

The LISA Science Ground Segment: A Distributed, Multi-Agency Infrastructure for Gravitational Wave Science.

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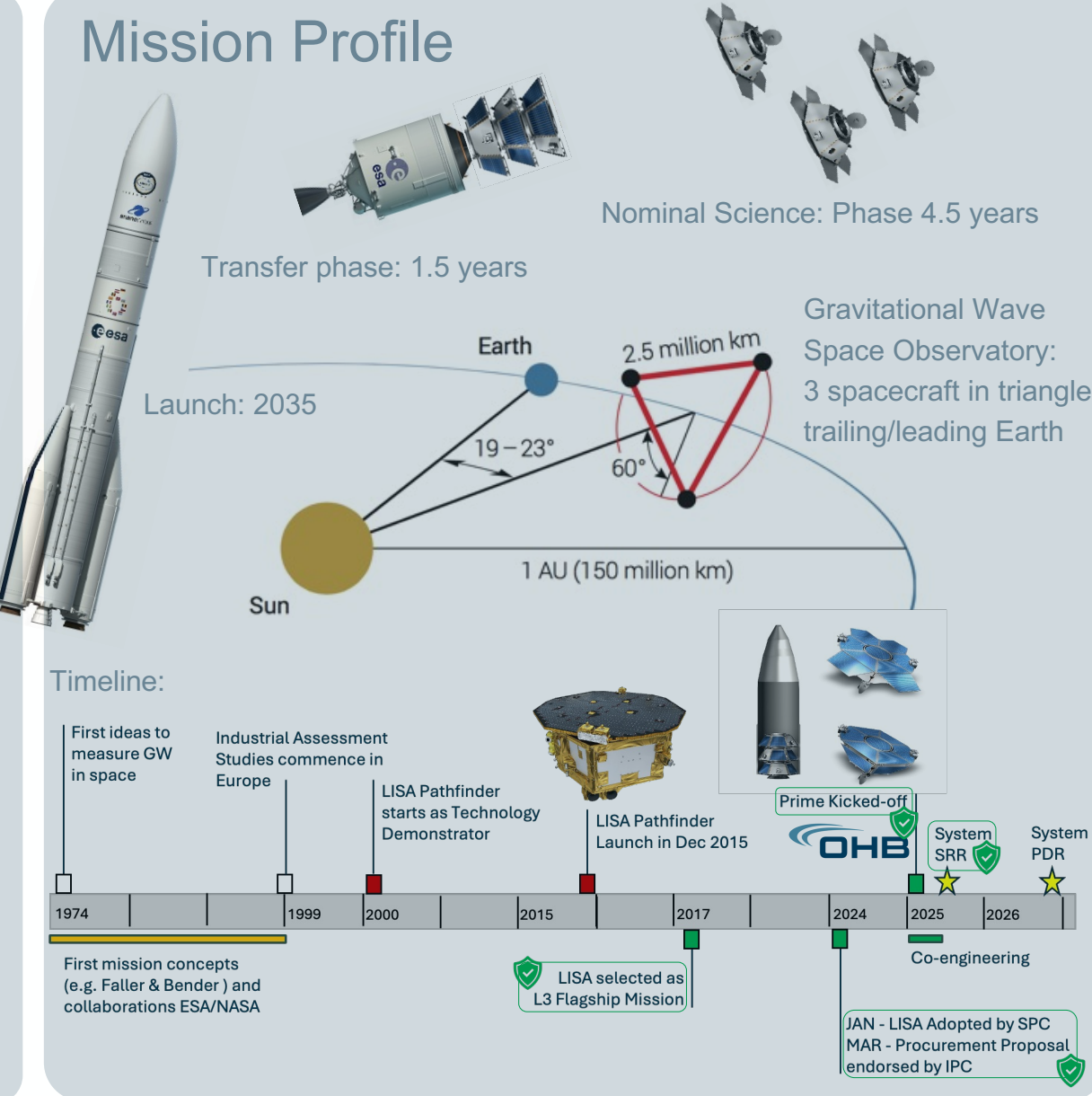
25th ADASS, November 2025, Görlitz, Germany



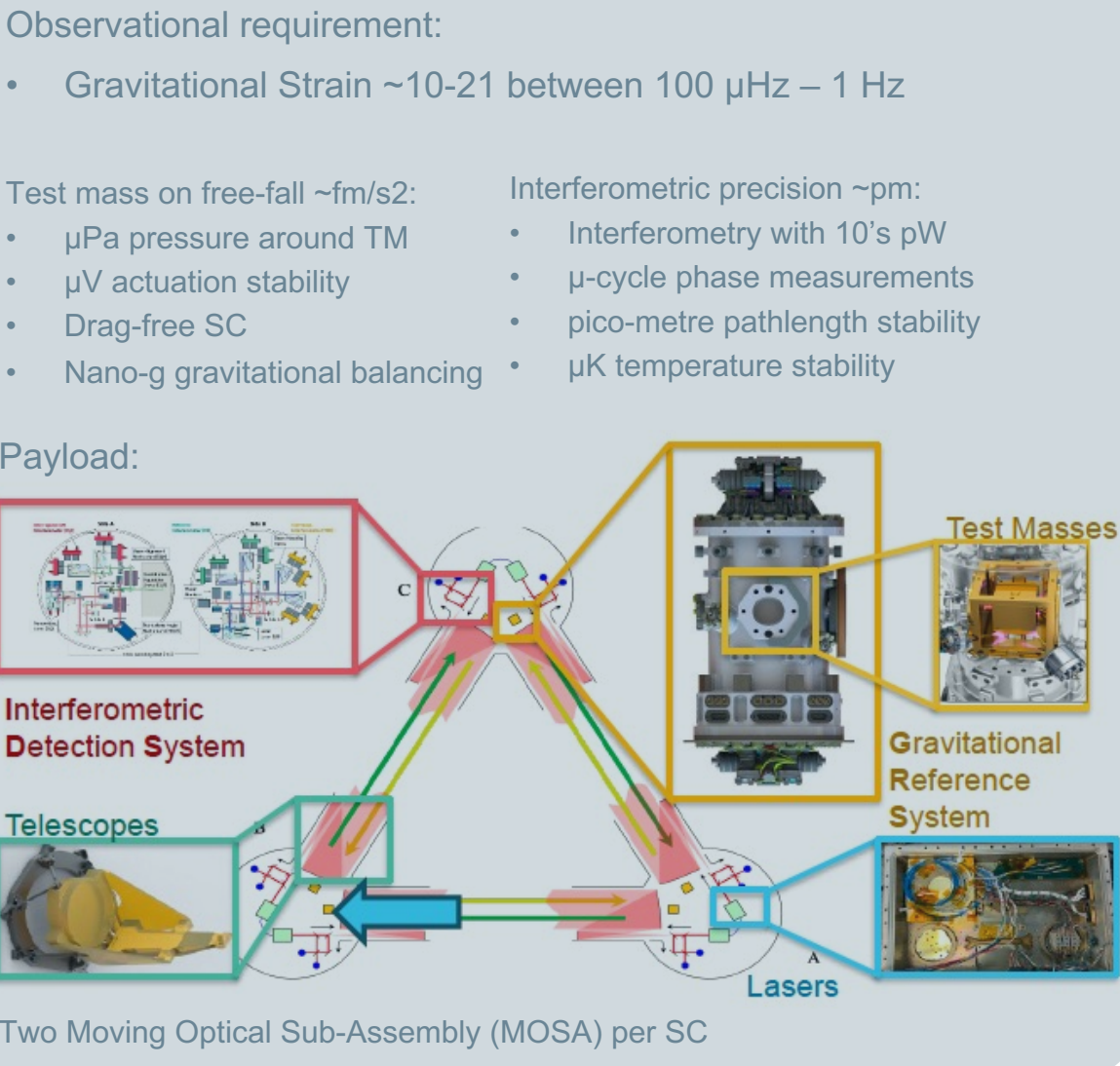
Science Objectives

- Galactic Binaries
- Massive Black Holes
- Extreme Mass Ratio In-spirals
- Stellar-Mass Black Holes
- Fundamental Nature of Gravity
- Expansion of the Universe
- Stochastic GW Background
- Unforeseen sources

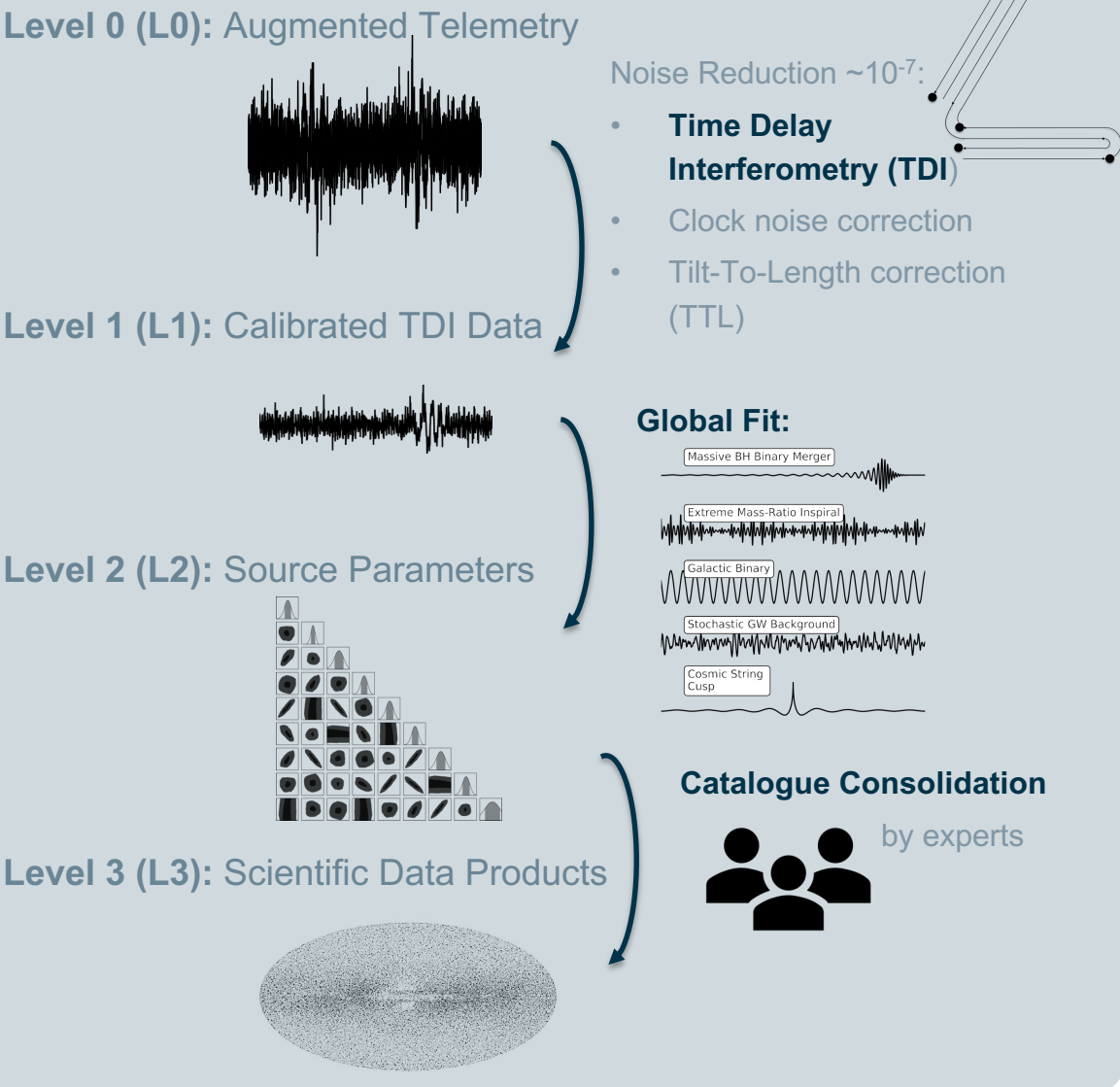
Mission Profile



Constellation Overview



Data Analysis



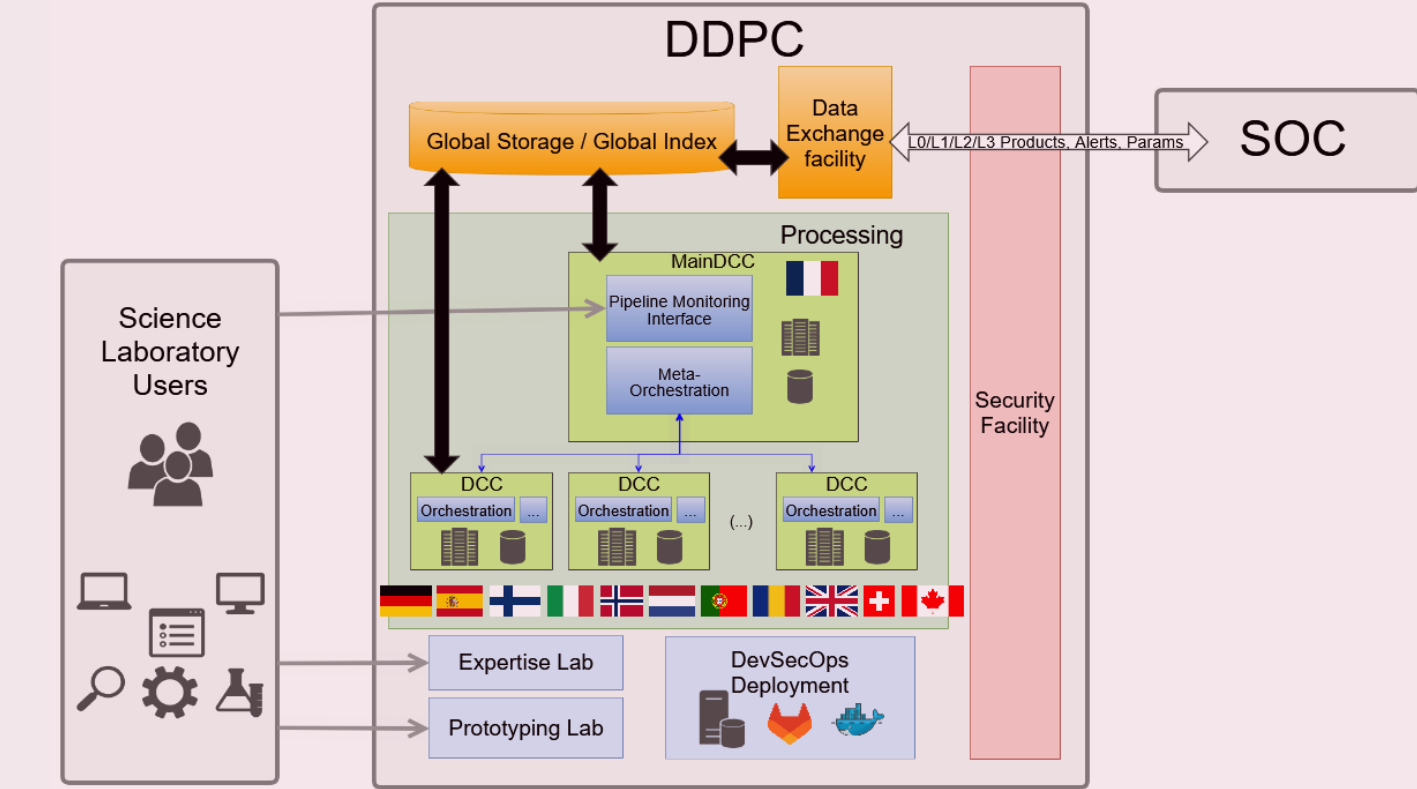
Distributed Data Processing Centre (DDPC)

DDPC hosts the development and execution of the European pipeline

- L0-L1 and Low Latency Alert pipelines (core algorithms), Simulation pipelines, L2 pipelines (GlobalFit and Deep Analysis Alert Pipeline), Contribution to L3 catalog generation

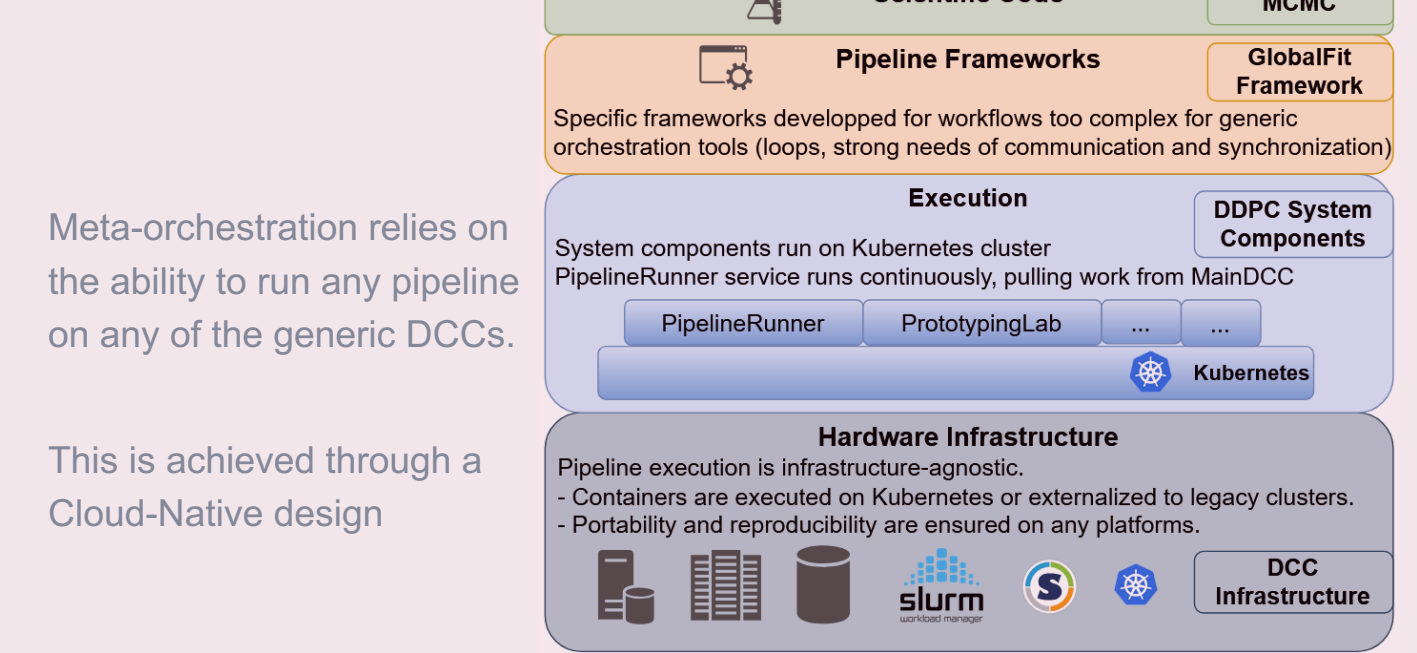
The key concepts of the DDPC System design are :

- Central components : Global Storage, Meta-Orchestration, various Labs opened to laboratories.
- Distribution of the processing on several Data Computing Centers (DCCs), provided by a dozen countries.



Meta-orchestration goals :

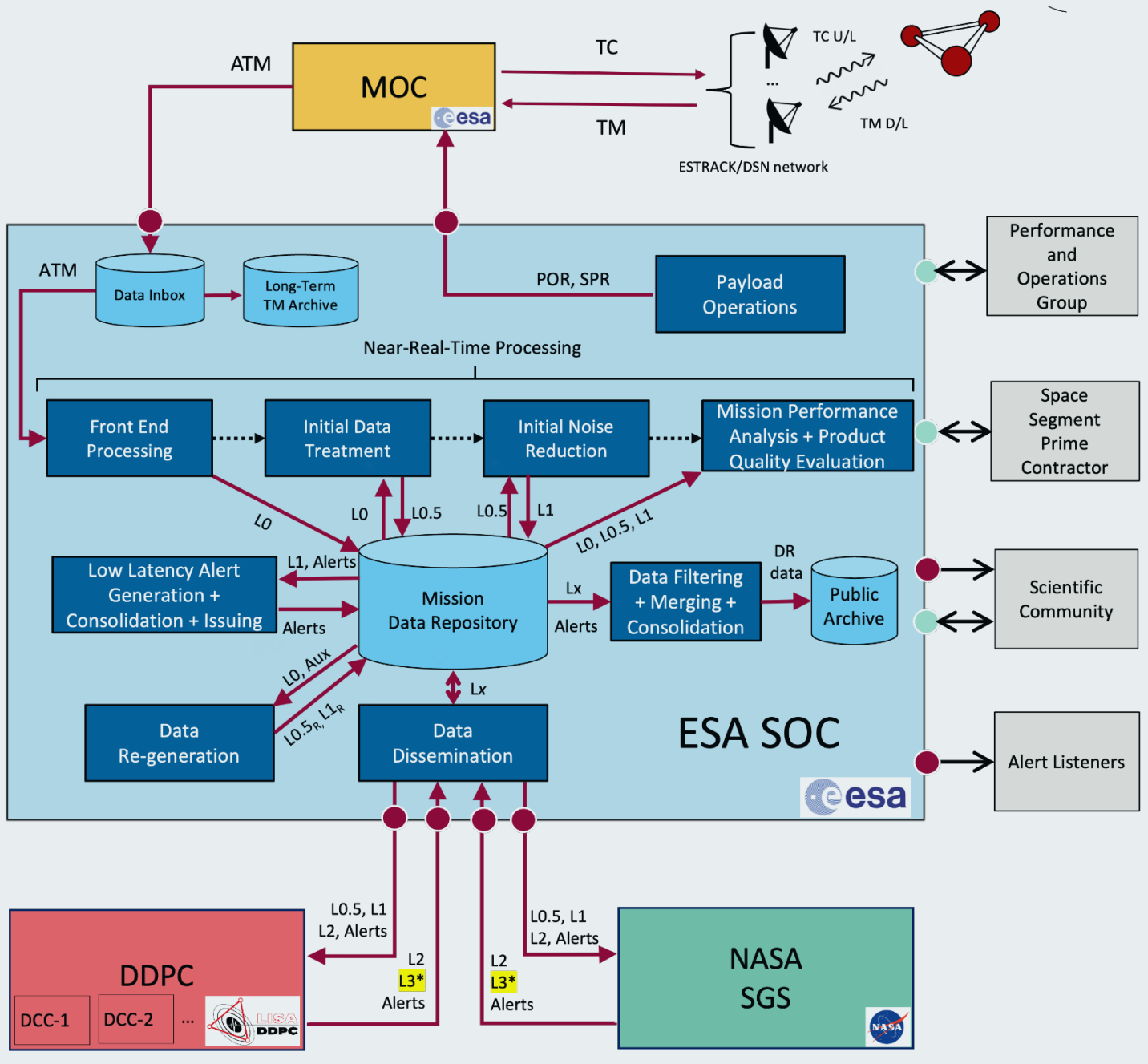
- Optimization of performances, costs and carbon footprint at any time, through a detailed resources monitoring
- Central monitoring & control for operators and scientists to follow pipelines execution



This is achieved through a Cloud-Native design

Science Operations Centre (SOC)

- Downlink chain
- Near-Real Time Processing: L1 data from Raw TM and Low Latency Alert Issuance within 1h of GW signal detected on-board for Multi-messenger Astronomy
 - Science Data Archiving and distribution to SGS partners
 - Oversee Catalogue Consolidation, Data Releases and User Support



Uplink chain

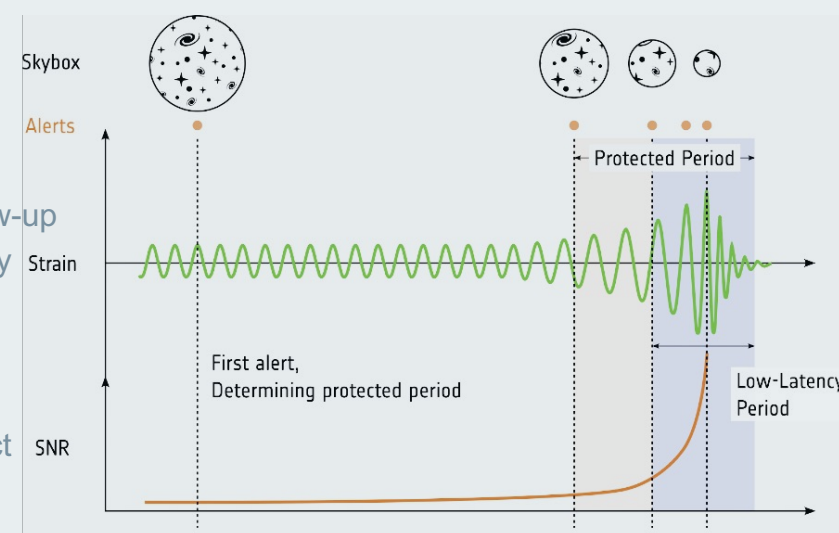
Operational Simplicity: No manoeuvres or pointing; constellation orientation set by orbit

Routine Commanding

- Offset lock planning for Doppler shift
- Periodic payload settings updates

Event-Driven Special Periods

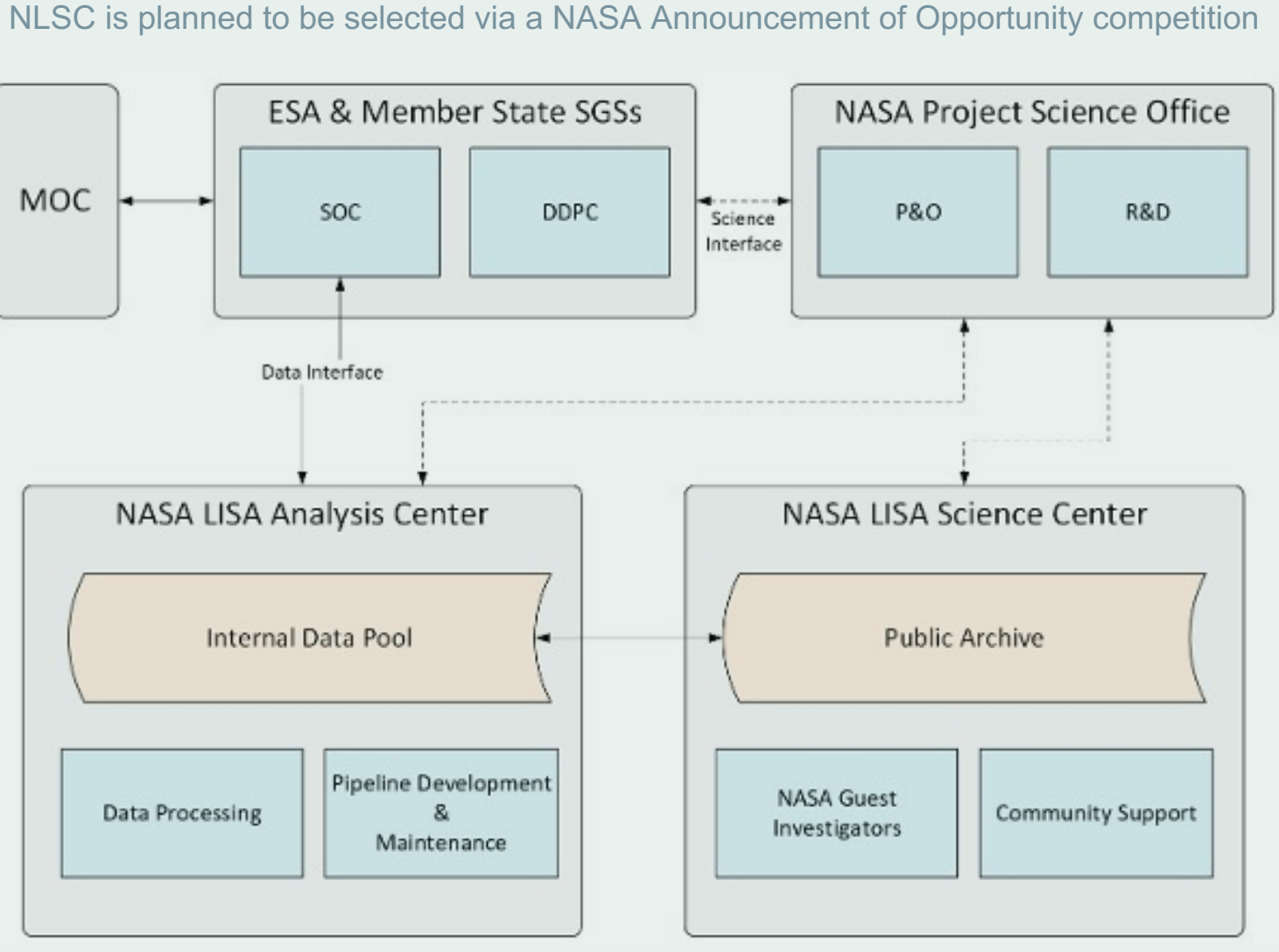
- Alerts: Enable multi-messenger follow-up
- Merger time known weeks ahead, sky location hours before
- Protected Periods: Up to 14 days of uninterrupted science collection
- Low-Latency Periods: Ground contact near alert time for rapid coordination



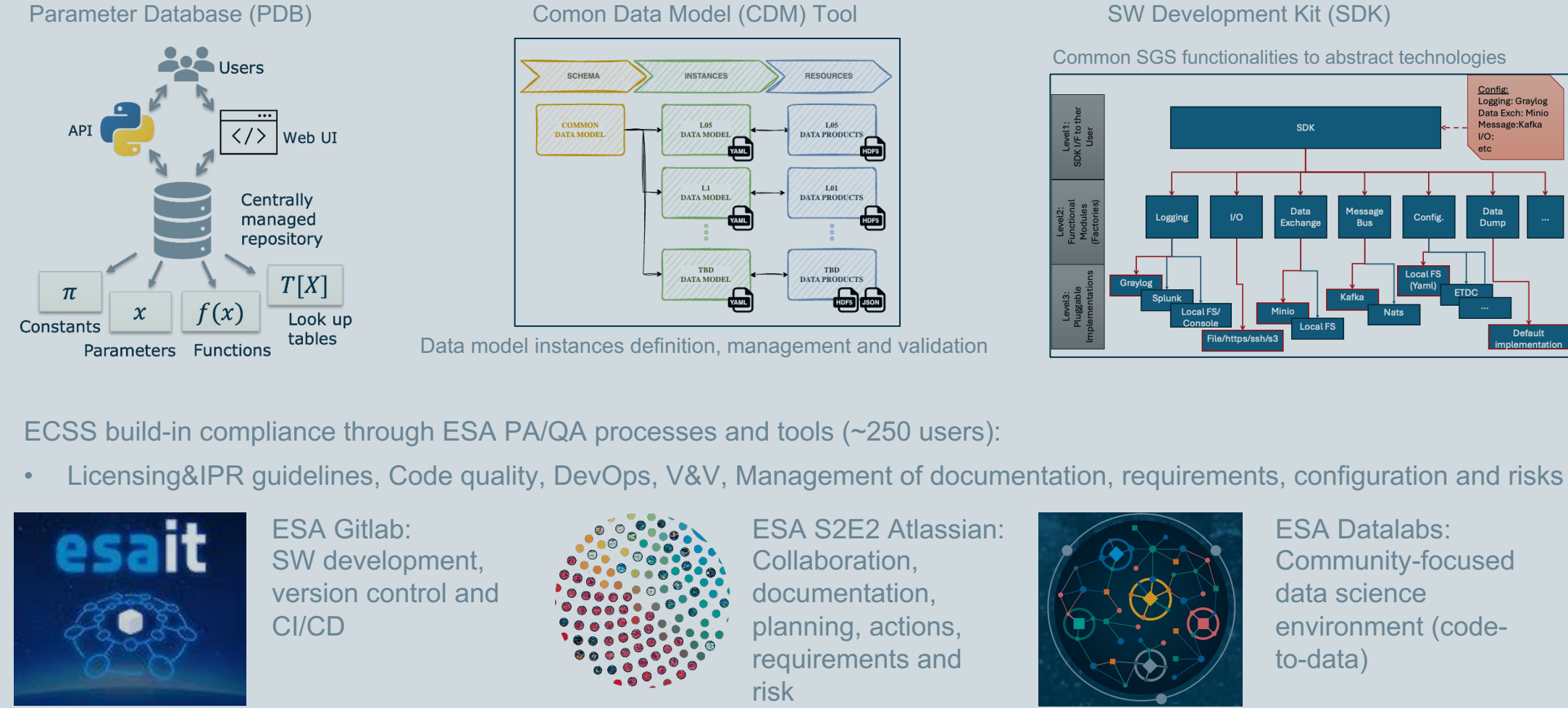
NASA Science Ground Segment (N-SGS)

- N-SGS Core Functions
- Data Processing & Analysis through the NASA LISA Analysis Center (NLAC)
 - Transforms Level 0.5 and Level 1 mission data into Level 2 science products and provides online alerts through 4 specialized science processing pipelines:
 - Initial Noise Reduction
 - Global Fit
 - Online Analysis
 - Contribution to Catalog Production
 - Science Support & Community Engagement through the NASA LISA Science Center (NLSC)
 - Provides public access to LISA data products for data access and utilization
 - Delivers comprehensive user support services for data access and utilization
 - Establishes and administers Guest Investigator program with grant funding support

NASA's Goddard Space Flight Center provides overall N-SGS management
NASA's Marshall Space Flight Center leads the development and operations of the NLAC
NLSC is planned to be selected via a NASA Announcement of Opportunity competition



Common Tools and Infrastructure



Conclusions and Outlook

- LISA's Science Ground Segment (SGS) is a long-term collaboration between ESA (SOC), European Member States (CNES led DDPC), and NASA (NSGS):
- Not a "big data" mission, but requires **intensive computation**, especially for source recovery (Global Fit).
 - Software must be designed for **longevity** (~20 years).
 - Built on a **cloud-native architecture**.
 - Supports **flexible execution** across globally distributed Data Computing Centres (DCCs).
 - Emphasis on **scalable infrastructure, modularity, performance, and maintainability**
 - Collaborative tools with built-in quality standards** are established early.
 - Designed to **evolve with mission needs**, accommodating extensions, new tools, and unforeseen discoveries.

