First POD Results on HY-2C

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Virtual Meeting
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INTRODUCTION

1. MOE/POE Configuration
2. Attitude
3. Empirical Accelerations
4. SLR Validations

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1. MOE/POE Configuration
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Operational processing

- *POE-F dynamic and measurements standards* (e.g., same as Sentinel-3A/B and Jason-3).
  - Nominal attitude (see next section).
  - Updated Solar Radiation Pressure macromodel (IDS box-wing) with respect to NSOAS Input Data for HY-2C POD.

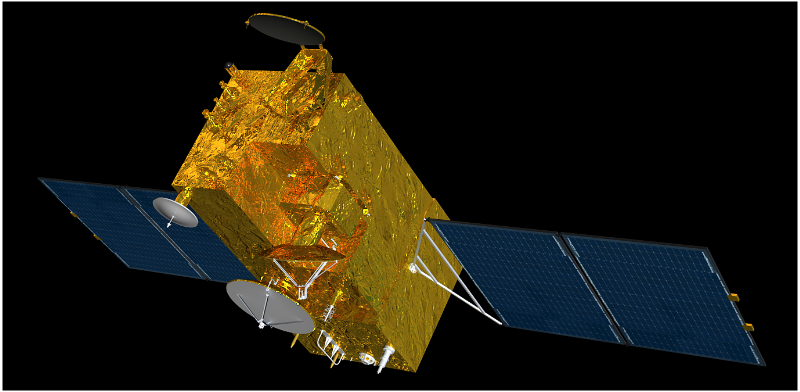

FIGURE : Artist's view of HY-2C.

Operational processing

- MOE/POE DORIS+GPS reduced-dynamic orbits.
  - MOE : GPS measurements available since November 20, 2020.
  - POE : GPS measurements available from cycle 007.

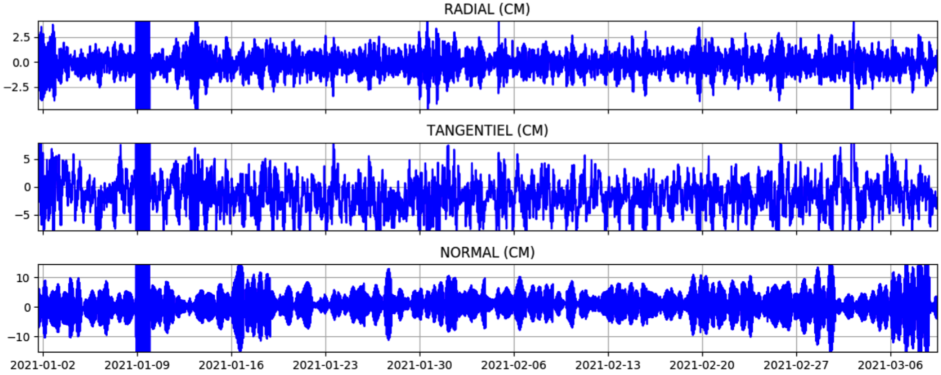

FIGURE : HY-2C MOE - POE orbits.

1. MOE/POE CONFIGURATION

Operational processing

- MOE/POE DORIS+GPS reduced-dynamic orbits.
  - GPS ambiguities can be fixed with a high rate (above 99%) in the POE orbits.
    $\Rightarrow$ Good behavior of the GPS receiver.

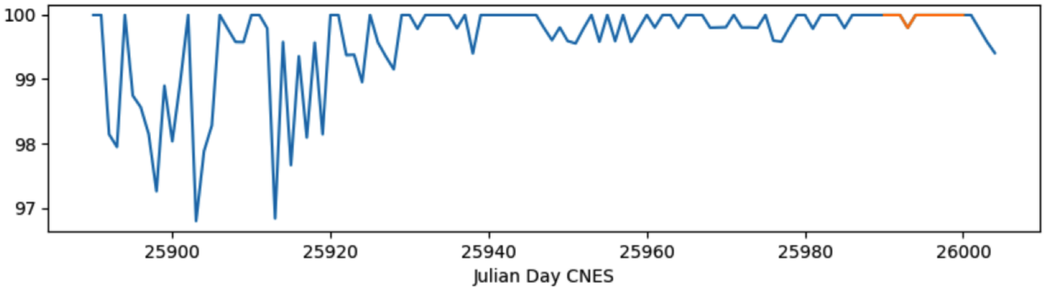

FIGURE : Fixing rates of GPS ambiguities for HY-2C.

1. MOE/POE Configuration

❖ Operational processing

➢ MOE/POE DORIS+GPS reduced-dynamic orbits.

- Updated GPS/DORIS PCO : $+2\ \mathrm{mm}$ in X, $-10\ \mathrm{mm}$ in Y and $+18\ \mathrm{mm}$ in Z directions.

  $\Rightarrow$ Having now access to a larger time span, the X offset can be neglected, SRP mismodeling signatures are well observed in Y and could partly explain the $-10\ \mathrm{mm}$ bias, and the Z offset can be rounded to $+20\ \mathrm{mm}$.

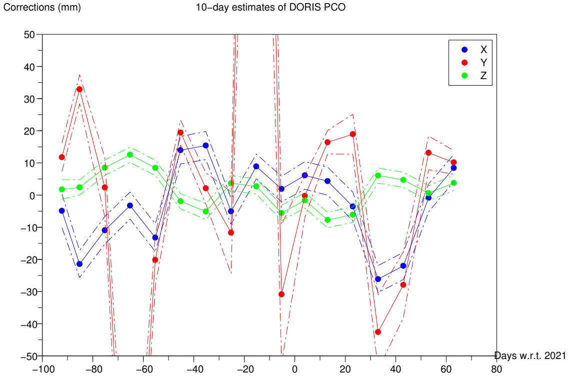

FIGURE : 10-day estimates of DORIS PCO.

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HY2C ATTITUDE

The description of the attitude is given in the documentation
(`HY2C_InputDataForPOD.pdf` at IDS)
but some points are missing :

- exact definition of the attitude transition events

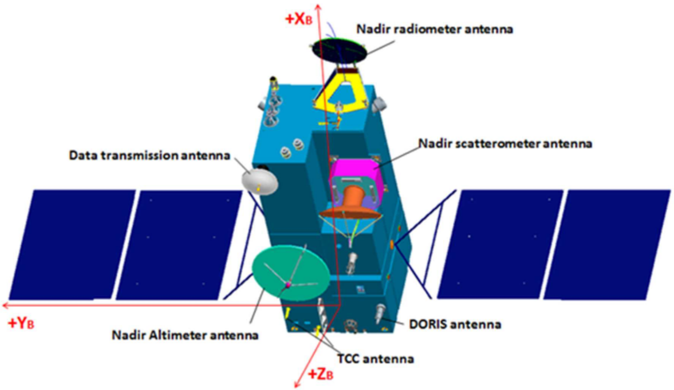
- solar array pointing definition

Presentation of the attitude characteristics

Some anomalies observed in flight, possibly due to the current attitude definition.

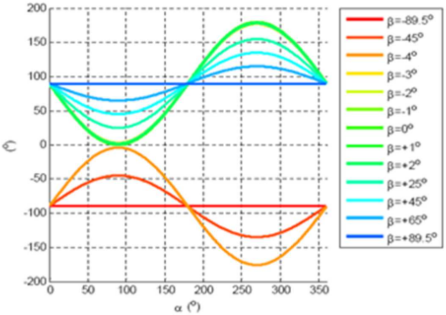
HY2C GEOMETRY

Sattellite axes definition



The attitude is a yaw steering attitude (like Jason or GPS satellites)
yaw rotation around the radial axis (z)
$-x$ axis pointing towards the sun.

HY2C ATTITUDE, DOCUMENTATION



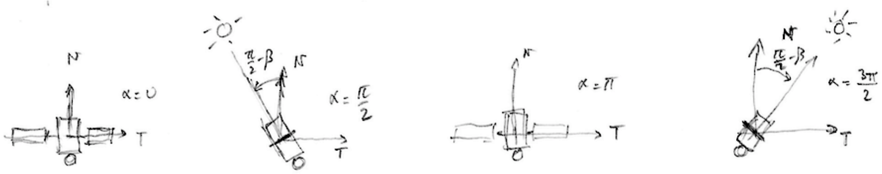
The nominal attitude of the satellite uses yaw steering model, with the X- axis pointing towards the sun and the Z+ axis pointing towards the earth surface. The specific yaw steering model is as follows (where $\beta_{\min}$ =-1.5°, $\beta_{\max}$ =75°) :

$$\psi_T = \begin{cases} \frac{\pi}{2}\operatorname{sgn}(\beta), & |\beta| > \beta_{\max} \\ \psi_{2T}, & \beta_{\min} < \beta < \beta_{\max} \\ \psi_{1T}, & -\beta_{\max} < \beta < \beta_{\min} \end{cases}$$

ψ is the yaw angle.

HY2C, YAW STEERING $\beta > 0$

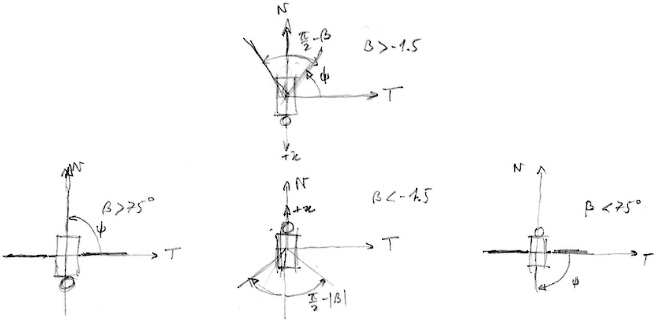
α : orbital angle, referenced to the sub-solar point
β : solar angle (sun direction relative to orbital plane)
ψ : yaw angle, here counted >0 from T to N (different from the documentation conventions)



$$\psi = (\frac{\pi}{2} - \beta) sin\alpha + \frac{\pi}{2}$$

Oscillation at orbital period around the normal axis N
The sun direction is performing a conical movement around N axis, with an angle $\frac{\pi}{2} - \beta$
The solar array is supposed to have a similar law, the angle is supposed to be proportional to $(\frac{\pi}{2} - \beta) cos\alpha$ (same amplitude as the yaw steering).

HY2C, DIFFERENT TRANSITIONS



$\beta > 75°$
fixed yaw

yaw steering
transition at -1.5°

$\beta < 75°$
fixed yaw

These transitions correspond to the documentation definitions, to have a continuous attitude the transitions must be at :

- $\alpha = \dfrac{\pi}{2}$ or $\dfrac{3\pi}{2}$ for the -1.5° transition (when the satellite x axis is parallel to the T axis)
- $\alpha = 0$ or π for the -75° and 75° transitions (when the satellite x axis is perpendicular to the orbital plane)

EFFECT OF AN ERROR IN THE TRANSITION EPOCH

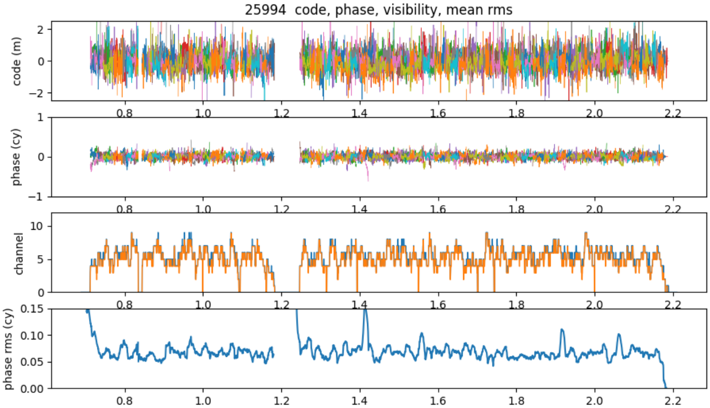
The transition is supposed to occur at the next allowed orbital position after crossing the β transition value.

If the transition epoch is erroneous, there will be some specific errors in the center of phase location.

- for high β, the effect for Doris will be oscillations along track (x offset) and cross track (y offset).

- for $\beta = -1.5°$, the effect is mainly in the normal axis N, but very important (a bias and a 2/rev term with a sign change for the x offset).

Observations on GPS processing (1)



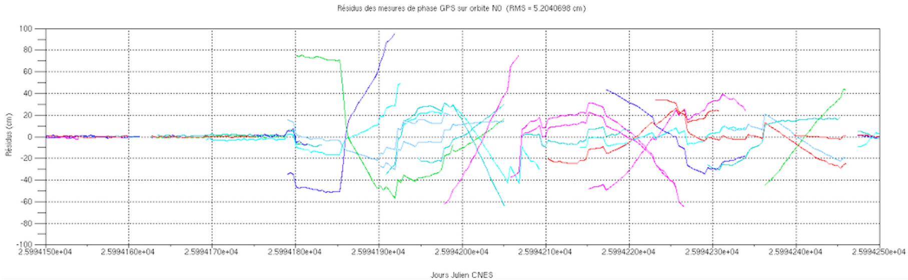
In this case, $\beta = -1.5°$ occurs around 25993.7

The GPS measurement anomalies occur near $\beta = -2.9°$ (12 hours later)

These anomalies are due to important outliers removed by the preprocessing.

Observations on GPS processing (2)

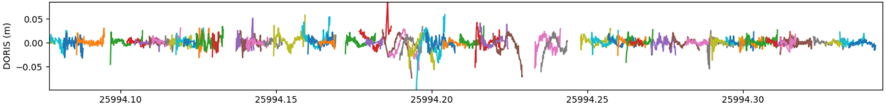
GPS phase residuals before outliers eliminations :



There is a clear signature in the residuals, beginning at 25994.185 (GPS measurements interruption), not explained, probably due to an erroneous attitude (transition or other event).

This has to be investigated further, to search also for a possible anomaly around $\beta = -1.5°$.

OBSERVATIONS ON DORIS PROCESSING (2)



There are also anomalies in the Doris residuals, around 25994.2, corresponding to the same perturbation as GPS.

Conclusion

The HY2C attitude can be constructed using the data in the documentation and some added hypotheses (mainly the solar array pointing law). The transitions epochs are not precisely defined.

Between the transitions this attitude model works well.

Observation of anomalies in some arcs around $\beta = -1.5°$, probably due to a bad transition epoch. This has to be investigated further.

Also check the other transitions ($\beta = 75°$ and $\beta = -75°$).

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❖ POE orbits

➢ Stable behavior of the adjusted *empirical accelerations*.

- Bias in the constant along-track accelerations at the beginning of the mission (outgassing ?).
- No clear signature linked to the evolution of the beta angle.

⇒ Dynamic models (e.g., drag & Solar Radiation Pressure) are correct.

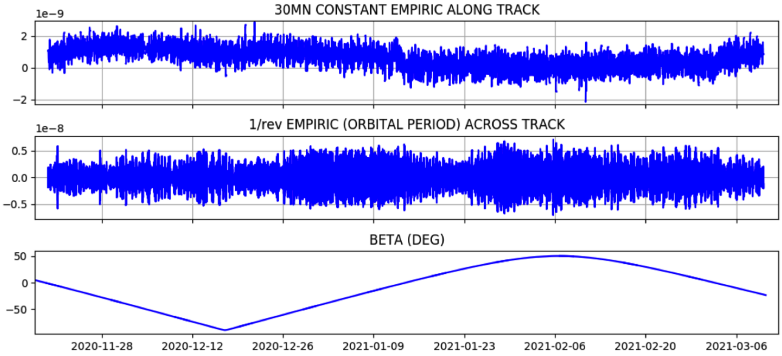

FIGURE : Empirical accelerations and beta angle for HY-2C.

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POE orbits

- SLR *core network* (7090, 7105, 7810, 7839, 7840, 7941, 7119, 7501).
  - Few measurements at high elevations.
  - Better than $1\ \mathrm{cm}$ RMS performance of the DORIS+GPS reduced-dynamic orbits.

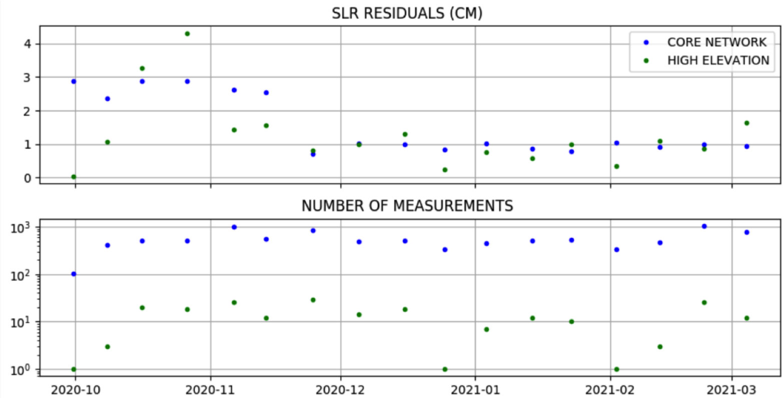

FIGURE : SLR residuals and tracking for HY-2C.