

LISA Technology Roadmap

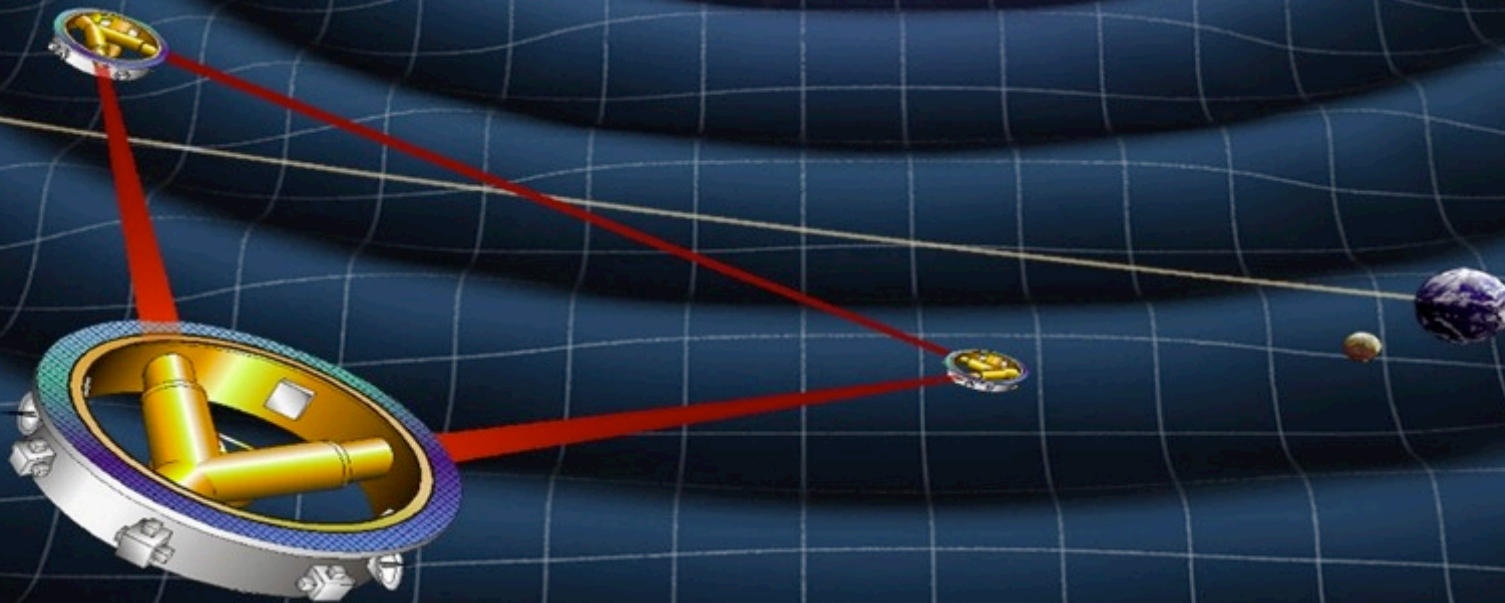
In preparation for the L2 selection

Karsten Danzmann

Albert Einstein Institute Hannover



LISA in 2012: 20 years of development!



Last year...



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Published online 22 March 2011 | *Nature* **471**, 421 (2011) | doi:10.1038/471421a

News

Europe makes do without NASA

US budget crisis forces European Space Agency to abandon plans for joint mission.

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- [L-Class missions](#)
- [LISA](#)
- [IXO](#)
- [ESJM-Laplace](#)

The European Space Agency (ESA) is pushing ahead without NASA support for its next big science mission, as the ongoing US budget crunch and competing priorities impose serious constraints on the US space agency (see [Nature 471, 278; 2011](#)). ESA last week told leaders of three large, or 'L-class', missions that are competing for funding to revise their proposals by leaving out the substantial US contribution that had previously been assumed.

"The decision was made very reluctantly," says David Southwood, director of science and robotic exploration at ESA. "NASA could not meet our timetable to launch."

This article elsewhere

 [Blogs linking to this article](#)

22 April 2011

- [China hopes research centre can quell food-safety fears](#)
22 April 2011

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- [US Mars mission takes pole position](#)
08 March 2011
- [ESA on countdown to flagship mission selection](#)

ESA Cosmic Vision L1 Downselection



- 04/2011 – 11/2011, Rescoping study
- 11/2011 – 02/2012, Technical assessment by ESA
- March 15, 2012, Delegations Meeting in Paris
- April 2, 2012, SSAC Meeting in Paris
- May 2, 2012, SPC Meeting, Selection

Technical Assessment



Prepared by G.Racca and the Review board
Reference LISA-EST-RP-1018
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DOCUMENT

L1 Mission Reformulation

NGO - New Gravitational wave Observer

Technical & programmatic review report

Technical Assessment



- We came out well!
- **LISA-EST-RP-1018:**

9 ACHIEVEMENT OF REVIEW OBJECTIVES

The major objective set in the procedure for this review was:

Overall feasibility and credibility of the reformulated LISA concept for a launch in 2022 and an ESA CaC of 850 M€ (e.c. 2010)

The review of the preliminary design of mission elements has not evidenced any show stopper and the mission is considered credible and achievable. Some elements have been highlighted that will require attention in the next study phase.

The high degree of heritage from LPF has made the current mission design more robust compared to the previous LISA mission design. Together with the reuse of the same elements at spacecraft, propulsion module and payload assemblies level, this allows to rank the overall mission risk to medium.

The launch scenario with two Soyuz-Fregat is credible and the alternative possibility of a single Ariane V launch option offers additional flexibility in case of unexpected large mass growing.

On the assumption that the highlighted issues are resolved, the preliminary schedule and the overall duration for the mission development are considered credible.



NGO: Revealing a Hidden Universe

Presentation to SSAC, Paris, April 2, 2012

Bernard Schutz and Karsten Danzmann
for the NGO Study Team

SSAC Recommendation



- **EUROPEAN SPACE AGENCY**
- **SPACE SCIENCE ADVISORY COMMITTEE (SSAC)**
- **Recommendation on the selection of the L1 mission**
- At its 138th meeting held at Paris on April 3-4 2012, the SSAC met to recommend the mission to be selected for the L1 launch slot of the Cosmic Vision Programme. The SSAC considered the three missions ATHENA, JUICE, and NGO.
- The SSAC carefully considered both the scientific and programmatic aspects concerning the three mission candidates, including their scientific value and the overall impact on the Science Programme.
- After an extensive discussion the SSAC came to a **consensus** and recommends the **JUICE** mission to be selected as the L1 mission leading to a launch in 2022.
- The SSAC **unanimously recognized the high science value of NGO** and therefore recommends continuing the necessary technology activities to enable a gravitational wave observatory to be a strong candidate for the next launch slot.
- The SSAC **also recognized the science value of ATHENA** and therefore recommends continuing the technology activities for enabling an X-ray observatory to be a strong candidate for the next launch slot

ESA SPC Decision





space science

European Space Agency

ESA Home

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News



JUICE is Europe's next large science mission

2 May 2012
PR 13 2012 - Jupiter's icy moons are the focus of Europe's next large science mission, ESA announced today.

The Jupiter Icy moons Explorer – JUICE – was selected over two other candidates: NGO, the New Gravitational wave Observatory, to hunt for gravitational waves, and ATHENA, the Advanced Telescope for High-Energy Astrophysics.

JUICE is the first Large-class mission chosen as part of ESA's Cosmic Vision 2015-2025 programme.

It will be launched in 2022 from Europe's spaceport in Kourou, French Guiana, on an Ariane 5, arriving at Jupiter in 2030 to spend at least three years making detailed observations.

ESA SPC Decision



European Space Agency

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News




17-May-2012

More about ESA's
Cosmic Vision...

The high scientific value of both NGO and ATHENA was also recognised by the Science Programme Committee in today's decision, and technology activities are planned to continue, enabling the missions to be considered as candidates for future launch opportunities. A second Call for Large Missions is expected in 2013.


New NASA Activities





National Aeronautics and Space Administration
Goddard Space Flight Center

- Goddard Space Flight Center
- Sciences and Exploration Division
- Astrophysics Science Division



Physics of THE COSMOS

Overview Projects Science Technology Studies Program Office Education

Links

- PhysPAG
- Inflation Probe Science Analysis Group
- Technology Science Analysis Group
- NASA Advisory Council
- Astrophysics Subcommittee

Physics of the Cosmos Program Analysis Group (PhysPAG) Meetings

Fourth Meeting: PhysPAG Workshop 2012

August 14-16, 2012
Holiday Inn Capitol
550 C Street SW
Washington, D.C.

Announcing the fourth PhysPAG meeting, a dedicated workshop in Washington, D.C. The PhysPAG Executive Committee is the Science Organizing Committee for this workshop (see pcos.gsfc.nasa.gov/physpag for more information) and encourages the entire PCOS community to attend. Webcasting will be available for those unable to attend in-person.

Current planned agenda topics include:

- Public presentation/discussion of the reports of PCOS Gravitational Wave and X-ray Studies
- Discussion of PCOS-related ESA missions, including activity on Euclid
- Dark Energy measurements from space (Organizer: Jason Rhodes, [jason.d.rhodes AT jpl.nasa.gov](mailto:jason.d.rhodes@jpl.nasa.gov))
- Meetings of all four Study Analysis Groups:
 - Inflation Probe SAG (Chair: Shaul Hanany, [hanany AT physics.umn.edu](mailto:hanany@physics.umn.edu))
 - X-ray SAG (Chair: Jay Bookbinder, [jbookbinder AT cfa.harvard.edu](mailto:jbookbinder@cfa.harvard.edu))
 - Gravitational Wave SAG (Chair: Guido Mueller, [mueller AT phys.ufl.edu](mailto:mueller@phys.ufl.edu))
 - Gamma Ray SAG (Chair: Elizabeth Hays, [elizabeth.a.hays AT nasa.gov](mailto:elizabeth.a.hays@nasa.gov))

Program News

11 May 2012
IPSAG One-Day Workshop, Aug. 15, 2012, Washington, D.C.
» [Details \[PDF\]](#)

2 May 2012
Fourth PhysPAG Meeting announced: Aug 14-16, 2012 in Washington, D.C. » [Details](#)

2 May 2012
ESA L1 selection announced: JUICE is Europe's next large science mission. High scientific value of NGO and ATHENA recognized and technology activities are planned to continue. » [Details](#)

Project News

Chandra News
9 May 2012
Overfed Black Holes Shut Down Galactic Star-Making » [Details](#)

Interest from China



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Max Planck Institute
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wegner@mpip-mainz.mpg.de

5. April 2012

Zusammenarbeit mit China
"Exploratory Round Table Conference (ERTC)"

Thema:
Space Science Research/Satellite Based Scientific Exploration,
Shanghai, Anfang November 2012

ESA's L2 Mission



- Next call for proposals 2013 or 2014
- Cornerstone scheme ?
 - Firm selection of L2/L3
 - Order and timing of implementation depend on readiness
 - LISA hard to beat after successful Pathfinder launch



ESA Member State Involvement



- Traditionally:
 - ESA: spacecraft bus
 - ESA member state agencies: science instrument
- In old ESA/NASA LISA:
 - Payload was European contribution paid for by ESA
 - Different from other L1 mission candidates
- In eLISA:
 - Use traditional approach of national consortium
- LISA =
class of laser interferometric missions with million km arms in heliocentric orbit using drag-free satellites
- eLISA =
„evolving LISA“ = specific LISA incarnation for an EU L-mission

What is the instrument on NGO?



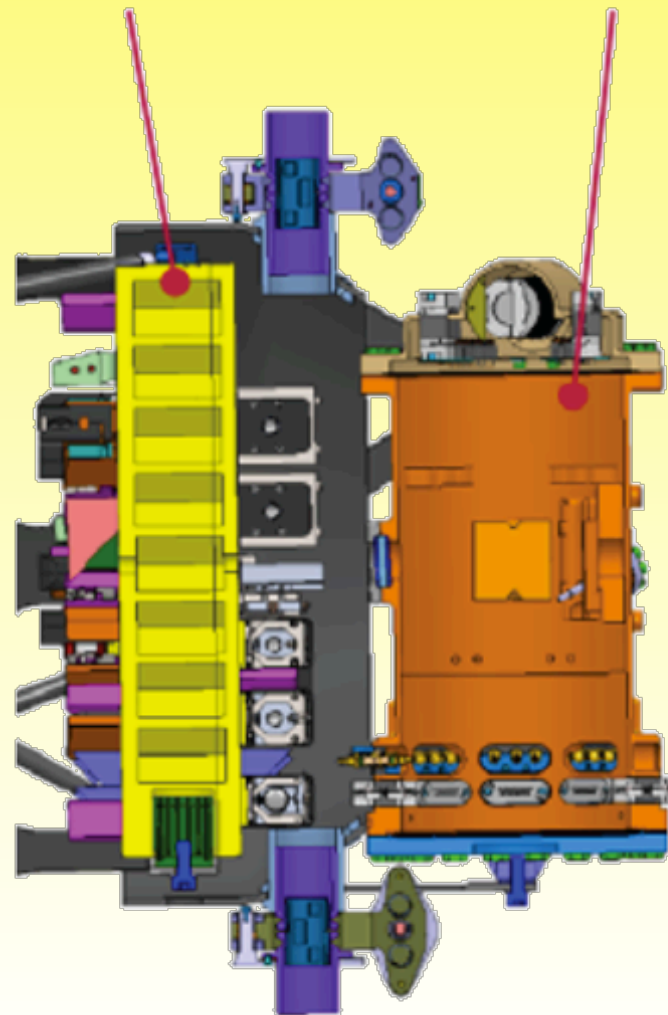
- Treat like focal plane instrument for Astronomy mission
- ESA responsible for:
 - Satellite platform, including:
 - Telescope, laser, and structure for optical assembly mounting
- Member States fund:
 - Scientific consortium to deliver integrated instrument consisting of:
 - Optical Bench with attached Inertial Sensor and detached Phasemeter, Electronics, Diagnostic System

The Science Instrument



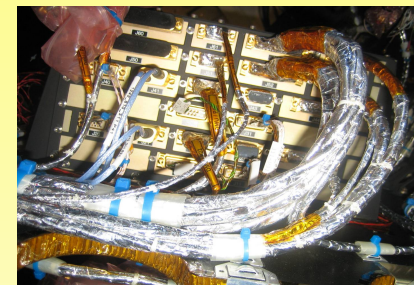
Optical
Bench

Gravitational Reference
Sensor (GRS)



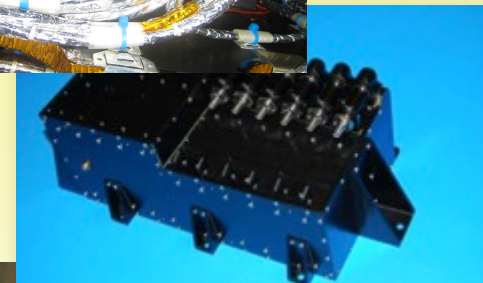
- 2 on Mother
- 1 each on Daughter

S/C mounted



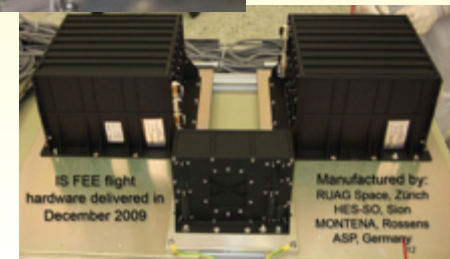
DMU

ULU



PM

FEE



Laser Subsystem



- Requirements for LISA/NGO Laser Subsystem largely compatible with the specs of available COTS laser sources
 - Master Oscillator Fiber Power Amplifier (MOFPA) architecture
 - Alternative technologies are maturing
 - NPROs for space application are available from TESAT
 - Planar Waveguide External Cavity Laser (e.g. NASA GSFC, Numata et al., 2012)
 - Eagleyard DFB Laser qualified for GAIA (eagleyard Photonics GmbH, 2010)
 - Fiber Laser (e.g. Koheras Boostik)
 - Fiber Amplifier technology is mastered by a number of suppliers
 - Available for space application from TESAT
 - 100 W single-frequency operation demonstrated in lab-environment (FSU Jena, A. Tünnermann, 2003)



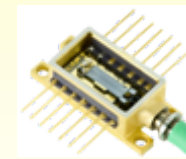
Innolight Mephisto
(NPRO)



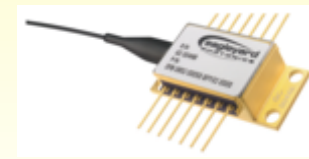
Koheras Boostik
(Fiber Laser)



Orbits Lightwave
(Fiber Laser)



PW-ECL
(NASA)



Butterfly Packaged DFB Laser
(eagleyard)

Laser Subsystem – Heritage of TESAT

Nd:YAG Lasers



Instrument	Laser Architecture	Optical Power	Models	Year
LCT on NFIRE	Nd:YAG NPRO + 2-stage Amplifier	1.5 W	2 FMs in operation	Launched 24. April 2007
LCT on TerraSAR-X	Nd:YAG NPRO + 2-stage Amplifier	1.5 W	2 FMs in operation	Launched 15. June 2007
GIFTS	Nd:Yag NPRO RLU	25 mW	1 FM delivered	2004
ALADIN on AEOLUS	Nd:Yag NPRO RLH	25 mW	2 FMs delivered	2006
ATLID on EarthCare	Nd:Yag NPRO RLH		1 PFM, 1 FM	
LTP on LISA Pathfinder	Nd:YAG NRPO RLU	40 mW ± 30%	1 PFM delivered	18. June 2010
LCT on Alphasat	Nd:YAG NPRO + 3-stage Amplifier*	5 W		2012
LCT on Sentinel 1-A		5 W	FM	2012
LCT on Sentinel 2-A		5 W	FM	2013
LCT on EDRS-A		5 W	FM	2013
LCT on EDRS-C		5 W	FM	2014
LCT on Sentinel 1-B		5 W		2014
LCT on Sentinel 2-B		5 W		2015

*an equivalent system was provided to AEI for testing wrt. LISA/NGO, showing adequate performance

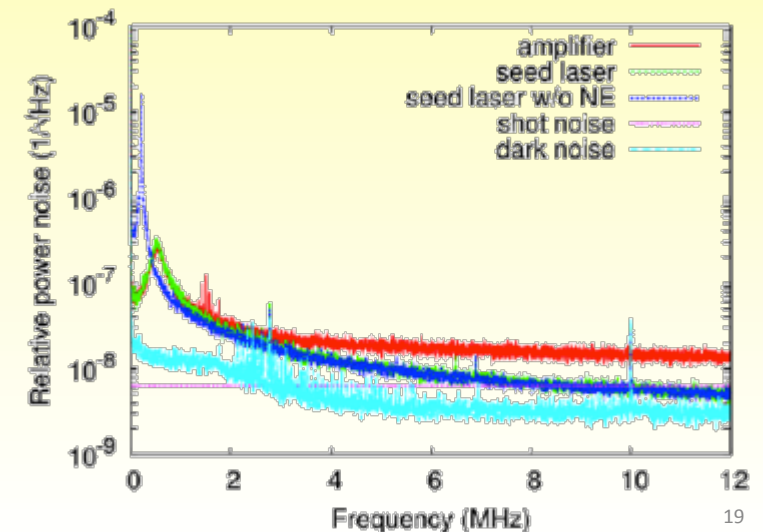
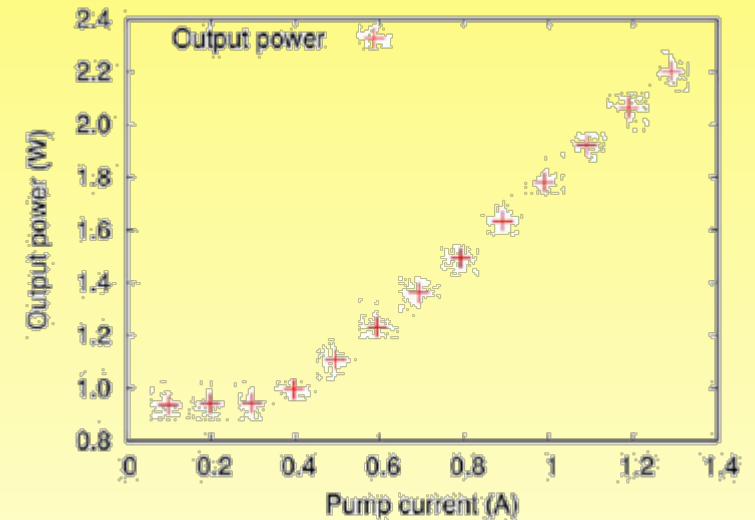
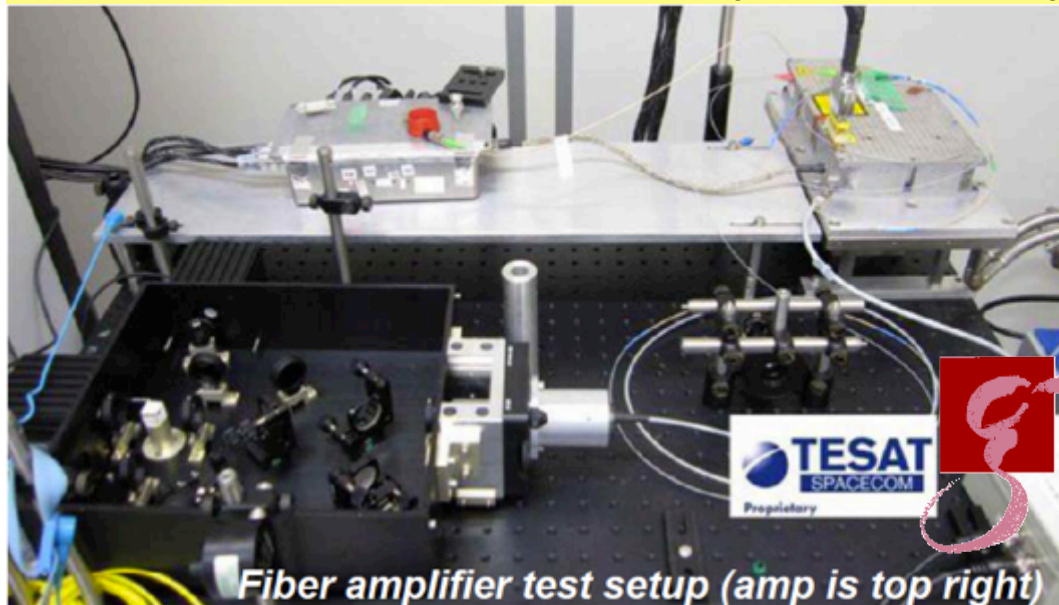
developments for space optical communications, operated at 1064 nm wavelength. TESAT is currently qualifying a 5 W fiber amplifier for the Laser Communication Terminals for the European Data Relay System EDRS, which will be mounted on EDRS spacecraft in geostationary orbit and Sentinel 1-2 spacecraft in low-earth orbit. Therefore, assuming this development is successful, the power level is not anticipated to be an issue. The low-power

ESA/SPC(2012)12

High Power Laser

→ Re-use LISA Pathfinder master and ERDS fiber amplifier

- Stable low-noise operation up to 2.2 W



Laser development for LISA



- LTP RLU, EOM, optical amplifier with control electronics available from Tesat Spacecom (with flight heritage or approval)
- Frequency- and power stabilizations only exist in breadboard version (High-Stability Laser project), require adaptation to Tesat laser
- Next steps:
 - build EM of laser system including stabilizations
 - performance testing
 - verify low differential phase noise for GHz sidebands in optical amplifier

Telescope Subsystem – Key Requirements



Parameter	Requirement	Comment
External Pupil Diameter	NGO 200 mm Original LISA 400 mm	The reduction of the Telescope Diameter for NGO is enabled by the reduction of the interferometer arm length from 5 Mio. km. to 1 Mio. km. The reduced diameter in turn facilitates an all-Zerodur design option, which is not reasonable for the larger 40 cm telescope of the original LISA, due to its higher mass.
Field of View	$\pm 200 \mu\text{rad}$	Minimum FoV required for initial beam acquisition. For standard telescopes, this value is equivalent to „on-axis“ operation. Note that the Telescope is an a-focal, non-imaging, monochromatic system, and the design is specifically optimized for such operation.
Wavefront Error	$< \lambda/30$ rms total for Z5 and higher (Noll)	This requirement drives the absolute tolerancing of the telescope mirrors. See next slide for a discussion.
Pathlength Stability	„System“ CTE $< 2 \times 10^{-7}$ m/K	The required picometer pathlength stability of the Telescope within the LISA band is achieved by a high temperature stability (within the LISA band) in combination with a low „System CTE“. The main stability requirement to the Telescope Subsystem is therefore solely a requirement to ist effective temperature coefficient , compatible with standard engineering practices and considered to be within the current state-of-the-art.

band of NGO, which is over few tens of minutes in the time domain. It is unlikely that a telescope system can be manufactured that is permanently stable at the picometre level, even by fully mastering the thermal environment, because of ageing effects in the materials and space radiation damage. However, meeting the requirement over the NGO frequency band is likely possible, in particular by filtering out very low frequency changes such as ageing through the phase data processing on ground, while preserving the useful science signal. A

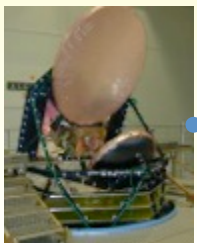
ESA/SPC(2012)12

- This wording appears misleading:
 - The first sentence is not relevant for LISA and in the context of the paper extremely misleading for a layman.
 - The second sentence seems to imply the correct meaning: the picometer pathlength stability only has to be provided for Fourier frequencies within the LISA band, but not in an absolute sense.

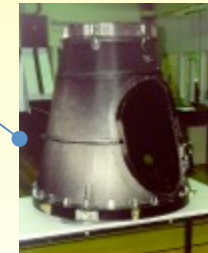
Telescope Subsystem – Heritage



- CFRP thermostable structures, supporting mainly Zerodur mirror substrates (abridged list)
 - $\mu\text{m}/\mu\text{rad}$ absolute accuracy and stability required for all instruments below



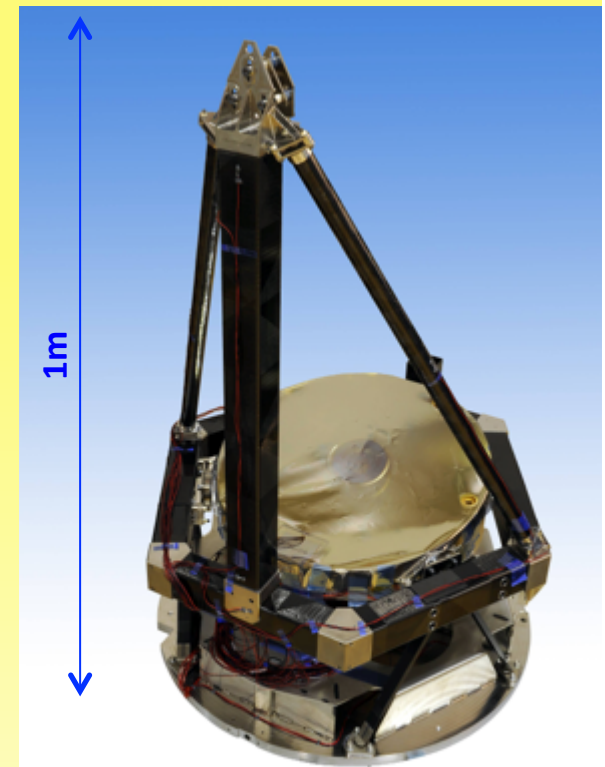
Instrument	Models	Status
Gomos on Envisat (LEO)	2 FM's + 1 QM	in orbit since 2002
Cartosat-2 (LEO)	4 FM's	in orbit since 2007
Kompsat 3 (LEO)	1 FM	in orbit since 2012
Kompsat 3A (LEO)	1 FM	launch in 2013
Seviri on MSG (GEO)	4 FM's + 1 QM	in orbit since 2002
Planck reflectors (L2)	1 FM + 1 QM	in orbit since 2009



Telescope Subsystem Running LISA CTP

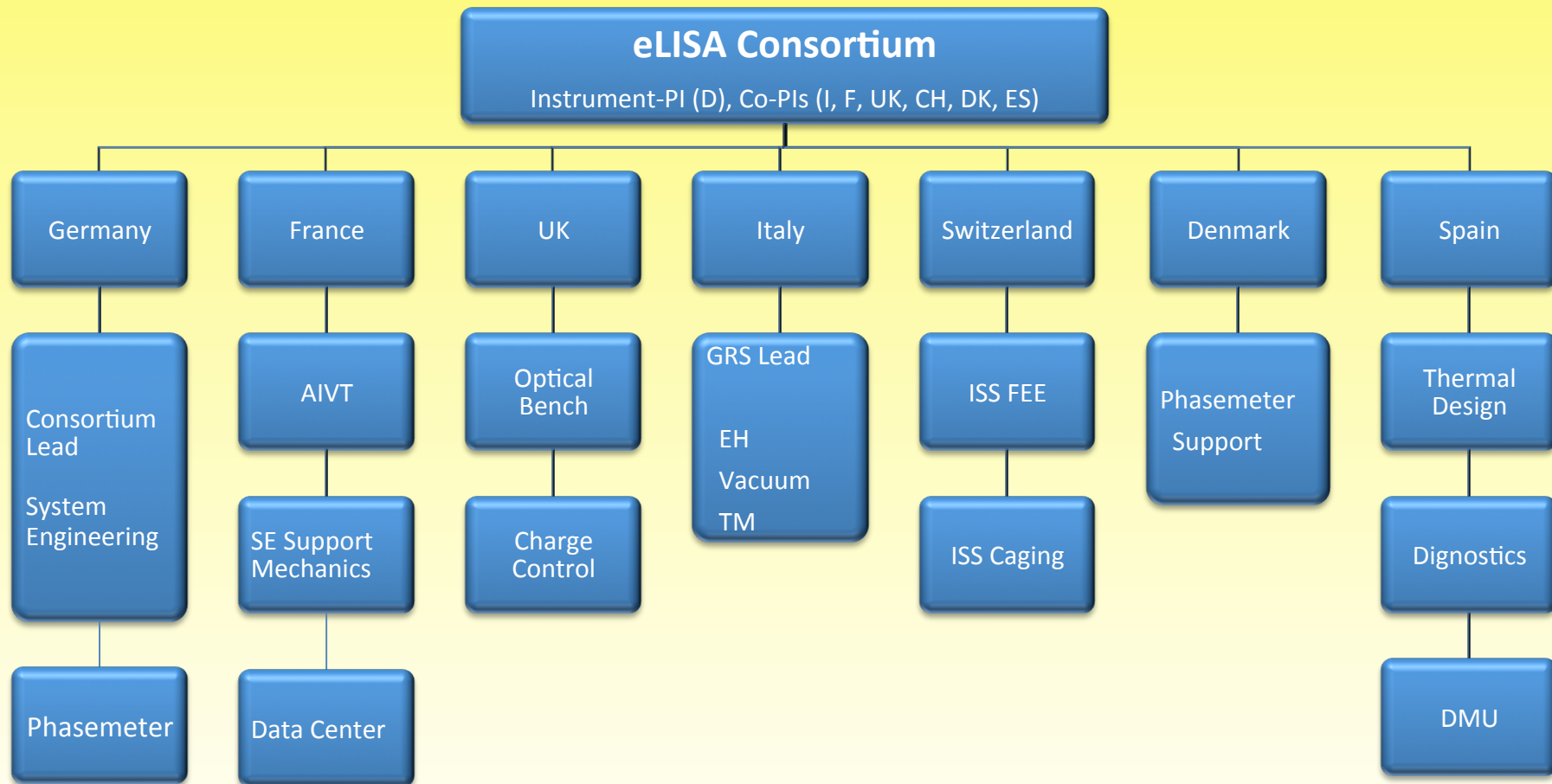
- Telescope Assembly for LISA OSC
 - EBB representative of FM design
 - All requirements are predicted to be satisfied
 - Current status:
 - Activity is on schedule
 - Telescope structure delivered to TNO for testing
 - Begin of thermo-elastic test in July 2012
 - If test is successful:
 - TRL6 is achieved
 - System CTE < 10⁻⁷ K⁻¹ demonstrated, even with an off axis telescope design

- Design concept for smaller telescopes (NGO)
 - Possibly, an all Zerodur design is feasible: no effect of moisture
 - Use of Zerodur as structural material matured through LTP on LISA Pathfinder
 - Fracture properties
 - Mechanical & Thermal testing
 - Insert & Bonding Technology
 - etc. ...



Specification	Requirement	Predicted results
Mass, w/o mirrors	< 5.5 kg	4.79 kg
First eigenfrequency	> 80 Hz	82.2 Hz
Gravity		
M1 surface distortion	< 10 nm _{rms}	5.7 nm _{rms}
ΔT=100K		
Distance M1-M2	< 6 μm	2.1 μm
Rel. lat. displ. M2-M1	< 2 μm	0.7 μm
Rel. tilt M2-M1	< 20 μrad	8.2 μrad
18K axial T-gradient		
Distance M1-M2	< 6 μm	0.4 μm
Rel. lat. displ. M2-M1	< 2 μm	0.6 μm
Rel. tilt M2-M1	< 20 μrad	1.5 μrad
Moisture desorption		
Distance M1-M2	< 6 μm	0.1 μm
Rel. lat. displ. M2-M1	< 2 μm	~ 0 μm
Rel. tilt M2-M1	< 20 μrad	4.7 μrad

NGO Consortium (NC) maintained as eLISA Consortium





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Gravitational Wave Astronomy in Space
eLISA/NGO

Listen to Black Holes

Science

Summary

Mission

eLISA/NGO

LISA Pathfinder

Paving the way!

News

eLISA/NGO: Gravitational wave mission in space reformulated

1 2 3 4

eLISA/NGO – A New Astronomy

First eLISA Consortium Meeting on October 22-23 at APC in Paris, France

More

Getting ready for next time: European gravitational wave community strengthens its space collaboration

During the 9th international LISA Symposium, held May 21 – 25 in Paris, the international LISA* community analyzed the new situation after ESA's decision to choose JUICE for Europe's next large space science mission. As the eLISA** mission, despite not being selected, was reported to have been unanimously ranked first by ESA's scientific review committee in terms of scientific interest, strategic value for science and strategic value

Team

unitn.it
UNIVERSITY OF TRENTO - Italy
Collaboration

eLISA in ESA

eLISA in NASA

D Drupal Legal info@elisa-ngo.org Top

ESA appoints TASAT



- Technology Activities Science Advisory Team for Gravitational Wave Missions
 - Chair: Oliver Jennrich
 - Members: Pierre Binétruy, Karsten Danzmann, Stefano Vitale, Harry Ward

I have the pleasure of inviting you to become a member of the Technology Activities Science Advisory Team for a Gravitational Waves mission (GW-TASAT).

Yours sincerely,

A handwritten signature in blue ink, appearing to read 'Ana M. Heras'.

Ana M. Heras
Science Coordination Office
Directorate of Science and Robotic Exploration
ESA ESTEC

Germany:



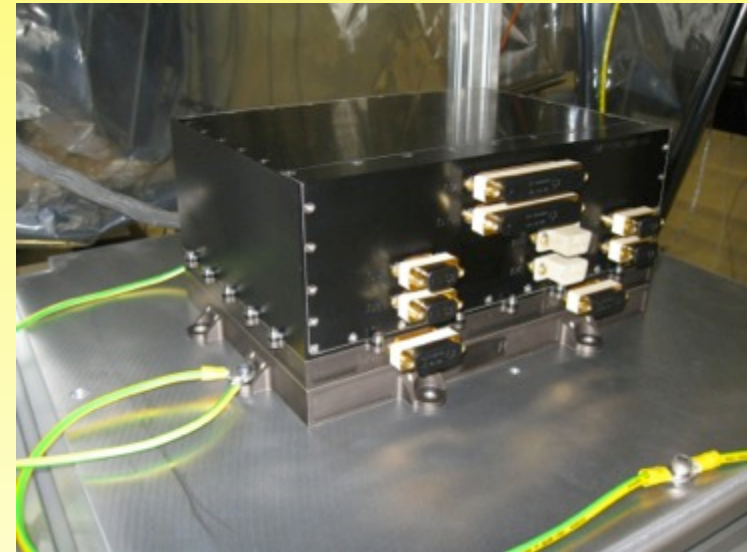
Consortium Lead and System Engineering

- Coordination and management of instrument consortium and deliverables
- System Engineering
- Requirements Specifications
- Instrument test plan
- Shadow Engineering
 - Interface control

Germany: Phasemeter



- Some heritage from LISA Pathfinder
 - For LISA, PM was NASA-provided item
 - Laboratory experiments in Europe
 - German/Danish team
 - Performance well in spec
-
- German funding available for complete unit
 - Support from Denmark: few FTEs/y TBC
 - Treated as contingency



Phasemeter TRP

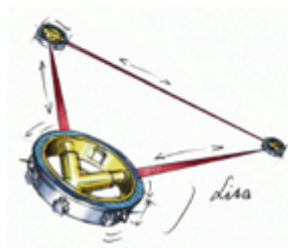


LISA Metrology System

Metrology system consolidated architecture Full version

ESA ITT Reference Number AO/1-6238/10/NL/HB

TN1-2



Version	1.0
Date of issue	September 28, 2011
Issue	Release

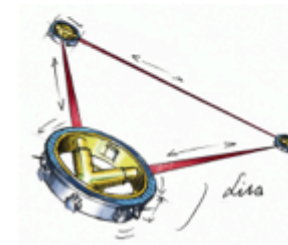


LISA Metrology System

Metrology system demonstration model design description and test results Full version

ESA ITT Reference Number AO/1-6238/10/NL/HB

TN1-3



Version	1.0
Date of issue	September 28, 2011
Issue	Release



LISA Metrology System

Vol. 1

Technical Proposal

Prepared in response to ESA ITT AO/1-6238/10/NL/HB

Lead Proposer:

National Space Institute – DTU Space, Technical University of Denmark,
Copenhagen, Denmark

Represented by: Allan Hornstrup, Head of Astrophysics

Subcontractors:

Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut),
Hannover, Germany

Represented by: Karsten Danzmann, Director

Axcon ApS, Kgs. Lyngby, Denmark

Represented by: Rolf V. Østergaard, CEO

DOC. NO. & ISSUE:	LISA/DTUS/SYS/PRO/0001(1)
DATE:	2010-09-28
PREPARED BY:	The LISA Metrology System Proposal Team
AUTHORIZED BY:	Eigil Friis-Christensen, Director
CLASSIFICATION:	Restricted for internal use in ESA and the proposing institutions

ESA TRP Contract

- Now in Phase 2
- 20-channel prototype
- Professionally engineered
- Hardware space qualifyable
- **Delivered to AEI on August 17 for testing!**

Phasemeter Situation



- Contract ends Dec 2012
- Only electrical tests
 - Signal simulator fundamentally not sufficient
 - Need photons to bits tests
- No redundancy, no flight hardware
- No complete system testbed

→ Need second study:

LISA Metrology System E2E characterization!

→ Was foreseen in ESA plans!

→ DLR takes over until 2015!

France



- Three major contributions:
 - Overall Instrument AIVT responsibility
 - System Engineering support
 - Related to AIVT
 - Mechanical and thermoelastic
 - Data Processing Center
 - Data intake from ESA SOC
 - Provision of Level 2 and 3 data to National Data Centers and to SOC for later community delivery

France: Data Center at APC



- Data storage, software provision and support
- Data input from ESA SOC
- Timely provision of Level 2 and 3 data
 - to SOC and NC national data centers

- Already used for Pathfinder
- CNES funds Level 0 study for LISA

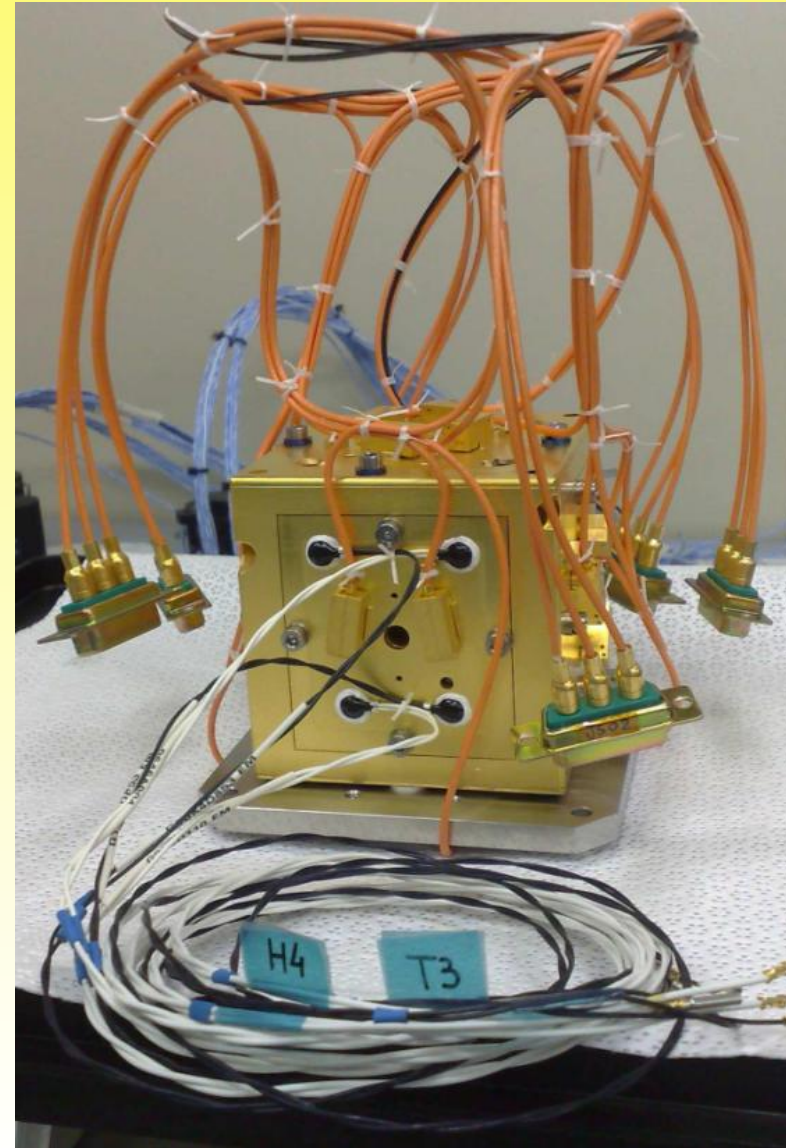


Italy: GRS Lead

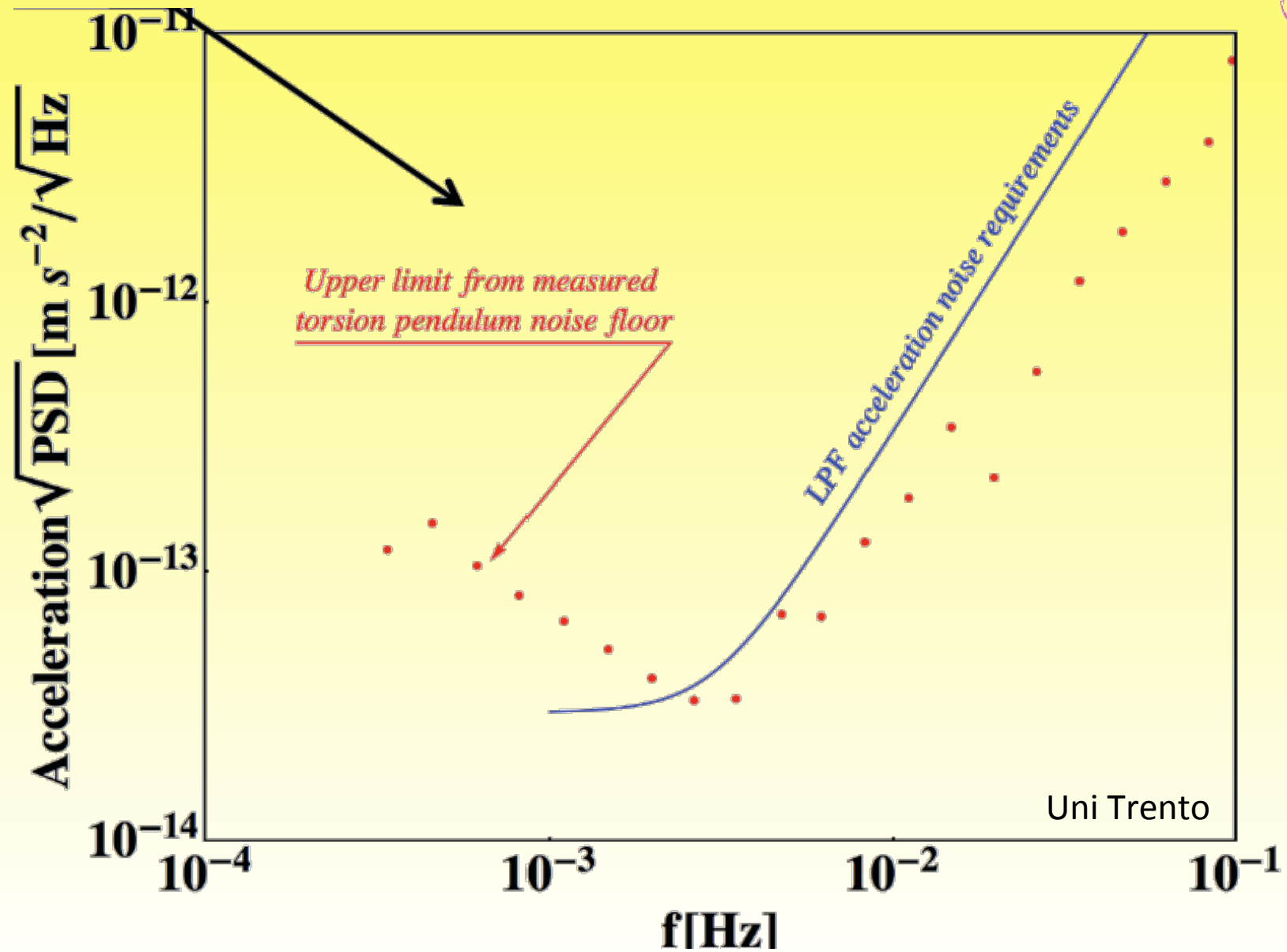


- Italy provides
 - Electrode Housing, Vacuum, Test Mass
- Italy receives
 - Front-End Electronics (CH), Charge Management (UK)
Caging (CH), some Diagnostics (ES)
- Italy performs
 - Integration of complete GRS
 - Functional and performance testing
 - Environmental testing
 - Delivery to AIV responsible (F)

Italy: GRS Lead LISA Pathfinder Heritage



Performance on Ground



GRS Situation



- Italy fully supporting LISA
- First priority is LISA Pathfinder
- After successful flight move on to develop and provide same for LISA

UK

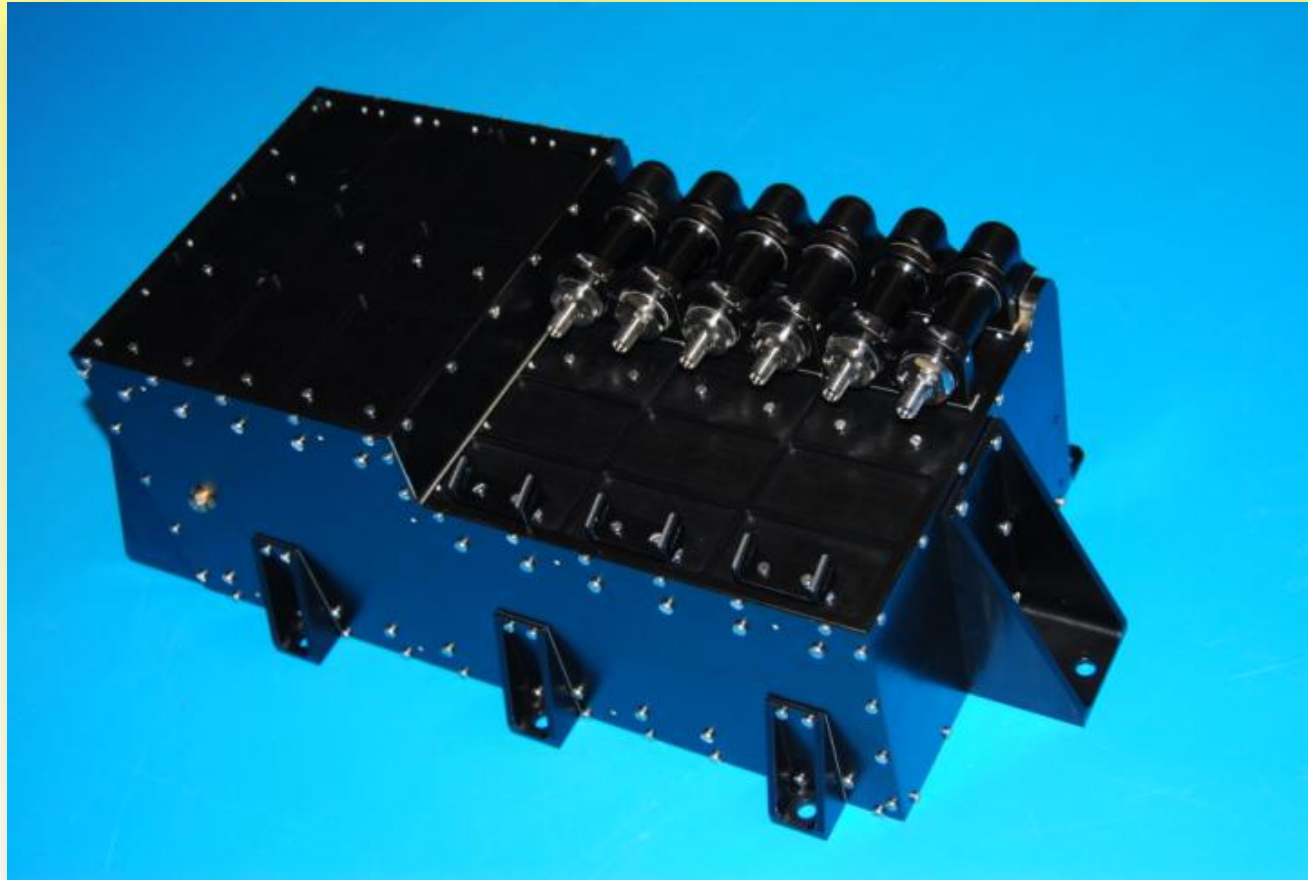


- Major contributions:
 - Charge Management System
 - UV light source assembly (ULU)
 - Fiber optic harness
 - IS UV Feedthroughs
 - Integration and testing
 - Optical Bench
 - Zerodur base plate
 - Optics etc.
 - Integration and testing

UK: Charge Management System



- LISA Pathfinder Heritage
 - New developments: UV diodes
 - ESA TRP ongoing



Charge Management Situation



- Current ESA contract Phase 1 ends Oct 2012
- UV LED technology with added AC synchronisation is important next step

→ Need Phase 2 contract

→ Was foreseen in ESA plans

→ No UKSA funding for this before 2016

UK: Optical Bench



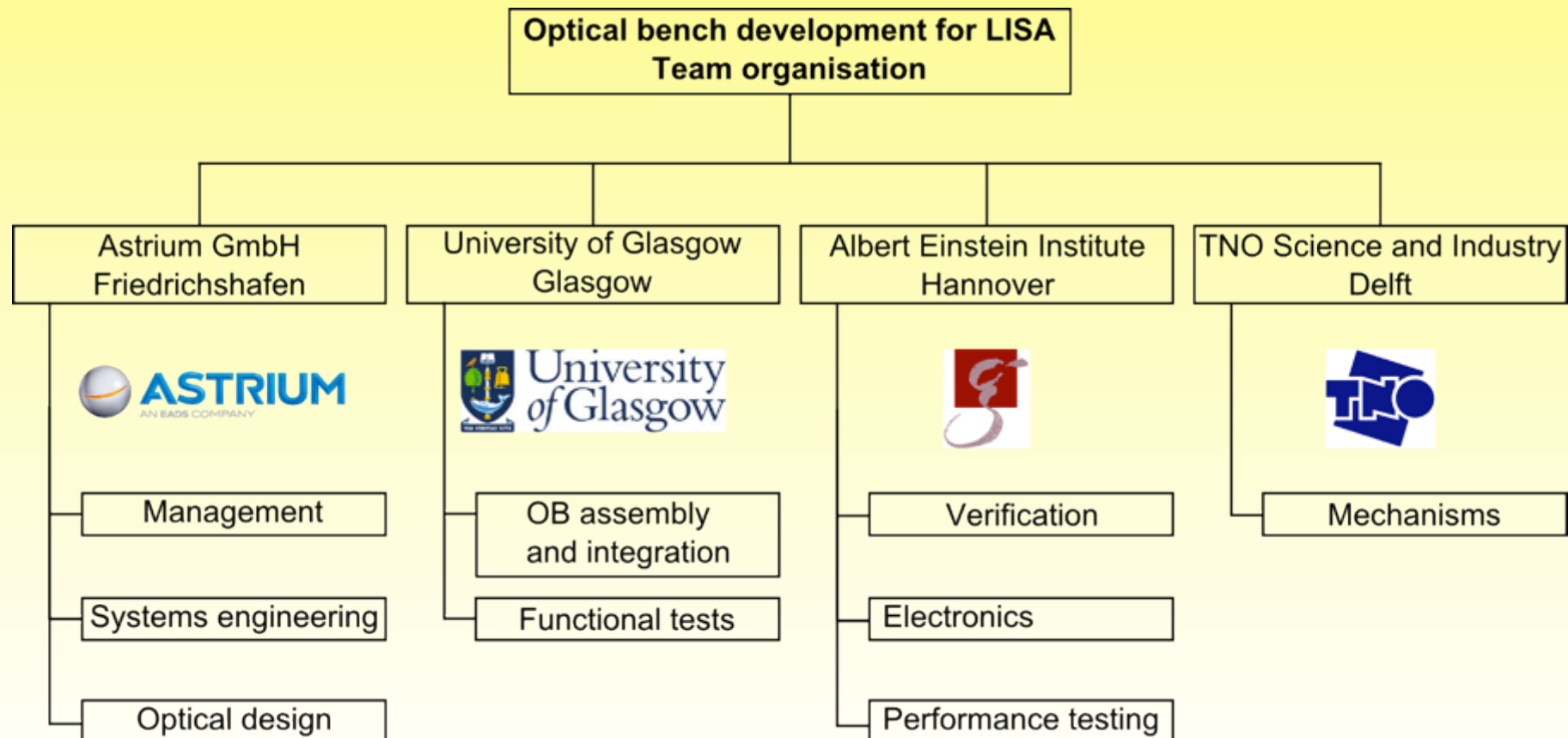
- LISA Pathfinder Heritage



UK: Optical Bench



- TRP funding by ESA for LISA-like OB
 - Needs only changes in layout detail for NGO



Optical Bench development for LISA



- In running optical bench contract, reciprocity of backlink fiber was demonstrated
- Backlink fiber is unavoidable source of stray light
- In current topology, effects of stray light need to be subtracted (suppression of more than two orders of magnitude required)
- Possible solutions to mitigate stray light effects:
 - Noise subtraction as demonstrated → requires twice as many photodiodes for redundancy
 - Strap-down architecture with additional low-power laser per optical bench to avoid stray light contamination

Optical Bench Situation



- Present contract ends 2013
 - Severely impacted by LPF work
-
- Need adaption to eLISA needs
 - Concentrate on key subsystems instead of complete Elegant Breadboard
 - Full support from DLR
 - UKSA funding funding problem in 2013!
ESA may help!
UKSA picking up again in 2014/15!

Switzerland

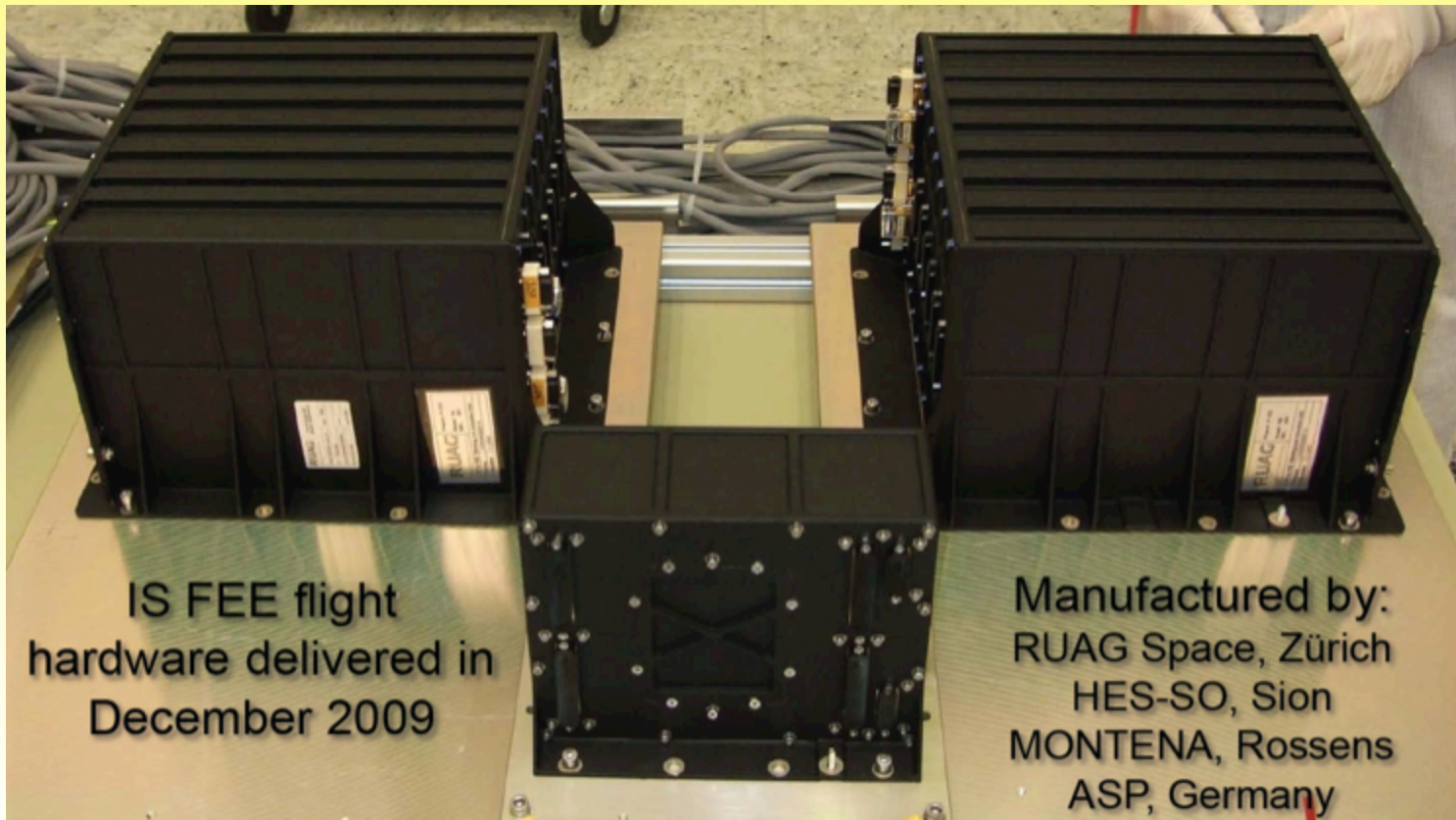


- Major contributions:
 - GRS Front-End Electronics
 - Delta qualification from LPF
 - Caging Mechanism
 - Launch lock
 - GPRM

Switzerland: GRS Front-End Electronics



- LISA Pathfinder heritage
 - Needs delta qualification for lower frequencies
 - ESA TRP ongoing



GRS FEE Situation



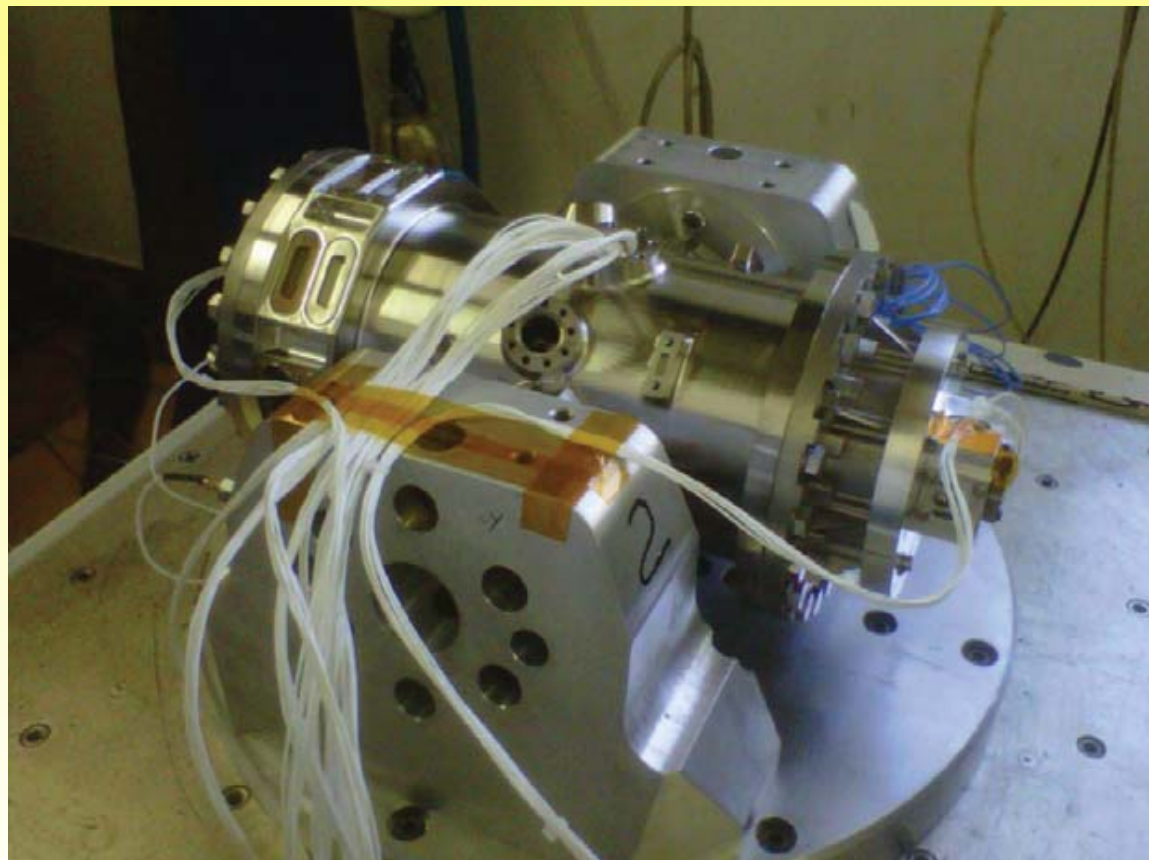
- Present contract ends Feb 2013
- Only preparatory work for full LISA specs

→ Phase 2 of FEE will now be kicked off in 2013!

Switzerland: Caging Mechanism



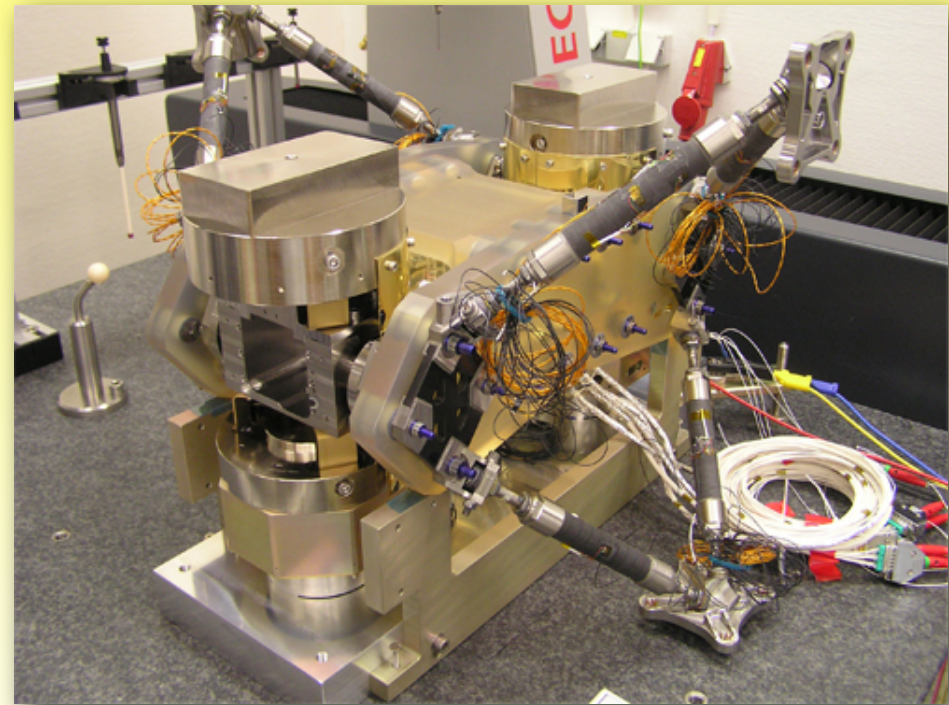
- LISA Pathfinder Heritage
- After successful LPF flight available as is



Spain: Diagnostic System



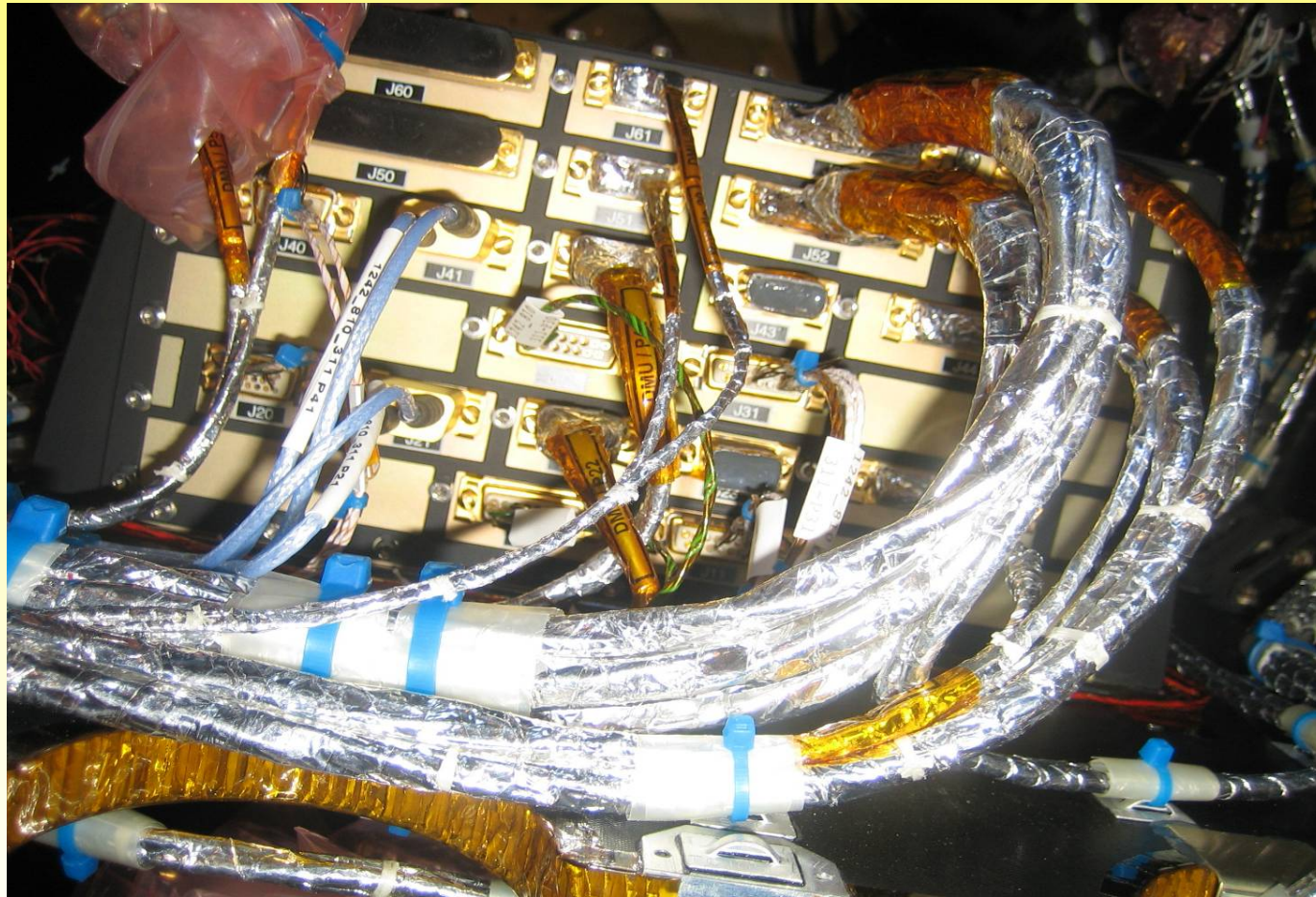
- Extensive Systems Experience
- Thermal
 - Temperature sensors
 - Heaters
- Magnetic
 - Magnetometers
 - Coils
- DMU
- Charging
 - Radiation Monitor



Spain: Diagnostic System



- LISA Pathfinder Heritage
 - Needs more channels for NGO



Diagnostic System Situation



- Spain is fully behind LISA
- Willing to fund improvements in Diagnostic System necessary for LISA
- No money for other contributions



LISA

Ref. : LISA-AEI-RP-6001
Issue : 1 Date: August 10, 2012
Rev. : 0 Page: 1



eLISA Technology Roadmap 2012-2015

Document No. LISA-AEI-RP-6001

Report

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Technology Roadmap



- Most technologies well in hand, some crucial finishing touches missing
 - Previous tech development geared towards ESA providing all of LISA P/L
 - Instrument consortium well established, MSs willing and able to provide flight hardware
- Preliminary agreement reached at consolidation telecon with Member States and ESA, 8th October, 2012
- Interim funding 2013 – 2015 reasonably secure

Delegations Telecon Draft MoM



MEETING

Meeting Date:
8 October 2012

Ref: ESA/SRE(2012)8

Meeting Place:
Teleconference

Chairmen:
A. Heras (ESA),
F. Safa (ESA)

Minute's Date:
8 October 2012

Participants:
E. Bachem (DE),
O. Botta (CH),
C. Castelli (UK),
K. Danzmann (GW-TASAT)
E. Flamini (IT),
Ph. Gondoin (ESA),
O. Jennrich (ESA),
S. Leon (FR),
N. Rando (ESA),
P. Roman (ES),
S. Vitale (GW-TASAT),
H. Ward (GW-TASAT).

Subject: Technology
Development Activities
for a future
Gravitational Wave
Mission.

Copy: F. Casoli (FR), A.
Gianolio (ESA), A. Parmar
(ESA), F. Favata (ESA), P.
Binetruy (GW-TASAT)



2) Foreseen technology development activities and distribution of responsibilities

In the future, ESA will be in charge of the TDA's for the laser and the telescope, while it is expected that the Member States will support the TDA's for the remaining part of the payload including e.g., the optical bench, the charge management control, the phasemeter and the gravity reference system (GRS).

Since eLISA mission criticality is essentially on the payload , ESA proposes to develop a full payload model, at Engineering Qualification Model (EQM) level, including all elements of the payload (i.e. the laser and telescope provided by ESA but also all other payload elements to be provided by the Member States). The development of such EQM could start in 2016 providing (i) a successful LISA PathFinder (LPF) in-orbit demonstration and (ii) that eLISA is selected as L2 mission.

The development of the eLISA EQM shall be completed by 2019/20 before starting the development phase of the eLISA mission. The EQM development shall be a joint effort between ESA and the Member States with ESA in charge of the system level assembly and integration of the payload elements.

ESA Summary



4) Meeting Summary

ESA acknowledged the general support of all participants to eLISA, should it be selected as L2, and the decision from all involved member states to support as affordable the bridging phase of eLISA development activities, as a minimum up to L2 selection. ESA also noted the general support for the payload EQM development, should the mission be selected as L2 and LPF in orbit demonstration be successful.

The representatives of the Members States and TASAT participants thanked ESA for this useful meeting.

First eLISA Consortium Meeting APC-Paris October 22-23



The topics for the first eLISA Consortium:

- will be the programmatic situation of LISA-like missions in Europe and other parts of the world
- the state of the technology preparation before the L2 selection in 2015
- the programmatics and schedule of the L2 selection, the division of work within the Consortium
- the prospects of international contributions for an eLISA-ESA L2 mission
- the status of eLISA-related data analysis and astrophysics, and the setting up of working groups and planning of the work schedule.

Secretary and Contact:

Sabine Tesson

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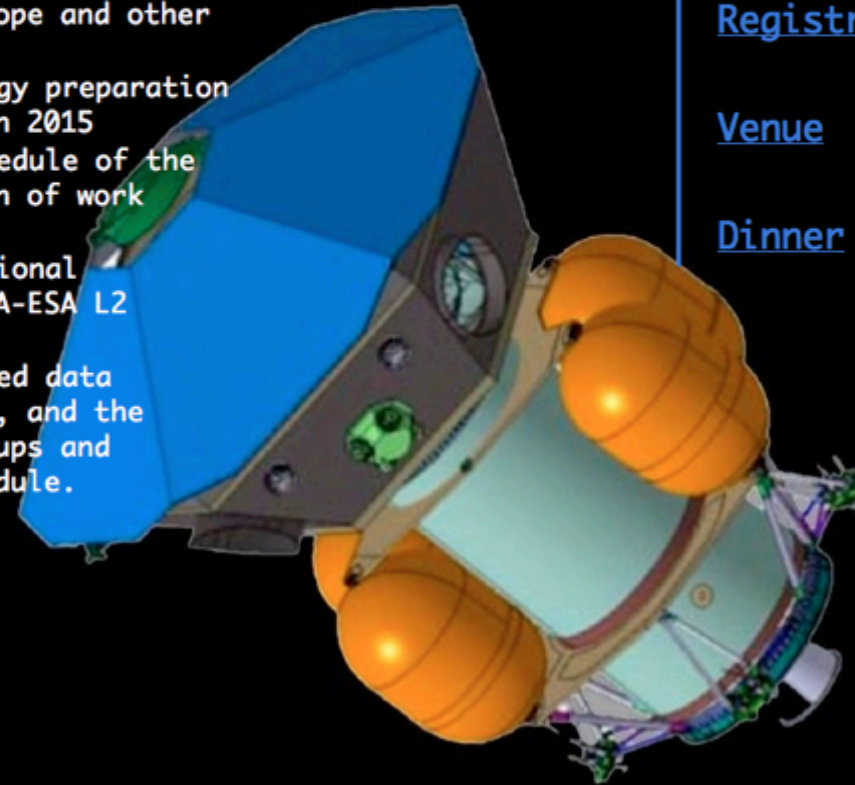
[Welcome](#)

[Programme](#)

[Registration](#)

[Venue](#)

[Dinner](#)

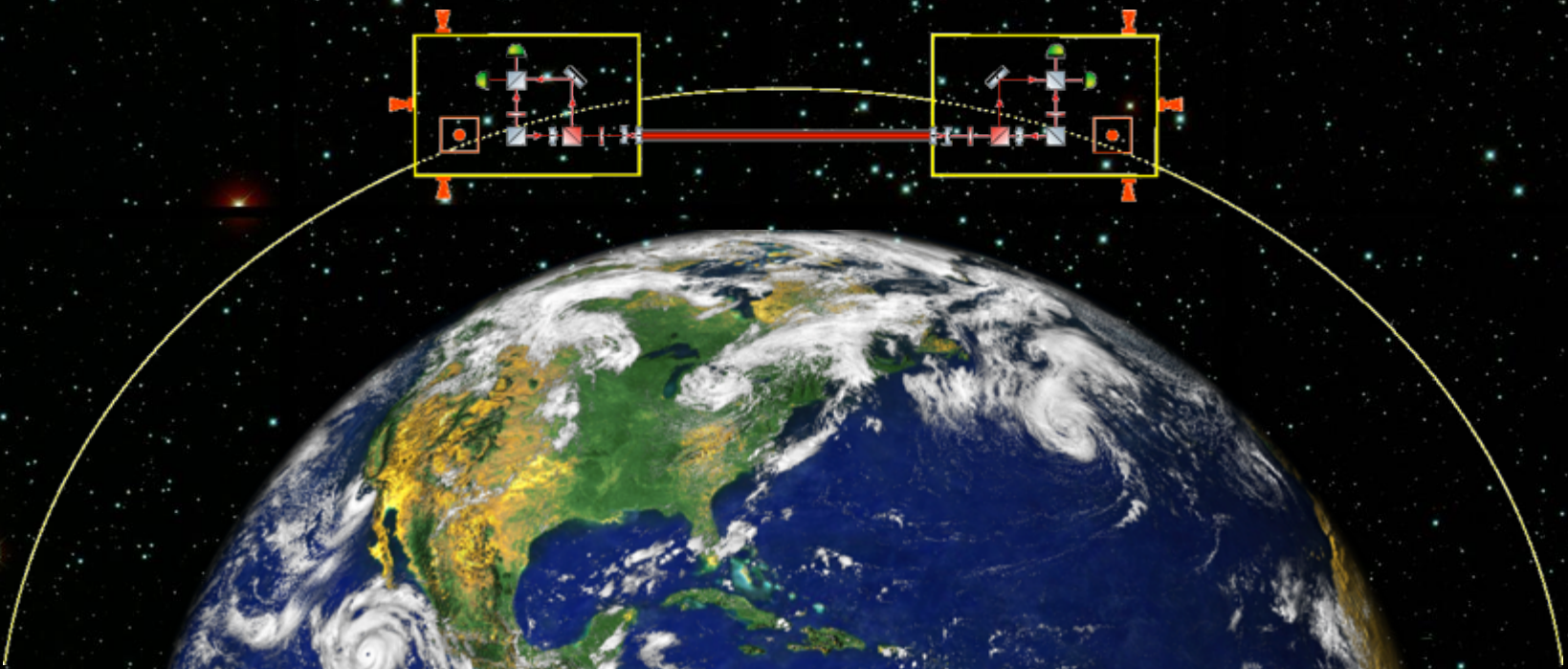


Goals of the Meeting

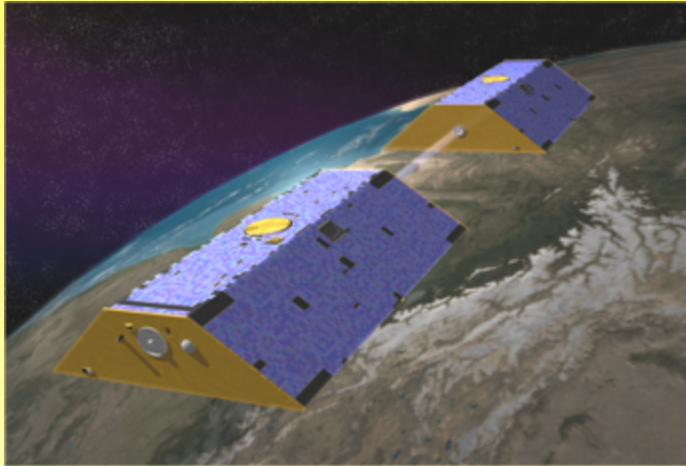


- Keep and grow the wonderful science
- Fix technology gaps before L2 selection
- Organize Working groups
- Discuss contributions from US and China
- Need modularity

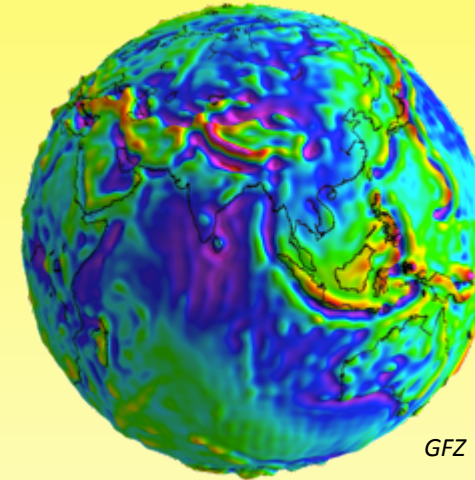
LISA Technology for Earth Gravity Field Missions



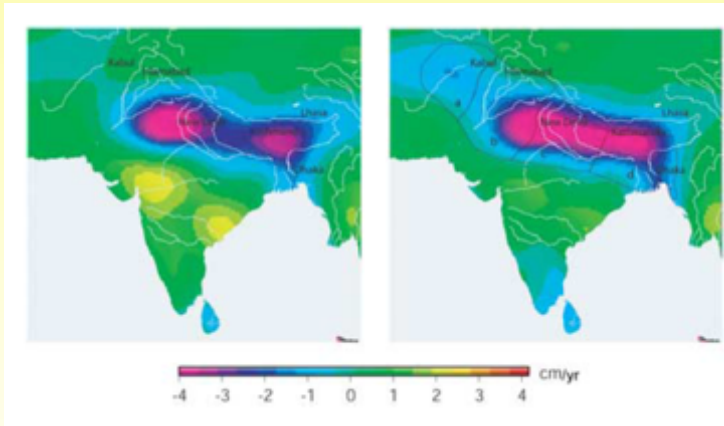
Gravity Recovery and Climate Experiment (GRACE)



GRACE Mission (UTCSR, GFZ, DLR, JPL). Image credit: NASA

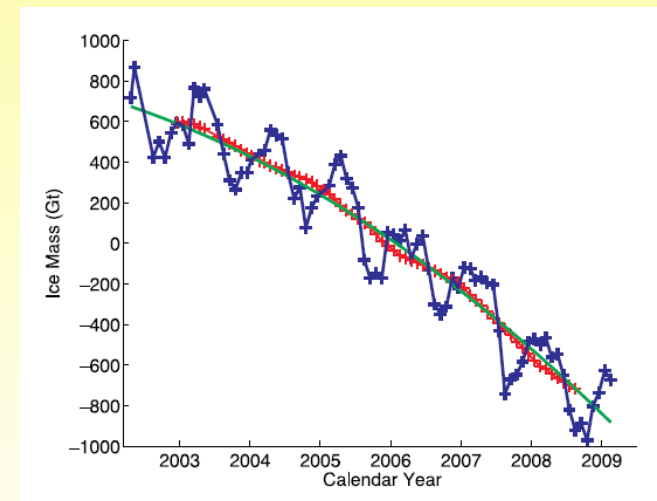


GFZ



Tiwari et al., "Dwindling groundwater resources in northern India, from satellite gravity observations", *Geophys. Research Lett.* **36**, L18401 (2009).

Ground water loss in India



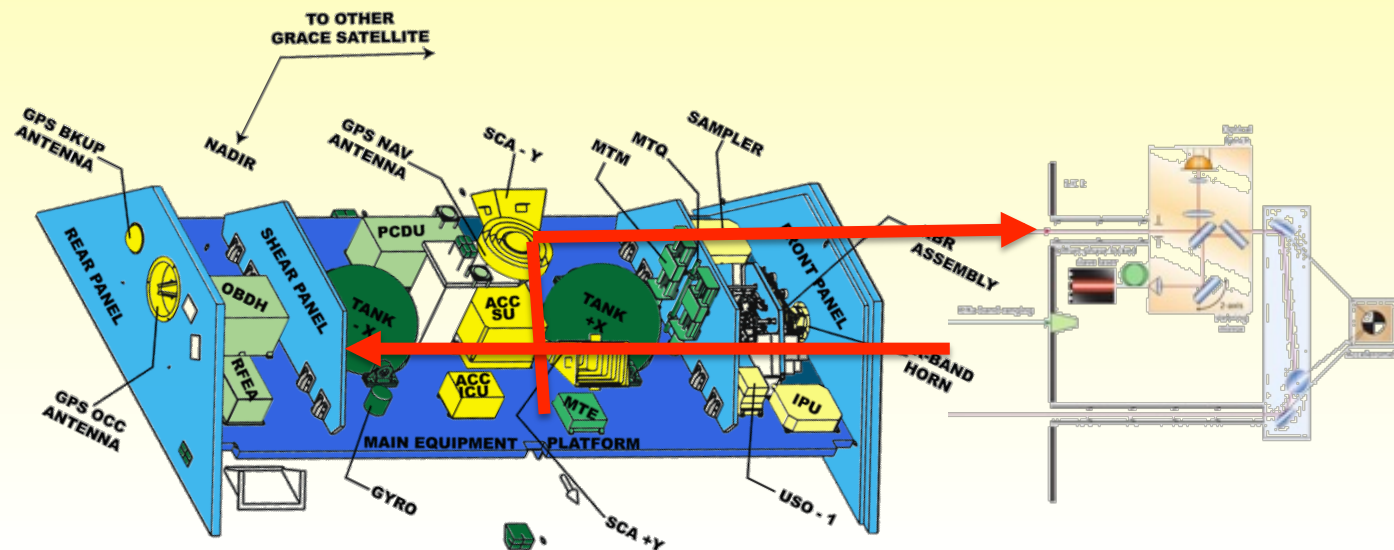
Velicogna, "Increasing rates of ice mass loss from the Greenland and Antarctic ice sheets revealed by GRACE" *Geophys. Research Lett.* **36**, L19503 (2009).

Ice mass loss in Greenland

GRACE Follow-On Mission Approved!



- USA/Germany, approved in Germany last week
- Launch in 2017
- First-ever intersatellite laser ranging instrument!
- Satellite built in Germany with US money
- Russian launcher paid with German money
- Carrying German/US laser interferometer with German laser paid by US money



LISA Pathfinder



- Waiting for a launch in 2015!

Roadmap for LISA



- Preselection of eLISA for L2 in 2013/14
- Confirmation after successful LISA Pathfinder flight in 2015
- Fixing of technology gaps not covered by LPF in 2013 – 2015
- Build EQM of complete Payload in 2016 – 2020
- Start industrial implementation in 2020
- Launch in 2028