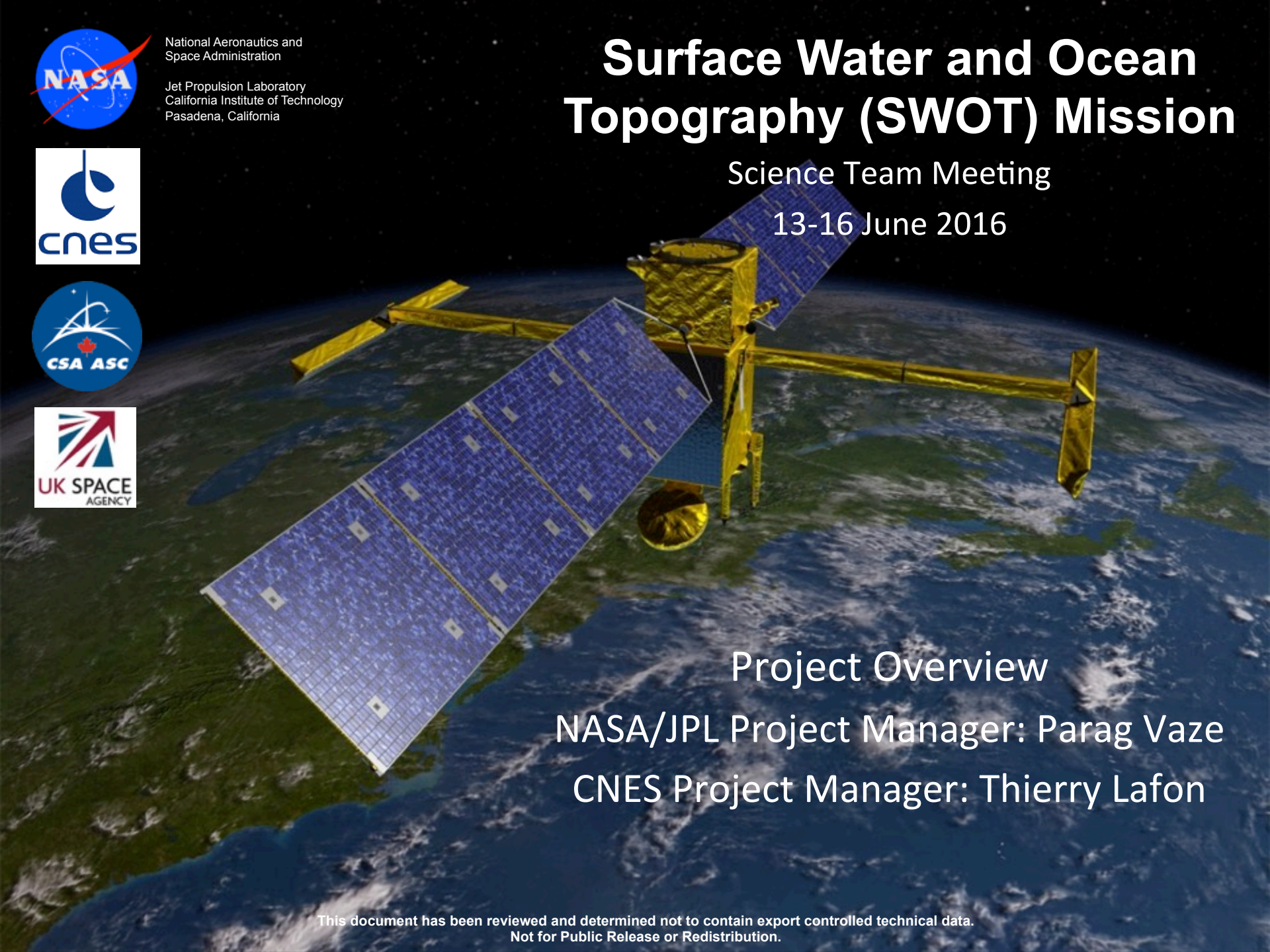


National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Surface Water and Ocean Topography (SWOT) Mission

Science Team Meeting

13-16 June 2016

Project Overview

NASA/JPL Project Manager: Parag Vaze

CNES Project Manager: Thierry Lafon

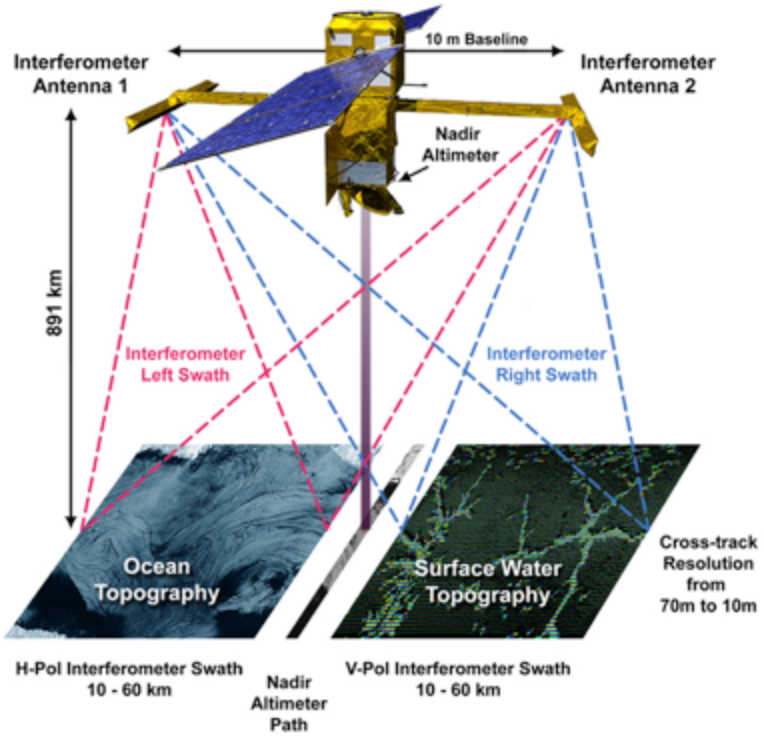
Mission Overview

Mission Science

Oceanography: Characterize the ocean mesoscale and sub-mesoscale circulation at spatial resolutions of 15 km and greater.

Hydrology: To provide a global inventory of all terrestrial water bodies whose surface area exceeds $(250m)^2$ (lakes, reservoirs, wetlands) and rivers whose width exceeds 100 m (rivers).

- To measure the global storage change in fresh water bodies at sub-monthly, seasonal, and annual time scales.
- To estimate the global change in river discharge at sub-monthly, seasonal, and annual time scales.



Mission Architecture

- Ka-band SAR interferometric (KaRIn) system with 2 swaths, 50 km each
- Produces heights and co-registered all-weather imagery
- Use conventional Jason-class altimeter for nadir coverage, radiometer for wet-tropospheric delay, and GPS/DORIS/LRA for POD.
- On-Board interferometric SAR processing over the ocean ($500m^2$ resolution) for data vol. reduction.

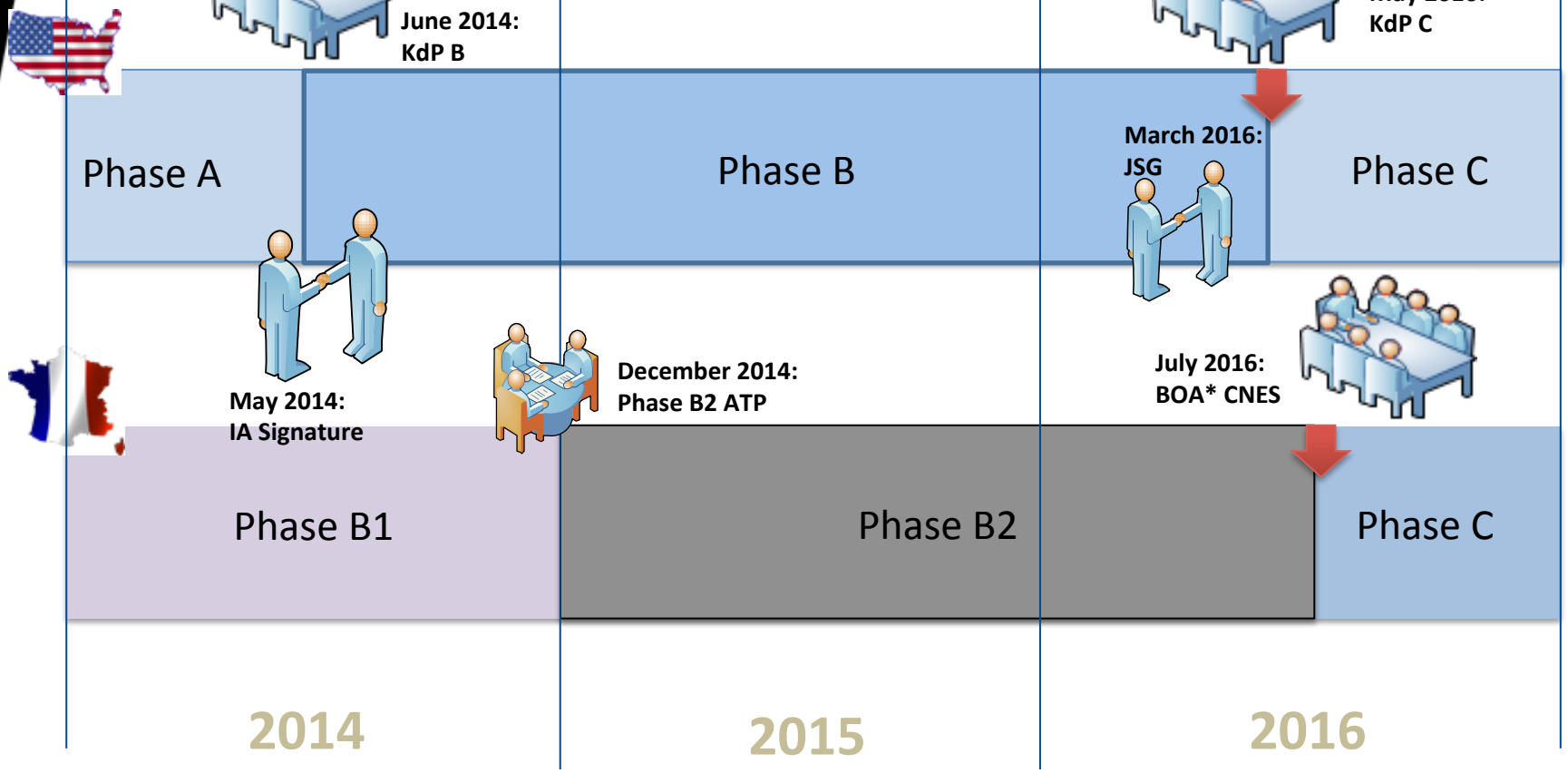
- Partnered mission with CNES & CSA
- Science mission duration of 3 years
- Cal orbit: 857 km, 77.6º Incl., 1 day repeat
- Science orbit: 891 km, 77.6º Incl., 21 day repeat
- Flight System: ~2400kg, ~2100W
- Launch Vehicle: NASA Medium/Intermediate class
- Cat 2 Project, Risk Class: C*, Cat 2 LV
- Target Launch Readiness: April 2021

* Compliant with 8705.4

Project Summary Since Last SDT

- Developed designs to PDR maturity (Requirements, models, BB/EM Hardware)
- Completed Technology Development Plan
- Closed all system level trades and consolidated Technical resource budgets:
  - Baselined Cross-Track (2-beam Radiometer)
  - Enhanced data downlink (additional ground stations)
- Conducted reliability study and implemented enhanced reliability program to respond to the SMAP radar failure lessons learned
  - Descoped KaRIn Nadir Chanel capability
- Started Launch Vehicle procurement process
- Reconciled budget and schedule:
  - Revised Launch date (from Oct 2020 to April 2021) to establish credible schedule with good margins
- Completed rigorous technical pre-PDR reviews.
- Project PDR completed 5-7th April 2016 @ JPL
- Successfully completed the NASA KDP-C 19th May 2016 : Now in Phase-C
- Upcoming near-term events:
  - CNES S/C PDR (last week of June)
  - CNES Board of Administrators – Program Authorization (Beg of July)

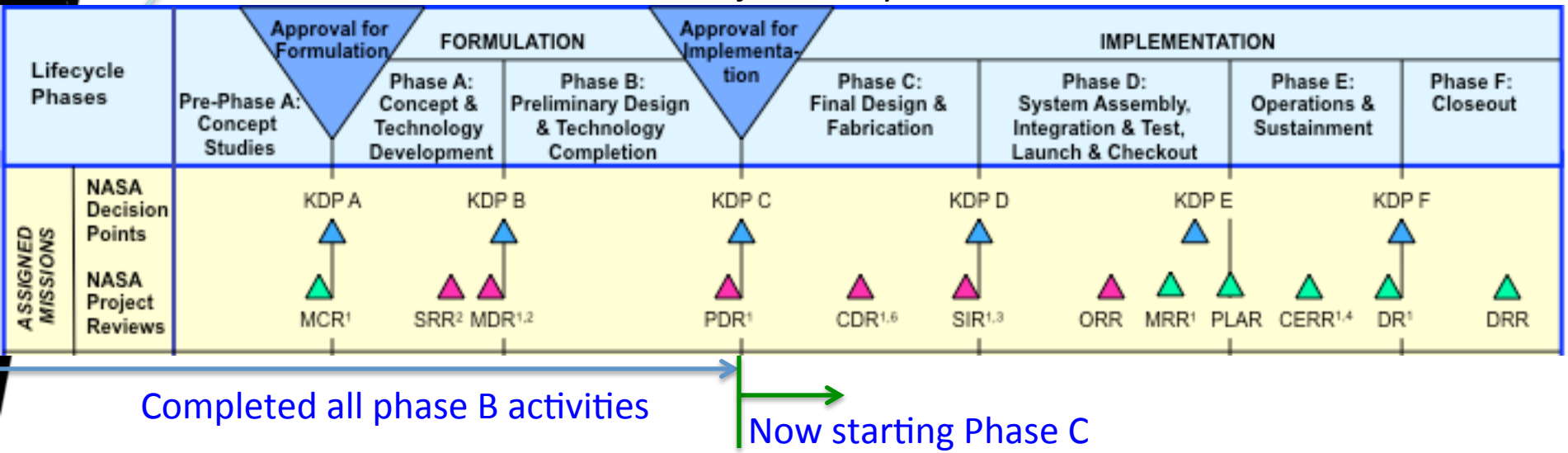
CNES & NASA transition to Phase C



BOA* : Board of Administrators

SWOT Project Lifecycle

NASA Project Lifecycle



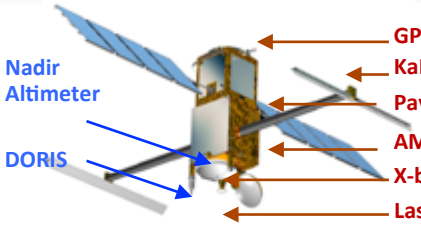
Completed all phase B activities

Now starting Phase C

- Now completed all reviews to enter phase C
- Moving now to Final Design and Fabrication Phase with Emphasis on:
  - Design baselines for implementation
    - Engineering Models to Flight Models for HW/SW
  - Change control as any significant changes likely have large and sometimes unintended impacts
  - Focus on simplification and risk management
  - Detailed plans and preparations for launch and operations

Mission System Architecture

NASA – KSC/LSP
Launch Vehicle
(TBD)



CNES Elements
NASA Elements
Joint Elements

*CNES ops

Science Downlink
711 Mb/s (X-band); ~ 21 passes/day
(Info rate: ~620 Mb/s; ~7.9 Tbits/day)

Uplink/Commanding,
HK/Eng. Telemetry
64 Kbps U/L (S-band)
>600 Kbps D/L (S-band)
2 passes/day

CNES S+X-band Network:
KRX, IVK AUX, HBX, KUX & KER (S-only)

S-band
Cmd & Tlm

X-band
Telemetry
Files

To JPL POC:
S/C Telemetry (stored & RT), Payload R/T Engineering

To CNES SCC: Payload commands

S/C Control Center (SCC)

To SCC: S/C & P/L telemetry

To NOC: Commands

CNES Network Ops Center (NOC/COR)

To CNES SCC:
Payload
Commands

To CNES POC:
S/C Telemetry

X-Band Telemetry Files

X-Band
Telemetry
Files

CNES
File Exchange Server
(in CNES Science Data Processing Center)

JPL Payload Operations Center

CNES Payload Operations Center

AirSWOT, Instrumented Cal/Val Ground Sites

JPL

JPL Science Data Processing Center

Altimeter, KaRIn (Eurasia), POD & Cal/Val data

KaRIn (non-Eurasia,Ocean), Cal/Val data

CNES Science Data Processing Center

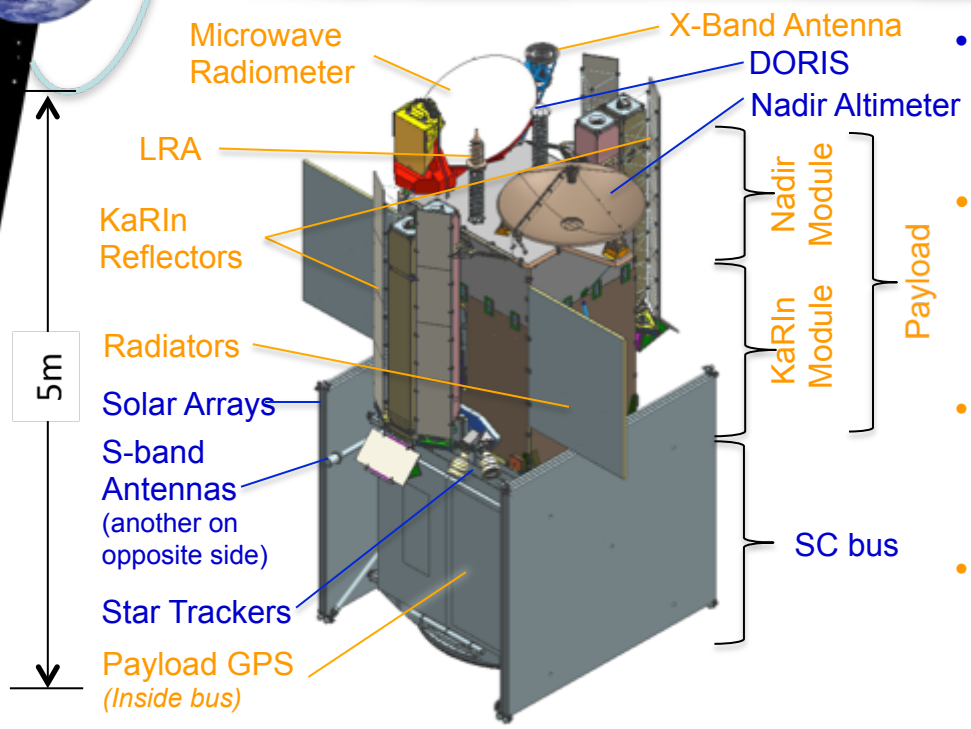
cnes

NASA Science Data Archiving and Distribution
PO. DAAC

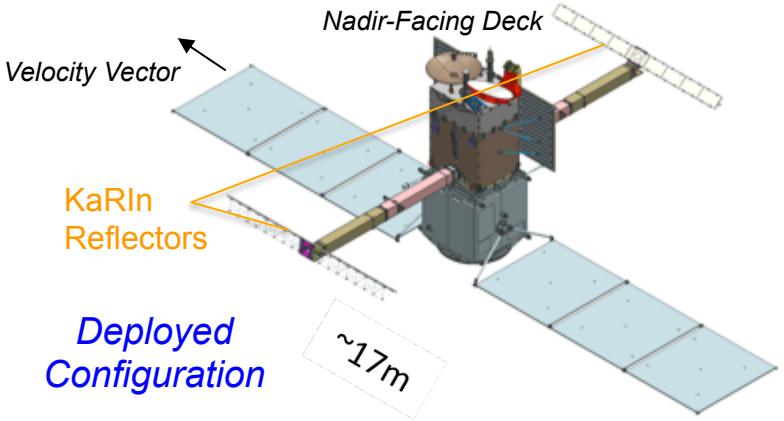
Auxiliary Data:
Tropo model(s), Iono info, Tide model(s),
Mean Sea Surface, Digital elevation models

CNES Science Data Archiving and Distribution

Flight System Summary



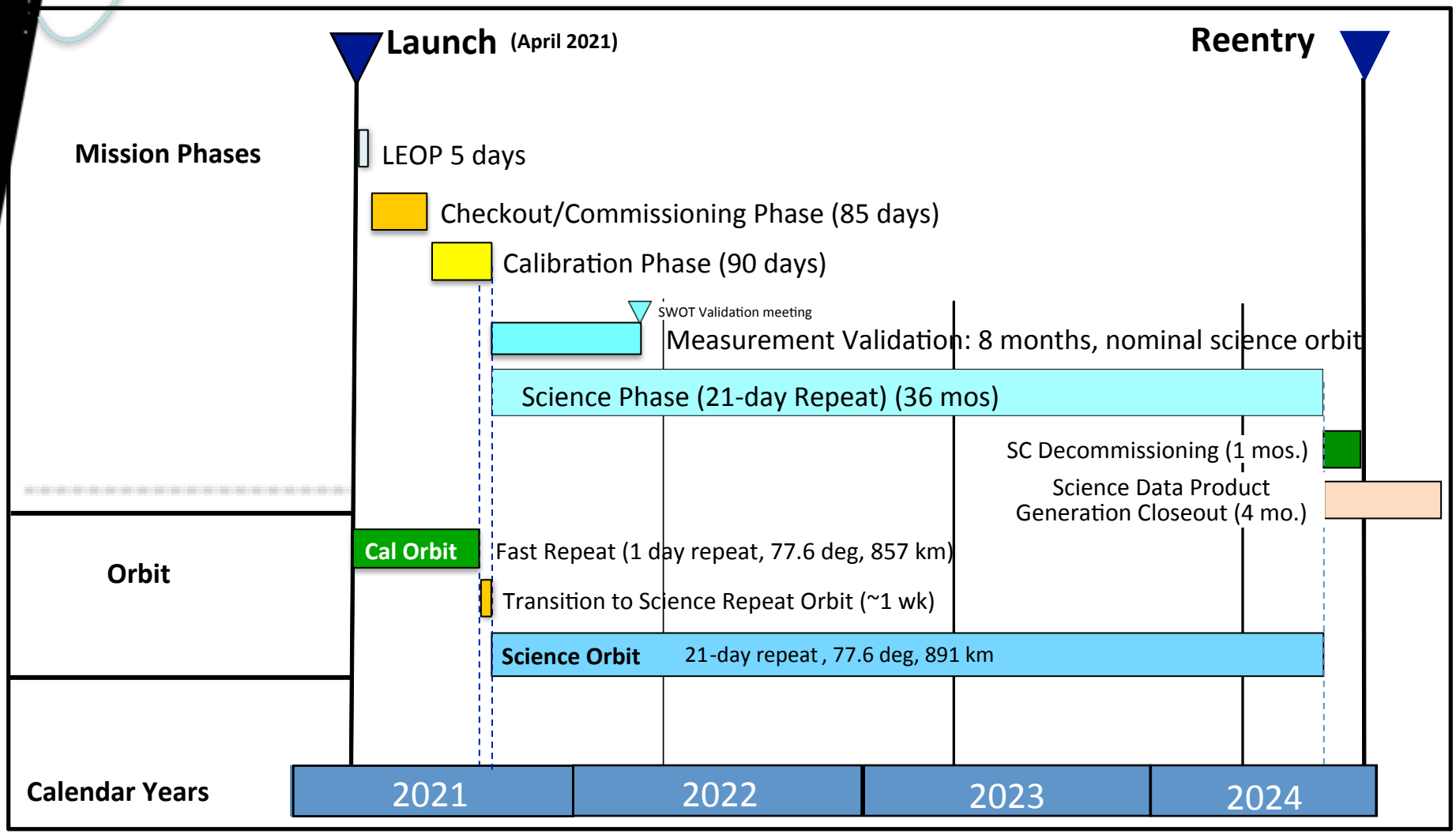
Stowed Configuration



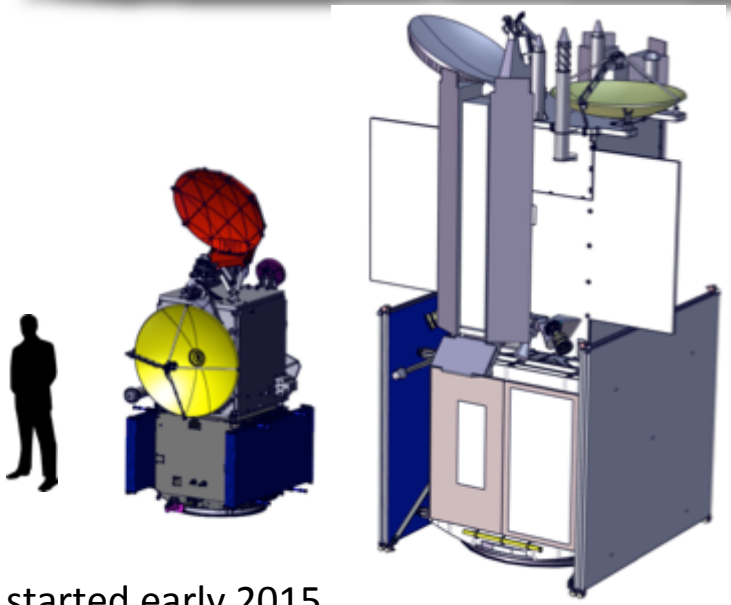
Deployed Configuration

- SC Bus (CNES)
  - Includes C&DH, Power, ACS, solar arrays, thermal, S-band telecom
  - Star trackers located on the KaRIn Module
- Payload (JPL)
  - KaRIn Module: Accommodates KaRIn
  - Nadir Module: Accommodates other instruments and X-band telecom
  - GPSP is accommodated on the SC bus
- X-band Payload Telecom (JPL)
  - High rate downlink (711 Mbps)
  - X-band Telecom (*Provided by JPL; Operated by CNES as part of SC telecom subsystem*
- Ka-band Radar Interferometer (JPL)
  - The primary instrument, to measure swaths of surface elevations
  - CNES-provided RF subsystem
  - CSA-provided EIKs (part of high power assembly)
- Nadir Altimeter (CNES)
  - To measure absolute height, calibration at cross-overs, ionospheric delay
  - Ku/C-band, nadir looking
- Microwave radiometer (JPL)
  - To measure wet tropospheric delay
  - Cross-track design (2 beams)
- Instruments for Orbit Determination
  - GPSP (JPL), DORIS (CNES), LRA (JPL)

Mission Phases/Timeline



CNES Phase B major achievements : S/C

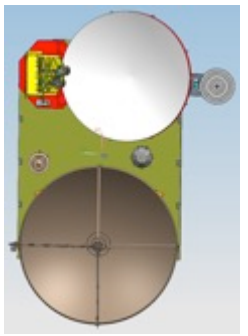


- Phase B started early 2015
- Mass/ Power budget consolidated for NASA PDR
- Platform procurement started
- **Risk Mitigation**:
  - Priority on Interfaces definition and Interface simulators early delivery (SIS) to JPL
  - Flight system Interface review in Sept. 2015
- Platform PDR in June 2016
- AIT Plateform starts in Sept. 2018
- Controlled reentry compatible

PlatformDATA Sheet :
- Provider : TAS/ Ca
- P/L allocated capacity 880 kgs
- 8000 W power BOL
- >3 Tbits deMass memory
- Hydrazine tank capacity 623 l (Controlled reentry)

Nadir Module Interior View

-X Access Panel not shown



Nadir Deck Panel

Nadir Altimeter (NA) RFU

+Y NA Panel

Nadir Altimeter PCU

DORIS BDR

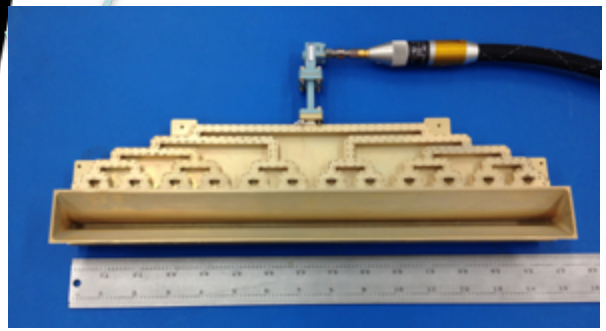
Harness Connector Panel

-Y Panel

Telecom Components

+X Telecom Panel

KaRIn Prototype Hardware Development and Risk Reduction

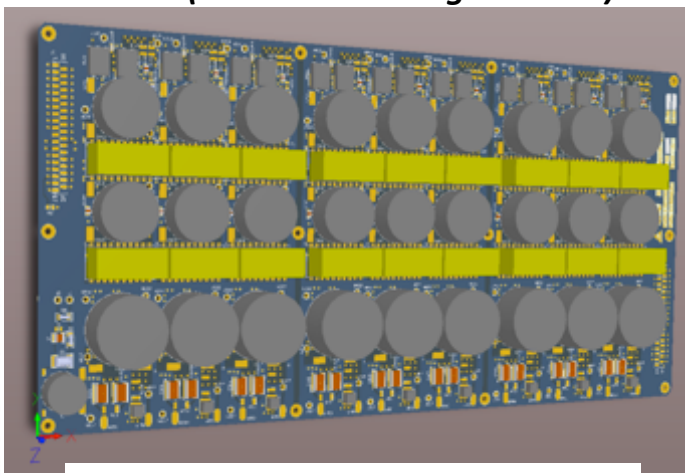


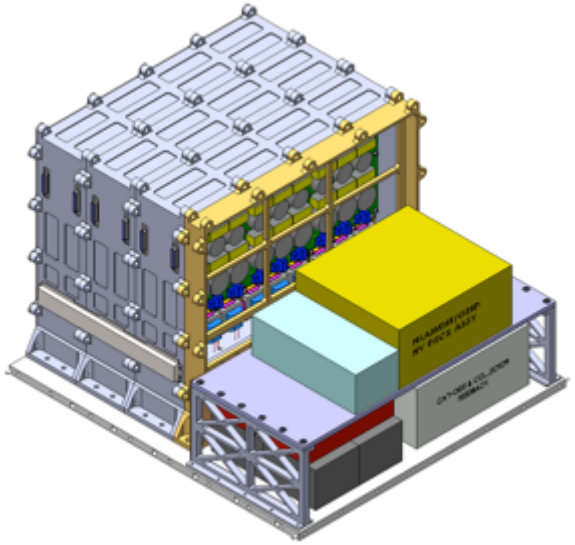
Feed Horn Prototype

V-Pol feed in anechoic chamber

Digital SuB-System GSE

(HVPS Low Voltage Section)



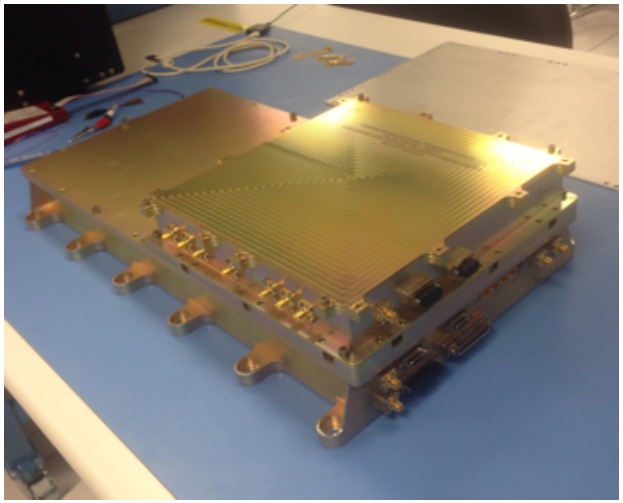


HPA EM Packaging Design

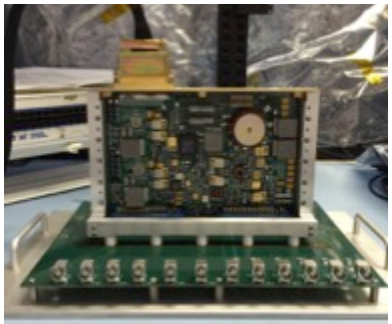
KaRIn EM Hardware

HVPS HV Collector Assembly (minus transformers)

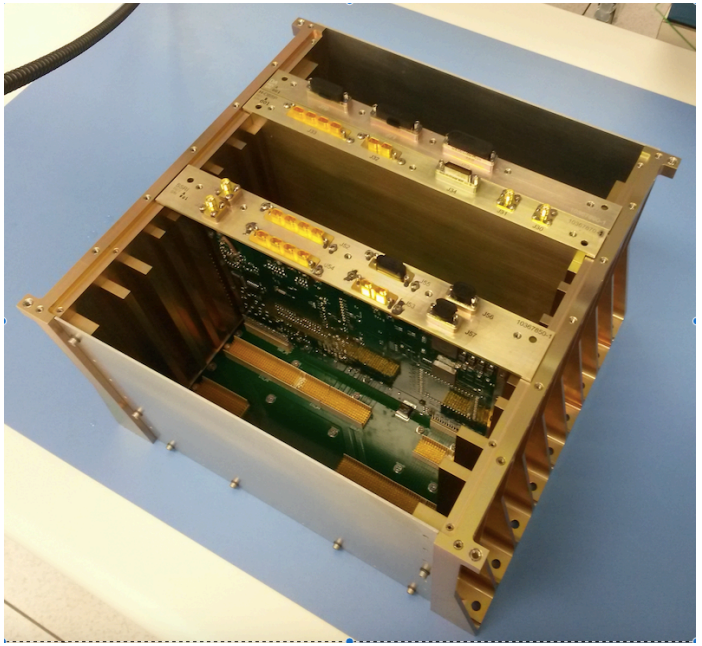
HVPS Power Converter Assembly



KDES - sADC Assembly

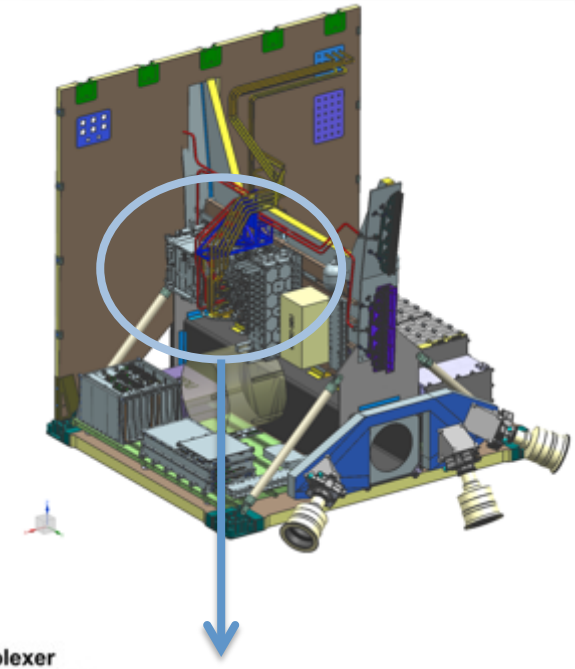


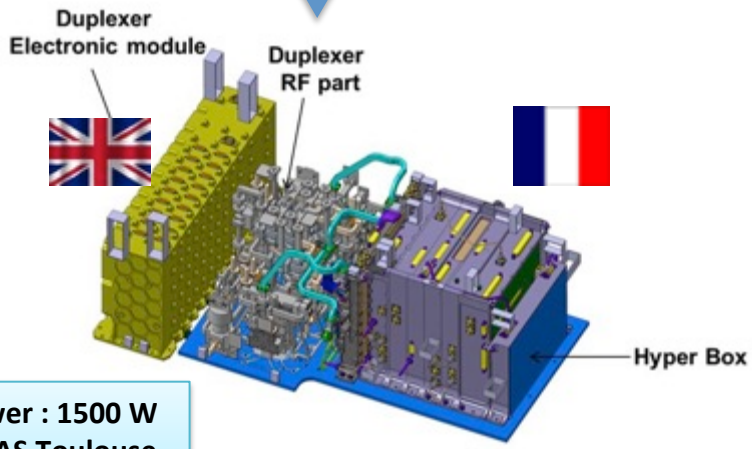
cPDU in test, and sPDU



KDES - Chassis

CNES Phase B major achievements : RFU





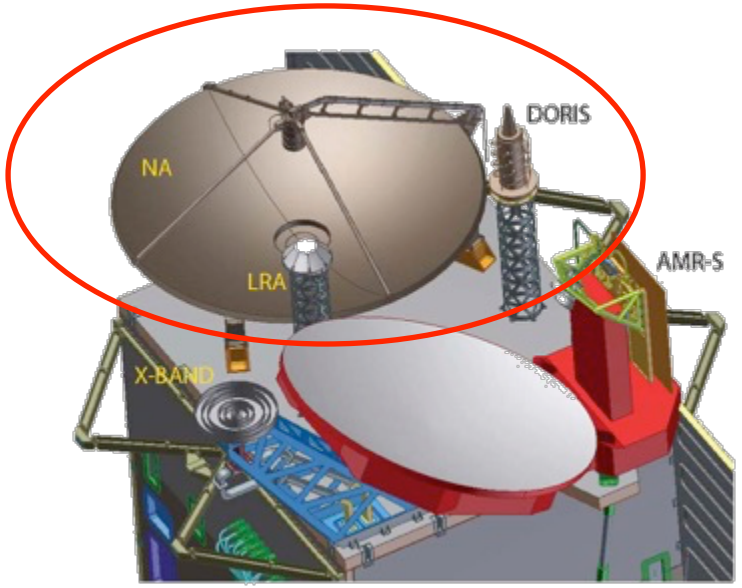
Peak Power : 1500 W
Prime : TAS Toulouse.
Sub: COMDEV UK

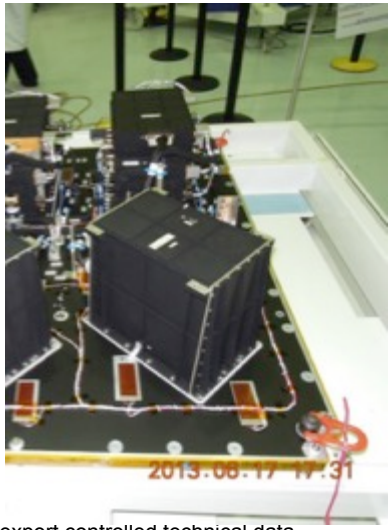
- Phase B started early 2015
- TRL increased from 3 to 6+
- Met KaRIn PDR expectations
- **Risk Mitigation**:
  - Important resources allocated for Phase B
  - EM development started early Phase B
  - Pre-KaRIn PDR Peer review
  - LLI anticipation (RFU and Duplexer)
  - Power handling test performed with EIK GSE
  - Digital module contact test on going at TAS with KDES counterpart
  - RFU delivery rescheduled to accomodate comprehensive verification at Dx EM and PFM level

CNES Phase B major achievements : Nadir Alt. And DORIS

- **DORIS PFM:**
  - manufacturing on going
  - No Risk: recurrent SENTINEL 3 design
  - Significant margin on delivery plan

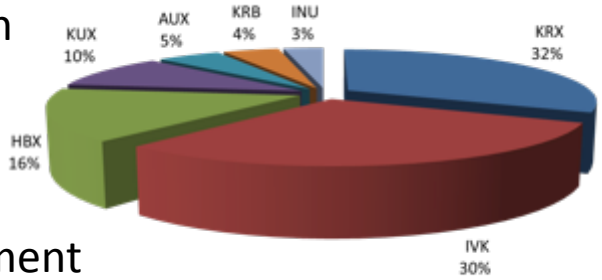
- **NADIR ALTI** :
  - Phase C/D contract on going
  - **Risk mitigation**:
    - SWOT peculiarities assessment
    - Obsolescences treatment
  - Successful EQSR in January 2016.
  - Open point : Alt. Antenna sine levels
  - Schedule nominal





CNES Phase B major achievements : Mission ground

- **Control Center/ network**
  - CC requirements end 2016, Phase B in 2017,
  - Ground network availability assessed,
  - OPS concept, Ground / bord I/F, System Test plan released.
  - **Risk Mitigation**:
    - X-Band I/F peer Review in Nov. 14
    - CC heritage from on-going generic development
    - Ground network workload and margins assessed
    - System Interfaces review in November 2015



- **Mission center**
  - Mission center perimeter defined and budgeted,
  - Workshare agreement with NASA/ JPL on ADT/ operational algorithms,
  - SDS Architecture & interfaces end 2016,
  - Phase B in 2017
  - Algorithm Development Plan, Algorithm description Implementation Plan agreed and released.

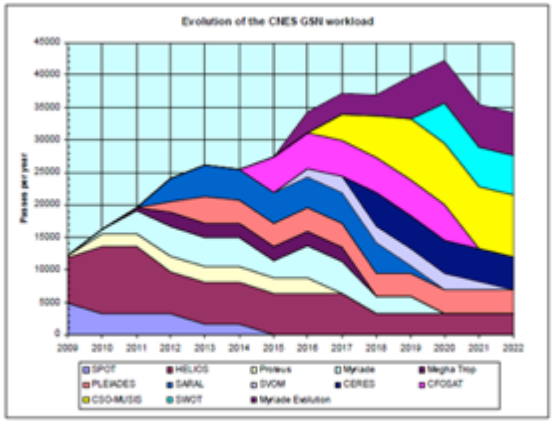


Figure 3: Evolution of the CNES Ground Station Network workload.

Looking forward

- Focus now on finalizing designs for implementation along with building/testing HW/SW for flight.
- Science Related Key items: (Priority driven by items that will be fixed in the design)
  - Urgent focus on algorithm baselines for On-Board Processor
  - Further Ramp Up Algorithm development:
    - ATBD's, Prototype Code,…
  - Refinement of science data products definitions/formats:
    - Standard, Expert, value-added, …
  - Detailed Cal/Val Planning
  - Data distribution and Applications

Summary

- Project has made excellent progress and now into implementation phase
- Science team involvement is very important going forward on executing the science priorities to prepare for launch and operations
- Implementing SWOT has many engineering and science challenges:
  - Maintaining discipline on establishing and maintaining baselines, careful change control, resisting scope creep and being flexible/realistic working as a collaborative team is critical.
  - Project teams are working hard to Maximize science return while balancing mission risk.