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REPORT ON SPACECRAFT ANOMALIES FROM SOLAR EVENTS

In response to CGMS action PA 2

This paper reports about all anomalies attributed to solar events that have been detected on the EUMETSAT in-orbit satellites (i.e. Meteosat-6, 7, 8 and 9 and Metop-A) from November 08 till September 09.

These events include two Met-9 transitions to Safe Mode (respectively on 17-4-09 and 15-8-09) and several outages of the Metop A instruments.

The anomalies on EUMETSAT spacecraft due to solar events before November 2008 were reported in CGMS-35 EUM-WP-05 and CGMS-36 EUM-WP-05.

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. Meteosat-6, 7, 8 and 9 and Metop-A) from November 08 till September 09.

All similar events occurred before November 08 can be found in CGMS-35 EUM-WP-05 and CGMS-36 EUM-WP-05

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 in-orbit event that has a sudden impact on the satellite status or performances (e.g. unexpected outages, re-configurations, triggering of on-board protections, loss of performances) and are due to in-orbit radiation effects, meteorites or debris impacts and other similar sudden events (as opposed to ageing) that can be attributed to the space environment.

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)

2.1 Meteosat Satellites

There are currently 4 Meteosat satellites in operations, two of the first generation (i.e. Meteosat-6 at 67.5 deg East, and 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).

The sections below list and describe briefly all solar events on board the Meteosat satellites from November 08 till September 09.

2.1.1 Meteosat-9 Transitions to Safe Mode

Two transitions to "Safe Mode" were experienced on board Meteosat-9 on 17-4-09 and on 15-8-09 respectively. When in Safe Mode the satellite has the payload switched off and all (or most of) the vital on-board functions moved from nominal to redundant units.

Safe Mode on 17-4-09

Meteosat-9 experienced a transition to Safe Mode on Friday 17.04.09 @ 15:51 UTC. Accordingly the Meteosat-8 Rapid Scanning Service (RSS) was halted and Meteosat-8 reconfigured to support Full Earth Scanning (FES) mode to replace the Meteosat-9 standard service. Most of the services were resumed by 19:15 UTC on 17.04.09 with Meteosat-8.

After two teleconferences with ESA and Thales Alenia Space it was assessed that the Meteosat-9 transition to Safe Mode was likely due to a spurious event as there were no indications in the housekeeping telemetry (i.e. voltages, temperatures, currents) suggesting a permanent spacecraft problem.

The Meteosat-9 safe mode recovery operations commenced at 13:19 UTC on 20.04.09 and were successfully completed at 08:30 UTC on 21.04.09 when the Meteosat-9 SEVIRI imaging restarted (although without dissemination to external users). The successful recovery confirmed that the anomaly was not caused by a satellite permanent damage.

Due to Meteosat-9 being in safe mode one day longer than in previous cases, the spacecraft was cooler upon the start of the safe mode recovery and hence the restoration of the thermal stability necessary to reach the expected image and meteorological products quality took about one day longer.

Meteosat-9 dissemination restarted on 23.04.09 at 09:00 UTC and Meteosat-8 RSS image dissemination restarted at 11:00 UTC on 23.04.09.

Subsequent investigation into this Meteosat-9 Safe Mode have confirmed that the most likely cause of the anomaly was a spurious event caused by a heavy ion on an radiation sensitive component in the circuit used to protect the satellite in case of battery under-voltage.

Safe mode on 15-8-09

Meteosat-9 experienced a transition to Safe Mode on Saturday 15.08.09 @ 05:13 UTC. Accordingly the Meteosat-8 Rapid Scanning Service (RSS) was halted and Meteosat-8 reconfigured to support Full Earth Scanning (FES) mode to replace the Meteosat-9 standard service. Most of the services were resumed by 09:00 UTC on 15.08.09 with Meteosat-8.

After two teleconferences with ESA and Thales Alenia Space it was assessed that the Meteosat-9 transition to Safe Mode was likely due to a cosmic radiation event causing a spurious power shutdown of the satellite main computer. In fact all indications in the housekeeping telemetry and in the buffer of anomalies were suggesting a spacecraft problem very similar to the Meteosat-8 transition to Safe Mode in September 2006 which was indeed assessed to be caused by a spurious power shutdown of the satellite main computer.

With the above in mind, the Meteosat-9 safe mode recovery operations commenced at 08:30 UTC on 18.08.09 and they were successfully completed on this same day at 18:30 UTC when the Meteosat-9 SEVIRI imaging restarted (although without dissemination to external users). The successful recovery confirmed that the anomaly was not caused by a satellite permanent damage.

The restoration of the thermal stability necessary to reach the expected image and meteorological products quality took something more than 2 days before full operations with Meteosat-9 could be resumed.

Meteosat-9 dissemination restarted on 21.08.09 at 08:00 UTC and Meteosat-8 RSS dissemination restarted at 10:00 UTC on 21.08.09.

Subsequent investigation into this Meteosat-9 Safe Mode have confirmed that the most likely cause of the anomaly was a spurious event caused by a heavy ion on an radiation sensitive component in the power supply circuitry of the satellite main computer.

2.1.2 Meteosat-9 Latch Current Limiter spurious switch on

On 3-4-09 at 23:38 UTC the status of the Latch Current Limiter number 31 (LCL31) unexpectedly changed from Off to On. The unexpected LCL31 switch on occurred exactly at the time of the satellite entering eclipse. LCL31 is used to supply power to the redundant Functional Control Unit (FCU) of SEVIRI which is not in use being SEVIRI operated via the nominal FCU. The un-commanded LCL31 switch on did not cause the FCU to switch on as this would need an additional command from ground to take place.

After consultation with ESA and Thales Alenia Space at 13:26 UTC on 6-April-2009 the LCL31 was successfully switched OFF.

As indicated below in section 2.1.3 the investigation is not fully completed, however industry has noted that a possible cause may be a Single Event Upset on the LCL hybrid.

2.1.3 Meteosat-8 spurious events

The following spurious events were observed on board Meteosat-8:

- Latch Current Limiter #38 unexpected switch On
- Power Conditioning Unit (PCU) auxiliary power supply unexpected switch Off
- Latch Current Limiter #12 unexpected switch On

Due to the above anomalies EUMETSAT, with the support of ESA and Thales Alenia Space, is conducting an examination of the risks associated with unexpected LCL switching (either On or Off during the nominal mission and during critical spacecraft operations in order to see if an unexpected equipment switching could pose a health and safety risk not currently identified.

LCL38 unexpected switch On

On 21-10-2008 at 11:04 UTC the status of the Latch Current Limiter number 38 (LCL38) unexpectedly changed from Off to On. LCL38 is used to supply electrical power to a Solid State Power Amplifier (SSPA) which is not used and therefore permanently off. The un-commanded LCL38 switch on did not cause the SSPA to switch on as this would need an additional command from ground to take place.

After discussion with ESA and Thales Alenia Space, EUMETSAT switched off LCL38 in the afternoon of 23/10/2008.

The possible cause of the LCL38 unexpected switch ON need to be further defined, however it has been noted by industry that a possible cause may be an SEU on the LCL hybrid.

Power Conditioning Unit auxiliary power supply switched Off

At 17:56 UTC on 29/03/09 the nominal Power Conditioning Unit (PCU) auxiliary power supply switched off unexpectedly. All the PCU generated housekeeping telemetry became unavailable (e.g. Battery Discharge status, Battery Charge status, Main Bus current and Solar Array current).

The lack of PCU housekeeping telemetry was judged as an unacceptable risk in view of the upcoming eclipse and therefore the command to switch on again the nominal PCU was sent at 20:12 UTC. Subsequently the PCU housekeeping telemetry was back in a nominal status indicating that the PCU was successfully powered again. All other telemetry was nominal and the satellite passed through the subsequent evening eclipse uneventfully from a spacecraft health and safety perspective.

In subsequent investigations it was confirmed by Thales Alenia Space and ESA that among the possible causes for the anomaly, a radiation induced event on one of the Latch Current Limiter in the PCU was deemed the most likely cause.

Latch Current Limiter #12 unexpected switch On

On 25-8-09 at 19:05 UTC the status of the Latch Current Limiter number 12 (LCL12) unexpectedly changed from Off to On. LCL12 is used to supply power to the Thermal Bus of SEVIRI for decontamination and for the Launch Locking Device relays. The un-commanded LCL12 switch on did not cause the heaters to switch on as this would need an additional command from ground to take place.

Based on previous discussions on similar spurious LCL switching, EUMETSAT successfully switched Off LCL12 on 25-August-2009 at 19:47 UTC.

Although the investigation is not fully completed, industry has noted that a possible cause may be a Single Event Upset (SEU) on the LCL hybrid.

2.2 Metop-A Satellite

The table here after gives an overview of anomalies attributed to a Single Event Upset during the reporting period. In most of the cases, the mission data availability was impacted. The geographical location of Metop A is also given as additional information.

EVT.UTC	Inst.	Mission Impact	Comment	Geo location
09/12/2008 20:28:51	IASI	Science Data Production Interrupted	Autonomous transition due to SET on the protection circuitry of the main converter (CV1) supplying DPCs and FMU	Northern Polar Region
08/01/2009 10:36:00	A-DCS	Science Data Production Interrupted	SEU Caused all high and low rate messages to be lost	South Atlantic Anomaly
19/01/2009 17:04:57	MHS	None	MHS anomaly counter incremented. No effect on scientific data production.	South Atlantic Anomaly
15/03/2009 12:45:08	MHS	Science Data Production Interrupted	Spin state anomaly that was self recovered by the instrument control loops.	South Atlantic Anomaly
09/08/2009 02:00:00	A-DCS	Science Data Production Interrupted	95% of Mission TLM Corrupted	Southern Polar Band
26/08/2009 11:09:31	IASI	Science Data Production Interrupted	Autonomous transition due to SEU in the IASI Data Processing Subsystem (DPS). (DPS_Status_Mode_Power_Acquisition and DPS_Pixel_Mode_Acquisition)	South Atlantic Anomaly
07/09/2009 18:17:20	IASI	Science Data Production Interrupted	Autonomous transition to Heater Refuse mode due to OOL detected by IMS on parameter ENC0013 (CCM Status & Mode Acquisition).	Northern Polar Band

3 CONCLUSIONS

As a 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 (i.e. Metosat-6, 7, 8 and 9 and Metop-A) from November 08 till September 09.

All similar events till October 08 can be found in CGMS-35 EUM-WP-05 and CGMS-36 EUM-WP-05.