

The Status of the GOCE High-level Processing Facility

Radboud Koop⁽¹⁾, Thomas Gruber⁽²⁾, Reiner Rummel⁽²⁾

(1) SRON Netherlands Institute for Space Research

(2) Institute for Astronomical and Physical Geodesy, TU München

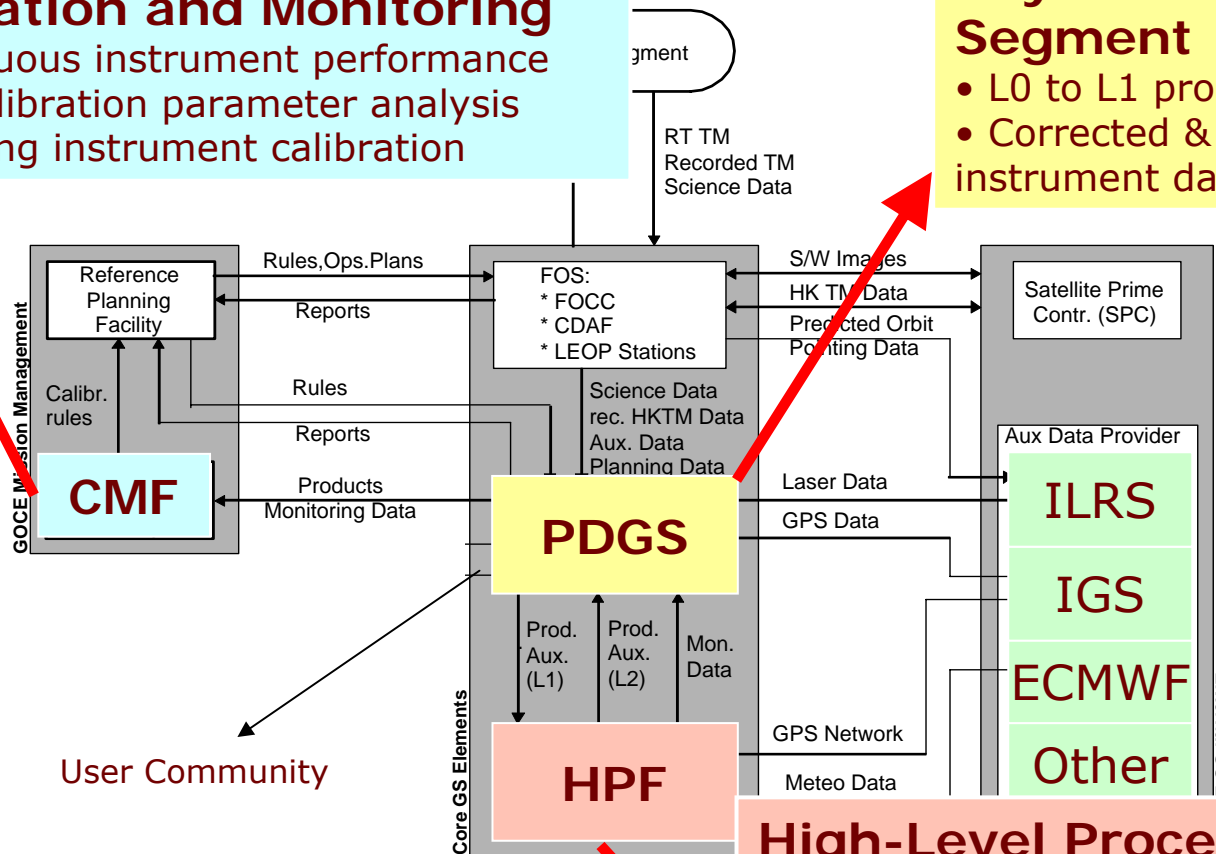
GOCE Ground Segment

Calibration and Monitoring

- Continuous instrument performance and calibration parameter analysis
- Initiating instrument calibration

Payload Data Ground Segment

- L0 to L1 processing
- Corrected & calibrated instrument data time series



High-Level Processing Facility = Science Data Processing System

- L1 to L2 processing (gravity fields & orbits)
- Continuous quick-look gravity field performance analysis
- Developed and operated by EGG-C



European GOCE Gravity consortium



AIUB: Astronomical Institute University Bern

CNES: Centre Nationale d'Etudes Spatiale, GRGS, Toulouse

FAE/A&S: Faculty of Aerospace Engineering, TU Delft

GFZ: GeoForschungsZentrum Potsdam

IAPG: Institute of Astronomical and Physical Geodesy, TU Munich

ITG: Institute for Theoretical Geodesy, Univ. Bonn

POLIMI: Politecnico di Milano

SRON: Netherlands Institute for Space Research

TUG: Institute of Navigation and Satellite Geodesy, TU Graz

UCPH: Department of Geophysics, University Copenhagen





History



- **CIGAR:**
 - 4 studies on precise gravity field determination methods and mission requirements
 - 1989 – 1996
- **From Eötvös to mGal:**
 - 2 studies on scientific development of novel approaches for GOCE data processing
 - 2000 – 2002
- **Pre-EGG-c:**
 - Definition of high-level architecture of Level 2 processing system
 - end 2001 – mid 2003
- **HPF:**
 - Development, implementation and operation of GOCE Level 2 processing system
 - April 2004 – ...

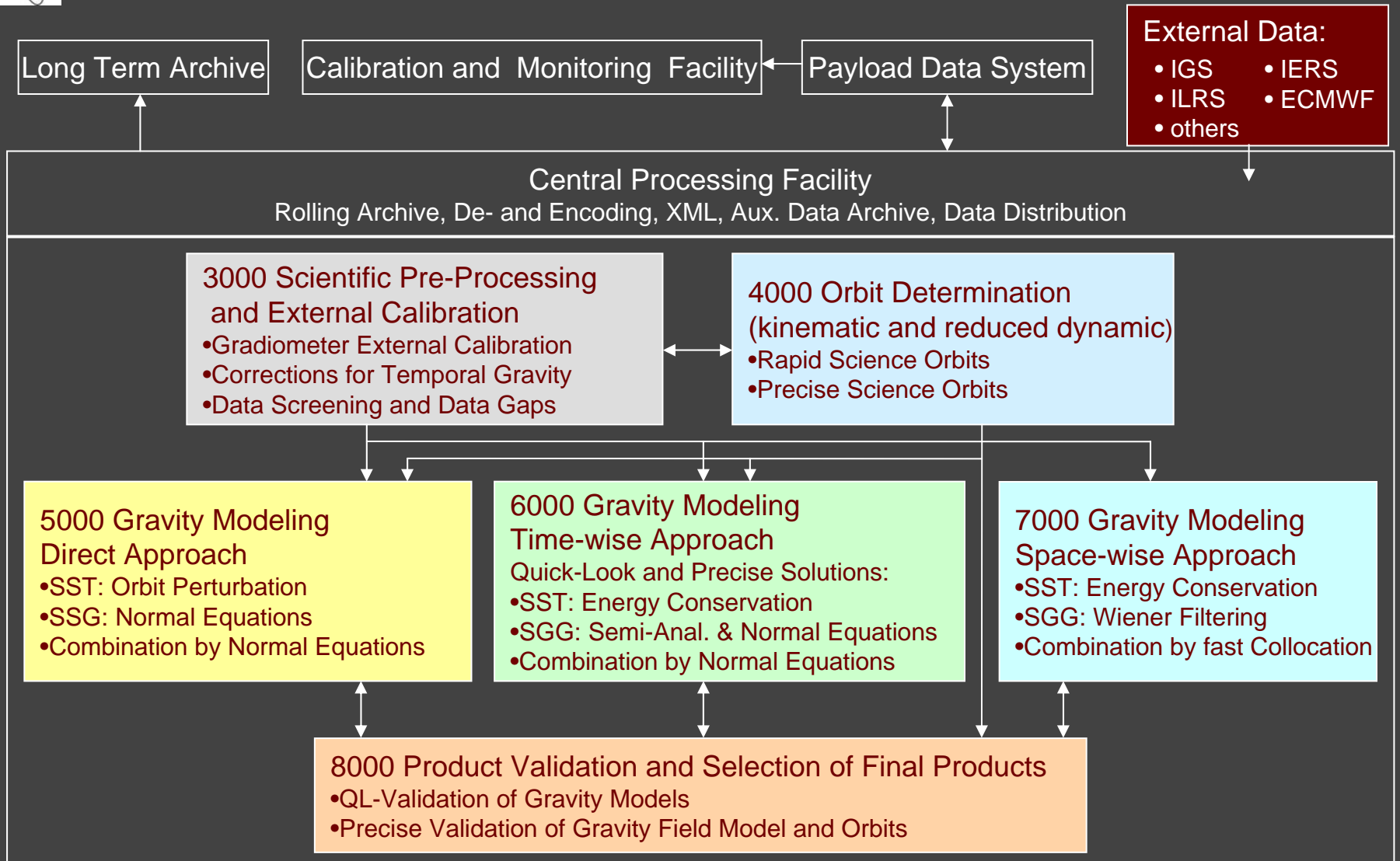


HPF facts

- HPF **joins** the scientific and operational gravity field modeling and data processing **expertise** of 10 European institutes
- HPF encompasses both **complementary** (specialists covering the whole range of relevant topics) as well as **overlapping** (for validation and back-up) expertise
- HPF combines **consolidated** and **novel** (gradiometry!) approaches for orbit and gravity field processing
- HPF system design is **tailored to GOCE** data processing, aiming at the best GOCE gravity field solution
- HPF is designed, developed, implemented and operated under **ESA contract** with substantial **national/institutional support**
- HPF **PI** is Prof. R. Rummel and HPF is **managed** jointly by IAPG/München and SRON/Utrecht
- HPF groups are organized as a single entity with only **one interface** to ESA and the end-users



High-level Processing Facility

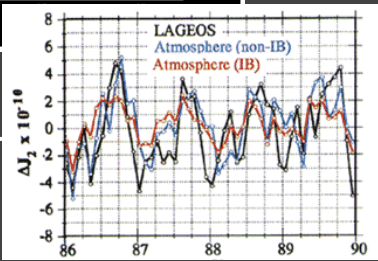
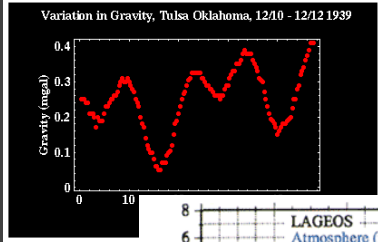




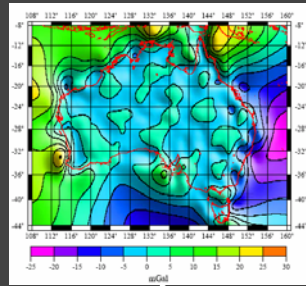
Gravity Gradient Pre-processing



IAPG
FAE/A&S



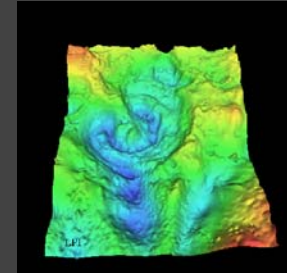
UCPH



FAE/A&S



Frame trafo

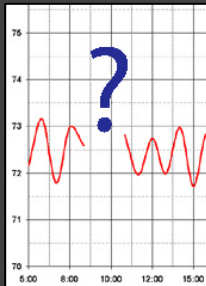
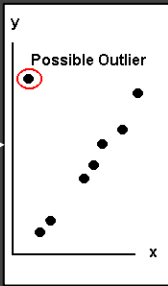


L2

SRON

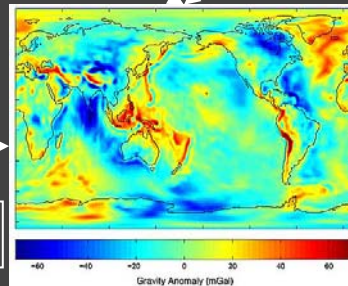
Temporal corrections

SRON



Outliers, data gaps

SRON

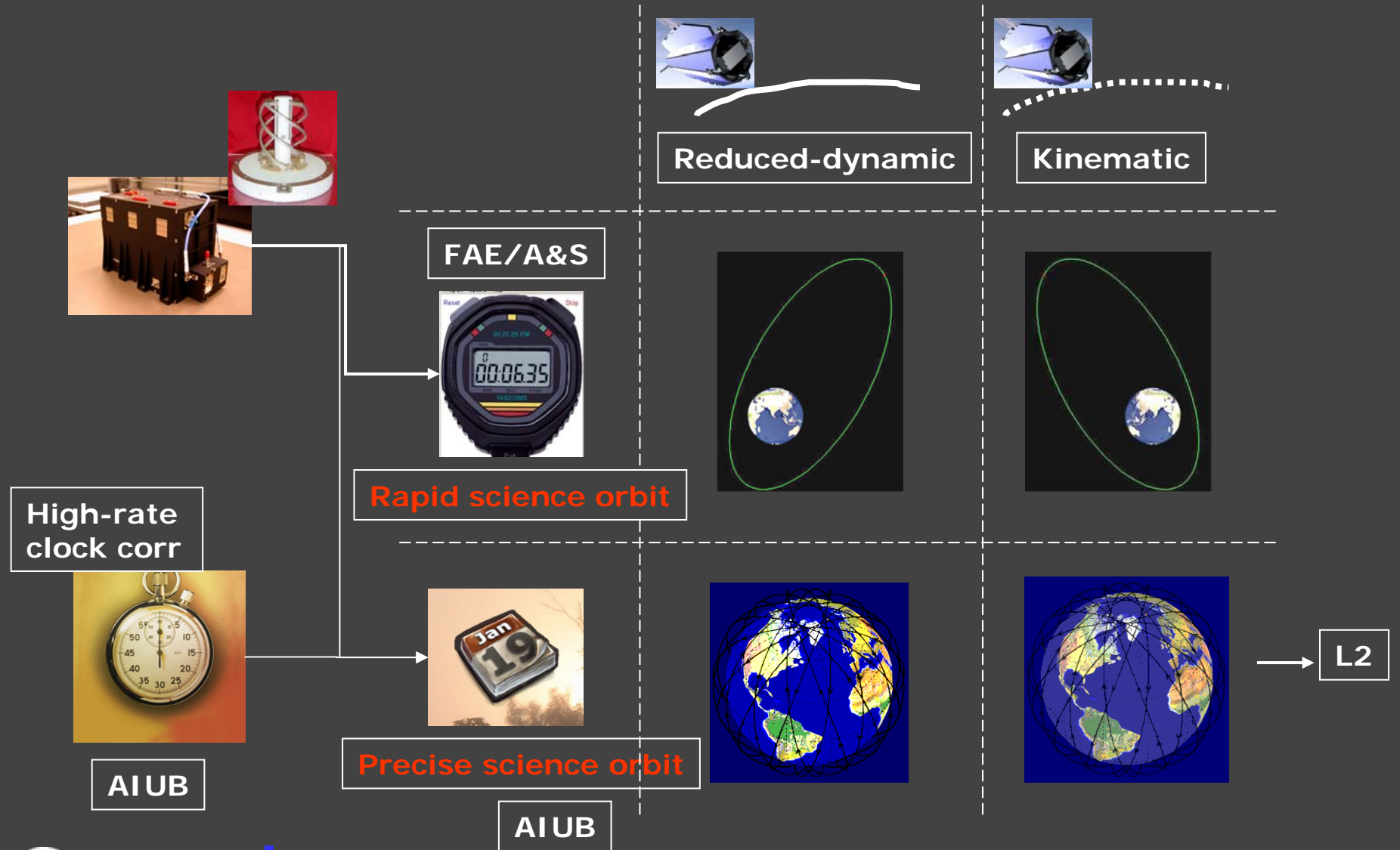


External calibration

L2



Orbit determination

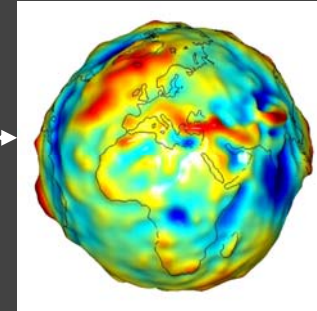




Gravity modeling



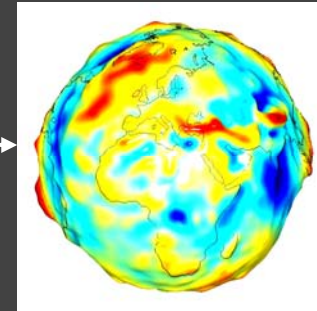
Direct approach



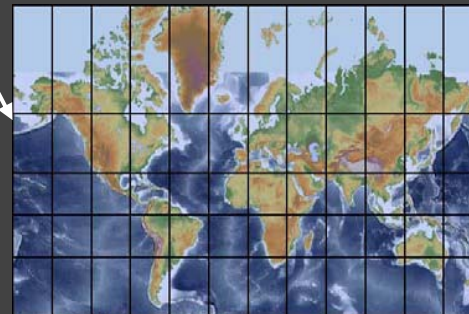
CNES
GFZ



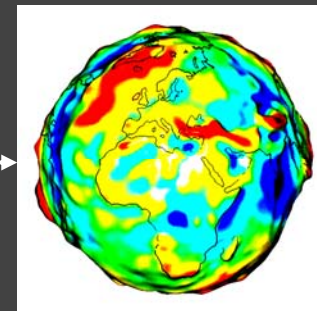
Time-wise approach



TUG
ITG
IAPG

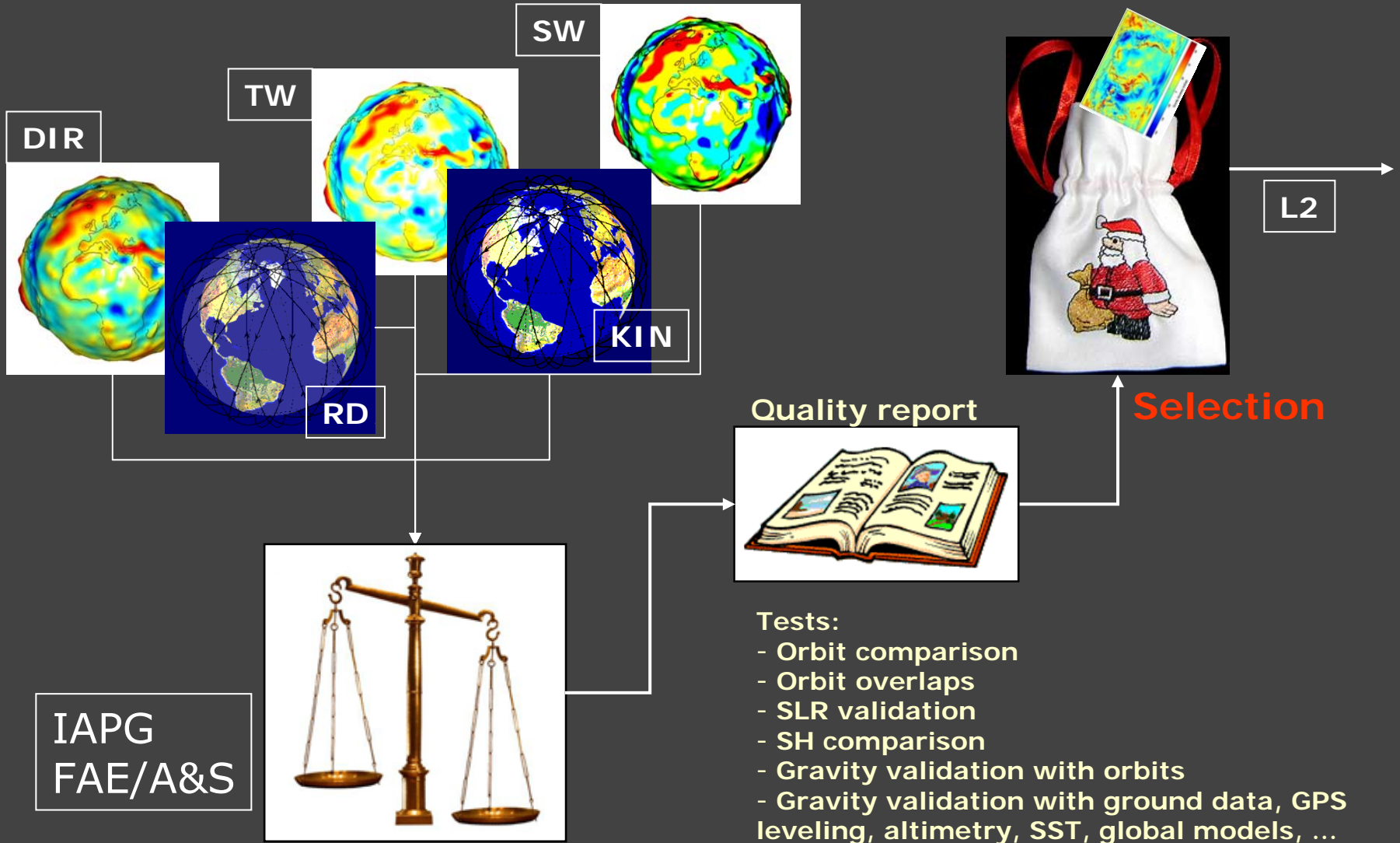


Space-wise approach



POLIMI
UCPH

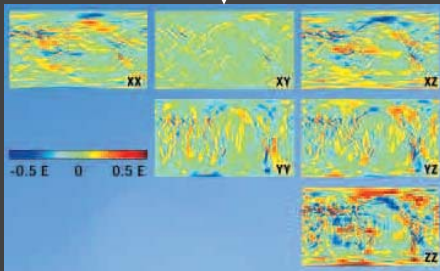
Solution evaluation and selection



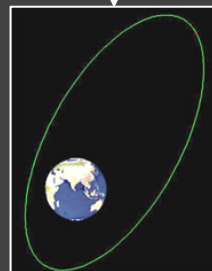
Quick-look processing



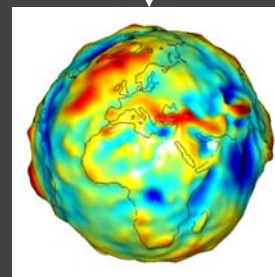
Quality reports



QL gradients



RSO



QL gravity fields

... to CMF



GOCE Level 2 Products



| Identifier | Description |
|------------|--|
| EGG_NOM_2 | <ul style="list-style-type: none">Externally calibrated and corrected gravity gradients in GRF (2 weeks latency)Corrections to gravity gradients for temporal gravity variationsFlags for outliers, fill-in gravity gradients for data gaps with flagsStatistical information |
| EGG_TRF_2 | <ul style="list-style-type: none">Externally calibrated gravity gradients in Earth fixed reference frame including error estimates for transformed gradientsTransformation parameters to Earth fixed reference frame |
| SST_PSO_2 | <ul style="list-style-type: none">GOCE precise science orbits final productQuality report for precise orbits |
| EGM_GOC_2 | <ul style="list-style-type: none">Final GOCE Earth gravity field model as spherical harmonic series including error estimates. Target: 1-2 cm / 1 mGal up to degree and order 200 corresponding to 100 km spatial resolution.Grids of geoid heights, gravity anomalies and geoid slopes computed from final GOCE Earth gravity field model including propagated error estimatesQuality report for final GOCE gravity field model |
| EGM_GVC_2 | <ul style="list-style-type: none">Variance-covariance matrix of final GOCE Earth gravity field model |



L2 Product Formats

All products available for users from PDGS archive in **XML** format.

| Identifier | Format | Coverage | Resolution |
|------------|-----------------------|-------------------|----------------------|
| EGG_NOM_2 | GG format (timewise) | 1 day | 1 s |
| EGG_TRF_2 | GG format (spacewise) | 1 MOP | 1 s |
| SST_PSO_2 | SP3c | 1 day | 1 s (KN) / 10 s (RD) |
| EGM_GOC_2 | ICGEM (SHC) GRID | 1 MOP, Mission | Lmax |
| EGM_GVC_2 | VCM format | 1 MOP, Mission | Lmax |

HPF development (1/2)

Version 0
Nov 2004



- Design and architecture
- Interfaces
- Formats and data flow

Version 1
Nov 2005



- Full, integrated system
- Performance of algorithms, products and systems
- Realistic test data from ESA's GOCE system E2E simulator

Version 2
Nov 2006



- Full, integrated system
- *Improved* performance of algorithms, products and systems
- *More* realistic test data from ESA's GOCE system E2E simulator



HPF development (2/2)

- Parts of the HPF system consist of **existing SW** (packages), other parts have been minor or major **updated or modified** from existing software, and some parts have been developed **from scratch**
- All versions of the full HPF system have undergone the full cycle of **formal acceptance testing** (algorithm and sub-system test, test readiness review, full system test, reporting, review, acceptance)
- System development in compliance with relevant **PA** requirements
- Apart from the regular system tests, dedicated negative tests, non-regression tests and operational performance tests have been performed
- Version 2 has been finalized with only a minor delay of 6 months as compared to the original **schedule**



Conclusion and outlook

- HPF system has been **successfully** developed, implemented and tested by the scientific **EGG-consortium** under ESA contract
- HPF has some **unique features**:
 - Multiple solution strategies, each with its own capabilities
 - Extensive evaluation of the solutions
 - Selection of the final models for the end users
- HPF version 2 is in **conformance** with the GOCE mission performance **requirements**
- HPF version 2 is ready to accept real GOCE data during the **operational phase** starting with L
- **HPF Bridging Phase** up to 09-2007 shall be used to:
 - Further improve the system beyond the performance requirements by including certain add-on features
 - Develop and test Version 3 for ultimate performance
 - Study and prepare for selected failure cases
 - Solidify theoretical and scientific basis of HPF in view of the extreme performance of GOCE