



# **ESA & The LISA Mission**

Martin Gehler

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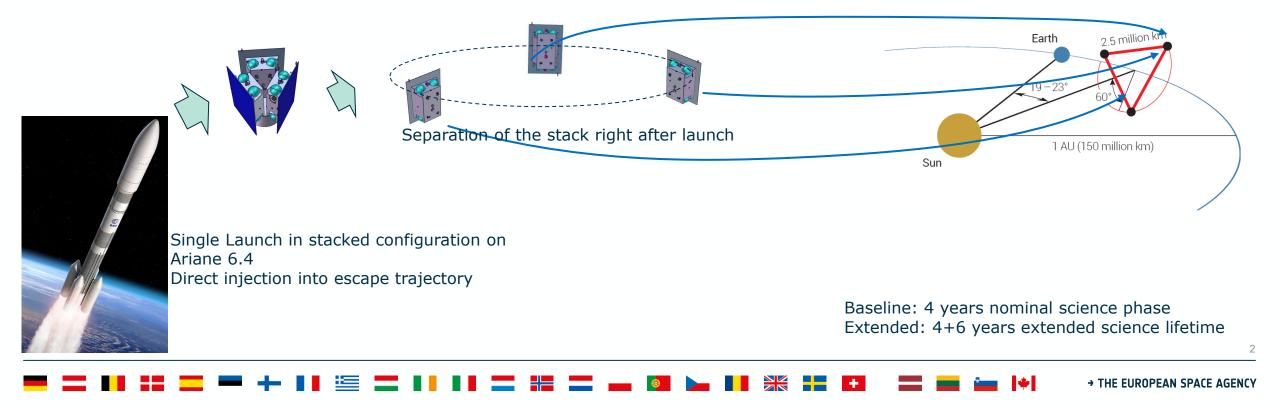
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### **LISA Mission Overview**



- LISA selected for the L3 launch opportunity in ESA's Cosmic Vision Programme
- □ Follows in the footsteps of JUICE (L1), Athena (L2)
- □ Large Missions cost ap at 1.05 BEUR (e.c. 2017) as set by SPC at selection
- LISA Pathfinder demonstrated key technologies for LISA (GRS, micropropulsion, optical bench technology, ..)



### A brief history of LISA



1974First ideas to measure GWs in space1985First mission concept proposed by Faller/Bender et.al. "LAGOS"1993LISA proposed to ESA as M3 in Horizon 20001995LISA selected as 4 <sup>th</sup> cornerstone in Horizon 20001997/1998Collaboration with NASA on LISA starts1999Industrial Assessment studies commence in Europe2000Selection of "LPF" as SMART-2 technology demonstration mission2005Mission Formulation Study commences in Europe2007LISA moved to Cosmic Vision programme in competition with TSSM, EJSM, IXO2011Reformulations due to decadal survey outcome to European-only solutions2013Gravitational Wave Observatory selected as the theme for the third large class launch slot in CV	Date	Event
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2015 Launch of LISA Pathfinder	2015	Launch of LISA Pathfinder
2016 Call for Missions for a Gravitational Wave Observatory (L3)	2016	Call for Missions for a Gravitational Wave Observatory (L3)

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### **LISA Key Milestones**



	2017	Mission Proposal Submission to ESA	
	2017	Mission Selection by ESA SPC	
	2018	Phase A Kick-Off	
	2021	Phase A close out: Mission Formulation Review	$\checkmark$
Today 🗕	2022	Phase B1 Kick-Off	
	2024	Mission Adoption	
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	2025+	Mission Implementation	

### LISA Partners (post Phase A)



### ESA (Lead)

- Mission Implementation Responsibility
- Mission Architect
- Space Segment
- Ground Segment
- Launcher
- Overall System
   Engineering
- Platform Hardware

#### NASA

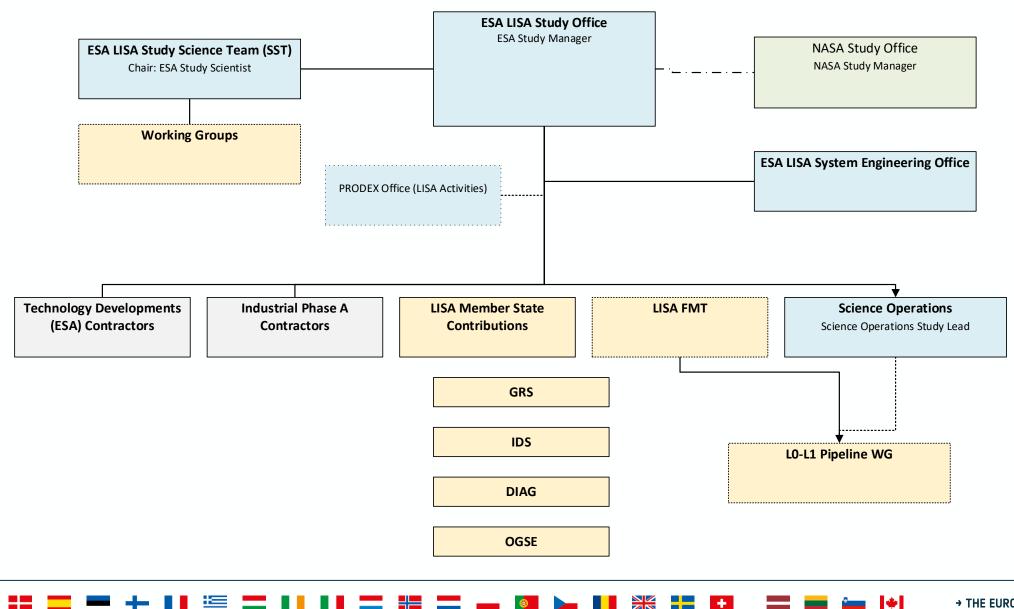
- Collaboration partner to ESA
- Telescopes
- Laser Systems
- Charge Management Devices
- Contribution to Science Exploitation

#### ESA Member States / Consortium

- Instrument Hardware Contributions
  - (Gravitational Reference Sensor System, Interferometric Detection System, Data and Diagnostics)
- Performance Test GSE
- Science Data Processing
- Performance Modelling and Monitoring
- System Support

### **LISA Study Organisation**





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## **NASA Hardware Contributions**

#### Telescopes

- Two 30cm class telescopes per spacecraft transmit and receive the laser beams for interferometry to/from the other two, remote spacecraft
- Demonstrator and predevelopment activities ongoing at NASA GSFC and under contract with L3Harris

#### □ Laser Systems

- Generate the laser light used for interferometry
- 2W class laser, 2x2 system per spacecraft plus one reference cavity for frequency stabilization
- Development led by NASA GSFC, TRL 4/5 unit under testing in Europe at CSEM

#### Charge Management Devices

- Provides UV light @ ~245 nm to discharge the free-falling test masses.
- Under development at U Florida under NASA contract





TRL-4 Master Oscillator Power Amplifier #2 deliverable to ESA.

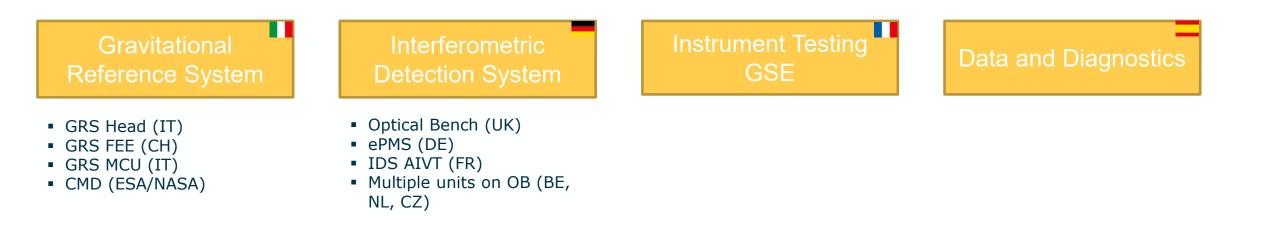




### **Nationally Provided Items (post Phase A)**



- MOSA perimeter (as per mission proposal) has been found to create a challenging interface with overlap of responsibility in addition to challenges in funding.
- □ The newly created Interferometric Detection System envelope contains all key interferometric functions with clean, manageable interfaces to the telescope, the laser system, as well as the overall system.
- □ Four clean major contribution envelopes by Member States



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### **Non-hardware Consortium contributions**

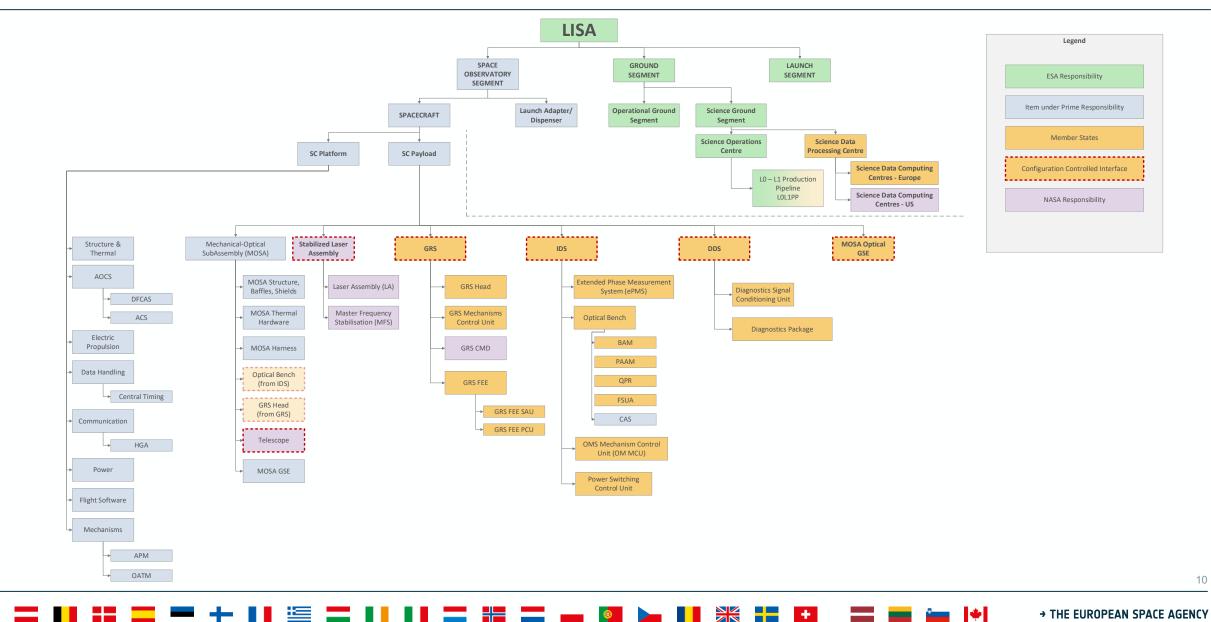


- Distributed Science Data Processing Centre, under French leadership, processing L1 data received from ESA Science Operations Centre to Level 2 and Level 3 data. Contributions to the science data processing are coming from other member states and NASA, through computing centres and/or pipeline development.
- Performance Modelling, Operations and Calibration Planning, Level 0 to Level 1 pipeline preparation support to ESA, as a Consortium level contribution, undertaking the End-2-End performance modelling as a service to ESA, assisting the Agency with instrument operations and calibration planning, as well as assisting in the development of the L0-L1 data processing pipeline in the ESA Science Operations Centre.



### **LISA Product Tree**





## **Status of Phase A/B1 Activities – Industrial**

- Two parallel industrial contracts for "LISA System Phase A Study"
  - 5.5 MEUR each.
  - Awarded to **Airbus** Defence and Space GmbH and to **Thales** Alenia Space S.p.A.
- Status: Bridging phase. Rider valued at placed on both contracts to continue as "LISA Phase B1 System Study"
  - Proposal phase (4.5 MEUR each)
  - Kick-off expected in April 2022
  - Includes RFI campaign (to be announced on esa-star news (<u>esa-star Publication</u>)

### • Next steps:

- Phase B1 leading up to Intermediate Review (consolidation of requirements to contributions)
- →In addition to Phase A industrial contracts, ESA investing ~30 MEUR in technology development contracts for LISA. (includes contracts already established under eLISA)







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### 6. CONCLUSIONS

The Board declares this review **successful with actions** to be completed by the end of the bridging phase. A short report shall be provided on the status of the actions before the end of the bridging phase.

The Board acknowledges the significant amount of work performed by the Panels, as well as the progress achieved by the Study Team, NASA, the industrial partners, and the Consortium. The Board thus wishes to thank all involved parties for their dedicated work and all participants for their valuable contributions to the Review.



April 2022 Phase B1 Kick-Off (New Requirements Architecture ready)
Q4 / 2022 Intermediate Review (Consolidation of requirements to CFIs)
Q2 / 2023 Instrument SRR ("Adoption review for CFIs")
Q4 / 2023 Mission Adoption Review
Q1 / 2024 Mission Adoption (TBC)

□ Instrument SRR: Is the adoption review for the CFIs. Data Packs due ~May 2023.

□ Technology Readiness Assessments: Will be run in 2022 and 2023 – ESA to reach out to all CFIs.

□ Affecting: GRS, FEE, OB, Mechanisms, QPR, Diagnostics, ...

Small delta-TRAs after I-SRR before MAR to check final status (have issues been closed)

□ Intermediate Review will generate the CFI Requirements package harmonized between the primes

□ No harmonization for "standard GDIR" or non-critical interfaces



□ Contributions to ESA to mission elements could be envisaged in two categories:

- Platform equipment
- Instrument equipment

Any contributions would preferably improve the technical maturity and programmatic situation:

- □ Well-specified element with clear interfaces and responsibility envelope
- Reduce cost to ESA or existing Member State contributions
- □ Fit into the schedule developed by the ESA prime contractors
- Be of sufficient maturity given the advanced state of development

Contributions to be set in the Multi-Lateral Agreement (drafting starts next year)

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### **Potential (further) Ground Segment Contributions**



□ Contributions to L1 pipelining:

□ L1 data generation is ESA responsibility – contributions to be agreed with ESA and the Consortium

- □ Contributions to L2/L3/general science:
  - Consortium responsibility

□ Full scheme for data processing still to be set (proprietary periods, international collaboration (NASA))



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