GERB Operations Report

James Rufus

GIST 34 - Toulouse - 8\textsuperscript{th} Oct 2014
Daily GVMPERR OOL on GERB-1 Despin Mirror, 2013-14

Sun avoidance season

Number of OOL packets

0 10/13 11/13 12/13 01/14 02/14 03/14 04/14 05/14 06/14 07/14 08/14 09/14 10/14
Daily GVMPERR OOL on GERB-1 Despin Mirror, 2013-14

- All single spikes
- One sticking event
- Multiple events

Sun avoidance season

Number of OOL packets

10/13 11/13 12/13 01/14 02/14 03/14 04/14 05/14 06/14 07/14 08/14 09/14 10/14
Daily GVMPERR OOL on GERB-1 Despin Mirror, 2012-13

Sun avoidance season

Number of OOL packets

- All single spikes
- One sticking event
- Multiple events

Timeline:
- 10/12
- 11/12
- 12/12
- 01/13
- 02/13
- 03/13
- 04/13
- 05/13
- 06/13
- 07/13
- 08/13
- 09/13
Daily GVMPERR OOL on GERB-1 Despin Mirror, 2011-12

Sun avoidance season

Number of OOL packets

- All single spikes
- One sticking event
- Multiple events
Torque Level Test on GERB-1, 5th August 2014
Torque Level Tests on GERB-1 DSM
Torque Level Tests on GERB-1 DSM
GERB-2 Operations since GIST 33

[Diagram showing operations timeline with various symbols for safety, satellite manoeuvres, calibration activity, SUNBLOCK, and L-band outages.]

- SAFE
- Satellite Manoeuvres
- Calibration Activity
- SUNBLOCK
- L-band outages
- OFF
Torque Level Tests on GERB-2 DSM
Torque Level Tests on GERB-2 DSM
Lunar Observations

Moon not frozen by despin mirror, moves west to east as columns scanned. SW scans observed in deep space window beginning 18° from NORMAL image center. TOTAL scans begin 13.4° from NORMAL image center, moon observed over ~10 mins thus three images in each region.

316 lines @ 0.21 arcmin
282 lines @ 4.22 arcmin
Lunar Images

GERB1 Feb 1\textsuperscript{st} 2010 SW channel lunar images

GERB2
Apr 30\textsuperscript{th} 2012

GERB1
Nov 6\textsuperscript{th} 2011
Lunar Images

GERB1 Feb 1st 2010 SW channel lunar images

GERB2 Apr 30th 2012

GERB1 Nov 6th 2011
Lunar Observations by Pixel

GERB1 - 52% pixels
GERB2 - 49% pixels

Lunar illumination
0.84±0.10
max 0.98, min 0.51

Not separated for:
Channel
Scan Direction

Does exclude partial images.
### Calmon Photodiodes

<table>
<thead>
<tr>
<th>Diode</th>
<th>Material</th>
<th>Range (microns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>GaP</td>
<td>0.30 – 0.50</td>
</tr>
<tr>
<td>B</td>
<td>Si</td>
<td>0.32 – 1.06</td>
</tr>
<tr>
<td>C</td>
<td>InGaAs</td>
<td>0.90 – 1.60</td>
</tr>
</tbody>
</table>
Calmon Photodiodes on GERB-2 over 4 Years
Calmon Photodiodes on GERB-1 over 4 Years
## Diode Performance Changes

<table>
<thead>
<tr>
<th>Year</th>
<th>GaP</th>
<th>Si</th>
<th>InGaAs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GERB-1</td>
<td>GERB-2</td>
<td>GERB-1</td>
</tr>
<tr>
<td>1</td>
<td>0.991</td>
<td>0.999</td>
<td>0.985</td>
</tr>
<tr>
<td>2</td>
<td>0.992</td>
<td>0.997</td>
<td>0.989</td>
</tr>
<tr>
<td>3</td>
<td>0.986</td>
<td></td>
<td>0.977</td>
</tr>
<tr>
<td>4</td>
<td>0.980</td>
<td>0.997</td>
<td>0.965</td>
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## Sphere Performance Changes

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<th>InGaAs</th>
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<tr>
<td></td>
<td>GERB-1</td>
<td>GERB-2</td>
<td>GERB-1</td>
</tr>
<tr>
<td>1</td>
<td>0.902</td>
<td>0.924</td>
<td>0.988</td>
</tr>
<tr>
<td>2</td>
<td>0.822</td>
<td>0.855</td>
<td>0.986</td>
</tr>
<tr>
<td>3</td>
<td>0.744</td>
<td></td>
<td>0.980</td>
</tr>
<tr>
<td>4</td>
<td>0.671</td>
<td>0.758</td>
<td>0.968</td>
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GERB-3 successfully completed functional and calibration commissioning in during August 2012.

The early operations showed a significant improvement to the pointing accuracy of the despinn mirror based on the new drive hardware running three nested control loops, position, velocity and torque.
27th April 2013 at 05:56 (All times UTC)
GERB-3 experienced a loss of lock on the DSM which caused an AutoSAFE.

In the next hour GERB-3 periodically exceeded a warning limit on instrument current (G1015Z, 1040 mA) and was switched off at 06:55.

The instrument was recovered to SAFE mode at 10:30 on the 27th.

Subsequent commanding to NORMAL mode failed to achieve mirror lock in SUNBLOCK on two instances (29th April, 2nd May.) Each time the instrument was returned to SAFE and the DSM disabled.
Comparison of Mirror FIFO data

128 mirror position values are given by the FIFO for every rotation for the Earthview regions. The mirror is driven successfully to position zero in the case of the Deep Space threshold violation but for the mirror sticking events no further movement in the DSM is recorded in either case. In case of mirror anomaly FIFO data is repeated (last two red and three black packets before SAFE) as no new valid mirror data is supplied.

![Graph showing mirror position values over time]
Comparison of Mirror FIFO data

![Graph showing comparison of Mirror FIFO data.](image-url)
## Recovery Operations I

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<td>Full rotation at 7.2° steps</td>
<td>DSM disabled. Test position error response.</td>
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Mirror Pulse over +5/0/-5/0°
Mirror ‘Tapping’ on GERB-2, 17th August 2012
A regular test of the GERB-3 bearing was attempted twice a week based on the example of the jam on ATSR which was resolved after its mirror was commanded each overpass. Over the course of 6 months (Oct ‘13- Mar ‘14) 31 tests including 6 using the survival heaters to raise the GERB baseplate temperature were attempted.
GERB-4 Launch, Commissioning and IOS

GERB-4 Launch

• Baseline launch date 2\textsuperscript{nd} July 2014
• Launch possibly as late as the end of October

GERB-4 Commissioning

• If launch is early in July commissioning will run in mid August 2015
• Otherwise commissioning will commence at the end of the 2015 Sun avoidance season

In Orbit Storage

• MSG-4 will got into IOS post commissioning (~Launch+5 months)
• During IOS GERB-4 will be activated for 3 days every 6 months (early Feb, early Aug) for mechanism conditioning in NORMAL mode and calibration scans
Open-Loop startup mode

- Constant torque, no dependence on mirror position feedback
- 8 commandable torque levels, 0 to 340 mN
- Forward or reverse direction
- Slow speed: 3.4 RPM (maximises torque)

Improvements in closed-loop mode (normal operation)

- 2 torque levels: 50%, 100%
- Anti-windup circuit
  - Improves operation through stiction events by avoiding velocity loop saturation.
  - This should speed up return to normal mirror rotation.
Other GERB-1 MSG-2 Issues

Well…

SEVIRI on MSG-1 in RSS most of the time so processing headache
Give RSS/FES schedule

Anything else?
A similar event has occurred once before on GERB-3 at 19:28 on 4th February.

After two OOL packets on GVMPERRF the hardware in-lock flag was deasserted and the AutoSAFE transition began.

In this case the instrument also raised alarms on the inner, high current limits overnight as the mirror attempted to drive to its zero position.

The instrument was power cycled at 09:00 on the 5th of February and successfully recovered to SUNBLOCK at 15:00 on the 6th and to NORMAL at 11:00 on the 7th.

The instrument remained in NORMAL until the 13th of February when it was commanded to SAFE for Sun avoidance.
GERB-3 has experienced three more AutoSAFE incidents since launch caused by high signal tripping the deep space column checks.

In these cases no current limits are violated in SAFE mode after the event.
AutoSAFE Incidents Compared
Initial Restart Attempts – Command to SUNBLOCK
The GERB-3 bearing ran for 106 days in NORMAL mode before the second sticking event. Comparing position errors recorded on GERB-3 with earlier instruments over the same period it can be seen that the GERB-3 bearing falls between the rough early running on GERB-1 and the smooth running GERB-2.

Events from a known anomaly on GERB-1 due to mispointing after a stationary mode were neglected.

<table>
<thead>
<tr>
<th>Incidents</th>
<th>Sticks</th>
<th>First Stick</th>
</tr>
</thead>
<tbody>
<tr>
<td>GERB-1</td>
<td>102</td>
<td>12</td>
</tr>
<tr>
<td>GERB-2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>GERB-3</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

Incidents are single events, sticking events consist of consecutive packets with DSM performance OOL.
GERB-3 Torque Monitor
Differences of GERB Drive Systems

The GERB-1/2 DSM drive system consists of a velocity controller with periodic position correction.

In GERB-3 the drive uses a vector control system with three nested loops controlling:

- Position
- Velocity
- Torque

The GERB-3 system adjusts torque applied automatically throughout the rotation to improve the pointing performance of the despin mirror.

The GERB-1/2 system adjusts corrects position once per rotation.

The coarse control is used in acquisition, Fine/Track is used under nominal conditions (0x4200, 0x4000 & 0x4028.)

Ripple rejection is used to further enhance the pointing accuracy of the DSM.

<table>
<thead>
<tr>
<th>Bit (15 = MSB)</th>
<th>TM mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td></td>
<td>Descan drive enable</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Coarse / Fine control</td>
</tr>
<tr>
<td>13</td>
<td>GSMCORS</td>
<td>Slew / Track</td>
</tr>
<tr>
<td>12</td>
<td>GSMSEW</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>GSMVE2</td>
<td>Velocity estimator 2 enabled (SAFE mode)</td>
</tr>
<tr>
<td>8</td>
<td>GSMTCF</td>
<td>Torque correction factors enabled</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>GSMVRIPL</td>
<td>Velocity ripple rejection enabled</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>GSMTRIPL</td>
<td>Torque ripple rejection enabled</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
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Torque Level Test GERB-1 vs. GERB-3
Mirror ‘Pecking’ on GERB-2, 17th August 2012
In analysis of the two DSM events on GERB-3 it was noted that they were both preceded by AutoSAFE events on the stray light checks.

To ensure no causal connection the torque monitor data was examined in those two incidents and the event from October.

Data is also shown from late in January 2013 when no safety transitions took place.

The proximity appears to be coincidental.
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Mirror Phase Sweep through 360°
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Mirror Pulse over +5/0/-5/0°
A planned test to heat the GERB-3 instrument and activate the DSM to free the mechanism led to a preparatory test on GERB-2. The GERB operational heaters have insufficient power, and are poorly placed to preferentially heat the DSM so the survival heaters were used instead. The successful test showed that the GERB-3 baseplate could be raised 7 degrees without endangering the detector or adversely effecting SEVIRI full Earth scans.
GERB-3 DSM Drive Logic

14 bit commanded angle

20 bit mirror angle

24 bit coarse DAC

12 bit coarse DAC

Coarse Slew position controller

Coarse/Fine mode Slew/Track mode

Velocity demand GVMVDEM

VRR select

15 bit fine DAC

Fine Slew position controller

Fine Track position controller

Fine posn.error GVMPEFF

RMS

20 bit mirror angle

Position feedback GMMPDSMS, GMMFDFD1

24 bit coarse DAC

15 bit fine DAC

Supervisor

Posn error > 20 pixels? R to D data check

Coarse Slew position controller

Velocity controller

Fixed threshold

IN-LOCK

Power Amp

Vector Torque controller

Torque feedback GVMTORQ

Dynamics

Motor

Torque ripple reject

TRR select

Velocity feedback GVMVELM

Source select

Velocity estimator select

Inductosyn

Graphics/Configuration/Version 1.2
Overview of GERB-3 DSM Anomalies

• GERB-3 has experienced two AutoSAFEs due to Despin Mirror (DSM) out of limits (OOL.)

• In early February the instrument was returned to NORMAL, with mirror lock achieved in SUNBLOCK after a power cycle.

• In late April the mirror failed to achieve lock in SUNBLOCK on two attempts to restart the mirror.

• In both case periodic high instrument currents which tripped the warning limits were observed short times after the AutoSAFEs.

• In AutoSAFEs not related to mirror performance these high currents were not observed and the mirror return to lock at the zero position over a few seconds.
Relocation of MSGs

MSG-3 3.4°W
Met-8 9.5°E
Met-9 0° 3.5°E
Met-10 3.4°W
Met-8 9.5°E
Met-9 0° 3.5°E