

# What is a Science Operations Centre Euclid SOC

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# Introduction



*"I keep six honest serving-men  
they taught me all I know..."*

I will aim to explain **what** is a Science Operations Centre, **why** is it needed, **when** is it useful, **how** does it work, **where** Euclid's one fits and **who** is involved.

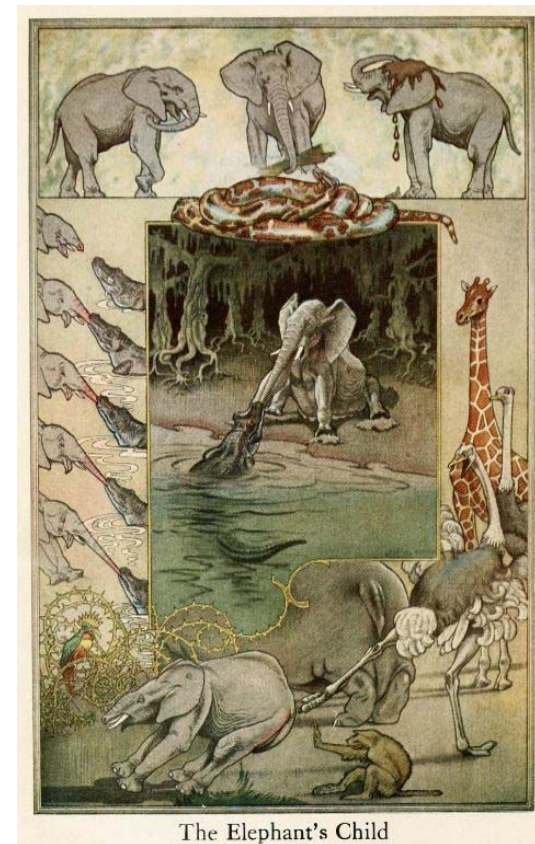
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The Elephant's Child

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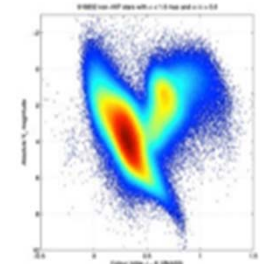
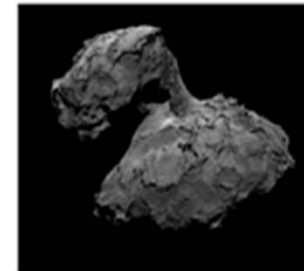
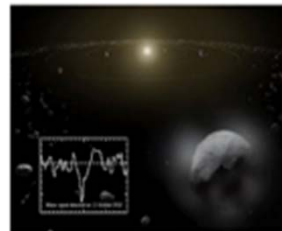
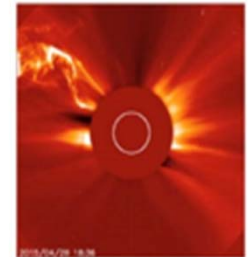
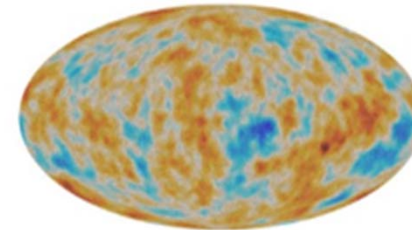
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## Space Mission, and end to end view

The scope of a Space mission is **the satisfaction**, through HW, SW and processes of the **user's needs**.

The mission is **more than** just the **Space Segment** (satellite) and **Ground Elements** in charge of contacting it and ensuring its safety and performance, or the **Processing of its data**.

Sometimes the **mission's objective becomes wider** (sometimes orders of magnitude) than the effort at space side, being this **just one experiment**.



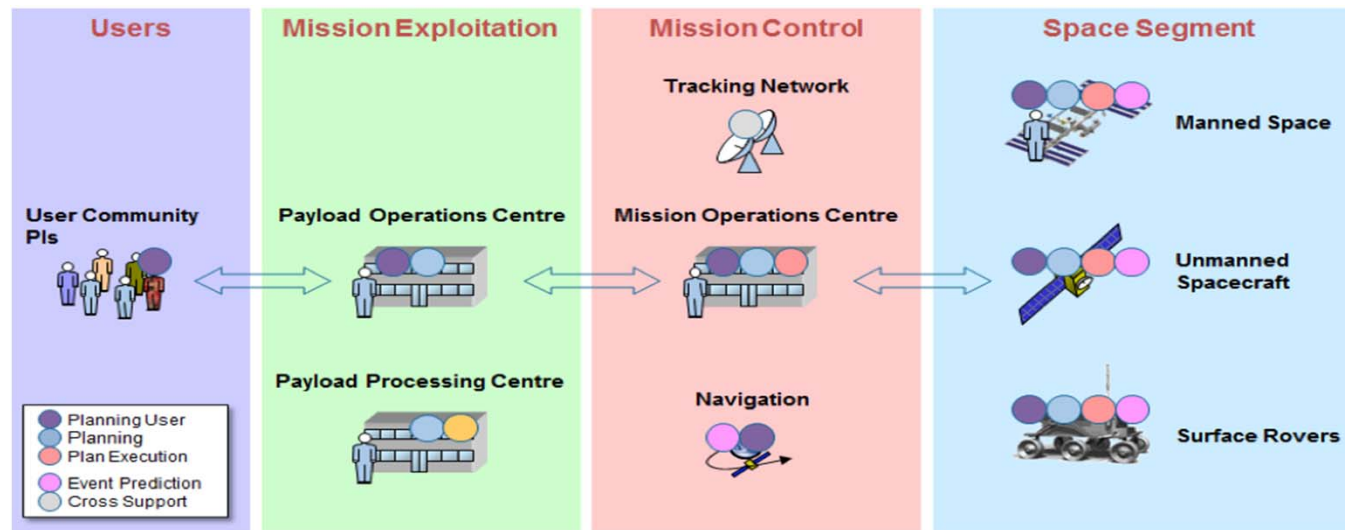
$W_p = -1$  ?



# Ground Segments: Where do they start and end?



We should aim for the “from fuzzy requests to structured returns”. The Ground Segments for Space Missions extend to include that of the User Community, and their interfaces with the Mission Control through the exploitation.



CCSDS MPS Green Book

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# ESA Operations Centres



**ESOC (GE)**. 50 years of expertise. LEOP and Routine operations of missions.

Managing ESTRACK (Ground stations network), developing systems, procedures and expertise. Over **70 missions flown**.

**ESAC (SP)**, 40 years of experience. **Over 20 Science Missions Operations handled**.

Hosts the archives of ESA missions.

**ESRIN (IT)** (EO missions)

**Redu (BE)** (Tech Missions)

EAC/Baltimore/Toulouse/Kourou...



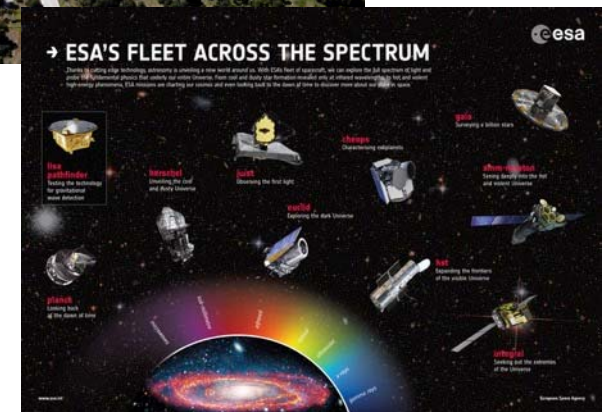
# ESAC history



European Space Astronomy Centre,  
ESAC, started life in 1975, as a Ground  
Station for ESA/NASA **IUE** and its  
**mission operations** (including **scientific  
ones**).

Then gave support **to ISO and XMM**, in  
all three cases a truly end to end  
portfolio of **all mission science** (and in  
the case of ISO, satellite) **services**.

Since 2004 **centre of science operations**,  
hosts **ESA's science archives**, and  
manages all **Science Operations Centres**.



# Astronomy and Science Missions



Planetary, Solar Systems, Astronomical or Cosmological fields.

Similarities with other areas as Earth Observation Science, Positioning Science, Tech Science,

Non commercial missions

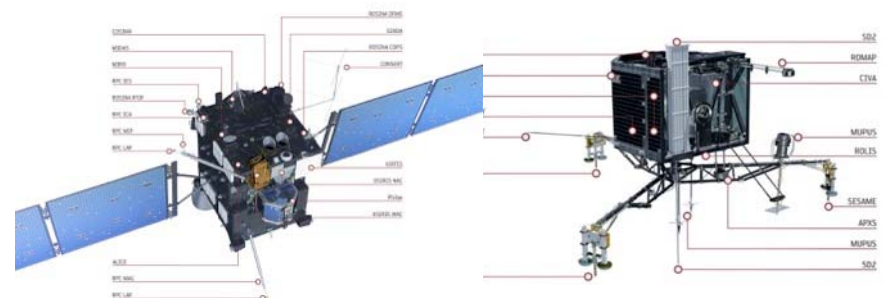
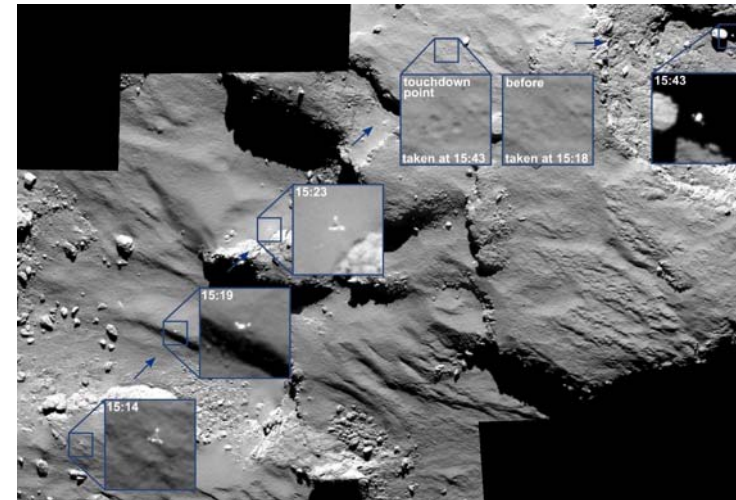
Variable number of instruments, typically “in kind” contribution from Scientific Institutions.

Big Scientific Consortia, composed ad hoc: not a strong management or hierarchical structures.

No standardization in the processes and services.

Missions tend to be one shot.

Space Mission operated as an instrument, the interest is in the data. Operations or S/C are not an area of interest for mission users.





# Why a Science Operations Centre (SOC)?



A SOC acts as an **interface** converting the **scientific interest** of the users into **operational items** compatible with the Space Segment capabilities, ensures that the **best use** of it can be achieved, and grants that **data is processed, distributed and preserved** adequately.

It **isolates the Mission Operations Centre** from the **complexity and variability** of the Science Segments, and it also provides **Operational feedback** and services to the **end users**.

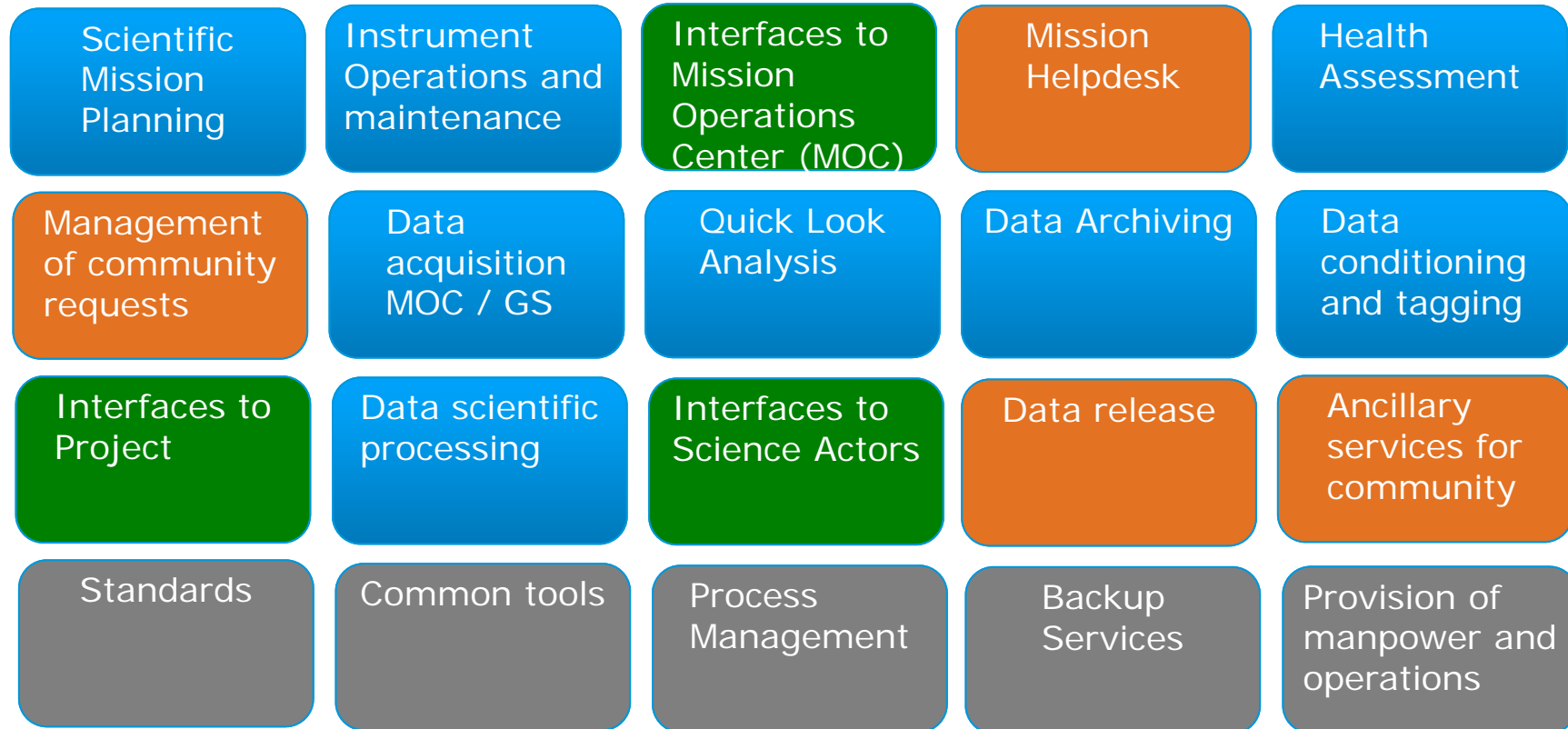
It helps **unifying the interfaces**.

It ensures **operational persistence**.





# Portfolio of a SOC's tasks and services



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# Euclid Mission Overview



M2 mission ESA Cosmic Vision Programme

Mission objectives: map the geometry and understand the nature of the Dark Universe (dark energy and dark matter).  
15000 degrees<sup>2</sup>

Actors: ESA and the Euclid Consortium (institutes from 14 European countries and USA, funded by their own national Space Agencies):

15 countries, 100+ labs, 1200+ members

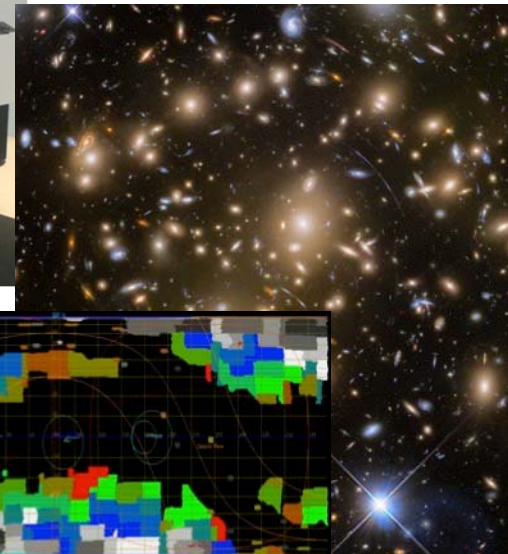
Biggest collaboration!

Adopted 2011, Launch 2021, 6 years.

For more information see :

<http://sci.esa.int/euclid>

<http://www.euclid-ec.org>



# Euclid Mission Ground Segment

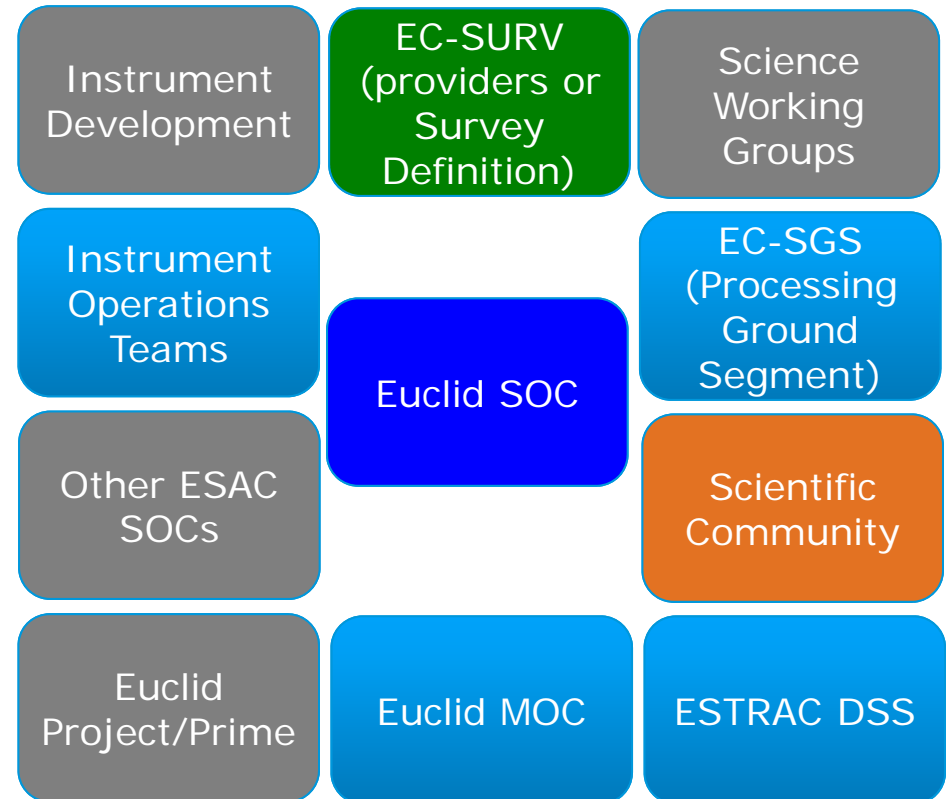


Actors influencing the Ground Segment  
(Instrument Development, Science  
Working Groups, Project/Prime, other  
SOCs)

Actors feeding inputs to the Mission  
Ground Segment (EC-SURV)

Actors implementing the Ground  
Segment functions (IOT, SOC, MOC,  
Processing SGS)

Actors consuming Ground Segment  
(Scientific community and Science  
Working Groups)





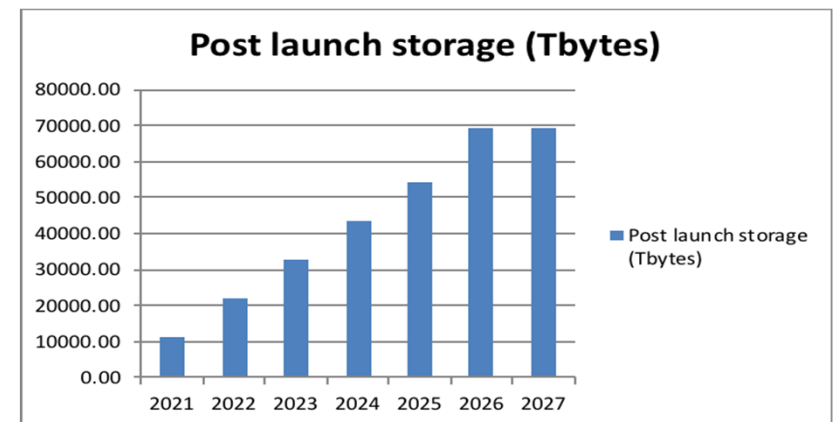
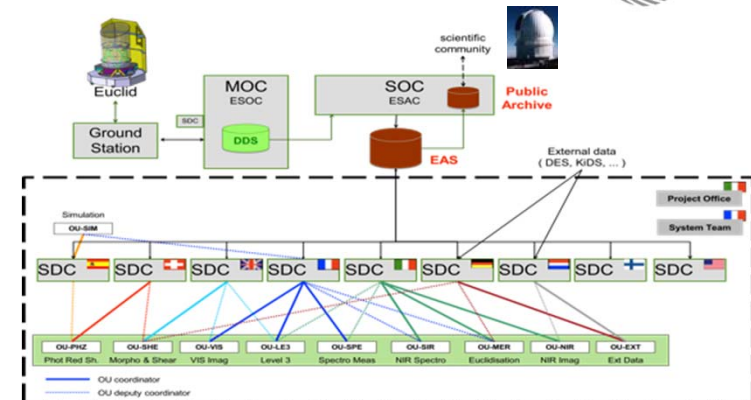
# Euclid Science Ground Segment



The **Science Ground Segment**, on its **processing** side, shows one of the **complexity of Euclid**. Data is expected to **boost and multiply in size as well as CPU needs**, processing itself is an experiment to get the best scientific merit.

**Highly distributed processing**, bring the **processing to the data** (reduce network load), **continuous development** and **integration of new pipelines**, schedule of **data releases** to community.

**Multiple actors**, need for coordination.



## Euclid Mission SOC

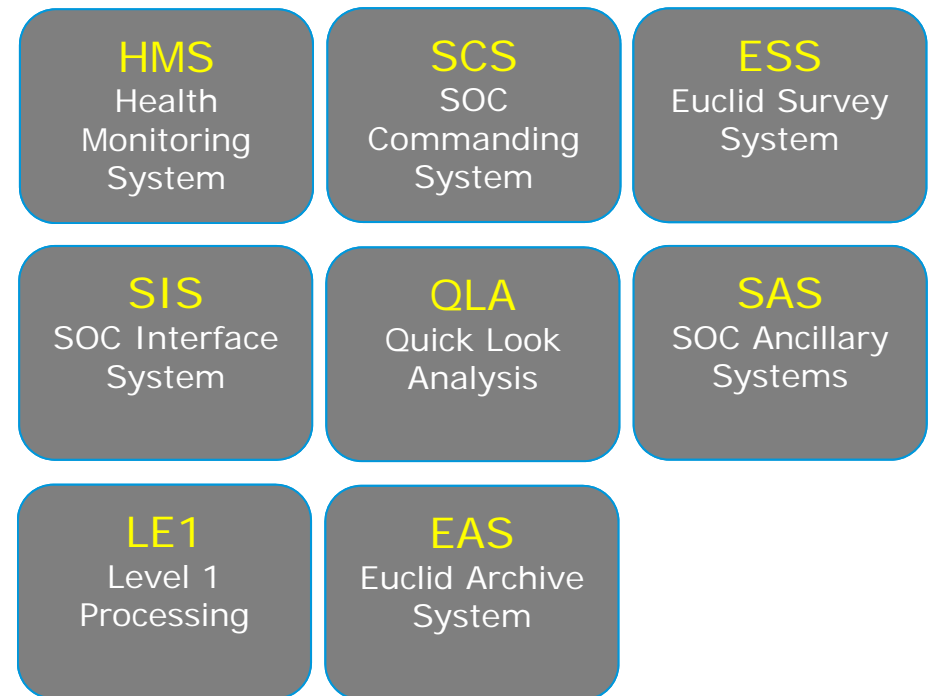


Implemented at [ESAC/ESA](#), near Madrid, Spain.

Benefits from [collocation with other ongoing SOC's](#) from ESA (Planetary, Astronomy, Solar).

Currently [12 people](#), [peaking 18](#) in operations.

Functionally implementing a set of [components and subsystems](#), both developed [in house](#), reused from [ESA/ESAC](#) or procured to industry.



# Euclid Mission Services

**Interfaces:** MOC, Processing SGS, Instrument Teams, Planning requesters.

Support during **mission development**

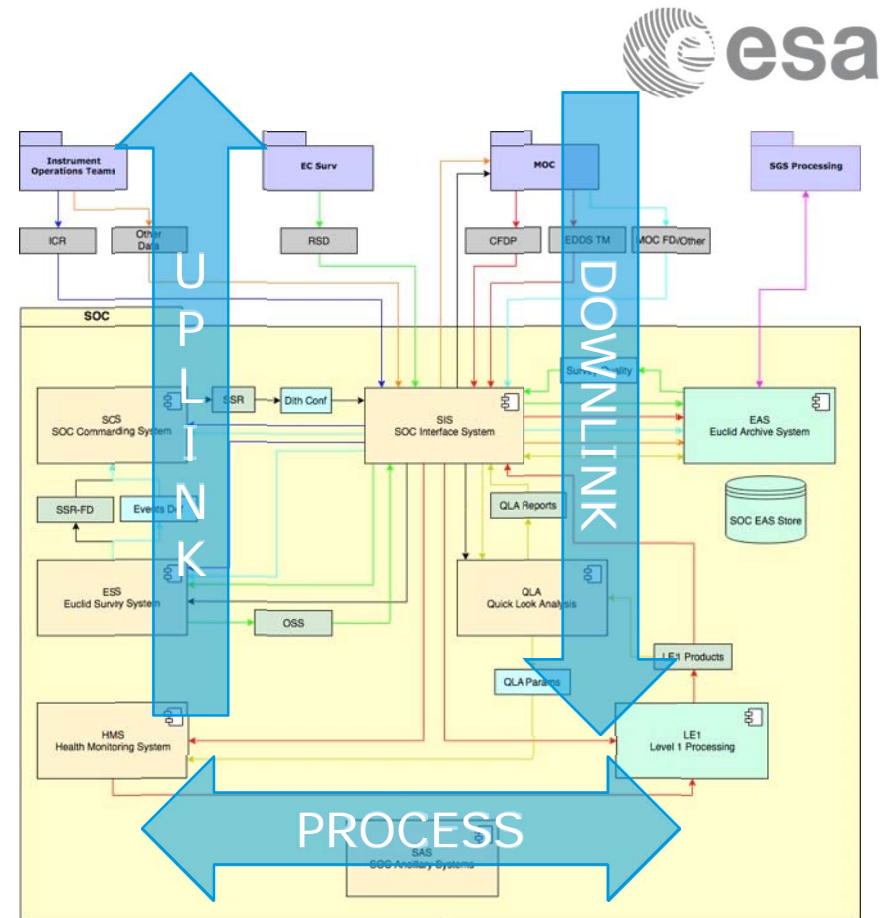
Scientific Operational **Mission Planning** process, sending planning inputs to MOC.

It receives the **raw science** and HKTM data and **formats** into a product ready for processing.

**Quick Look Assessment** on the science products, **Health Monitoring** trending on parametric data.

Manages the data **Production Archive**, and implements the **data release archive**, legacy.

**Ancillary supporting functions** (authentication, configuration control, helpdesk, etc.)





# SOC Benefits to Euclid Mission



It allows Euclid Processing Science Ground Segment to **focus on data processing** from a **standard input product**, collecting its basic elements and assessing its quality.

It allows to implement a **mission planning process** maintained along the mission.

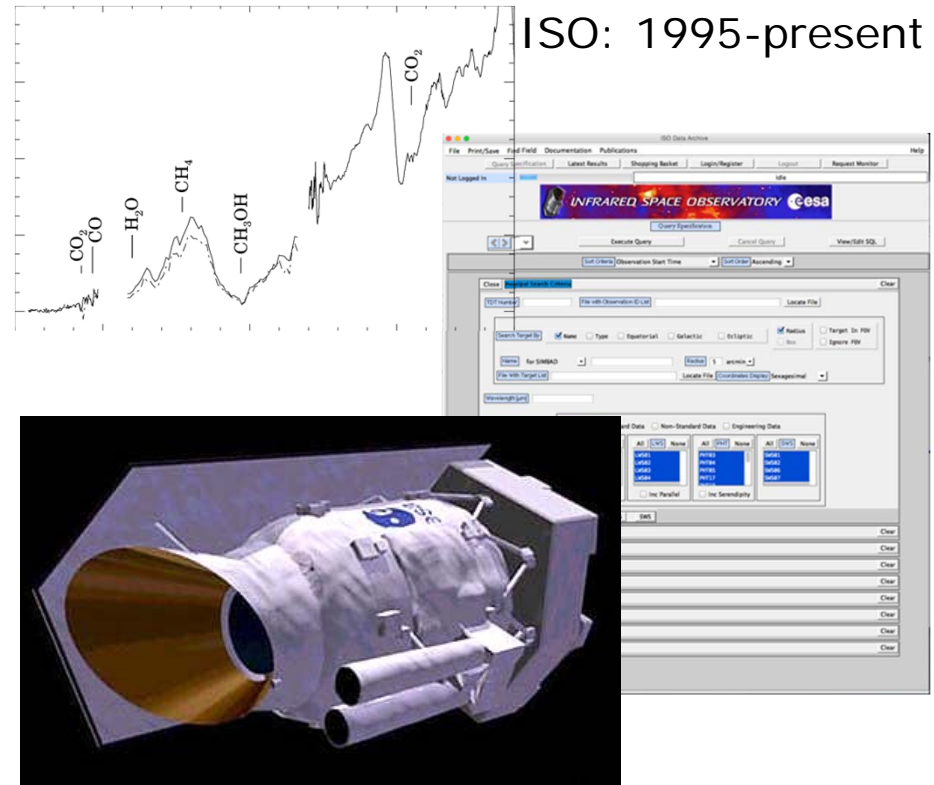
Provides **stable interfaces** to all actors.

Ensures up to mission end and beyond **operability of data and elements** (long exploitation phase foreseen).

Provides **data management and release** capabilities.

It brings into the mission the "**lessons learnt**" from others.

ISO: 1995-present



# Euclid SOC concepts and tools: reusability



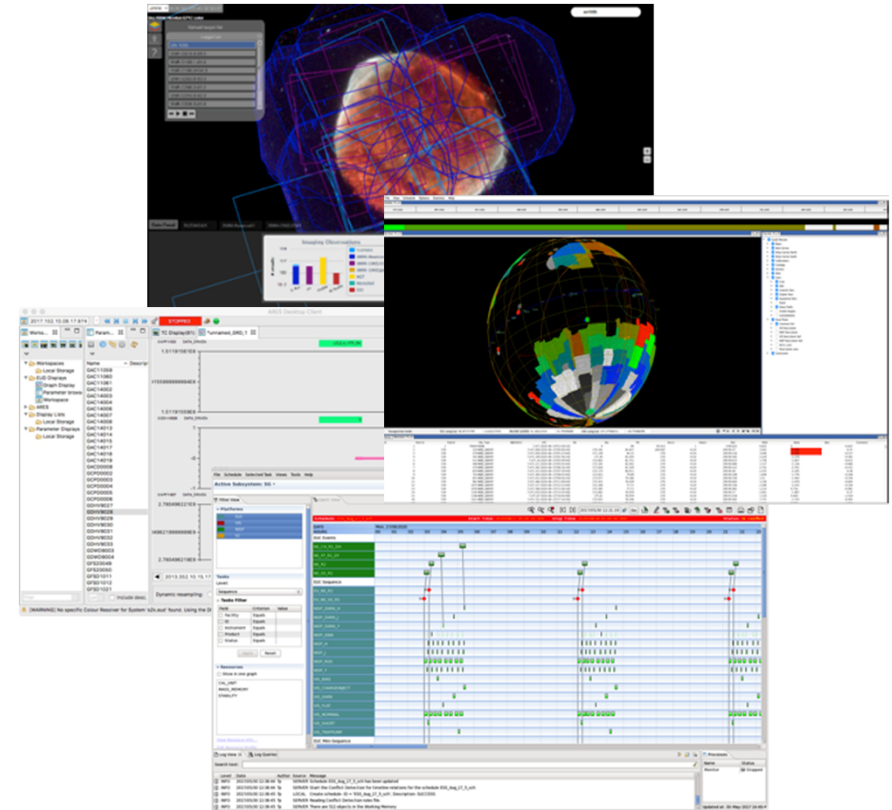
Mission Planning System (ESS) developed from Herschel → **core reuse**

ESA/ESOC Trending tools reuse (Health Monitoring System) → **reuse as is**

Archives infrastructure and common elements used (TAP, ESASky, Others) → **multi-mission development**

Procurement of SW programs demonstrated in other areas (SCS-flexplan) → **procurement**

ESAC processing and IT facilities (cloud, grid, others) → **common infrastructure**



# Future (on-going) SOC tasks

Inter-SOC reusability (eg. MAPPS, Common Frameworks), and development.

Standardization efforts

- CCSDS
- Archives (VO, TAP access)
- User request handling and format
- ESAC/ESO

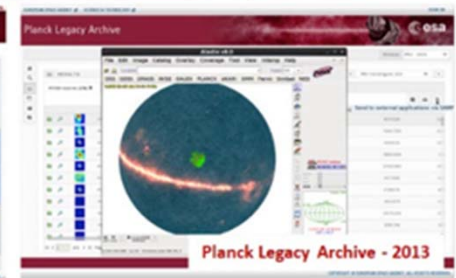
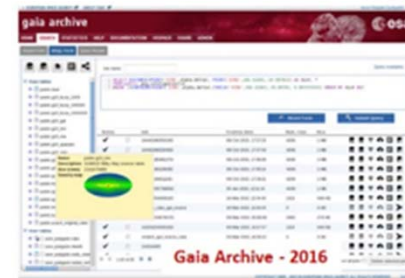
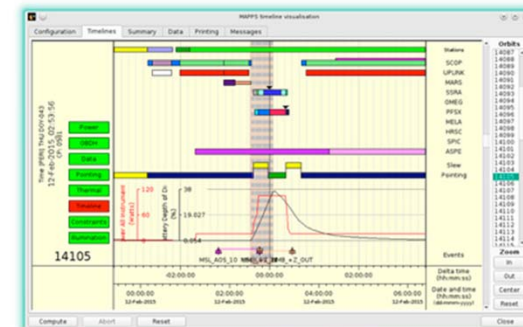
Lessons learnt database

MOC interfaces standards

Cross experience sharing with other

Science at ESA (EO, Tech)

Commercial packages analysis



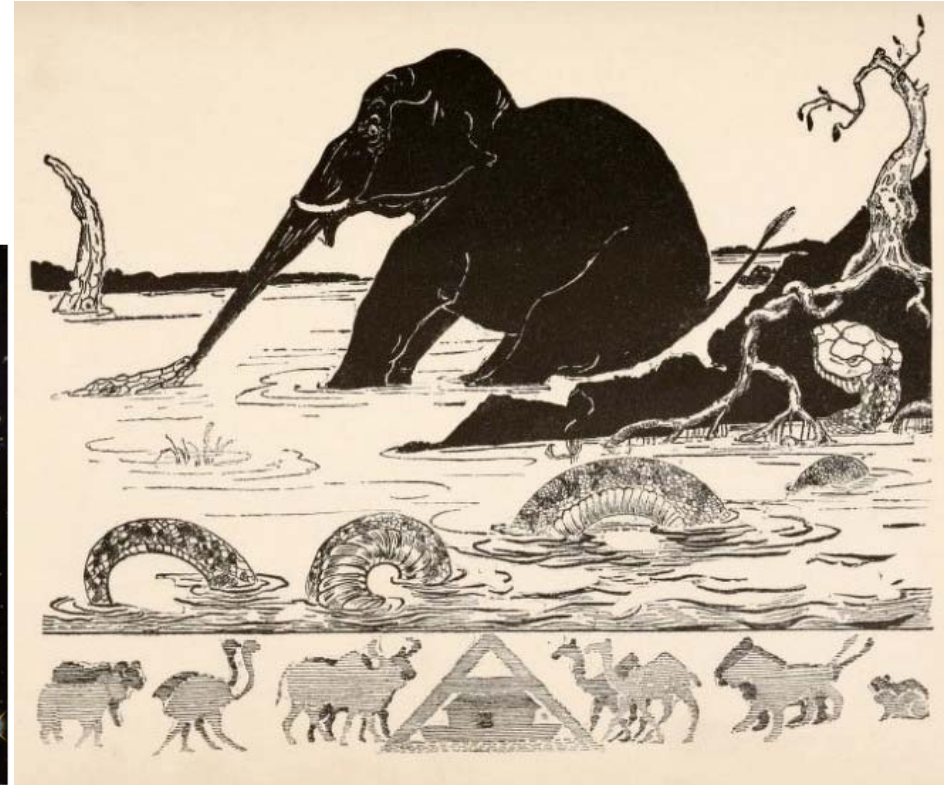
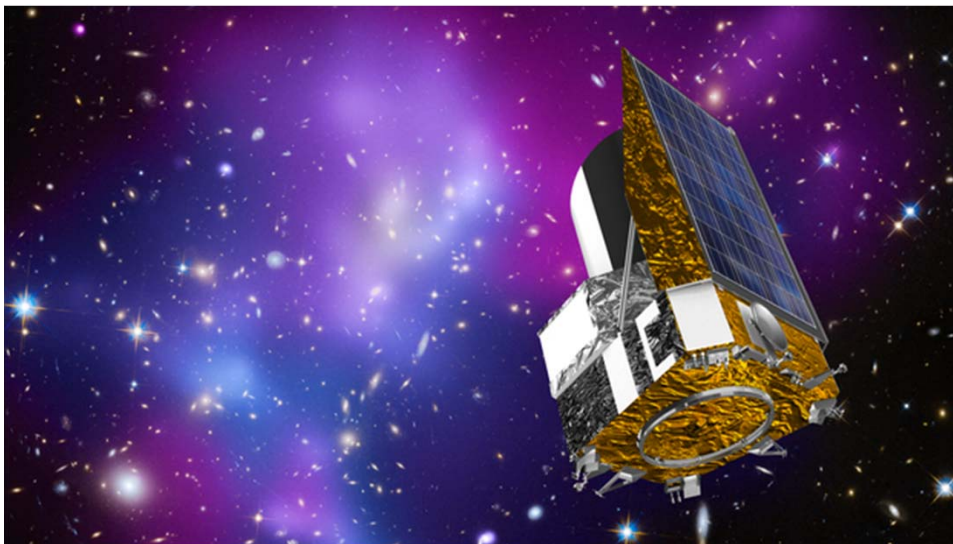
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# Thanks!



“...from the second Euclid opens its eyes  
one million **Hows**, two million **Wheres**,  
and seven million **Whys**!”



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## Bonus Slides: Abstract

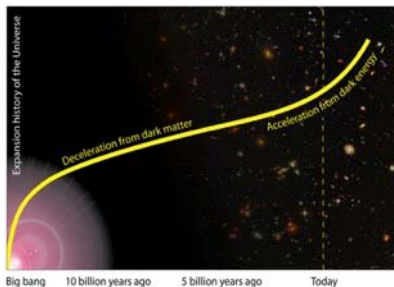
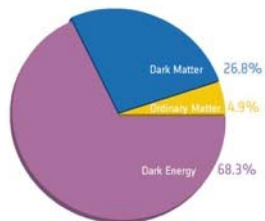
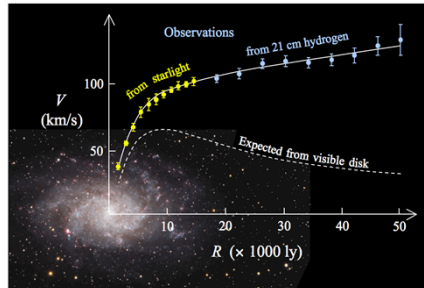


The operations of Science Space Missions often involve interconnecting well-standardized Mission Operations Centre's specialized in the handling of Spacecraft and Instrument operations with scientific communities whose interests are primarily the exploitation of data products and the ultimate science goals of the project.

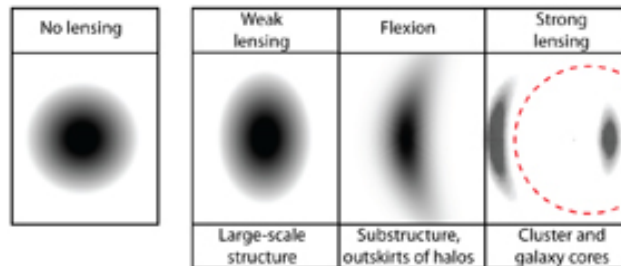
To this respect, a Science Operations Centre (SOC) implements a set of services and capabilities that aim to extend the scientific merit and return of the mission, ensuring a maximum return of science products while respecting operational considerations of the space segments, and serves as a connecting entity between the mission actors end to end. It also benefits from this function being performed and implemented in other similar projects, ensuring that optimization and shared development of tools and resources help to a sound and efficient operational return. Euclid is a European Space Agency (ESA) mission under development that will explore the Dark Energy and the Dark Matter in order to understand the evolution of the Universe since the Big Bang and, in particular, its present accelerating expansion. It is due for a launch in 2021, and will be used in this presentation as an example of the portfolio of services that the Euclid SOC at the European Science Operations Centre in Madrid offers to both the Mission Operations Centre in ESA/ESOC (Darmstadt, Germany) and to the Euclid Consortium, that represents a multinational scientific collaboration (European and EEUU) providing the mission instruments as well as the processing of the data in the Science Ground Segment and the operations of the instruments. There will be a special focus on areas as scientific mission planning, instrument operations support, science raw data formatting and processing, quick look analysis and science data archive; showing where, why and how these areas and activities represent an added value to the throughput of the production of mission science.

Furthermore, the presentation will focus also on the benefits of developing and operating the SOC along with those others of all the ESA's science missions, hinting where reuse of technologies, procedures and tools show a benefit, while understanding that the uniqueness of science missions prevent from a full standardization of processes and tools.

## Bonus Slides: Euclid Mission Science at glance

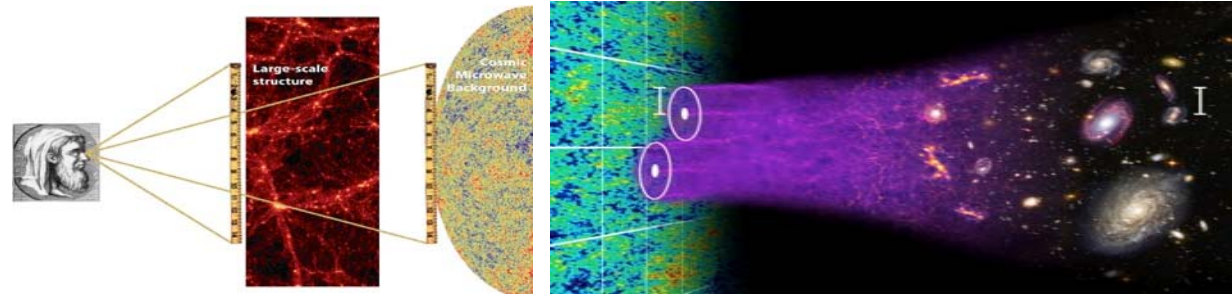


### Weak-Statistical Lensing



<http://www.euclid-ec.org/>

### Baryonic Acoustic Oscillations



<http://www.euclid-ec.org/>

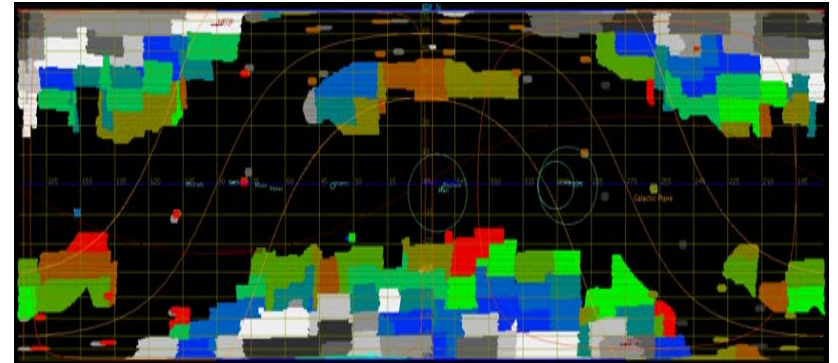
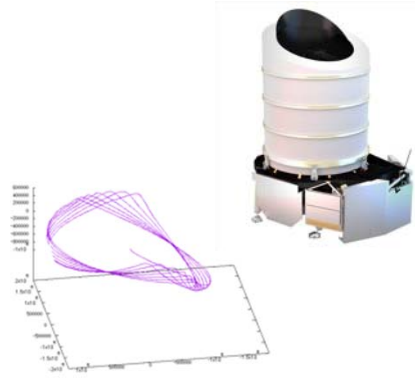
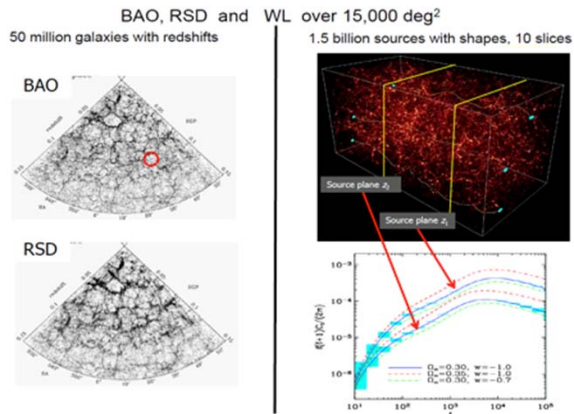
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## Bonus Slides: Euclid Mission at glance



- is dark energy merely a cosmological constant, as first discussed by Einstein, or is it a new kind of field that evolves dynamically with the expansion of the universe?
- alternatively, is dark energy instead a manifestation of a breakdown of General Relativity and deviations from the law of gravity?
- what are the nature and properties of dark matter?
- what are the initial conditions which seed the formation of cosmic structure?
- what will be the future of the Universe over the next ten billion years?

