CNES PROCESSING STRATEGY AT THE SERVICE D'ORBITOGRAPHIE DORIS (SOD)

SOD PROCESSING STRATEGY

- The Service d'Orbitographie DORIS
  - is not an institutional entity but part of the orbit determination department
  - is now working within the Altimetry and Orbit Determination ground system SSALTO
- Processing is operational
  - key function is to produce rapid and precise orbits for altimetry missions (TOPEX, Jason, ENVISAT)
  - processes are designed to operate automatically in any condition such as maneuvers and incidents
  - many steps have been added to increase robustness based on previous experience even though they would not be required on a day to day basis

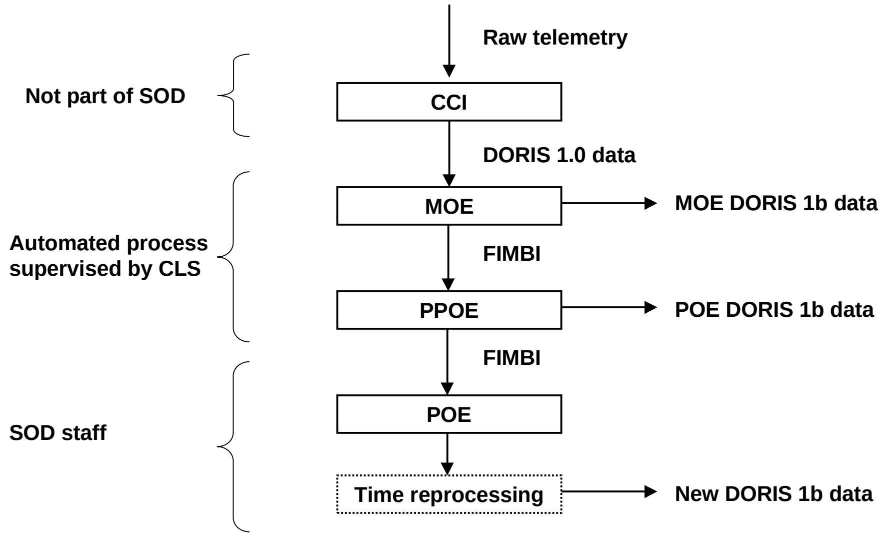
Overview

- Processing is a combination of elementary functions
- Key functions are

GP	• "geometrical" preprocessing which edits data based on elevation angle, length and symmetry of pass, ...
DP	• "dynamical" preprocessing which edits data based on residuals with respect to a "navigation" solution with slant range and timing biases adjusted
OD	• orbit determination which computes orbits with various combinations of adjusted parameters
TD	• time determination which estimates the relation between on-board time and TAI in the form of a polynomial
AI	• auto initialization which estimates initial conditions directly from the DORIS data without any external information
FD	• on-board frequency determination which estimates the on-board USO frequency offset in the form of a polynomial

- Processing chain are mostly a succession of these functions

Overview (2)



CCI

- **Decommutates telemetry to extract DORIS data**
- **Removes data flagged as bad by the receiver**
- **Compute the timetags of DORIS data**
  - **using a predicted ephemeris**
  - **model the time evolution as a polynomial**
    - linear per day or
    - quadratic over 4 days
- **Generates the DORIS 1.0 data products which contain nearly everything**
  - **timetags are provided but not the timing polynomial**
  - **timetags are rounded to the nearest microsecond**

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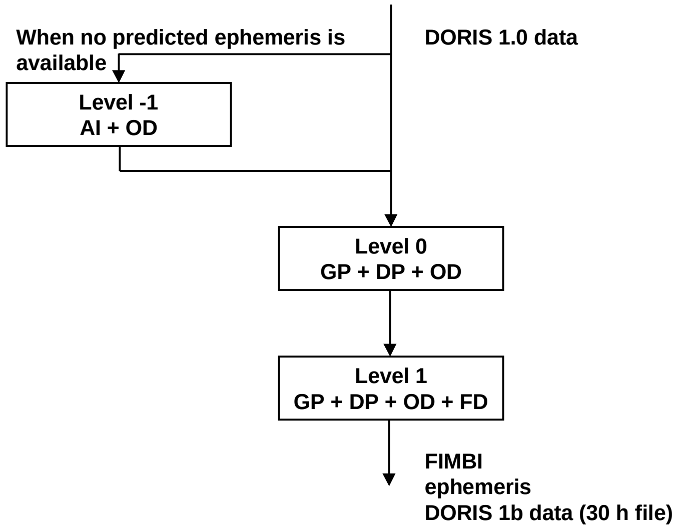
MOE



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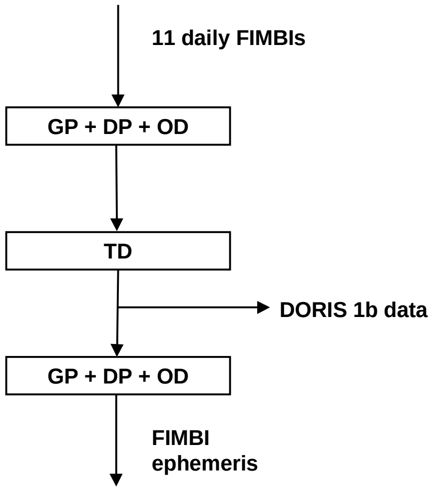
PPOE



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POE and new data

- **The POE is the result of an expert improvement of the PPOE**
  - **based on detailed analysis of residuals and empirical corrections**
  - **includes validation and intercomparison steps**
  - **revision of the delivery data following the POE step are exceptional**
- **An additional step to produce the new data**
  - **P. Willis legitimate request for coherent on-board time and frequency lead to the development of a modified datation function**
  - **this new function will replace the old one in the future**
    - it interacts strongly with the whole processing chain (suppression of the frequency modeling step)
    - it can only be integrated after the commisioning phases for the new satellites
  - **this step requires manual intervention**

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DORIS 1b data

- Key concepts
  - provide data
  - replace dual ionosphere c
  - compatible w
- Key equation
- Key variations
  - origin of the
  - nature of the
  - value of the c

Current CDDIS data (1.0):
- on-board frequency from frequency determination (polynomial)
- beacon frequency from pass solution
- t1, t2 times are TAI
- deltaT = actual TAI count interval (truncated on file)

Proposed revised format (2.0?):
- nominal frequencies
- t1, t2 times are on-board time
- deltaT = exact rounded TAI count interval

Modified revised format (2.1?):
- on-board frequency from timing polynomial
- nominal beacon frequency
- t1, t2 times are TAI (to check)
- deltaT = exact rounded TAI count interval

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Ionosphere correction

- **Derived directly from the dual frequency data**
  - **correction computed for the 2 GHz carrier**
  - **relation slightly more complex than for most dual frequency systems**
    - differences in count interval for "old" receivers
    - large inter frequency bias (10-20 μs)
    - takes into account difference in center of phase location

$$I = \frac{V - \beta V'}{1 - \alpha^2 \beta} - c \frac{\delta f_{beacon}}{f_{beacon}} \frac{(\eta_2 - \eta_1) - \beta(\eta'_2 - \eta'_1)}{(1 - \alpha^2 \beta)\, \Delta T}$$

  - **in practice**
    - the dependency upon the beacon frequency bias is negligible
    - the inter frequency bias does not play a major role
  - **this correction is not exactly the one implemented now**
    - the current formulation leads to results which are incorrect when the frequency bias is not estimated => cannot deliver passes which are completely eliminated

Time determination

- **This is the key difficulty**
  - **the network is not time synchronized as a whole, only two beacons offers time references**
    - a model has to be used to propagate the timing information (fill the gaps)
    - only long term timing is accessible
  - **the quality of the pseudo-range data is poor**
    - precision around 300 m
    - only one frequency transmitted in telemetry
    - asynchronous from phase measurement
  - **reference beacons only provide long term stability**
    - their short term behavior is similar to other beacons
    - their clock behavior is the superposition of short term variablity and long term stability

⇨ **efforts to process orbit and time simultaneously have failed (until now)**

  ⇨ **multi-step approach orbit -> time -> orbit -> time -> orbit !**

Data format issues

- **Measurement principle has changed drastically between generations**
  - **difficult to find common ground between old and "miniaturized" receivers**
    - old receivers: exact integer phase, uncertain time
    - miniaturized receivers: exact times, uncertainty on phase
  - **the current format is one of the only good compromises**
    - moving to a "rawer" format wil probably generate a schism
- **The relation between on-board time and TAI is a key concern**
  - **it is computed relatively late (during POE processing)**
  - **it depends upon the arc over which it has been computed**
    - thus it exhibits discontinuities and breaks in slope at arc boundaries

The RINEX data format

- An old issue ! But receiver independence is truly required now with all the generations of receivers in flight
- GPS-like Doppler version proposed two years ago
  - problem with timing information (but new solution proposed)
  - looses editing and correction informations
  - not suited for new receivers (fields for opening and closing offsets are not needed)
  - limited interest from the users group which met at CNES
- New receivers are better suited for phase GPS-like format
  - as long as continuous tracking remains in effect
  - requires different files for phase and pseudo-range measurements
  - no editing and correction informations
- Handling of meteo data is difficult
  - ideally reuse RINEX MET format with combination of all satellite for a given day
  - difficult to produce and to use

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Conclusion

- The difficulties in defining a data format reflect the inherent processing difficulties
  - the data are not self sufficient: a model has to be used to produce timing information
  - timing and orbit cannot easily be solved for in a single step
- The key defficiency of the current format has to do with how this timing/frequency issue is handled
  - it can only be solved if users perform their own timing solutions (adapted to their processing strategy)
  - are users ready to go through this added burden ?
- Adding the timing correction and pseudorange data on the side could be the solution
  - but will any one really process the added information ?
- Everything else is details that can easily be fixed
  - chronological sorting versus passes, day files versus cycles, etc.

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