Ground Support Network operations for the GRAS Radio Occultation Mission

R. Zandbergen, the GRAS GSN team (ESOC) and the
Metop GRAS team (EUMETSAT)
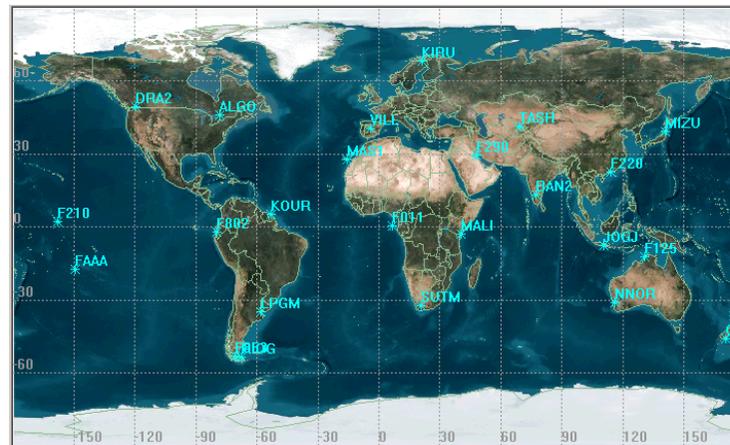
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GRAS GSN...

- **G**NSS
- **R**eceiver for
- **A**tmospheric
- **S**ounding

(on board Metop)

- **G**round
- **S**upport
- **N**etwork

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Presentation summary

- GRAS GSN requirements

- System architecture

- Operations concept

- Results and performance

- Evolution perspectives

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Sounding profile generation

- EUMETSAT will operate three Metop S/C (polar LEO)

- ... and generate atmospheric sounding products in NRT

- ... for delivery to Met Offices within 2:15 hours

- This processing requires precise orbits and clock solutions for both Metop and the occulting GPS satellite

- Metop POD to be performed in-house, using GRAS tracking GPS constellation through the zenith antenna

- The GPS products are considered 'Support Data', to be provided externally

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Support data definition (NRT)

- GPS orbits (for Metop POD and occultation processing)

- GPS clock solutions

  – Low-rate for Metop POD

  – High-rate for occultation processing

- Earth Orientation Parameters (for Metop POD)

- Auxiliary data (Meteo data, Nav. messages...)

- High-rate, selected, ground receiver data

- High-rate ground clock solutions ('*sounding support Data*')

} for differenced processing

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GRAS GSN High-Level Requirements

- Commitment to operational data delivery
- System availability of 99% on a 24/7 basis, with specific limitations on number and duration of outages
- Near-Real Time capability compatible with Metop / GRAS timeliness requirements
    - NRT products initially required within 60 minutes after sounding observation
- "Moderate" accuracy requirements (0.5 ns clocks)
- System can be operated for up to 15 years, 2 satellites
- Can be extended to other missions

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High-level architecture

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Dedicated receiver network
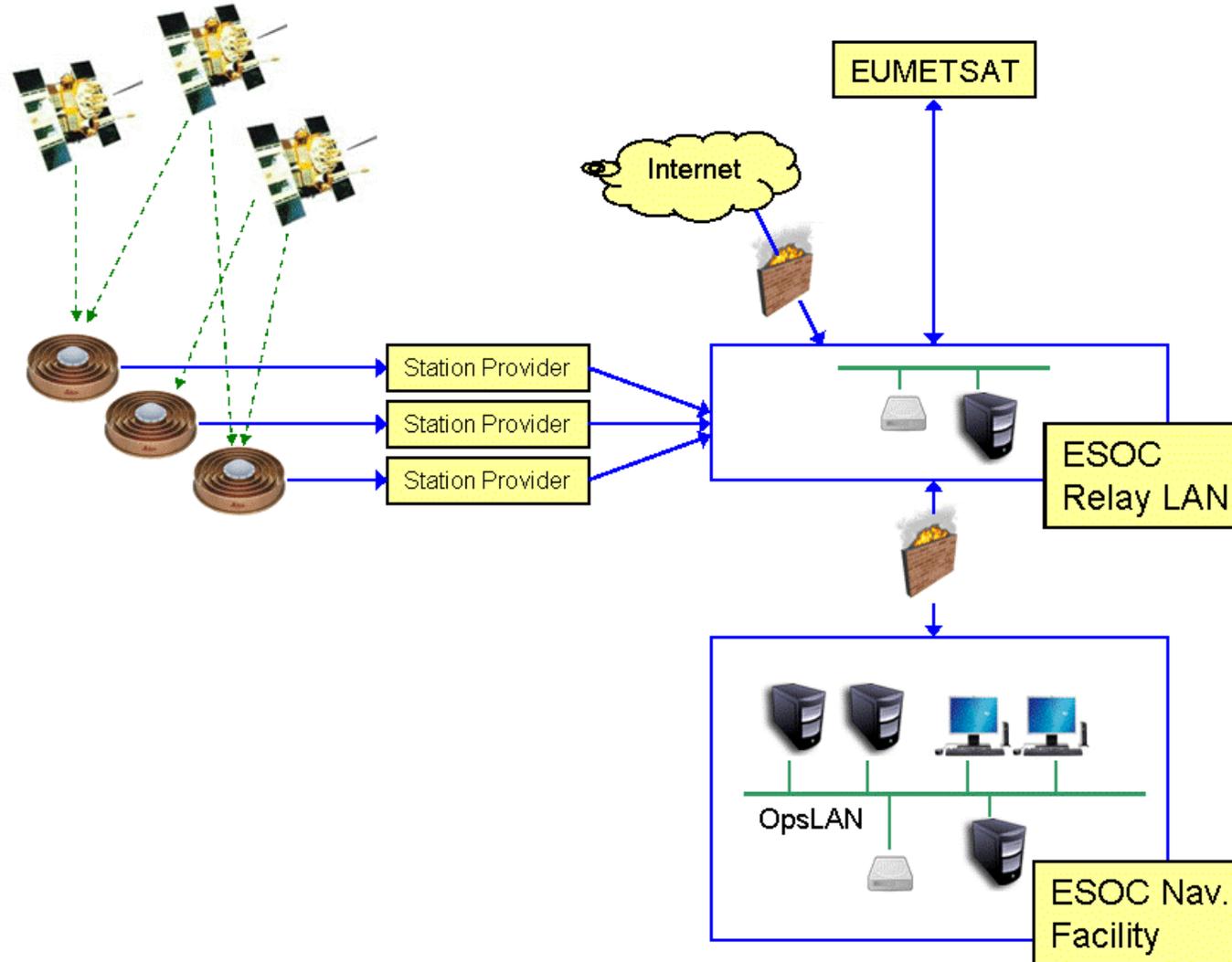
- ESOC plus three external network providers, built-in redundancy

- 46 sites, of which 25 'prime' which is the minimum to guarantee meeting all requirements

- Data delivered in 15-minute batch files. Extension to real-time is an option (all providers have RT experience)

- Dedicated permanent lines between station providers and ESOC (ISDN backup)

- Each provider collects its own stations and delivers to ESOC

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Operations concept

- Fully automated system, automated error recovery

- Alarm generation in case of hardware failures, or product delivery interruption (watchdog software)

- Operations team with on-call cell phones

- Redundant hardware based on ESOC's redundancy policy (physically separated data centres)

- Orbit products based on <u>predictions</u> of a few hours (run every 3 hours)

- Clock products based on clock <u>determination</u> tasks running every 15 minutes

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GRAS GSN operations monitoring

Key performance indicators

- System has been fully operational since Metop launch (October 2006), meeting requirements

- Extensive monthly report delivered to EUMETSAT including all key performance indicators

- Availability (measured): 99.7 %

- Service interruptions: 0-1 per month (required <3)

- NRT orbit and clock product accuracy met consistently

- *In July 2010 system migrated to state-of-the-art GNSS processing software (Napeos)*

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GPS NRT orbit accuracy (cm)
(impact of change to Napeos)

GSN metric

IGS metric

GSN near real time orbit vs IGS rapid product

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RMS and standard deviation

Issues solved / improved
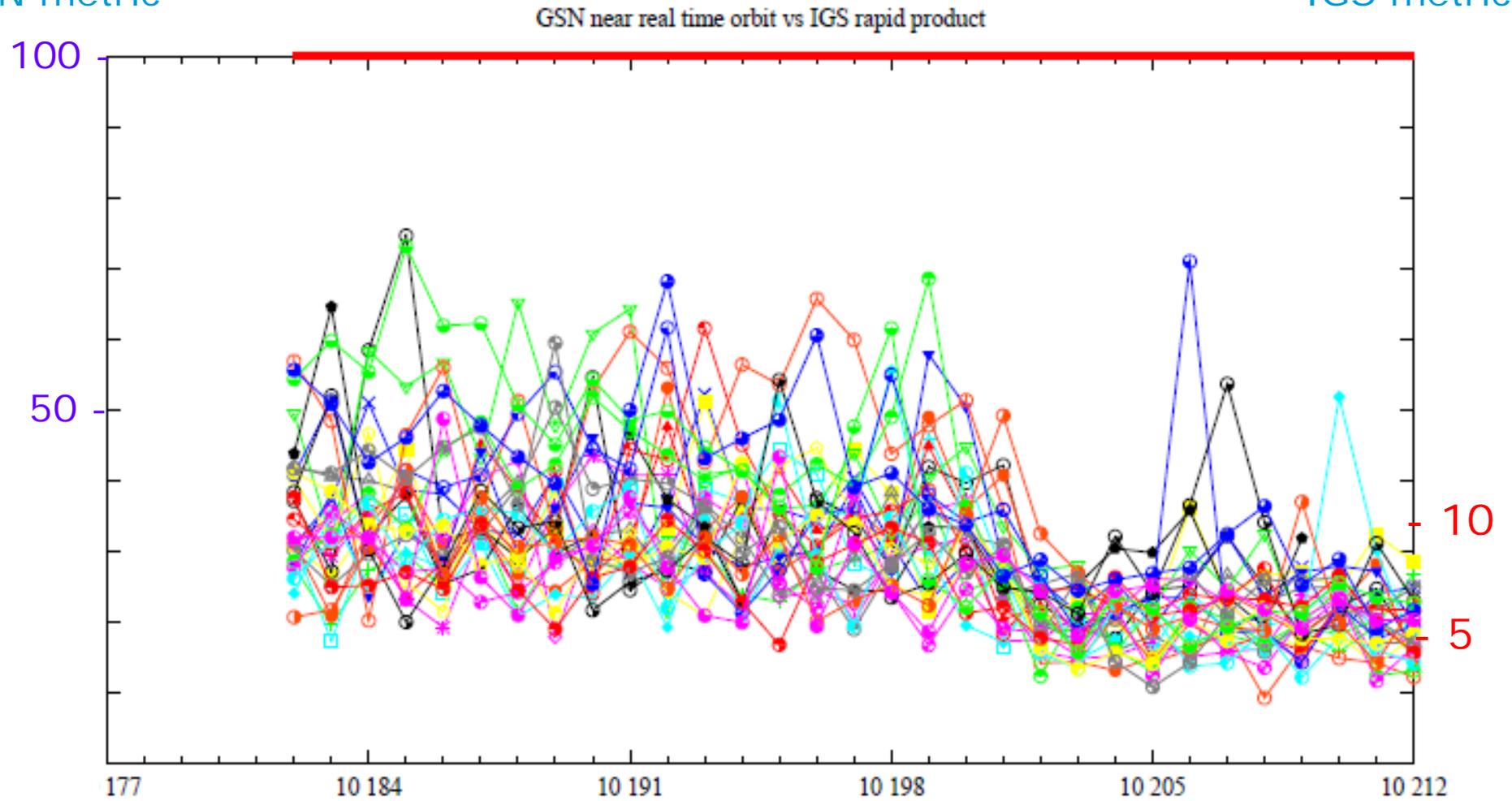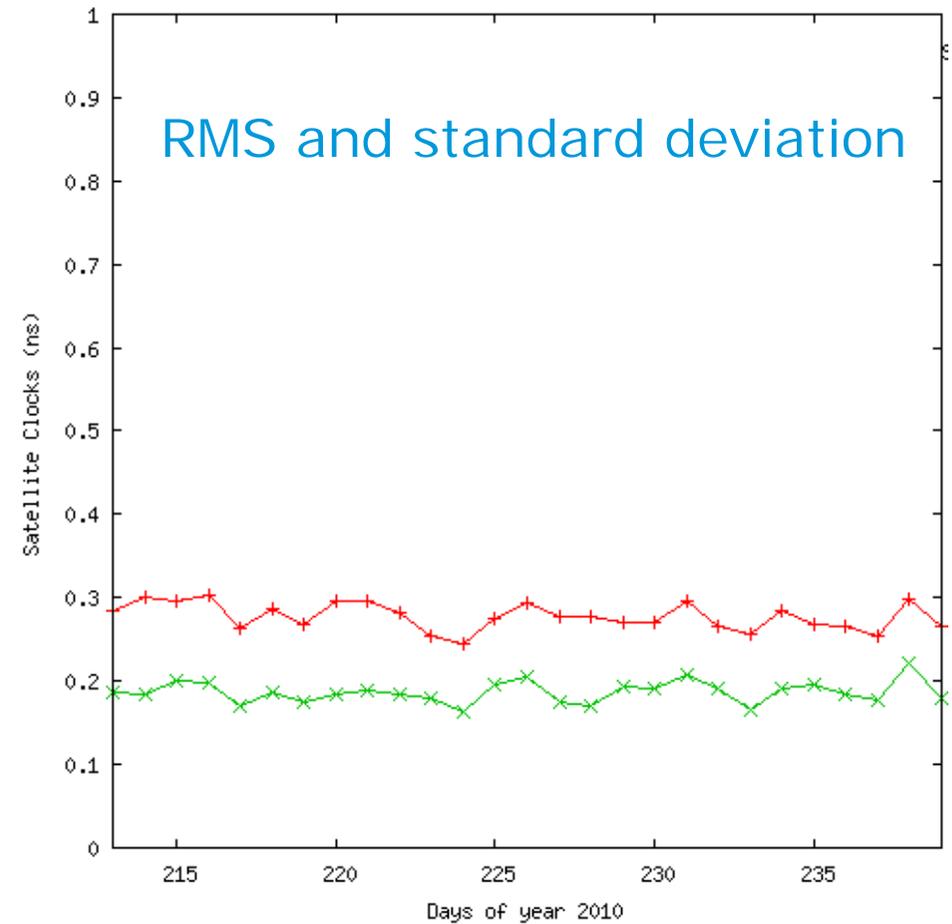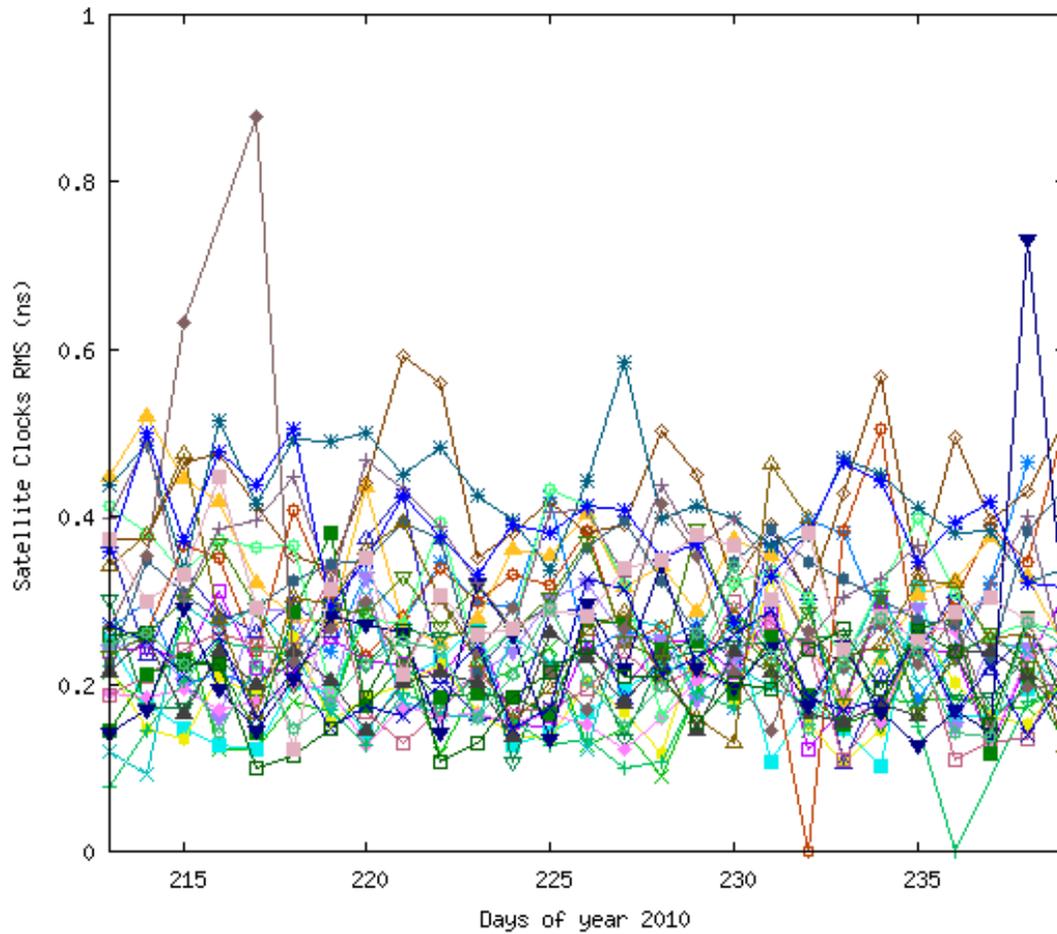
- Physical modelling in ESOC and EUMESTSAT systems now fully consistent and in accordance with current standards:

    - IERS 2003 standards

    - Use of absolute phase centres (GPS and stations)

- Orbit and clock products time tag used to drift away – is now automatically consistent with GPS time

- Independence from NANU's

- Re-introduction of a GPS satellite after an outage reduced from 48 hours to 24 hours

- Metop POD accuracy (EUMETSAT) improved

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Metop POD (batch system)

- Improvement due to introduction of Napeos (source: Y.Andres / EUMETSAT). Units are cm.

	Radial	Cross	Along	3D
Old GSN	4.3	5.2	8.8	11.1
New GSN	3.0	2.8	5.9	8.7

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GRAS GSN vs. IGS ultra-rapids

- Main differences between IGS ultra-rapid solutions (e.g. ESA products) and GRAS GSN products:

    - Timeliness is 1 hour (GSN) vs. 5 hours (IGS)

    - Network size = 40 (GSN) vs 120 (IGS)

    - Old system (GSN) did not allow ambiguity fixing

    - No strong incentive on GSN for highest possible accuracy, as all the needs of Metop are covered by requirements

- Note that the ESA IGS availability does not meet the GSN requirements

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Evolution perspectives (short term)

- Improve timeliness of NRT products from 60 to 45 minutes

    - Currently under discussion

    - In support of Antarctic dump facility and overall improvement of GRAS product timeliness

- Orbit prediction accuracy improvements (implementation of techniques already used in other projects)

- Tuning of ambiguity fixing

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Evolution perspectives (medium-long term)

- Implementation of a 'Navigation Bit' product delivery service
  - In support of raw sampling for low altitude occultation processing
- Application to other missions with similar requirements
- Towards a real-time system
  - Technically feasible from GRAS GSN side
  - Data availibility issues

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Station network providers:

Météo France Tahiti

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Thank you for your attention!

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