

MINUTES OF MEETING

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Project:	Copernicus Sentinel-1, -2 and -3 Precise Orbit Determination Services
Meeting:	CPOD – Quality Working Group #10
Date:	23 March 2021
Place:	Virtual Webex meeting
Secretary:	H. Peter / PosiTIm UG

ATTENDEES	
Name/Company/Signature	Name/Company/Signature
Pierre Féménias (PF) / ESA-ESRIN	Daniel Arnold (DA) / AIUB
Yago Andrès (YA) / EUMETSAT	Pieter Visser (PV) / TU DELFT
Jaime Fernández (JF) / GMV	Wim Simons (WS) / TU DELFT
Heike Peter (HP) / PosiTIm	Cyril Kobel (CK) / AIUB
Martin Wermuth (MW) / DLR	Bruno Lucas (BL) / EUMETSAT
Marc Fernández (MF) / GMV	Franck Borde (FB) / ESA-ESTEC
Bingbing Duan (BD) / TUM	Hugues Capdeville (HC) / CLS
Francesco Gini (FG) / ESA-ESOC	Patrick Schreiner (PS) / GFZ
Alexandre Couhert (AC) / CNES	Pascal Perrachon (PP) / CNES
Carlos Fernández (CF) / GMV	Adrian Jäggi (AJ) / AIUB
Oliver Montenbruck (OM) / DLR	Javier Berzosa (JB) / GMV
John Moyal (JM) / CNES	Denise Dettmering (DD) / DGFI-TUM
Flavien Mercier (FM) / CNES	René Zandbergen (RZ) / ESA-ESOC
Rolf König (RK) / GFZ	Roberto Pastor (RP) / GMV
Urs Hugentobler (UH) / TUM	Eléonore Saquet (ES) / CLS/CNES
Maurizio Cao (MC) / serco a.m.	Abderrazak Bouridah (KB) / ESA-ESTEC
Carolina Nogueira Loddo (CN) / EUMETSAT	Luning Bao (LB) / GMV
Florian Reckeweg (FR) / ESA-ESOC	Frank Lemoine (FL) / GSFC-NASA p.m.
Javier Berzosa Molina (JB) / GMV	Stefan Schaer (SS) / AIUB p.m.
Miguel Angel Munoz (MA) / GMV	Pablo Garcia (PB) / isardSAT a.m.
Sebastiano Padovan (SP) / EUMETSAT	Xinyuan Mao (XM) / AIUB
Stefan Hackel (SH) / DLR p.m.	

Attachments

- Annex01: 01_Copernicus POD_QWG10_20210323_agenda_final.pdf
- Annex02: 02_QWG10_GMV_Status of the Copernicus POD Service.pdf
- Annex03: 03_QWG10_GMV_Sentinel-1 Reprocessing Campaign.pdf
- Annex04a: 04a_QWG10_GMV_Sentinel-3 USO Clock Analysis.pdf
- Annex04b: 04b_QWG10_isardSAT_S3MPC USO study.pdf
- Annex04c: 04c_QWG10_CNES_S3A, S3B, S6 clocks analysis.pdf
- Annex04d: 04d_QWG10_TUM_S3A_clock.pdf

Annex05: 05_QWG10_TUM_Dettmering_Sentinel-3 orbit validation by means of altimetry Xover analysis.pdf
 Annex06: 06_QWG10_AIUB_SLR Bias Determination Study.pdf
 Annex07: 07_QWG10_GMV_Review of AI and Recommendations.pdf
 Annex08: 08_QWG10_DLR_S6A_Intro_PODRIX.pdf
 Annex09: 09_QWG10_CNES_Status S-6 processing at CNES.pdf
 Annex10a: 10a_QWG10_DLR_S6A_MultiSignal.pdf
 Annex10b: 10b_QWG10_CNES_S6 RUAG receiver ambiguity fixing.pdf
 Annex10c: 10c_QWG10_AIUB_CODE clock and phase bias analysis products.pdf
 Annex11: 11_QWG10_ESOC_S6A_POD_Status.pdf
 Annex12: 12_QWG10_EUM_S6_ROPOD_Receiver.pdf
 Annex13a: 13a_QWG10_POSITIM_Peter_S6APOD_QWG_summary.pdf
 Annex13b: 13b_QWG10_AIUB_Sentinel-6A orbits with BSW - I14 vs R20.pdf

Agenda	Distribution List
<p>(details see Annex01 attached)</p> <ol style="list-style-type: none"> 1. Welcome and purpose of meeting 2. Status Copernicus Service 3. Sentinel-1 reprocessing 4. Sentinel-3 USO/clock analysis 5. Altimetry cross-over analysis 6. SLR bias determination study 7. Review of AIs and recommendations 8. Status of GNSS receiver tracking and tracking tests 9. Status S-6 processing at CNES 10. Handling of different GNSS signals – impact on integer ambiguity resolution 11. GPS, GAL or GPS+GAL – Single or combined processing 12. Status and first results from GNSS-RO POD (TRIG) receiver 13. Summary of S-6 POD results from QWG 	<p>Attendees</p> <p>+ copernicuspod@gmv.com + berthyl.duesmann@esa.int + shailen.d.desai@jpl.nasa.gov + aurore.e.sibois@jpl.nasa.gov + pierre.potin@esa.int + ferran.gascon@esa.int + anja.stromme@esa.int + hilary.wilson@eumetsat.int + philippe.goryl@esa.int + betlem.rosich@esa.int + Olivier.colin@esa.int + franck.desbouillons@esa.int + alessandra.boungiorno@esa.int + jordi.farres@esa.int + patrick.grimont@esa.int + kate.symonds@esa.int + valentina.boccia@esa.int + s3mpc-stm-too@acri-st.fr + s3.stm@eumetsat.int</p>

Agreements, declarations, actions

Copernicus POD QWG#10 summary

General:

- The switch to the new external GNSS provider (EGP) has been successfully performed on 23 September 2020. It is now magicGNSS (GMV)+ DLR RETICLE (backup) instead of VERIPOS + magicGNSS (backup).
- The switch to a new orbit parametrization for the STC (S-3) and NTC (S-1&S-3) orbit products has been done in Feb 2021. The results show a significant improvement w.r.t. the previous parametrization.

Sentinel-3:

- Sentinel-3A & -3B CPOD Service operations are running nominally.

Sentinel-1:

- Sentinel-1A & -1B CPOD Service operations are running nominally.
- The switch to the new S-1 ARP configuration has been done in July 2020. The reprocessing of the S-1 orbit products since the beginning of the missions is close to be finished.

Sentinel-2:

- Sentinel-2A & -2B CPOD Service operations are running nominally.

Sentinel-6:

- Sentinel-6 is currently in commissioning. CPOD Service is preparing for operations which include hourly and daily RINEX and NRT orbit products.
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Contract and future plans:

PF summarizes the future of the CPOD contract. The current contract ends at the end of 2021, but it will be extended for another year (2022) with a CCN. The ITT#3 for the CPOD Service will be released at the end of 2021 – beginning of 2022, and it will cover up to 5 years (2023 – 2027) with an overlap period (Set-up Phase) starting in mid 2022. It will nominally cover the CPOD operations of the Sentinel-1, -2, -3 and S-6 NRT missions.

Status Copernicus POD Service (JF)

(details see Annex02 attached)

PF comments that the technical evolutions required to GMV, related with the API Rest, are part of a redesign of all Ground Segment services within ESA related to the Sentinels.

Sentinel-1 reprocessing (MF)

(details see Annex03 attached)

YA: How is the orbit combination done?

MF: The orbit combination is done as weighted mean of all solutions, similar to the IGS orbit combination.

DA: What will be done with the period in mid-2019, where a jump is visible w.r.t. the combined orbit?

ESOC (ambiguity-float) and TUDF (ambiguity-fixed) both using different GPS products, show a jump w.r.t. the other solutions.

AI on All to check their S-1 solutions again for the 2019 summer period doing the following tests:

- Use GRGS instead of CODE repro products for this period; also check if a jump occurs for the other Sentinels as well.
- Looking at the ambiguity fixing rates.
- Check, if ambiguity-float solutions also show this jump in the comparisons.
- Analyse attitude (should not be the cause, because only TUDF uses the attitude files, all others use nominal attitude)

Ref. QWG010-ALL-AI-008

Sentinel-3 USO/clock analysis**Presentation from JF**

(details see Annex04a attached)

OM: 28.333 MHz is not relevant, only the relative frequency evolution is relevant, which represents the clock drift.

Presentation from PG

(details see Annex04b attached)

PG: Range errors <1mm are not problematic for the altimetry processing.

FB: For our altimetry mission we are now targeting to identify sea level drift error to be less than 1 mm/year. The drifts are, therefore, more critical.

Presentation from FM

(details see Annex04c attached)

YA: RINEX in IMT? Reason is to get the comparison between DORIS and GPS?

FM: Yes, the correct frequency can be get from the IMT RINEX file. It helps to study and to understand better the SSA.

OM: IMT-related time scale with polynomial fitting would also be sufficient.

FM: Correct, but with the IMT RINEX the full signal can be seen directly.

YA: Two different RINEX files have to be generated due to this.

FB: Regarding S3A/B and S6 (or S3C/D) DORIS crystal resonators are very different. On S3A/B, the crystal directly resonates at 10MHz whereas on S6 it is 5MHz resonator and then there is a multiplier by 2 stage to get the 10MHz output.

OM: Have you already done tests using the GPS-derived clock in DORIS processing for S-3?

FM: To do so 1 Hz processing is needed for S-3A to account for the difference GPS-TAI. This is not practical for operational processing.

Presentation from UH

(details see Annex04d attached)

Proposal: Provide 1 Hz corrected clock correction for S-3A, -3B and -6 for DORIS community.

OM: With the model 1 Hz processing should no longer be needed?

UH: We take the clock differences and the noise becomes too large with 10 second processing.

FM: Do you suspect similar effects for S-3B and S-6

UH: S-3B less pronounced. S-6 does not show the cross-talk, so it is much nicer. Work on an operational procedure to provide the clock product to the DORIS community.

JF: Would a model be beneficial for the GPS POD processing?

UH: Clock modelling does not really help for GPS POD processing.

Recommendation #31 The CPOD QWG recommends to connect a GNSS receiver to an USO for any future EO mission for which an USO and a GNSS receiver are considered as payloads. Running the GNSS receiver on the USO allows to monitor the behavior of the USO in detail in support of the science mission such as Altimetry or SAR, e.g., when the satellite passes the SAA. This is particularly helpful for DORIS to correct data for SAA-induced frequency variations and it eventually allows to combine DORIS and GNSS at observation level in support of realization of the ITRF.

Altimetry cross-over analysis (DD)

(details see Annex05 attached)

OM: CNES is still best solution, isn't this somehow natural because J-3 orbit is also from CNES.

DD: True.

OM: Geocenter variations map into comparison? Maybe validate orbits, which use the same GNSS products or directly look at geocenter variations of the used GNSS products.

JF: Main difference between CPOD and CPOD in the analysed period is fixed vs. float orbit solutions; CPOD is not yet using the new parametrization for this period.

UH: How does the sun-synchronous orbit of S3 impacts the geographically correlated errors (GCE)?

DD: Effects could be visible in the altimetry corrections (e.g., ionosphere) but less in the GCE.

PV: GCE could also be related to errors in the static gravity field.

SLR bias determination study – AIUB, CNES & PTIM (DA)

(details see Annex06 attached)

Review of Als and recommendations from previous Copernicus POD QWG meetings:

(details see Annex07 attached)

Sentinel-6:**Status of GNSS receiver tracking and tracking tests****Presentations from OM**

(details see Annex08 attached)

Recommendation #32: The CPOD QWG recommends to lower the elevation cut-off angle of S-6A PODRIX tracking down to zero degree. Among other, this should maximize the occupancy of channels.

Recommendation #33: The CPOD QWG recommends to do an independent robot calibration of the RUAG PEC antenna, as it has been observed that the differences between the ground calibration and on-board estimation is up to ten times larger than the specification. Although this discrepancy has become again very apparent for S6 it has been already observed for all other Sentinels and an independent calibration would help to understand the differences better.

AI on ALL to check what the inter-system biases (ISBs) with the phase glitches on the nominal receiver would do on the clock estimation. To be checked if this could be problematic for altimetry.

Ref. QWG010-ALL-AI-009**Status S-6 processing at CNES (AC)**

(details see Annex09 attached)

YA: You could also use the daily RINEX files for the STC processing, because they are available early enough.

AC: Has to be checked with Sabine Houry who is responsible for the STC processing.

Handling of different GNSS signals – impact on integer ambiguity resolutions**Presentation from OM**

(details see Annex10a attached)

YA: L2L phase bias, can it only be estimated by parallel run of both receivers?

OM: In the beginning it was estimated from the parallel run of both receivers, but it can also be got from a ground test with a COTS receiver running in parallel.

OM: Temperature-dependent code biases are a good starting point for the code bias corrections.

Presentation from FM

(details see Annex10b attached)

OM: L2L-L2W receiver phase bias can be considered constant for the entire mission. Receiver code biases are temperature-dependent and these corrections are known from the ICDB. A small constant bias has to be added to get the full alignment between C1C/C2L and C1W/C2W, but this additional code bias also seem to stay constant over time.

Presentation from SS

(details see Annex10c attached)

GPS, GAL or GPS+GAL – Single or combined processing (FG)

(details see Annex11 attached)

Current analysis shows that Galileo only solution seems to have very good characteristics in terms of SLR residuals and internal consistency, even superior than GPS only solution.

FM: Differences in the optical properties for the macro model in the IDS document are because of considering thermal re-emission for part of the solar panels (top part, which is connected to the satellite body).

Status and first results from GNSS-RO POD (TRIG) receiver (SP)

(details see Annex12 attached)

OM: 31 Jan 2021, beginning of the day 3h data gap

SP: Also a data gap in the GNSS-RO data, but also other problems are present, which prevent getting a solution with Bernese GNSS Software for 31 Jan 2021.

YA: EUMETSAT is trying to make the S6-RO data from the zenith antenna available to the POD QWG. JPL has stated that availability shall be granted at the same time as S6VT gets the data.. Hopefully soon.

SP: PCO_Z estimate is similar than the one for the PODRIX.

Summary of S-6 POD results from QWG (HP/OM)

(details see Annex13a&13b attached)

YA: Four yaw flip manoeuvres are planned for a duration of four days when a zero beta angle crossing appears; possibly already in May.

OM: Longer period than four days would be better.

FL: It was already difficult to get four days.

AC: It was asked to perform these yaw flip manoeuvres within commissioning phase.

YA: QWG will be kept up-to-date about the manoeuvres.

Post-meeting comment: S-6A Yaw flip manoeuvre is planned for 14th of June (TBC) with a duration of 4 hours only (test).

YA: Different macro model than from the S6A POD document available?

FM: Different optical properties are the result of a model construction to balance energy transmission. Big solar array, one part is considered with re-emission and the other part without re-emission; the satellite probably has a very strange thermal behaviour.

YA: Feedback to ESTEC with reference to IDS document (=> CNES configuration).

Recommendation #34: The CPOD QWG fully supports to perform the yaw flip manoeuvres for S-6A. They will be very helpful to decouple inconsistencies in the modelling from errors in the center of phase offsets of the POD instruments.

List of action items

QWG010-ALL-AI-008 (15/04/2021): ALL to check their S-1 solutions again for the 2019 summer period doing the following tests:

- Use GRGS instead of CODE repro products for this period; also check if a jump occurs for the other Sentinels as well.
- Looking at the ambiguity fixing rates.
- Check, if ambiguity-float solutions also show this jump in the comparisons.
- Analyse attitude (should not be the cause, because only TUDF uses the attitude files, all others use nominal attitude)

QWG010-ALL-AI-009 (31/12/2021): ALL to check what the inter-system biases (ISBs) with the phase glitches on the nominal receiver would do on the clock estimation. To be checked if this could be problematic for altimetry.

List of new recommendations

Recommendation #31 (Open):

The CPOD QWG recommends to connect the GNSS receiver to the USO for any future EO mission for which an USO and a GNSS receiver are considered as payloads. Running the GNSS receiver on the USO allows to monitor the behavior of the USO in detail in support of the science mission such as Altimetry or SAR, e.g., when the satellite passes the SAA. This is particularly helpful for DORIS to correct data for SAA-induced frequency variations and it eventually allows to combine DORIS and GNSS at observation level in support of realization of the ITRF.

Recommendation #32 (Open):

The CPOD QWG recommends to lower the elevation cut-off angle of S-6A PODRIX tracking down to zero degree. Among others, this should maximize the occupancy of channels.

Recommendation #33 (Open):

The CPOD QWG recommends to do an independent robot calibration of the RUAG PEC antenna as regularly done for ground antennas in the International GNSS Service, as it has been observed that the differences between the ground and in-flight calibration is larger than 2 cm in radial direction, while the specified accuracy is at the mm level. This discrepancy has been observed for all Sentinels flying so far and an independent calibration would help to understand the differences better.

Recommendation #34 (Open):

The CPOD QWG fully supports to perform the yaw flip manoeuvres for S-6A. They will be very helpful to decouple inconsistencies in the modelling from errors in the center of phase offsets of the POD instruments.