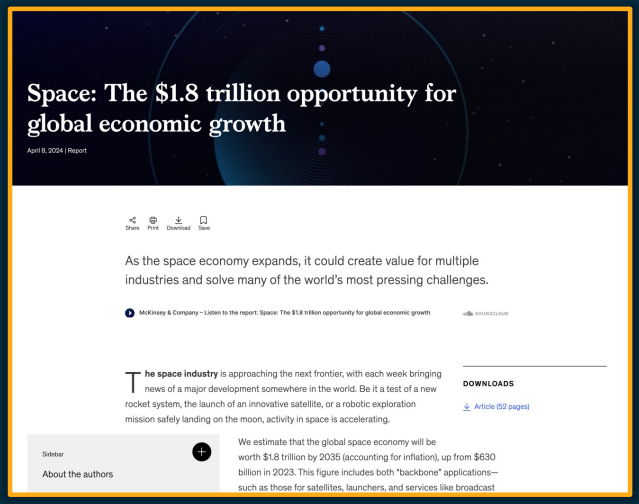
Systems Engineering at ESA

Space Environment and Context

- Space is booming
- New Space Economy
- ESA is expanding it's portfolio
- ESA is transforming

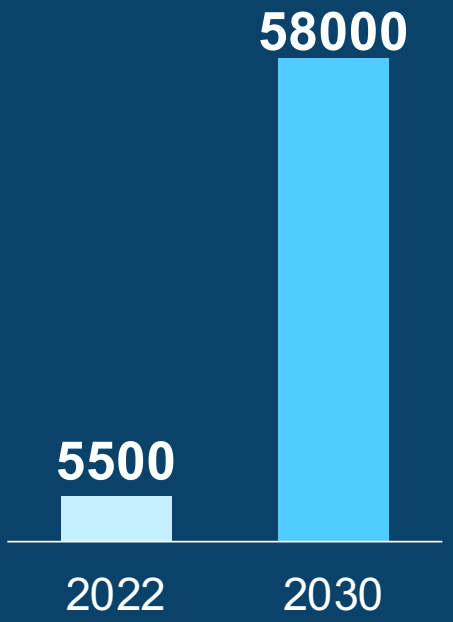


Average number of satellites in orbit per year

x 10.5
demand increase

80%
to come from constellations

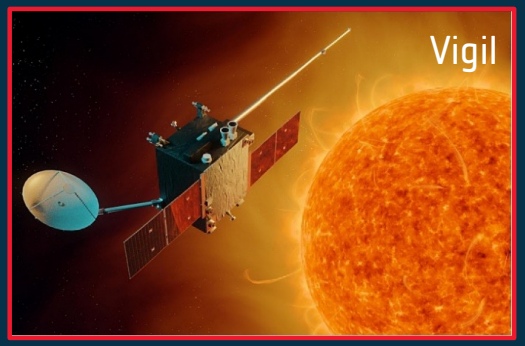
75%
revenues will come from governments

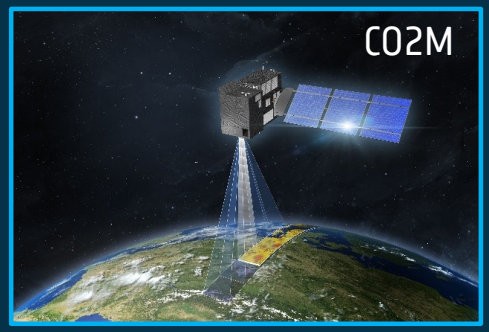


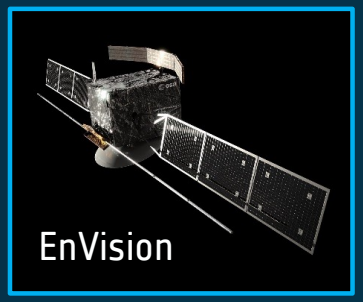
More Missions

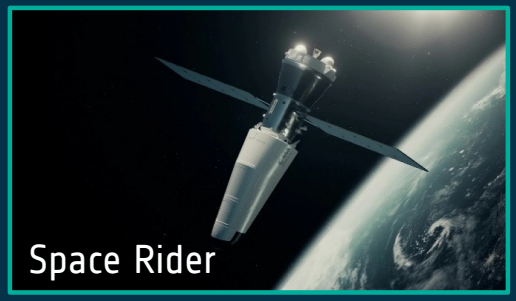
ExoMars, Ariane 6, Mars Sample Return, IRIS2, Cargo Return, Galileo 2G, Flex, EnVision, Metop2G, CO2M, Harmony, Lunar Gateway, HERA, Ramses, Moonlight, Themis, SAGA, Argonaut, Space Rider, ClearSpace-1, Athena, LISA, PLATO, Sentinel, Proba III, Vigil,

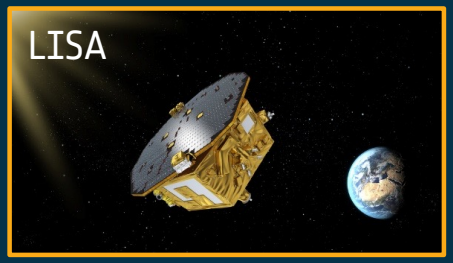
And many more....





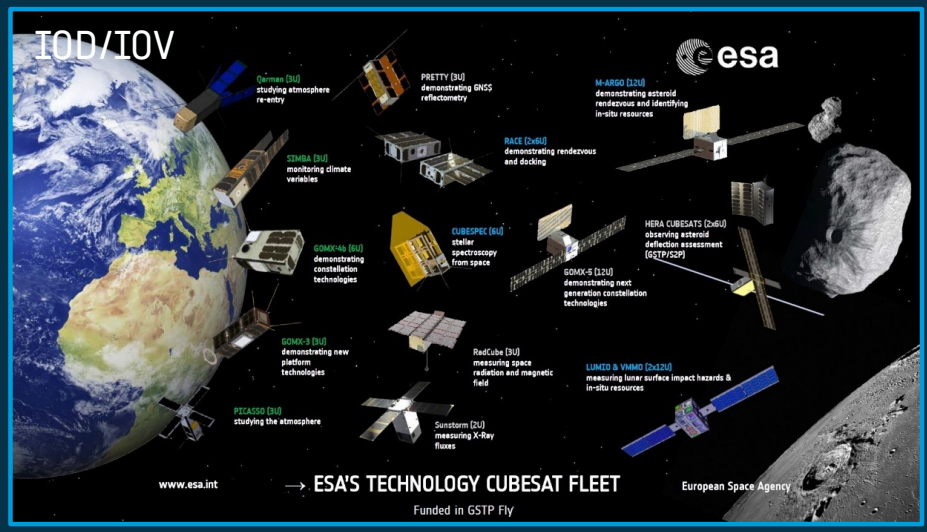


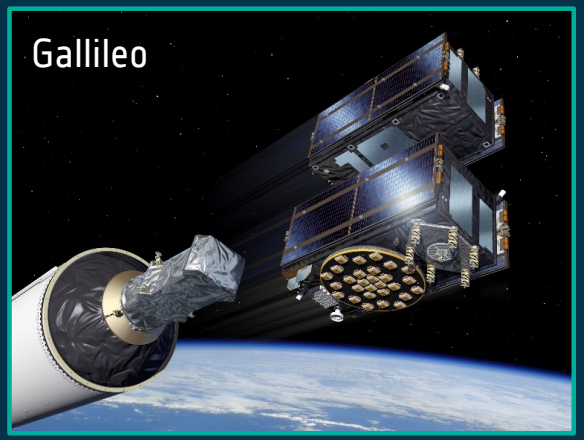




More (industrial and complex) missions ➔ smaller teams ➔ more (sub)system engineers

More Complexity, Faster & More Efficient





- Constellations
- Systems of Sytems
- AI & Quantum & Crypto technologies

Space System Engineers Profile

Multidisciplinary Role

Fast decision making and efficiency

Managing More Complex Missions (systems of systems)

Tool Evolution (AI, MBSE...)

Security

Improving Time to React

System Engineering Role is evolving and more demanding

System Engineers in ESA

MORE System Engineers:

Expand the pool of talents:

Multidisciplinary mindset , SE-directed career path ➔ expert ➔ subsystem ➔ system

Recognition: Career Path, Grading, Tools

BETTER QUALIFIED:

Training, System Engineering Community,

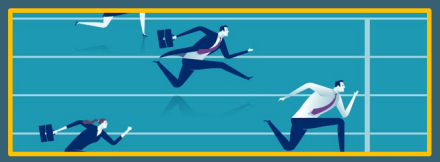
Mindset: Multi-disciplinary, System Engineering, decision making, Sustainable engineering, System Security, Cost Engineering, Concurrent Engineering,

BETTER Equiped:

MBSE, (Improved) Space Standards (ECSS NG), Interface Standardization, modern Requirements Engineering Tools, Streamlined processes, Mission Classification, Faster Review Processes, Simulation & Modelling, AI & Data Science

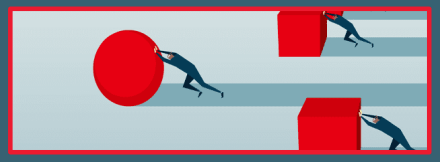
Standardisation

The Fundamental Need for (Space) Standards



Competitiveness and commercialisation

Strengthen industry competitiveness and sustain the development of new EU and international markets.



Product performance and quality

Improve performance, reliability, safety, and sustainability aspects thanks to a coherent approach to development, manufacturing, supply, and services.

Trade facilitation and interoperability

Reduce trade barriers (including new technologies), improve legislation, and develop trust.

Knowledge transfer

Enhance engineering and product assurance knowledge while developing the capabilities of new organizations (eg SMEs).

Education

Develop and strengthen engineering, quality, reliability, safety, sustainability, and management education avoid reinventing the wheel.

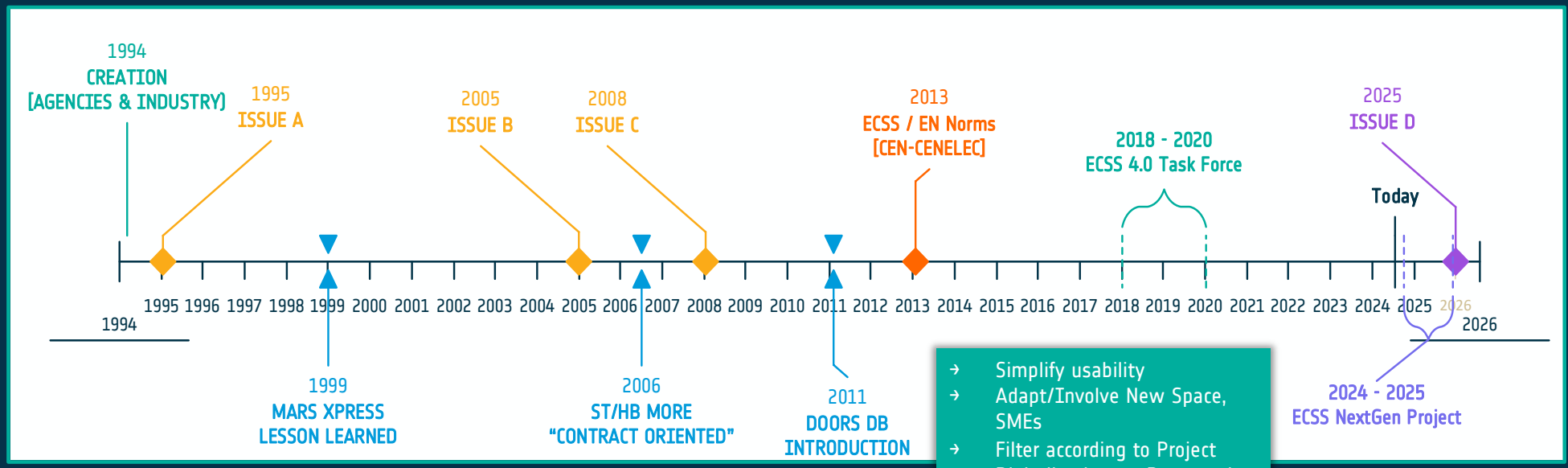
Why Was ECSS Created?

Back in the early 1990s...

- Each customer had its own set of standards (eg NASA, US MIL, Industry best practices)
- European Space Industry **had to meet different requirements**
- **Expensive**

- Need to develop a common standardization system
- ECSS created as a common system
- 1 pool of standards for all customers

ECSS Timeline, Evolution and ECSS NextGen Project



- → Simplify usability
- → Adapt/Involve New Space, SMEs
- → Filter according to Project
- → Digitalisation vs. Doc centric
- → E-RMS (ECSS Requirements Management System)
- → Industrialization (series production)

→ The ECSS system is fully operational (until publication of Issue D – expected by end 2025)

European Cooperation for Space Standardization ECSS

AIRBUS
arianeGROUP
OHB
ThalesAlenia Space
a Thales / Leonardo company
... and many smaller companies

ECSS + esa

+ ASD-EUROSPACE The Space group in ASD

agenzia spaziale italiana · cnes CENTRE NATIONAL D'ÉTUDES SPATIALES · DLR · Netherlands Space Office · Norsk Romsenter Norwegian Space Agency · UK SPACE AGENCY

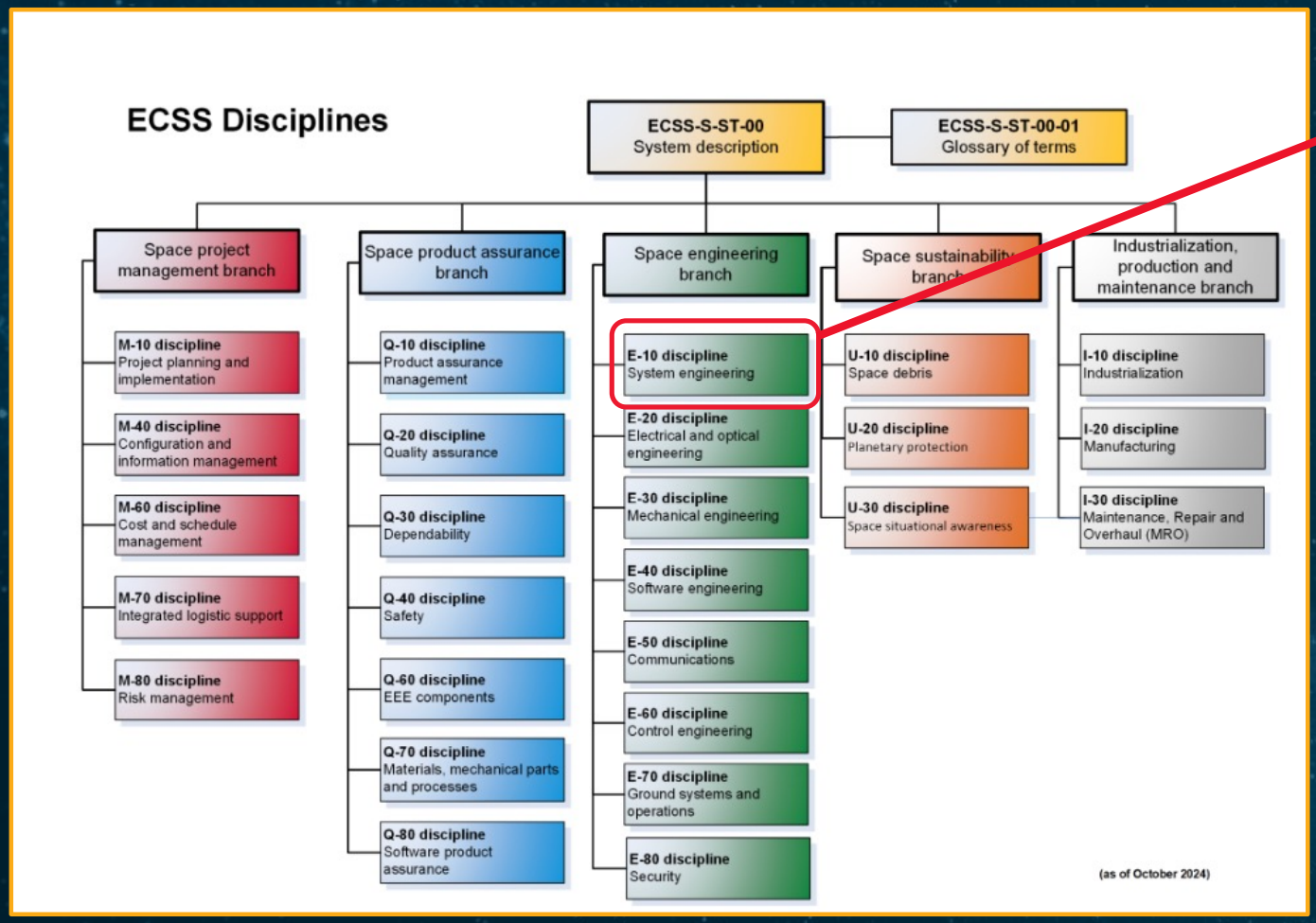
ECSS Purpose

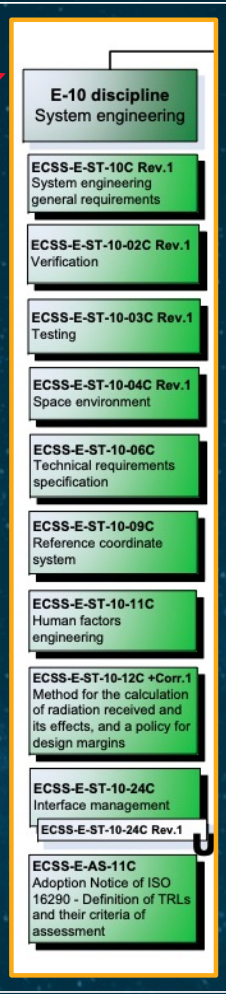
- Develop and maintain a single set of consistent space standards
- Recognized and applied for use by the entire European Space Community
- The European way of procuring space systems
- Standards are made applicable by contract

ECSS Way of Working

- Capitalises on more than 40 years of experience in space projects
- Developed through a partnership between ESA, National Space Agencies, and the European Space Industry (Eurospace)
- A liaison with CEN, European Committee for Standardization, ensures all ECSS standards become European Norms (ECSS / CEN MoU signed 2013)

European Cooperation for Space Standardization (ECSS.nl)





ECSS E-10 Standards Scope

The E-10 standards cover the following System Engineering areas:

- General principles, definitions and documentation (incl. DRDs)
- Requirements specification
- Interface management
- Verification
- Testing
- Coordinate Systems
- Space Environment / Radiation
- Human Factors

Several other areas of system engineering (traditionally) are covered by standards in other disciplines,

for instance:

- Space Segment Operability (E-ST-70-11C) which defines autonomy and system requirements for operability
- Software (ECSS-E-ST-40C) for the definition of the System inputs to SW
- Testing at subsystem level (e.g. propulsion) covered by the relevant discipline standards

Concurrent Engineering and Concurrent Design Facility

ESA ESTEC

Concurrent Design Facility (CDF)

ESA CDF is an Integrated Design Environment based on Concurrent Engineering Methodology

ESA CDF Website http://www.esa.int/CDF

Concurrent Design Facility (CDF)

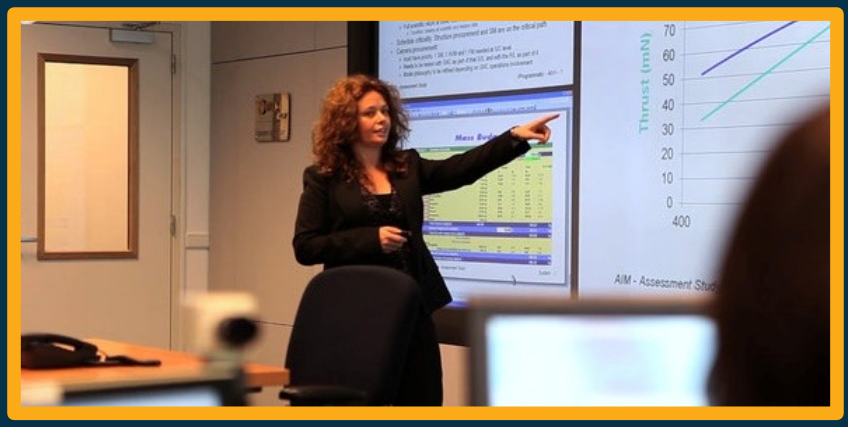
IT Infrastructure

AV Infrastructure

Design Process

CE Methodology

CE Methodology: Interdisciplinary Communication



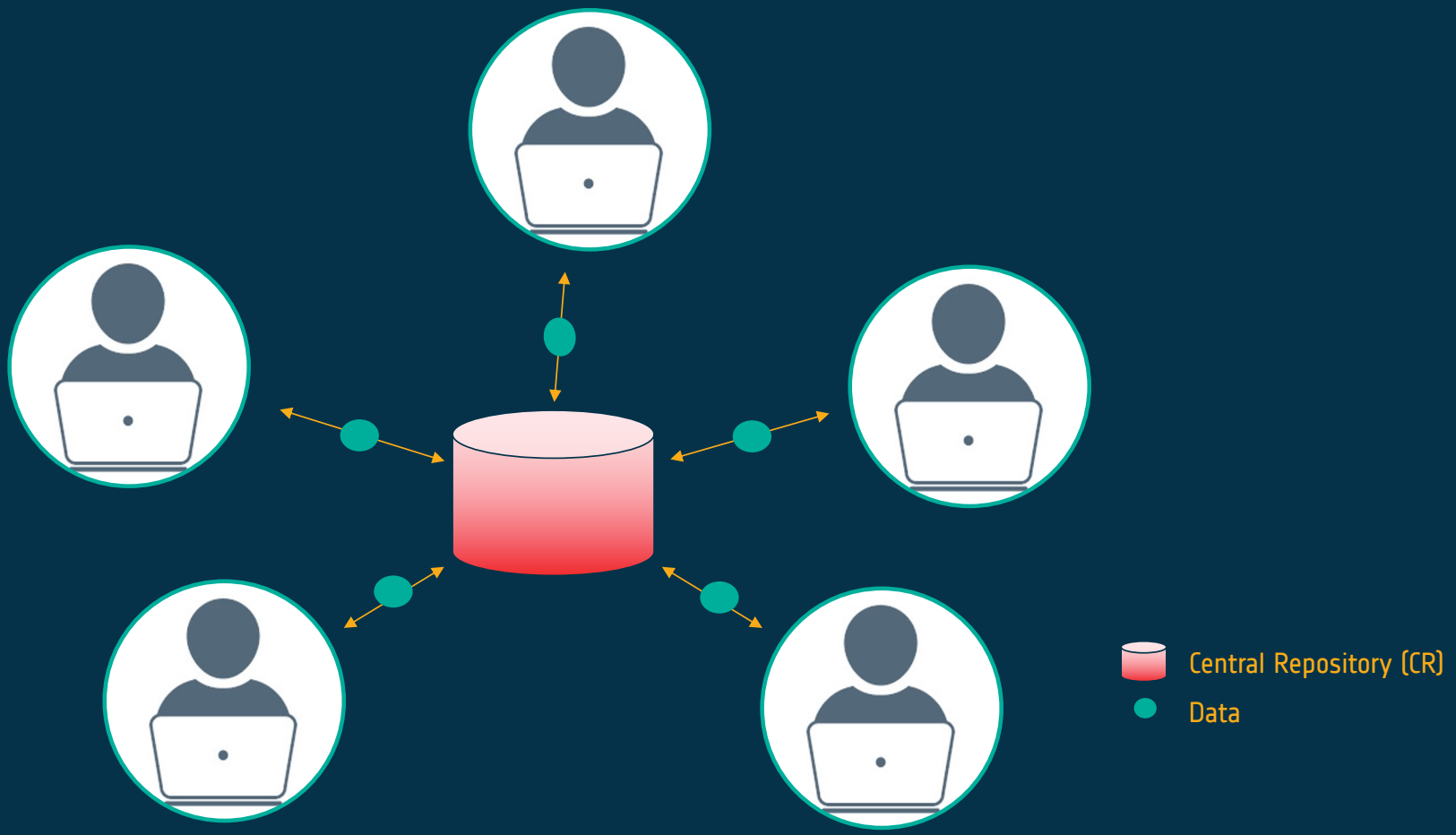
Approach:

- Multidisciplinary
- Holistic
- Systematic
- Centralized
- Focus on customer expectations
- ...

Methodology:

- Iterative presentations
- Debate
- Consensus
- System awareness
- ...

Multidisciplinary Data Exchange



CE Applications

CDF: An essential tool for the ESA Decision Making processes

CDF Performance

Features

ESA's Concurrent Design Facility performs about **10 to 15 studies per year.**

- Technical experts working together as a multidisciplinary team.
- In the same place and at the same time.
- Including domains such as Operations, Assembly Integration & Verification, Programmatics, Cost Engineering, Risk Analysis, CAD, and Simulation.
- Rapidly assessing the feasibility of new mission concepts.

Benefits

Increased performance

- Duration: reduction factor of 4
- Cost: reduction factor of 2

Improved quality

- CDF provides fast, consistent and complete mission design.

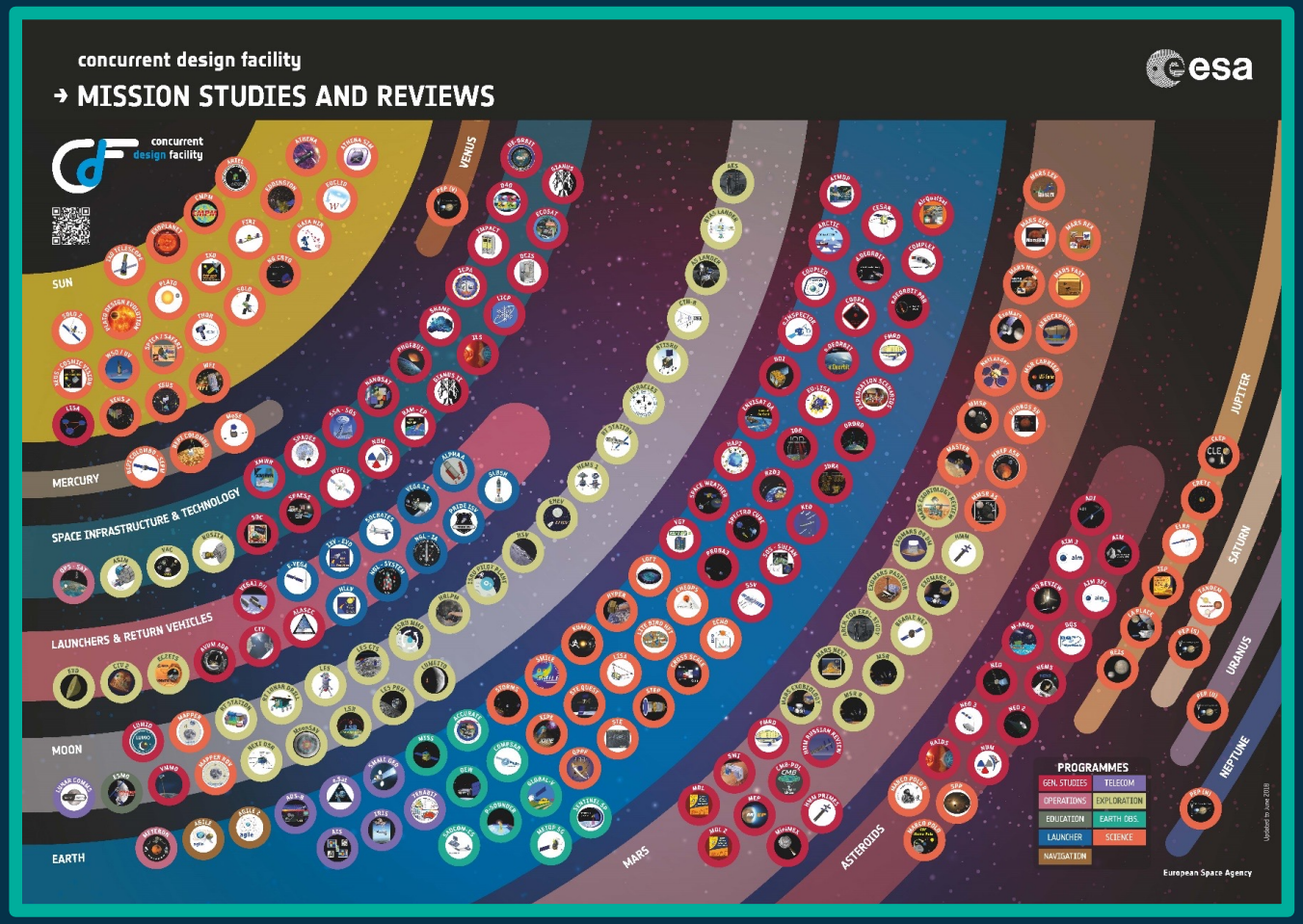
Detailed reporting

- Technical report becomes part of the inputs to subsequent industrial activities.

Capitalisation of corporate knowledge

- CDF promotes and enables further reusability.

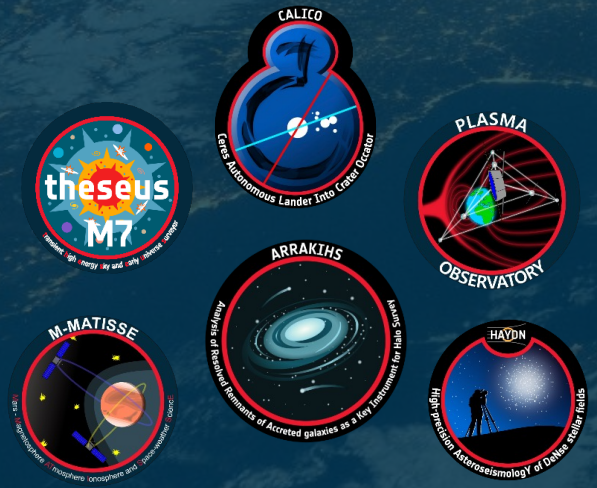
CDF Mission Studies and Reviews



Remarkable CDF Contributions

Zero Debris

Artemis



Voyage 2050 – F2 & M7

Human Inspirator