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REPORT ON SPACECRAFT ANOMALIES FROM SOLAR EVENTS

In response to CGMS action PA 02

This paper reports about all anomalies attributed to solar events that have been detected on the EUMETSAT in-orbit satellites (i.e. Metosat-6, 7, 8 and 9 and Metop-A) from 1 July 10 until 30 June 11.

Report on Spacecraft Anomalies from Solar Events

1 INTRODUCTION

This paper reports about all anomalies attributed to solar events that have been detected on the EUMETSAT in-orbit satellites (i.e. Metosat-6, 7, 8 and 9 and Metop-A) from 1 July 10 until 30 June 11.

2 SOLAR EVENTS

This working paper is the EUMETSAT response to the Permanent Action No. 02: "CGMS Members to report on spacecraft anomalies from solar events at CGMS meetings".

Solar events are here defined as any sudden in-orbit radiation or debris/meteorite impact events which have an operational impact on EUMETSAT satellites. An operational impact is defined as anything where some form of corrective action has to be taken by controllers, or where there is an interruption of services. This excludes known aging effects such as solar array degradation and, for example, memory corruption events which are detected and seamlessly corrected on-board the satellites.

The paper is divided in two main sections, the first one is dedicated to the geostationary satellites (Meteosat) and the second one to the polar satellite (Metop-A).

A list of acronyms is provided at the end of the paper.

2.1 Meteosat Satellites

There are currently 3 Meteosat satellites in operations, one of the first generation (i.e. Meteosat-7 at 57.5 deg East) and two of the second generation (i.e. Meteosat-8 at 9.5 deg East, and Meteosat-9 at 0.0 deg). Meteosat-6 was operational at 67.5 deg East until April 2011 after which it was successfully re-orbited and switched off on 2-5-11.

2.1.1 Meteosat-9 Latch Current Limiter spurious switch on

On 24-2-11 the status of the Latch Current Limiter number 07 (LCL07) on board of Met-9 unexpectedly changed from ON to OFF. LCL07 supplies power to the heaters on board and if left OFF it would have caused the on-board temperatures to drift until one of them would have triggered the temperature protections and caused an automatic re-configuration.

A pre-agreed reaction is currently in place in case of unexpected LCL switching and therefore the LCL07 was rapidly and successfully switched ON without any further issue.

Industrial investigation indicates that a possible cause is a Single Event Upset on the LCL hybrid component.

2.1.2 Meteosat-8 Safe Mode

On 30 July 10 at 1:05 UTC the Meteosat-8 satellite switched itself to Safe Mode. This was a recurrence of an anomaly which was first experienced on Meteosat-9 on 17-04-09 which was analysed and attributed to an SEU on the power distribution units of the satellite. Due to the similarity with this previous event, the satellite was rapidly commanded back to its nominal configuration and, therefore, the SEVIRI instrument was still very close to its operational temperature range. This limited the RSS outage to just 3 days (from 30-7-2010 at 1:05UTC until 2-8-10 at 08:30 UTC).

2.1.3 Meteosat-8 External Alarm set

On Saturday 28-5-11 at 10:19 UTC the parameter "D1151Z External Alarm" was set on Meteosat-8 without any other abnormal observation on the satellite. This is a recurrence, as on 13 May 2008 this same event caused a Meteosat-9 safe mode. As result of the previous investigation it was found that this parameter does not need to be monitored by the on-board software and its monitoring was therefore disabled. This prevented Meteosat-8 to enter into a Safe Mode on 28 May 2011. It was assessed that the “External Alarm” parameter was set in both cases by a Single Event Upset on one component of the Central Reconfiguration Module onboard the satellite.

2.2 Metop-A Satellite

This section gives an overview of anomalies attributed to SEUs during the reporting period. In most of the cases, the mission data availability was impacted. The approximate geographical location of Metop A is also given as additional information when known – this is to the level of regions of interest such as the South Atlantic nomaly (SAA), South Polar Region (SPR) and North Polar Region (NPR).

The table below summarises occurrences in chronological order. Further details of events can be found in subsequent sub sections.

Metop-A Events possibly due to SEU from 1 July 10 until 30 June 11					
EVT_UTC	**Inst.**	**Mission Impact**	**Comment**	**Geo location**	**Details**
24/08/2011 23:34	IASI	None	Spurious MAS ATC line activation	SAA	2.2.1
03/10/2010 13:56	MHS	Science Data Outage	Spin State Anomaly	SAA	2.2.4
12/10/2010 01:15	IASI	None	OBDH SEU	SAA	2.2.3
04/12/2010	ADCS	Science Data Corruption	SEU in Processing board	Unknown	2.2.7
30/01/2011 01:38	IASI	Science Data Outage	DPC SEU	SAA	2.2.2
03/01/2011 03:20	ASCAT	Science Data Degraded	HRS Switch Anomaly	Unknown	2.2.5
30/04/2011 15:27	IASI	None	OBDH SEU	SAA	2.2.3
03/05/2011 14:15	IASI	None	OBDH SEU	SAA	2.2.3
14/05/2011	ASCAT	Science Data Production Interrupted	Integrated Power OOL	SPR	2.2.6
23/05/2011 14:52	ASCAT	Science Data Degraded	HRS Switch Anomaly	Unknown	2.2.5
22/06/2011 11:53	IASI	Science Data Outage	DPC SEU	SAA	2.2.2

2.2.1 IASI Spurious MAS Line Activation

On 24th Aug 2010 at 23:34 UTC, an Active Thermal Control (ATC) line in the IASI Main Acquisition Subsystem (MAS) had become blocked on over the SAA. The anomaly was first detected several days after this by an alarm on the Mission Control System (MCS) as the temperature breached yellow limits. There was no impact on products or Instrument health and safety. Since a routine decontamination was planned the following week with a ca. 5 day outage, the decision was made to power cycle IASI immediately before the decontamination in order to recover control of the heater line.

2.2.2 IASI DPC Auto-restart

On 30th Jan 2011 at 01:38 UTC and 22nd Jun 2011 at 11:53, a Data Processing Chain (DPC) SEU occurred over the SAA. Previously, this type of anomaly caused IASI to enter Heater/Refuse mode resulting in an outage until the instrument was recovered manually. However, the new Instrument Management Software (IMS) uploaded in September 2009 is able to detect this anomaly and autonomously recover itself, impacting just one or two Product Data Units (PDU's). The IMS logic has to be re-enabled by an AUXILIARY-> NORMAL_OPERATION mode change. After the first instance (30th Jan) this had to be done manually from ground, impacting a further 2 PDU's. After the second instance (22nd Jun), a routine external calibration (which already contains the necessary mode transition) was due for execution within 6 hours, so there was no further action taken.

2.2.3 IASI OBDH SEU

On 12th Oct 2010, 30th Apr 2011 and 3rd May 2011 an SEU in the command transfer area of IASI was detected by the IASI IMS EDAC. The events were located over the SAA, SPR & SPR respectively.

IASI EDAC scans this memory area approximately once every 8 seconds and reports a corruption by incrementing the EDAC counter. However, IASI cannot correct a corruption in this memory area as it would require the IMS to write into its own command reception area. This anomaly can be recognised by the EDAC counter incrementing by 2 counts every 16s Telemetry cycle. IASI can continue to function nominally with one corrupted bit in this memory area, however two corrupted bits would be impossible to resolve and would lead to an IASI ICU Suspend causing an extended outage. The anomaly is recovered by manually sending a long non-operational command to IASI that completely fills this command transfer area and overwrites the corrupted bit. In both cases this operation was performed before a second corruption, thus preventing any loss of data.

2.2.4 MHS Spin State Anomaly

On 3rd Oct 2010 at 13:56 UTC, an MHS Spin State Anomaly occurred over the SAA causing approximately 18 hours of outage. The cause of such anomalies is a corruption in the position pointer register in the scan mechanism electronics. This causes a large error to be induced in the control loop, which causes the control loop to demand a correspondingly high motor current. Onboard monitoring then detects an Out of Limit (OOL) on the motor current and takes autonomous corrective action to switch MHS to Fault Mode and turn off the electronics.

2.2.5 ASCAT HRS Anomaly

On 3rd Jan 2011 at 03:20 UTC and 23rd May 2011 at 14:52 UTC, ASCAT exercised the HPA Redundancy Switch (HRS). This operation was embedded in the routine (monthly) gain compression monitoring procedure and is performed to maintain the magnetisation of the ferrite in the magnetic wave guide.

After both occurrences, it was found that ASCAT Radio Frequency (RF) output dropped by approximately 80% and ASCAT was warming up. It was concluded that this was most likely due to an SEU in the Scatterometer Front End Electronics (SFEE) sometime in the preceding month. In both cases, the situation was recovered by taking ASCAT down to Standby mode and recovering to measurement. The outages to data were 36 hours and 1 hour 47 minutes respectively.

As a lasting corrective action, the HRS switch is no longer exercised monthly and instead the RF output is monitored to confirm the ferrite core is maintaining its magnetisation

2.2.6 ASCAT Integrated Power OOL

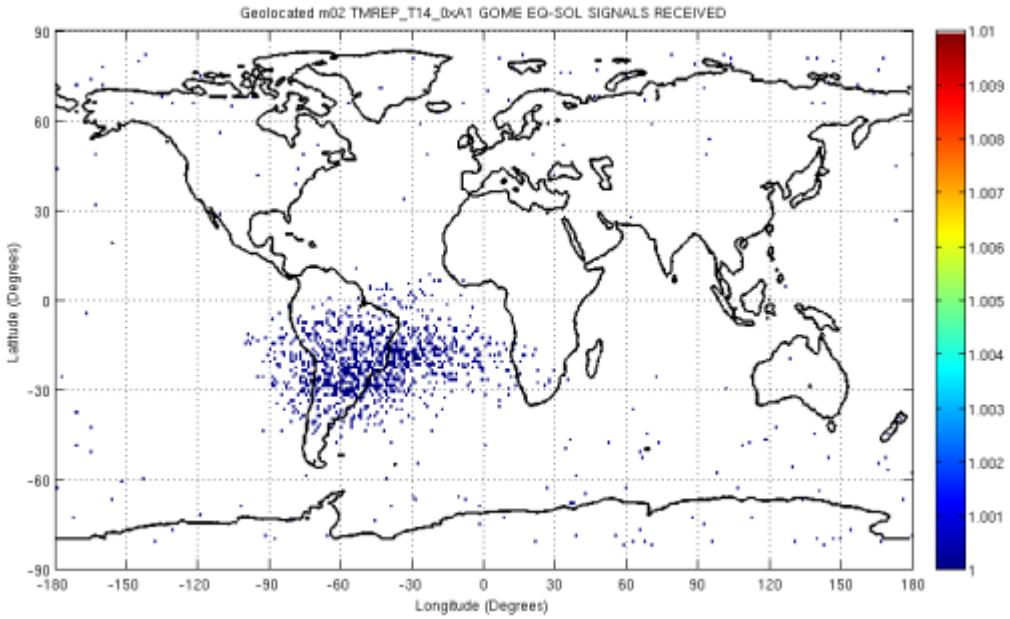
On 14th May 2011 at 10:49 UTC, ASCAT entered Heater Refuse over the SPR due to an OOL on the Integrated Noise Power. This anomaly is still under investigation, however it is believed an SEU is the most probable explanation. The Instrument was recovered by power cycling 48 hours after the event.

2.2.7 ADCS Message TLM Corruption

On 7th Dec 2010, CLS-ARGOS reported that ADCS messages had been corrupted since sometime on 4th Dec 2010. This type of anomaly is caused by an SEU in the processing board and is recovered by restarting the processor. This requires manual commanding of the instrument both from the Metop MCS in Darmstadt and the ARGOS control centre in Toulouse, following a well defined procedure.

2.2.8 GOME Ghost EQ-SOLs

GOME continues to experience Ghost EQ-SOL signals regularly during passes over the South Atlantic Anomaly. A RAM patch was applied during Metop-A SIOV to prevent the ICU from reacting to EQ-SOL signals, however they are still recorded in the history area. This patch is re-applied during any GOME reactivation and future flight models have a Resistor-Capacitor circuit installed to filter out any spurious signals. The diagram below shows the geolocation of events on Metop-A



3 CONCLUSIONS

As the EUMETSAT response to Permanent Action No. 02, this paper reports about all anomalies attributed to solar events that have been detected on the EUMETSAT in-orbit satellites from 1July 10 until 30 June 11.

List of Acronyms

ADCS	Advanced Data Collection System
ASCAT	Advanced Scatterometer
ATC	Active Thermal Control
CLS	Collecte Localisation Satellites
DPC	Data Processing Chain
EDAC	Error Detection and Correction
EQSOL	Equipment Switch Offline
GOME	Global Ozone Monitoring Experiment
HPA	High Power Amplifier
HRS	HPA Redundancy Switch
IASI	Infrared Atmospheric Sounding Interferometer
ICU	Instrument Control Unit
IMS	Instrument Management Subsystem
LCL	Latching Current Limiter
MAS	Main Acquisition Subsystem
MCS	Mission Control System
MHS	Microwave Humidity Sounder
NPR	North Polar Region
OBDH	Onboard Data Handling
OOL	Out Of Limit
PDU	Product Data Unit
RAM	Random Access Memory
RF	Radio Frequency
RSS	Rapid Scanning Service
SAA	South Atlantic Anomaly
SEU	Single Event Upset
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SFEE	Scatterometer Front End Electronics
SIOV	Satellite In-Orbit Verification
SPR	South Polar Region
UTC	Universal Coordinated Time