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STATUS OF THE EPS PROGRAMME

This document presents the status of the EPS programme as of August 2008. Main operations and changes concern:

- Status of the investigation on the HRPT failure;
- Metop A PLSOL on 19-3-08;
- Out of plane manoeuvre on April 08;
- Status of the Metop-A products.
- Planning for Metop-B and C Launches

CGMS members are invited to take note.

Status of the EPS Programme

1 OVERVIEW

Metop-A operations in support of the Routine Operations Phase have continued nominally during the reporting period with the exception of the direct broadcast missions on LRPT and HRPT which both remain off and several anomalous interruptions to the instrument operations, further details of which are supplied in the following subsections.

On 19th March 2008 the Service Module (SVM) detected a problem with the communications to the Payload Module (PLM). The onboard recovery action was for the SVM to switch immediately to the redundant units and switch off the complete PLM (PL-SOL). Following the anomaly, the spacecraft was manually reconfigured to use the nominal units and the payload was successfully reinitialised on the nominal side. During the course of this recovery it was decided to use the outage time to decontaminate IASI some months earlier than planned. Investigations of this transient anomaly are in progress.

A double-burn out-of-plane manoeuvre was executed successfully on 8th/9th April 2008 and it was followed by an in-plane manoeuvre on 24th April.

All instruments are currently performing nominally (with A-DCS on the B-side), although operational interruptions to several instruments have occurred due to manoeuvres and on-board detected problems. The out-of-plane manoeuvre on 8th/9th April required several instruments to be commanded off, and this significantly impacted the Metop-A mission (except ADCS, AVHRR and SAR) with an average of 20 hours of downtime.

General

- An IASI External Calibration was performed regularly once per month
  (6 external calibration activities for a total programmed outage time of 23h 50 min)
- A SEM TED and MEPED calibration was performed regularly once per week
  (27 calibration activities for a total programmed outage time of 21h 27 min)
- An ASCAT Gain Compression monitoring was performed every 28 days in average.
  (6 gain compression activities for a total programmed outage time of 31 min)
- ASCAT regular monthly external calibrations for May and June
  (8 calibration activities for a total programmed outage time of 45 min)

Dissemination of Metop-A products has evolved along the progress of product validation and commissioning during the reporting period. The operational level 1 product services: ATOVS, AVHRR, IASI, have continued nominally. The main outages are related on the one hand to nominal instrument operations of IASI external calibration, on the other hand to the spacecraft anomalies listed in the following Section.

The table below summarises the status and planned evolution of the Metop-A products generated at EUMETSAT.

Product	Current Status	Future Status
AVHRR/3 Level 1	Operational	
AMSU-A Level 1	Operational	
MHS Level 1	Operational	
HIRS/4 Level 1	Operational	
IASI Level 1	Operational	
ASCAT Level 1	Operational	
ASCAT Soil Moisture	Demonstrational	Pre-operational 8/2008 Operational QIV/2008
GOME Level 1	Operational	
GRAS Level 1	Operational	
ATOVS Level 2	Operational	
IASI Level 2 (twt, clp, ozo, trg)	Operational Demonstration	

The Level 1 products derived from NOAA-18: AMSU-A, AVHRR/3, HIRS/4 and MHS, were declared operational on 15/12/2007 following the operational status of the IJPS Service, see 3 below.

The ATOVS Level 2 products from NOAA-18 are planned to start trial dissemination in 8/2008.

The reprocessing activity for Metop-A data has started. The first data set to become available is the full GOME-2 L1 reprocessed dataset covering the period January 2007 through June 2008. The dataset will be available from the U-MARF upon request as of September 2008.

2 SPACE SEGMENT

2.1 Satellite Status and Configuration

Metop-A was launched on 19 October 2006.

The Metop-A platform service module (SVM) has been performing well for the majority of the reporting period, with a double-burn out-of-plane manoeuvre executed successfully on 8th/9th April 2008 followed by a touch up in-plane manoeuvre on 24th April. The SVM CCU is currently using the redundant I/O board following the incident #31 from January 2008 reported previously.
As a precaution measure, following in-orbit anomaly on a relay component (GP3) of a CNES Spot5 satellite reaction wheels thermal regulation limits used by the central flight software were modified on 26th May and 02nd June 2008. This allowed the relay on several platform subsystems to operate in a safer thermal environment.

On 19th March 2008 the SVM reconfiguration reported above caused an autonomous switch-off of all payload and instruments. Once the SVM had been reconfigured to a fully functional configuration on 20th March, the PLM recovery actions were able to start immediately, with instrument operations fully restored by 22 March, with the only exception of IASI that continued the decontamination activities until the 26th of March. Details of the instrument outage are provided in the next section.

Concerning the platform payload module (PLM), the LRPT remains non-operational following the failure in 2006 of the LRPT-A and the subsequently detected interference of LRPT-B with HIRS which led to the decision to switch-off LRPT-B on 29 January 2007.

HRPT-A suffered a permanent failure on 4 July 2007 and the HRPT-B has remained off while investigations into the root cause of that failure continue with the exception of a short in orbit test on 8th July. Please refer to section 2.3 below for more details.

The A-DCS instrument is configured on the redundant, B-side since 22 March 2007 and is performing nominally in this configuration.

All instruments are currently performing nominally (with A-DCS on the B-side), although operational interruptions to several instruments have occurred due to on-board detected problems. In all cases, the operations team, with support of Industry have been able to fully recover nominal operations:

> Instrument impacted by the PLSOL mentioned above, the EPS mission data outage was 20 hours and due to decontamination activities, IASI total outage was about 7 days and 13 hours.
> IASI – Interruptions to the IASI mission have occurred due to Single Event Effects causing an autonomous transition to Heater Refuse (4, 9 February and 21 July). Full recoveries were made on each occasion limiting the outage to less than 7h for the first occurrence and less than 4 hours for the second. The outage has been reduced to 3 hours for the last occurrence. More details are provided in the next section.
> MHS – on 6th of June, a re-occurrence of a spin state anomaly previously reported led to an autonomous transition to a non operational mode. A full recovery was possible such that less than 7.5 hours mission data was lost.
> GRAS - On 11 July 00:20 UTC Gras went to standby mode because of the unavailability of a GPS satellite, but the root cause of the problem is still under investigation. The GRAS mission data have been resumed the same day at 15:20.

2.2 SVM Reconfiguration on 19 March 08

On 19th March 2008 the Service Module (SVM) software detected a problem to communicate with the Payload Module Computer "PMC-1".

During the subsequent autonomous reconfiguration, the internal CCU bus was switched to the redundant one and due to the breakdown of the communication protocol with the Payload Module Computer, the entire Payload Module (including all instruments) was switched down.

The SVM data-bus and all bus couplers were swapped to B-side and functional assembly put in “backup” mode. Following the satellite anomaly procedure, the Controller re-acted rapidly switching back to “Working” the functional assembly in order to avoid a satellite safe mode should another anomaly occurred.

On 20th March with the support of the industry, Eumetsat switched ON again the PMC 1 on bus-coupler A, using data-bus B. All equipments indicated a nominal status, so it was decided to switch the data-bus on the A side. This successful operation allowed the investigation team to conclude that Metop-A had suffered a transient anomaly caused by a Single Event Upset. The SVM was then put back to its nominal configuration allowing the start of the PLSOL recovery procedure.

2.3 HRPT Failure Investigation Progress

Following the failure of the nominal HRPT subsystem on Metop-A on 4 July 2007, there has been no AHRPT mission, since a decision was taken not to switch-on the redundant unit while the failure investigation process established the root cause of that failure. This decision was taken due to concerns that the B-side would most likely be subject to a similar failure in a time-frame measured in a few weeks to several months.

The conclusion of this failure investigation process, contained in the ESA Failure Investigation Board Report issued in March 2008, indicated that the B-side is indeed at high risk of failure due to heavy-ion and possibly proton radiation. The board recommended to EUMETSAT not to use the redundant SSPA on Metop-A at high latitudes or over the South Atlantic Anomaly region. Furthermore, the Board stated that it is clear that there are no safe areas around the globe for the SSPA operation on METOP, only the probability of failure is reduced depending on the local heavy-ion and possibly proton environment. The board therefore recommended that EUMETSAT switches the HRPT assembly depending on our own assessment of the risk associated with the local environment (with ESA support being offered to undertake this assessment).

EUMETSAT has subsequently proceeded to analyse operational scenarios which would provide the most useful data return to EUMETSAT Member States, while minimising the risks associated with the AHRPT operation. The focus is on maximising the value of the data returned while restricting the risks to the minimum possible.

The HRPT SSPA CLY38 transistors proved to be extremely sensitive to heavy-ion radiation during the testing performed in the failure investigation process. Therefore, the final scenario chosen for HRPT operation is likely to be far more restricted than that originally envisaged. Nevertheless, using this restricted operation, coupled with further mitigation measures using enhancements to our ground segment to provide a fast extract of the X-band dump at Svalbard, the local and regional needs of the European user community should be well served, provided of course we are not subject to the occurrence of another radiation event.

On 8th July, an in-orbit validation of the AHRPT B side took place, with data successfully acquired by Lannion, Maspalomas and Athens confirming very good signal strength.

Based on the analysis of further heavy-ion flux data supplied by NOAA, it is anticipated that the definition of the zone for systematic sustainable operations will be in place to allow the restricted AHRPT operations re-start in the August timeframe.

Enhancements to the ground segment X-band dump acquisition and fast extract will complete the failure mitigation scenario in a step-wise manner over the following months, aiming to give descending pass high-timeliness data for northern European latitudes and subsequently ascending pass high timeliness data for all of Europe.

In the meantime, the NOAA-17 HRPT in the mid-morning orbit provides a partial mitigation for direct broadcast service users.

Saturation of GOME FPA channel 3 (400 and 600 nm) is observed over bright surfaces such as deep convective tropical clouds, impacting approx 5% of all measurements. This causes non-linear photon to electron conversion, resulting in an artificial alteration of e.g. NO2 concentration retrievals. This unpredictable problem can be avoided by reducing the integration time for individual measurements. As such, a change request to increase the maximum reference fluxes has been raised and a complete new science data processor software upload is planned to be up linked in September 2008.

2.4 IASI Single Event Upsets (SEU) Investigation

Susceptibility to SEU observed on IASI is greater than the prediction. It is mandatory to better characterise this effect with respect to the solar activity cycle and ageing factor in order to define appropriate mitigation actions to minimise the mission outage for Metop A and also the follow-on satellites. A working group led by CNES has released the final report in June 2008, indicating that a modification to the on-board data processing software is the best trade-off between obtaining a sensible reduction of the outage times due to SEU and the complexity and cost of the solution to be implemented. The way forward proposed is to have the modification applied as a patch to the unit flying on Metop-A (FM2) and implemented in the baseline SW for the next units (PFM and FM3).

Upon the last occurrence of this problem on 21 of July at 23:44 UTC, early identification of the cause of the anomaly resulted in a quick recovery of the instrument at 02:47 UTC on 22 July 2008. This has been achievable thanks to recent procedure updates and agreement with CNES to identify the signatures of previously

experienced SEUs and to avoid the necessity for the involvement of CNES experts in anomaly analysis and recovery. The level 1 product generation and dissemination have been immediately resumed, with products being of degraded quality until about 03:15 UTC.

2.5 Main Metop-A Events February 2008 to June 2008

All remaining instruments are operational on their nominal configuration, although several outages have occurred as a result of autonomous switch-downs following on-board detection of anomalies. These could all be identified and recovered (see following table for more details Note: autonomous on board reconfiguration are shown in bold.

Metop-A Major Events	
Date	**Event**
04 Feb	IASI Heater Refuse because of an SEU in CCM – successfully recovered (outage< 7h)
09 Feb	IASI Heater Refuse because of an SEU in DPS – successfully recovered (outage< 4h)
03 Mar	IASI DPS TOP Parameter Upload following a IASI-TEC request.
From 07 Mar to 04 Apr	ASCAT Cross calibration campaign. (51 calibration activities for a total of 4h 49 min of programmed outage)
19 Mar	SVM reconfiguration caused by a SEU in the PMC Bus Coupler. As consequence, a PLSOL was triggered.
20 Mar	AMSU-A1 Selective Refuse mode due to known anomaly (PLLO 2 selection at start-up) Successfully recovered in the frame of the general PL-SOL recovery.
22 Mar	ALL INST–Recovery from PL-SOL, 20th – 22nd Mar, IASI in Decontamination. Outage times between < 23h (AMSUs and SEM) and 3 days 13 hours (MHS)
26 Mar	IASI completed the Decontamination activities. Total outage time including PL-SOL recovery and decontamination activities was about 7 days and 14 hours
08/09 Apr	Out of plane manoeuvre. Programmed outage times for instruments between <21 h (AMSUs and ASCAT) and 23.5 h (IASI)
24 Apr	In-Plane Manoeuvre. Programmed outage times for instruments SEM ~6.25h and GOME ~3 h No outage for other instruments.
06 June	MHS in fault mode after spin state anomaly due to an SEU – successfully recovered (outage< 7.5h)
10/21 June	GOME SU autonomously switched-off due to a known software bug on 10th & 21st Jun 2008. The instrument recovered autonomously – 6 and 10 minutes of scanning data were lost respectively.
11 July	GRAS in Standby (data outage 15 hours)
21 July	IASI in heater refuse mode (data outage 3 hours)

Metop-A major events February 2008 – July 2008

Metop current orbital status at end of June 2008 is as follows:

Semi-major axis: 7195.653 (around 48 m above the reference orbit semi-major axis)
Inclination: 98.722 (around 20 mdeg above the reference orbit inclination)
LTDN: 09:29:58.4 (1.6 seconds below the reference LTDN)
Eccentricity vector: -0.000016, 0.001165 (0.000028 away from reference eccentricity)

The estimated fuel reserve is 282.30 kg. The Metop re-orbiting strategy is currently under consolidation-so this may have a significant impact on the fuel budget. On the assumption that lowering the current orbit by about 40 km is the preferred re-orbiting strategy, and taking the assumption of one autonomous transition per year to thruster controlled modes, the fuel currently available indicates a Metop-A End-of-Life around 2014.

It should be noted that other vital functions on board, including instrumentation and data transmission subsystems are not designed for these extended lifetimes and hence may become the limiting factor to the Metop-A operational mission lifetime.

2.6 Main Metop-B / C Launch Planning

The baseline launch date for Metop-B is April 2011. Note that if Metop-A is in good health, a decision to delay the launch for up to one year (April 2012) may be taken.

The baseline launch date for Metop-C is currently planned as October 2015. However, it shall nominally be launched no earlier than 4.5 years after Metop-B, so could be one year later due to the above mentioned possibility to delay the Metop-B launch. In addition, a similar logic for delaying the Metop-C launch date will be considered, should Metop-B be in good health, thus helping to ensure continuity of measurement data up to the readiness for operations of the Post-EPS mission.

3 GROUND SEGMENT

The EPS Ground Segment has been used to support the routine operations of Metop. The stability of the Ground Segment remains at a very high level and the availability may be summarised as follows:

At the **EUMETSAT Polar Site facility in Svalbard**, both Command and Data Acquisition (CDA) stations have been available, CDA1 mainly supporting Metop and CDA2 supporting NOAA blind orbits. Some problems were experienced leading to limited data losses, in particular the Antennae Tilt Gear mechanism. The data losses have now been removed by the replacement of the Antennae Tilt Gear mechanisms and workarounds are in place and actions are underway to fix the other remaining anomalies.

In the **EPS Mission Control Centre**, all the Ground Segments have performed well, with Ground Segment 1 (GS1) supporting Metop spacecraft control and data circulation. GS3 has been used as the prime maintenance verification environment for new software releases and hardware upgrades and GS2 has been used for operational validation. In particular commissioning products are tested on GS3 and validated on GS2 before going operational on GS1. Several upgrades to all facilities have been made during the year, without any interruption to operations.

The **Back-Up Control Centre** (BUCC) in Madrid is activated by the local INSA staff weekly and periodically staff from EUMETSAT travel to upgrade the systems to the latest version, perform a full maintenance and operations validation. This now occurs every two to three months.

The **S-band Telemetry, Tracking, and Command (XTTC) networ**k operated by ESOC is now activated weekly, and has been used to support the recovery of spacecraft PLSOL anomalies. In early 2008, two of the three XTTC stations: Dongara, Australia and Fairbanks, Alaska – stations external to the ESA network, were replaced by ESA tracking stations Perth, Australia and Vilspa, Spain.

The **Initial Joint Polar System (IJPS)** service continues to support NOAA for blind orbits and to process NOAA spacecraft dumps from NOAA via the Transatlantic Trunk (TAT) link on GS1. The NOAA Fairbanks support for Metop Telemetry Tracking and Command (TT&C) is fully operational and the transfer of Metop data to NOAA has functioned without problems. The NOAA Blind-orbit support has now been fully automated.

In this timeframe, the Secretariat addressed the longer term evolution of the maintenance arrangements by analysing critically the actual needs and assessing the running costs. This allowed identifying opportunities for both financial savings and improved level of service and/or responsiveness by negotiating direct contracts with the Core Ground Segment subcontractors.

This analysis was building on the direct discussions that took place end 2006/early 2007 with the subcontractors but did not materialise due to the criticality of the operational phase and the need to acquire more key knowledge within the EUMETSAT team. This is not relevant anymore. Consequently, the decision was taken to formally request offers from the subcontractors in competition with the updated TAS offer for the routine maintenance. Negotiations are now engaged with the subcontractors and if successful, would result in placing direct maintenance contracts with the subcontractors starting September 2008.

4 EPS SERVICE PERFORMANCE

The METOP end to end service performance (number of PDUs and Full Products vs expected) was consistently in the 99% range for periods not affected by the PL-SOL event and the out of plane manoeuvre.

The monthly NOAA-18 service performance was generally stable above 95 %. The losses are mostly due to loss of raw data at the CDA. In February a problem with high

elevation passes at the CDA caused the blind orbit service performance to drop to 71 %.

Metop product dissemination via EUMETCast reflected the overall EUMETCast performance (see section 3.4). Product dissemination to NOAA and UMARF was generally 100% or close to 100%.

The dissemination of Metop products to GTS showed nominal behaviour.

5 PROJECTS

5.1 Metop-B Project

The Metop B satellite is scheduled for launch in April 2011. The purpose of this project is to prepare the EPS system for this launch, commissioning and subsequent entry into operations.

Due to the current good health of Metop-A, it appears possible to maximise the return on investment by maintaining Metop-A once Metop-B becomes operational. The Ground Segment is being improved to allow a flexible architecture that would allow for rapid selection of products from the operational (e.g. Metop-B) or other (e.g. Metop A) satellite in the event of failures.

The project has recently passed through a System Definition Key Point Review and is now in the implementation phase.

5.2 NOAA 19 Operations Support Project

The NOAA-19 Operations Support Project kicked off in April 2008 with the task of assessing and implementing changes to the design and operation of the EPS System in order to support

the provision of services to NOAA for the NOAA-N' (to be redesignated NOAA-19 after the completion of Commissioning) spacecraft, and the implementation of services based on data derived from it.

The Operations Concept Document for the support to NOAA-19 will shortly be issued, with the EPS System capable of supporting a single operational NOAA-provided spacecraft in the context of the Initial Joint Polar System (IJPS), while at the same time supporting a second non-operational spacecraft on a best-effort basis within the current sizing of the EPS System.

In parallel with the Operations Concept definition, detailed assessment of the modifications required to the various aspects of the EPS System were conducted. These have now defined the required changes to the system and its operation. Key areas identified include:

1. Relative operational prioritisation of Metop and NOAA spacecraft support
2. Provision of TM/TC and Blind Orbit support to NOAA-19

3. Processing and dissemination of products derived from NOAA-19
4. Planning and implementation of transition from NOAA-18 to NOAA-19
5. Future utilisation of NOAA-18 after transition to NOAA-19

In most cases, the systems are already capable of supporting NOAA-19 but require full implementation of as-yet unvalidated NOAA-19 processes and sub-systems. Where appropriate, discussions with sub-system developers have confirmed the validity of the approach to be taken and the lack of need for any further license procurement.

Each affected aspect of the EPS System has performed a review of the required changes and the scheduling required to achieve the system readiness in time for the NOAA-N' launch (currently scheduled for Jan/Feb 2009).

System development and testing activities have now commenced with no blocking issues identified as yet. These will continue through October 2008, at which time system integration and operations scenario testing will begin.

Detailed discussions with NOAA have commenced in order to identify the involvement of EUMETSAT with NOAA during NOAA-19 Commissioning, to define the transition process from NOAA-18 to NOAA-19 in the context of the IJPS, and the future of support to, or services derived from, NOAA-18.

The project current schedule has the EPS System ready to support services to and from NOAA-19 in January 2009.