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IDEAS+ Swarm Weekly Report 2015/07 : 09/02/2015 – 15/02/2015

Abstract : This is the **Instrument Data quality Evaluation and Analysis Service Plus** (IDEAS+) Swarm Weekly report on Swarm products quality, covering the period from 9 to 15 February 2015.

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AMENDMENT POLICY

This document shall be amended by releasing a new edition of the document in its entirety. The Amendment Record Sheet below records the history and issue status of this document.

AMENDMENT RECORD SHEET

ISSUE	DATE	REASON
1.0	20 Feb 2015	First issue

1. INTRODUCTION

This document refers to the activities carried out in the framework of the Sensor Performance, Products and Algorithms (SPPA) Office [RD.1], and as such it reports on work related to:

- Algorithms and Processors Development, Maintenance and Evolution: these include all algorithm and software evolution and maintenance aspects for the different components, for both the Operational processors (OP) and Prototypes processors (PP) of L1 and L2 chains.
- Performance Assessment: these include all Quality Control activities (on-line and offline, systematic or on-demand), for the applicable product levels.
- System Calibration: these include the activities related to calibration, from sensor to system level. They also include aspects like cross calibration and handling of external calibration sources.
- Product validation: these include definition and maintenance of product validation plans.
- End-to-end Sensor Dataset Performance: these include activities related to the organisation and coordination of Quality Working Groups and all aspects of the Experimental platform. It also covers the product baseline, coordination and handling of external communities, and all aspects of ADF handling (both for the operational processors and for the prototypes).

This weekly report constitutes a work in progress throughout the mission life time, and new parts and complements will be added while the consolidation of knowledge on Swarm data and instruments will progress.

Section 2.1 always gives an overview of the general quality status of the mission instruments and products, while the main observations of the week are summarized in Section 2.4.

The document also includes information on data quality for the three Swarm spacecraft, inferred from automated HTML quality reports which are produced on daily basis for each product. Please contact the IDEAS+ Swarm team if interested in accessing the reports via web or FTP (all details about interfaces and folder structure available on [RD.2]). Such quality reports represent the core of the Routine Quality Control (Chapter 3). A description of the implemented quality checks is given in [RD.3], and references therein.

Basing on specific findings of the routine quality control, or on-demand from other entities (i.e. Swarm PDGS, FOS, Mission Management, Post-Launch Support Office, Expert Support Laboratories, Quality Working Groups, user community), anomalies can be triggered and preliminary characterisations and investigations of such anomalies are given in Chapter 4.The anomalies documented in the Weekly Reports are tracked in the following way:

1. If triggered by ESA Eohelp or within the Service: IDEAS+ action and ticketing system (http://requests-sppa.serco.it/RT3/index.html).

2. If triggered by IDEAS+ Swarm team or other entities:

    2a. If the observation/analysis leads to an anomaly to be addressed to the processor provider (GMV): SPR on EO ARTS (https://arts.eo.esa.int), **SWL1L2DB** project.

2.b. If the observation/analysis does not lead to an anomaly or the investigation shall be escalated to other entities (PLSO/industry, ESL, PDGS): Action tracked on EO ARTS, **SW-IDEAS** project, then addressed to the proper tracking system if needed (e.g. JIRA for ESLs, SW-CP-AR project on EO ARTS for PDGS)

Information on Level 1B Swarm products can be found in [RD.4].

1.1 Current Operational configuration of monitored data:

- Processors Version: L1BOP 3.11p3, L2-Cat2 1.12
- L0 input products baseline: 02
- L1B baseline: 03 (for definitions and description of the data baseline concept see https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/swarm/data-access/product-baseline-definition)
- Level 2 – Cat 2 baseline: 01
- Input auxiliary files baseline: CCDB 0009, ADF 0101
- MPPF-CVQ v.2.12p1

1.2 Reference documents

The following is a list of documents with a direct bearing on the content of this report. Where referenced in the text, these are identified as RD.n, where 'n' is the number in the list below:

[RD.1] Sensor Performance, Products and Algorithms (SPPA), PGSI-GSOP-EOPG-TN-05-0025. Version 2.3.

[RD.2] Swarm PDGS External DMC Interface Control Document, SW-ID-DS-GS-0001, Issue 3.2.

[RD.3] Swarm MPPF-CVQ Monitoring Baseline Document, ST-ESA-SWARM-MBD-0001, Issue 1.7.

[RD.4] Swarm Level 1B Product Definition, SW-RS-DSC-SY-0007, Issue 5.13.

[RD.5] Swarm IDEAS Configuration Management Plan, IDEAS-SER-MGT-PLN-1081 v0.14.

[RD.6] Swarm Quality Control Project Plan, IDEAS-SER-MGT-PLN-1071

[RD.7] SW_L1BOP_status_20141124_MoM

[RD.8] Planned Updates for Level 1b, SW-PL-DTU-GS-008, Rev: 1dC.

[RD.9] IDEAS+ Swarm Weekly Report: 25/08/2014 – 31/08/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20140825_20140831.pdf (ref. for SWL1L2DB-9)

[RD.10] IDEAS+ Swarm Weekly Report: 29/09/2014 – 05/10/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20140929_20141005.pdf (ref. for SW-IDEAS-34)

[RD.11] IDEAS+ Swarm Weekly Report: 06/10/2014 – 12/10/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20141006_20141012.pdf (ref. for SW-IDEAS-36)

[RD.12] IDEAS+ Swarm Weekly Report: 20/10/2014 – 26/10/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20141020_20141026.pdf (ref. for SW-IDEAS-40, GPS sync loss)

[RD.13] IDEAS+ Swarm Weekly Report: 15/09/2014 – 21/09/2014, IDEAS+-SER-OQC-REP-2071_SPPA_SwarmWeeklyReport_20140915_20140921.pdf (ref. for SW-IDEAS-27)

2. SUMMARY OF THE OBSERVATIONS

2.1 General status of Swarm instruments and Level 1B products quality

- **ASM Failure on Swarm C.** CNES identified the cause of the failure: a transistor was burnt after being hit by energetic particles. Unfortunately, due to design issues, we have a general weakness for such kind of components, that proved to be shielded not well enough from radiation and cosmic rays. Therefore, we have to expect a very high probability for such kind of failures in the future (evaluated in 90% over the nominal mission duration!), especially when solar activity is strong. We have to be prepared for an "exit strategy", i.e. to be able to perform magnetic data calibration without the ASM.

- **TII scrubbing** still on-going on Swarm B. Former ESA project team members have been consulted, trying to better understand what has been done during pre-flight tests with regards to pushing the flight models to the high voltage limits. Very few concerns are expressed on the opportunity to raise the phosphor voltage up to 8000 V, even though still no clear evidence or documentation is available for demonstrating this really causes no harm. Discussions are ongoing, but the mission management orientation is towards starting playing a bit (of course with a grain of caution) with one satellite (most likely Swarm C) with the aim of pushing the scrubbing further. Overall, there is still confusion about the actual physical cause of the image anomaly: after many scrubbing cycles now, the contaminants trapped in the MCPs should have been expelled and, in any case, one does not see the reason why the image quality worsen again after some time after the scrubbing.

2.2 Plan for operational processor updates

L1BOP 3.12 and L2-Cat2OP 1.13 have been delivered to PDGS the 28th of November. Verification and integration tests will take place in the next weeks, before the final deployment of the processors in operation in January.

Due to several issues (SPRs not completely fulfilled, non-regression issues, other problems found in data in the meanwhile which underlie bugs in the processor) the manufacturer released L1BOP 3.13, 3.14 and 3.14 patch 1. For that reason some delay in the deployment in operations has been introduced. Final tests are ongoing and the deployment in operations of L1BOP 3.14 patch 1 is foreseen for CW 09 (23-27/02).

2.3 Quality Working Group and Cal/Val Coordination

Coordination is in place for organizing the 6th Swarm Data Quality Workshop in Paris (hosted by IPGP) in late September 2015.

Following the QWG recommendations in Potsdam and the scientists need in view of the IUGG conference in June, the preliminary plasma dataset will be released end of January 2015.

According to the last coordination meeting within the MAGNET QWG (22/01/2015) the following decisions have been taken:

- With the data provided by DTU/ESL, further analysis can be performed by industry (ADS, DTU-MI, other scientific groups (e.g. Richard Marchand and Stephan Buchert on plasma induced fields), and of course by ESA. The agreement is - as always - that results will be shared with all others on the Task Force.

- DTU/ESL will further refine the Lesur-Tøffner-Clausen model parametrisation and share a final description of the process (input data, model description, output results and tests) (by mid February).

- In parallel, GFZ will distribute the Lühr-Michaelis results, and a number of people (e.g. Malcolm Dunlop, Yulia Bogdanova, Arnaud Chulliat, Patrick Alken) will further support the analysis of these datasets. (by mid February).

- The PDGS will generate the currently VFM missing data on Charlie due to the ASM failure (by end February).

- DTU/ESL will share the final set of corrected data by early March. These corrected data will also contain the dBsun correction, providing the users the possibility to access to uncorrected data.

- The corrected data will be distributed by ESA to all Swarm users (by early April and no later than 20th April). The correction will also be implemented in the OP. Until this is fully validated, it is agreed that the operational processing will continue as nominal without the correction.

- Next Task Force meeting: **9-10 April**. The meeting will be held in ESTEC.

2.4 Summary of observations for 2015, Week 07 (09/02-15/02)

During the monitored week the following events have been found and investigated:

1. **Strange features observed at times in the MOD-GPSNAV solution difference:** again we often notice a marked “spiky” behaviour, with deviations from the average which are not normal spikes but lasts for several seconds if not minutes (**SW-IDEAS-34**, [RD.10]), especially on S/C B this week.

2. **Attitudes rejected for few seconds** on S/C A and B, due to simultaneous occurrence of BBO and Invalid measurements on the three cameras (**SW-IDEAS-57**).

3. ROUTINE QUALITY CONTROL

3.1 Gaps analysis

- **Magnetic production lost on S/C C for the whole week**, because of the ASM switched off.

3.2 Orbit and Attitude Products

The following events have to be reported:

Observation ID	Description	Affected parameter	Sect. of Obs. Description	Sect. of Obs. analysis
SW-IDEAS-34	OBS_ROUTINE: large number of spiky features observed in the NAV-MOD difference	Orbits (position and velocity)	3.2.2.1	[RD.10]
SW-IDEAS-57	OBS_ROUTINE: 2015, week 07 (9-15/02), STR S/C A and B out of range.	STRASCI_1A STRAATT_1B STRBSCI_1A STRBATT_1B	3.2.1.2 3.2.2.2	3.2.1.2 3.2.2.2

Table 1: list of events related to attitude and orbit products to be reported in the monitoring for 2015, Week 07: 09/02 - 15/02.

The relevant parameters that have been monitored are:

- Position difference between calculated Medium Accuracy orbits (**MODx_SC_1B**) and on-board solution (**GPSxNAV_0**). Threshold values for such differences have not been assessed yet: we have just monitored the average values and maximum variations around the week, and reported in tables in the sections below, along with some example from the HTML daily reports. For the time being we evaluated an anomaly should be raised if one (or more) of the following conditions occurs:
    - The **average difference** on a given day exceeds the position accuracy requirement for the mission (1.5 m),
    - The variability around the average is quite high: **standard deviation** threshold has been arbitrarily chosen to be twice the position accuracy requirement for the mission (2-sigma = 3 m).
    - At least 4-5 spikes are observed on a given day, exceeding +/- 50 m.
- Visual inspection of Star Tracker characterisation flags (**STRxATT_1B**)
- Deviation of the quaternion norm from unity (deviation threshold = +/- 10^{-9})
- Visual inspection of Euler Angles derived from quaternions.

3.2.1 Swarm A

3.2.1.1 Position statistics

In Table 2 one can see the statistics of the differences between MOD and on-board solution positions. In the third column the maximum differences (maximum negative and maximum positive) are reported with, in parentheses, the ITRF component affected by such difference. The maximum standard deviation is in the fourth column: it usually refers to the Z component which is always the most disturbed; in case another component is most affected, it will be specified in parentheses.

Swarm A, 09/02 – 15/02, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard deviation (m)**	**Notes**
09/02	0.21	-14.7, 11.3 (Z)	1.5	
10/02	0.1	-10.6, 9 (Z)	1.5	
11/02	0.1	-7.2, 10.4 (Z)	1.5	SW-IDEAS-34 [RD.10]
12/02	0.22	-12.7, 6.7 (Z)	1.6	SW-IDEAS-34 [RD.10]
13/02	0.001	-10, 9 (Z)	1.5	SW-IDEAS-34 [RD.10]
14/02	0.1	-10, 19.3 (Z)	1.5	Isolated spike on Z comp.
15/02	0.2	-9 (X), 7 (Z)	1.6	SW-IDEAS-34 [RD.10]

Table 2: Swarm A, difference between MOD and on-board solution positions.

Below some plot example follows of such differences taken at the beginning of the week (09/02, Figure 1), in the middle (12/02, Figure 2) and at the end (15/02, Figure 3). From top to bottom the plots show: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The values are given in Km.

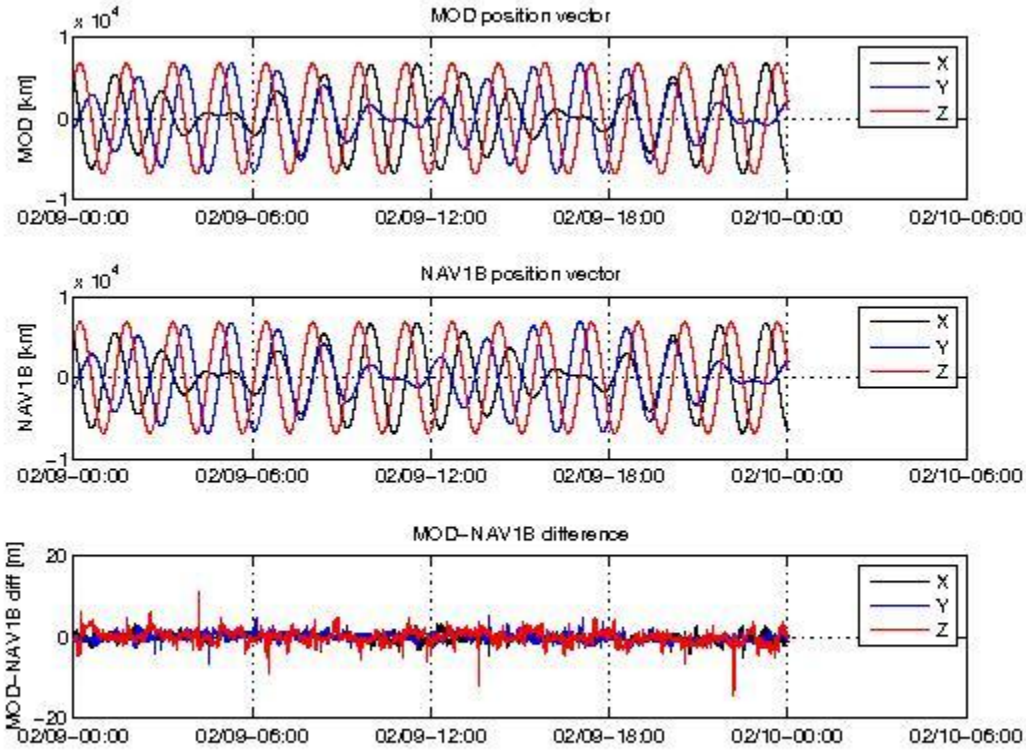

Figure 1: Difference MOD-GPSNAV, sc A, 09/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

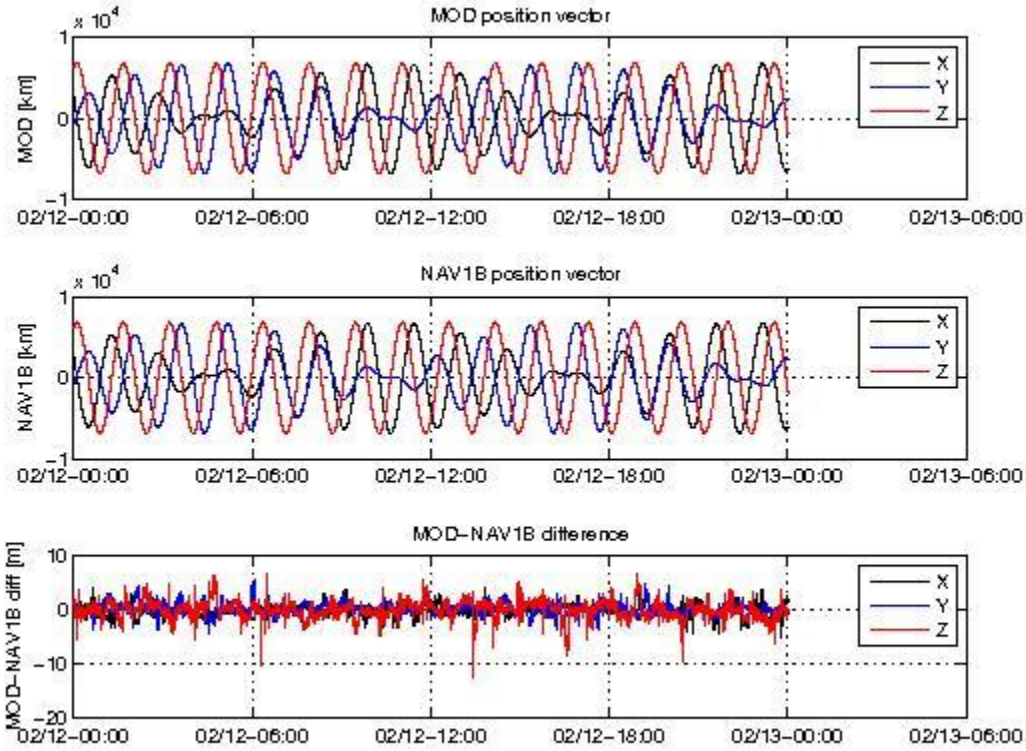

Figure 2: Difference MOD-GPSNAV, sc A, 12/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

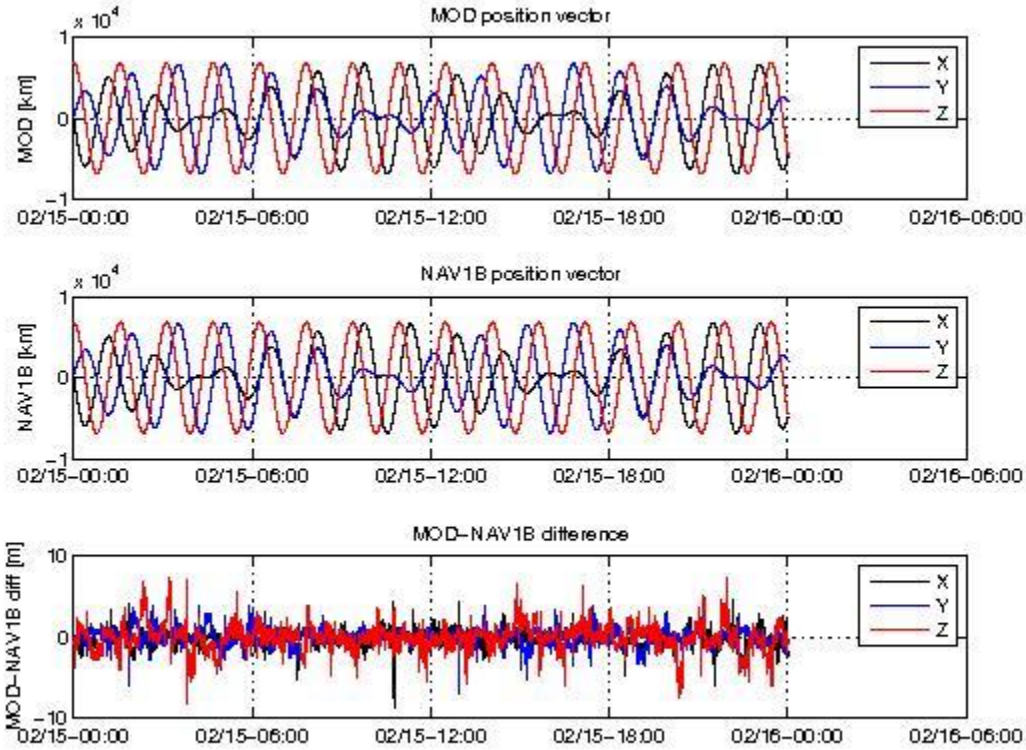

Figure 3: Difference MOD-GPSNAV, sc A, 15/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

3.2.1.2 Attitude observations

- **SW-IDEAS-57**

  Affected products:

  SW_OPER_STRAATT_1B_20150113T000000_20150113T235959_0302

  11 seconds out of range (Flags_q=255, no attitude available). See details in Table 3 below.

Start Out-of-range	Stop Out-of-range	Duration (s)
13FEB2015 01:26:54	13FEB2015 01:26:59	6
13FEB2015 23:20:52	13FEB2015 23:20:56	5

Table 3: Attitudes out-of-range, S/C A, 2015, week 07.

The cause of such rejected attitudes is the simultaneous occurrence of BBOs on cameras 1 and 3, and invalid measurements for camera 2 in the specified intervals.

3.2.2 Swarm B

3.2.2.1 Position Statistics

In Table 4 one can see the statistics of the differences between MOD and on-board solution positions. In the third column the maximum differences (maximum negative and maximum positive) are reported with, in parentheses, the ITRF component affected by such difference. The maximum standard deviation is in the fourth column: it usually refers to the Z component which is always the most disturbed; in case another component is most affected, it will be specified in parentheses.

Swarm B, 09/02 - 15/02, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard Deviation (m)**	**Notes**
09/02	0.14	-8.3 (Z), 5.7 (Y)	1.3	SW-IDEAS-34 [RD.10]
10/02	0.04	+/- 8 (Z)	1.4	SW-IDEAS-34 [RD.10]
11/02	0.02	-10, 14 (Z)	1.7	SW-IDEAS-34 [RD.10]
12/02	0.07	-12.3, 7.6 (Z)	1.7	SW-IDEAS-34 [RD.10]
13/02	0.11	-13.2, 7.5 (Z)	1.7	SW-IDEAS-34 [RD.10]
14/02	0.12	-9 (Z), 12 (X)	1.6	SW-IDEAS-34 [RD.10]
15/02	0.16	-9.2 (Z), 9.5 (Y)	1.5	SW-IDEAS-34 [RD.10]

Table 4: Swarm B, difference between MOD and on-board solution positions.

Below some plot example follows of such differences taken at the beginning of the week (09/02, Figure 4), in the middle (12/02, Figure 5), and at end of the week (15/02, Figure 6). From top to bottom the plots show: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The values are given in Km.

In Figure 6 examples of SW-IDEAS-34 ([RD.10]) anomaly is shown (red-circled areas): the MOD-NAV solution difference departs from the average value taking higher/lower values for several minutes.

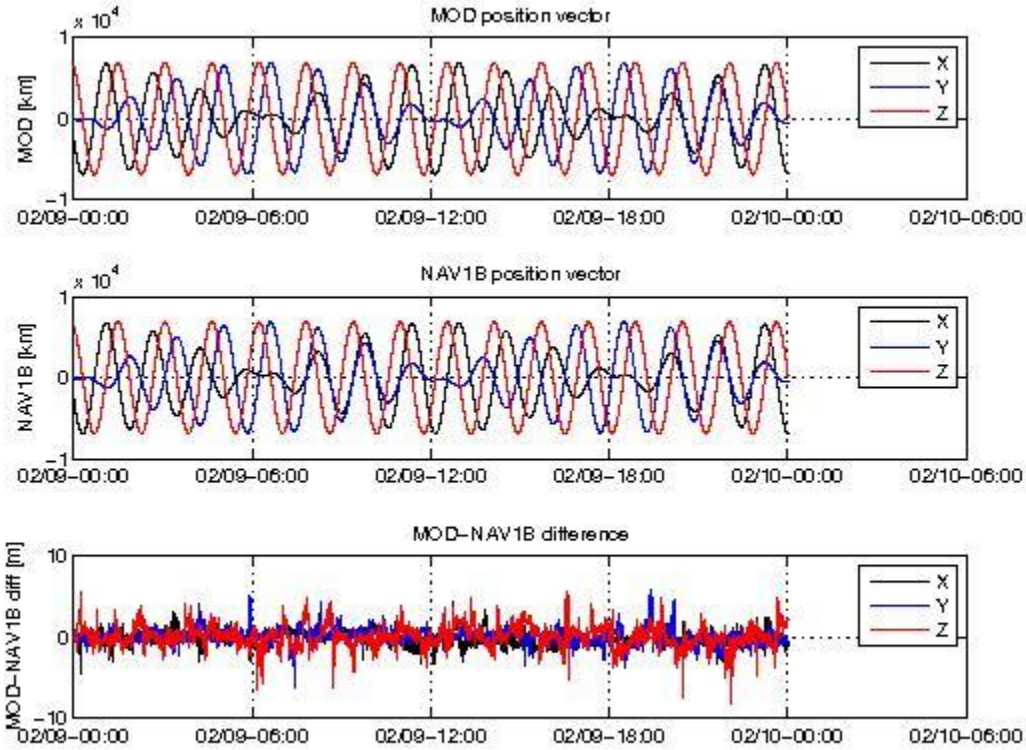

Figure 4: Difference MOD-GPSNAV, sc B, 09/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

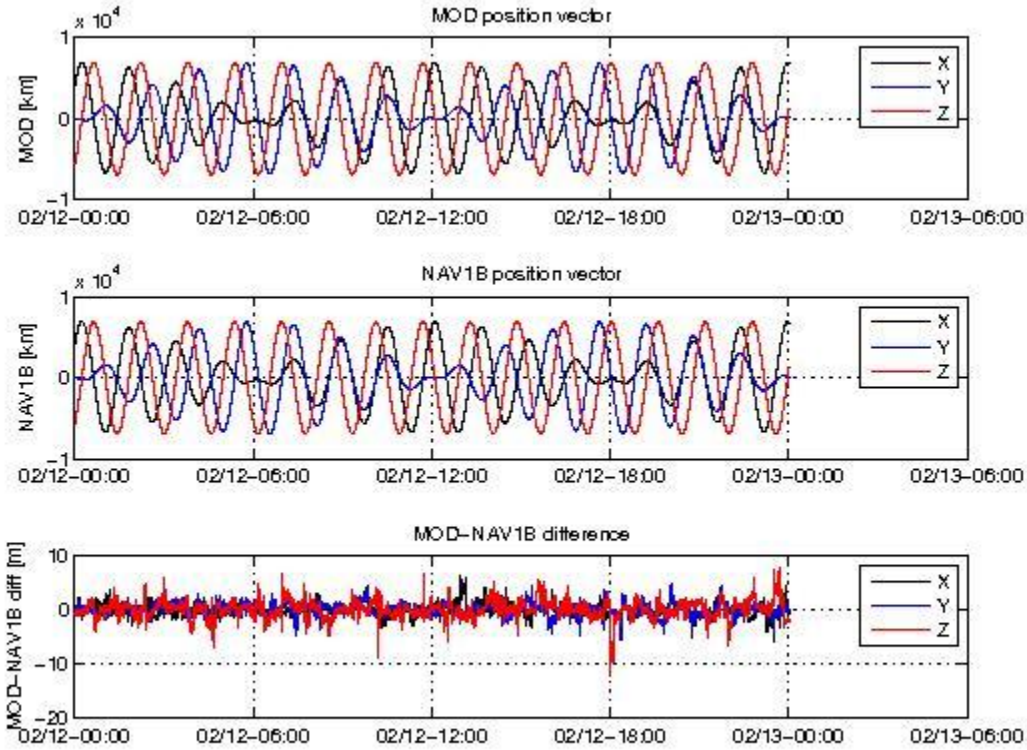

Figure 5: Difference MOD-GPSNAV, sc B, 12/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two.

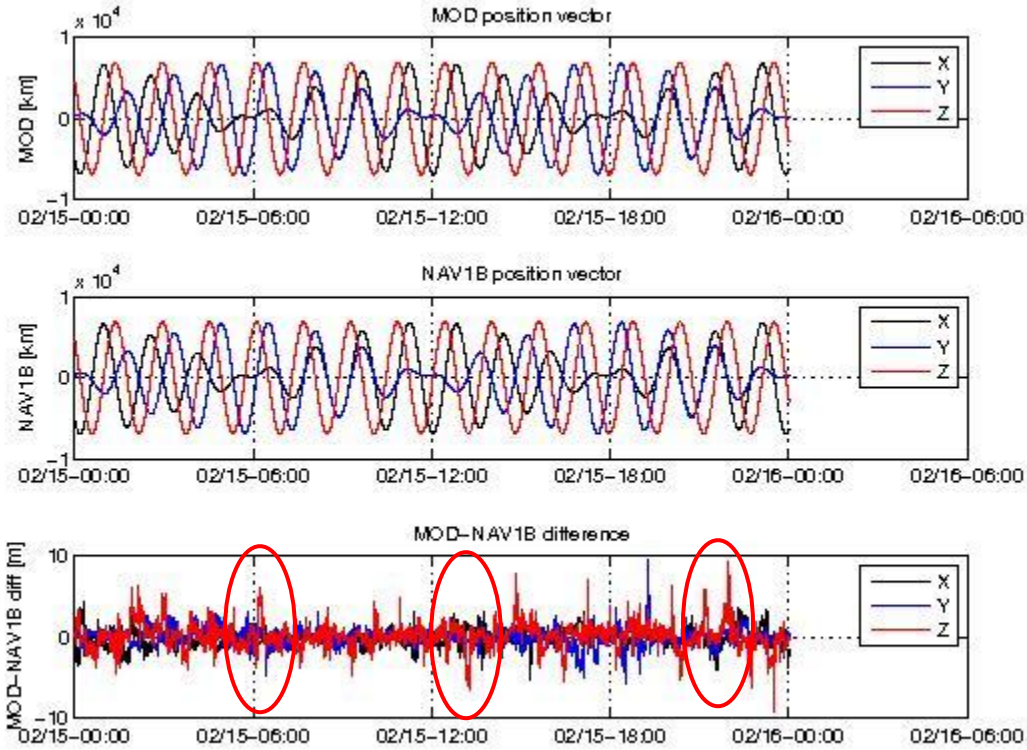

Figure 6: Difference MOD-GPSNAV, sc B, 15/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, the difference between the two. The red-circled areas evidence a time interval characterized by SW-IDEAS-34 ([RD.10]) anomaly occurrence.

3.2.2.2 Attitude observations

- **SW-IDEAS-57**

  Affected products:

  SW_OPER_STRBATT_1B_20150109T000000_20150109T235959_0302

  15 seconds out of range (Flags_q=255, no attitude available). See details in Table 5 below.

Start Out-of-range	Stop Out-of-range	Duration (s)
09FEB2015 00:07:51	09FEB2015 00:08:05	15

Table 5: Attitudes out-of-range, S/C B, 2015, week 07.

The cause of such rejected attitudes is the simultaneous occurrence of BBOs on the three cameras in the specified interval.

3.2.3 Swarm C

3.2.3.1 Position Statistics

In Table 6 one can see the statistics of the differences between MOD and on-board solution positions. In the third column the maximum differences (maximum negative and maximum positive) are reported with, in parentheses, the ITRF component affected by such difference. The maximum standard deviation is in the fourth column: it usually refers to the Z component which is always the most disturbed; in case another component is most affected, it will be specified in parentheses.

Swarm C, 09/02 - 15/02, Position difference				
Day	**Average Difference (m)**	**Maximum difference (m)**	**Standard Deviation (m)**	**Notes**
09/02	0.27	-12, 7.2 (Z)	1.3	
10/02	0.1	-8.3, 10.2 (Z)	1.5	
11/02	0.07	-6.3, 8.3 (Z)	1.3	
12/02	0.2	-8, 8.7 (Z)	1.5	SW-IDEAS-34 [RD.10]
13/02	0.07	-13, 10 (Z)	1.5	SW-IDEAS-34 [RD.10]
14/02	0.07	-6, 8 (Z)	1.3	
15/02	0.2	-7.6, 6.5 (Z)	1.4	SW-IDEAS-34 [RD.10]

Table 6: Swarm C, difference between MOD and on-board solution positions.

Below some plot example of such differences follows, taken at the beginning of the week (

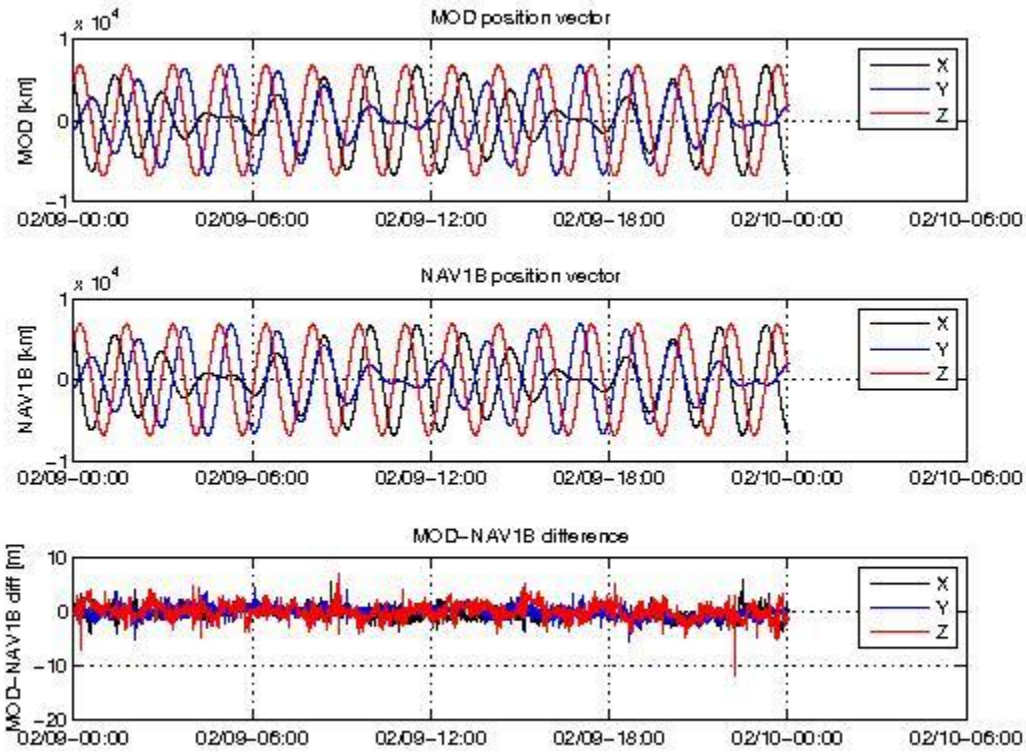

Figure 7), in the middle (12/02, Figure 8) and at the end (15/02, Figure 9). From top to bottom the plots show: the S/C position determined from the MOD calculation, the S/C position determined on-board, and the difference between the two. The values are given in Km.

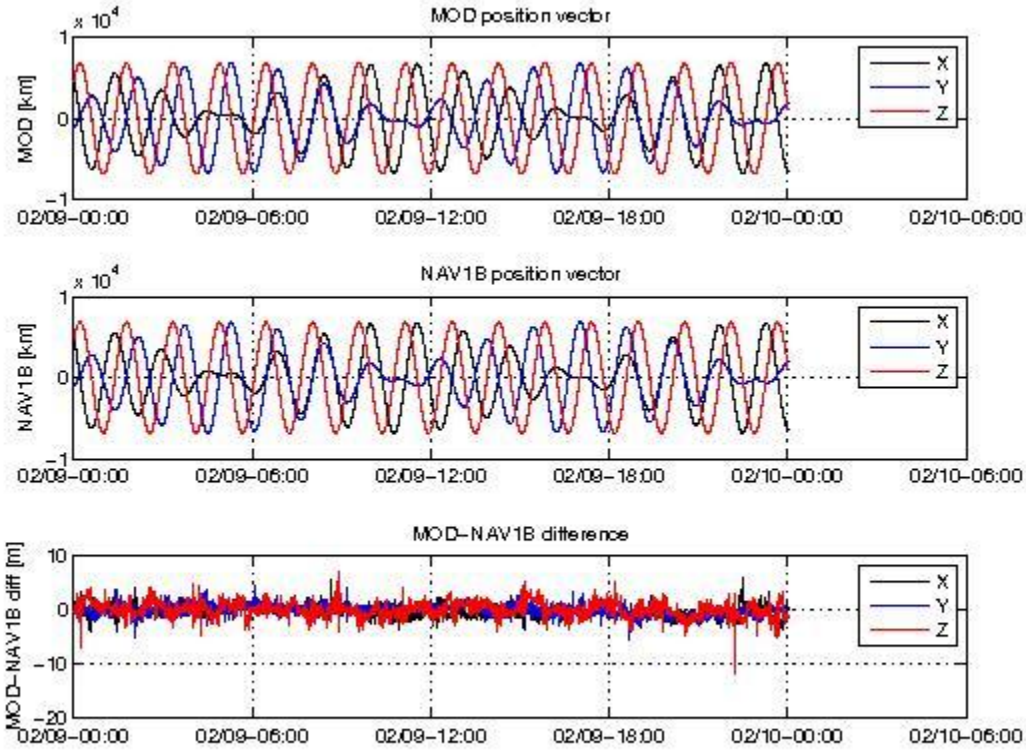

Figure 7: Difference MOD-GPSNAV, sc C, 09/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, and the difference between the two.

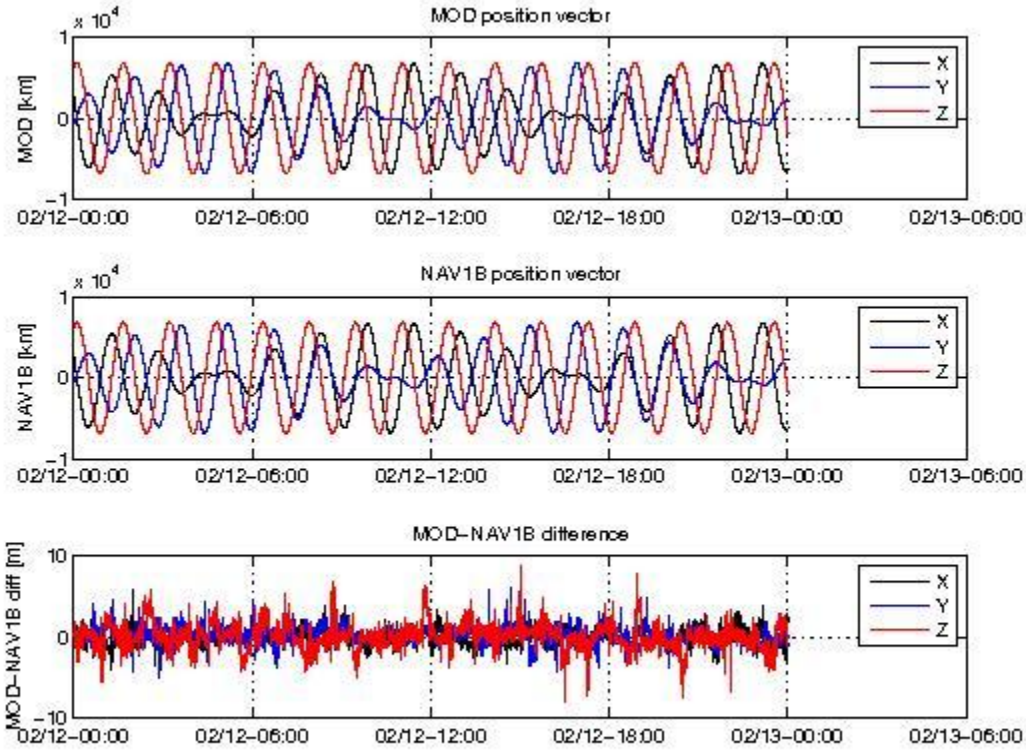

Figure 8: Difference MOD-GPSNAV, sc C, 12/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, and the difference between the two.

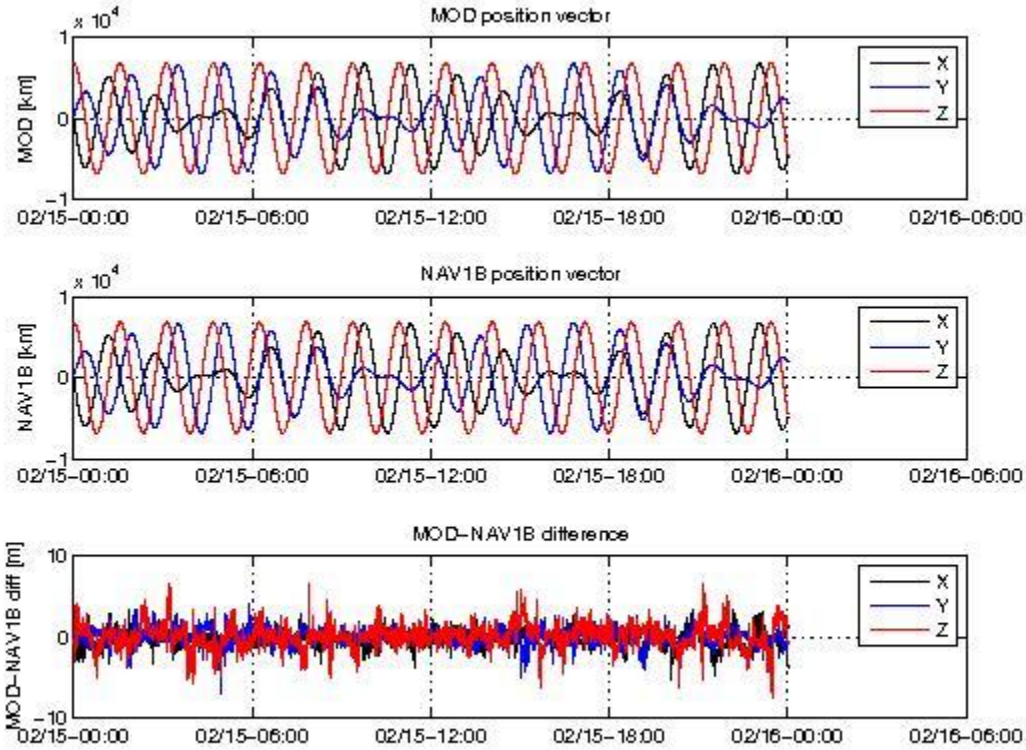

Figure 9: Difference MOD-GPSNAV, sc C, 15/02/2015. From top to bottom: the S/C position determined from the MOD calculation, the S/C position determined on-board, and the difference between the two.

3.2.3.2 Attitude observations

Nothing to report.

3.3 Magnetic Products

For the magnetic products the weekly monitoring consists in:

- Visual inspection of daily time series of magnetic field intensity F, $\mathbf{B_{NEC}}$ and $\mathbf{B_{VFM}}$. Looking for gaps (or zero values in case of **MAGx_LR_1B** products), out-of-threshold values (i.e. exceeding +/- 60000 nT), and other strange features.

- Monitoring of the **VFM-ASM known anomaly**: visual inspection of $|B_{NEC}|$ - F and recording of daily maximum variations. If +/- 5 nT are exceed on a given day, an alert is raised.

- TCF.VFM parameters monitoring (VFM calibration parameters): series of biases, scales, non-orthogonality factors and RMS. **This check is performed on monthly basis.**

SW-IDEAS-27 [RD.13]: The geomagnetic activity is low throughout the week, so that we do not observe high level of noise in the high frequency region of the spectra.

3.3.1.1 Magnetic time series visual inspection

An example of representative magnetic field time series for S/C A can be seen in Figure 10 (15/02/2015).

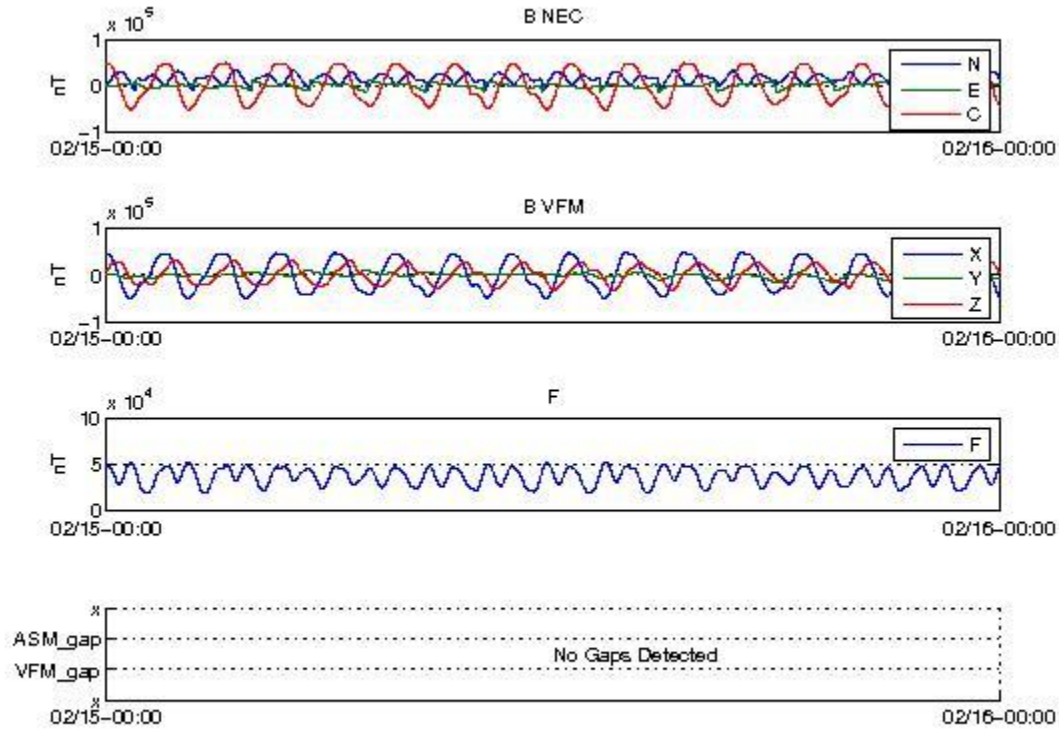

Figure 10: Time series of the geomagnetic field, for 15/02/2015, S/C A. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.1.2 VFM-ASM anomaly

The daily peak-to-peak difference around the week is, on average: [-3.5, 1.5] nT.

Below two example plots of such differences follows: taken at the beginning of the week 09/02 (Figure 11) and at the end of the week 15/02, (Figure 12). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

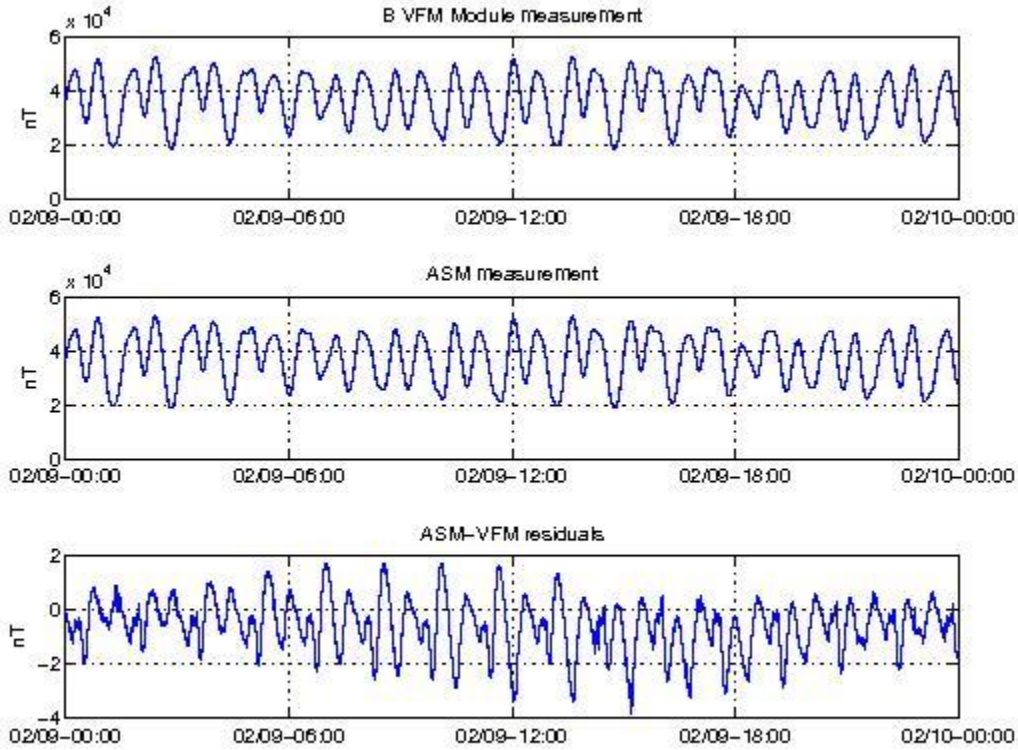

Figure 11: VFM module, ASM module and ASM-VFM residuals for S/C A, 09/02/2015.

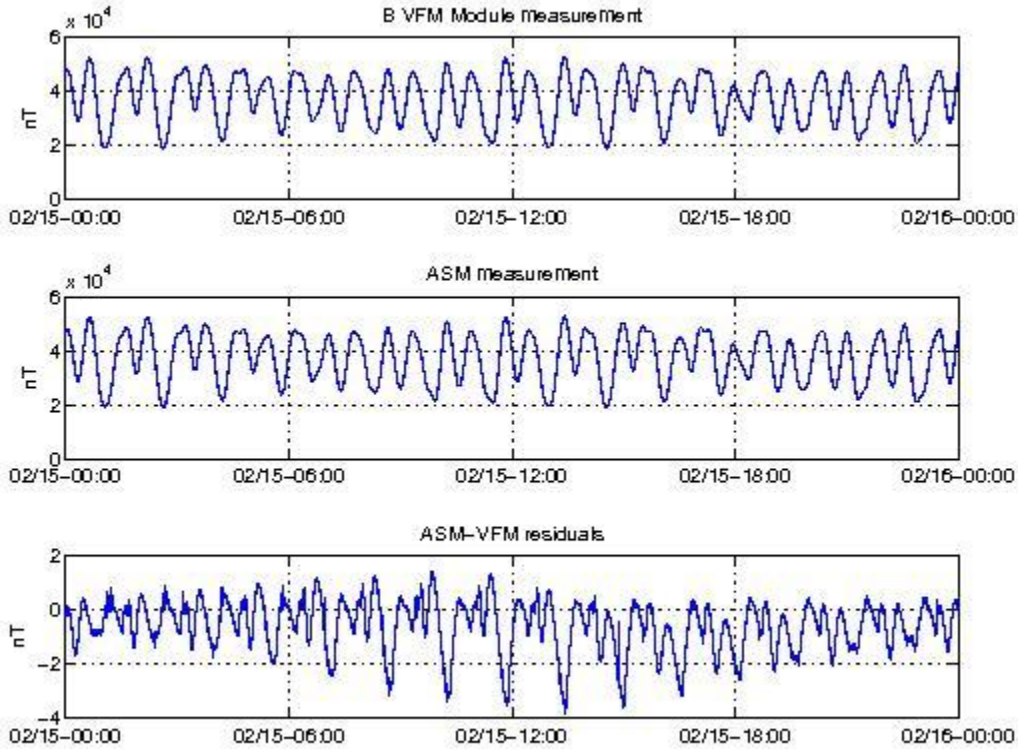

Figure 12: VFM module, ASM module and ASM-VFM residuals for S/C A, 15/02/2015.

3.3.1.3 TCF.VFM monitoring

The TCF.VFM monitoring is a monthly check and will be contained in the first report of March, related to February 2015.

3.3.2 Swarm B

3.3.2.1 Magnetic time series visual inspection

Nothing relevant to report. An example of representative magnetic field time series for S/C B (15/02/2015) can be seen in Figure 13 below.

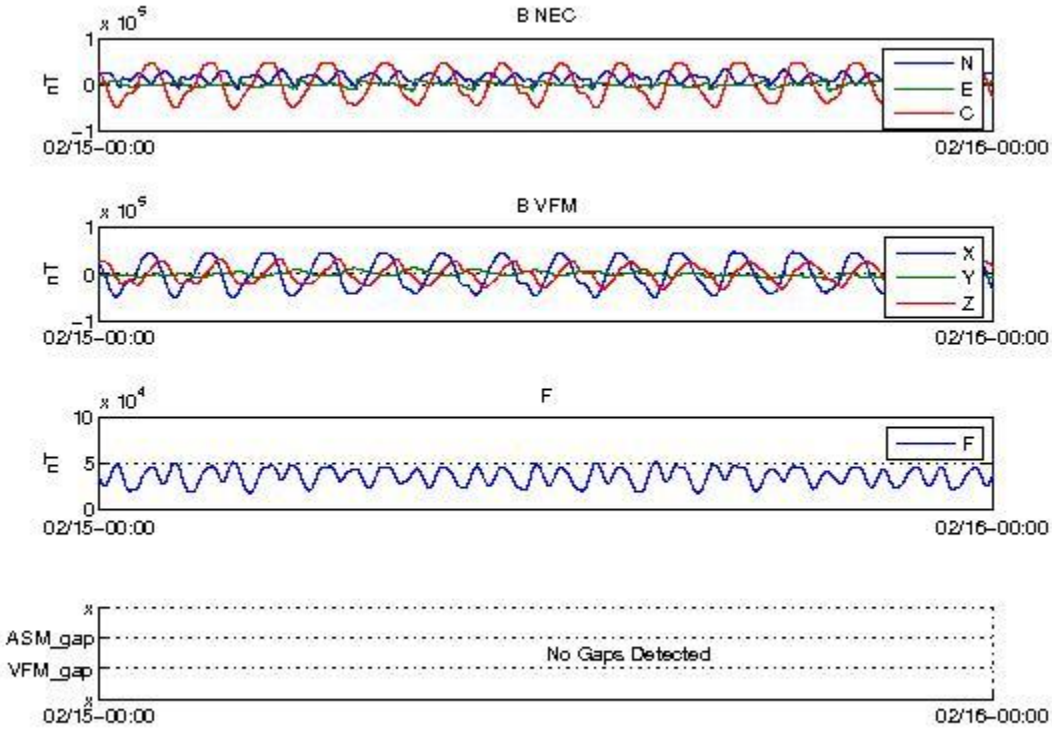

Figure 13: Time series of the geomagnetic field for 15/02/2015, S/C B. From top to bottom: magnetic field components in NEC reference frame, magnetic field components in the VFM reference frame, magnetic field intensity (F) from ASM, and location of gaps (if any).

3.3.2.2 VFM-ASM anomaly

The daily peak-to-peak difference around the week is, on average: [-1.5, 2.5] nT, with peaks of about 6 nT.

Below two example plots follows of such differences: 09/02 (Figure 14), and 14/02 (Figure 15). From top to bottom the plots show: The VFM module, the ASM module, the difference ASM-VFM.

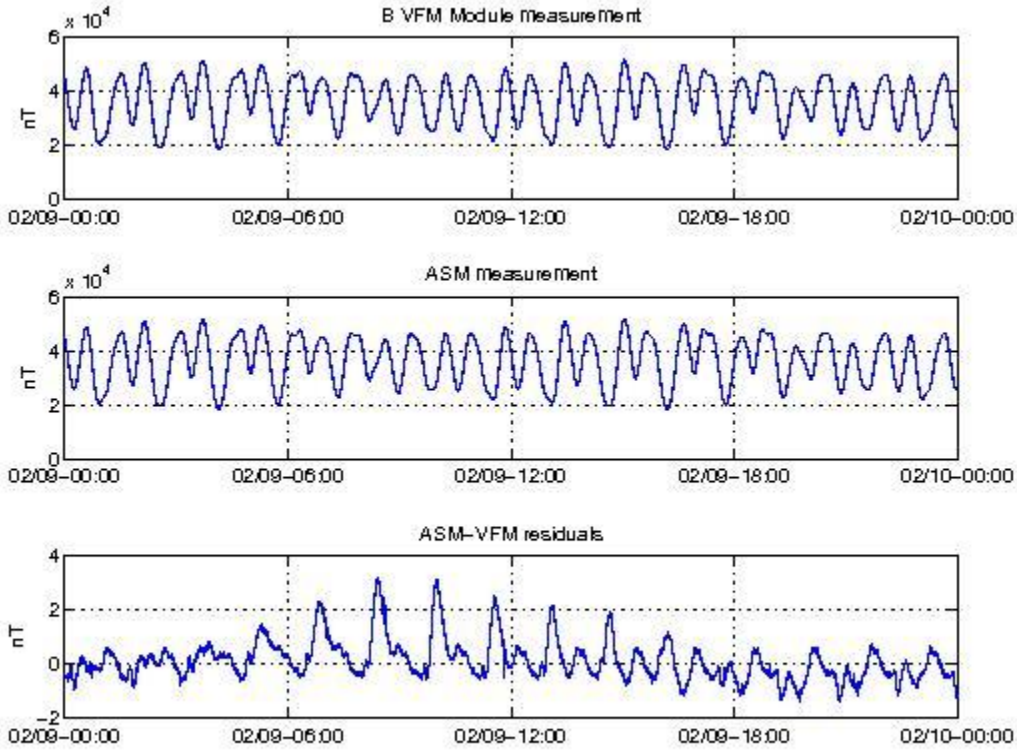

Figure 14: VFM module, ASM module and ASM-VFM residuals for S/C B, 09/02/2015

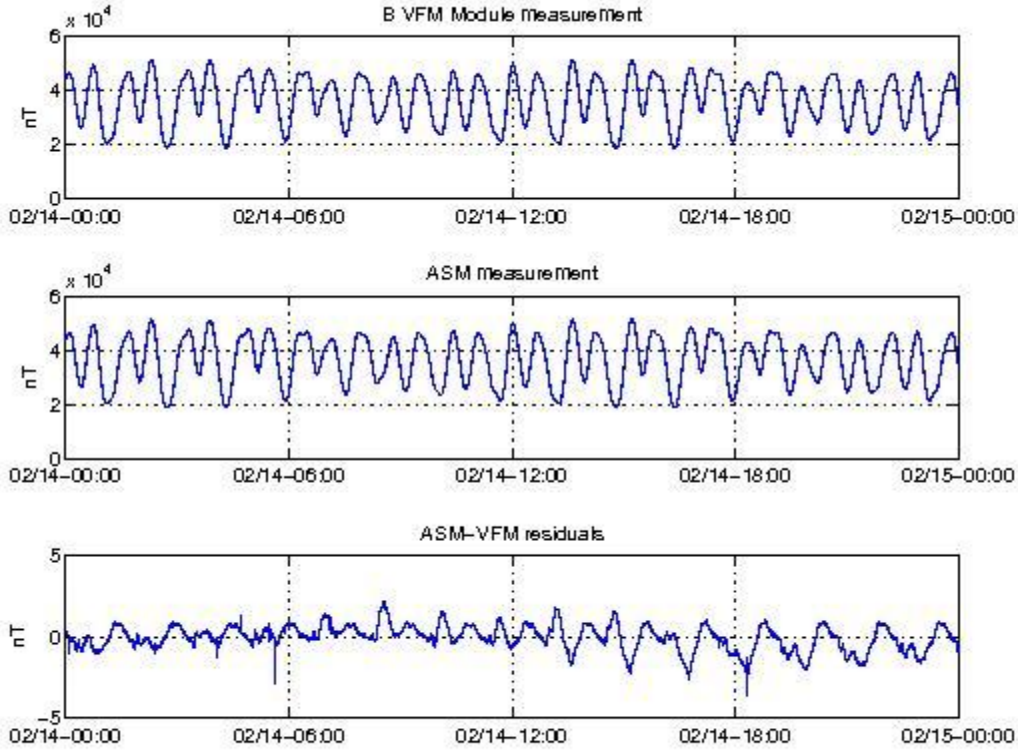

Figure 15: VFM module, ASM module and ASM-VFM residuals for S/C B, 14/02/2015.

3.3.2.3 TCF.VFM monitoring

The TCF.VFM monitoring is a monthly check and will be contained in the first report of March, related to February 2015.

3.3.3 Swarm C

3.3.3.1 Magnetic time series visual inspection

No data because ASM is still switched off

3.3.3.2 VFM-ASM anomaly

No data because ASM is still switched off

3.3.3.3 TCF.VFM monitoring

No data because ASM is still switched off

3.3.4 Summary of TCF behaviour for the three S/C

The TCF.VFM monitoring is a monthly check and will be contained in the first report of March, related to February 2015.

4. ON-DEMAND ANALYSIS

Nothing to report.

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