GRAS GSN near-real time data processing

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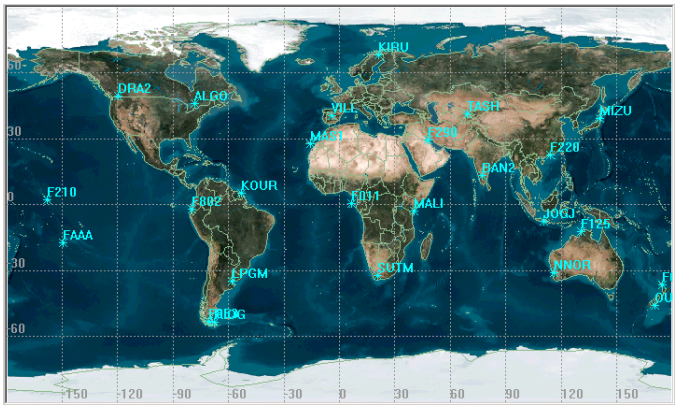
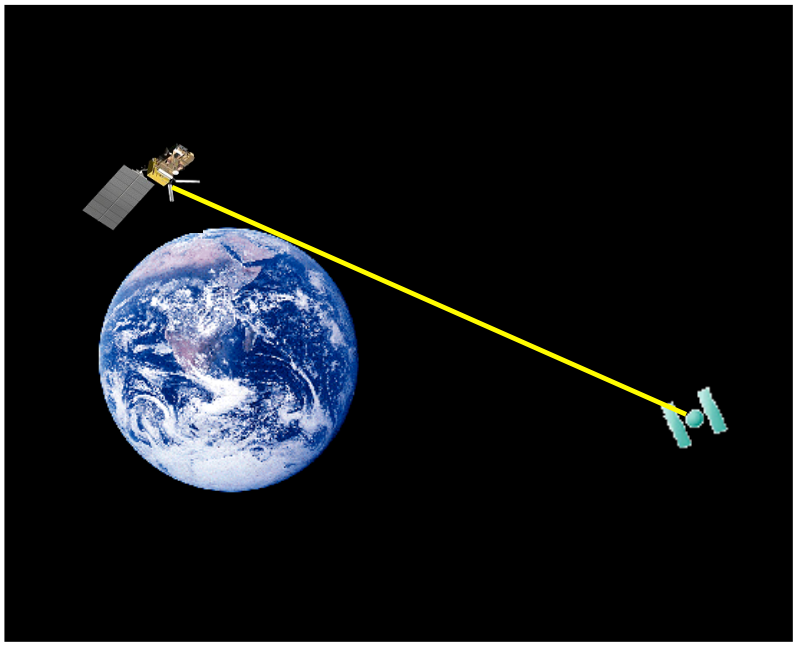
- **G**NSS
- **R**eceiver for
- **A**tmospheric
- **S**ounding

… on board Metop

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



Atmospheric Sounding



- GPS signal travels through atmosphere
- Through relative S/C motions, occultation profiles are generated
- Fore and aft antennas on Metop allow monitoring of both setting and rising occultations
- Two occultations can be observed by each antenna
- Total per day per satellite ~500 occ.

Generation of sounding profiles

- EUMETSAT will operate three Metop S/C (polar LEO)
- … and generate atmospheric sounding products in NRT
- … for delivery to European Met Offices within 3 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 through the zenith antenna
- The GPS products are considered ‘Support Data’, to be provided externally

Support data for occultation processing

- GPS orbits (for Metop POD and occultation processing)
- GPS clock solutions
  - Low-rate for Metop POD
  - High-rate for occultation processing
- EOP data (for Metop POD)
- Auxiliary data (TZD, Meteo, Nav msg…)

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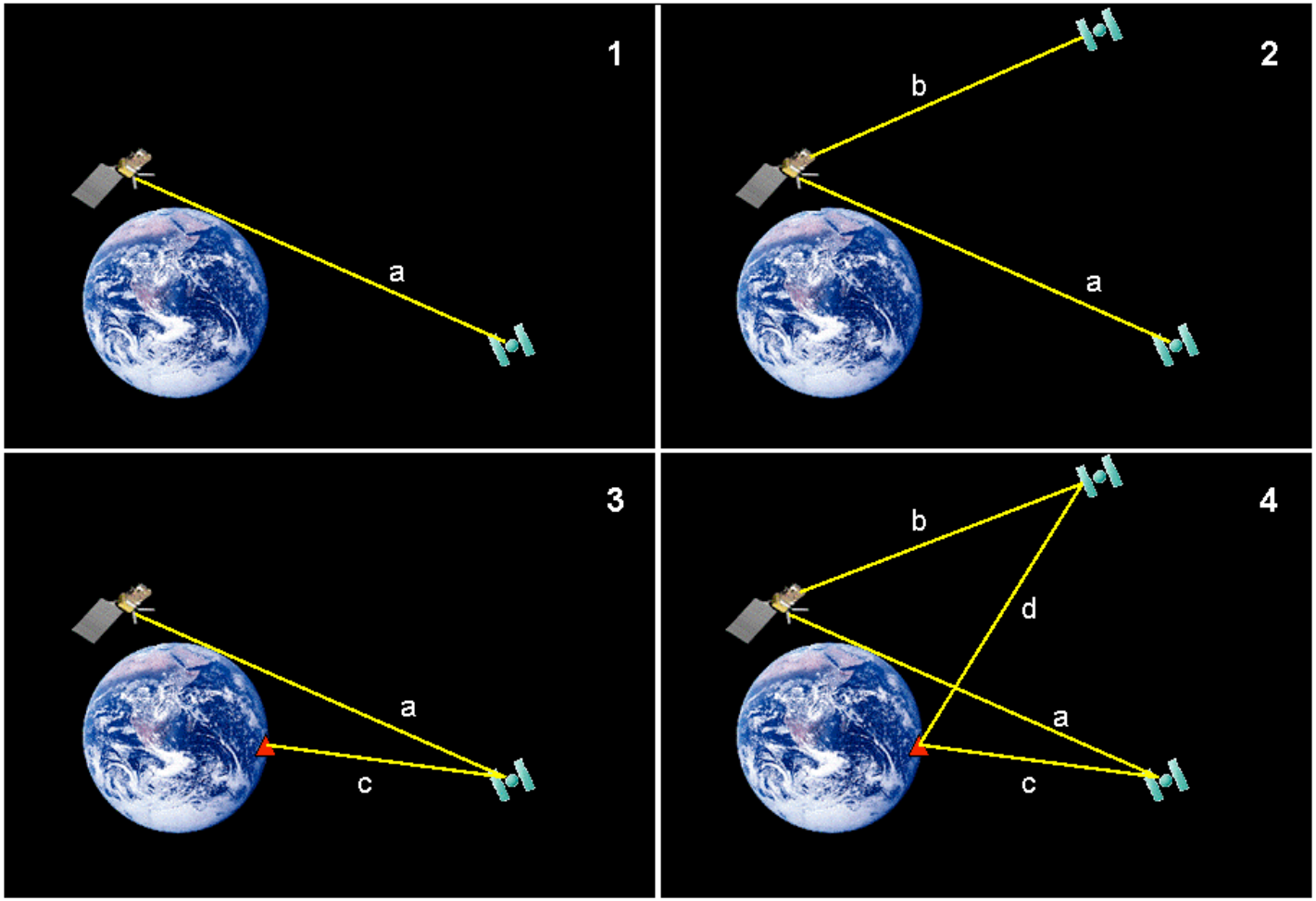
- GPS clock solutions
  - Low-rate for Metop POD
  - High-rate for occultation processing
- EOP data (for Metop POD)
- Auxiliary data (TZD, Meteo, Nav msg…)
- High-rate, selected, ground receiver data
- High-rate ground clock solutions

} why?

Supporting differenced processing methods



Ground (Sounding) Support Data

- Method 1: undifferenced
- Method 2: eliminate GRAS clock
- Method 3: take out the GPS clock (replace by ground clock)
- Method 4 not yet implemented

- For method 3, accurate ground clock solutions and ground tracking data of the occulting satellite are required
- EUMETSAT deliver a table of predicted occultations to ESOC and ESOC return the necessary ground data (SSD)

Support data key requirements

- EUMETSAT approached ESOC, due to our experience in IGS and earlier collaboration in satellite operations
- The most fundamental requirements were studied in 2001:
  - Timeliness: 60 min. for orbits and clocks
  - Clock accuracy: 1 ns at 2-sigma for each satellite
  - Can be interpolated at 50 Hz
  - GPS satellite velocity accuracy requirement!
  - Guaranteed high availability (99% & limited interruptions)
  - Can be operated for 15 years, 2 satellites in parallel
  - Extensible to other missions with similar requirements

High-level design

- After the study, it was agreed to proceed as follows:
- To set up a dedicated and fully redundant network of approximately 20 sites (i.e. in total 40)
  - Resulted in contracts with existing network operators: GFZ, NRCan and Fugro Seastar
- Build up a processing centre in ESOC
- GPS orbits computed every few hours, using predictions
- Clocks computed every 15 minutes, not predicted
- To support the 50 Hz GRAS data, deliver 1 Hz GPS clocks (not interpolated)
- Largely based on IGS S/W with relevant new components

The GSN Network

	Prime sites	Backup
ESOC	7	1 (*)
GFZ	8	8
Fugro	8	8
NRCan	2	2
Total	25	19

The GSN Network (prime sites)

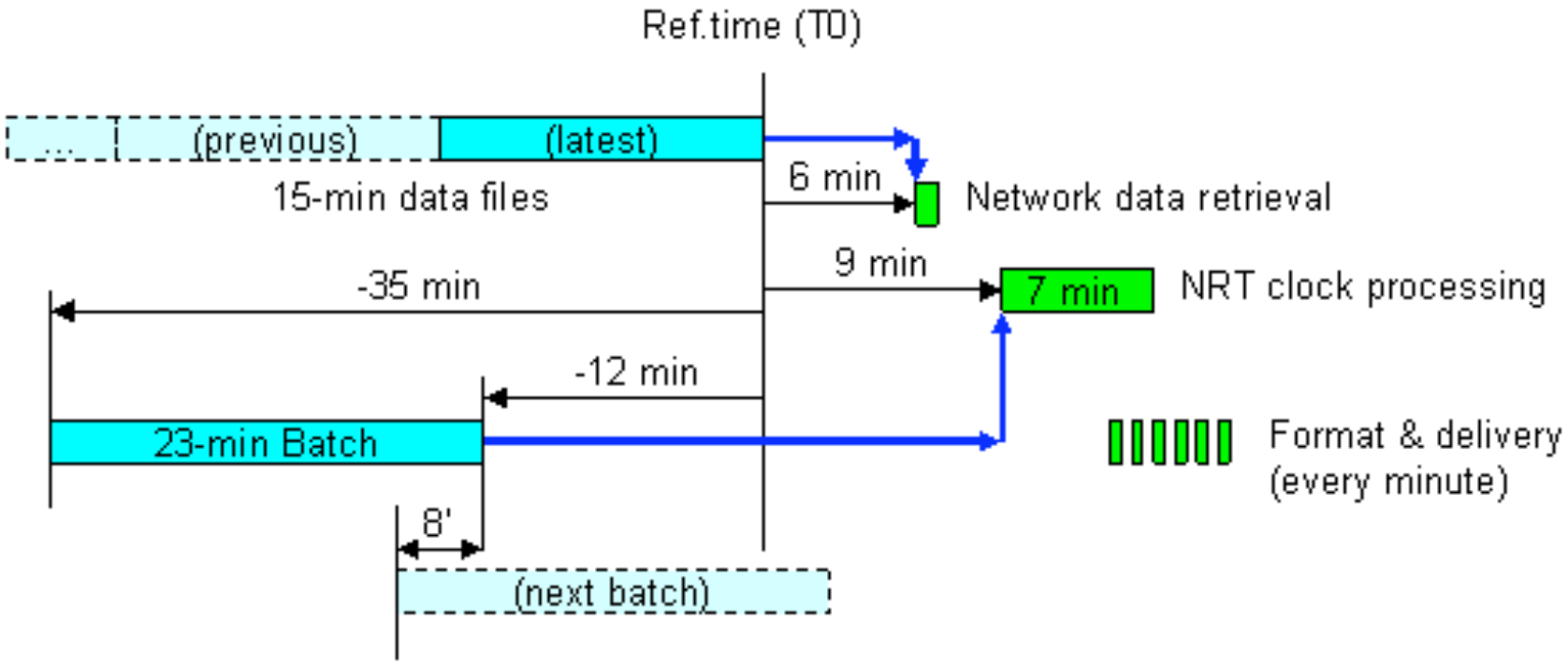
The ‘network providers’

- Both real-time and batch data delivery were originally foreseen for the GSN
- ‘Keep it simple’: start with 15-minute batch data delivery
- Each network provider collects its own station data and delivers it to ESOC
- As a backup, the provider also stores the data on a server at its site, for ESOC to ‘get’ via the internet
- Direct lines between ESOC and each operator (Potsdam, Oslo, Ottawa) have been established
- Key requirement: 98% availability over 15° elevation
- The change to RT transfer is an option

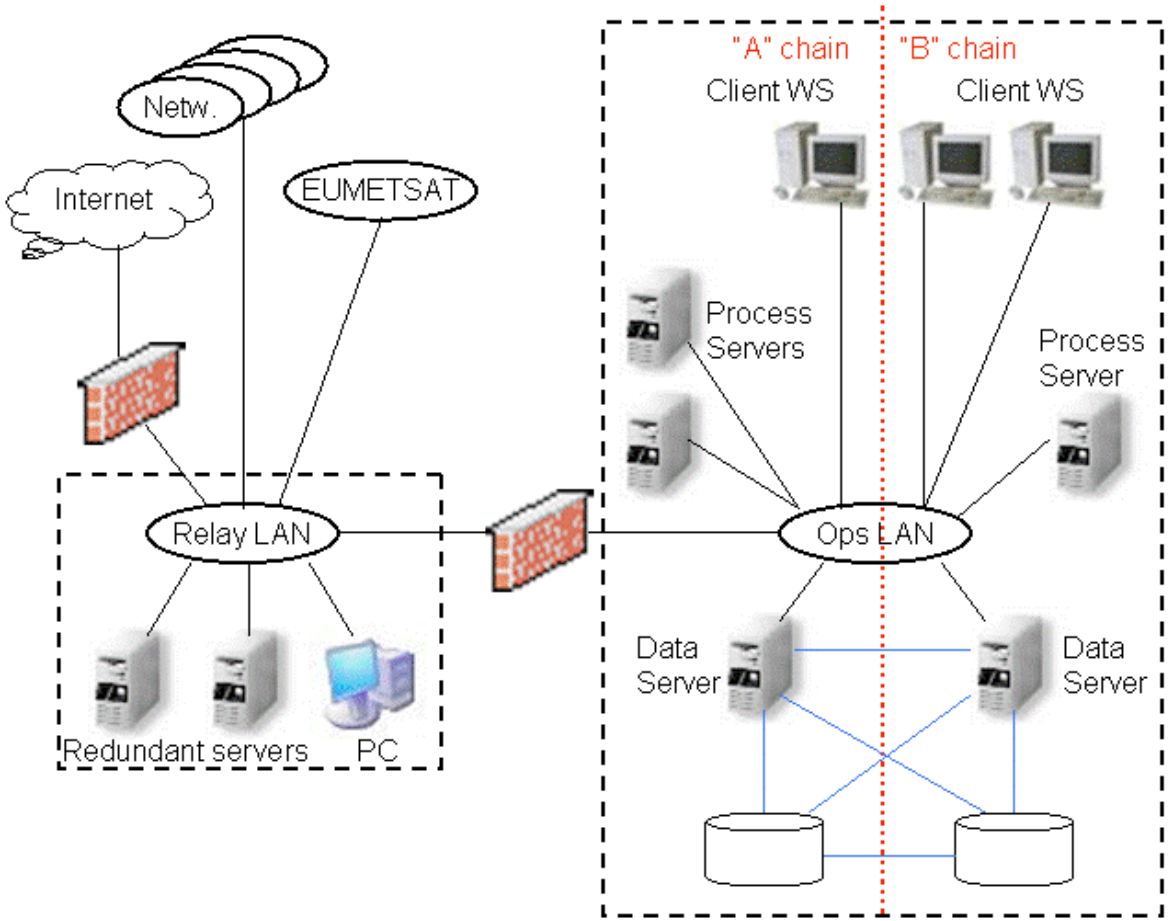
Timing of the clock product generation

- Network data delivered in 15-minute batch files, within 5 minutes after the last epoch
- (Network providers required 98% availability only on the prime sites)
- Wait another minute, then: data preprocessing
- Using already available orbits, batch clock determination for 23 minute arcs (15 + 8 minutes overlap) every 15 minutes
- Dedicated TZD determination batch jobs, also every 15’
- Every minute, submit any new available products to EUMETSAT

Timing of the clock products



Computer infrastructure for GNSS Ops.



The ‘velocity requirement’

- Accurate profiles depend on accurate range rate between the two S/C involved.
- GPS velocity determination requirement:
  Cumulative velocity error drift <7 mm/s over 100 sec
  (i.e. contant velocity bias not relevant)
- Validation: should be compared in inertial frame
- No reference velocities available (IGS)
- Minor offsets in longitude (right ascension) of the test and reference solutions ‘drown’ the signal being checked
- Analysis confirmed requirement ‘almost certainly’ met

Current status

- Integration of the system was completed in May 2005
- Permanent links to network providers November 2005
- Successful validation in February 2006
- Launch of the first satellite (Metop-2) is due 17 July
- Activation of GRAS GSN operations one month prior to launch
- Currently in ‘hibernation’ operations, including automatic delivery of data but without close monitoring

Evolutions

- Software will evolve with improvements coming in the frame of our IGS work
- In particular foresee change from good old Bahn to Napeos
- Network data retrieval can evolve to real-time
- Support of double-difference occultation processing can be implemented easily
- Two more Metop S/C will be coming…
- The GSN can be easily extended to supporting other radio occultation missions ….
- …. and to orbiting multi-system receivers (Galileo)

Acknowledgments are due to:

- Station network providers:

GFZ POTSDAM

FUGRO

Ressources naturelles Canada | Natural Resources Canada

- Météo France Tahiti

For the excellent quality of their support and data products