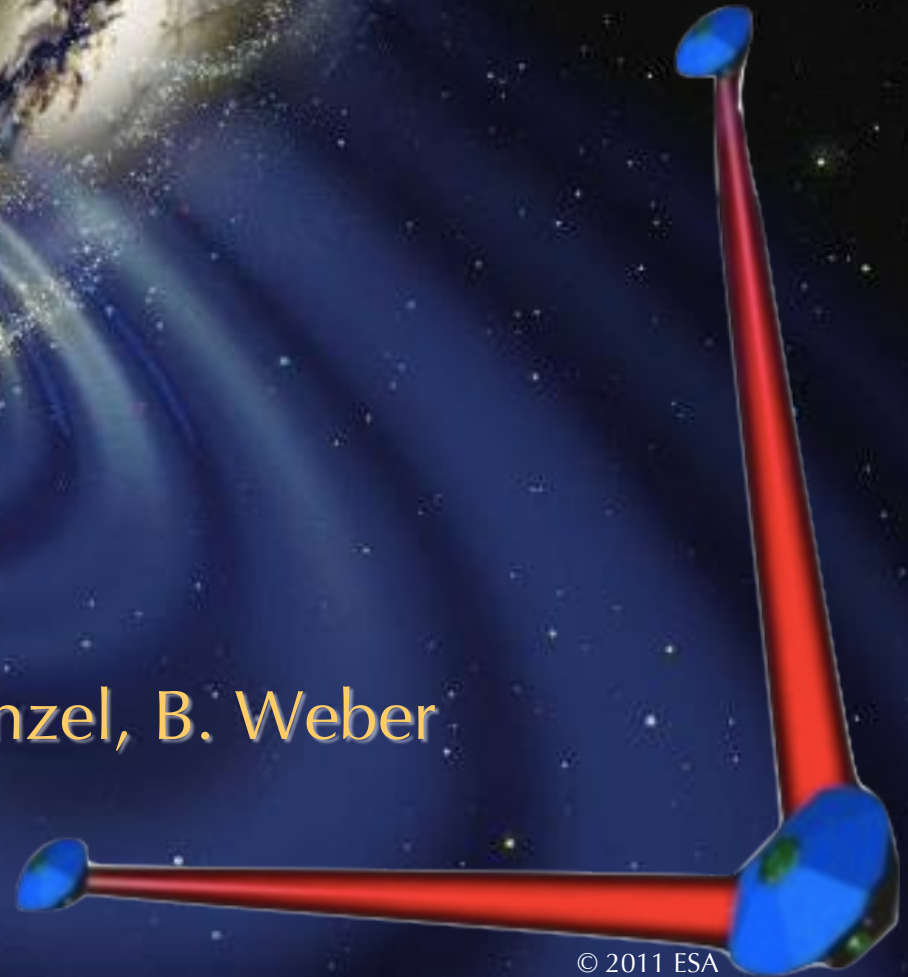


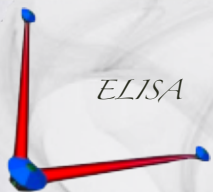
# Science of measurement

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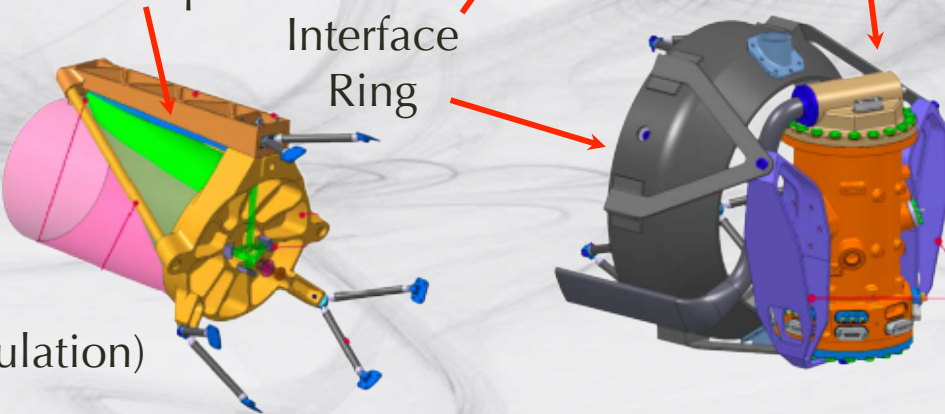
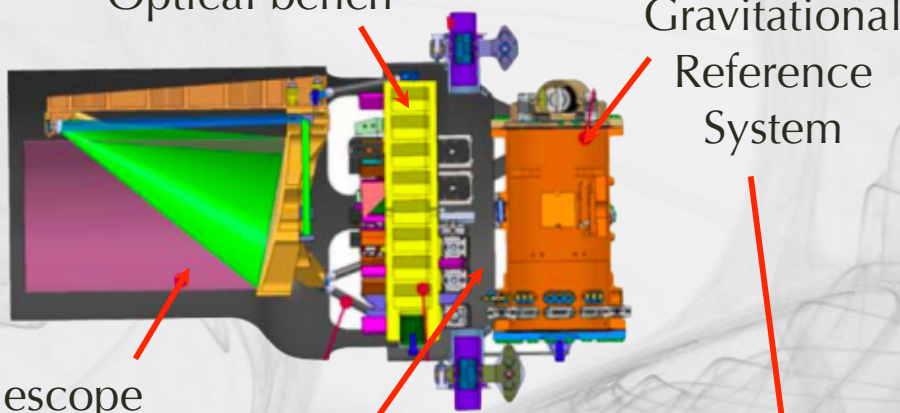
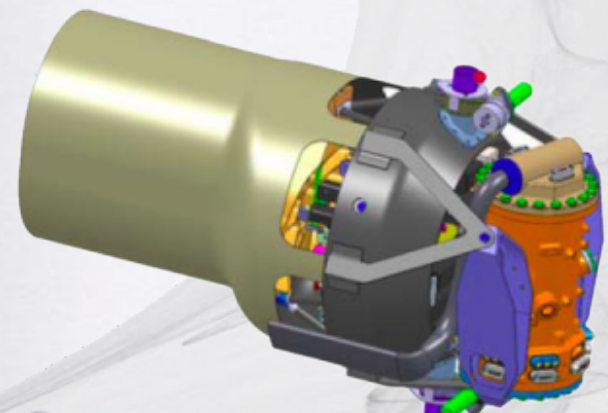
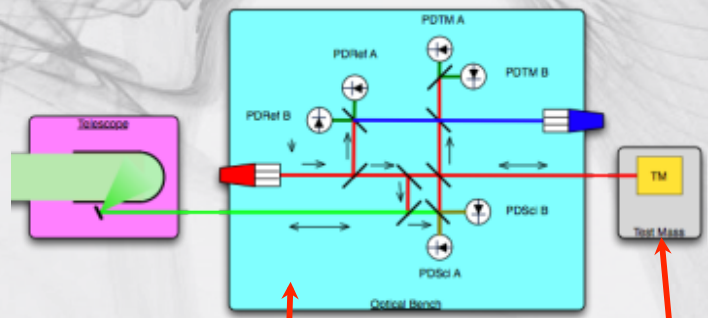
H. Halloin, G. Heinzl, B. Weber



© 2011 ESA



# Payload Design



- + acquisition electronics (phasermeter)
  - + FEE
  - + charge management system
  - + diagnostics
  - + laser source
- (seed+stabilisation+amplifier+modulation)



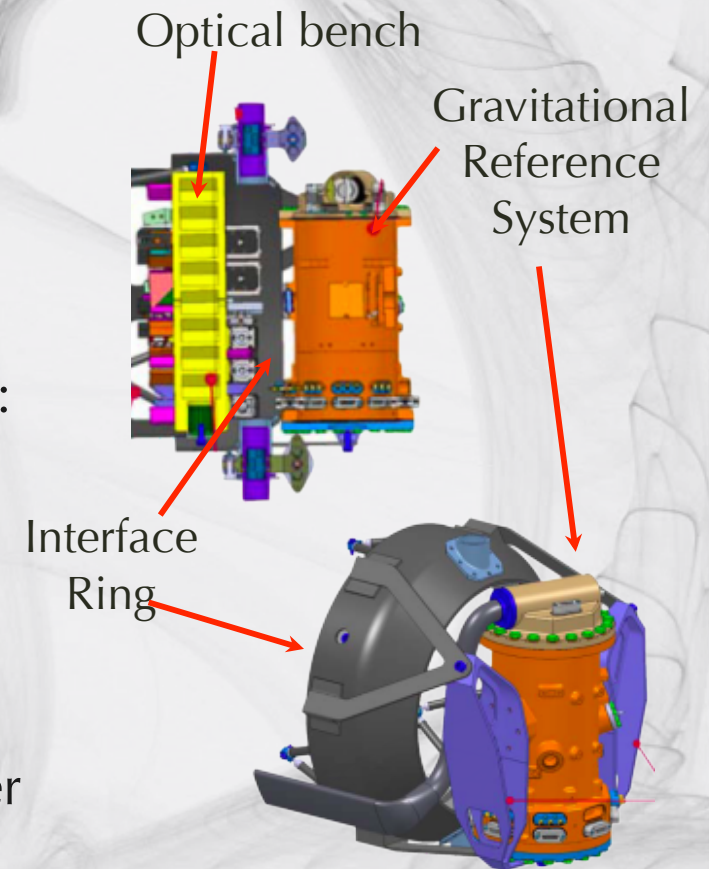
# Contributions of the member states

— The MS are in charge of the realization, validation and delivery of the *Instrument*, which consists of :

- ✓ the GRS and its FEE (Front End Electronics)
- ✓ the Charge Management System (CMS)
- ✓ the Optical Bench
- ✓ the Phasemeter
- ✓ the interface ring structure
- ✓ the diagnostics (housekeeping) system

— ESA will deliver the telescope and the laser source

- ✓ sub-contracting to industrials





# Member contributions (as of March 2012 proposal)

— The Instrument Consortium consists of 7 members :

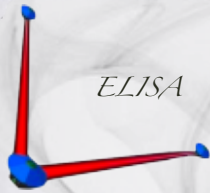
- ✓ Germany (instrument leader) :
  - Consortium management
  - System Engineering
  - Phasemeter development and delivery
  - Data preparation and data analysis
- ✓ France :
  - Ring structure
  - AIT/AIV (incl. OTMS simulator with UK, GSE design/interfaces)
  - part of SE (mechanics architect)
  - Data processing centre
- ✓ Italy :
  - System lead and key parts of the GRSS
- ✓ Switzerland :
  - Caging Mechanism (CM)
  - GRS Front-End Electronics (FEE)
- ✓ United Kingdom :
  - Optical Bench (OB)
  - Charge Management System (CMS)
- ✓ Spain :
  - Data and Diagnostics Subsystem (DDS)
  - Contribution to thermal modeling, ground support and data analysis
- ✓ Denmark :
  - Contribution to the phasemeter development

→ The deliverables also include GSEs and SCOEs (Special Check-Out Equipment)



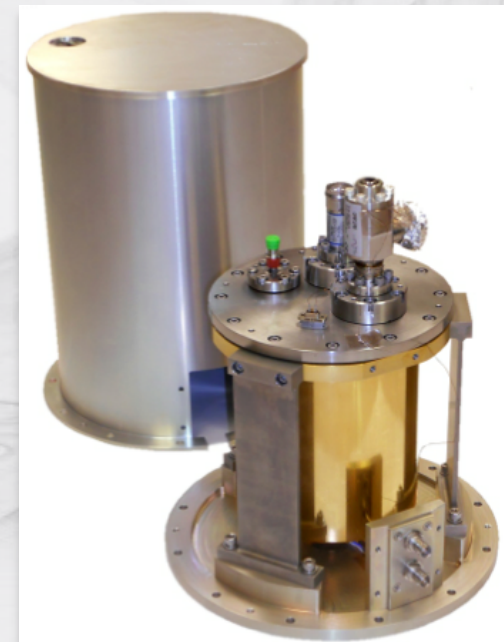
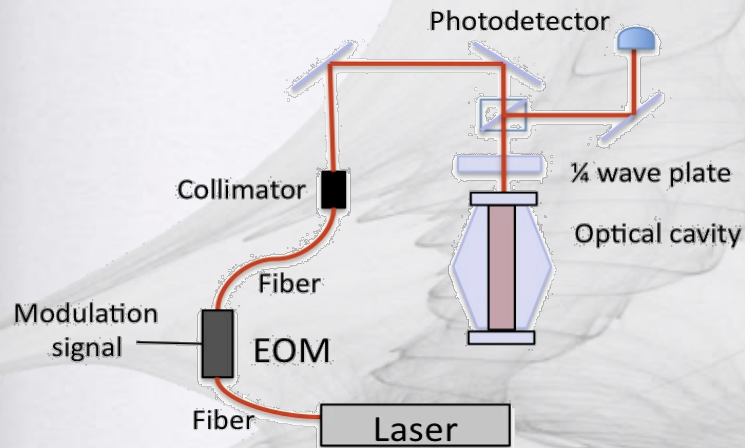
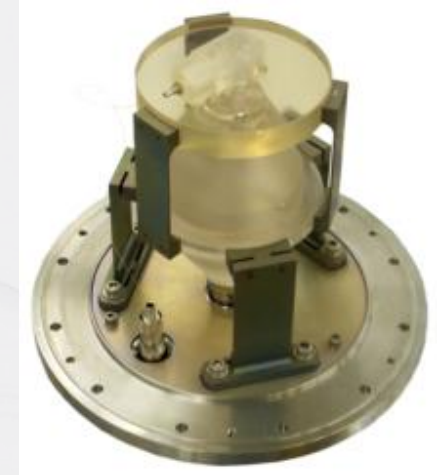
# Milestones

- Updating the technical proposal for L2 selection
- Development schedule for the earliest possible launch date (2028)
  - Development of a complete EQM (Engineering Qualification model) starting around 2015 (ends before 2020)
    - ✓ Fully representative of FM (flight model) except that a lower standard of electrical components may be used.
    - ✓ The standard of these components shall be the highest achievable within the schedule constraints but using the same manufacturer, the same type and the same package as for the FM. Only the testing and the screening of the parts might be different compared to the FM.
    - ✓ Subject to the full equipment level qualification test sequence
  - Critical technologies should be at TRL 5 by 2015
    - ✓ TRL 5 : Breadboard / component validation in a relevant environment
- What are the limits of the EQM ? full instrument
  - ✓ Telescope + OB + GRS + laser source + acquisition electronics
  - ✓ All GSEs (incl. software) + SCOEs
  - ✓ Tests procedures
  - ✓ Interfaces
  - ✓ ...



# Laser frequency stabilisation

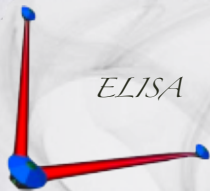
- US solution developed for GRACE-FO
  - ✓ Same requirements (30 Hz/sqrt(Hz))
  - ✓ Space qualified reference cavity developed by Ball Aerospace and tested at JPL
- European solution ?





# Optical Bench

- Ongoing ESA contract (Astrium/Glasgow/TNO/AEI) now stalled due to funding problems in UK
- Only Glasgow has bonding and alignment technology at the moment
- Considered solved:
  - Construction technique
  - PAAM
  - Acquisition sensor
- Questions:
  - Depending on arm pointing concept: either backlink or in-field pointer
  - Beam compressors
  - Photodiodes / preamplifiers



# Critical items (from the Technology Roadmap)

- System level :
  - ✓ Confirmation of optimal trade-off for eLISA (arm-length, telescope size, etc)
  - ✓ Feasibility of In-Field pointing vs. backlink (assessment of the risks/benefits, costs, etc.)
  - ✓ Review of phase Center Offset allocation and mitigation
  - ✓ Consolidation of the payload architecture
- Laser system :
  - ✓ Characterization/mitigation of differential phase noise of the fiber amplifier between GHz sidebands (clock synchronization) and carrier
- Optical Bench
  - ✓ Realization of the fiber collimator (FIOS)
  - ✓ Back link phase referencing (experimental validation)
  - ✓ In-Field Pointing
  - ✓ Development of an elaborate Telescope Simulator (phase center offset characterization and control)
  - ✓ Opto-mechanical design of an OB EBB for eLISA
- Charge control
  - ✓ Design and Testbed for new UV sources (LED or lasers) : currently on-going
  - ✓ Development of an EBB for UV light sources (representative of the eLISA requirements and flight design, full software model)
- Phasemeter
  - ✓ Continuation of present work with Danish partners
  - ✓ Representative (optical) testbed for clock synchronization, ranging, data transfer, signal phase noise performance estimation
- GRS FEE
  - ✓ Precise requirements specification (compared to LPF, especially down to 0,1 mHz)
  - ✓ Manufacturing and tests of an FEE breadboard





# Other items for eLISA

## ➤ Interferometry

- ✓ 'Final' technology choices (e.g. backlink/In-field pointing, freq. stab. System)
- ✓ Photodiodes, imaging optics
- ✓ Laser freq. stabilization system : ESA responsibility ?
- ✓ Telescope : ESA responsibility... in coordination with the Consortium
- ✓ End to end (i.e. photons to TDI) simulation : Is it needed ? When ?

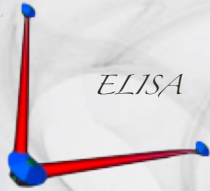
## ➤ GRS

- ✓ Mother - Daughter control and actuation
- ✓ Capacitive / optical readout sensitivity on non-IFO axes
- ✓ EH and TM surface properties
- ✓ Improved torsion pendulum verification benches

## ➤ System level studies :

- ✓  $\mu\text{N}$  Thrusters : reliability, livetime ?
- ✓ Updated environmental models (thermal, gravitational, EM, noise models) ?
- ✓ Interfaces, GSEs definition, preparation to AIT/AIV

➤ ...



# Past organization

- Until 2011: Two Working Groups attached to LIST:
  - GRS (Sumner/Buchman)
  - Interferometry (Müller/Heinzel)
- Both working groups held joint sessions in recent years
- Typically 1/2 day ... 1 day sessions before LIST meeting, summary given to LIST
- Focussing on institute research activities, little interaction with industrial studies
- How to continue?



# Actors

- ESA
- National Agencies
- MS Scientific community
- Industries
- US partners
- Chinese partners
  
- This WG must efficiently interact with all these actors
  - ✓ Scientific requirements
  - ✓ Interfaces between (sub)systems
  - ✓ Needs visibility of industrial studies
  - ✓ The WG should coordinate the technology developments together with TASAT



# Organization proposal

## ➤ Sub-systems teams :

- ✓ 2 main teams needed (interferometry and GRS) with sub-teams added as necessary
- ✓ All critical items covered and all on-going contracts reported on

## ➤ WG coordination, relationship with TASAT ?

- ✓ Prepares / defines, with the instrument teams, a development schedule
- ✓ In charge of organizing / following the technical developments, initiates actions as needed to stay on the development schedule
- ✓ Ensures smooth information flows between ESA, research groups and industries
- ✓ Close interactions with the DA group for developing a (software) end to end simulator (as done for LPF) + Data Challenges
- ✓ Organizes regular reviews and meetings, collect reports from technical groups, writes and distributes minutes of the meetings, ...
- ✓ ...