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IN RADAR ALTIMETRY SYMPOSIUM

IDS WORKSHOP

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ARCHITECTURE FOR A COMBINED DORIS-GNSS RECEIVER

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Introduction, context

Precise Orbit Determination (POD) missions frequently use both DORIS and GNSS measurements made by **two different receivers using different time generators**.

These systems are very accurate, but also very expensive, and have heavy mass-consumption-volume (MCV) requirements.

Their calibration at the cm level can be tricky

On the other hand, ground infrastructures for DORIS are bound to be operational and maintained until the end of the last planned mission today, i.e. Sentinel3D by 2033

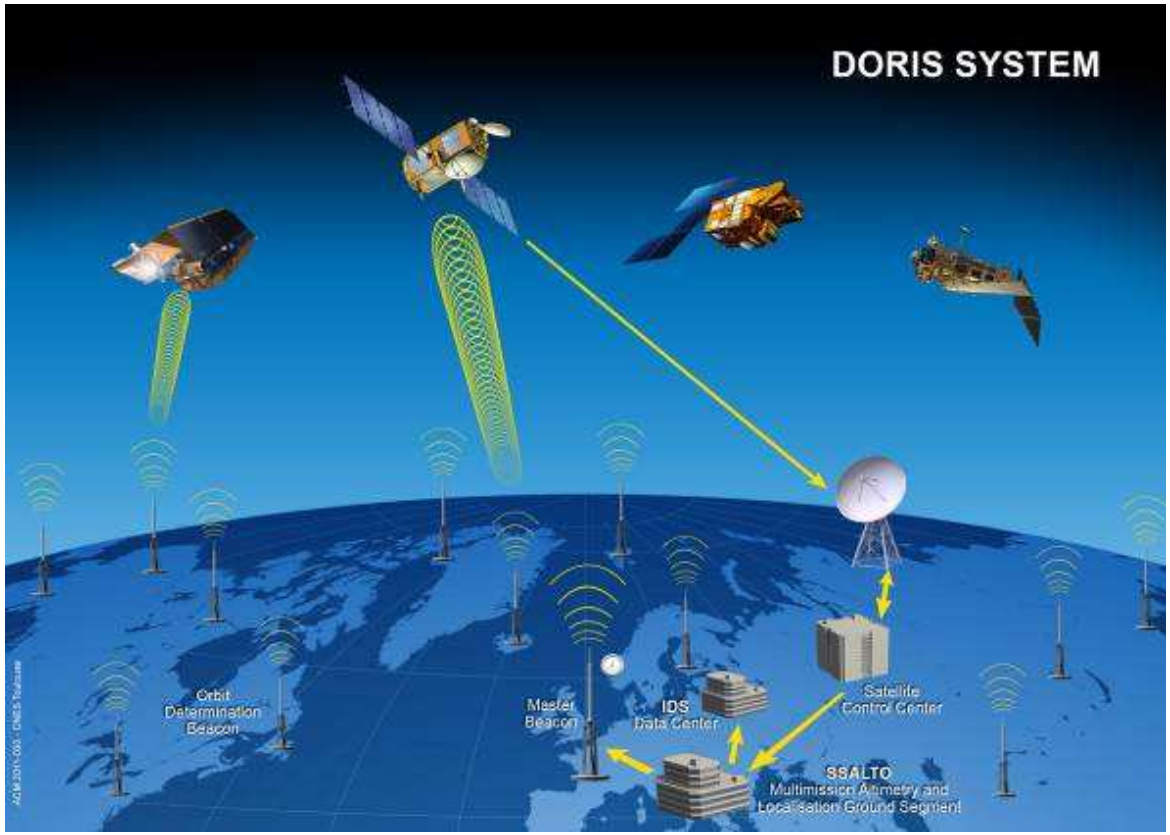
… and GNSS too ☺

DORIS system : overall concept

> Designed in early eighties for precise orbit determination of ocean altimetry missions

> Based on Doppler shifts measurements of RF signals transmitted by a world wide beacons network

> Accuracy :
0,3 mm/s ≈ 3mm



> There is no limitation for the number of satellites carrying DORIS receivers

Re-conception of the DORIS receiver

Current receivers derive basically from a 2000 conception

A deep re-conception of DORIS receivers becomes useful, taking into account recent years evolutions of on-board technologies (electronics, GNSS technologies, ...).

> New RF and NUM components are now available, designed for on-board applications and conceived to implement a wide set of functionalities, using Software Define Radio (SDR) solutions.

Such a POD receiver needs to be carefully examined wrt accuracy specifications as well as MCV and costs requirements, in order to define optimal hardware and software architectures based on these new components and SDR technologies.

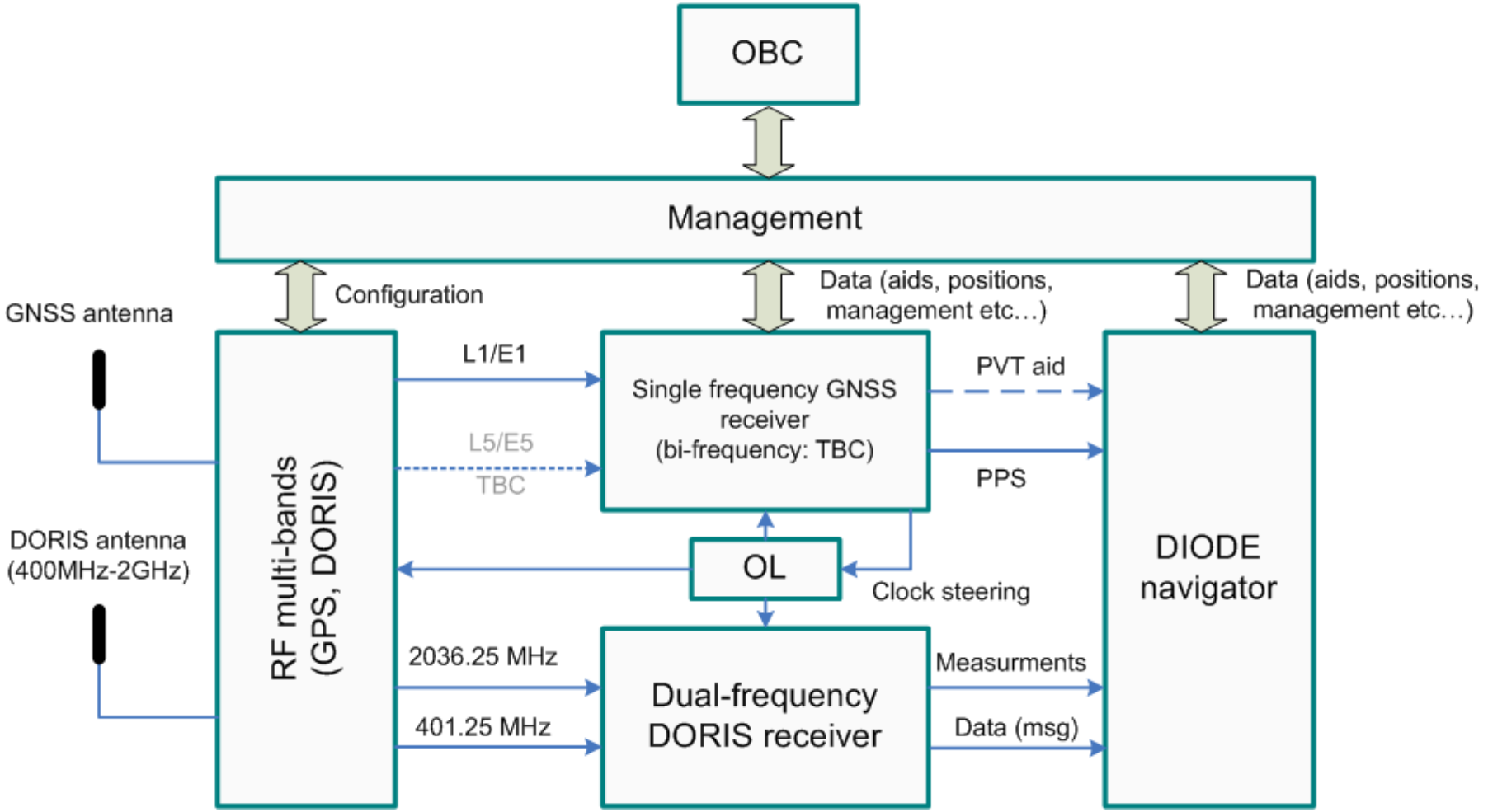
Study for architecture of a new twin DORIS-GNSS receiver

This study aims at defining an architecture for a receiver using both DORIS and GNSS signals, based on SDR and presenting a MCV and cost significantly reduced with respect to current DORIS or POD GNSS receivers.

- study the feasibility for DORIS or GNSS receivers, parts or total,
- evaluate the complexity of integrated functions, potentially common to both DORIS and GNSS receivers,
- identify the possible impact on performances of such an implementation,
- quantify the improvements in terms of mass-consumption-volume and cost (prototype or series),
- in a second phase, if feasibility is shown, realize a prototype of critical functions.

The new design is based on a common on-board clock (next slide)

Architecture : preliminary definition



Hybridization design

Several possibilities, current design choice =

- T/F given by GNSS,
- orbit determination by DORIS

GNSS Time&frequency observability, will provide DORIS with a permanent information (next slide). GNSS Time determination is a standard now.

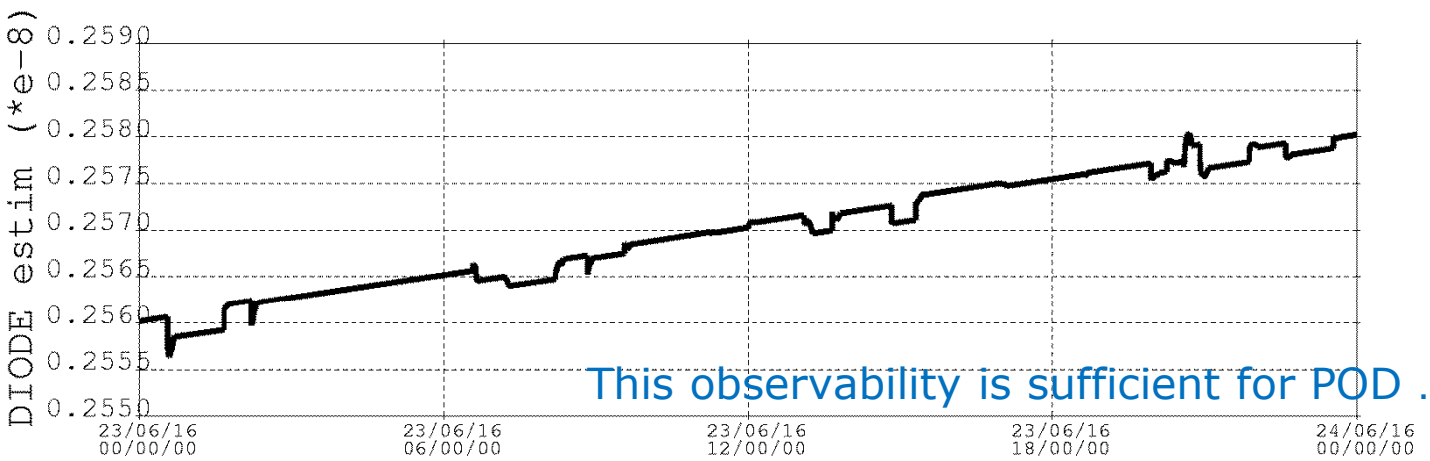
On-board orbit determination in real-time, at the few centimeter level : possible using DORIS phase/delta Phase measurement only

Later possibly add GNSS phase/delta Phase measurement processing

Hybridation design

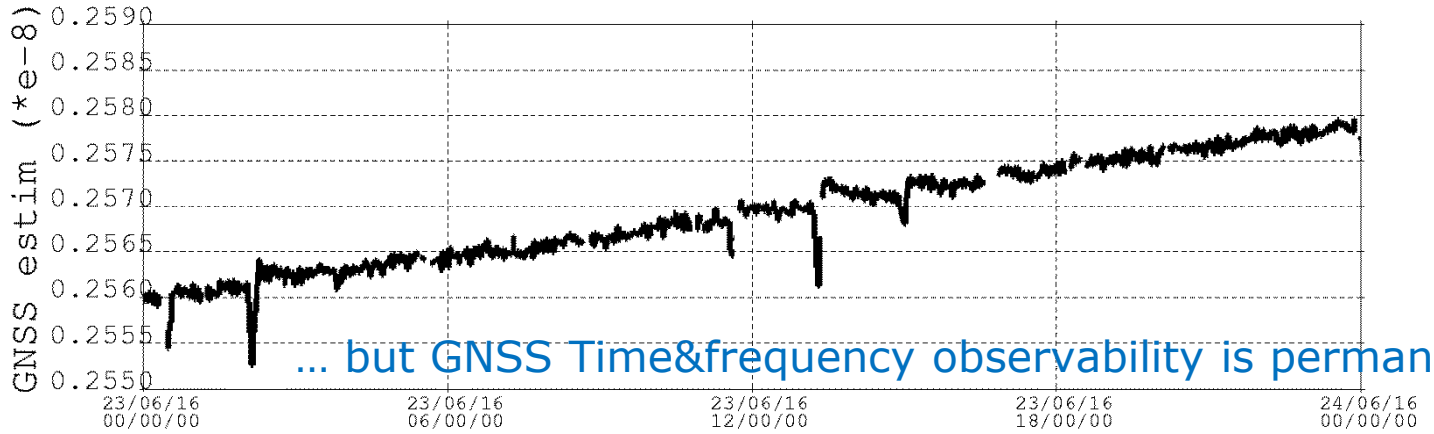
Time&frequency better seen by GNSS

Upper plot, computation of the DORIS on-board USO frequency as seen by **DORIS/DIODE** through processing of Time &Frequency Reference beacons



This observability is sufficient for POD …

Lower plot, as seen by **GNSS**



… but GNSS Time&frequency observability is permanent

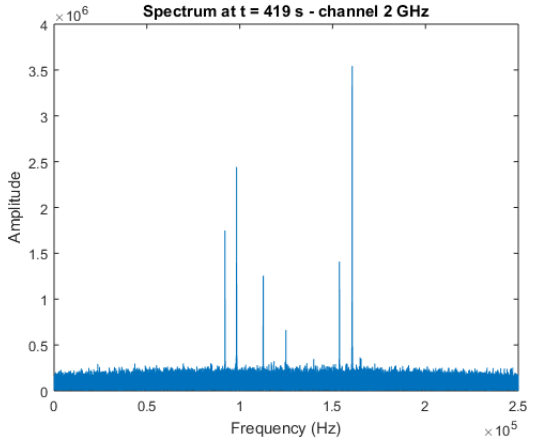
Tests performed

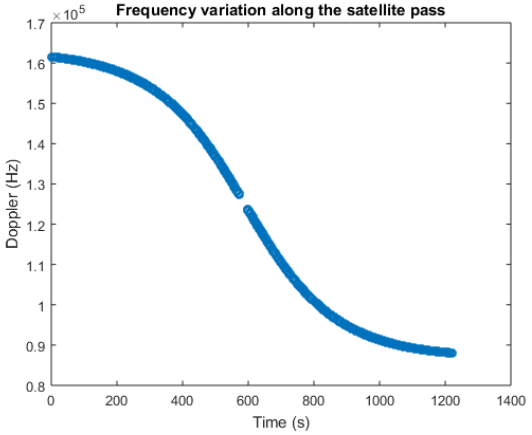
Tests performed at the DORIS laboratory, July 2018, 4th -> 6th

- Simulation by the DORIS EGSE of RF emissions
- Tracking phase measurements and Beacon messages, data recorded by a dedicated card (and also by a classical DORIS receiver in order to perform comparisons)
- Phase loops implementation and tuning,

Then navigation accuracy may be checked

Test results : beacon tracking along the pass

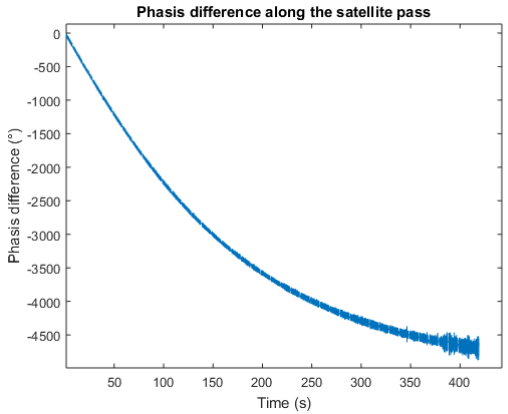


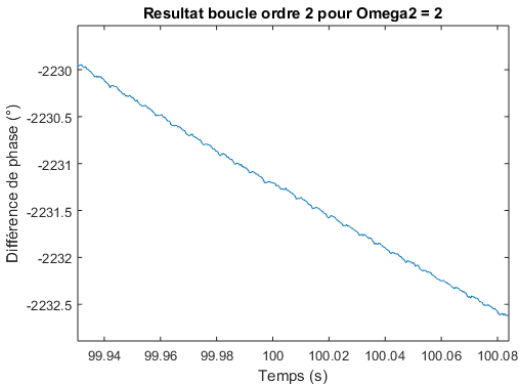


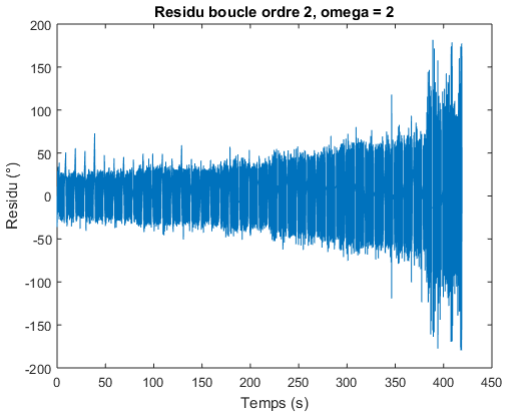
Beacons are successfully detected along the pass of the satellite

- Robustness regarding collisions of beacons and false detections
- Frequency is estimated at each iteration (1s)
- Rough phase is deduced
- Demodulation of navigation message was implemented in order to retrieve beacon IDs and to get another timing reference

Tracking loop applied to the phase difference







In open-loop, without ultra-tight coupling, second order phase-locked loops are sufficient to :

- Obtain an accurate phase estimation (<0.1 °)
- Without observing any pursuit effect on the phase residue

Phase measurements at specific timing are then retrieved and used as an input to DIODE, through an intermediate file.

An on-going improvement consist in the ultra-tight coupling with the on-board navigator to reduce the tracking dynamics and improve the tracking quality.

Main goals for such a twin receiver

Main goals for such a receiver are :

- significantly **reduce the cost** of such a system (wrt to current DORIS-GNSS separate design), in order to allow access to new missions,
- reduce MCV requirements in order to **facilitate integration** on smaller space platforms.

- This twin receiver will bring an interesting alternative between existing configurations :

Real-Time accuracy = a few meters

Simple GNSS receiver

Twin receiver (under study)

Real-Time accuracy = a few centimeters

Complex and Accurate DORIS receiver for POD

Complex and accurate GNSS receiver for POD

Systems complementarity

The study goes on next year, in order to produce an EM prototype.

GNSS and DORIS coupled in real-time processing should improve the efficiency (initialisation delays, observability, reduction of error sources, ...)

Ground computations in POD programs will also benefit from having both systems coupled (only one clock controlled wrt GNSS time)

INDEPENDENCE of DORIS and GNSS solutions : is it a problem for scientific users ?

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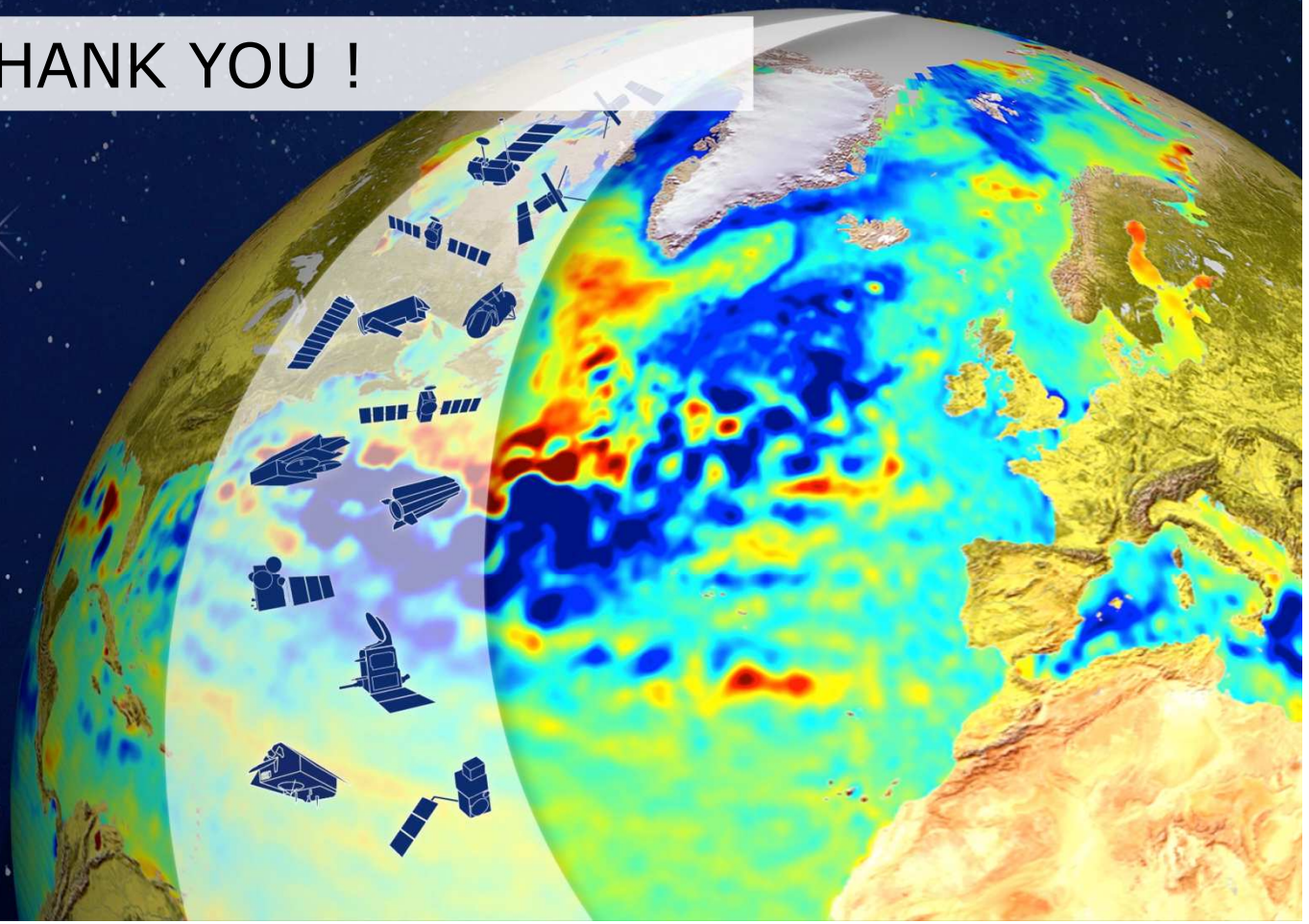
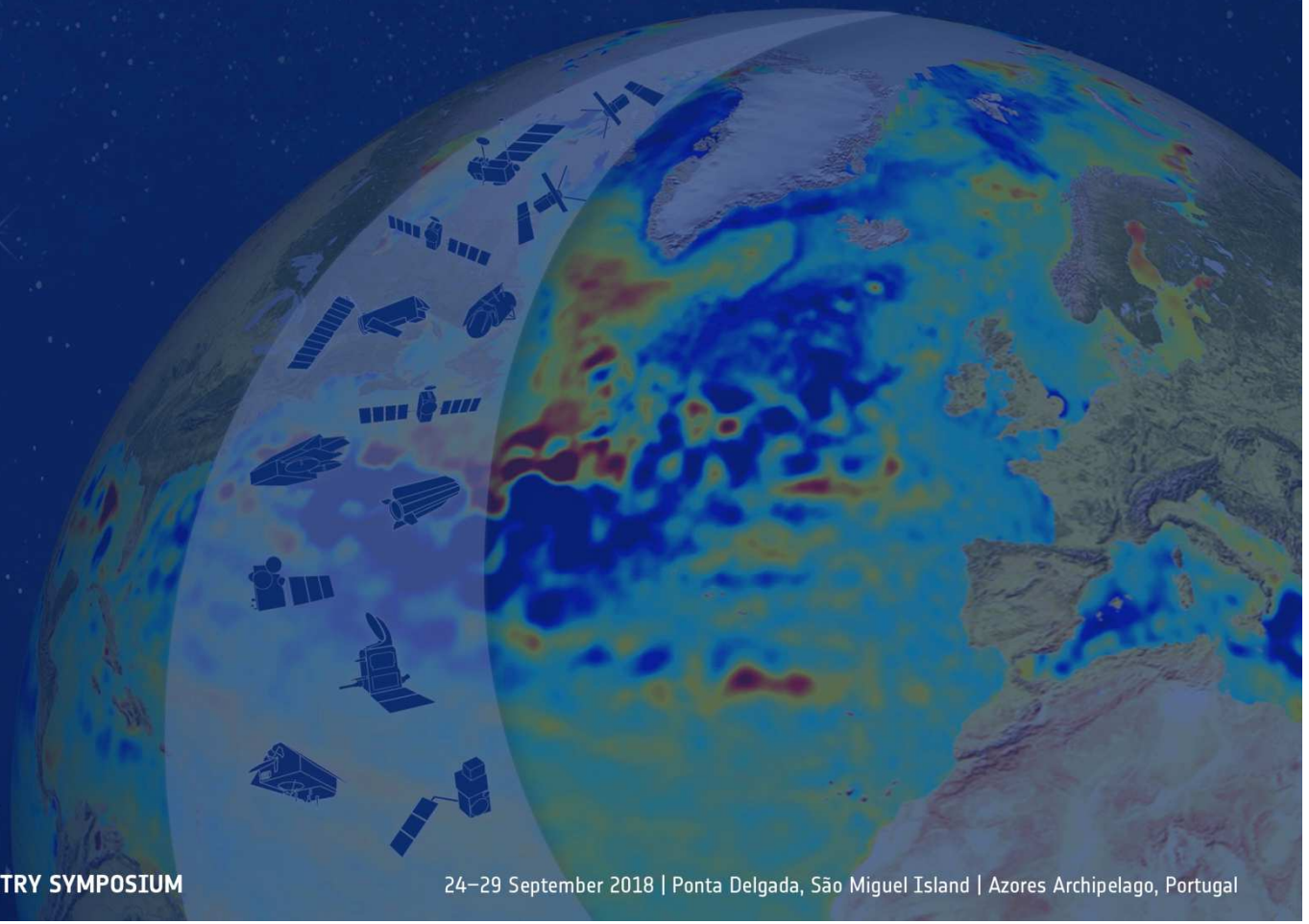
THANK YOU !



(back-up slides)



Abstract

ARCHITECTURE FOR A COMBINED DORIS-GNSS RECEIVER

(Christian Jayles, Thierry Robert, Jean-Pierre Chauveau, Olivier Dumond, Cécile Manfredi)

Precise Orbit Determination (POD) missions frequently use both DORIS and GNSS measurements made by two different receivers using different time generators. These systems are very accurate, but also very expensive, and have heavy mass-consumption-volume (MCV) requirements.

A deep re-conception of DORIS receivers becomes useful, taking into account recent years evolutions of on-board technologies (electronics, GNSS technologies, ...). New RF and NUM components are now available, designed for on-board applications and conceived to implement a wide set of functionnalities, using Software Define Radio (SDR) solutions. These components and SDR solutions have already been studied in details, suggesting their possible use for such a GNSS / DORIS receiver. Nevertheless, such a POD receiver needs to be carefully examined wrt accuracy specifications as well as MCV and costs requirements, in order to define optimal hardware and software architectures based on these new components and SDR technologies.

This study aims at defining an architecture for a receiver using both DORIS and GNSS signals, based on SDR and presenting a MCV and cost significantly reduced with respect to current DORIS or POD GNSS receivers. The goals are many :

- study the feasibility for DORIS or GNSS receivers, parts or total,
- evaluate the complexity of integrated functions, potentially common to both DORIS and GNSS receivers,
- identify the possible impact on performances of such an implementation,
- quantify the improvements in terms of mass-consumption-volume and cost (prototype or series),
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Main goals for such a receiver are :

- significantly reduce the cost of such a system, in order to allow access to new missions,
- reduce MCV requirements in order to facilitate integration on space platforms.

For the future, GNSS and DORIS systems are complementary and their association in real-time processing should improve the efficiency of independant solution (initialisation delays, observability, reduction of error sources, ...)