Integral Users Group Meeting #17

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5/2/2015

Issue/Revision: 1.0
Reference:
Status: N/A

Deorbiting Operations - Background

1. Change of orbit now to influence long term orbital evolution forcing re-entry in February 2029
2. Casualty risk < 2.8E-05 (target 3.0E-06, 11m2, 266kg returns), requirement 1.0E-4
3. Permanent solution, disposal assured even in case of future catastrophic failure
4. 4 burn strategy
    a. 13/1/2015: Gives Perth / NNO perigee coverage for next Delta-V
    b. 24/1/2015: Main Delta-V (4 revolutions later)
    c. 4/2/2015: Main Trim Delta-V (4 revolutions later)
    d. 12/2/2015: Final Trim delta-V (3 revolutions later), if necesssary
5. Targeted orbit duration of 2days 16hours, repeats 3 in 8 days
6. Expected to use roughly half remaining fuel – on target

Deorbiting Operations - Status

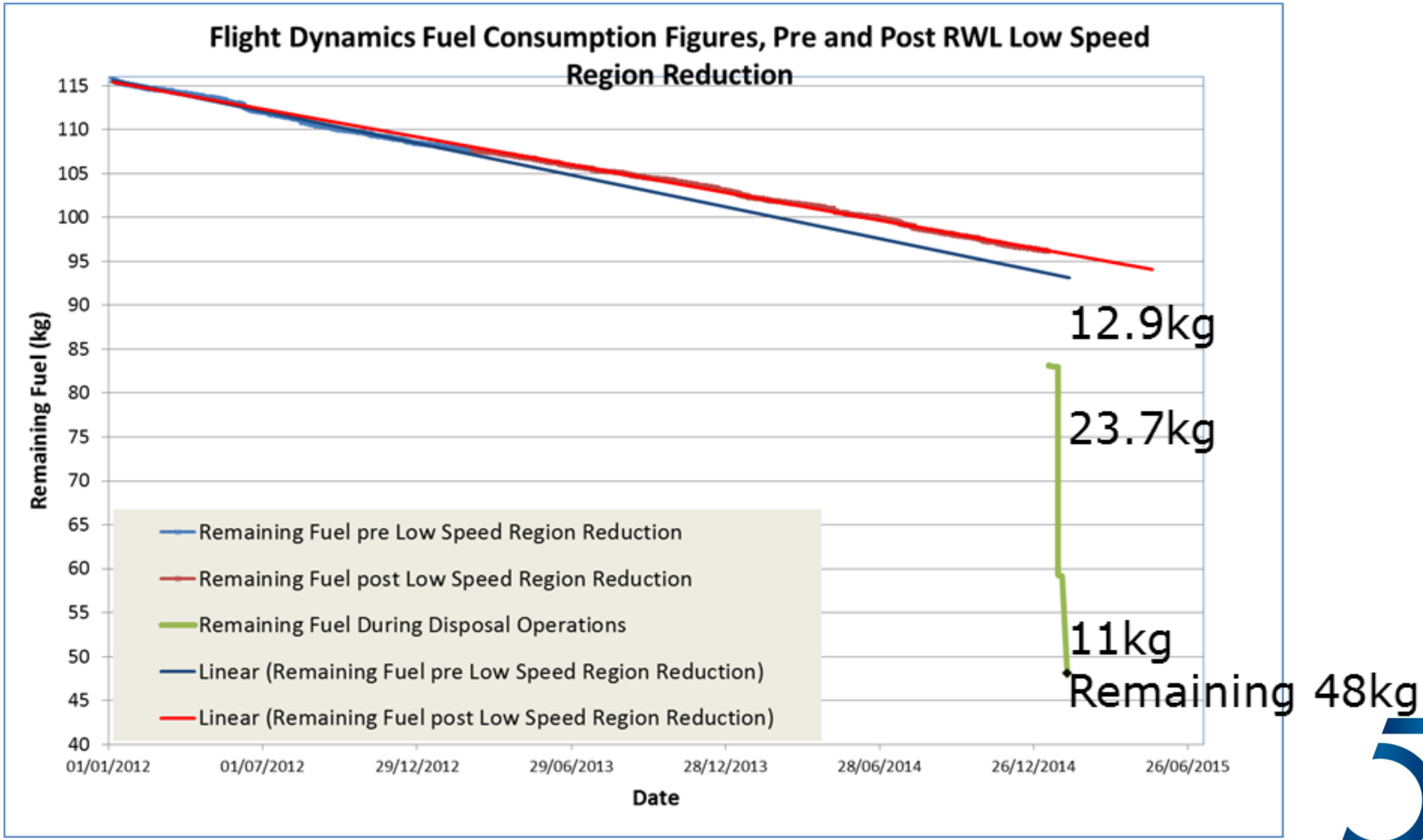
1. 1st 3 manoeuvres performed
   a. RCS performance slightly worse than predicted, cost about 3kg propellant overall
   b. 1st manoeuvre underperformed by about 10%
   c. 2nd manoeuvre perfect, following calibration exercise of manoeuvre 1, however as it was longer then initially planned it became less efficient
   d. Last manoeuvre yesterday @ 15:30, preliminary results indicate nominal execution, slightly smaller than originally planned

Deorbiting Operations – Science during Deorbiting

1. Revolutions 1496 to 1513 impacted:
    a. 1495 Loss of science time ~5hours
    b. 1496 poor TCO until 14:22 on 14/1/2015
    c. 1496 – 1498 Loss of science time ~4hours / revolution
    d. 1499 Loss of science time ~6hours
    e. 1500 TCO not impacted
    f. 1500 – 1502 Loss of science time ~4hours / revolution
    g. 1503 Planned Loss of science time ~6hours
    h. 1504 Possible poor TCO for 1st 36hours
    i. 1504 – 1506 Loss of science time ~4hours / revolution
    j. 1507 Planned Loss of science time Full Revolution (calibration revolution)
    k. 1508 – 1513 Loss of science time ~1hour / revolution
    l. 1514 onwards, nominal operations

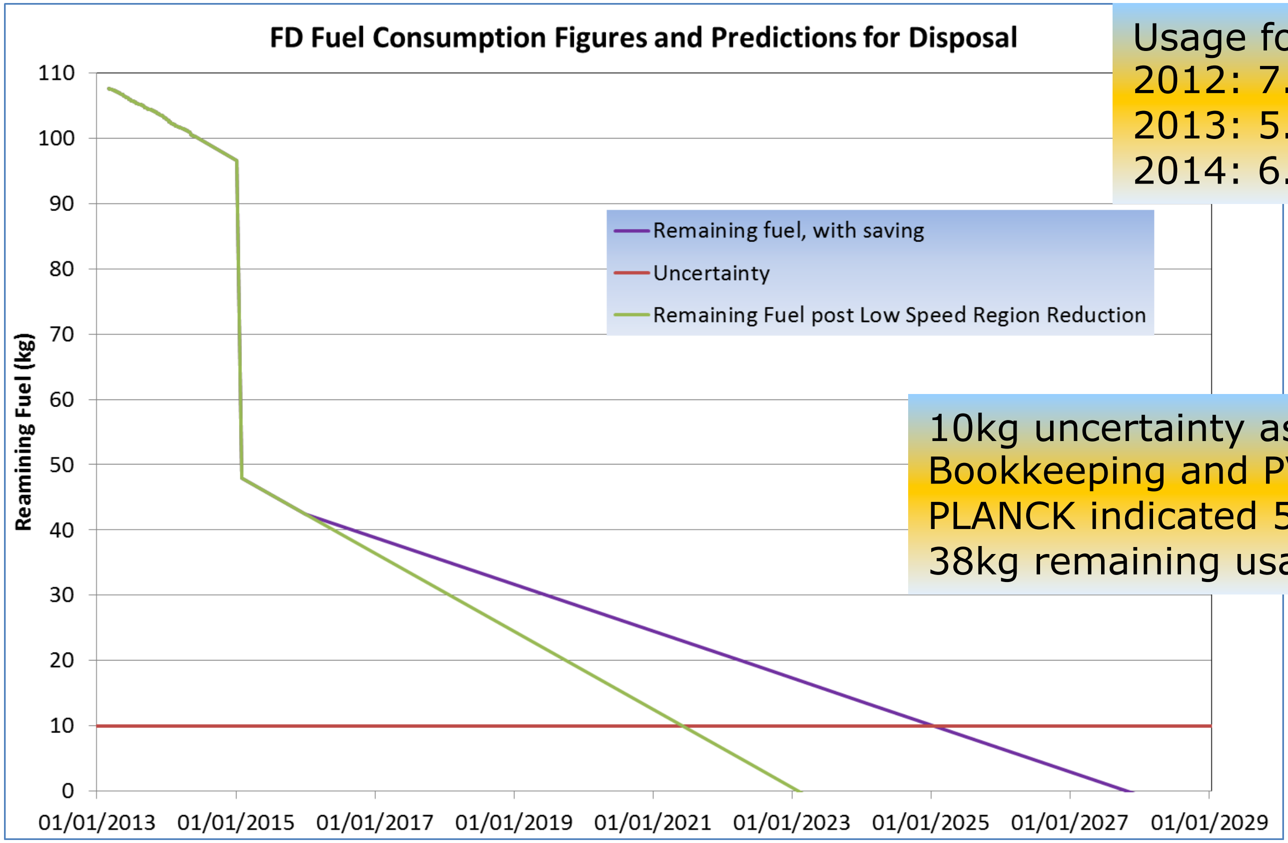
Fuel Consumption

Deorbiting Fuel Consumption



Fuel Consumption - Projected

1. Target should be 2025 (see power below)
2. => Reduce usage by 30%, options being studied

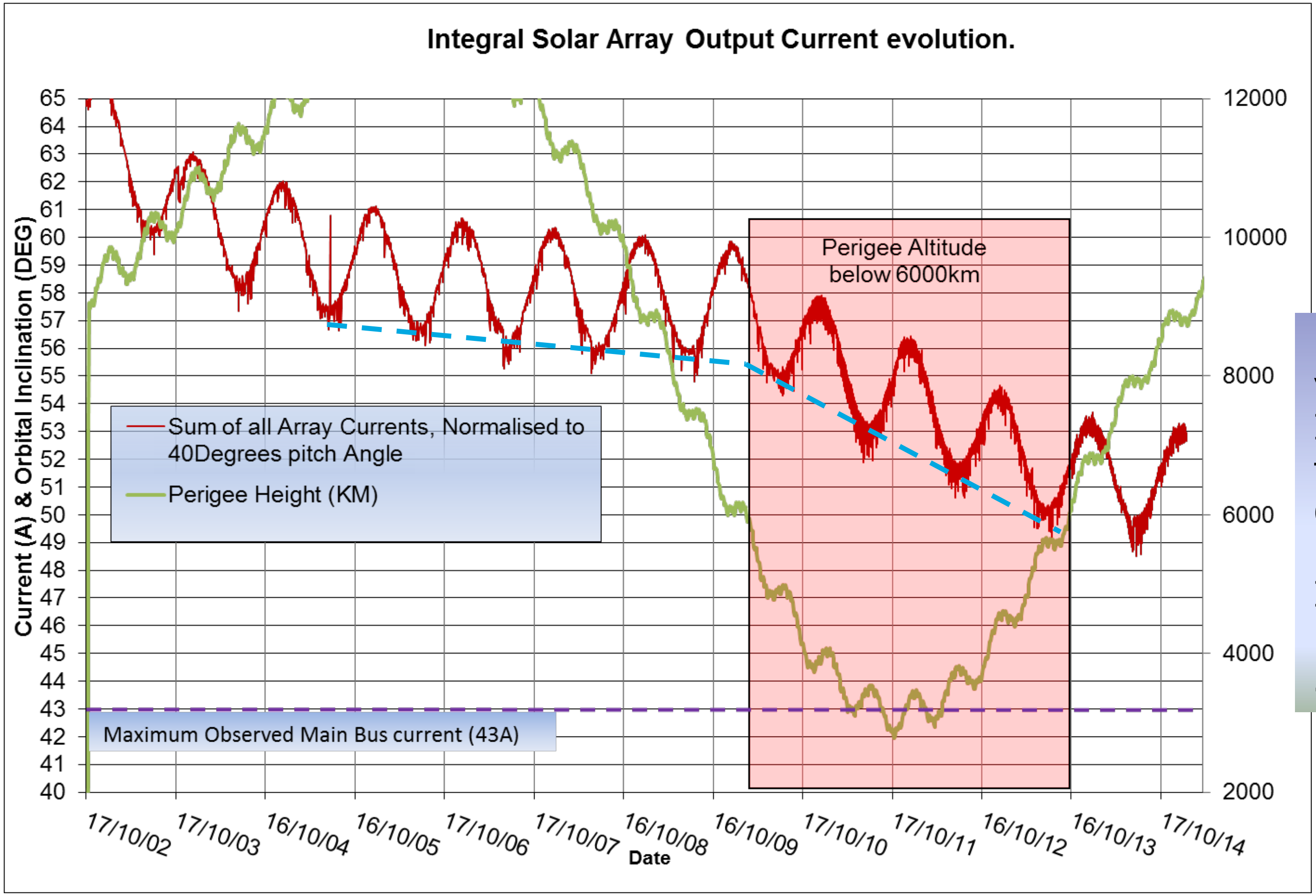


Usage for Routine Operations
2012: 7.3kg
2013: 5.5kg
2014: 6.7

10kg uncertainty assumed.
Bookkeeping and PVT agree to within 3kg.
PLANCK indicated 5kg
38kg remaining usable

Solar Arrays Status

1. Solar array Output since launch

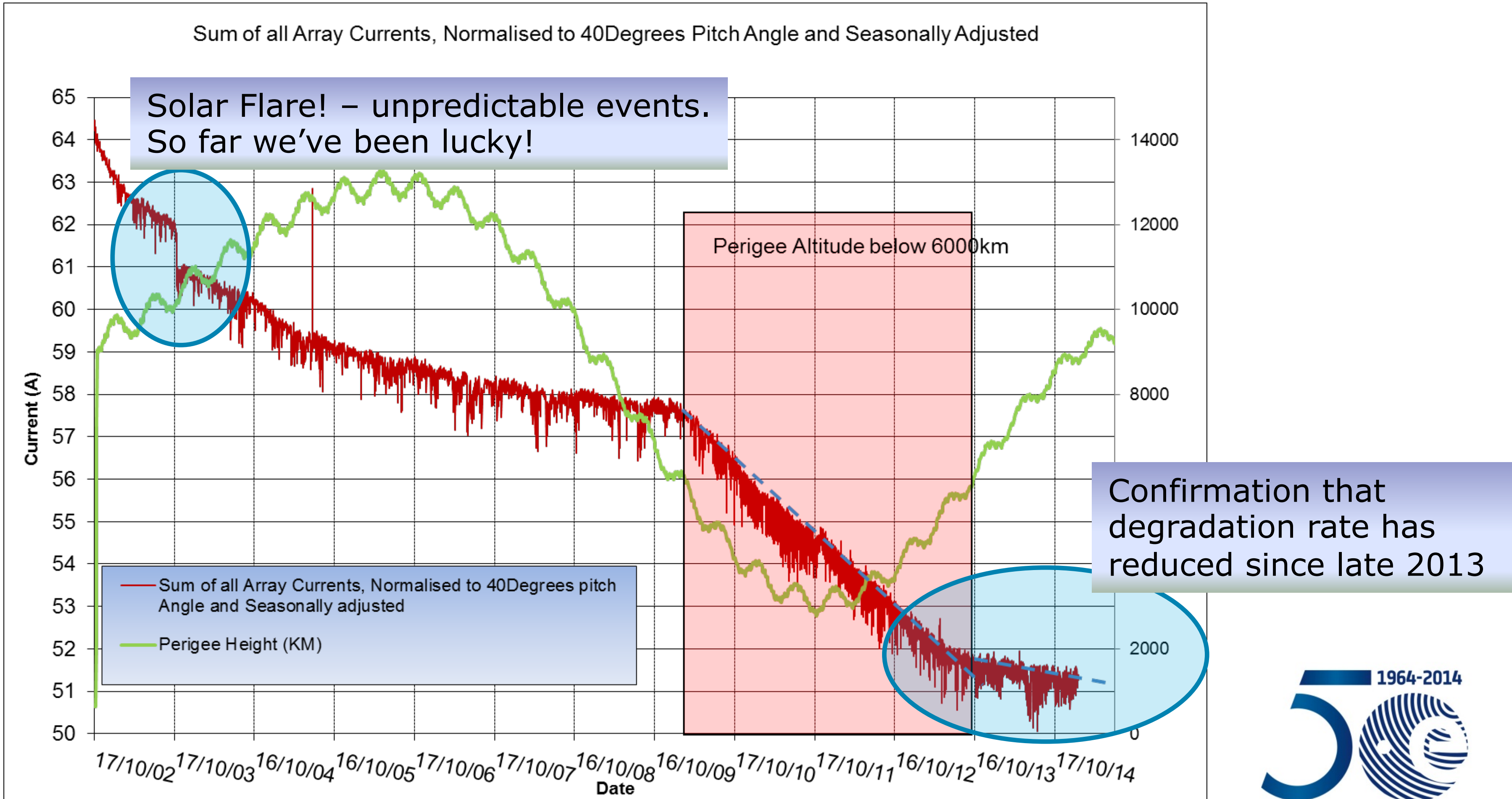


Effect of low perigee very obvious.
Increased degradation from altitude of about 6000km

Indications that effect has stopped since late 2013

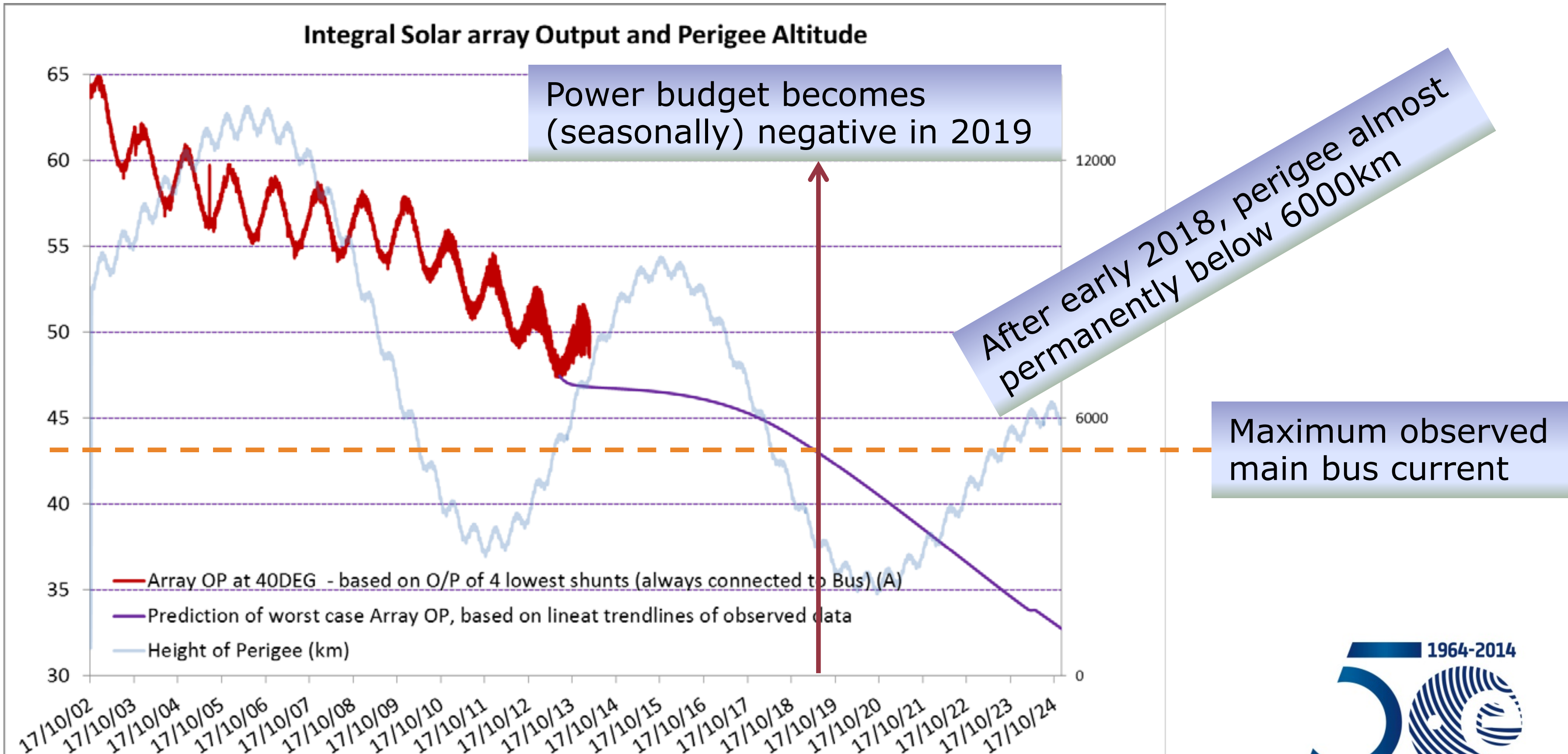
Solar Arrays Status – perigee > 6000km

1. Solar array Output since launch



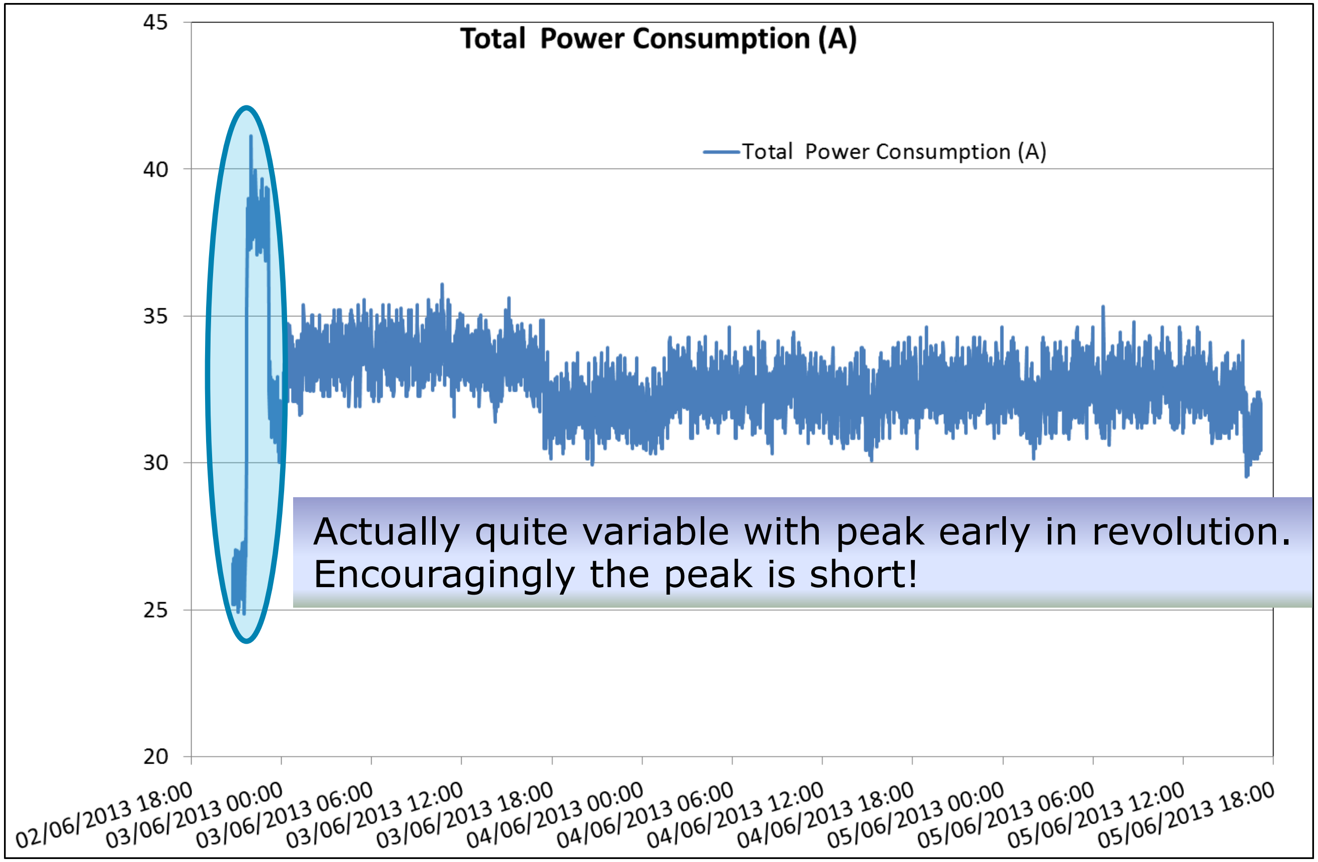
Perigee and Array Output Evolution

1. Array Output Current Evolution
2. Generated voltage not visible



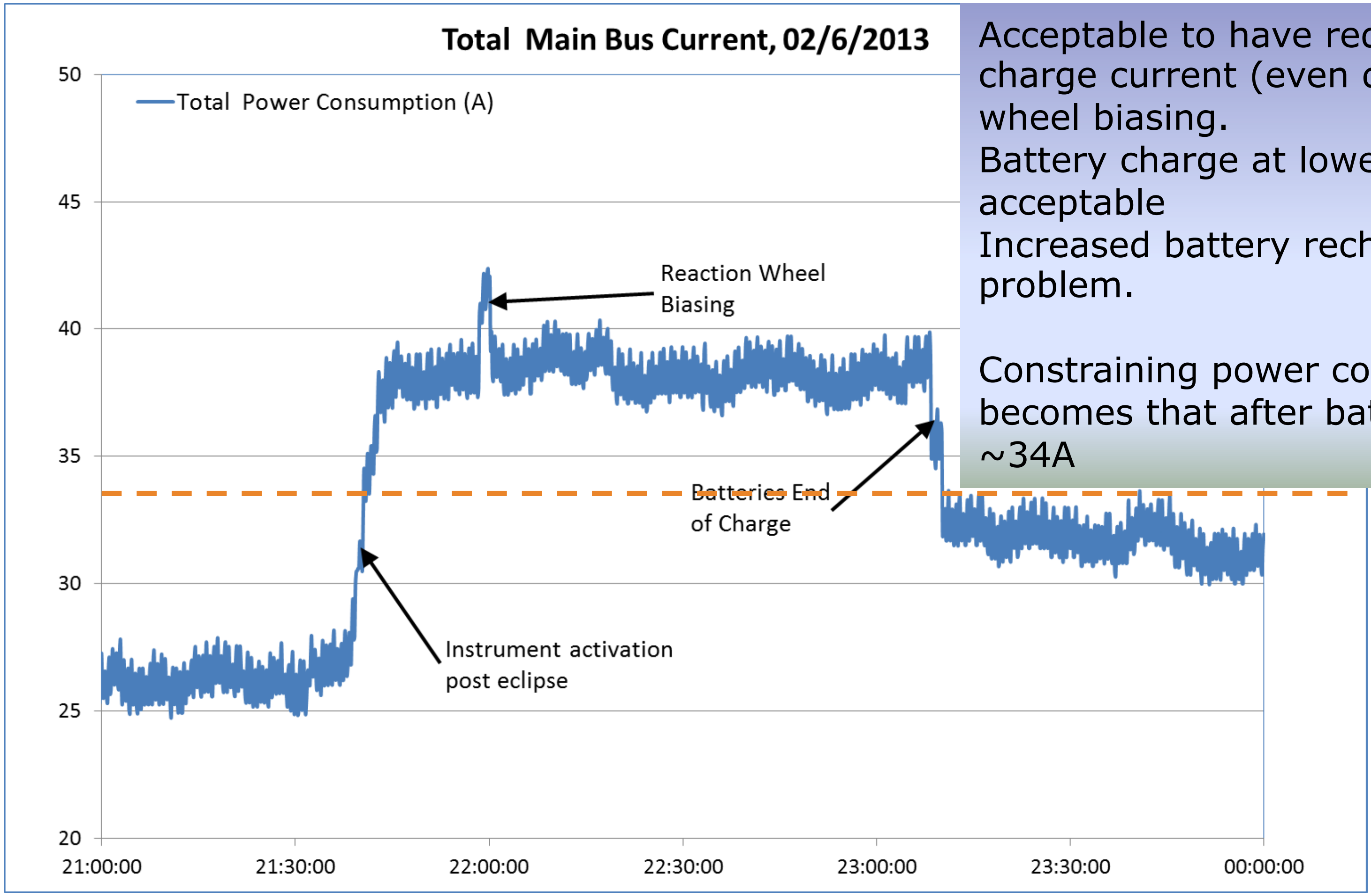
Solar Arrays - Demand

1. Examination of Demand on arrays
2. Complete Revolution – typical including eclipse



Solar Arrays - Demand

1. Peak Demand – a closer look and causes can be identified

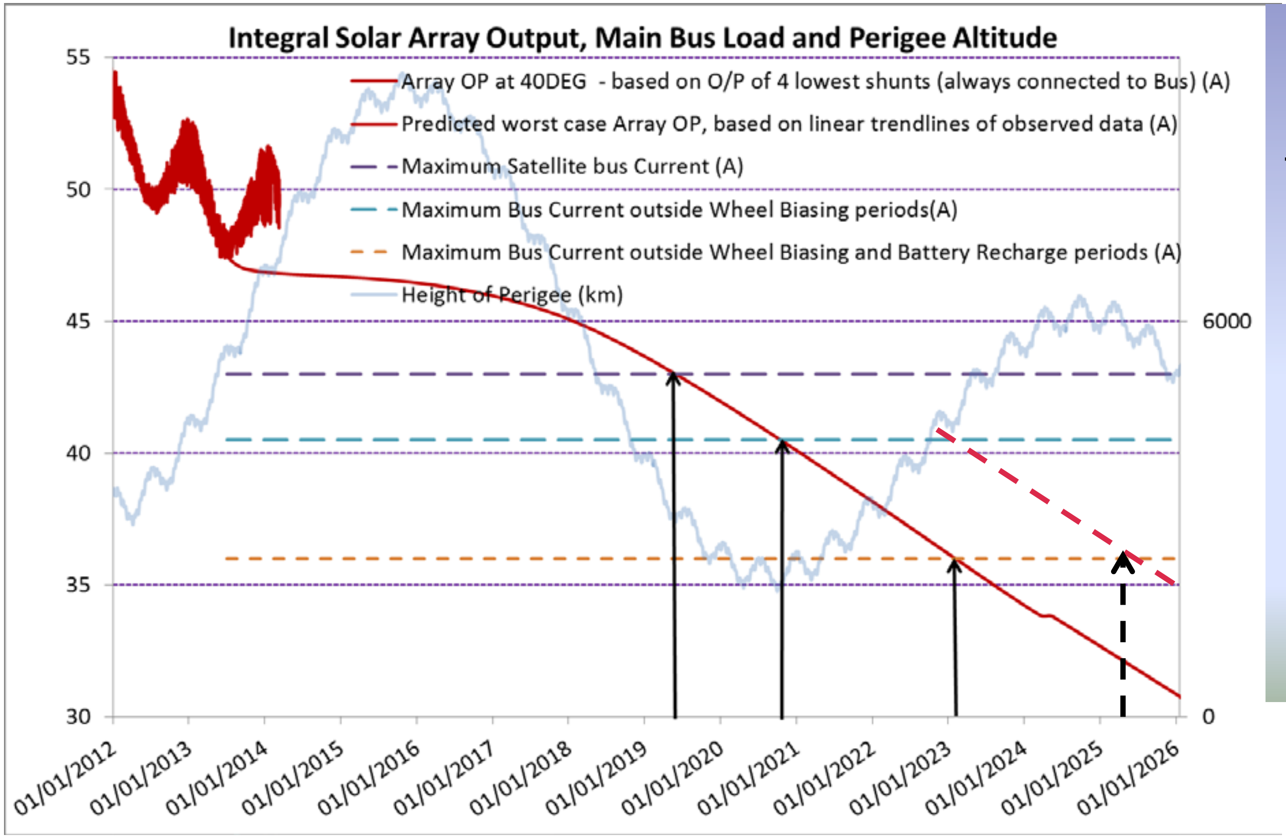


Acceptable to have reduced battery charge current (even discharge) during wheel biasing.
Battery charge at lower current also acceptable
Increased battery recharge time not a problem.

Constraining power consumption becomes that after battery recharge ~34A

Supply and Demand

1. Array Output projected with real demand constraint



Real constraint on the arrays is ~34A, not 43A!

Takes us to early 2023

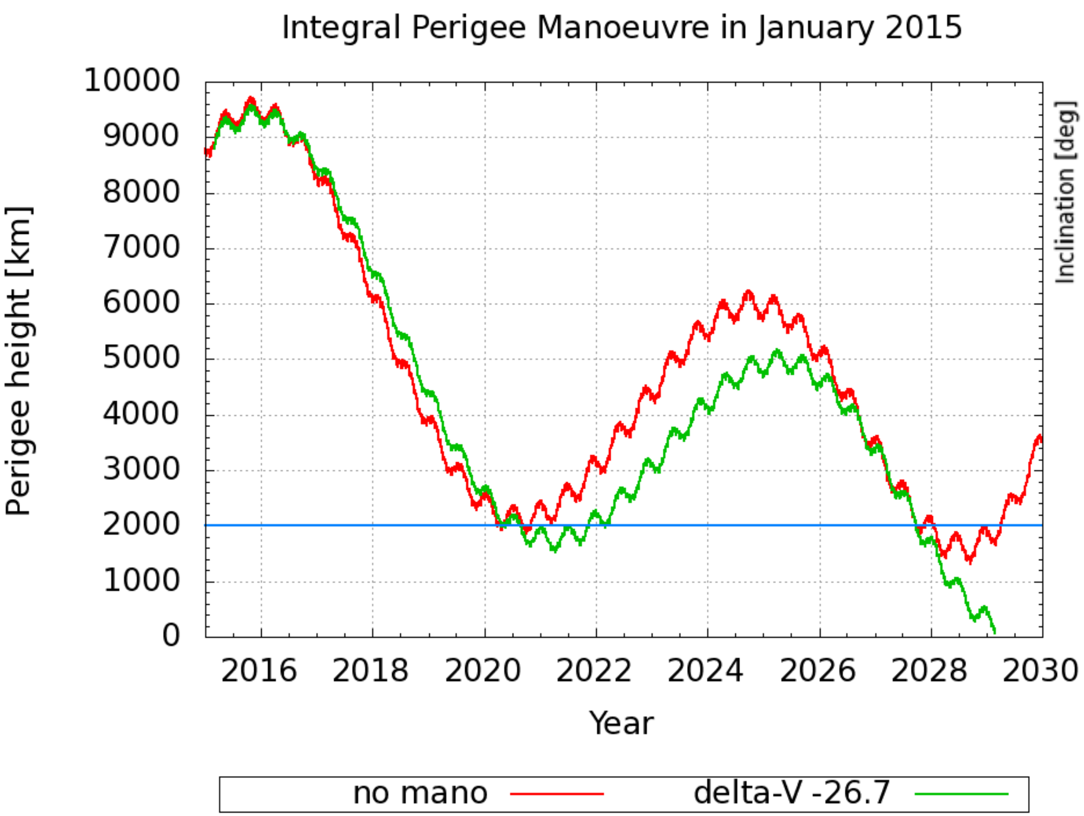
Note that the amplitude of the yearly variation in array output is about 4A, so initially constraint is only seasonal

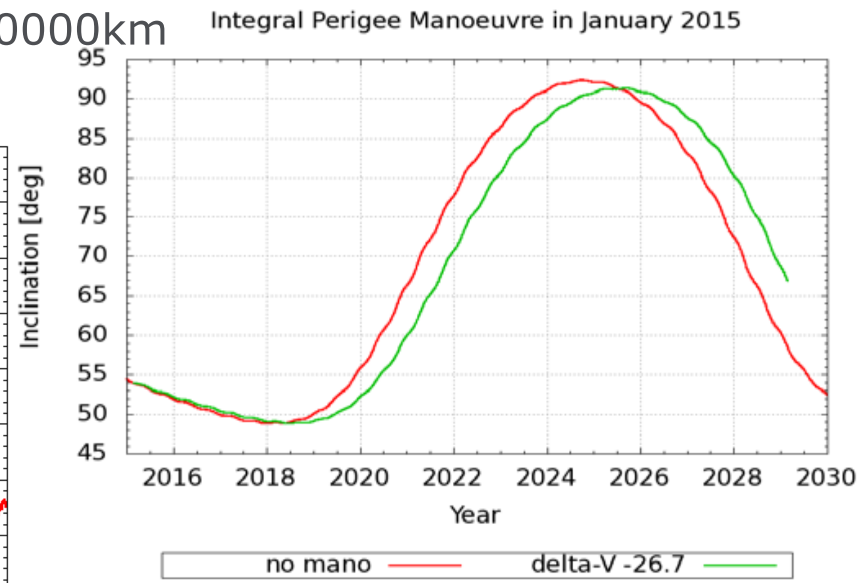
Restriction to 30 degrees in pitch would increase worst case main bus I by about 4A

OR reduce demand!

Orbital Evolution post Deorbiting

1. Orbital period now 64hours, was 72hours.
2. Perigee Evolution is almost unchanged
3. APOGEE reduced from 160000km to 140000km

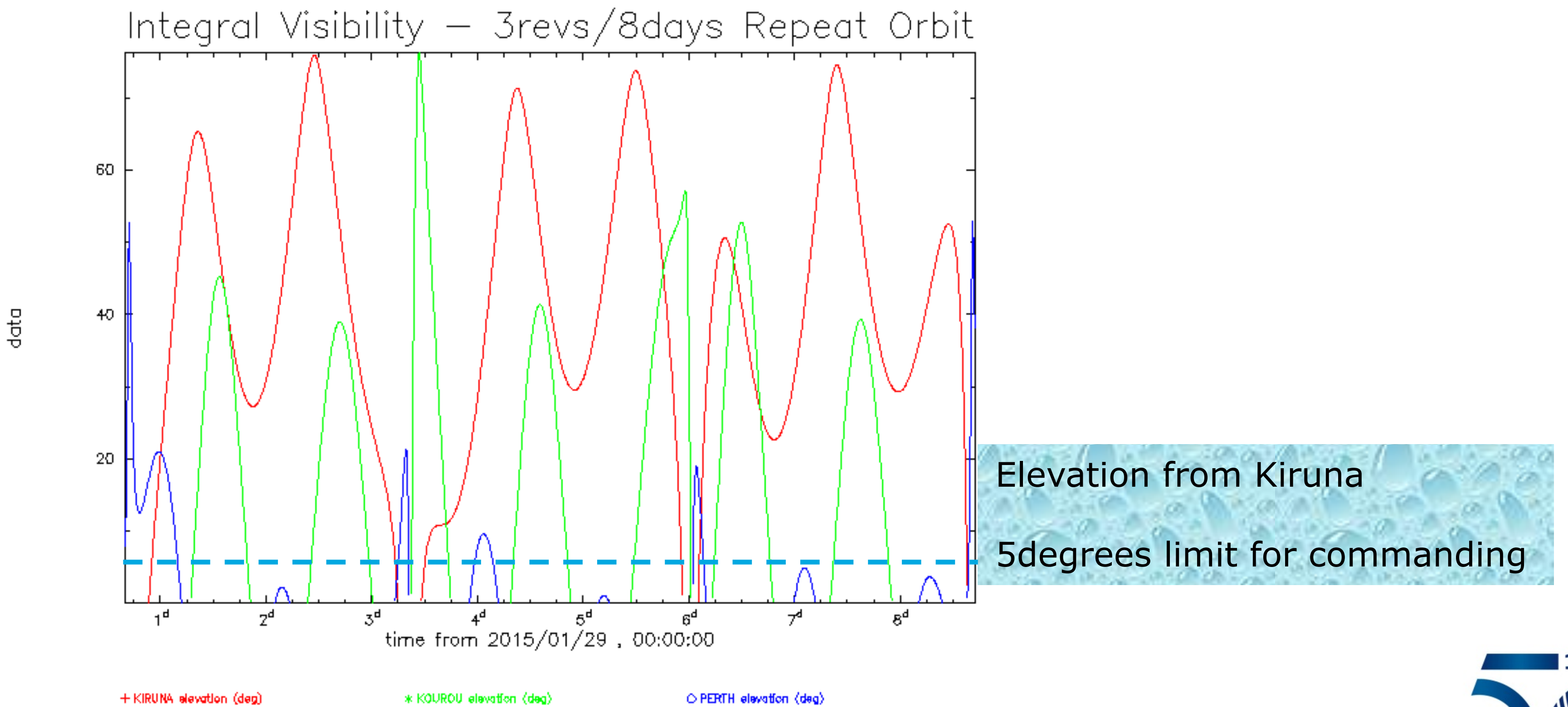




Other parameters will be controlled to maintain station coverage

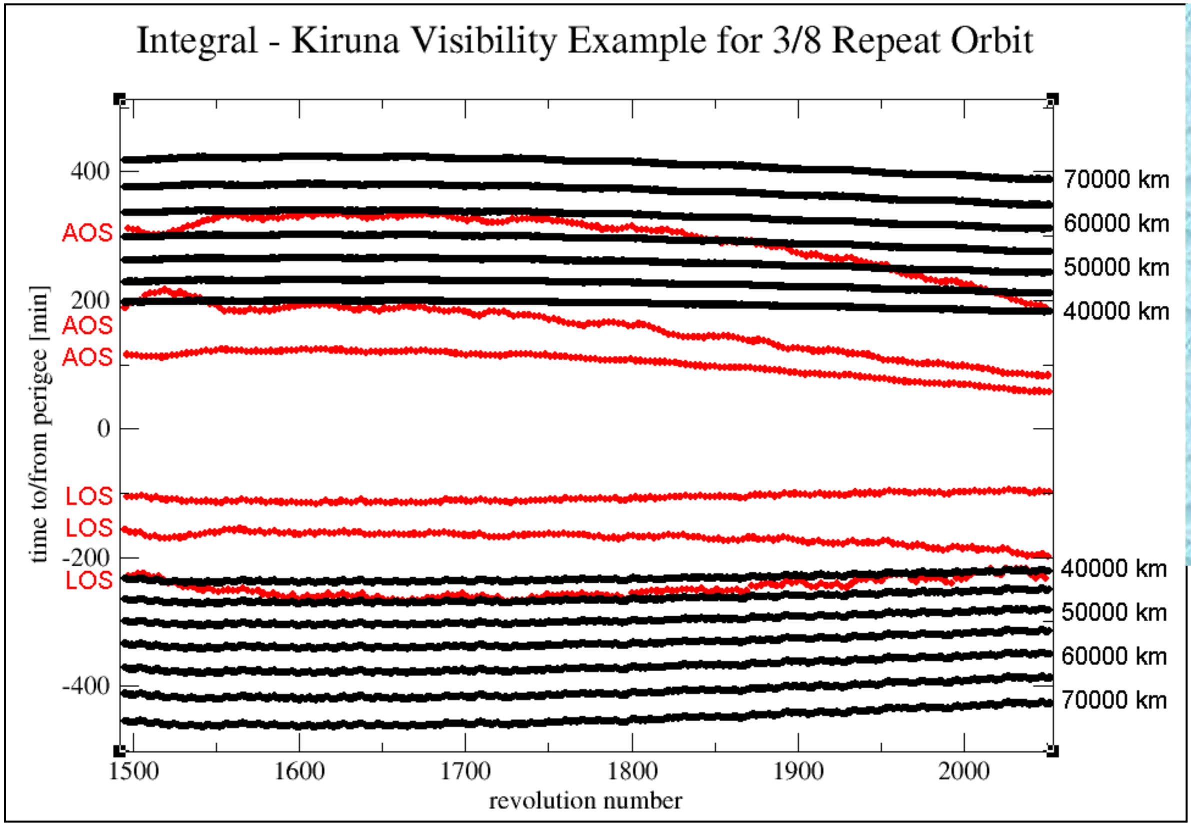
Station Coverage

1. Kiruna Visibility remains good, gaps close to perigee only
2. Orbit ground track repeats every 8 days (3 revolutions)



Kiruna Coverage @ Perigee

1. Visibility close to perigee allows us to use full time outside Van Allen belts for 2 out of 3 revolutions



Loss of observing time due to observation constraints close to perigee AND reduced orbital duration is 3.7%

Could be reduced slightly by use of NNO but added complexity and cost

Some issues currently regarding variable belts entry settings in BCPKT

MOC

1. FCT:
    a. Richard Southworth (SOM) - everything
    b. Jutta Huebner (SOE / deputy SOM) – payload / simulator
    c. Dave Salt (SOE) – AOCS
    d. Stefano de Padova (SOE) – OBDH, MCS
    e. Norbert Pfeil (SOE 50%) – EPS, JEM-X, MCS Testing
    f. Timothy Finn (SOE 50%) – Ground Stations, OMC
    g. Liviu Toma (SOE 50%) – AOCS, automation
    h. Bruno Gandolfo (analyst) – Planning, Database, Reporting
2. Stations:
    a. Prime Kiruna
    b. B/U VIL2, Maspalomas, Weilheim, Kourou, NNO
3. MCS fully migrated to Solaris 10 system based on virtualisation

Hibernation

1. **INTEGRAL is not designed to hibernate** (very limited on-board autonomy)
2. Regular contact needed --> FCT and FD teams have to be maintained (reduction possible), MCS & G/S & FDS etc. have to maintain functionality
    a. *Design is 36 hours autonomy, could be relaxed at low risk to 5 days(tbc)*
3. Spin up INT to gain stability for longer autonomy?,
    a. *Only practical for relatively short periods since we need to track the sun, would require a new operation mode (FDS) and procedures*
    b. *Sun tracking operations complex (de / re-spin or move spin axis)*
    c. *ESAM entry would use large quantity of fuel in this mode = > not practical for hibernation*
4. Once people are gone/moved to other projects, the detailed knowledge is gone and no fast reaction is possible anymore.
    a. *Reaction period estimated at 2 - ∞ months (hard to predict)*
5. - Saving wrt fuel (low) & costs TBD

Hibernation

6. *Station costs: almost the sole customer for KIRUNA1, income lost from Integral will be redistributed as costs to other SRE missions (EO use little station time!).*
   a. *In the worst case KIR1 will be disposed of making resumption of operations difficult and potentially more expensive*
7. *Conclusions:*
   a. *To save money by reducing operational return, enlarge the perigee gap - still a stupid idea since it re-distributes costs to the other missions so our science return is reduced at a net saving of 0,*
   b. *Easy to implement & easy to get back to nominal operations scenario.*
   c. *To save fuel go for 4WD or possibly remove wheels Low Speed region*
   d. *Operate the bloody thing for as long as possible, that's what it's there for!!!*