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TAKING THE PULSE
OF OUR PLANET FROM SPACE



TRUTHS: a new ESA Earth Watch mission for climatology and radiometric calibration from Space

A.Marini, T.Fehr, A.Zuccaro Marchi, T.Ivanov, J.Moreno-Ventas, E.Joffre, M.Piñol Solé, V.Ficaja, R.Duca (ESA/ESTEC), H.Côme (ESA/ESOC), D.Biancu, C.Lopes (ESA/ESRIN)

26/05/2022

TRUTHS Program context

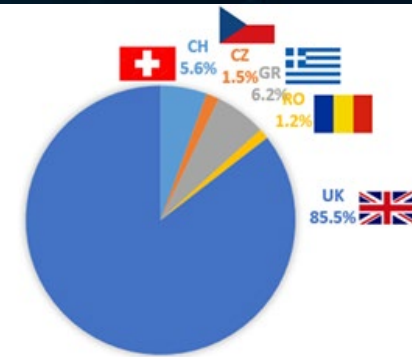
TRUTHS Definition Phase Activities

- Industrial Study
- Science activities run by ESA

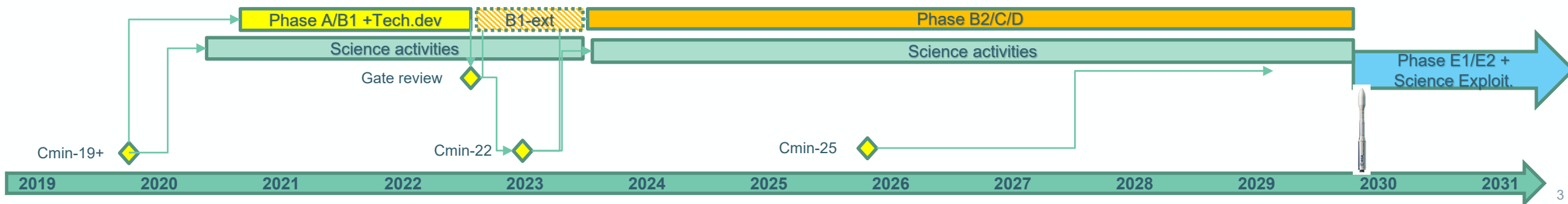
Outlook on TRUTHS Implementation phase

TRUTHS Program context

- TRUTHS was proposed by UK-SA in May 2019 as a new Earth Watch (EW) Element of ESA EO program
- TRUTHS Phase A/B1 has been fully subscribed at CM-19+ by 5 Participating Countries: UK, CH, CZ, GR, RO
- Industrial Phase A/B1 system studies and technology predevelopments initiated in Oct-20.
 - Phase-A kicked-off in Oct-20 and completed at end-July 2021
 - Phase B1 being completed, as scheduled (Q2-2022). ISRR on-going
- Science study in parallel (TMAC) and MAG formed and operated in support of entire A/B1
- Steering Board established as governance body with Delegations of the participating ESA Member States
- Programmatic “Gate Review”: go/no-go decision, in July-22, to submit program to CM-22.
- Phase B2/C/D/E to be funded at CM-22/-25
- Estimated Launch date Q1-2030

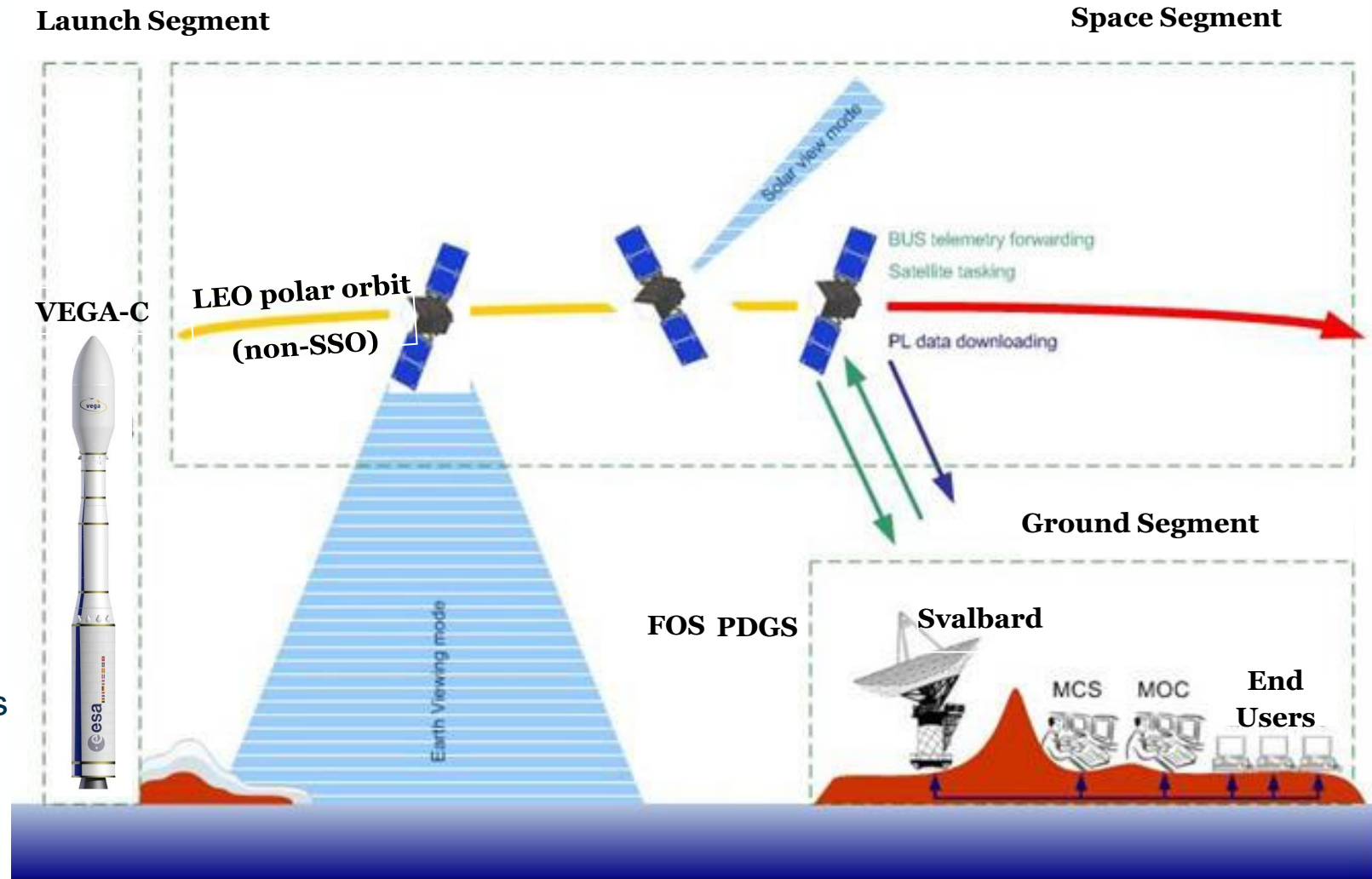


TRUTHS A/B1 SUBSCRIPTION - @SPACE19+



System Architecture

- Lifetime 5 yrs + 3 extension
- Space Segment:
 - Orbit 614 km, polar (90°) non-SSO
 - 1 satellite – agile, design for non-SSO
 - Novel Payload
- Launch Segment:
 - Vega-C (-E) single launch
 - Option co-passenger to be explored
- Ground Segment
 - LEOP/early comm. @ ESOC
 - Routine FOS in UK (hand-over)
 - 1 polar station baselined, 2nd GS passes for downlink robustness, compression.
 - PDGS in UK+ data access at ESRIN (ESA open data access policy)



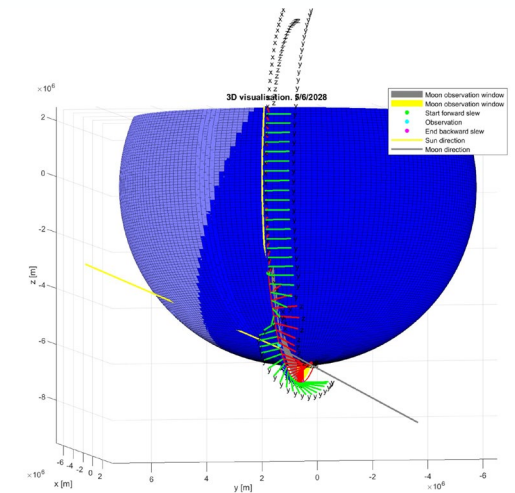
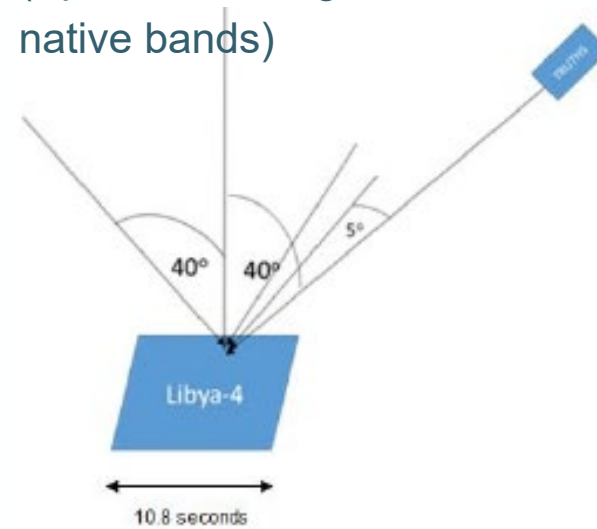
Climate application drives:

- **Spectral range 320-2400 nm** → P/L wideband optical design
- **Radiometric accuracy <1%** → Payload & calibration design
- **Non-SSO orbit** → calibration at low SZA, P/F design
- **Data Rate/volume 900Mb/s DL** → compression, binning

Cross-calibration application drives:

- **Ground sampling (50 m)** → detector size, data rate
- **Radiometric accuracy 0.3-÷1%** → spectral and spatial straylight, non-homogeneous scenes, spectral knowledge in-orbit
- **Different targets (PICS/Moon/ other sats)** → P/F agility
- **Non-SSO orbit** → platform and P/L thermal design

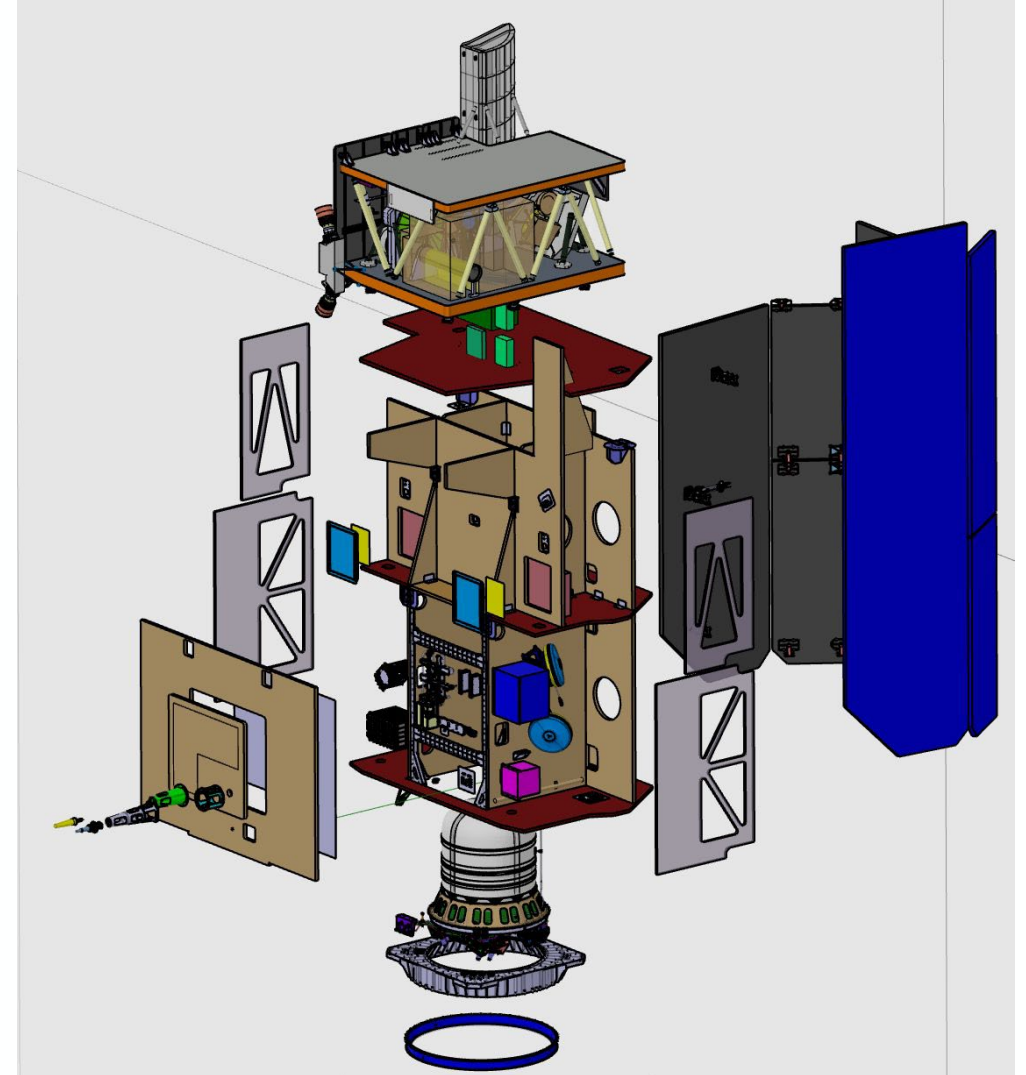
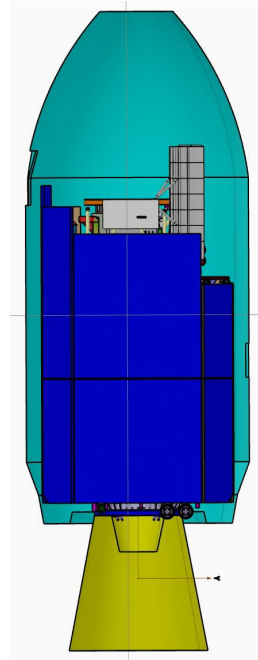
(Spectral binning allowed to match cross-calibrated satellite native bands)



LEVEL 1 Products	Spectral range (nm)	Spectral resolution (nm)	Uncertainty % (2σ)	SNR _{native_ssd@L_{ref}}	SSD product (m)
Earth Radiance Spectral	320 to 2400	≤ 4, for λ < 800 nm ≤ 6, for 800 nm < λ < 1000 nm ≤ 8, for 1000 nm < λ < 2400 nm	0.3 (goal) <1.0 (thresh.)	15 (UV) 25 (blue) 100(Vis-SWIR)	100 (land / coast) 300 (ocean) 50 (cross-calibration)
Solar/ Lunar Spectral Irradiance	320 to 2400	SSI: ≤ 1, for λ < 400 nm ≤ 4, for 400 nm < λ < 800 nm ≤ 6, for 800 nm < λ < 1000 nm ≤ 8, for 1000 nm < λ < 2400 nm LSI: ≤ 20, for λ < 380 nm ≤ 10, for λ > 380 nm	0.3 (goal) <1.0 (thresh.)	300 for LSI NA for SSI*	NA
Total Solar Irradiance	300 – 30.000	NA	0.02 (goal) <0.05 (thresh.)	NA*	NA

*binning over all spatial pixels and repeated acquisition will suffice to guarantee the needed signal level

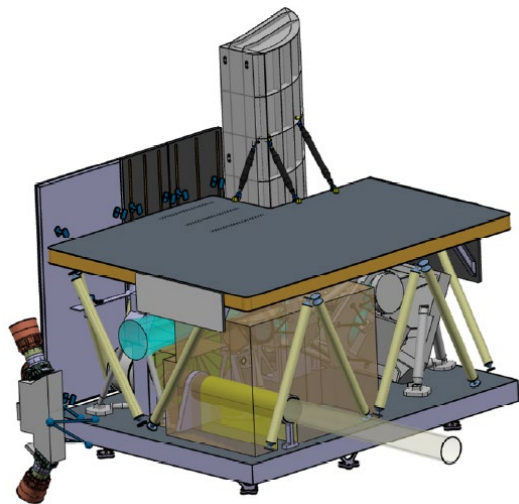
- Architecture based on recurrent CRISTAL platform
 - Structure compacted, -> reduced Mol for agility
 - Trimmed Solar arrays, adapted radiators/TC
 - Dry Mass ~1.5 ton (preliminary) + ~260 kg fuel (controlled re-entry)
 - Power ~1 kW peak
- Compatible with single launch Vega-C, smaller co-passenger



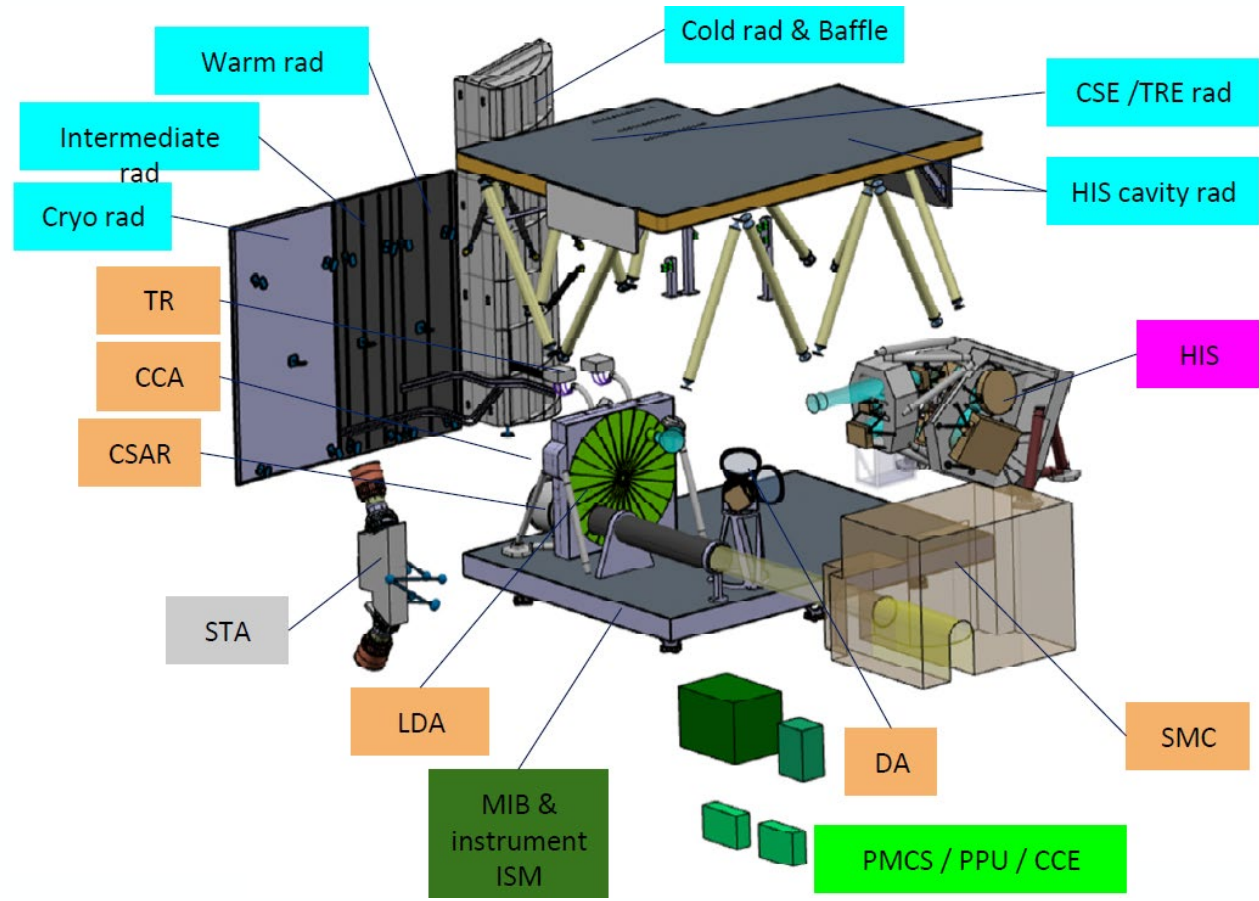
Payload Overview

Payload, composed of three elements:

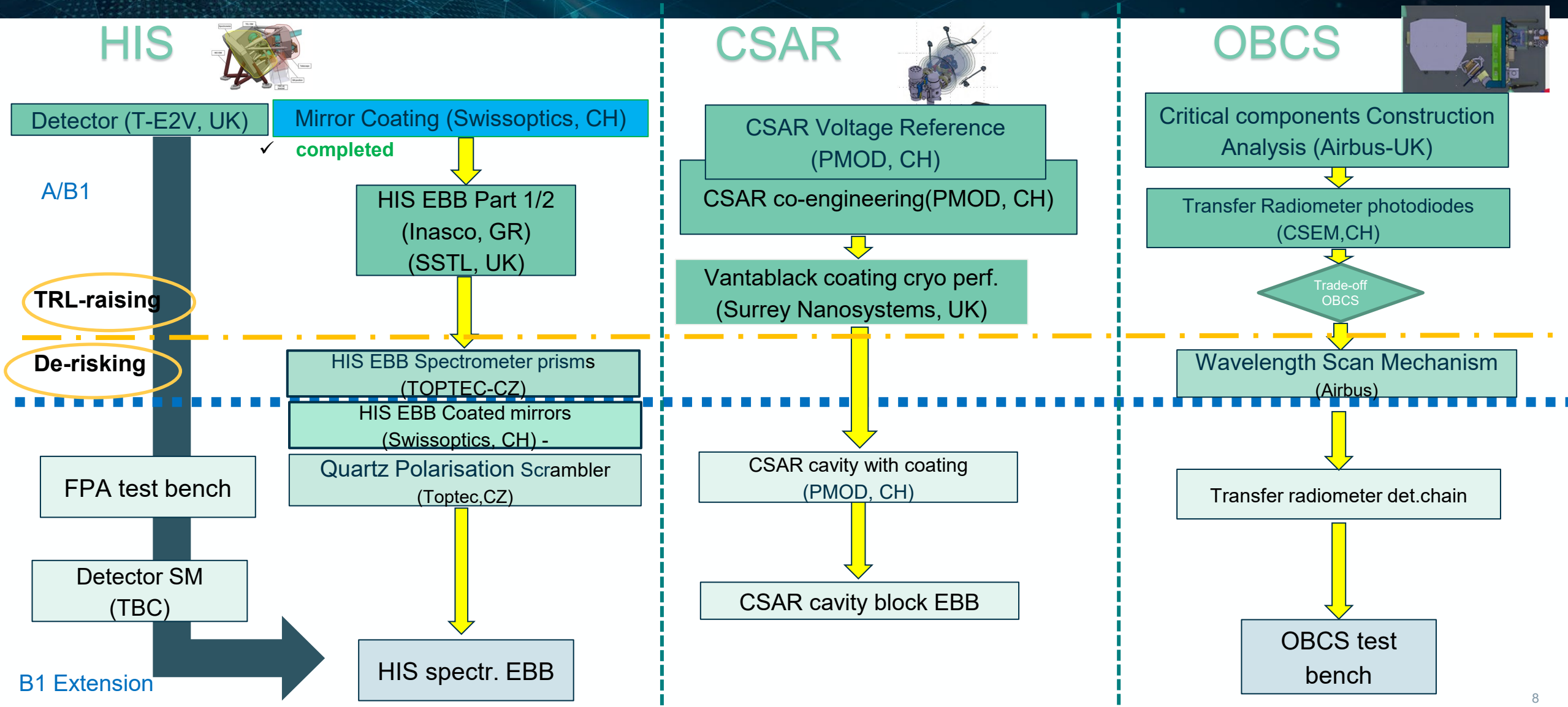
- **HIS** (Hyperspectral Imaging Spectrometer) UV to SWIR (320-2400 nm), single detector, 50 m resolution, 100 km swath
- **CSAR** (Cryogenic Solar Absolute Radiometer) – operated at 60 K, the “absolute radiometric reference”
- **OBCS** (On-Board Calibration System) – transferring the CSAR solar absolute measurement to the HIS



Hyperspectral Imaging Spectrometer
On Board Calibration System
Main Instrument Structure
Thermal Structure Assembly
Star Tracker Assembly
Spacecraft Located Electronics



Technology pre-developments

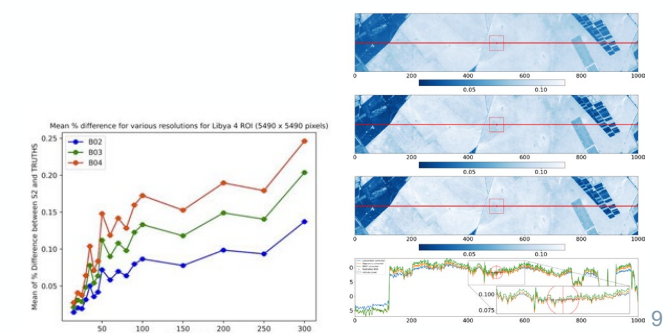
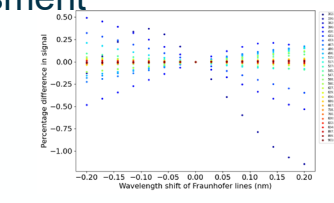
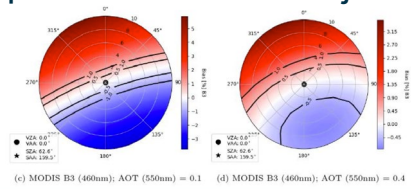
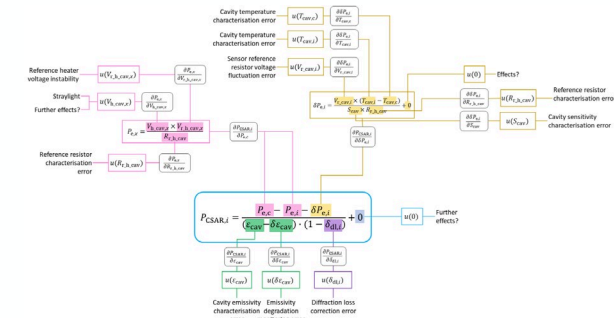
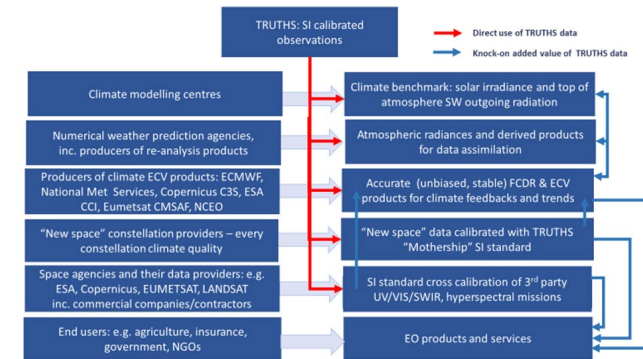


TRUTHS Science activities - 1



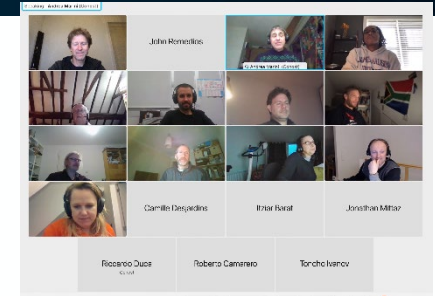
Science Studies have been implemented since start of Phase A/B1:

- Independent User requirements study completed in 2020 resulting in “User Requirements” and “Traceable Mission Requirements Review” Documents
 - Identification and survey of key user groups for an operational climate mission
 - User requirements identified and prioritized, different Use Cases explored
 - Importance of SI-traceable Earth reflected and solar observations confirmed
 - Mission objectives consolidated, primary and secondary applications identified
- TRUTHS Mission Accompanying Consolidation (TMAC) Study providing scientific support to the ESA Project ongoing since January 2021
 - Reference scenes (sand, coastal water, vegetation, land, ice, clouds, crops) for E2E Simulator
 - Interface and requirements of L1c product to generate level 2; Level 2 Surface reflectance product algorithm baseline
 - FIDUCEO methodology developing the metrological method for TRUTHS uncertainty tracing
 - Support to the Sensor-to-Sensor inter-calibration priorities and match-up radiometric accuracy
 - Support to TRUTHS Project Reviews and Science Readiness Level Assessment



TRUTHS Science activities - 2

- TRUTHS Mission Advisory Group (MAG) established in December 2020
 - 12 members, 2 Experts (NPL, U. Iasi) plus 3 observers from EUMETSAT, ECMWF/C3S, NASA (CLARREO-PF)
 - Essential and constructive support to the TRUTHS project in the science and performance assessment, including discussions on requirements relaxations, straylight and orbit
- TRUTHS presented at COP-26 in Blue and green-zone-> lot of interest!
 - Ground-breaking mission, new benchmark for climate observations from space
 - Detection of climate changes as short a time as possible. Support of Climate Action
- TRUTHS at LPS-22: science and invited sessions
 - B1.01: SI-Traceable Satellites - a Gold Standard for Climate and Intercalibration
 - B3.04: TRUTHS: a new ESA Earth Watch mission for climatology and radiometric calibration from Space



Phase A/B1 Partners

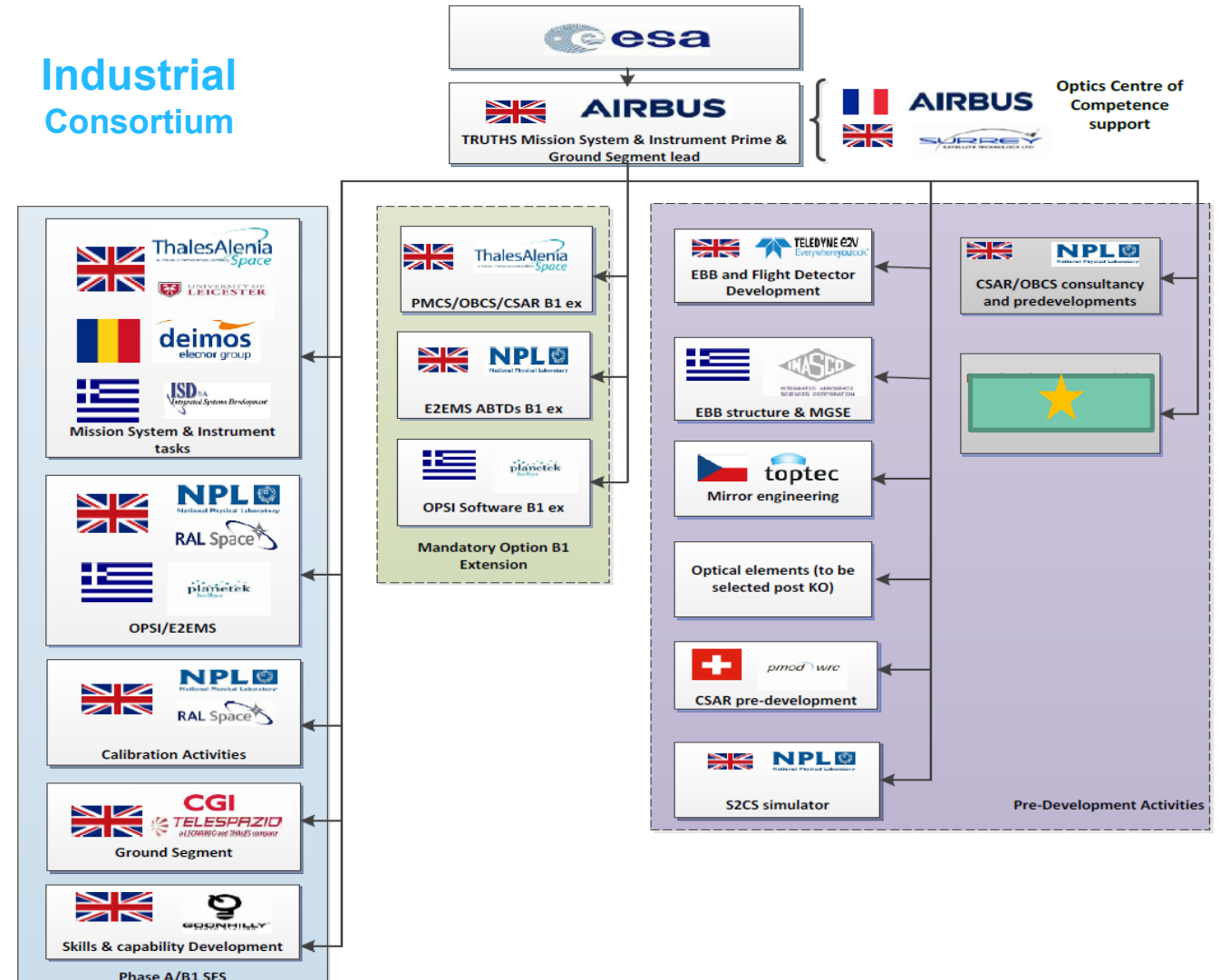


Agencies



Science institutes

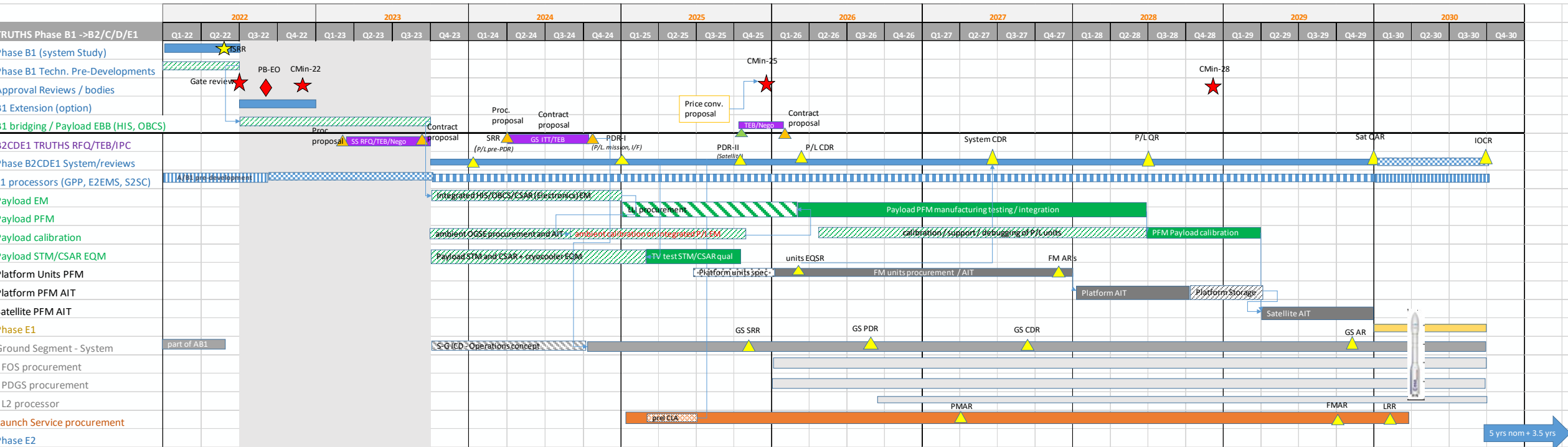
Industrial Consortium



Master schedule –Implementation plan



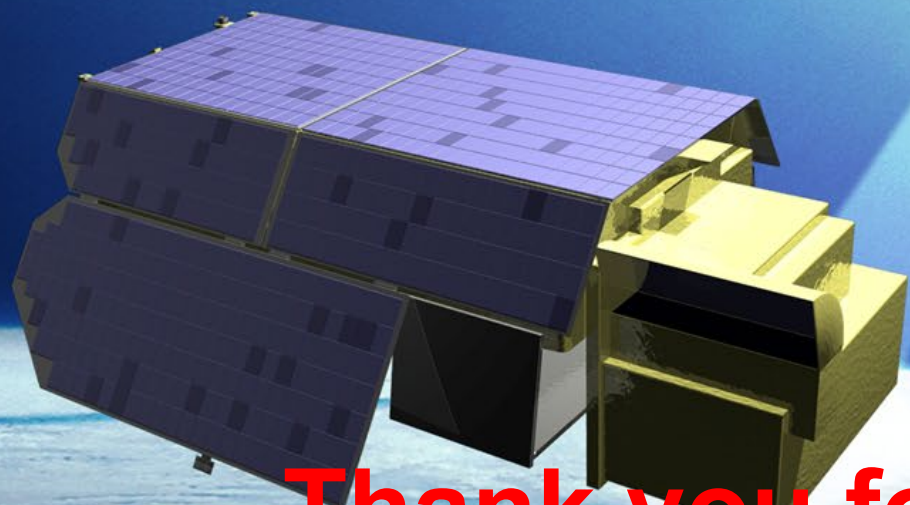
2 steps implementation to reduce payload risks first before engaging the flight satellite and system industrial activities



CMin	Activity
2022	Phase B2/C0: System work up to PDR (and GS SRR), simulators and GPP with focus on calibration, EM of the HIS and OBCS (with CSAR EBB) with ambient calibration , CSAR and cooler EQM (+ P/L partial OBCS STM), procurement of P/L and P/F LLI . Launch services procurement (Vega-C single or with co-passenger). ITT for G/S (system work up to SRR)
2025	Phase C/D/E1: System and processor up to and Phase E1, Satellite and Payload PFM , Ground Segment (Procurement of FOS and PDGS), Phase E1 and operations (Phase E2 TBC)
CFI	<i>Launch service procurement (ESA), LEOP and P/F Commissioning (ESOC), science campaigns and support (ESA), PDGS data access at ESRIN (ESA policy)</i>



- TRUTHS profiles as an Earth Watch element with a strong climate-oriented aim and with the possibility of opening operational services of metrology and calibration in space.
 - The need for TRUTHS mission and SITsats is now clearer than ever.
 - Operational climatological mission and opening up to a new international system of climate/metrology observatories
- At end of Phase A/B1, the consolidation work has permitted to fully appraise its science value and its complexity – at once.
 - Mission class commensurate to its complex, multifold objectives
 - Need for a sound technical / programmatic approach
- Upon successful Gate Review the mission will be proposed at CM-22 for implementation, in 2 steps:
 - CM-22: phase B2/C0 with strong focus on payload de-risking
 - CM-25: Phase C/D/E1
- Europe will exploit a new metrology laboratory in space and operational climate mission from 2030



Thank you for your attention!