Integral Users Group - MOC

Richard Southworth
(Integral Spacecraft Operations Manager)

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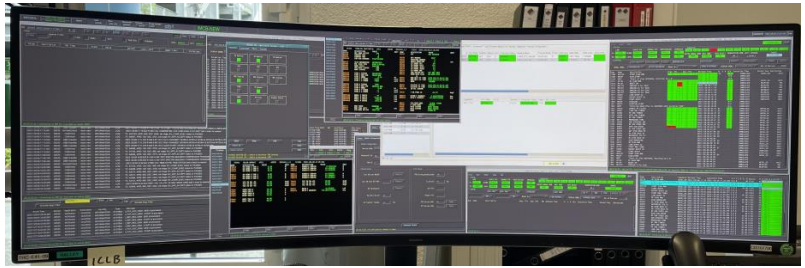
Flight Control Team

- Richard Southworth (Ops Manager, System @60%, also 20% CHEOPS)
- Jutta Huebner (Ops Engineer, P/L @50%)
- Ian Benson (Ops Analyst 100%)
- Marius Baab (Systems Analyst @50%)
- Liviu Toma (Ops Engineer, AOCS, also 50% XMM)
- Thomas Godard (Ops Engineer, AOCS + automation, also 50% XMM)
- Stefano De Padova (Ops Engineer, MCS + OBDH , also 50% XMM) – left end April
- Timothy Finn (Ops Engineer, RFS, P/L, also 50% XMM)
- Norbert Pfeil (Ops Engineer, EPS + TCS + MCS, also 50% XMM)
- Greta De Marco (Ops Engineer, OBDH, Planning + automation, 100%)
- Jim Martin (On-board software modifications, B/U SOM)

MOC



- No major activities currently
  - Possible MCS hardware migration
- Control room recently refurbished
  - Controller shared with XMM, Gaia, EUCLID
  - Priority EUCLID > Gaia > XMM > INTEGRAL
- KIR is prime station, reliability and coverage are very good
- Regular coverage also from VIL1 / 2, MSP
- Occasionally Goonhilly, KRU

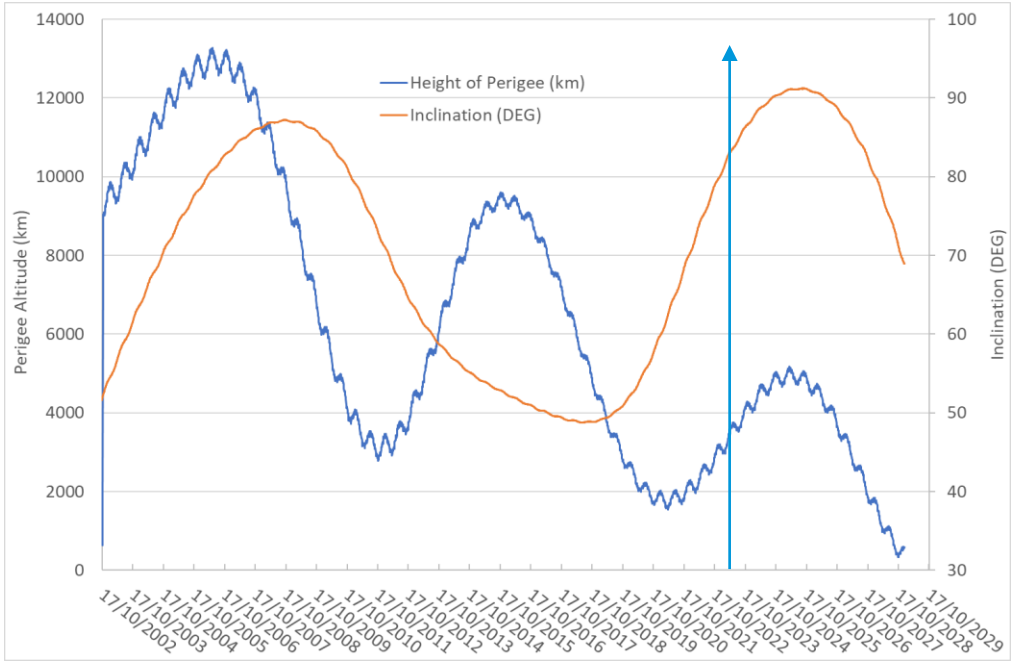
Orbital Evolution

Perigee below 6000km until end of mission

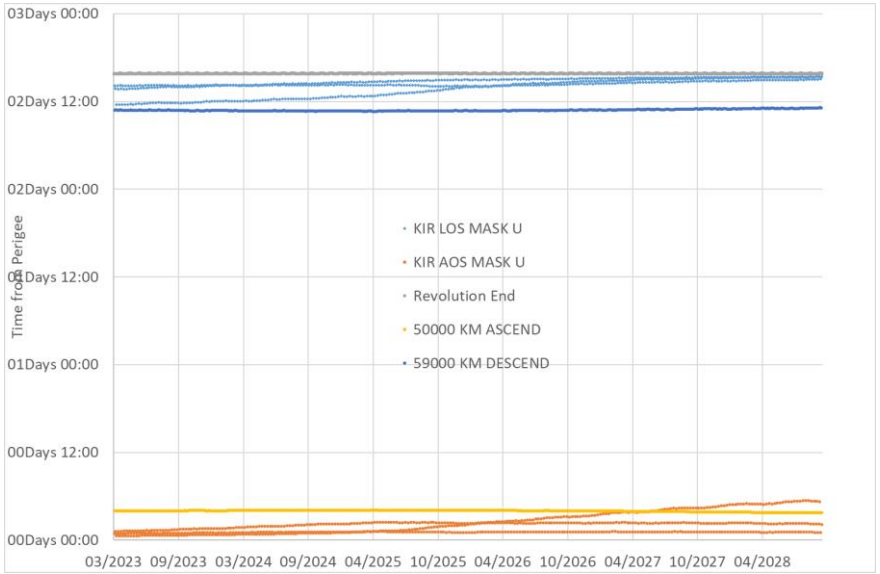
- Faster rate of SA degradation
  - See later slides
- Increased earth albedo exposure @ perigee
- Other consequences for components?
  - CDMU problem – VCA?
  - SPI DPE?

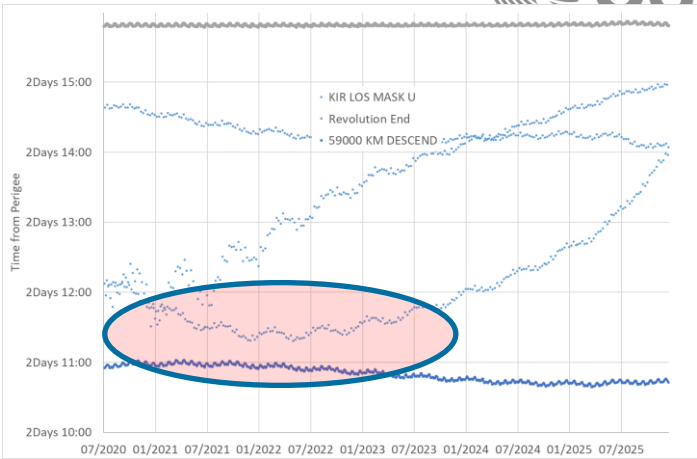
Increased inclination good for station visibility

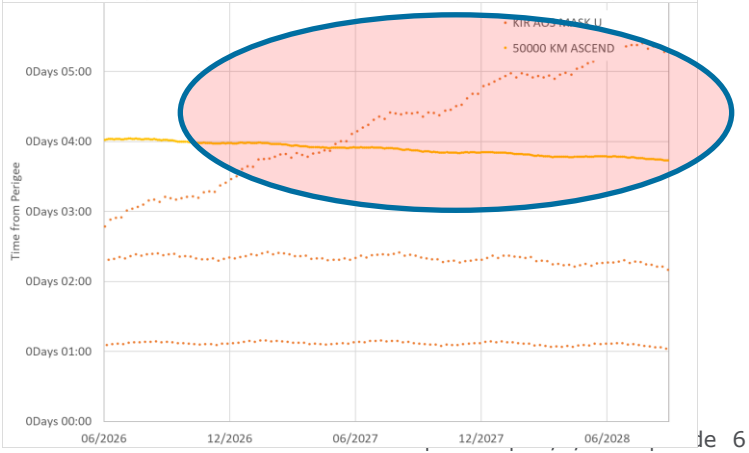
Re-entry in early 2029



Orbital Evolution – Station Coverage @ KIRUNA







Close to full coverage from KIRUNA until end of mission

- Late AOS every 3rd revolution 2027 & 2028
- Early LOS every 3rd revolution to end 2023

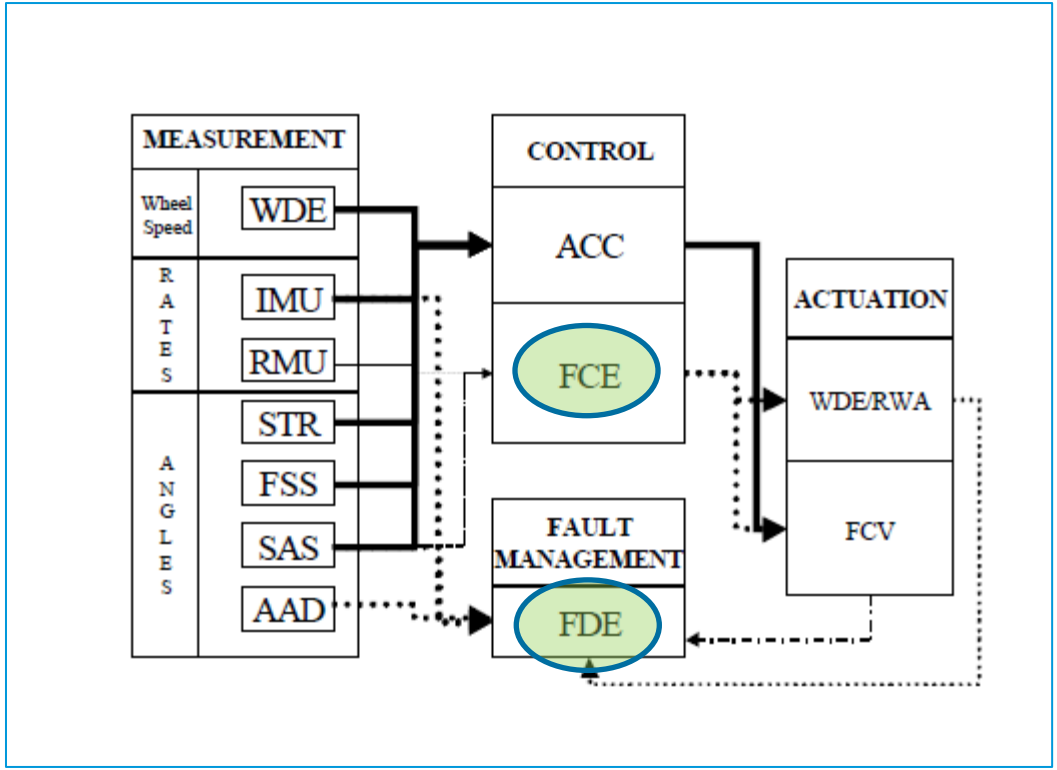
New Safe Mode

Old safe mode (ESAM)

Hardware based

Fully contained within AOCS subsystem

- FDE: Failure Detection Electronics
- FCE: Failure Control Electronics (ESAM controller)



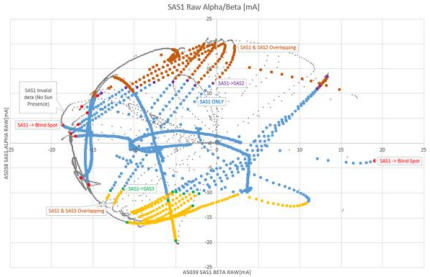
New Safe Mode

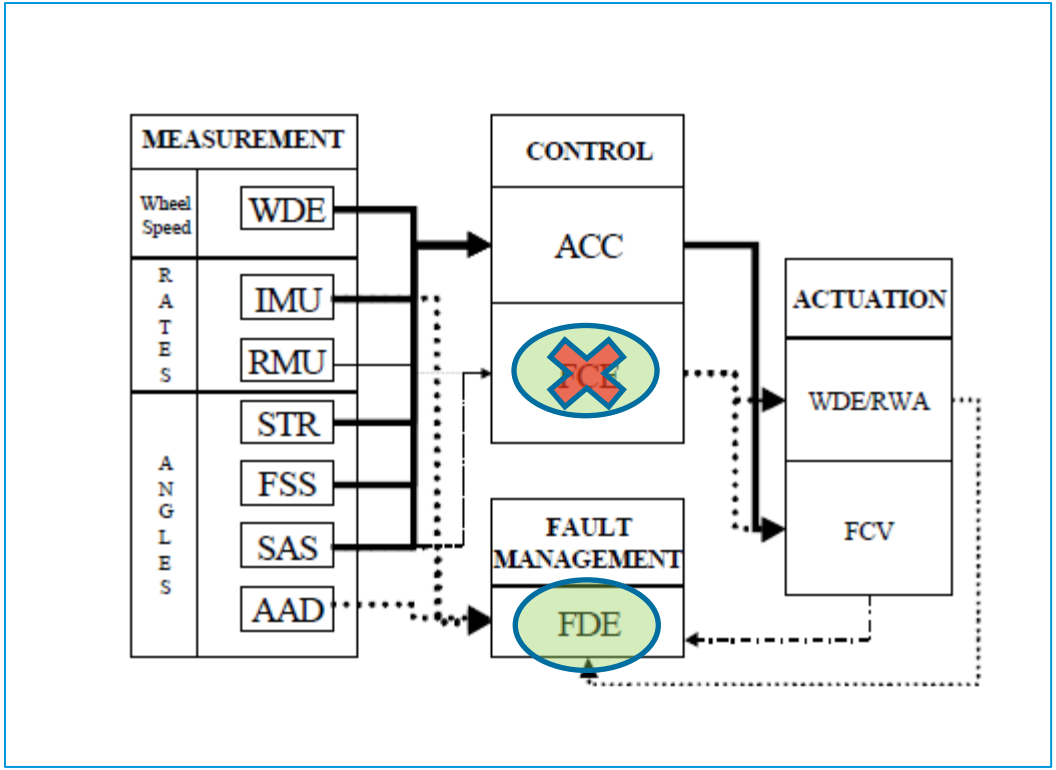
Propellant System Failure May 2020

FCE: Failure Control Electronics (ESAM controller) no longer useful

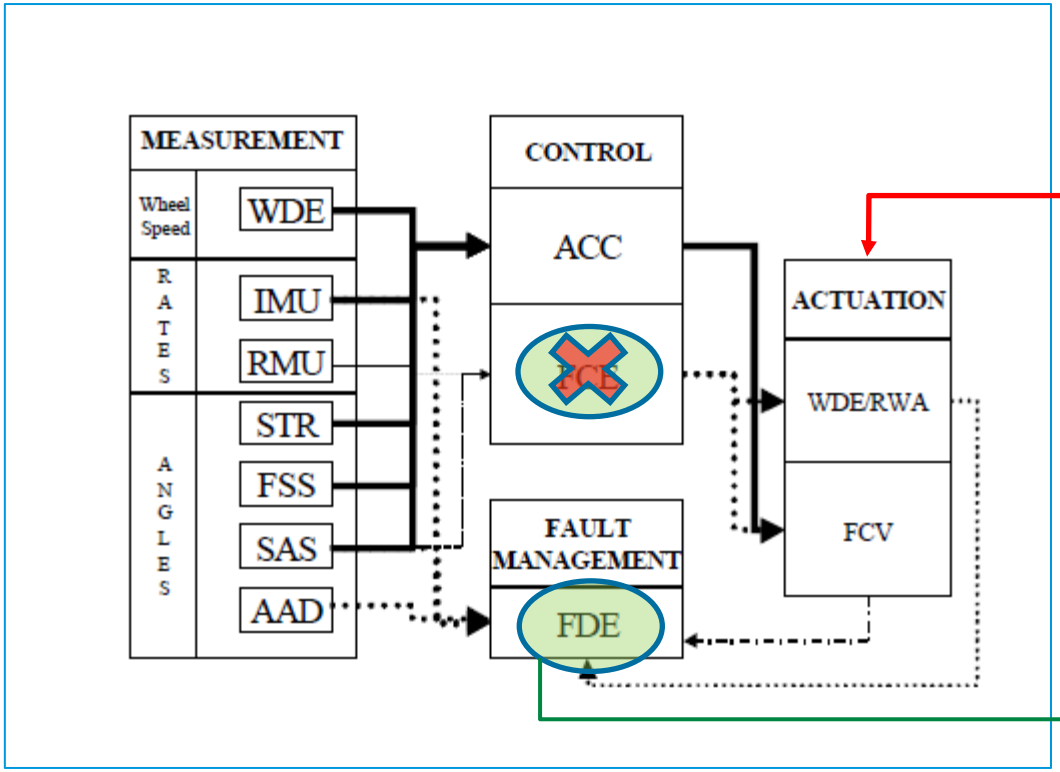
No effective safe mode controller

- See September 2021





New Safe Mode



CDMU

Monitors output of FDE for failure detection

Commands RWLs etc directly

Independently of the AOCS

New Safe Mode - High level Sequence of Events

1. Trigger based on existing (ESAM) criteria
2. On-board monitoring task reacts: configure hardware, ACC Mode transition (SSA), activate NSM controller
    - SSA allows direct wheel momentum demand / rates change commanding (RCS isolated!)
    - Broadcast packet safes instruments
3. NSM Controller: Reduce rates by commanding wheel demands, **4 wheels used**
4. Check if commanded demands achieved:
    - All 4 wheels achieve demanded momentum?, Go to 6
    - One wheel does not achieve commanded momentum?, declare failed and go to 6 with 3WD
    - No wheel achieves commanded momentum, go to 5
5. Load new OBM entry to trigger on ARO to command alternative hardware (ACC, IMU), ACC Mode transition (SSA), de / reactivate NSM controller, go back to 3
6. When rates have reached the demanded ones, return to Sun based on SAS outputs and apply demand to reach Sun pointing attitude – 2 axis control.
7. Apply step 6 until SSA is less than a required angle, until rates are 0 and ground takes control, and option apply fixed yaw rate to spin satellite around z-axis.

New Safe Mode – Implementation Steps

Extended Memory Patch

- Reallocated data areas as programme areas to increase available memory (just 1.7K available initially)

On-board monitoring extension patch

- Extended capabilities of on-board monitoring (250 commands total, was 50)
- More than 3 commands / entry

IO Patch To demonstrate that:

- CDMU can access all required data types
- CDMU can issue all required commands

NSM Controller patch

Implemented in 18 months

Low cost development

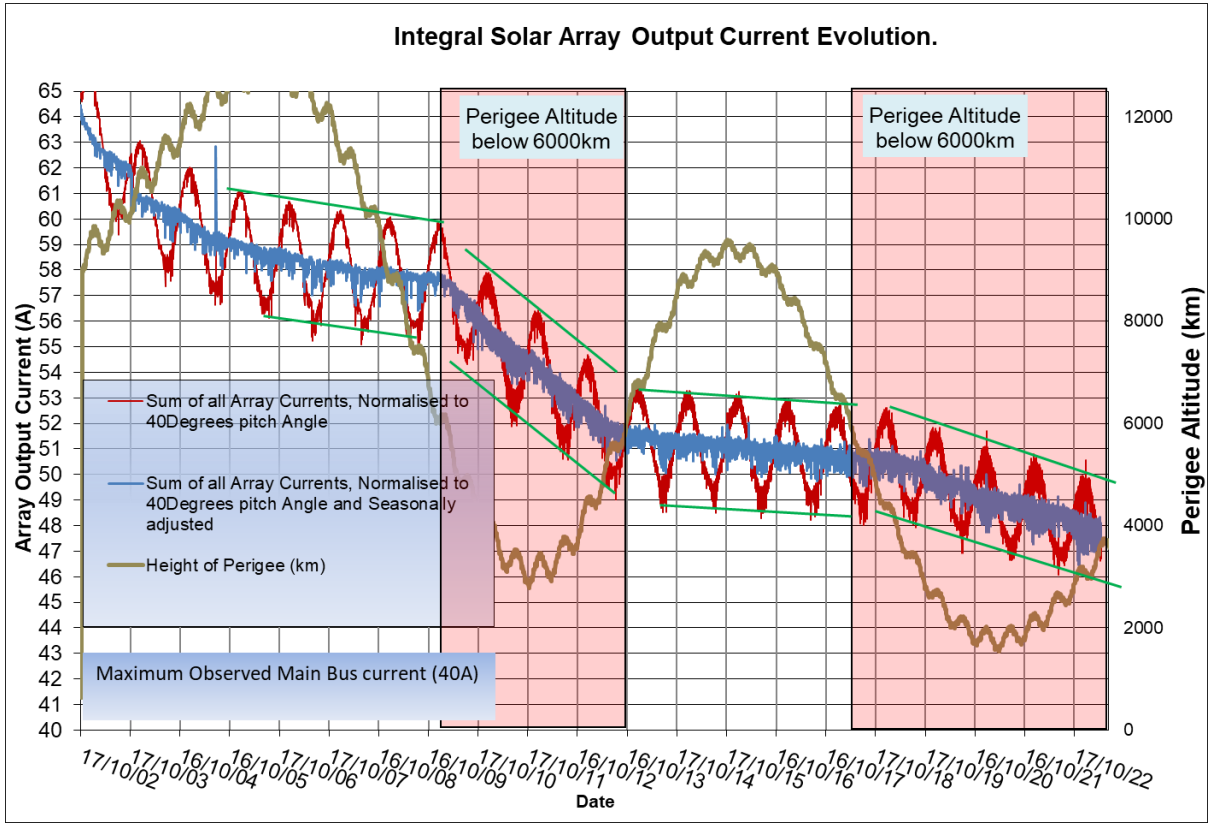
Restores full satellite functionality

Array Degradation

To recap, 2 issues:

- Power Budget evolution
- Autonomous reconfiguration ECL(s/e) at eclipse entry may occur in sunlight at large pitch angles => unplanned instrument switch-off

Array Degradation – Power Budget



Degradation less than expected

Updated predictions very positive

Demand reduced – no wheel momentum offloading!

Peak demand is battery recharge

EPS limits battery charge in case of excess demand

- => Flexible margin of about 6A
- Reduction in charge rate

Limited discharge in sunlight OK – **batteries are healthy!**

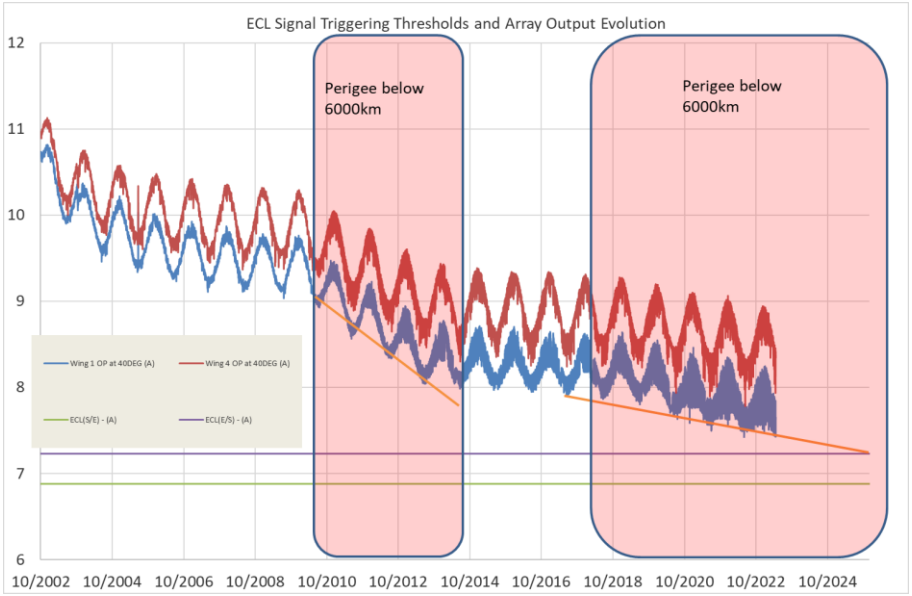
Probably no power constraint before re-entry

(Constraint only if battery discharge in sunlight is significant)

Array Degradation – ECL (s/e)

The ECL Issue

- Autonomous reconfiguration at eclipse entry
- Based on array output current (Threshold 6.9A)
- Reconfiguration for power (safety) reasons
- Approaching threshold at max pitch angle in Sun
- Powers off PLM unexpectedly – long recovery!
- Not before end **2024** – probably later



The proposed solution

- Constrain pitch angle (planned) <u>in eclipse season only</u>, disable ECL(s/e) outside eclipse season
  - Initially limitation to 35DEG is sufficient, later maybe 30DEG
  - Ensure safety with OBM entry to re-enable autonomy in emergency outside eclipse season
  - Temporary loss of small part of celestial sphere visibility for about 90 days / year

Start depends on observed degradation – lower than expected

AOB

I will Retire in about a year from now

- Jim Martin is probable replacement
    - worked on XMM since 2004
    - Led every aspect of the New safe Mode development
        - Proposed for DG Award!