# Integral Users Group – MOC and Spacecraft Status

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# Overview

- MOC Operations Status
  - FCT & MOC evolution
  - SPACON merger with Gaia
- Propellant Evolution and future saving proposals
- Power Budget Status and Evolution
- Disposal Update

# Spacecraft Operations Status - FCT

FCT:

- Richard Southworth (SOM, System) at 50%, also supporting CHEOPS
- Jutta Huebner (SOE PLM, simulator porting) at 50%
- Stefano De Padova (SOE OBDH, ground segment, simulator porting) at 100%
- Bruno Gandolfo (Analyst, Mission planning, OBSM) at 100%
- Dave Salt (AOCS) at 50%, also supporting XMM
- Liviu Toma (AOCS) at 50%, also supporting XMM
- Timothy Finn (RFS, SPI, OMC Ground Stations) at 50%, also supporting XMM
- Norbert Pfeil (MCS, IBIS, EPS, TCS) at 50%, also supporting XMM
- Thomas Godard (JEM-X, Automation) at 50%, also supporting XMM
- Controller team of 6 at 50%, also supporting XMM

# Spacecraft Operations Status - MOC

Facilities:

- Ground Stations
  - Kiruna prime, almost full coverage for science, high reliability
  - B/U Weilheim, Kourou (poor visibility)
  - VIL2, Perth, REDU, Maspalomas no longer available
- Control room fully modernised, VMs + DTUs, shared with Gaia, XMM
- MCS HW and OS supported into early 2020s, further evolution options available, high reliability, flexibility, low maintenance, high commonality with XMM
- Simulator porting on-going from VMS HW + OS procured 1998!, to modern LINUX based environment, high commonality with XMM
- Automation system has been tailored and introduced to support operations

# Spacecraft Operations Status – Gaia Merger

Proposal agreed to reduce manpower (costs) by reducing SPACON complement

- Currently 6 (INT / XMM) + 3 (Gaia)
- Reducing to 6 (INT / XMM / Gaia) + 1 (flexible)

Gaia require ~2 hours dedicated attention / day

- During this time reaction to critical INT / XMM anomalies only
- Delayed recovery to none critical anomalies (e.g. IREM crash) – performance!!
- Pre planned sequence of operations runs as now – no change
- Complemented by automation of some routine operations / standard anomaly recoveries

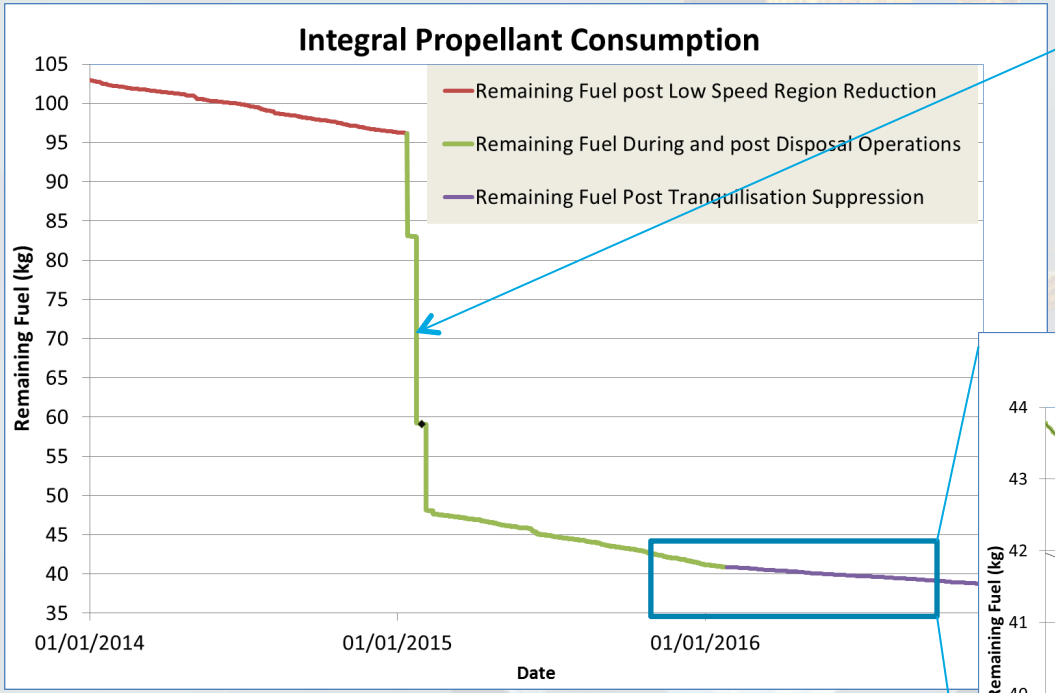
SPACONs no longer trained to recover Instrument anomalies (safety only)

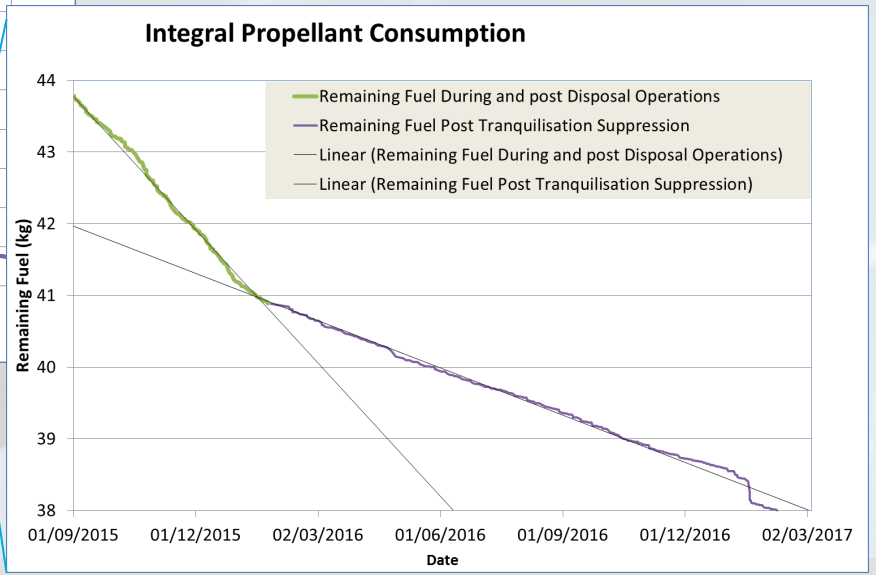
- Flexible position will do this on next working day (or automation)
- In 2016 this would have implied possible delayed recovery from
    - 16 IREM crashes (OMC, IBIS) – we are working on automation of this CRP
    - 6 JEM-X DFEE CRC Anomalies – automated procedure available and tested

# Propellant Evolution

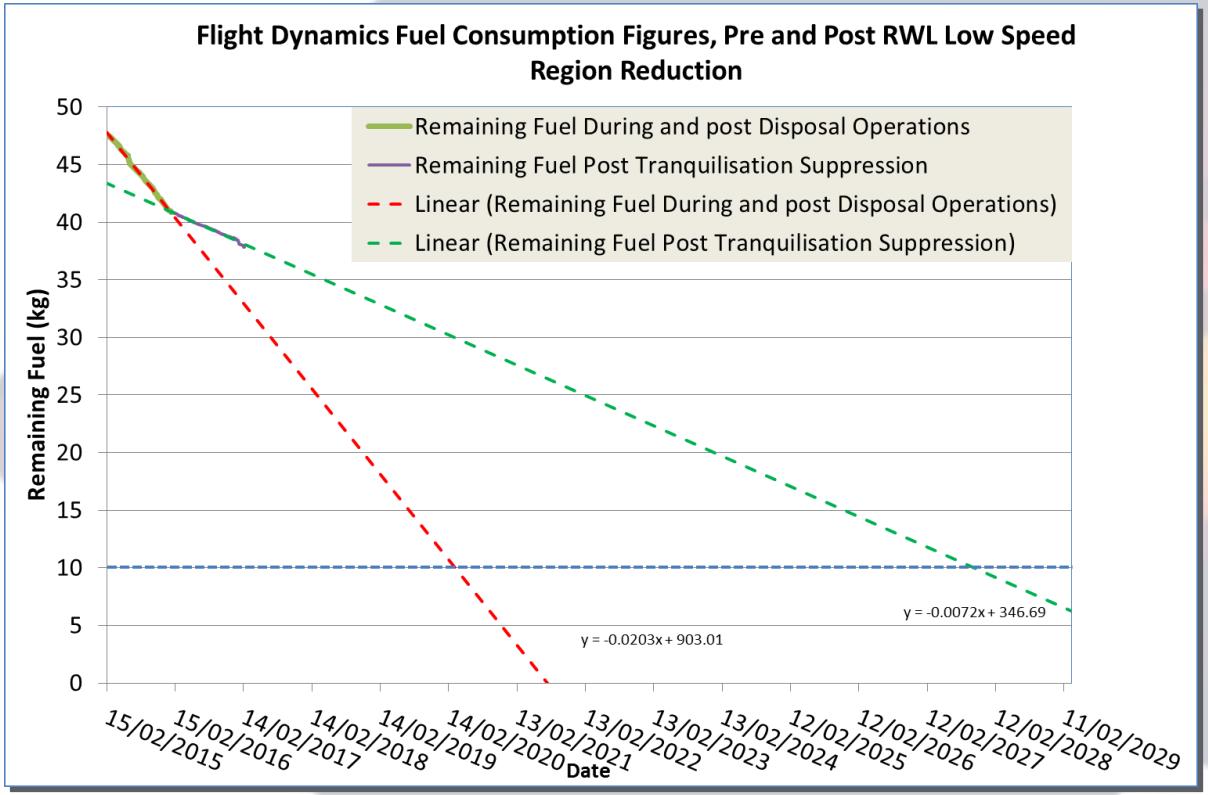
Disposal manoeuvres used roughly half remaining propellant

FCT investigated ways of mitigating this



# Propellant – Thruster Tranquilisation Suppression

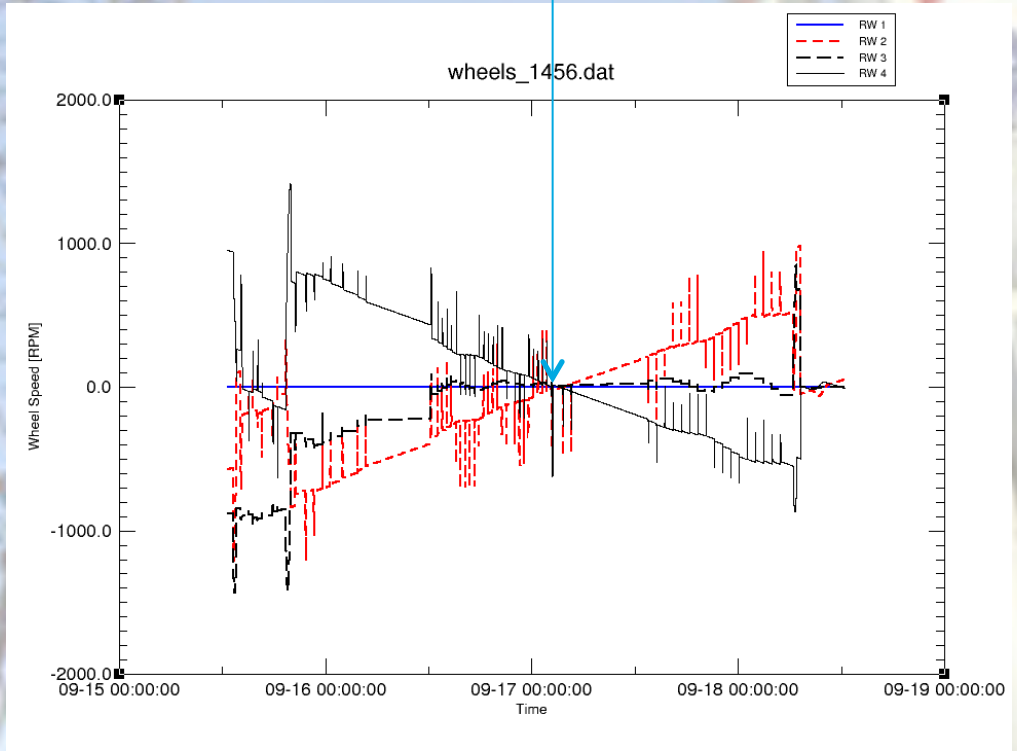



Propellant consumption reduced by > 50%

Effect of the disposal manoeuvres on mission lifetime has now been negated!!!

Scope for further improvement

# Propellant – use of Wheels low speed Region



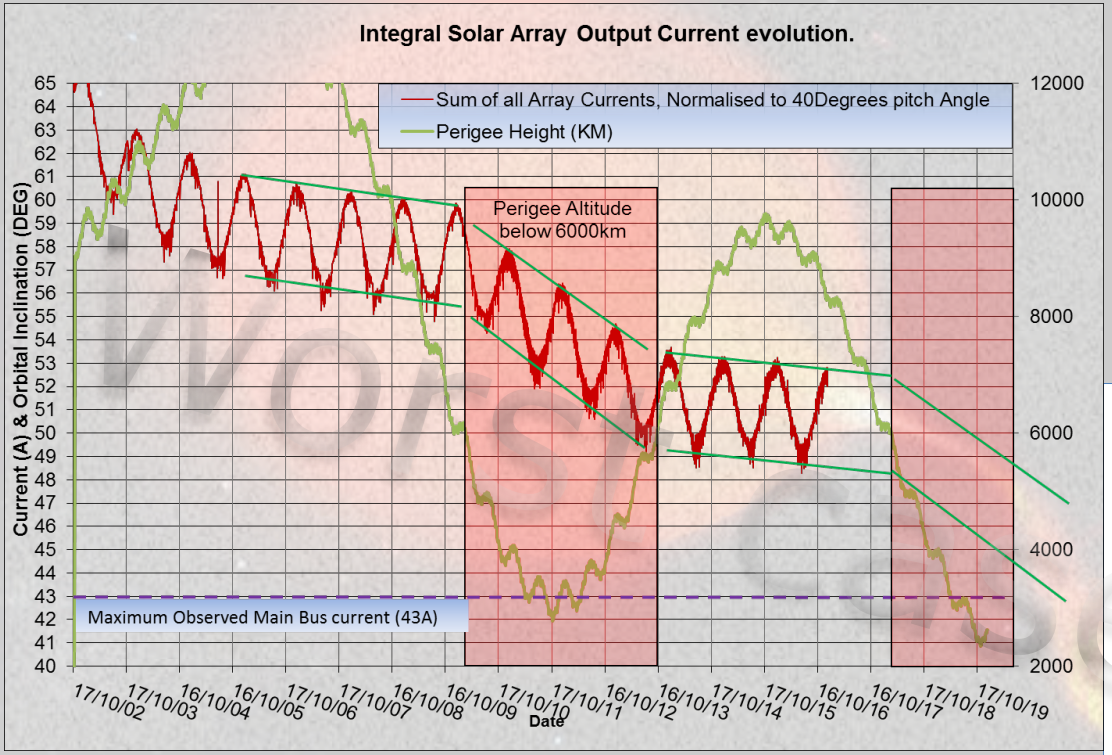

Currently using the wheels like this is forbidden by industry.

We use propellant (and time and effort) to avoid doing this!!

- Tests have shown attitude control works well at these speeds.
- Flight Spare RWL on test for more than 1 year in this regime – no degradation / effects.
- Bearing assembly tested by industry regime – no degradation / effects.

Proposal for modified wheel usage shortly

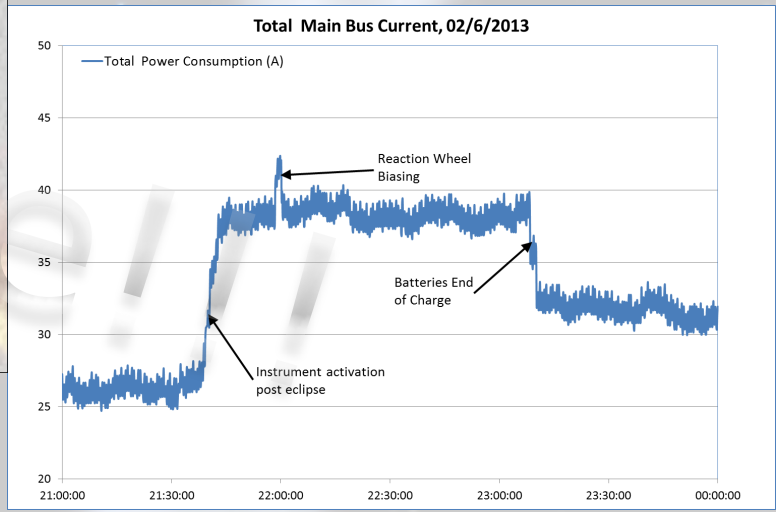
# Power Budget Status and Evolution – Arrays OP




Perigee below 6000km from 2018 until end of mission

Typical peak power demand – limited duration

Batteries can be used to complement the arrays during such periods




No limitation due to array degradation until well after 2020

Then only seasonally initially (eclipse…).

# Power Budget Status and Evolution – Batteries

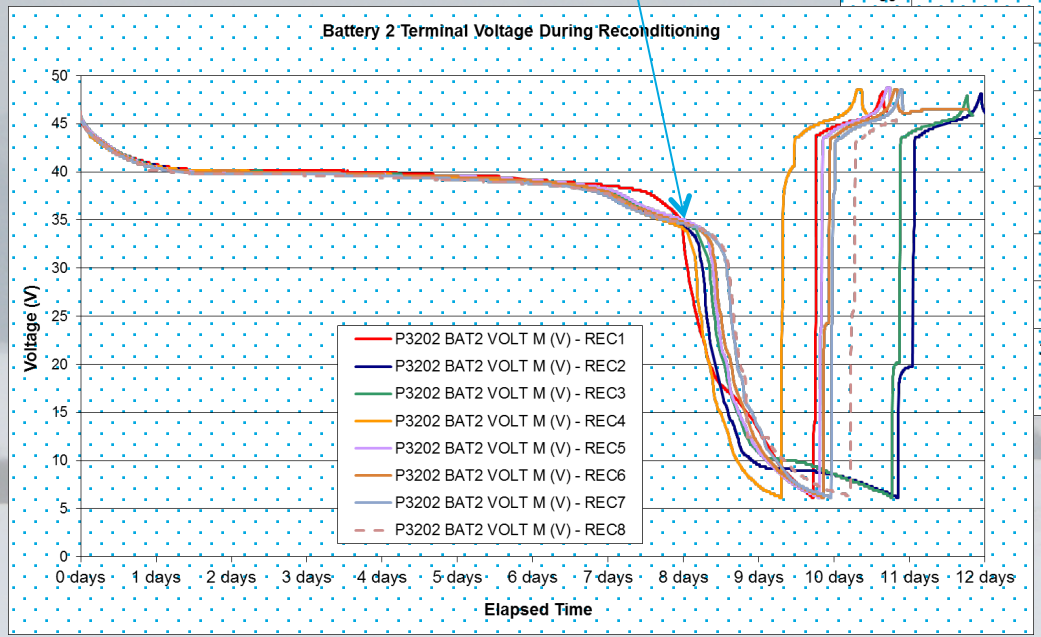
| Reconditioning | Battery 1 | | Battery 2 | |
|---|---|---|---|---|
| | Discharged Capacity | Recharged Capacity | Discharged Capacity | Recharged Capacity |
| Spring 2004 | 35.71Ah | 38.67Ah | 35.94Ah | 38.67Ah |
| Summer 2006 | 35.97Ah | 38.67Ah | 36.65Ah | 38.67Ah |
| Summer 2008 | 35.86Ah | 38.67Ah | 36.94Ah | 38.67Ah |
| Winter 2009 | 36.7Ah | 39.57Ah | 35.2Ah | 38.67Ah |
| Spring 2011 | 35.6Ah | 38.67Ah | 36.17Ah | 38.67Ah |
| Autumn 2012 | 35.7Ah | 38.67Ah | 36.22Ah | 38.67Ah |
| Spring 2015 | 36.4Ah | 38.4Ah | 36.4Ah | 38.67Ah |
| Autumn 2016 | 36.4Ah | 38.67Ah | 36.8Ah | 38.67Ah |

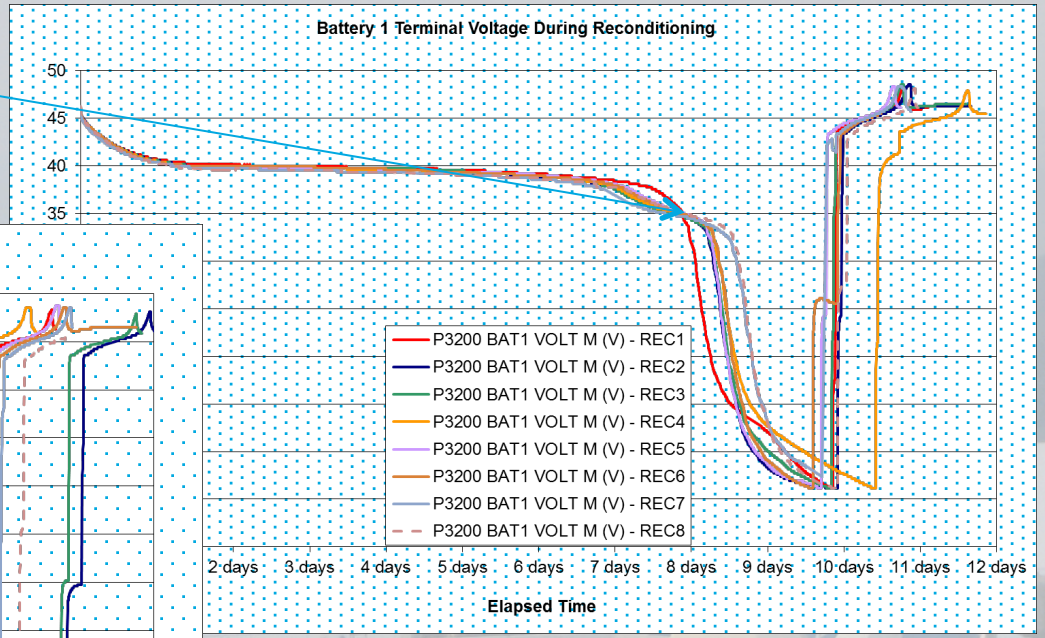
Reconditioning consists of long full discharge and recharge to combat the memory effect.

- Capacity variations are due to temperature (attitude) changes.
- No measurable evolution.

# Power Budget Status and Evolution – Batteries

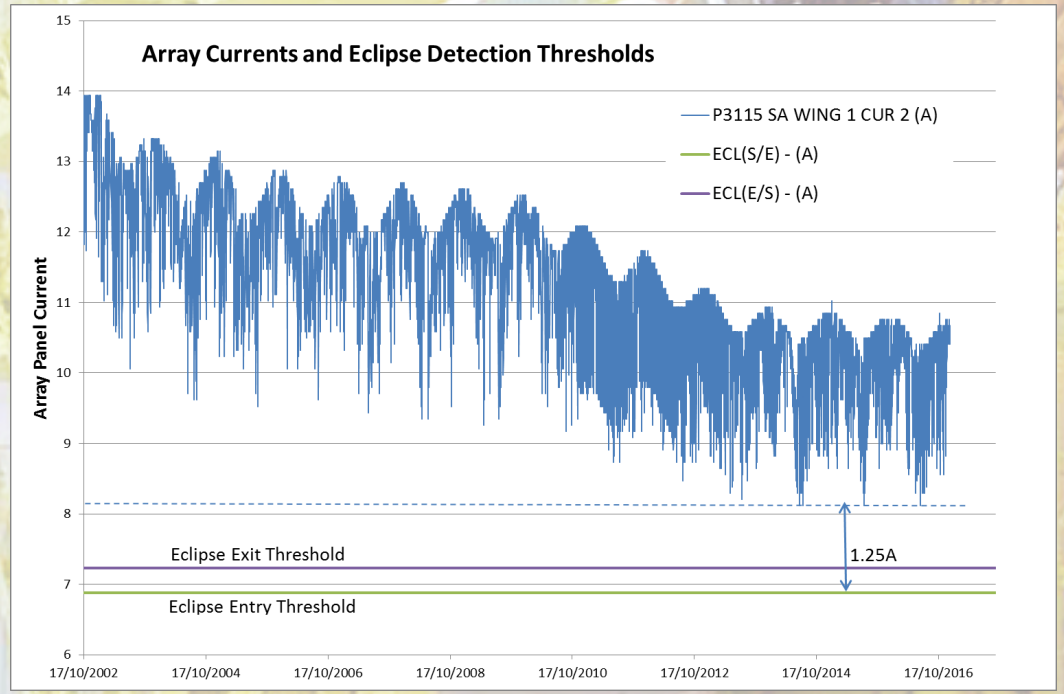
Usable capacity



# Power Budget Status and Evolution – Eclipse Entry

## A further power related problem!!




Worst case array current is approaching eclipse detection threshold!!.

- Leading to possible spurious eclipse detection / instrument switch-off.
- This threshold is hardwired!
- Can be disabled, but entering a real eclipse without detection is extremely dangerous, could lead to loss of satellite.
- This may also force pitch angle restrictions in eclipse season.
- Checking for other safe solutions.

# Disposal

## Re-entry will occur on the 27th February 2029

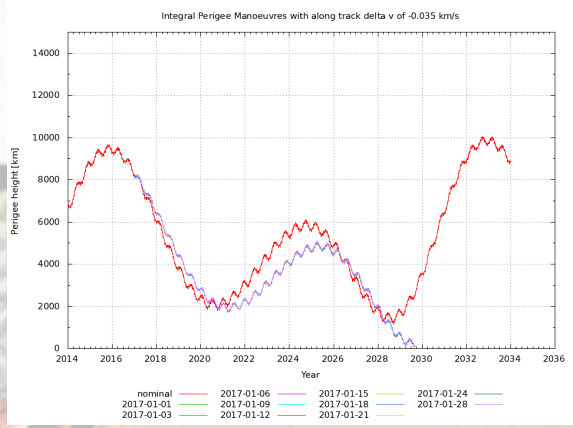
- Propellant exhausted, SA badly degraded, no science capability
- Re-entry time varies ~1.5 hrs  due to drag / radiation pressure
- Re-entry time varies ~6 - 8 hrs depending on mission end date
- Re-entry Latitude band between -45 and -70deg

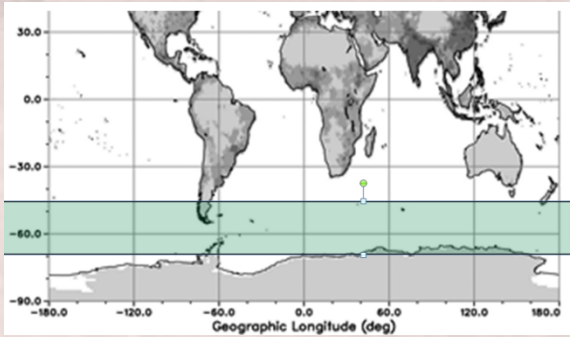
## Possible Manoeuvre to fine tune re-entry?

- Low last perigee ensures re-entry in 1 revolution – no circularisation
- Latitude and Longitude adjustment?
- The later the better

## Re-entry attitude selection to ensure breakup and demise?

- Chaotic but not fully random if only gravity torques considered
- Effect of drag / radiation pressure  analysis pending



# Disposal - Long Term Orbit