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On-Ground Demodulation of Navigation Data Bits in GRAS Open Loop Data

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Abstract:

BACKGROUND:
GMV has developed the Ground Processor Prototype 1b (GPP) for GRAS-METOP instrument. The work consisted in the definition, implementation and validation of the algorithms to convert from GRAS level 0 products (CCSDS packets) into level 1b products (bending angle, impact parameter, phase and doppler atmospheric residuals, ...).
When the CNo of the sounding signal is very low, GRAS instrument does not lock the phase tracking loop and provides the open loop data (Raw sampling in GRAS instrument nomenclature).
GPP is also able to process GRAS open loop data and convert it to bending angle.
The benefit of having & processing open loop data is that the atmospheric propertioes can be computed at very low altitudes (i.e. when C/No is very low)
One drawback of the open loop data collected by GRAS is that the navigation data bits of the GPS message (50 Hz rate) are modulated on the I&Q components of the open loop dat (1 kHz sampling rate, nominally). The presence of this bit modulation on the open loop data will distort the final atmospheric measurments and it is needed to compensate for it.
Nowadays, in GPP, the open loop data can be demodulated for those periods when close loop data is simultaneous. This is possible as GRAS instrument can simultaneously provide open loop and close loop data.

However, with this mode, an important part of the open loop data (i.e when no simultaneous close loop data is available) is not used in the processing. This data will correspond with the lowest part of the occultation.
In the frame of the GPP validation, GRAS real data was used. "Real data" means that it comes from an experiment where GRAS was directly connected to a GPS signal simulator. This data has examples of occultations with open loop data modulated with the GPS navigation data bits.

RECENT INVESTIGATION:
By analysing the I&Q open-loop data as it is provided by the receiver, it seems possible to demodulate on-ground the navigation data bits. Promising results have been found with the "GRAS Real" data used for GPP validation. The method is valid even when the close loop data is not simultaneous to the open loop data (i.e when only open loop data is available) and without using any external source of navigation message.
To assess this conclusion, we have compared the new method versus the method based on the use of simultaneous close loop data and the demodulated data complitely matches.
With the available data, and the use of this method, the length of the useful occultation data is enlarged by 4-5 seconds in the lowest part of the occultation, which corresponds to 2-3 km of tracking.

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Overview

- General Background on:
  - Processing tool: Ground Processor Prototype (GPP).
  - Open Loop Data.
- On-ground demodulation of open-loop data:
  - Using simultaneous close loop data
  - New method.
- Presentation of results with the new method for demodulation.
- Summary and Conclusions

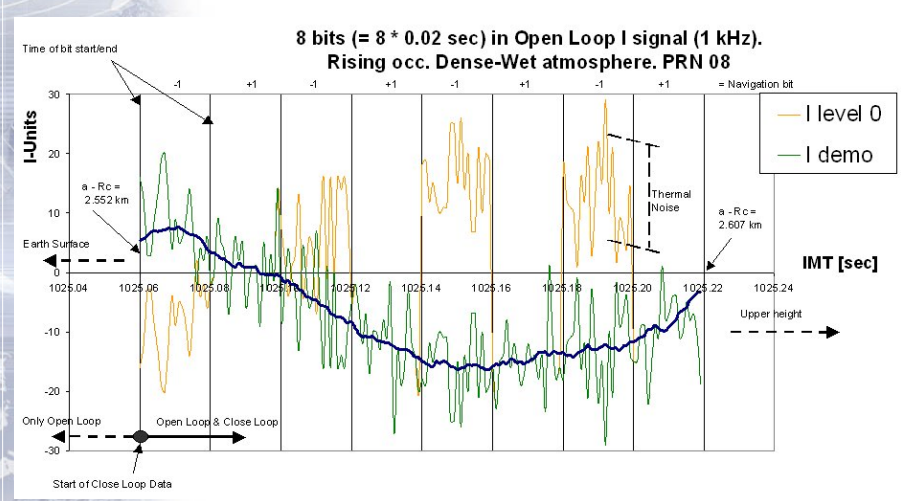
General Background

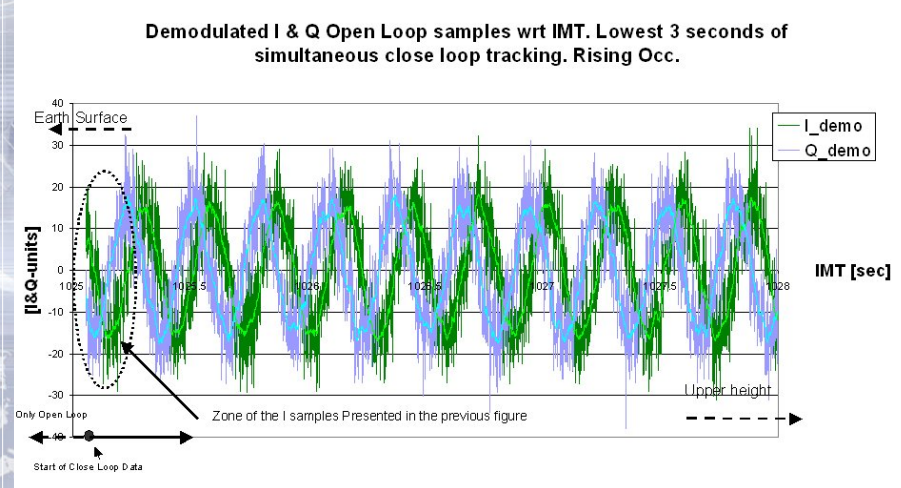
- Ground Processor Prototype 1b (GPP) for GRAS-METOP instrument:
  - From level 0 products (CCSDS packets)
  - To level 1b products (bending angle, impact parameter, phase and doppler atmospheric residuals, ...).
- Open Loop Data:
  - When CNo of the sounding signal is low ⇒ GRAS provides it.
  - Benefit of OL data ⇒ atmospheric properties at very low height
  - GPP also processes OL data and converts it to bending angle (using Back-propagation retrieval method).
  - One drawback of the OL data:
    - navigation data bits (50 Hz) **modulated** on the I&Q phase components (1 kHz)
    - ⇒ it is needed to compensate for it.

On-ground Demodulation

- Current demodulation method in GPP:
  - only in periods when close loop data is simultaneous.
  - ⇒ an important part of the open loop data is not used. This data will correspond with the lowest part of the occultation.
- Investigations on new demodulation method:
  - Data used:
    - GRAS directly connected to a GPS signal simulator.
    - Available open loop data modulated data bits
    - Setting and rising occultations
    - No diffraction effects: dense-wet or thin-dry
  - Method based on self-consistency of I&Q open loop data:
    - **No need of external info**.
    - **No need on simultaneous close-loop samples**.

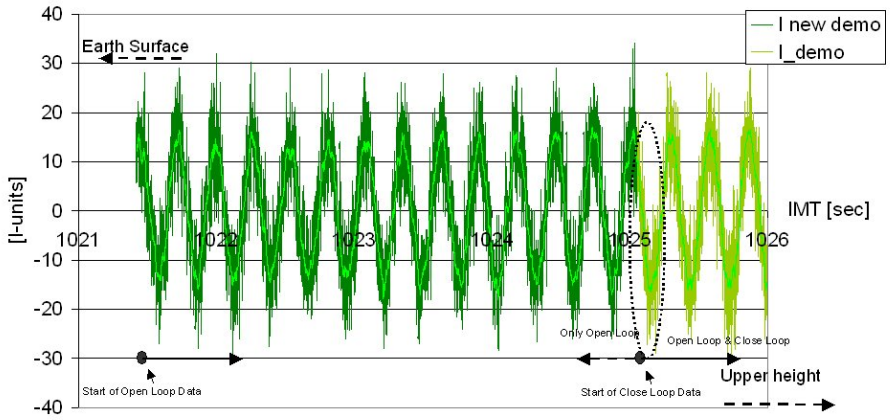
50 Hz modulation on GRAS I/Q data





Performances of new demodulation method (I)

Demodulated Open Loop I data with the new method. No simultaneous close loop data. Rising occultation.



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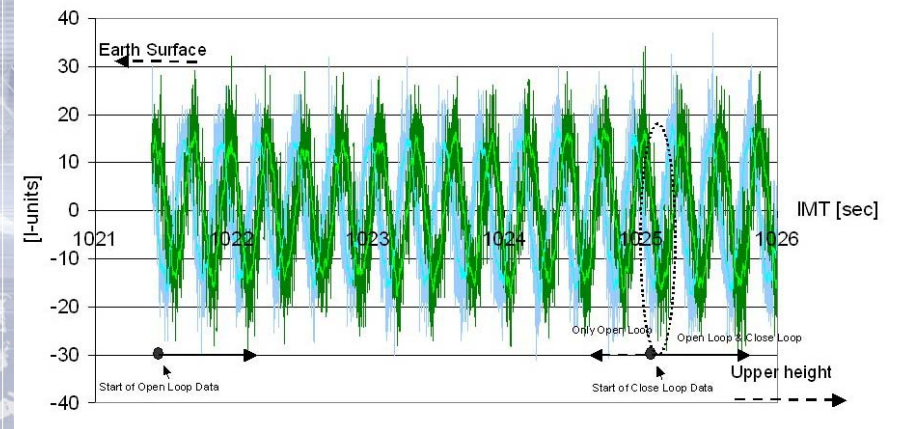
Performances of new demodulation method (II)

Demodulated Open Loop I&Q data with the new method. No simultaneous close loop data. Rising occultation.



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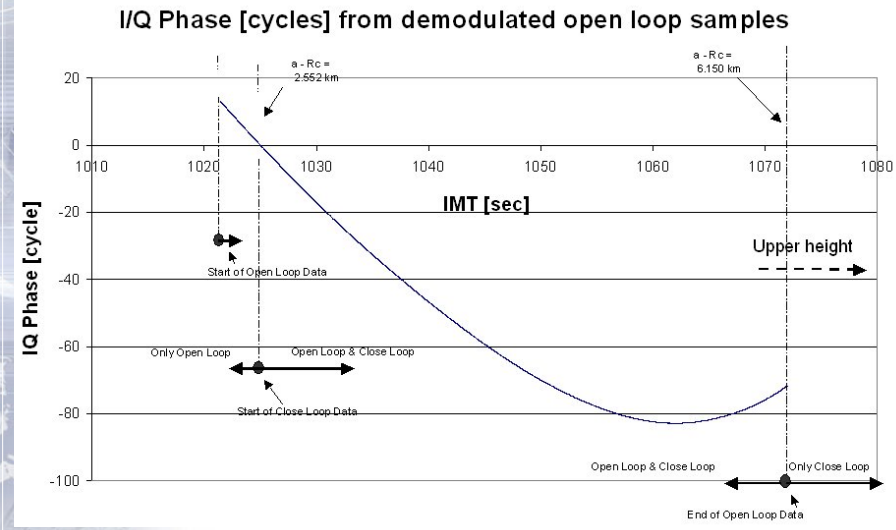

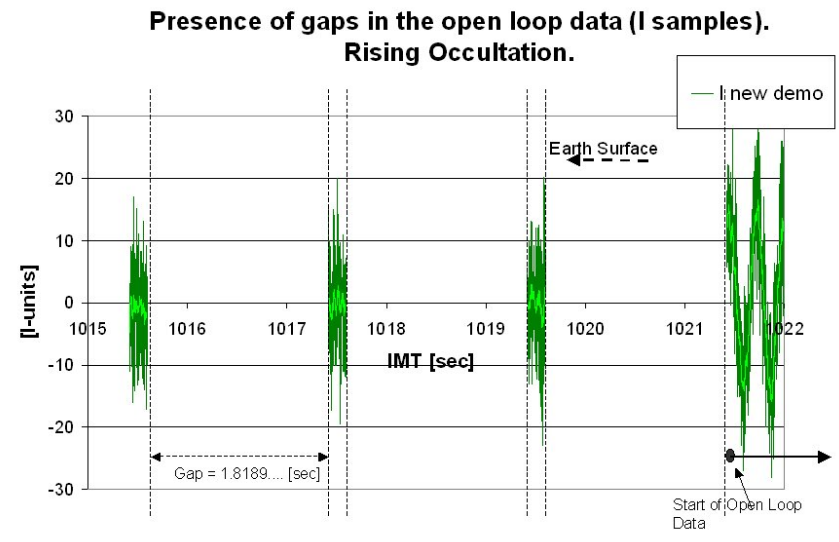

Summary & conclusions

- Currently in GPP, the OL dat is demodulated in zones where OL & CL data are simulatenous.
- In this OL&CL zone, the GRASGPP demodulated(+filtered) OL produce the same carrier phase (and BA) than in CL.
- It seems possible to demodulate on-ground the navigation data bits even in zones where no simultaneous close-loop data is available.
- Promising results have been found with the "GRAS Real" data used for GPP validation:
  - Real GRAS instrument
  - No atmospheric diffraction conditions
- To test the new method: comparison versus the method based on the use of simultaneous close loop data.
- In the analysed occultation: the useful occultation data is enlarged by 4-5 seconds in the lowest part of the occultation to 100-500 m of tracking.
- There is room to improvement & robustness in the new algorithm.