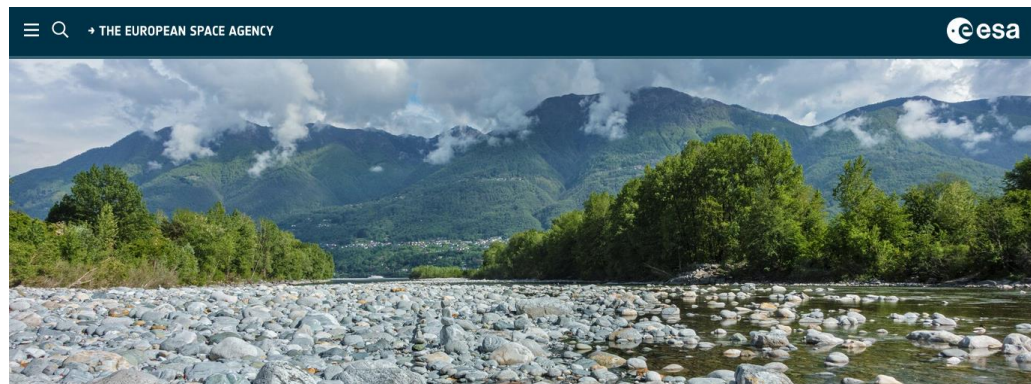# Roadmap towards a MAGIC Processing Facility and Products

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Technical University of Munich, Astronomical and Physical Geodesy

The future of gravity is MAGIC

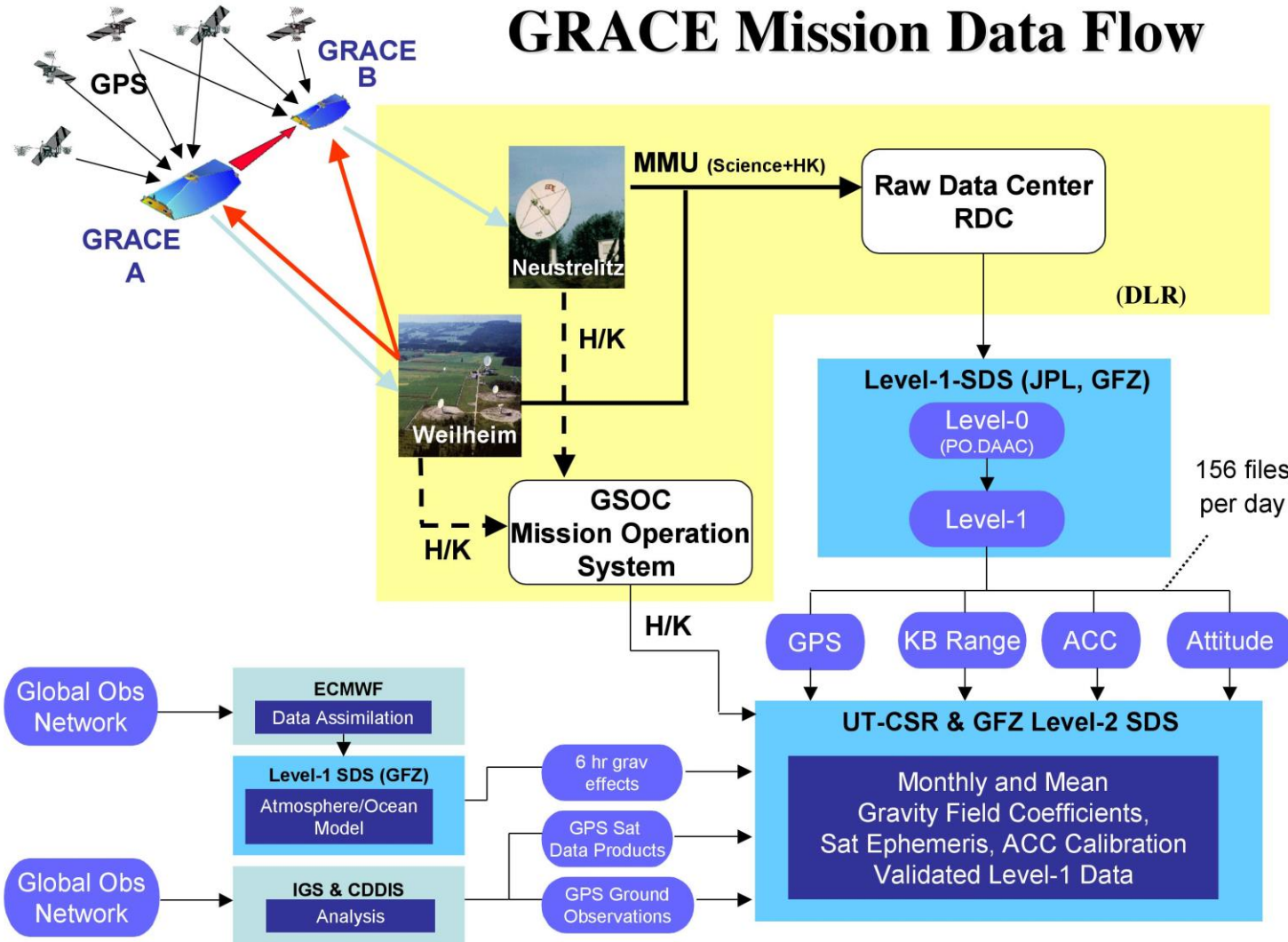25/04/2023   7000 VIEWS   69 LIKES

Applicable to MAGIC Ground Segment

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Some Initial Remarks

- Initial ideas for a MAGIC processing facility and related data products have been developed by the NGGM Phase A science support study team.

- In the following a first sketch of MAGIC products at different processing levels and the required processing steps has been developed.

- Lessons learnt from the GRACE and GRACE-FO Science Data Systems, the GOCE Payload Data System and the GOCE High Level Processing Facility are considered in order to propose a ground processing system, which is capable to deliver an optimal science return with shortest possible latencies.

- Experiences show that a close link between "industrial" and "scientific" processing facilities shall be established.

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GRACE/GRACE-FO Ground Processor Design


©https://www2.csr.utexas.edu/grace/asdp.html

➢ L0 to L1 processing facility @ JPL

➢ Three L2 processing centers @ CSR, GFZ, JPL delivering gravity field time series

➢ Standardized ancillary data products used by all processing centers

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GOCE Ground Processor Design

Level 1b to Level 2 – GOCE Ground Segment (left) and HPF Architecture (right)

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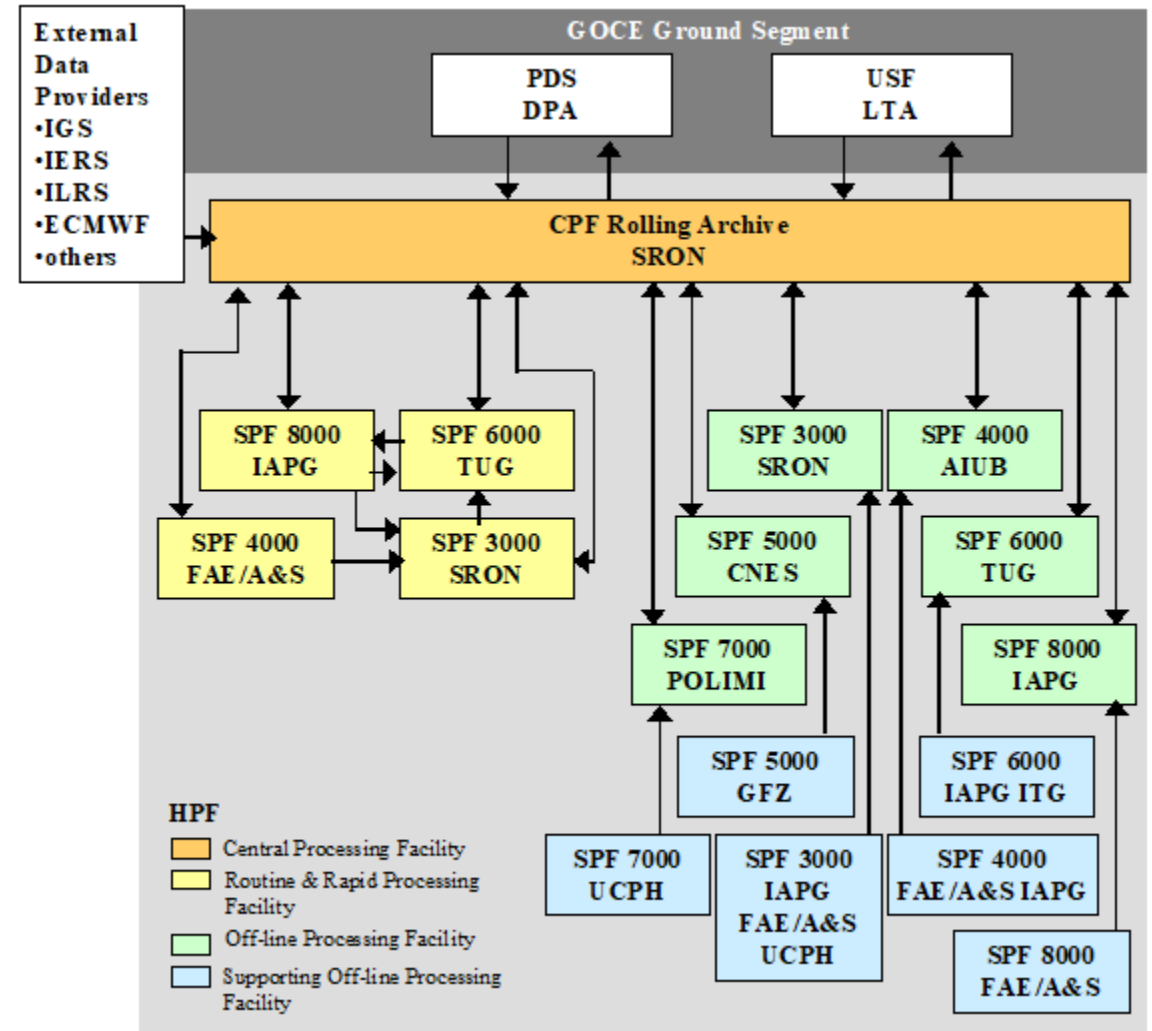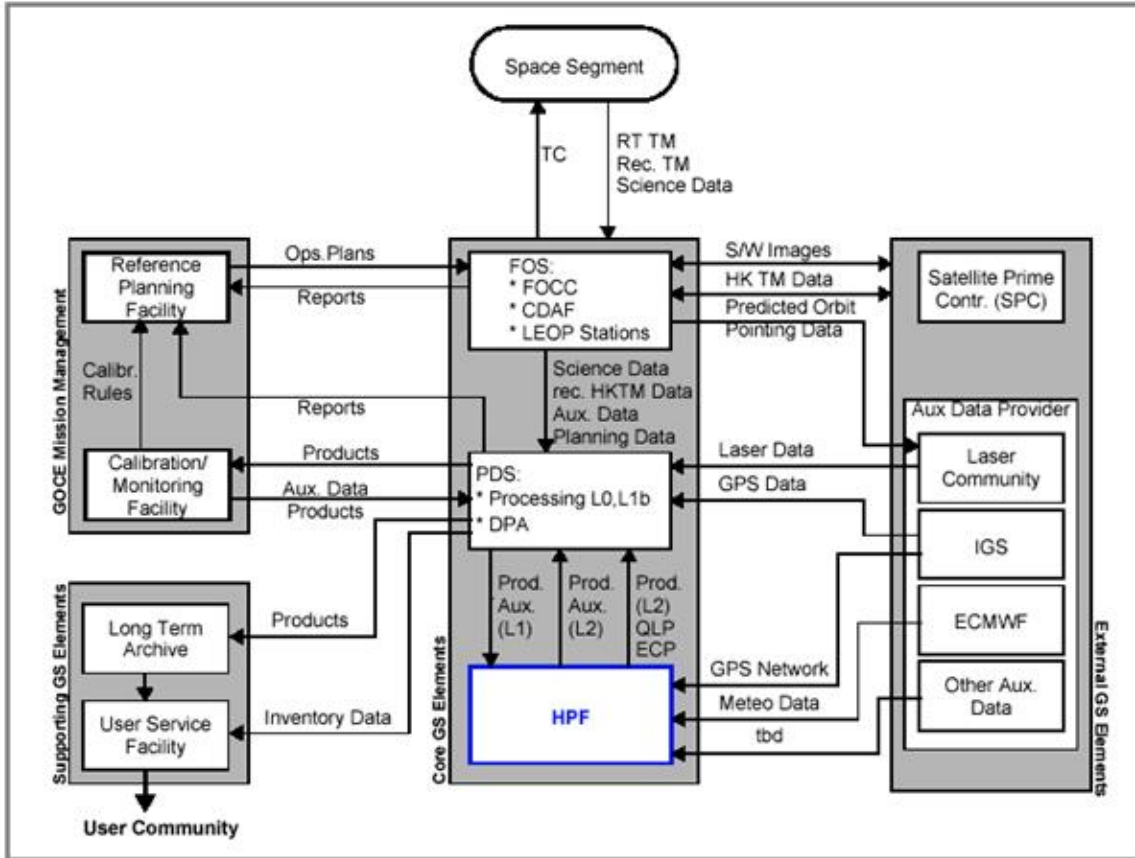
MAGIC Ground Processing Facility

Ground Processing System Architecture - Options

Centralized (L0 to L3)	Distributed (L0 to L3)	Mixed Variant (L0 to L1b; L1b to L3)
Pros:	**Pros:**	**Pros:**
➢ All processors under control at one place ➢ Centralized data archive at processing facility ➢ Low demands on data traffic	➢ High flexibility in case of failures ➢ Computing power distributed among processing centers ➢ Expertise available at processing centers	➢ Medium demand on comp power ➢ Expertise to a large extent available at processing centers ➢ Medium demand on data traffic ➢ Partial flexibility in case of failures depending on processing task ➢ Partially centralized data archive
Cons:	**Cons:**	**Cons:**
➢ Low flexibility in case of failures ➢ High demands on computing power ➢ Expertise needed for all processing tasks in case of Software problems	➢ Processors version control challenging ➢ High demands on data traffic ➢ De-centralized data archive or additional component required (Central processing facility)	➢ Expertise not always available for all processing tasks ➢ Partial flexibility in case of failures depending on processing task ➢ Partially centralized data archive ➢ Partially limited computing power

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MAGIC Ground Processing Facility

Ground Processing System Architecture - Recommendations

Key Features for Ground Processing Facility

➢ Centralized data archive: Single point of access for all data products

➢ Distributed computing power: Parallel processing feasible; Higher flexibility in case of failures

➢ On-site expertise for all processing tasks available: Software maintenance easier

Requirements

➢ Definition of a central processing facility for product storage, products quality control and products exchange at all product levels

➢ Definition of processing standards, conventions and ancillary data to be implemented in complete ground processing facility

Recommendation

➢ Distributed Architecture with smaller centralized units where applicable (mixed architecture) → Lego approach

➢ Industrial and scientific expertise needed for L0 to L1 processing: For GOCE finally a nominal industry processor and a scientific processor was implemented -> significant benefit to reach mission goals.

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MAGIC Ground Processing Facility

Data Level Definitions, Products and Processing Flow Level 0 to Level 3

Data Level	Definition
Level 0	Raw data telemetry
Level 1a	Decoded and decomposed L0 data per instrument and HK data sets with original sampling converted to physical units (e.g. ACC, LRI, STR, GNSS, thrusts and other HK data).
Level 1b	Down-sampled instrument and HK data time series calibrated, preprocessed and converted to physical quantities (e.g. accelerations, biased ranges, range rates, range accelerations, quaternions, GNSS code and phase, thrust accelerations, others).
Level 2a	Precise orbits and estimated Earth gravity field SH coefficients
Level 2b	Corrected and filtered Earth gravity field SH coefficients (e.g. low degrees replaced, added back mean SH coefficients)
Level 3	Mass variations for Earth system components

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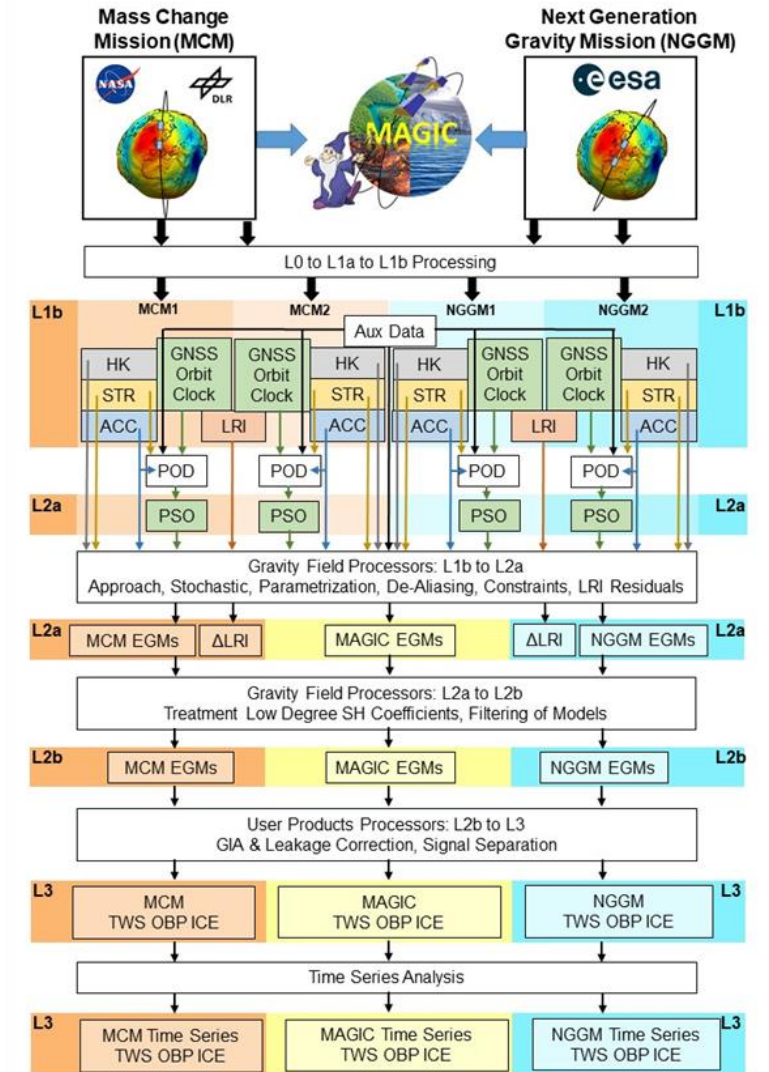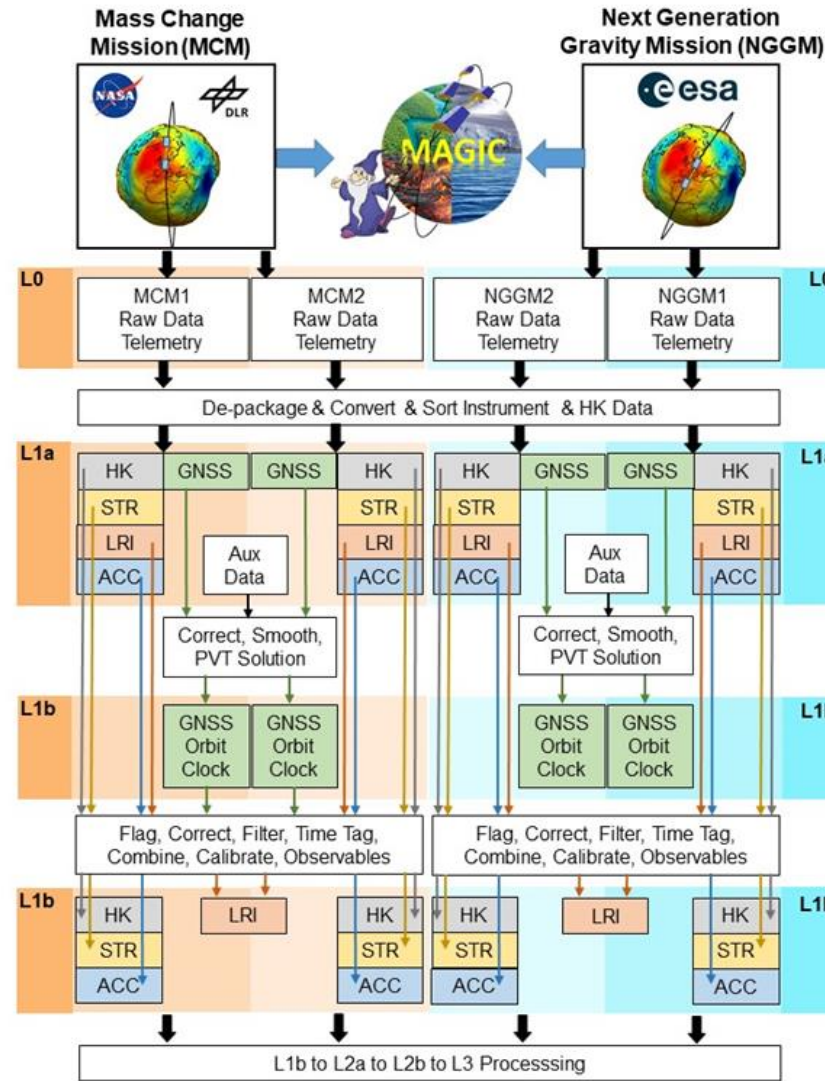
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Products and Processing Flow Level 0 to Level 1a
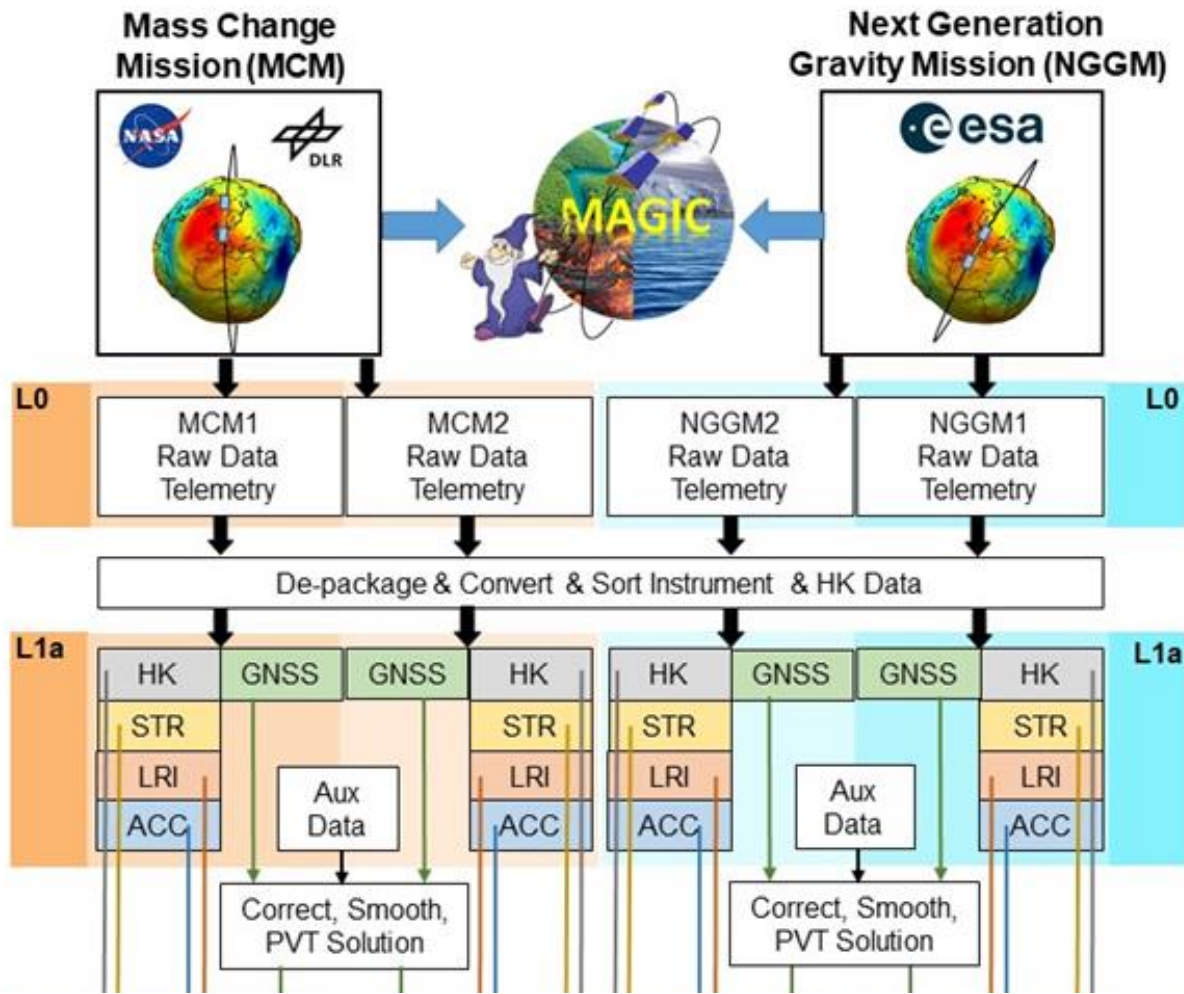
- ➢ L0 (raw data telemetry) or L1a data of both missions available at both ground processing facilities (MCM and NGGM)

- ➢ L1a: Sorted time series of instrument and HK data with identified data gaps in identical format for each satellite of MAGIC constellation as separate files per instrument (ACC, LRI, STR, GNSS, HK)

- ➢ Defined processing standards, conventions and ancillary data to be applied for both pairs at ground processing facility

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Products and Processing Flow Level 1a to Level 1b
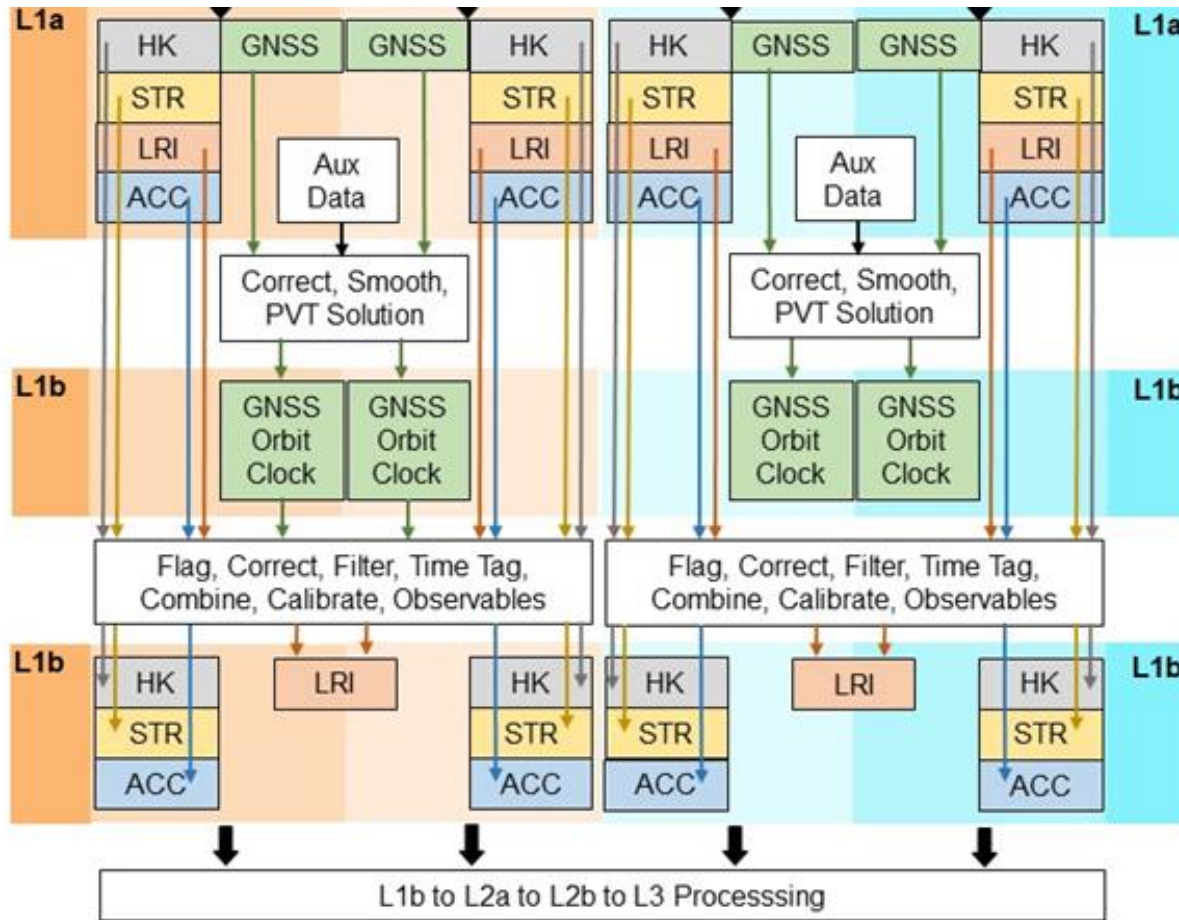
- ➤ L1b: Compute orbit and clock solutions per satellite
- ➤ L1b: Preprocessing of instrument data: Flag, correct, interpolate, filter, time-tag, etc.
- ➤ L1b: ACC: Estimate and apply external calibration parameters
- ➤ L1b: LRI: Compute light time correction, scale factors, steering mirror correction, etc.
- ➤ L1b: LRI: Compute biased range and numerical derivatives applying auxiliary LTI corrections.
- ➤ L1b: Optimally combine ACC and STR data for attitude reconstruction
- ➤ L1b: Processing and uncertainty modelling of atmospheric and oceanic de-aliasing products
- ➤ Industry and science processor to be implemented

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MAGIC Ground Processing Facility

Products and Processing Flow Level 1b to Level 2a
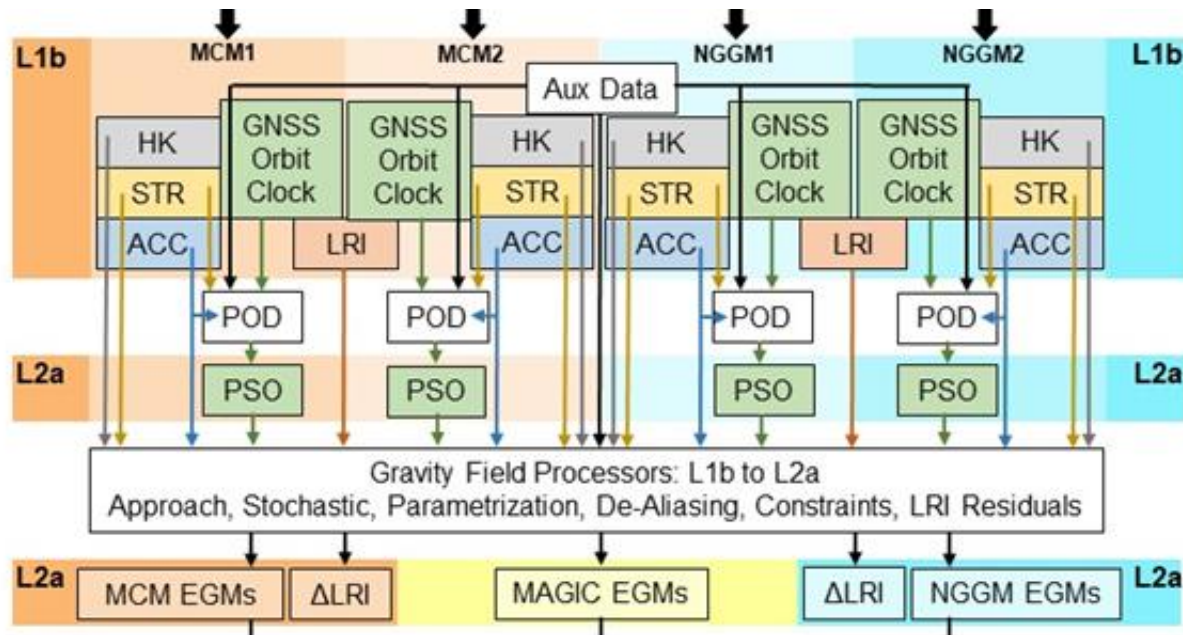
- ➢ L2a: Precise orbits per satellite including POD based accelerometer calibration
- ➢ L2a: Residual LRI observations (pure gravitational)

Multiple gravity field solutions per processing center applying different techniques and parameter models per satellite pair and MAGIC constellation (e.g. for cross validation)

- ➢ L2a: Stochastic noise modelling (product errors, background models)
- ➢ L2a: Global gravity field solution per analysis period
- ➢ L2a: NRT gravity field solutions
- ➢ L2a: Regional gravity field solutions

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Products and Processing Flow Level 2a to Level 3
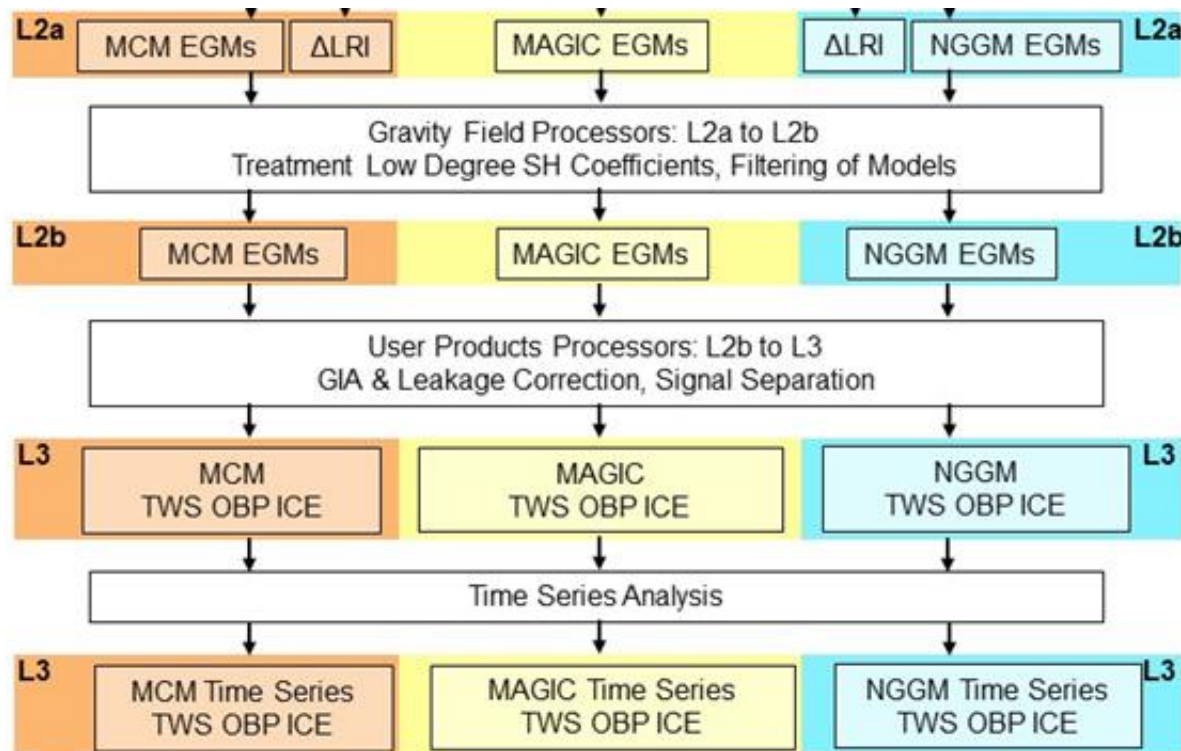
Multiple gravity field solutions per processing center applying different techniques and parameter models per satellite pair and MAGIC constellation (e.g. for cross validation)

➤ L2b: Updated gravity field solutions: Treatment low coefficients, Decorrelation filter, GIA correction, etc.

Gravity field model combination

➤ L3: Combined global gravity field solution

➤ L3: Terrestrial water storage

➤ L3: Ocean bottom pressure

➤ L3: Ice mass change

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MAGIC Ground Processing Facility

Summary and Recommendations

- Distributed Architecture with smaller centralized units where applicable (mixed architecture)

- L0 raw data telemetry (or L1a data) of both missions available at both ground processing facilities (MCM and NGGM)

- L0 to L1b: Parallel industrial and scientific processors to be implemented

- L2a/L2b: Multiple gravity field solutions per processing center applying different techniques and parameter models per satellite pair and MAGIC constellation with corrections and filtered (low degree coefficients, decorrelation filter, other)

- L3: Combined global gravity field solution (time series)

- L3: Mass change estimates for designated variables (terrestrial water storage, ocean bottom pressure, ice mass, others)