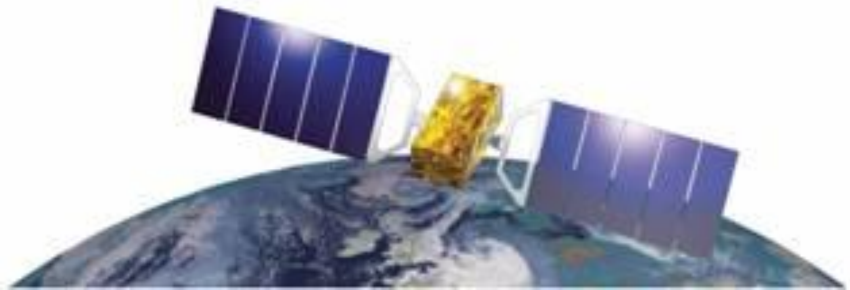
Ground Support Network for the GRAS Mission – Status and Evolution

the GRAS GSN team (ESOC) and the Metop GRAS team (EUMETSAT)

02/04/2012

NAVIGATION FACILITY



Contents

- GRAS GSN Requirements
- System architecture
- Current status
- Open-loop tracking and Navigation bits
- System evolution

Atmospheric sounding observation

- EUMETSAT operational processing of RO data 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 through the zenith antenna
- The GPS products are considered ‘Support Data’, to be provided externally

Support data key requirements

- The key requirements were derived in 2001:
  - Timeliness: 60 min. for orbits and clocks (now: 45 min.)
  - Clock accuracy: 1 ns at 2-sigma for each satellite
  - Can be interpolated at 50 Hz
  - GPS satellite velocity accuracy requirement!
  - Guaranteed high availability (24/7 principle, 99% and constraints on interruptions)
  - Can be operated for 15 years, 2 satellites in parallel
  - Extensible to other missions with similar requirements

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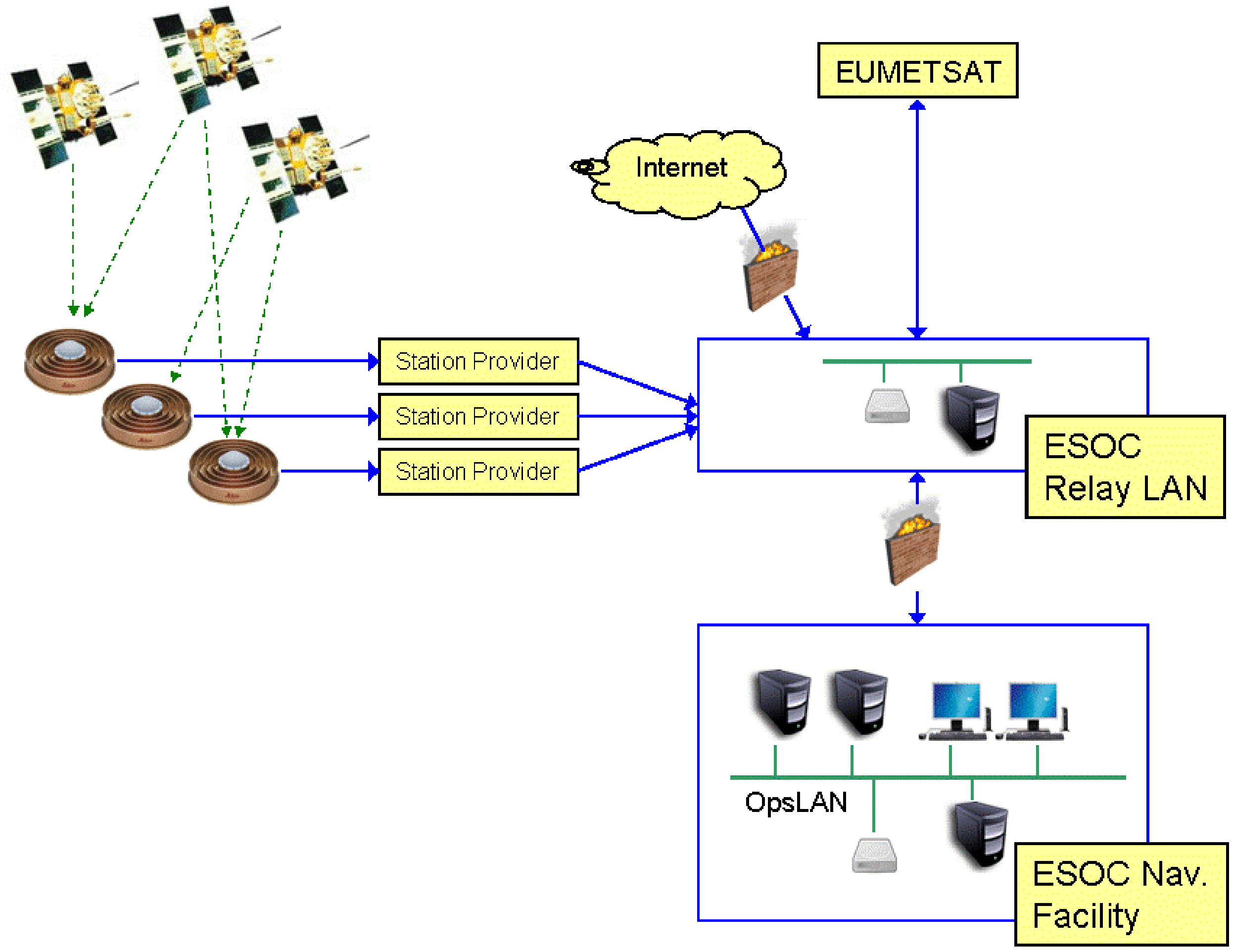
High-level GRAS GSN architecture



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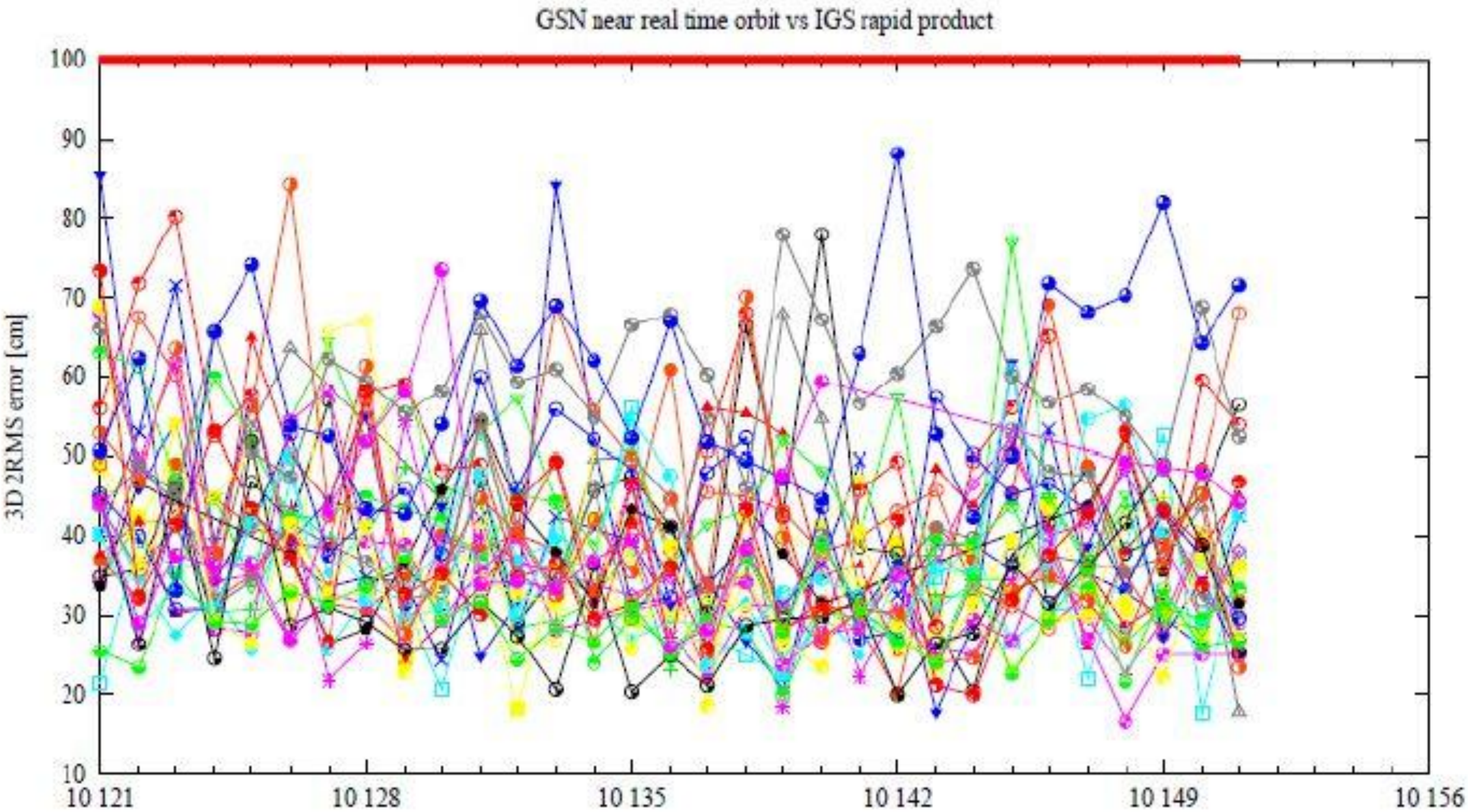
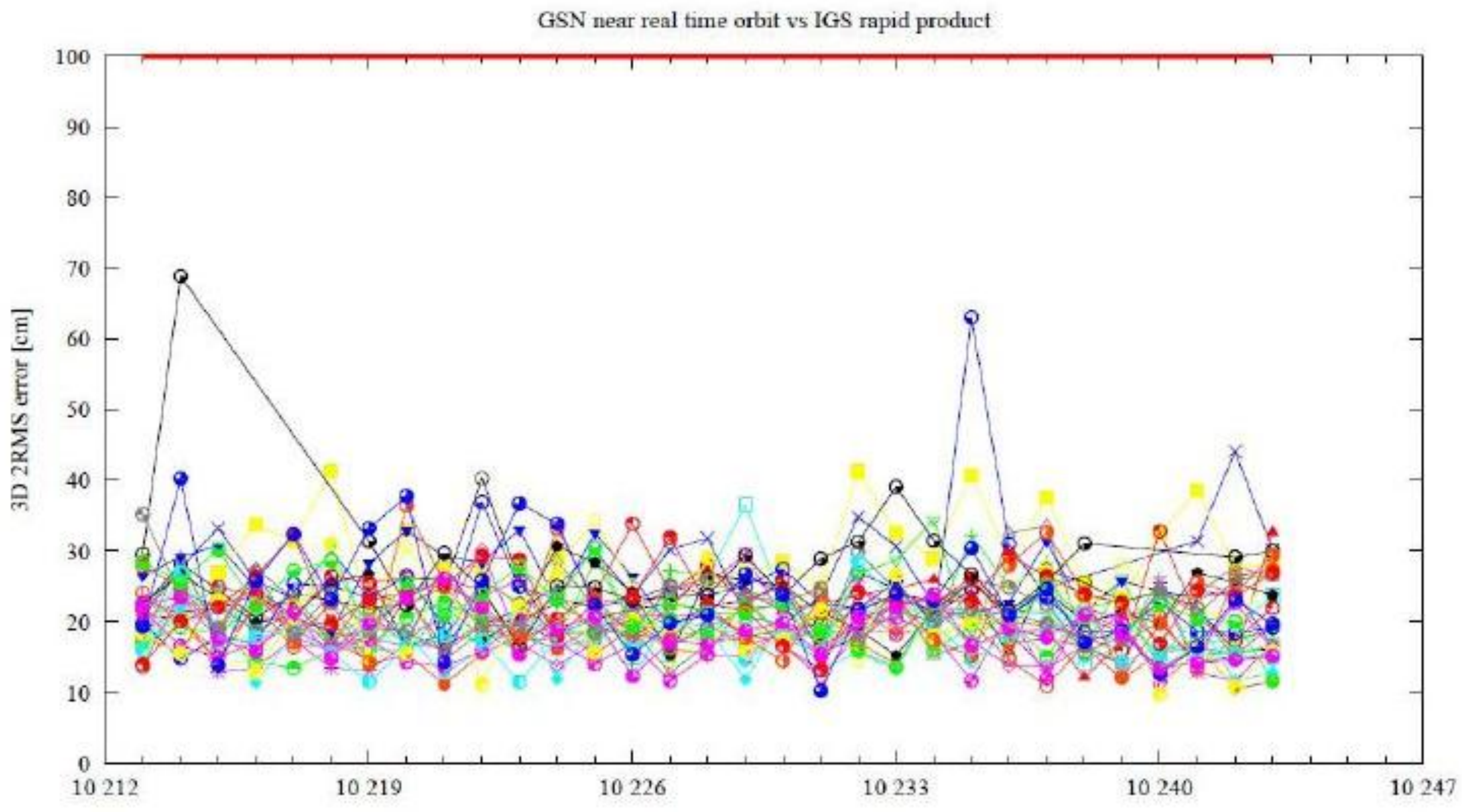
Evolutions over the last 4 years

- Computer infrastructure re-distributed over two data centres, improving redundancy
- Replacement of legacy GNSS orbit and clock determination software by state-of-the-art Napeos
- 1-Hz to 5-second clock outputs reducing product size
- New IERS and ITRF standards, absolute phase centre
- Replacement of dedicated lines to network providers by internet (cost saving)
- NRT product timeliness from 60 to 45 minutes
- Reporting with IGS-style metrics

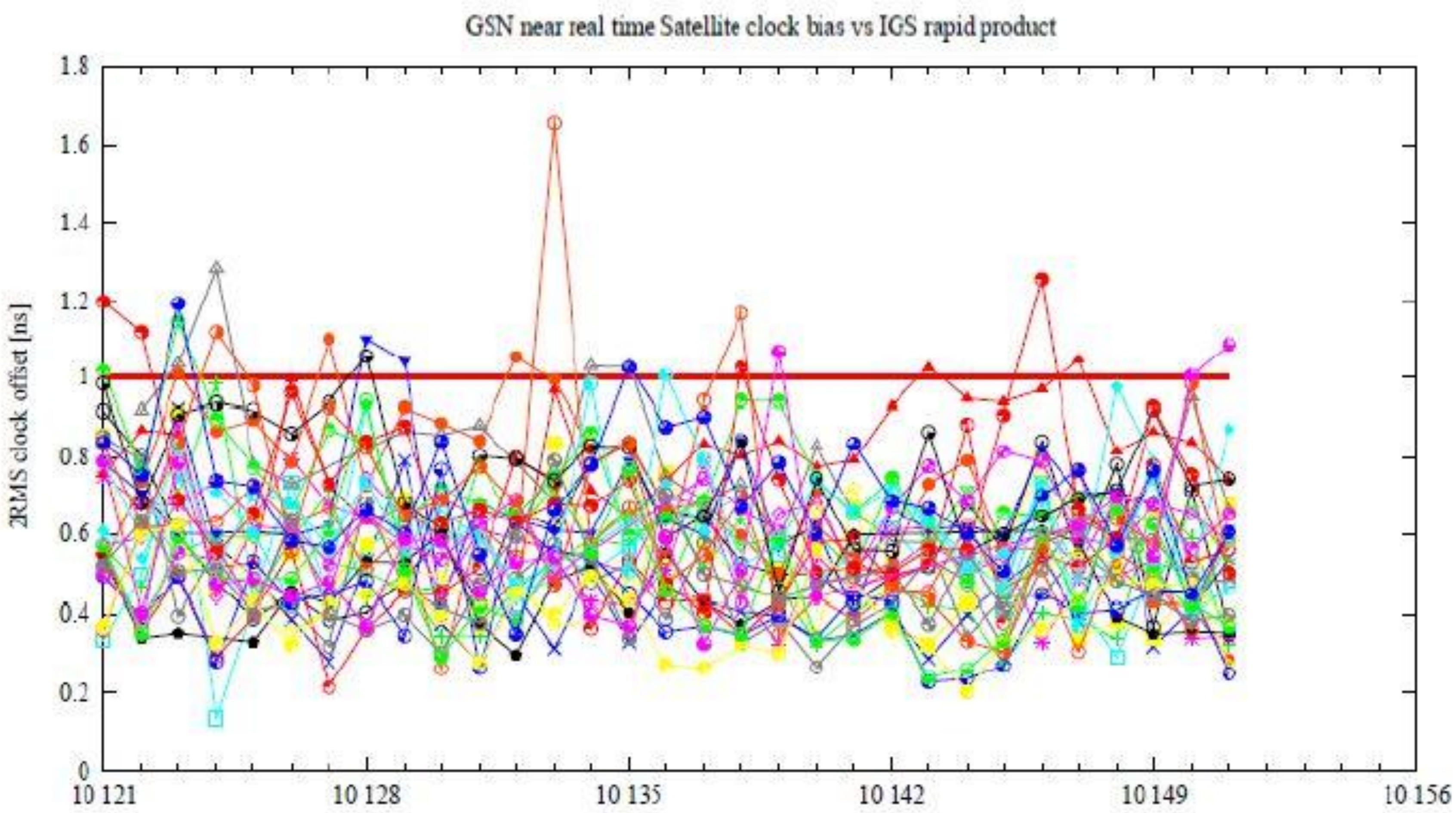
Orbit accuracy (May 2010)



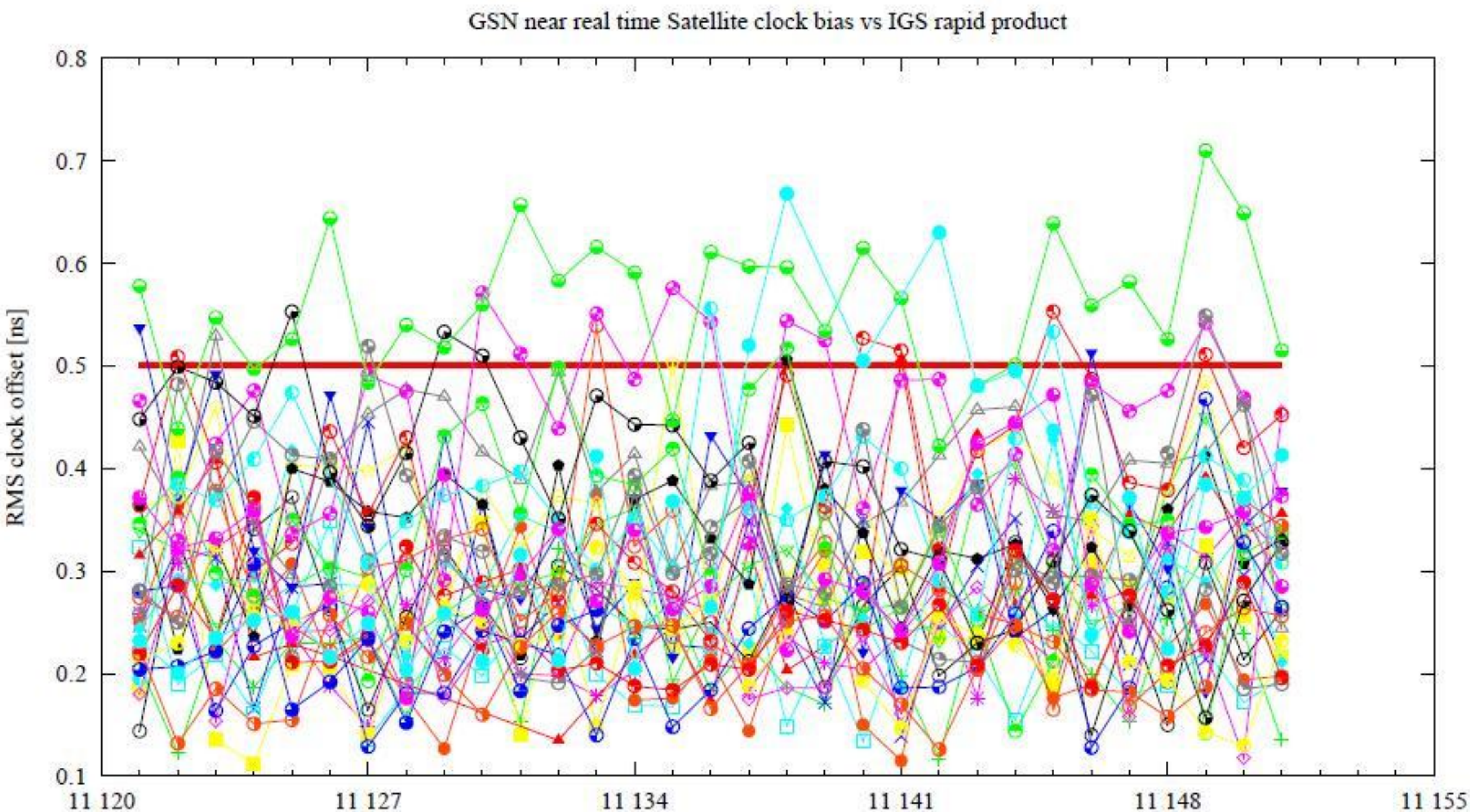
Orbit accuracy (May 2011)



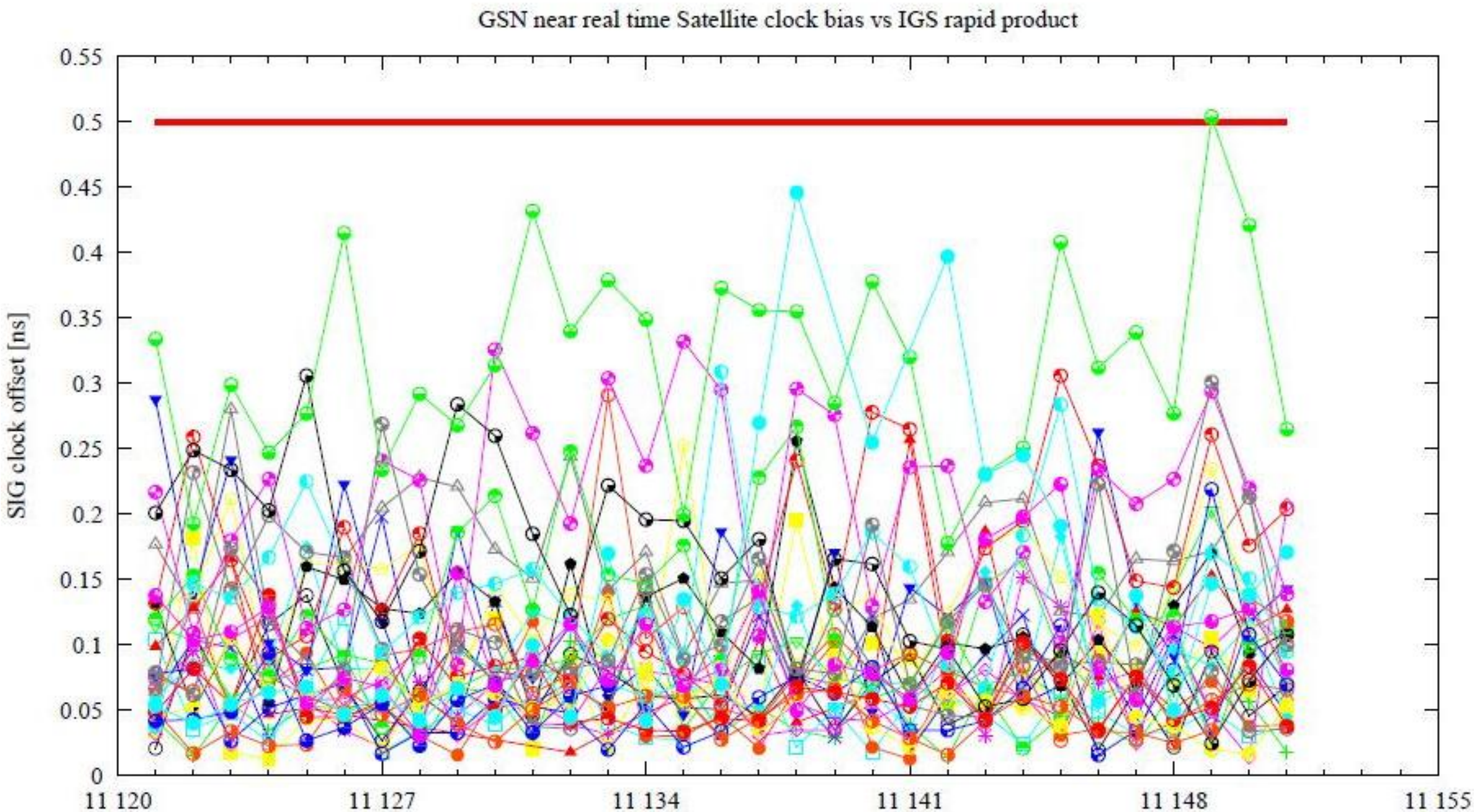
Clock accuracy (May 2010)



Clock accuracy (May 2011 - RMS)



Clock accuracy (May 2011 - Sigma)



Clock accuracy (May 2011 - Sigma)

- Worst satellite:
  0.32 ns
- Overall constellation:
  0.23 ns

- Sigma measured in February 2012:
- Worst satellite:
  0.16 ns
- Overall constellation:
  0.11 ns

GRAS GSN current status summary

- System has been operational since Metop-A launch (October 2006), meeting requirements
- Atmospheric sounding profiles have become a key data set for modelling the upper atmosphere
- Orbit typical RMS: 5-6 cm, clock sigma: 0.1 – 0.15 ns
- Measured availability: 99.95 % over last 4 years
- GRAS GSN contract extended twice, now until May 2014
- Experimental Navigation Bit Stream Service being implemented…

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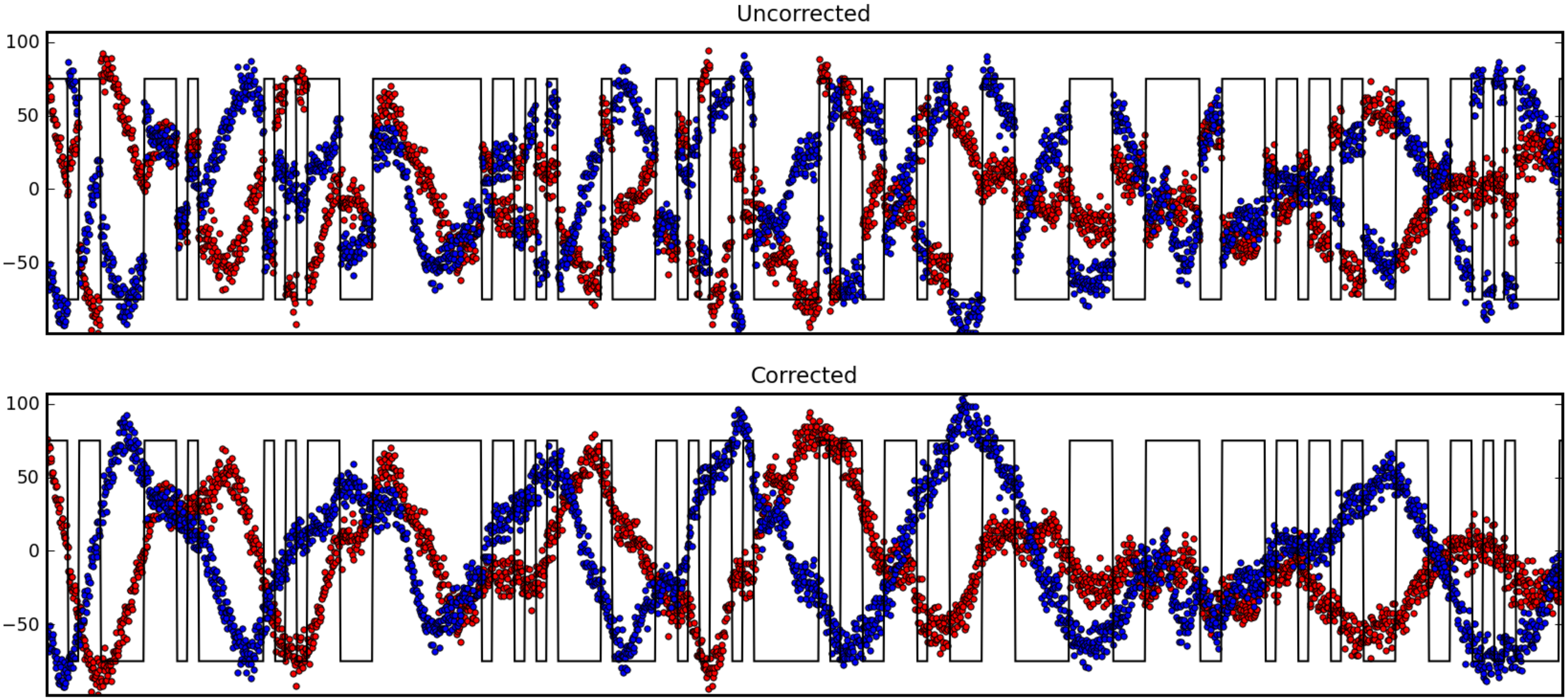
Navigation bit removal (example)



3-sec time interval

Existing solutions

- For support to the COSMIC mission, UCAR has set up a ‘bitgrabber’ network
- Consists of 6 receivers distributed globally, which record and deliver the navigation bits as data files
- Coverage is not complete
- GFZ have similarly deployed an increasing network of receivers
- Coverage now essentially complete
- Product generated operationally and available off-line

EUMETSAT request

- EUMETSAT have requested ESOC to extend the GRAS GSN service with an NBS product
- The system should become operational and near-real time (45 minutes delay)
- Availability requirements should be similar to the existing GRAS GSN products
- Implemented in collaboration with GFZ

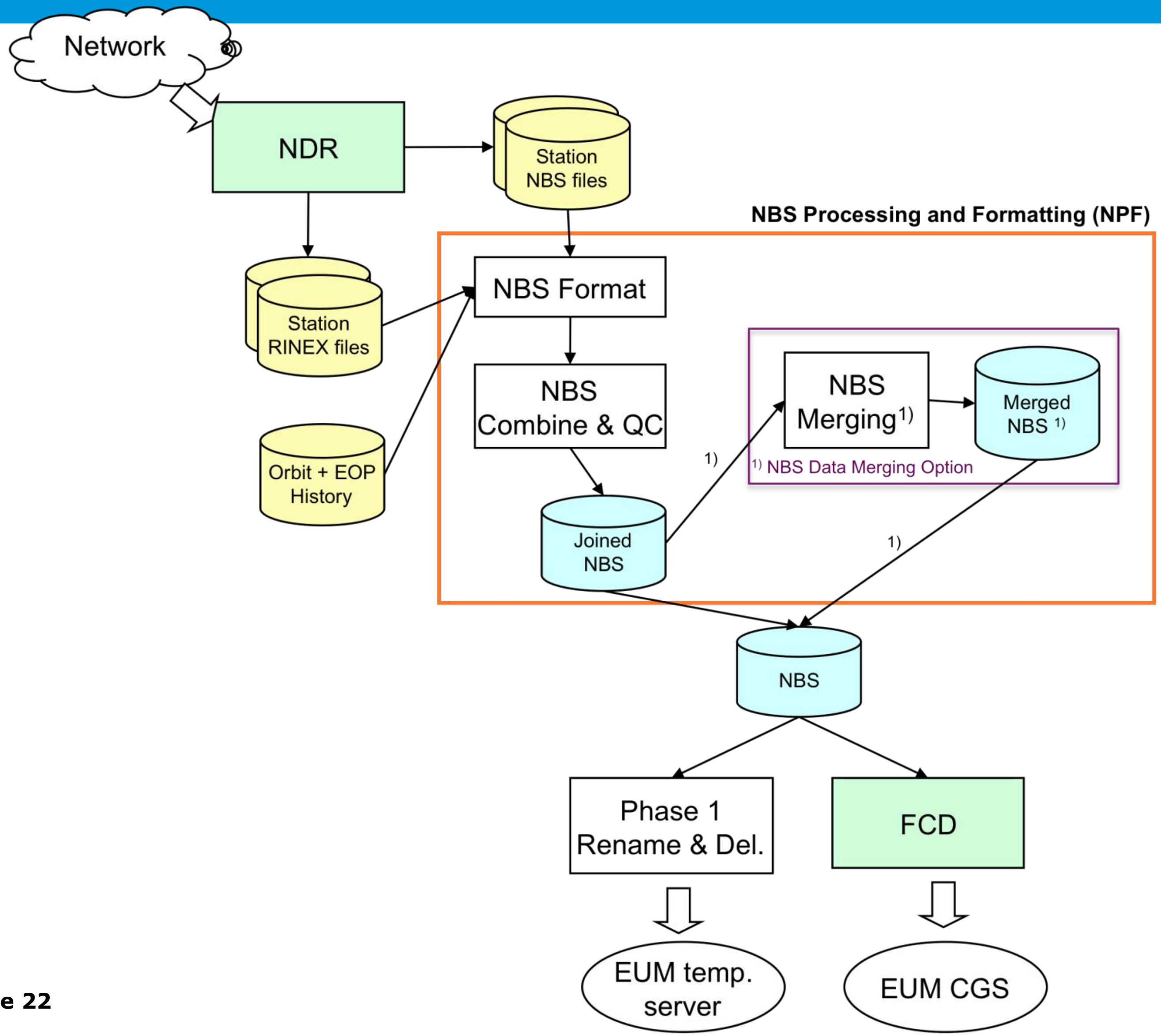
NBS implementation approach

- A two-phased approach is taken:
- Phase 1:
  - Definition of interfaces and products
  - Setup of a prototype network and prototype data delivery at best effort, for 6 months, based on existing receivers
  - Analysis of possible network configurations
  - Definition of operational requirements
- Phase 2 (pending approval to go ahead):
  - Conversion to operational system

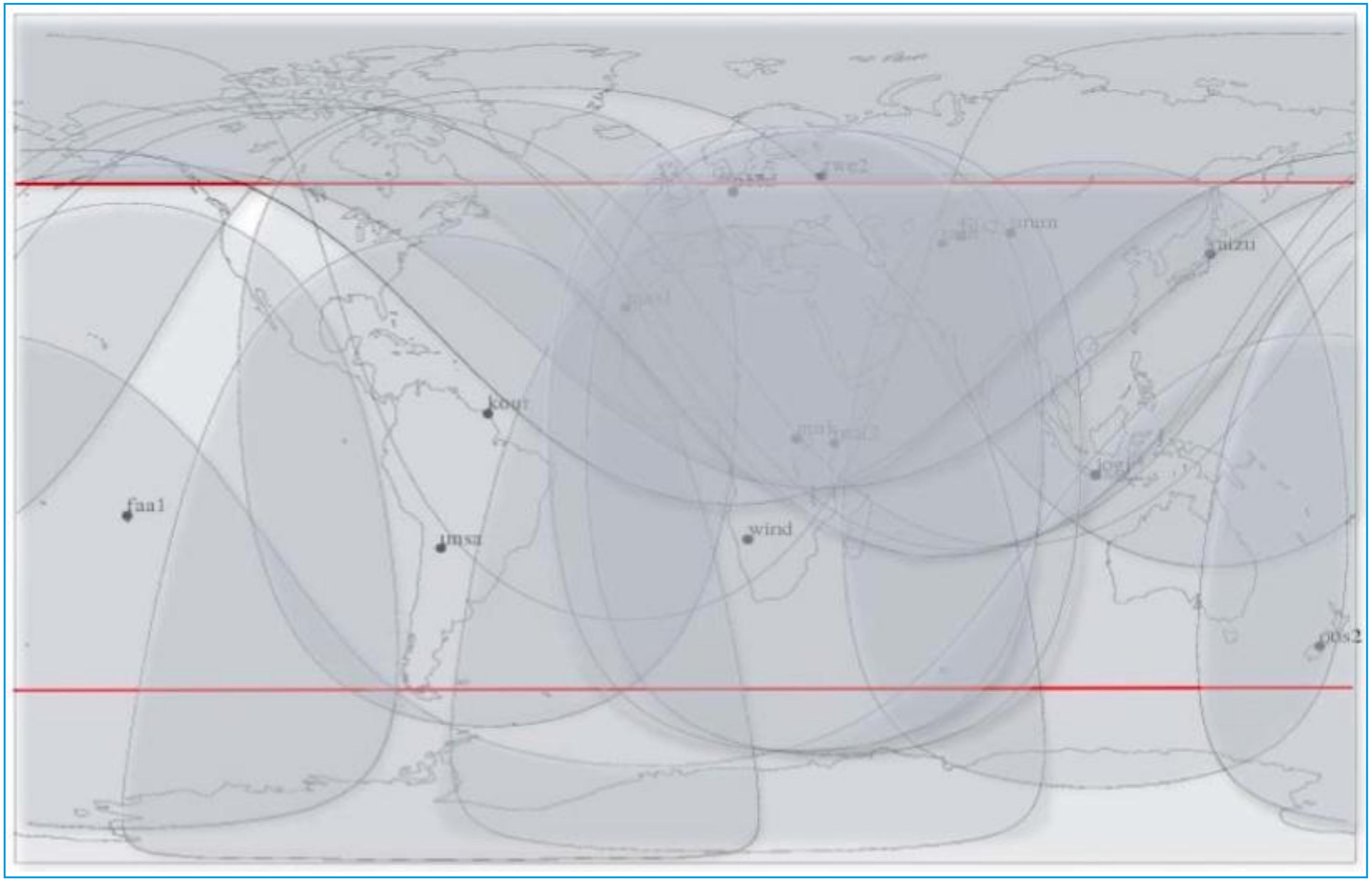
NBS Phase 1

- Phase 1 lasted from July 2011 to January 2012
- Use of modern GNSS receivers that have capability to store navigation bit data internally
- Use of TEQC undocumented feature to extract this into a raw ASCII format
- Software at ESOC converts to a more general-purpose format, and combine into 15-minute products from all receivers
- Experimental network of 11 GFZ and 4 ESOC receivers, running since end October 2011

NBS processing architecture

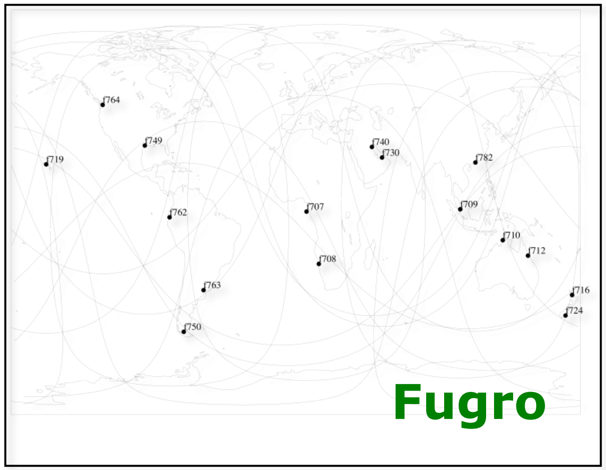


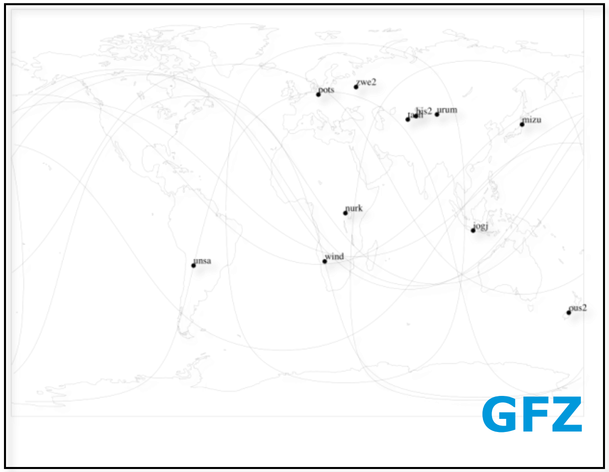
NBS Phase 1 experimental network



NBS Phase 2 operational network design

- All 4 GSN data providers have agreed to participate …
- DOC-3 network can be easily achieved



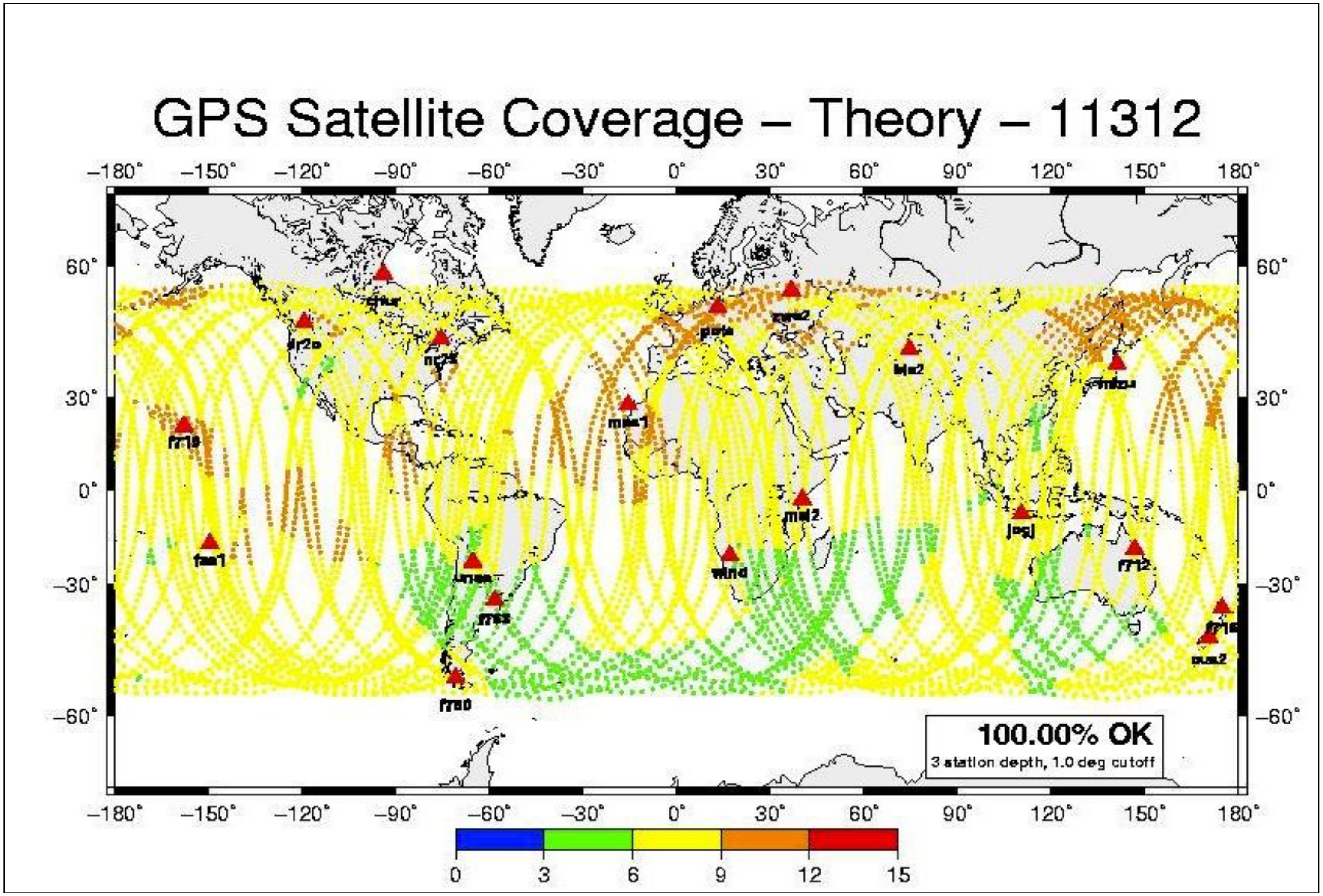


Proposed operational network

- Prime + redundant stations

Provider	**Num**	**Stations**
ESOC	3+**2**	**mal2, mas1, faa1, <u>kour</u>, <u>earg</u>**
Fugro	5+**3**	**f712, f716, f719, f763, f750, <u>f707</u>, <u>f782</u>, <u>f740</u>**
GFZ	8+**3**	**unsa, zwe2, mizu, ous2, pots, bis2, jogj, wind, <u>nurk</u>, <u>tash</u>, <u>urum</u>**
NRCan	3+**1**	**dr20** (at drao), **chur**, **nr23** (at nrc1), **<u>yel2</u>** (at yell)
	19 + **9**	

Nominal coverage proposed 19-stn network



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Short-term evolutions

- Conversion of NBS system into operational system
- Move to IGS-08 reference frame
  - Improved antex information is expected to improve clock solutions
- GRAS GSN is ready to support Metop-B in parallel to Metop-A
- Continuous tuning of availability, accuracy
- Move from Solaris to Linux environment (in 2012)

Evolution perspectives (longer term)

- GSN system could move towards a real-time system:
  - Existing network providers all have proven real-time capability
  - Number of real-time stations world-wide is rapidly increasing
  - ESOC playing a leading role in the IGS real-time pilot project
- Extension towards (Glonass and) Galileo due to inherent capability in the ESOC software systems
- Challenges from new RINEX and other format changes

Thank you for your attention