Athena Ground Segment

Current Planning & Assumptions focusing on ESA Science and Mission Operations

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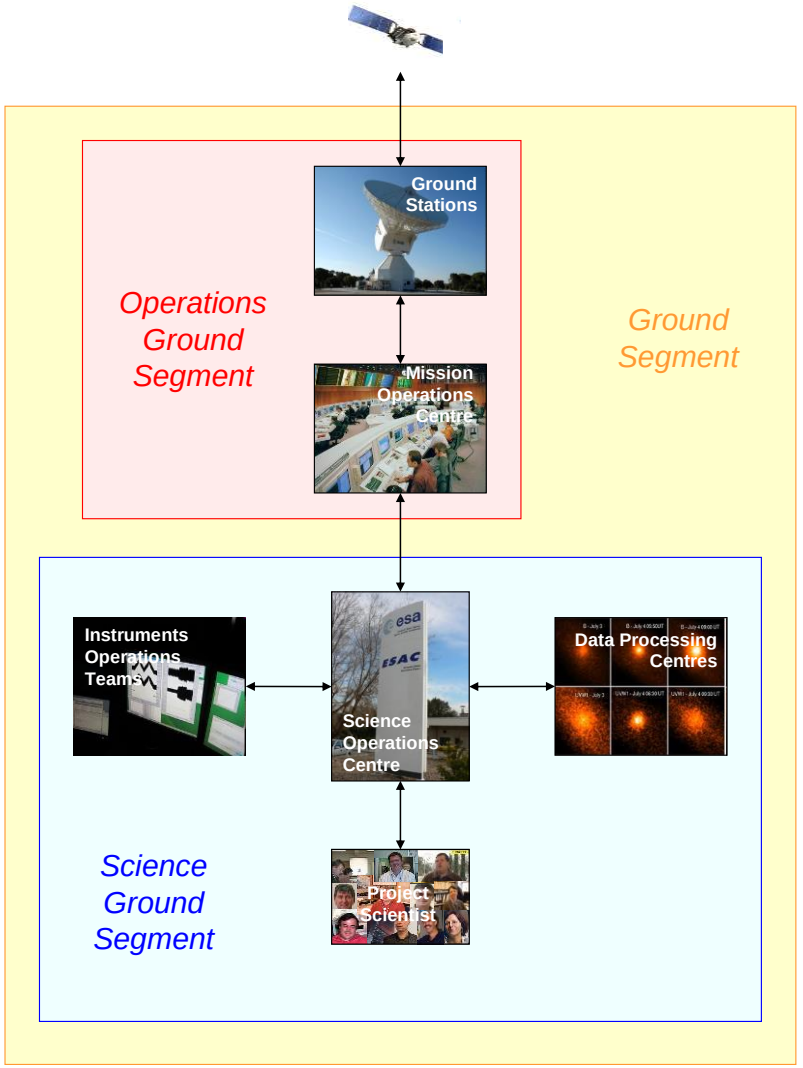
Overview: Ground Segment of an ESA mission

Main actors of a Ground Segment:

- **Operations Ground Segment (OGS)**
  (see MAD=Mission Assumption Document)
  ⇒ Mission Operations Centre **MOC** @ESOC
  + Ground Stations (ESTRACK)
- **Science Ground Segment (SGS)**
  (see SOAD=SciOps Assumption Document)
  ⇒ Science Operations Centre **SOC** @ESAC
  + Instrument Operations Teams
  + Data processing Centres / Science Centres
  + Project Scientist

ESA funds the OGS, the SOC & PS

IOTs & DP/ISCs are **nationally funded**



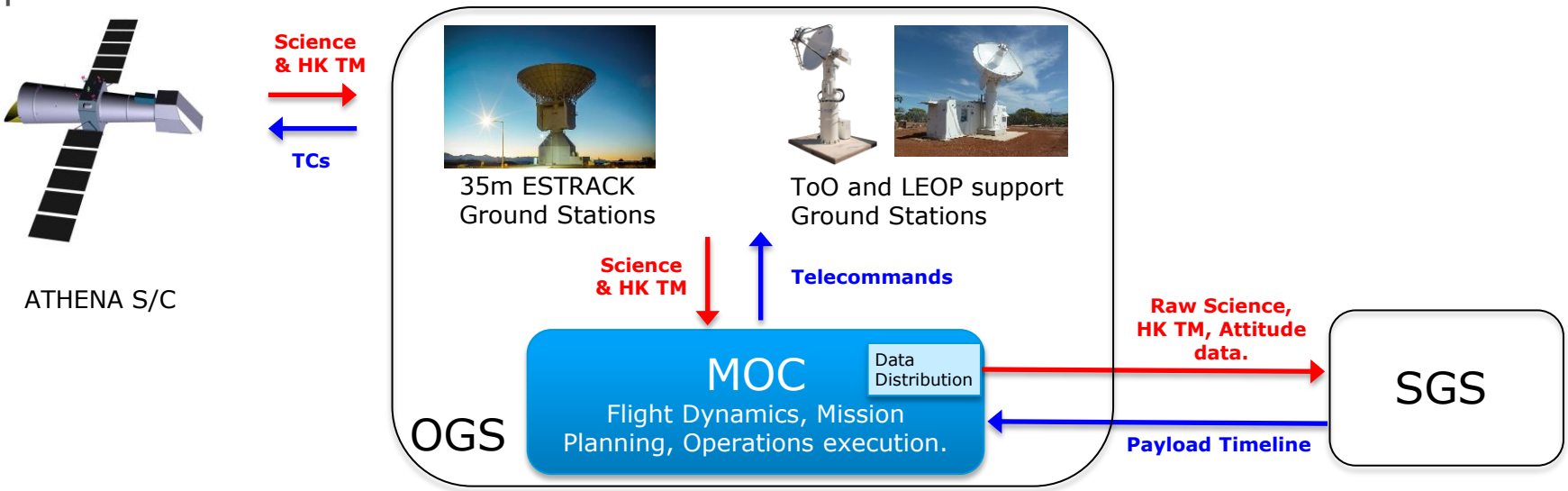
Athena Mission Operations Assumptions:
MOC & Ground Station Approach

Mission Operations Centre (MOC) main responsibility:

Uplink all Telecommands for control and operations of the *Athena* Spacecraft.

Receive all Telemetry covering both Science and Housekeeping data.

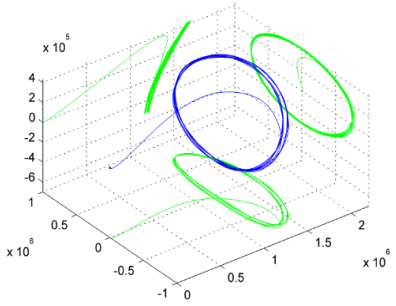
MOC for *Athena* will be in Darmstadt Germany at ESA's European Space Operations Centre ESOC.



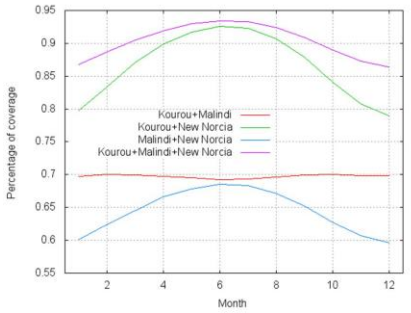
ESOC will utilise its access to multiple ESTRACK Ground Stations including 35m antennas which will be routinely used to command and control *Athena*.

Science driven MOC activities.

To support *Athena* operations, MOC will provide:



- Support Launch & Early Orbit Phase (LEOP) activities, followed by Transfer phase to reach the operational L2 orbit.
- Ground station coverage optimised for each operational phase:
  - LEOP: 24 hours per day for 2 days
  - Transfer & Commissioning: 8 hours per day (35m antennas) for 90 days
  - Routine: 4 hours per day (35m antennas). ToO 2m to 4.5m antennas.



- On board mission autonomy
  - Allowing for up to 3 days routine operations without ground contact (on-board s/w & storage)
  - Automated corrective actions (e.g. use of redundant h/w) in case of single on-board anomalies => minimizing Science outage.

- Routine uplink of Mission timelines and dumping of science data.
- All Science data to SGS within 5 working days from observation.
  ToO QLA data within 2 hours.
- Orbit Control manoeuvres foreseen monthly to maintain the L2 orbit.

- Debris mitigation de-orbiting at end of mission.

Athena Science Operations Assumptions:
SOC & Instrument Science Centres

As elaborated in SOAD and used for Instrument Consortia Consolidation.

Based on intense discussions with

- Proto-Consortia PIs (Didier Barret & Paul Nandra)

and especially members of Community Working groups:

ESA Athena Science Study Team (ASST)

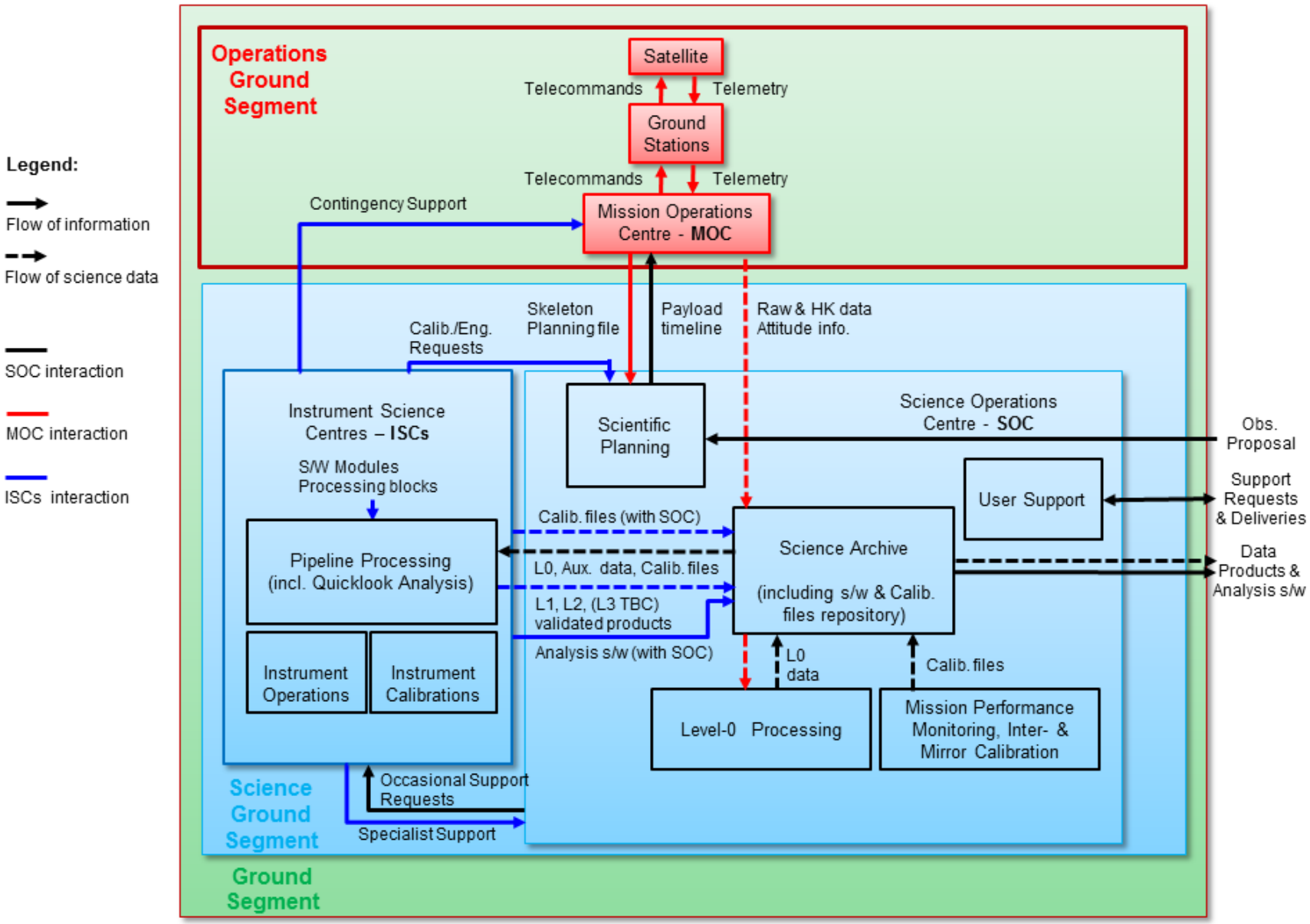
M. Guainazzi (Chair), K. Nandra (Science Lead & WFI), D. Barret (X-IFU), A. Decourchelle, J.W. den Herder, A.C. Fabian, H. Matsumoto (JAXA), L. Piro, R. Smith (NASA), R. Willingale.

SWG1	SWG2	SWG3	TWG4	MWG5
Hot Universe	Energetic Universe	Observatory	Telescope	Mission Performance
Fabian, Reiprich, Ohashi	Nandra, Cappi, Brenneman	Decourchelle, Matsumoto, Smith	Willingale, Pareschi	den Herder, Piro, Rau
SWG1.1 Evolution of galaxy group and clusters *Allen, Ota, Pointecouteau*	SWG2.1 Formation and growth of earliest SMBH *Aird, Comastri*	SWG3.1 Solar System & exoplanets *Branduardi-Raymont, Güdel*		MWG5.1 Science ground segment *Watson, Webb*

This map shows the members of our community and their working groups positioned in their institutes of reference.
Please, in case you do not find yourself, contact us at aco@ifca.unican.es

- kudos for help in reaching this level of agreement!

Athena Science Operations Assumptions:
SOC & Instrument Science Centres



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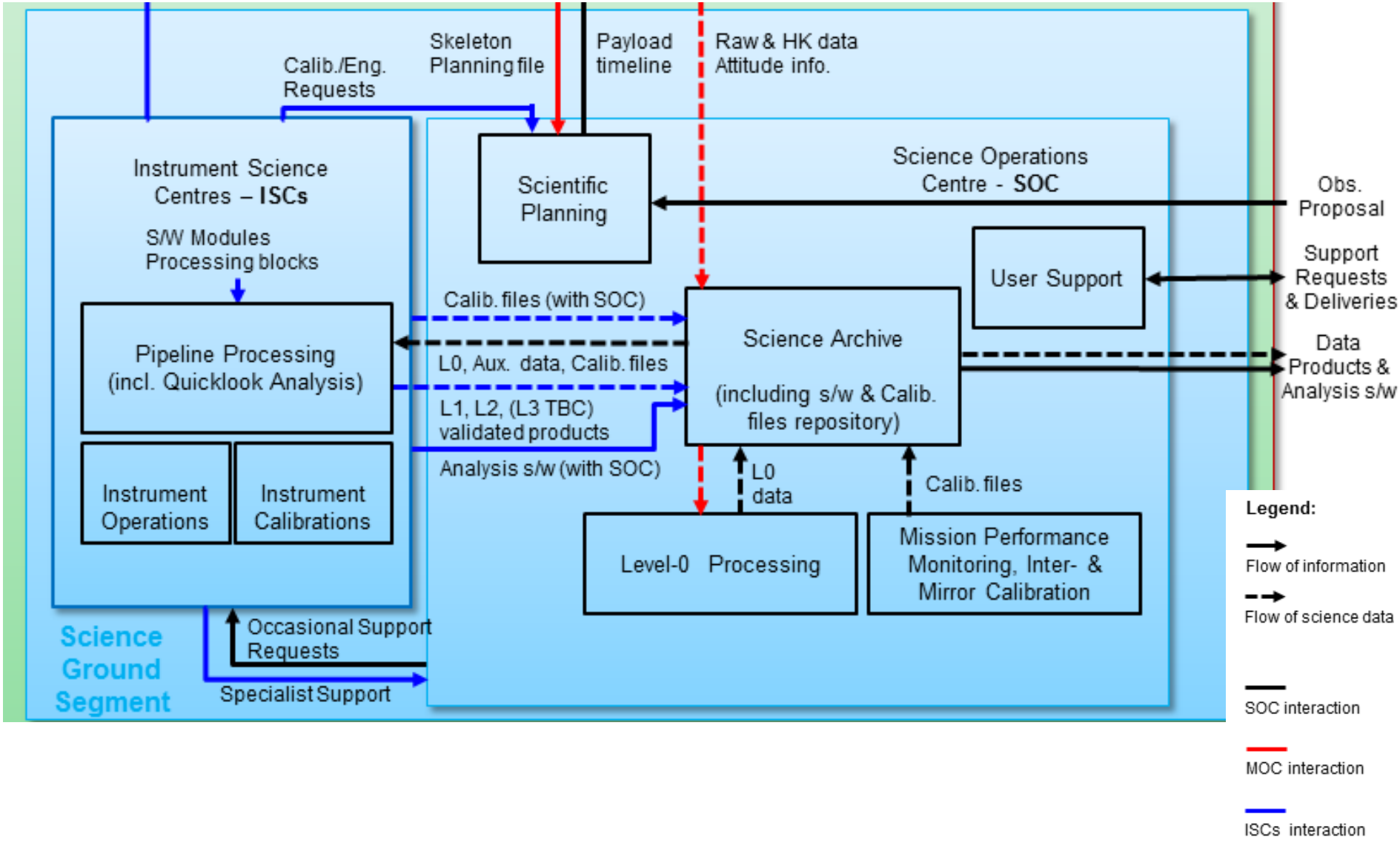

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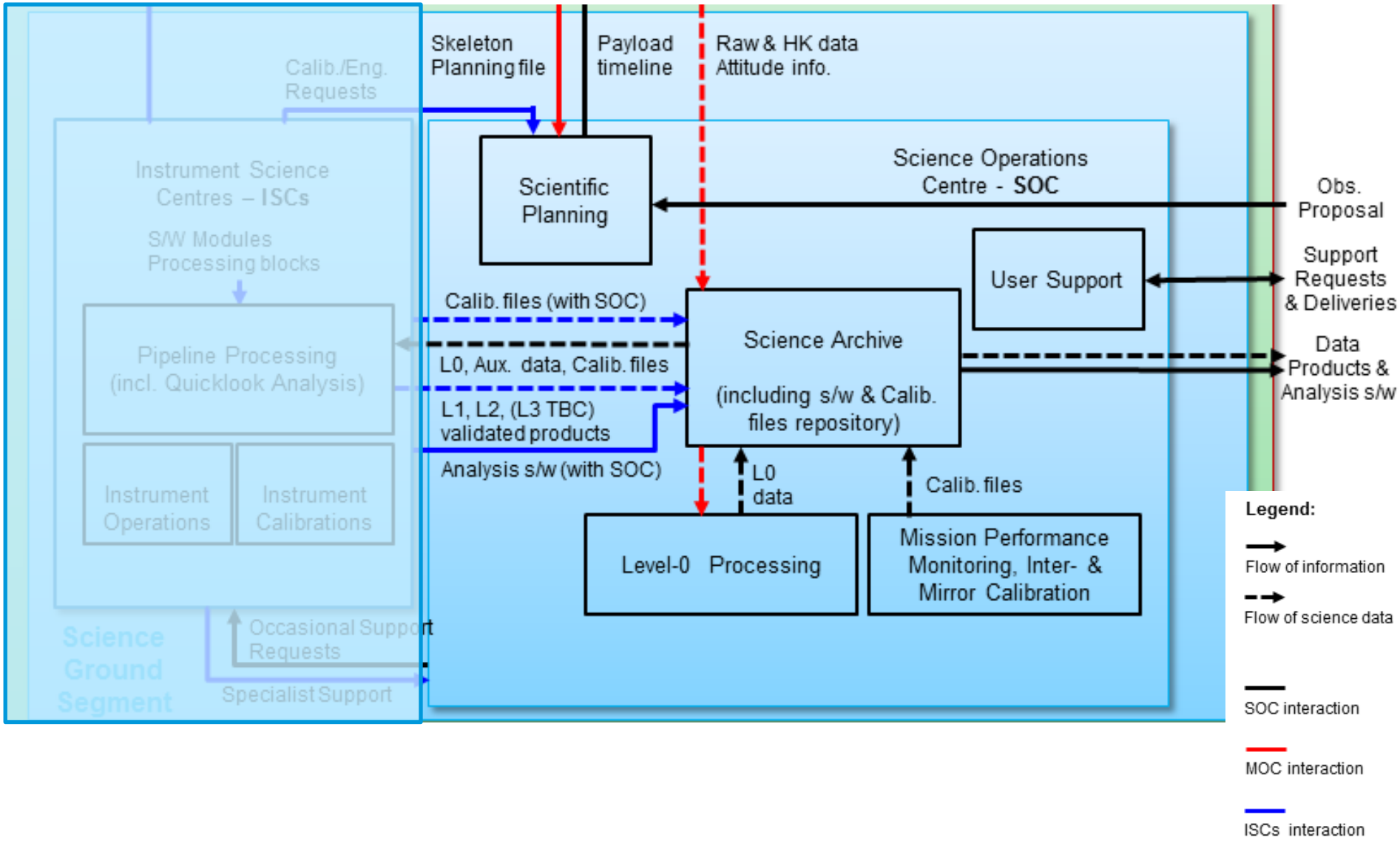

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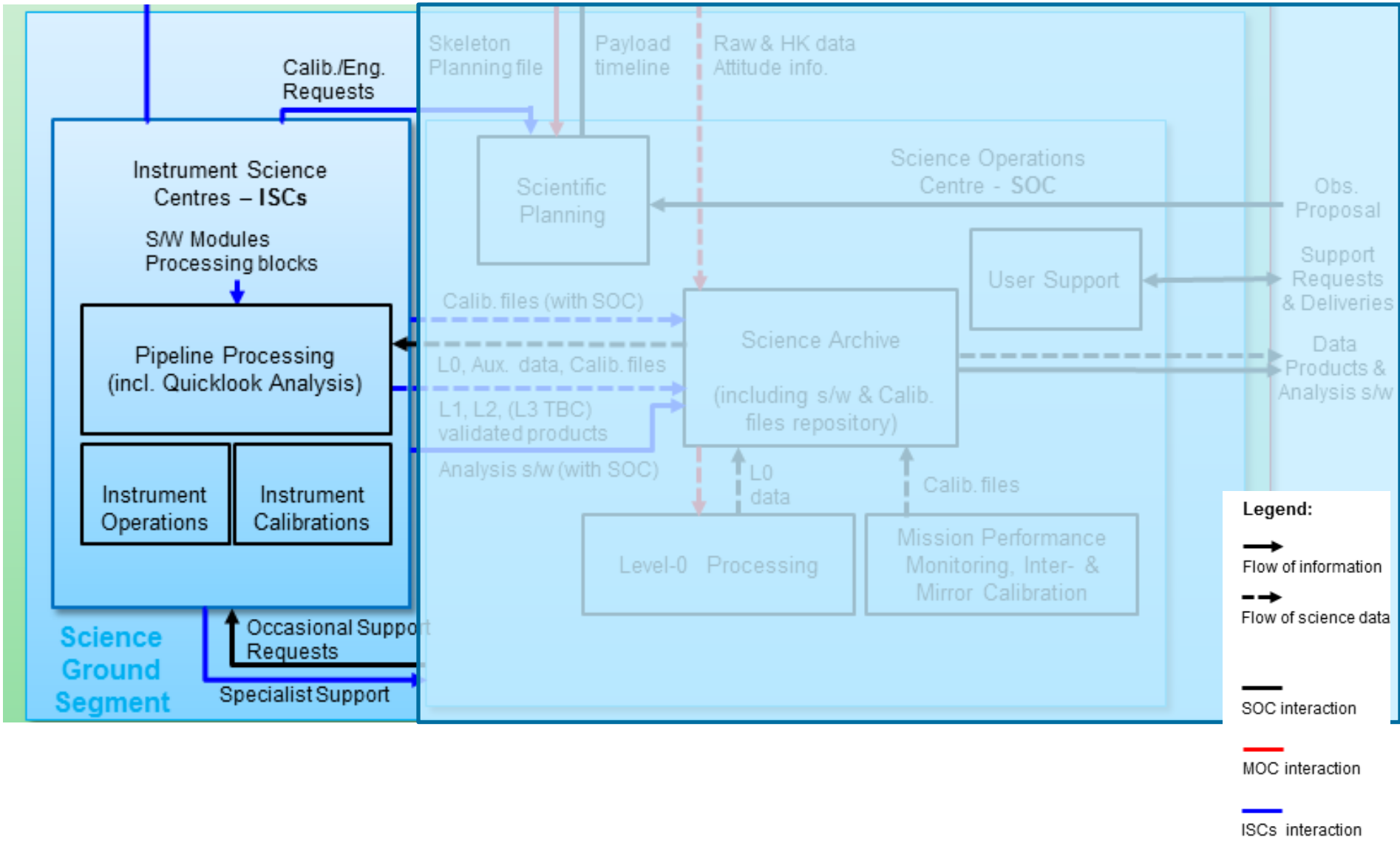

Athena ToO handling at SOC/MOC

For **Target of Opportunity Operations (ToO)** it is assumed that a **highly automated** process can be set up that satisfies *Athena* repointing requirements.

SOC is assumed – **after ToO approval by Project Scientist** - to provide MOC with:

- **target quaternion**, i.e. target position,
- **time** when ToO observation should start (i.e. SOC calculates the slew durations),
- Payload **parameter updates** if needed,
- **duration** of the observation,
- target quaternion for '**re-join of timeline**' observation (same as previously planned, or different)

MOC assumed activities:

- **Momentum management**. On board automation needed to support ability for load or dump of momentum,
- execute highly **automated verification & constraint checking** of ToO requested by SOC,
- uplink telecommands using either **scheduled 35m antenna** pass or additional requested support from **ToO available ground stations**.
- Depending on pass duration and timing for ToO, execution could be monitored from ground. Verification of completion & return to routine timeline during following routine pass coverage.

Autonomous ToO Study

Autonomous Targets of Opportunity for Astronomy Mission.

Study KO Q4 2018 (initial results after 8 months, final after 18 months)

The objective of this study is to define an approach for execution of on-board autonomous planning and execution of ToOs.

- Investigation of state-of-the-art autonomous slew capabilities & comparison with current practice for ToOs observation. Assessment of all operational and dynamic constraints: Identify necessary high level architectural functionalities & requirements (On-Board s/w, Attitude & Orbit Control System, Fault Detection Isolation & Recovery Techniques)

  => Define an operations concept for Autonomous ToO.

- Design, prototyping and demonstration of algorithms for:
  - Target vetting, spacecraft management, autonomous slew planning and execution.
  - Logic for returning to planned mission timeline already on board to minimise observation outage and loss of planned activities.

Next Steps

After successful Instrument Consortia Consolidation (ICC), work on details can be started, e.g. definition of work packages, interfaces, milestones, …

Direct interactions between ESA study team (PoC: M. Ehle as Science Operations Study Leader) and Science Ground Segment Working Group.

Assumptions (and current Cost Estimate) to be monitored & cross-checked against future evolutions.

Study Team Milestones: Remainder of Phase A and B1 (i.e. up to adoption)

- Generation of SciOps Concept Document (full SGS) "SOCD"
- System Engineering and generation of Science Implementation Plans "SIP" (for ESA & for Consortia)
- Contribution to the SGS Requirements Review
- All in Coordination with other elements of the GS

=> your contribution goes here…