LISA AIV/T

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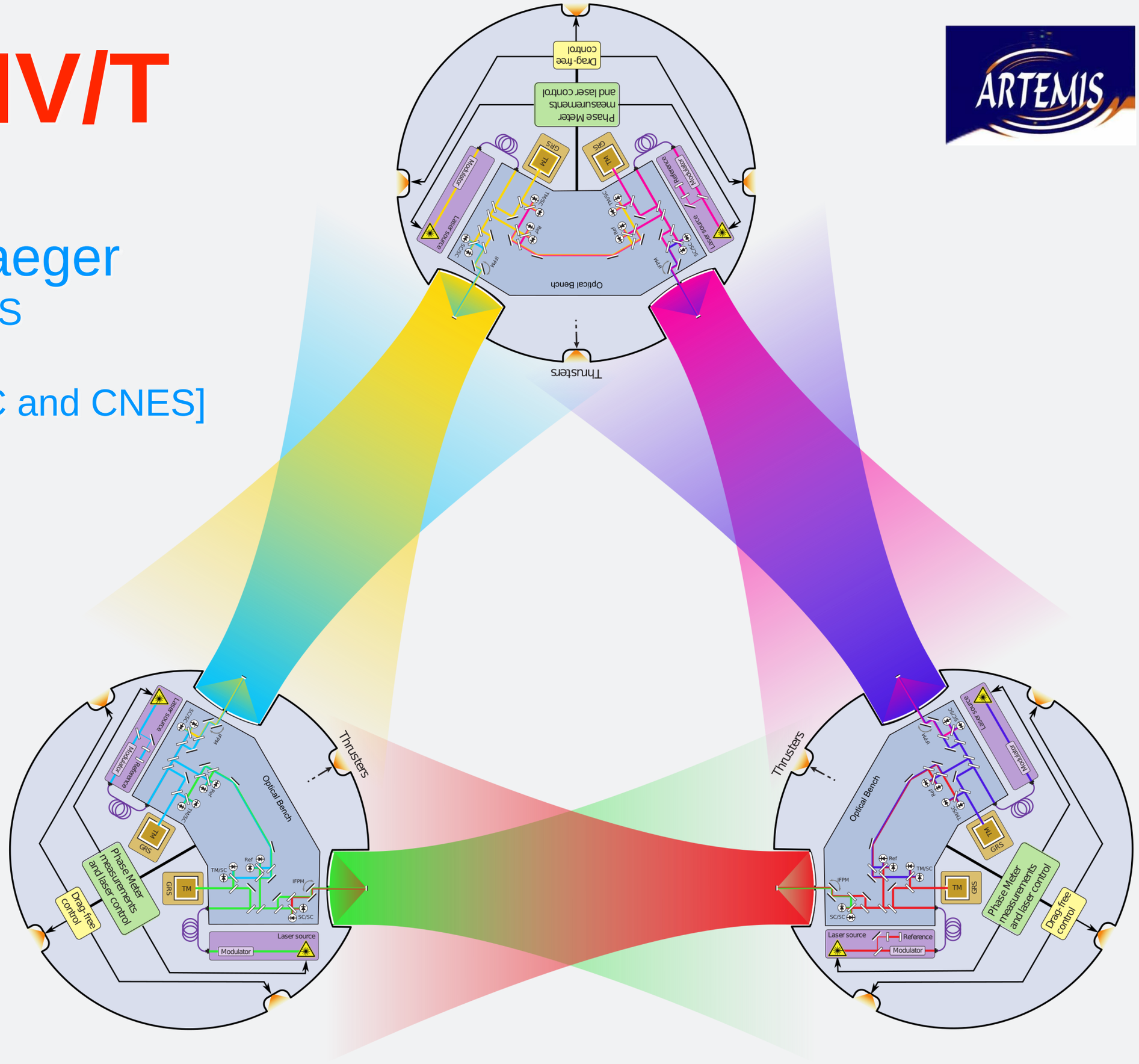
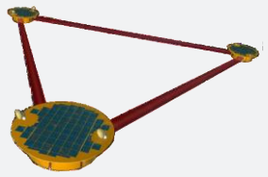
ARTEMIS

[joint work with APC and CNES]



Outline

- General configuration of LISA payload & MOSA
- Top level MOSA AIV/T flow description
- Main French MOSA AIV/T activities
- Proposal for French activities organization
- Possible activities for scientific laboratories teams



LISA Payload elements on each S/C

Grav.Ref. Sensor (GRS) + Optical bench (OB) + Telescope (T) = Moving Optical SubAssembly (MOSA)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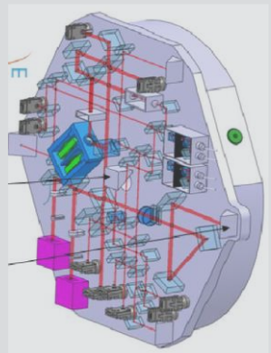
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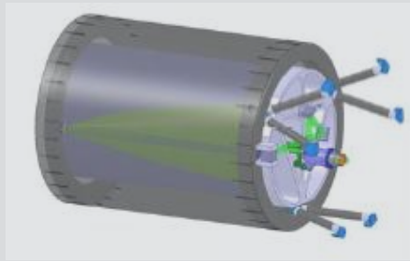
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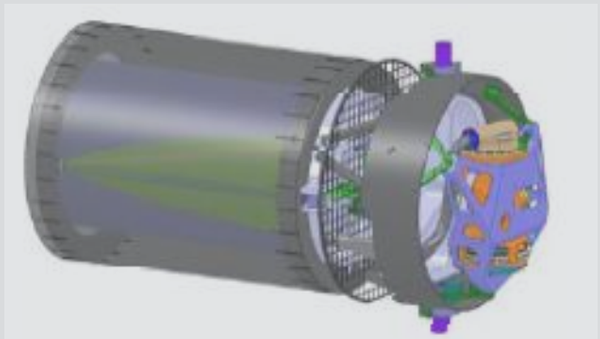
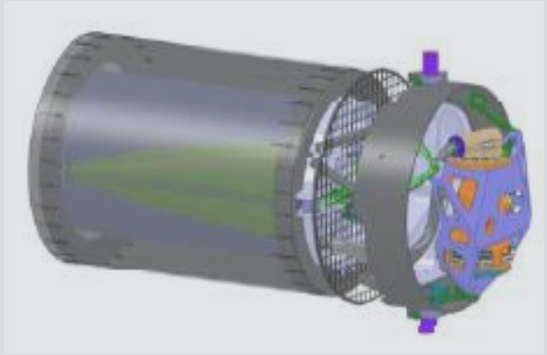


2x MOSA = LISA Core Assembly (LCA)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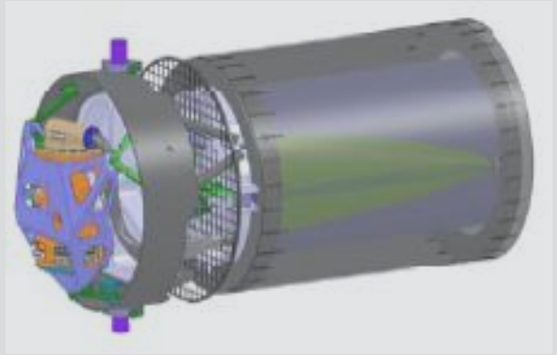
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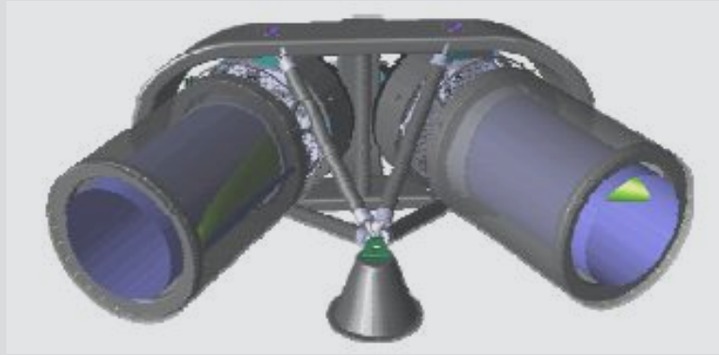
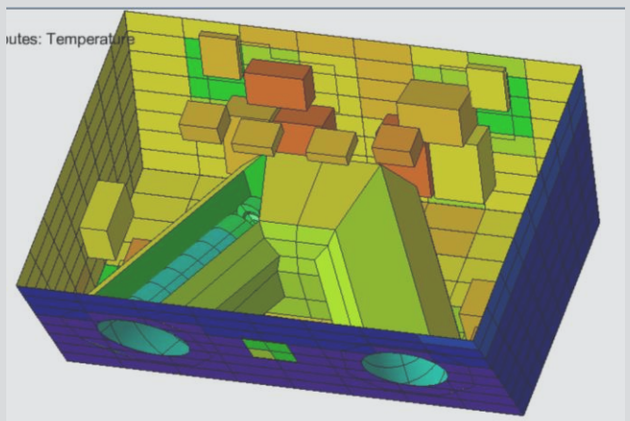


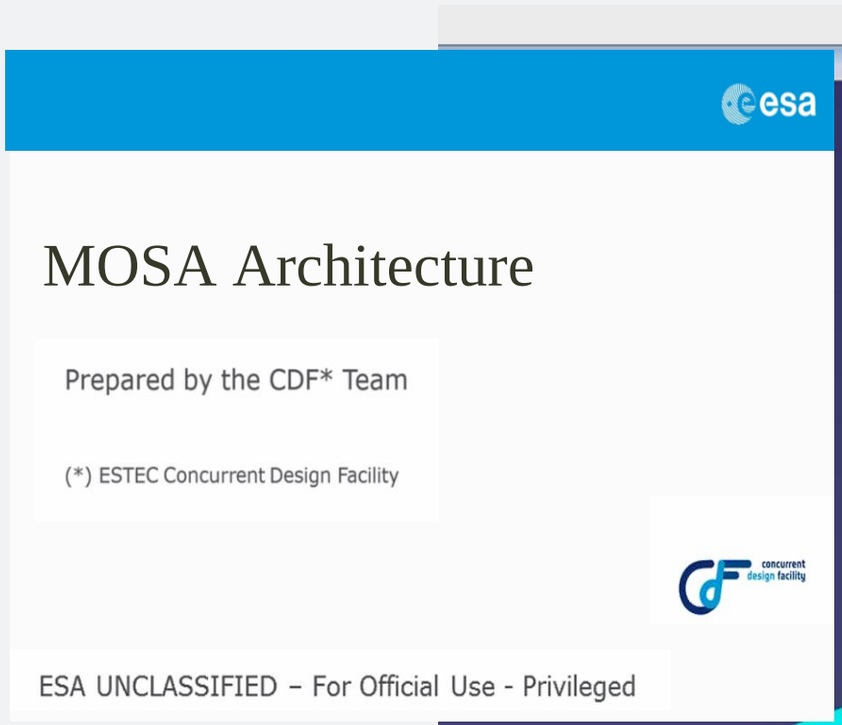
LCA + Electronics boxes = Payload

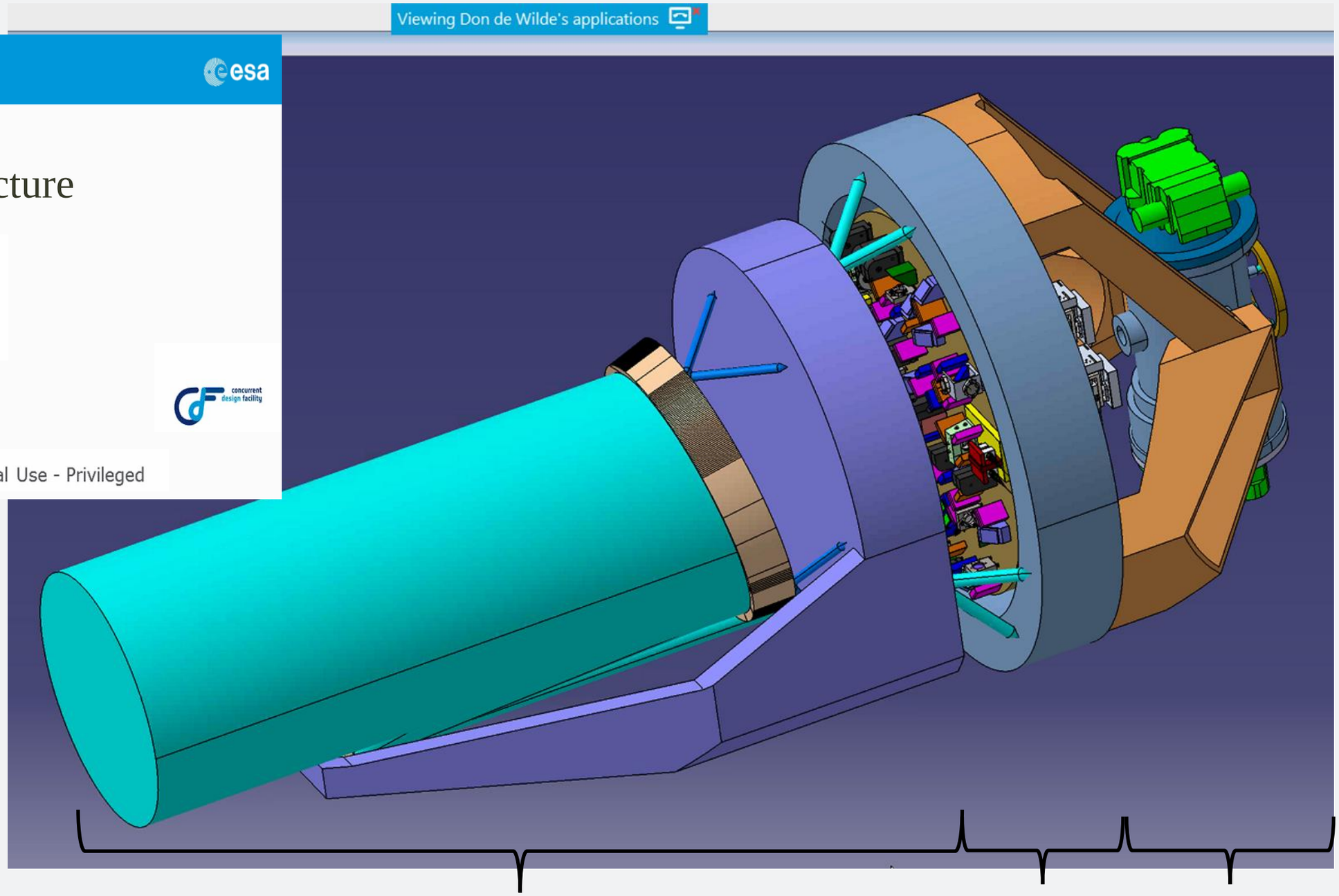
(Phasemeter, Laser Assembly, GRS FEE, Computers (on-board+payload), etc.)



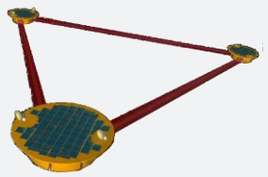
EADS Astrium & CDF/ESTEC drawings

Most recent MOSA architecture (based on new USA telescope design)





MOSA support structure with internal interfaces between OB, Tel & GRS head still to be defined



MOSA Top Level AIV/T Flow

Optical Bench (OB) + Diag. Equip. + Harness
Unit Test Bench (Super/Hyper-RoB)
- UK

OB Incomming inspection & acceptance tests

MOSA support structure + Diag. Equip. + Harnais Board
Unit Test Bench + MGSE tbd
- ESA/prime contractor

MOSA structure Incomming inspection & acceptance tests

OB + MOSA structure Integration & alignement
- France MGSE

Optical Bench Assembly (OBA)

OBA GSE:
- OB Unit Test Bench (Hyper-RoB) /UK

OBA functional tests
- OB internal alignement verification
- I/F verification etc

Telescope (T) + Diag. Equip. + Baffle
Unit Test Bench + FarField-OGSE
- USA

T Incomming inspection & acceptance tests

T + OBA Integration & alignement
- France MGSE

Telescope Optical Bench Assembly (TOBA)

TOBA1 GSE:
- OB Unit Test Bench (Super-RoB) /UK
- FarFiled-OGSE /USA

TOBA1 functional tests
- OB internal align., OB-Tel align, etc

TOBA1 GSE tbd
- France

TM-OGSE (TM simulator)
- Italy

TOBA2 functional & performance tests
- OB internal align.
- OB/Tel+FF-OGSE/TMOGSE axes+lateral align
- long-arm beam tilts (DWS zero)
- FarField PAA verification
- data link reception/generation verification
- phase lock on incomming pW beam
- Sci-IFO perf. tests: pm/rtHz@0.1-1Hz
- TM_IFO perf. tests: pm/rtHz@0.1-1Hz
- stray light test tbd
- Constellation Acquisition Sensor (CAS)

TOBA2 GSE:
- Laser GSE
- PM GSE
- PAAM controller GSE
- back-link simulator GSE
- Payload computer GSE
- stabilized power supplies
- others GSE tbd
- France + others contributors tbd

Laser Assembly (LA) + Diag. Equip. + Harness
Unit test Bench
- USA

LA Incomming inspection & acceptance tests

Phasemeter (PM) + Diag. Equip. + Harness
Unit test Bench
- Germany

PM Incomming inspection & acceptance tests

TOBA3 functional & performance tests
- idem TOBA2 or a subset of tests tbd

TOBA3 GSE tbd

Grav. Ref. System Head (GRSH) +
GRS Electronics (tbc) + Diag. Equip. + Harnais
Unit Test Bench
- Italy

GRS Incomming inspection & acceptance tests

GRSH + TOBA Integration & alignement
- France MGSE

Telescope Optical Bench & Inertial Sensor (TOBIAS)

TOBIAS functional tests tbd
(OB-Tel-TM align. verification)

TOBIAS GSE tbd

Thermal insulator (Multi-layer insulation) tbd
- Responsible tbd

MLI Incomming inspection & acceptance tests

TOBIAS + MLI Integration
- France MGSE

Moving Optical Sub-Assembly (MOSA)

MOSA functional tests tbd

MOSA GSE tbd

MOSA delivery to LCA integrator

Legend of colours:
Magenta: units + additional elements to be delivered by various providers
Light blue: acceptance tests, to be defined by various units providers, carried out by France with units providers
Light green: functional/performance tests to be carried out by France (+help of various providers)
Dark green: GSE to be developed by France (+ other contributors)
Dark blue: integrated sub-assemblies

MOSA Top Level AIV/T Flow
N. Dinu Jaeger (ARTEMIS)/ H. Halloin (APC)
V0.2 21/09/2017

Units test benches

- Delivered together with the corresponding unit (OB, Tel, LA, PM etc.)
- Aimed to be used for units acceptance tests (check that units satisfy the specifications) at the entrance to the integration facility
- When possible, they can be used for tests during integration steps
- Example: OB unit test bench
  - RoB
    - Opto-mechanical GSE
    - Read-out box: simple, battery powered, allowing to read out spot position from individual phootodiodes (a suitable laser should be connected to the system);
  - Super RoB (already prepared for LISA Pathfinder)
    - Same as RoB, but with its own laser system, that can illuminate fiber inputs
    - Able to read out all photodiodes simultaneously;
    - Can be used to monitor and minimize distortions during various integration stages;
    - Gives functional tests of OB: integrity of fibers and optics on the bench, integrity, function and position stability of photodiodes
  - Hyper-RoB
    - To be developed
    - Including Optical Telescope simulator
      - Simulates the laser beam entering from the Telescope to the OB
      - Monitor and record the properties of the beam sent from OB to Telescope

Specific simulators delivered by units providers

- Far-Field Optical Ground Support Equipment (FF-OGSE)
  - Simulates the characteristics of the laser beam entering the telescope
    - Direction
    - Low intensity (nW/m^2)
    - Truncated Gaussian beam shape (it should illuminate more than telescope diameter)
    - Wavefront quality
    - …..

- Test-Mass Optical Ground Support Equipment (TM-OGSE)
  - Mirror with 3 DoF (2 angles and 1 translation)
  - Mimic the movement of the test mass within its enclosure

Main French AIV/T activities

- Set-up a dedicated integration facility
- Carry out the reception of main MOSA units, units test benches and specific simulators
  - OB, Telescope, GRS, LA, Phasemeter delivered by consortium/USA providers
  - MOSA mechanical structure, provided by ESA Prime contractor
  - Simulators: Far Field OGSE, Test Mass OGSE by consortium/USA providers
  - Perform inspection and acceptance tests, with support from units providers
- Integrate the OB, Telescope and GRS head into the MOSA mechanical structure
- Test the alignment and shows that it stays into the defined budget
- Carry out functional and performance tests at various integration steps and shows that various assemblies satisfy the specifications
- Deliver integrated and tested MOSA to prime contractor

Proposal for French AIV/T activities organization

- MOSA AIV/T requires two specialized teams
  - Flight equipment integration
  - Precise/fine metrology

- Proposal
  - Set-up the integration activity in a unique place/site in France, having:
    - Dedicated infrastructure
      - Clean-room of large surface (50-100 m^2), class 100
      - Mechanical GSE
        - Big vacuum chamber with thermal/vibration control (~2 m diameter, 2-3 m long)
        - µm precision 3D coordinates measurement machine
    - Trained/authorized personnel with background on integration
      - Takes in charge the main integration steps, excepting the environment tests
      - Develop MGSE equipment's for integration and alignment
        - Ex: Mechanical bench required to maintain full MOSA elements
  - Precise metrology under the responsibility of scientific laboratories teams
  - Work in combined team (integration + metrology) on integration site

Possible activities to be developed by scientific laboratories teams

- Define specifications of functional/performance tests to be carried out at various MOSA integration steps
  - Heterodyne efficiency
  - Pointing stability
  - Photodiodes calibration
  - Stray light
  - …..
- Design, develop & commission specific test benches (OGSE, EGSE) to MOSA integration facility for MOSA functional/performance tests during integration
- Train the personnel at integration facility site to use test benches and to perform tests
- Process the test results and validate the performances
- When tests are not possible (too long, costly etc.), perform modelling for performance validation
- (Some) required competences
  - Electronics, optics, software…..

Additional slides

(Some) required infrastructures

- Required equipments during the integration / validation phases:
  - ~50 m^2 electronics lab (ambient cleanliness level)
  - ~50 m^2 clean rooms (1000 / 10000 / 100 000)
  - Coordinate measurement machine (~1 µm level, 1.5x1.5x1.5 m^3)
  - Thermal vacuum tanks with associated equipments (temperature sensors, etc.)
  - Programmable power supplies, precision multimeters, communication protocols inspector, precision phasemeter/counters, etc.
  - High bandwidth data logging devices and infrastructure (acquisition and analysis SW, archiving, …)
  - Optical benches (Zerodur ?), lasers (seeder, frequency reference, modulator, amplifier), optical components, single element and quadrant photodiodes, …
  - Piezo driven actuators, thermal compensating mount set-up, remote alignment translation tables

Key performance values

- Telescope:
  - 30 cm diameter,
  - Pathlength stability: ~ 1 pm/√Hz
- Laser
  - Wavelength 1064 nm, 2 W emitted (received ~750 pW)
  - RIN : $<10^{-8}$ /√Hz above 5 MHz
  - Frequency stability ~300 Hz/√Hz
  - Frequency modulation amplitude: ±30 MHz
  - Phase modulation at (2.3±0.5) GHz
- Phase measurement bandwidth
  - 5-25 MHz
- Timing jitter in clock distribution: ~4×10^{-14} s/√Hz
- Absolute ranging accuracy: ~10 cm
- Thermal stability (optical bench): < 1mK/√Hz at 1 mHz
- Laser beam pointing jitter: ~2 nrad/√Hz
- Alignment accuracy of the sub systems during integration: ~10 µm / 1 mrad

Proposed model philosophy

- The consortium is responsible for delivering
  - integrated/tested/validated MOSAs

- Model philosophy (definition still in progress)
  - Elegant BreadBoard (EBB)
    - Demonstrates mechanical/optical/electrical interfaces
      - OB - Telescope: optical, mechanical
      - OB – PM - Laser: electrical, optical, functional; should be at unit level?
      - OB - Telescope-GRS: mechanical
      - CAS – Telescope
      - …..
      - Uses representative assemblies, but non flight (still modifiable)
  - Structural/Thermal Model (STM)
    - Validates mechanical interface, mechanical charges and thermal comportment
      - Uses dummy assemblies/units
  - Engineering (Qualification) Model (E(Q)M)
    - Validates MOSA/payload conception and its AIV/T process
    - Uses flight representative assemblies/units
    - It is submitted to qualification tests (launch resistance and spatial environment)
  - 6 Flight Models (FM)
    - Idem as E(Q)M
    - Submitted to acceptance tests (verification of technical conformity) and non-qualification