# Integral Users Group - MOC

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Integral Spacecraft Operations Engineer

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# Overview

- Flight Control Team + MOC
- Orbit Evolution
- Propellant Consumption
- Radiation Environment
- Array Degradation
- AOB

# Flight Control Team – 6.5 FTEs

- Richard Southworth (Ops Manager, System, also 50% CHEOPS until April 2020)
- **Jutta Huebner (Ops Engineer, P/L @50%)**
- Bruno Gandolfo (Ops Analyst, planning + Ops DB)
- **Marius Baab (Ops Analyst @50%)**
- Dave Salt (Ops Engineer, AOCS, also 50% XMM)
- Liviu Toma (Ops Engineer, AOCS, also 50% XMM)
- Stefano De Padova (Ops Engineer, MCS + OBDH)
- Timothy Finn (Ops Engineer, P/L, also 50% XMM)
- Norbert Pfeil (Ops Engineer, EPS + TCS + MCS, also 50% XMM)
- Thomas Godard (Ops Engineer, P/L + automation, also 50% XMM)

Temporary support:

- **Jim Martin (RS B/U during CHEOPS activities @ 20% in 2019)**

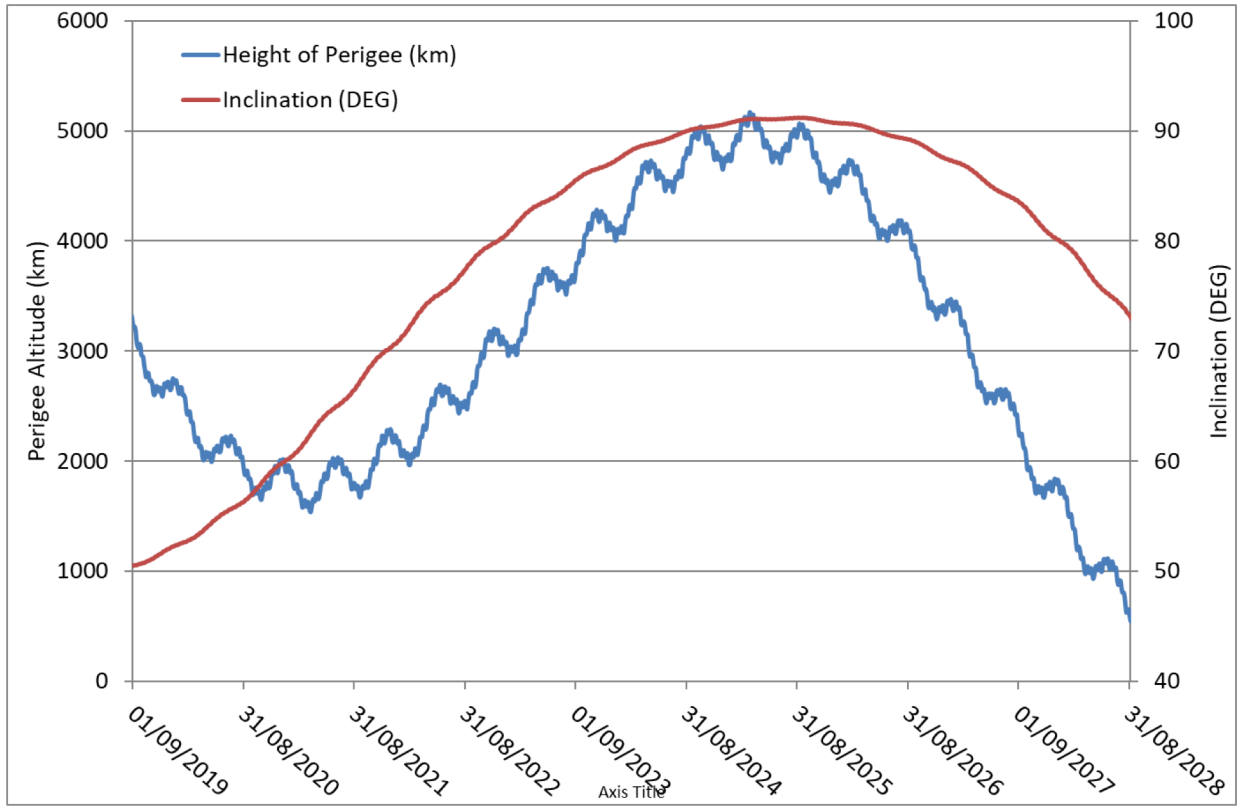
# MOC

- No major activities currently
- Open VMS Simulator ported to LINUX (Simulus 5) – Continuity until EoM.
- VIL1 and MSP (INTA) validated and available, good performance
    - VIL2 early 2020
- KIR availability, reliability and coverage are very good
- Next MCS Evolution planning in 2020/21

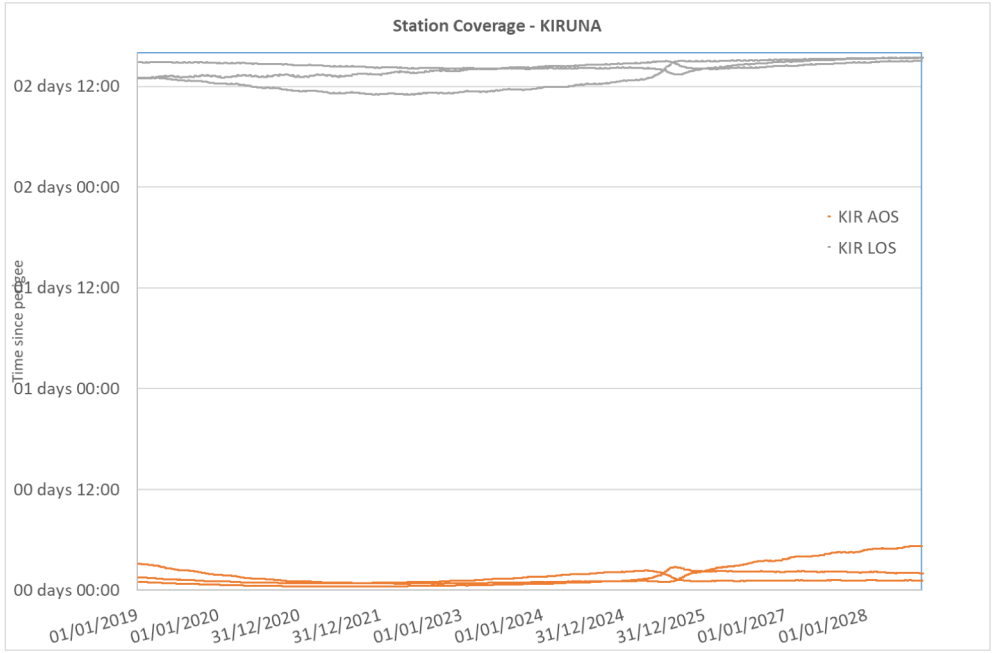
# Orbital Evolution

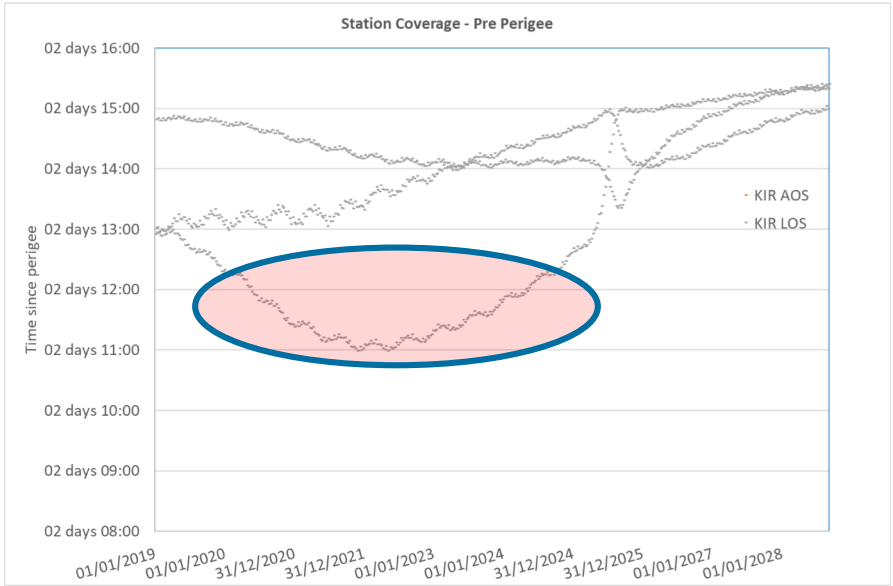
Perigee below 6000km until end of mission

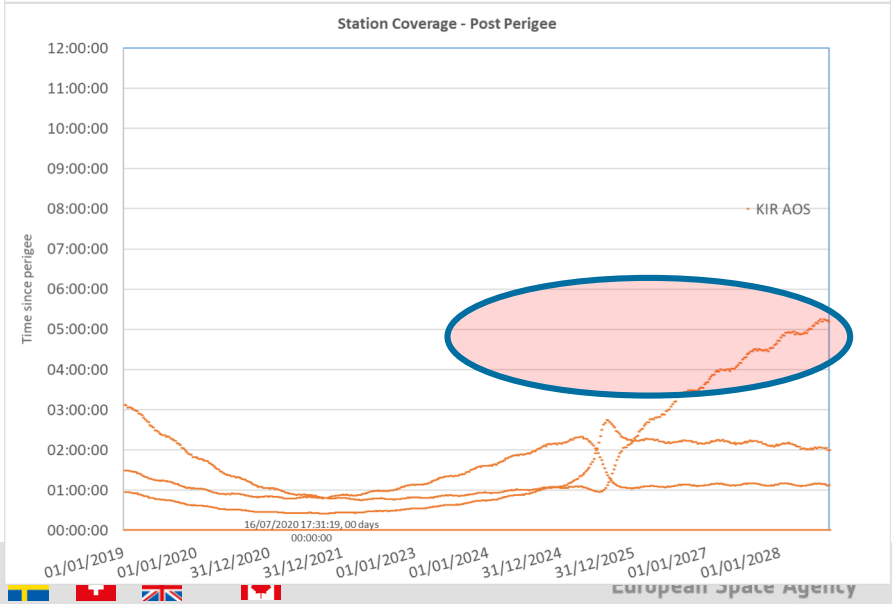
- Faster rate of SA degradation
  - See later slides
- Increased earth albedo exposure @ perigee
  - Not yet observed
- Degradation/Aging of electronic components
  - CDMU - S/W Task  Overflow
  - SPI DPE – Sticky Bits
- Increasing inclination good for station visibility
- Re-entry in early 2029



# Orbital Evolution – Impact on KIRUNA Station Coverage



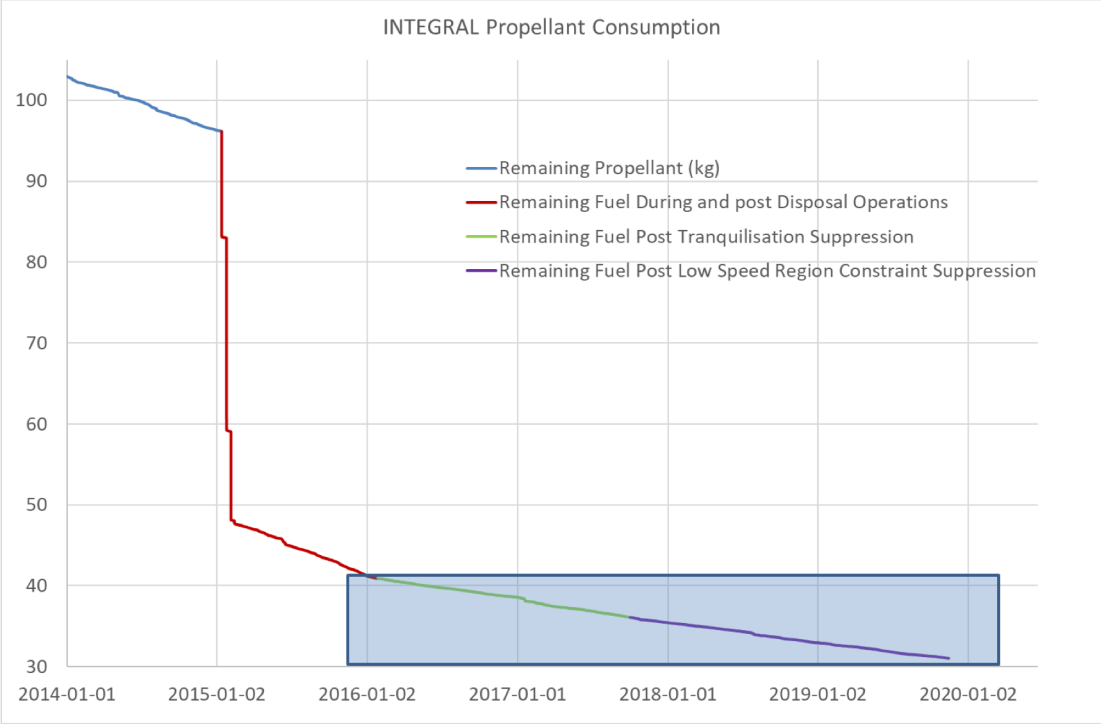




Close to full coverage from KIRUNA until end of mission

- Late AOS every 3rd revolution 2027 & 2028
- Early LOS every 3rd revolution 2021 to 2024

# Propellant Usage

## Disposal manoeuvres in 2015 used half remaining propellant



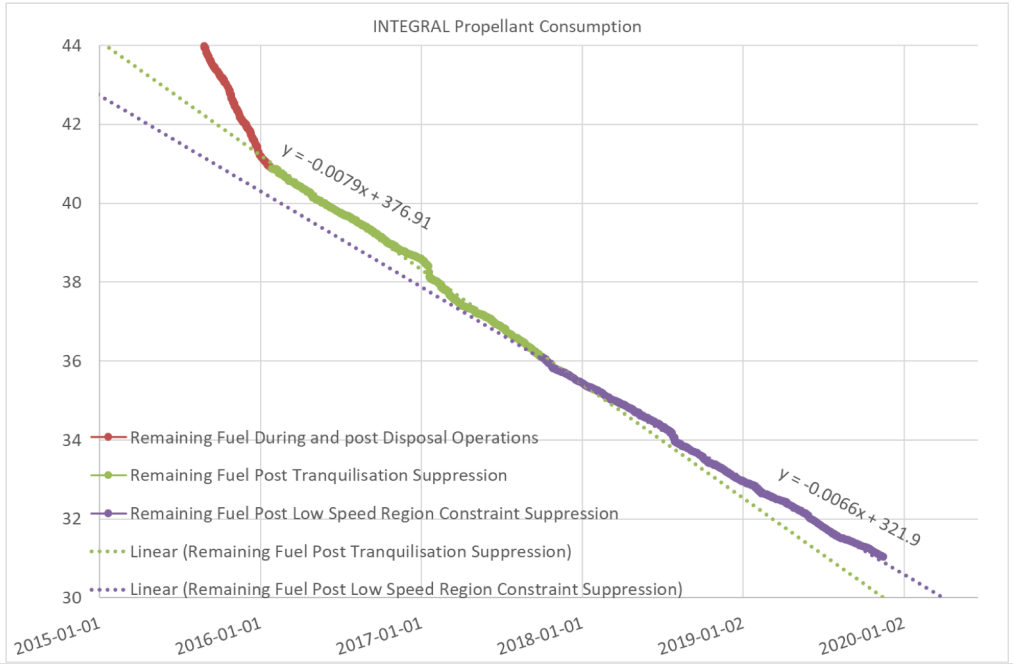

## Consumption reduced by:

Stopping thruster tranquilisation post wheel bias:

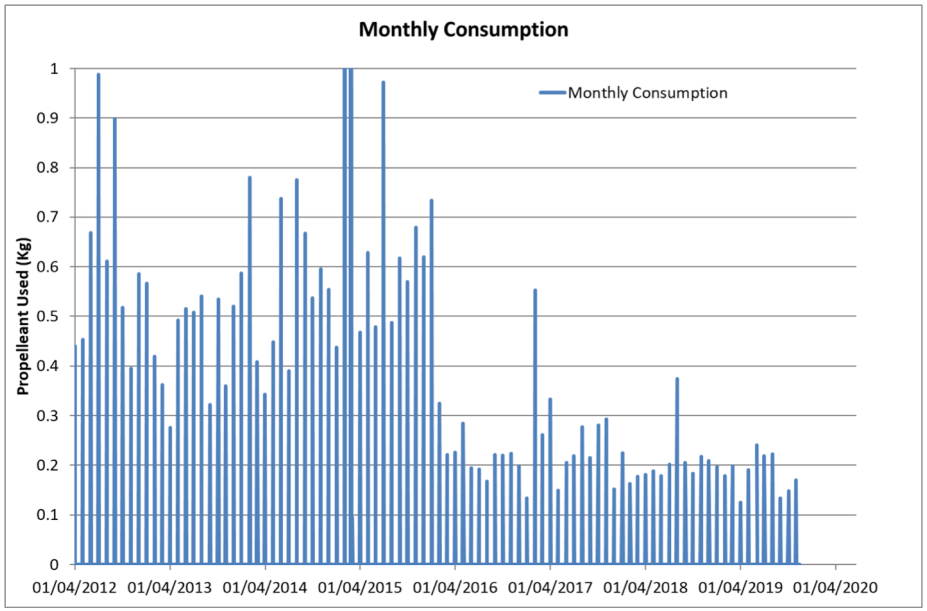
- 20g to ~9g/day (attitude stability OK)

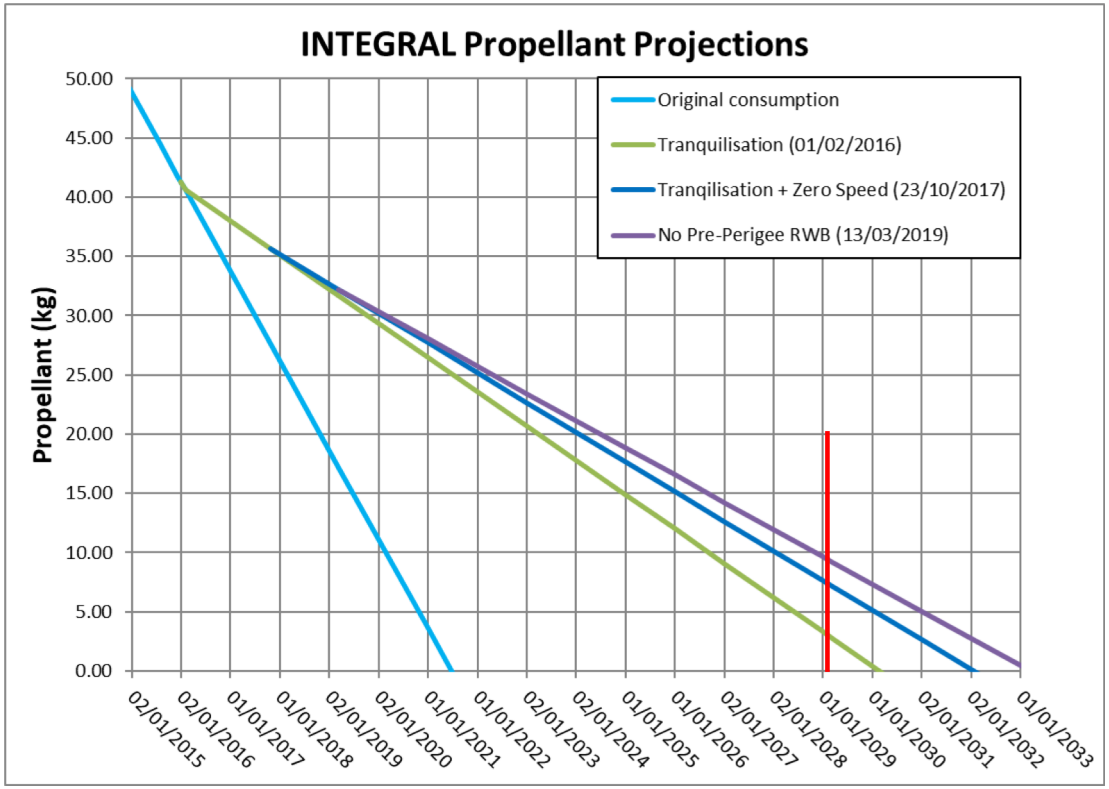
Removal of Reaction Wheels low speed constraint:

- 9g to ~7g/day (attitude stability + wheel health OK)
- Chance of safe mode entry reduced by ~50%!!



# Propellant Usage and Predictions



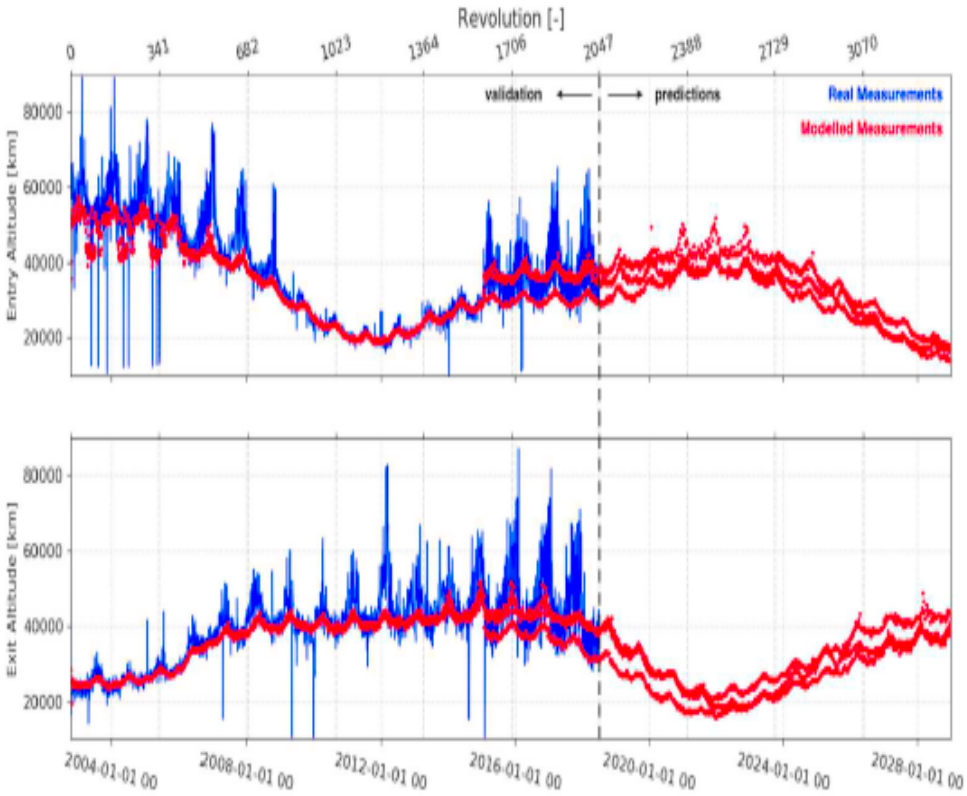




Remaining 1/11/2019: 31.2kg

- Usage 2014: 6.7kg!!
- Usage 2017: 3.2kg
- Usage 2018: 2.5kg
- Expected 2019 onwards: ~2.2kg
- KEY MESSAGE! - Effects of disposal manoeuvres fully compensated
- => Propellant will probably not be exhausted before re-entry

# Radiation Environment

- Van Allen Belt crossing determine instrument activation/deactivation times
- ESAC 5DRBM-e Model predicts long term (smoothed) trend that will extend science window
- Same trend observed in IREM data
- Benefit of less time spent in belts
  - Increases science window – dependent on station visibility
  - Reduces total accumulated dose and thus electronic component degradation



# Solar Array Degradation – Radiation and Ageing Effects

**From IUG 19**

**Action 19–3 on RS Due: end 2017**

Prepare Technical Note on options for Eclipse Entry handling when array currents approach critical threshold.

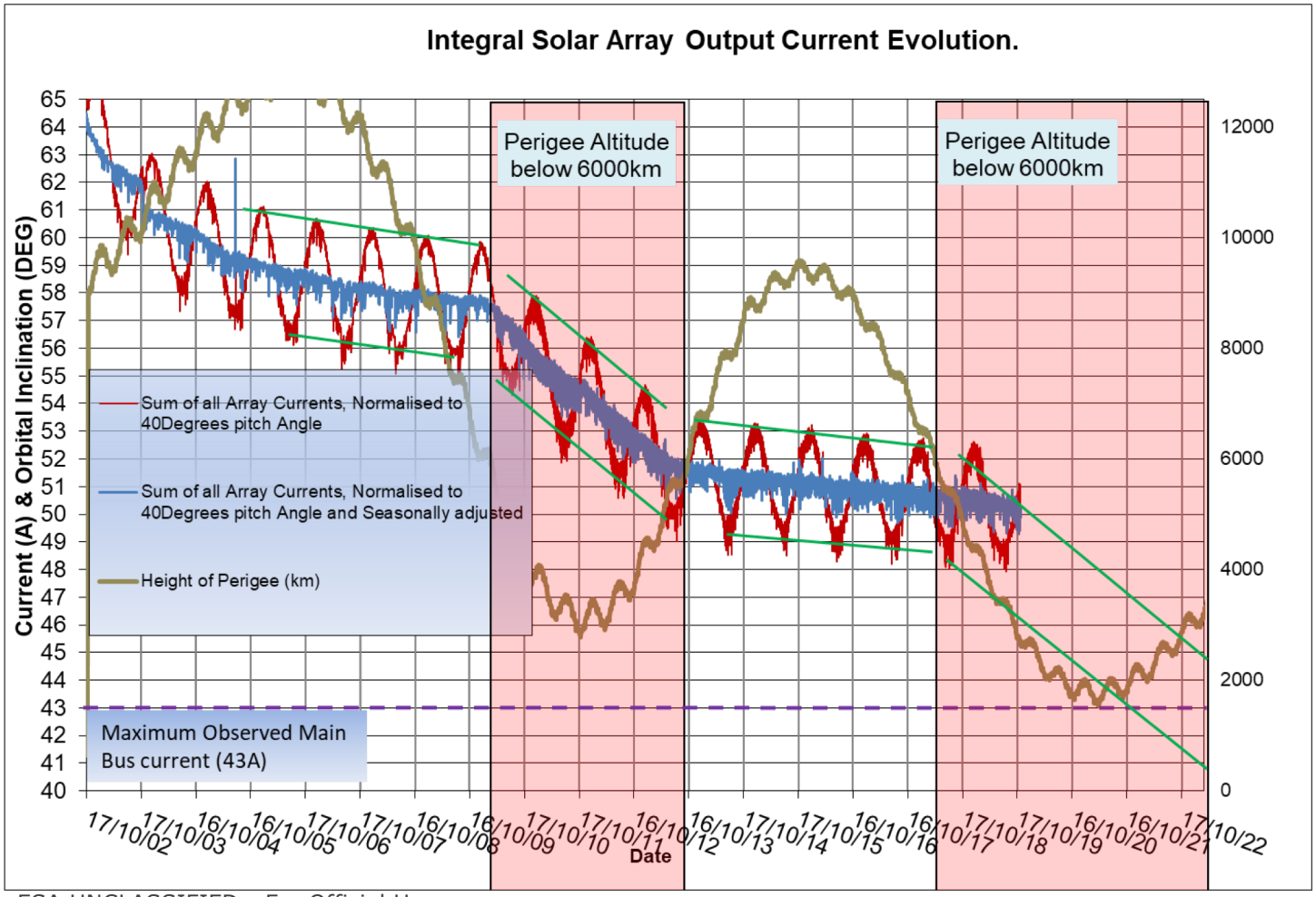
2 Critical Issues:

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

TN available, clear mitigation strategy proposal for both issues – see next slides

- Exact timing tbd, depends on further evolution

# Array Degradation – Power Budget




**Degradation less than expected**

Short duration peak power demand (10min)

EPS limits battery charge in case of excess demand

- => Flexible margin of about 6A
- Occasional reduction in charge rate from 2022 (probably later)

Limited discharge in sunlight allowable – **we know the batteries are healthy**

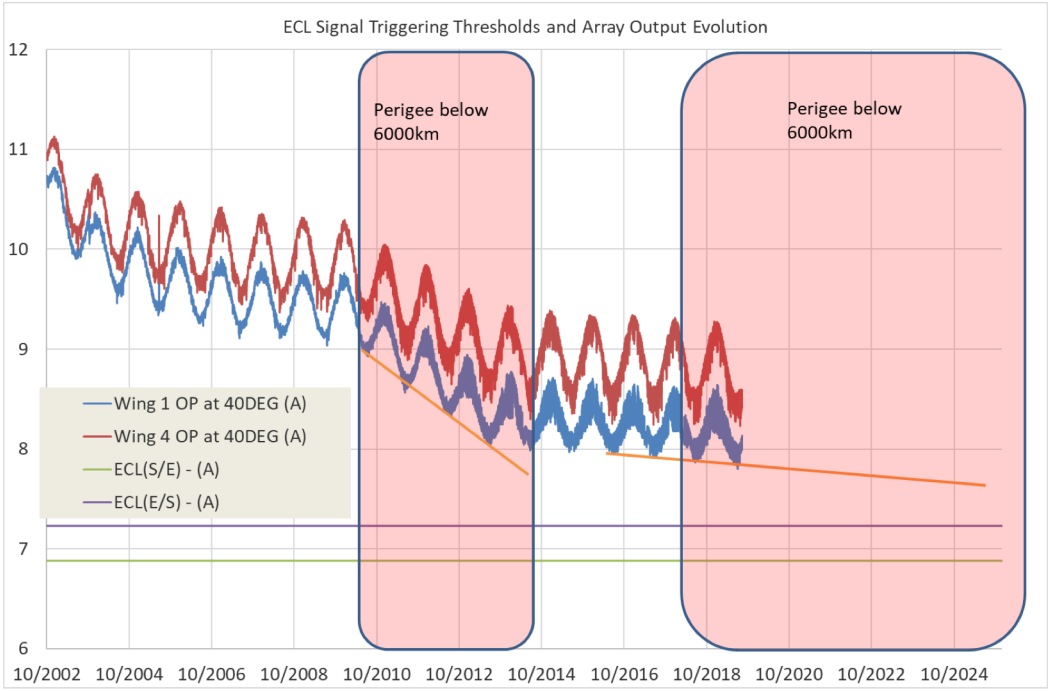
**No power constraint before end 2023 (probably later)**

**Constraint only when battery discharge in sunlight is significant**

# Array Degradation – ECL (s/e)

## The Spurious ECL Issue

- EPS 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 2021 – probably later




## The proposed solution

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

Start depends on observed degradation – lower than expected

Study of observed and predicted array degradation initiated at ESTEC

# AOB

Questions?