XMM-Newton

Longevity through continued modification

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The X-ray Universe 2014

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Some XMM-Newton history

- Mission was built for 2.25 years
- Mission was designed to be compatible with 10 year lifetime
- Before launch there was some 100 kg mass margin that was used to 'top up' the fuel
- Mission was built to be 24/7 controlled from ground – no intelligence – no significant command stack
- We launched with only 3 quadrants of EPIC-PN working ! (There's nothing like a good shake)

- I started working on XMM-Newton in 1988 – 26 years ago ➔ Knowledge management is an issue
  - Usually KM documents a design and what the system CAN do – not what it COULD be made to do

Mission Consumables

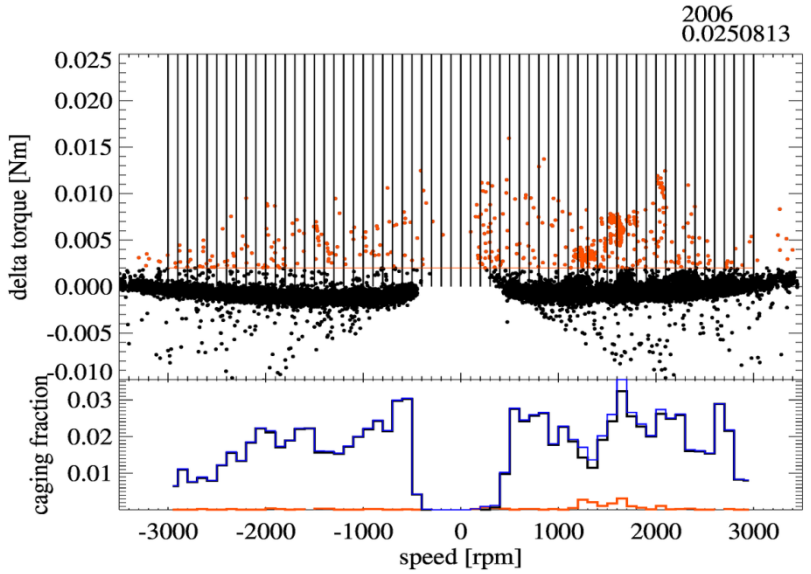
- Solar Array Power
  - end-2018: max. Consumption 1350 W – 350 W margin
- Batteries
  - No detected capacity change – Lifetime predict 15+ years
- Gyros/IMU's
  - Used ~20% of qualification value
- RF and Transponder Switches
  - One RF switch stuck – Use transponder switching
  - Qualification : 25,000 – Used : 1000
- Thruster pulses (RCS Flow control valves)
  - Qualification : 200,000 - Used : 150,000 – ~5 years + redundant branch left
- Reaction Wheels
  - Caging detected – action required
- Fuel
  - Original prediction/usage – depletion by 2019 – action required

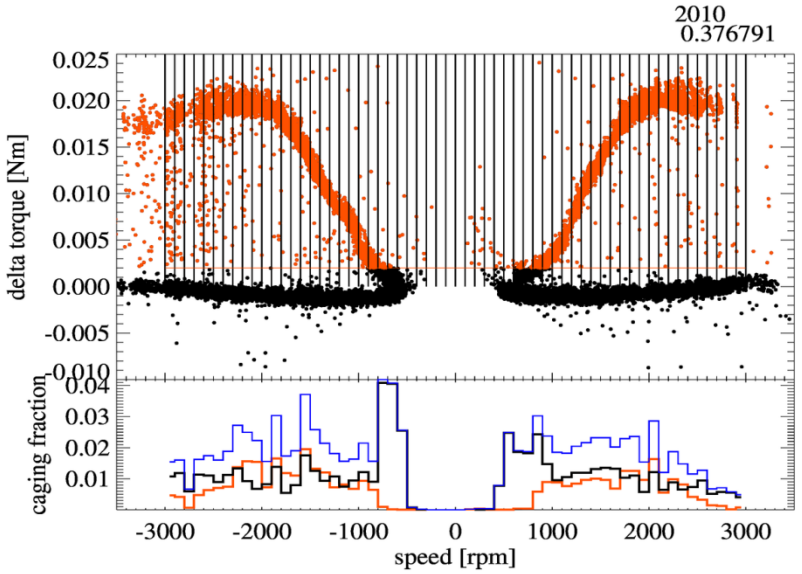
Reaction Wheels

- Known to be susceptible to an effect known as 'caging instability'
  - Commonly addressed through re-lubrication
  - Re-lubrication effectively cured RW2, but not RW1
- XMM-Newton was designed to run on 3 RW's (out of 4 present)
- New diagnostics were needed to seek solutions

Diagnostic: delta-torque speed

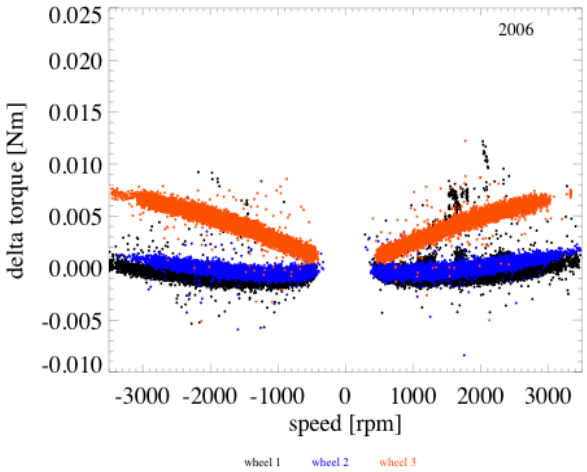
- produce torque wheel correlations subtracting theoretically required torque (UHB) from the actual one as a function of wheel speed
- if value is significantly different from 0 (zero) → cage instability
- The caging instability shows a clear speed dependence
  → **caging more frequent at higher speeds with a peak around 2000 rpm**

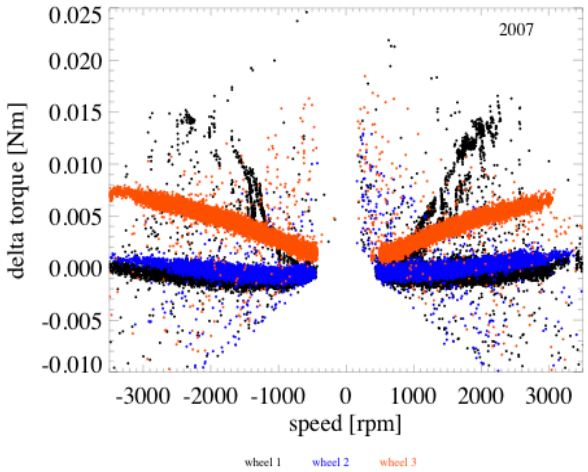


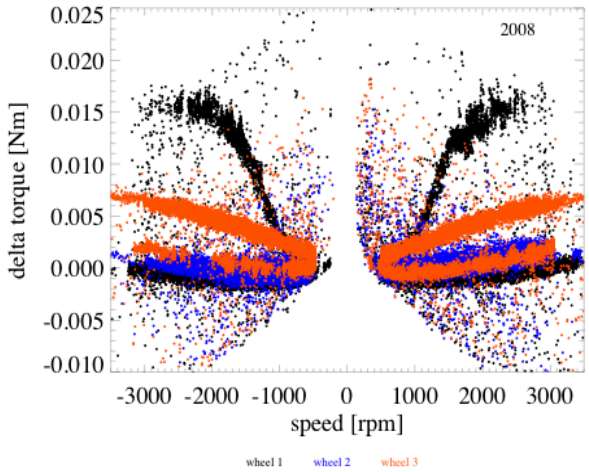


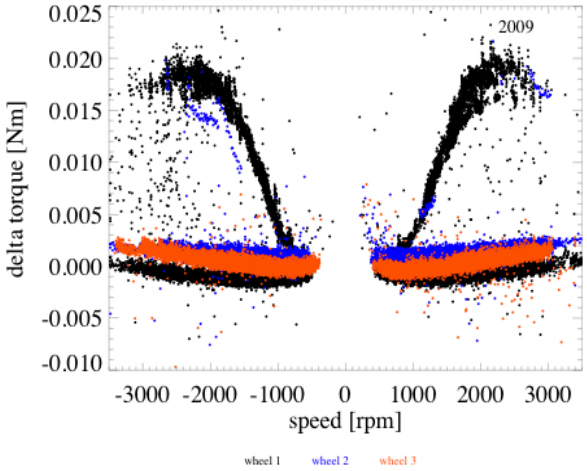
no caging **caging**

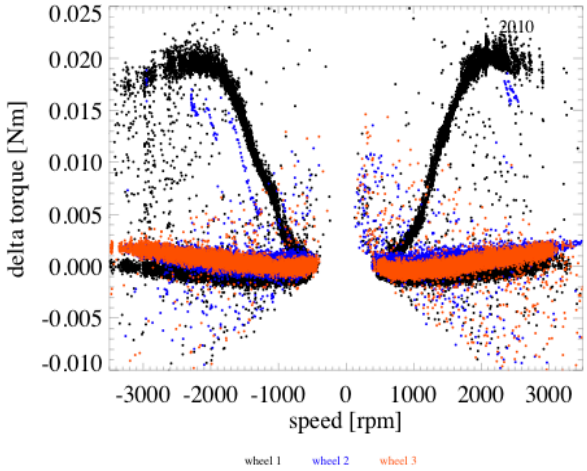
Temporal evolution RW1, 2 and 3

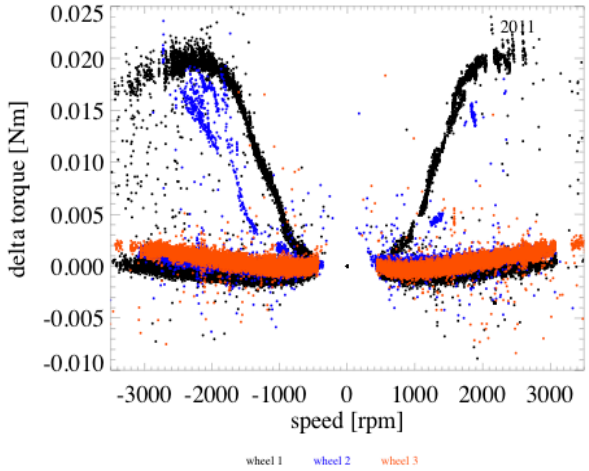






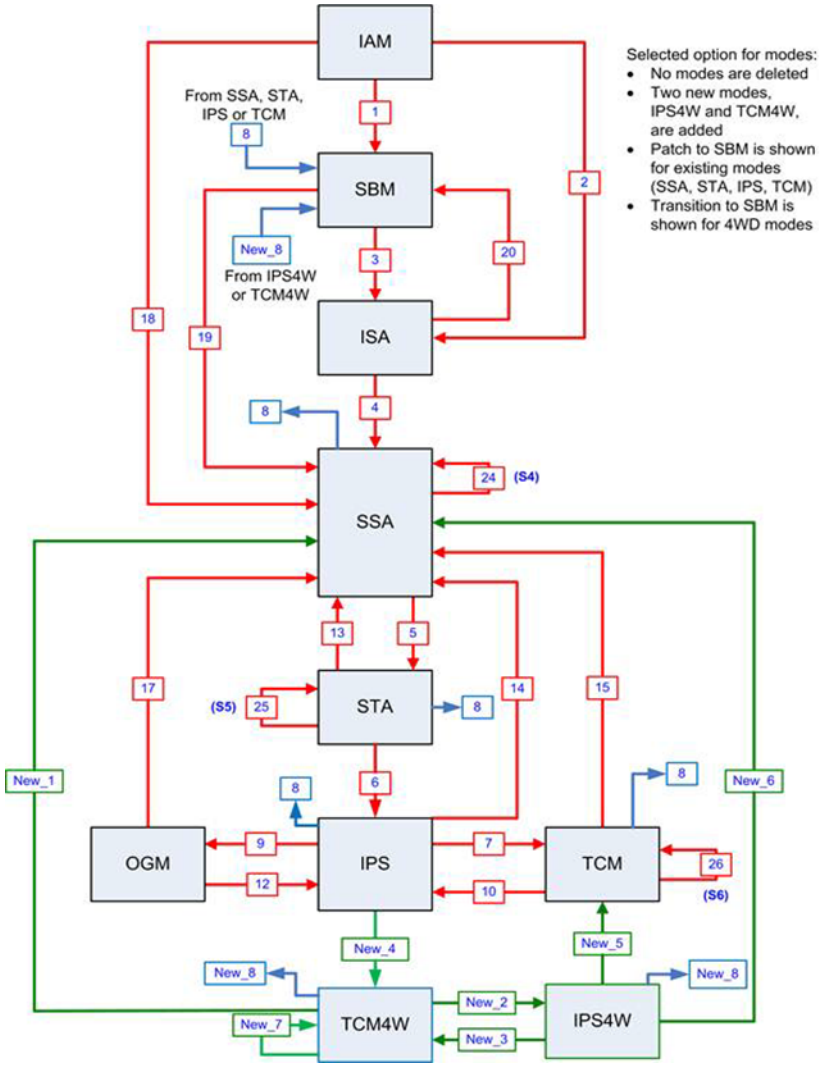






How to achieve lower average wheel speeds ?

- Introduction of fourth reaction wheel in control loop introduces more freedom to choose wheel speed regime
- The degree of freedom that is introduced by this change, not only allows to change wheel speeds without changing the S/C total momentum but also reduces the fuel consumption
- Had to patch the ACC into unused memory while running (expert knowledge from the early days needed…)

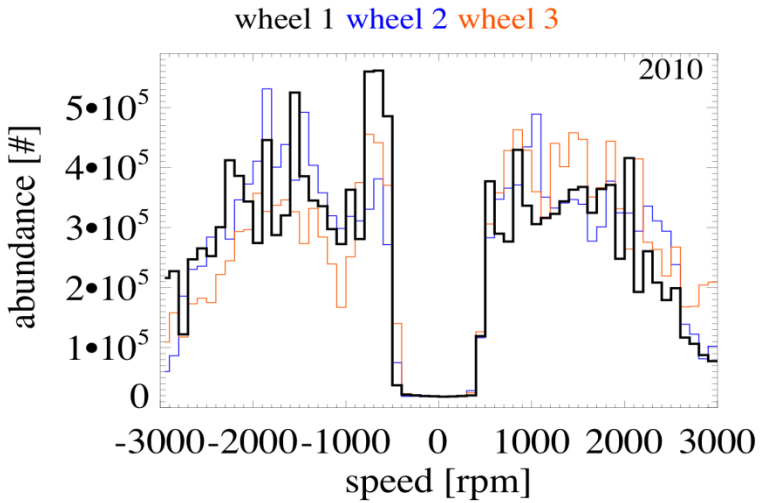


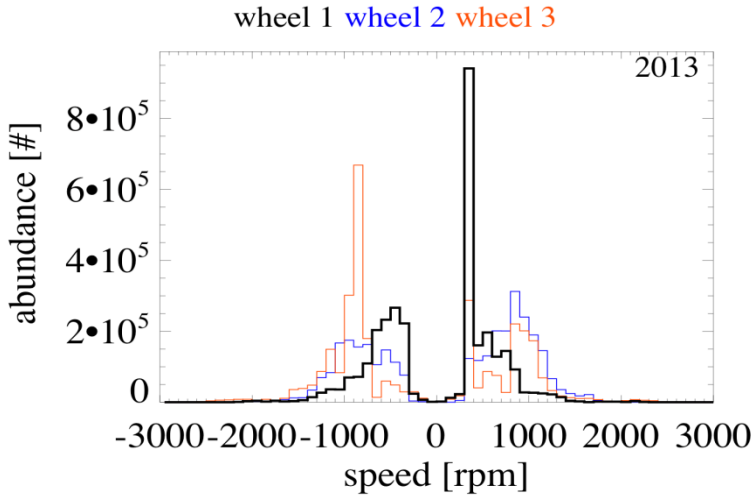
The result

- with 4WD much higher flexibility in the choice of wheel speed regimes
  → **operate the wheels at much lower speeds**
  - 3WD: speed distribution up to 3500 rpm
  - 4WD: peaked distribution below 1000 rpm

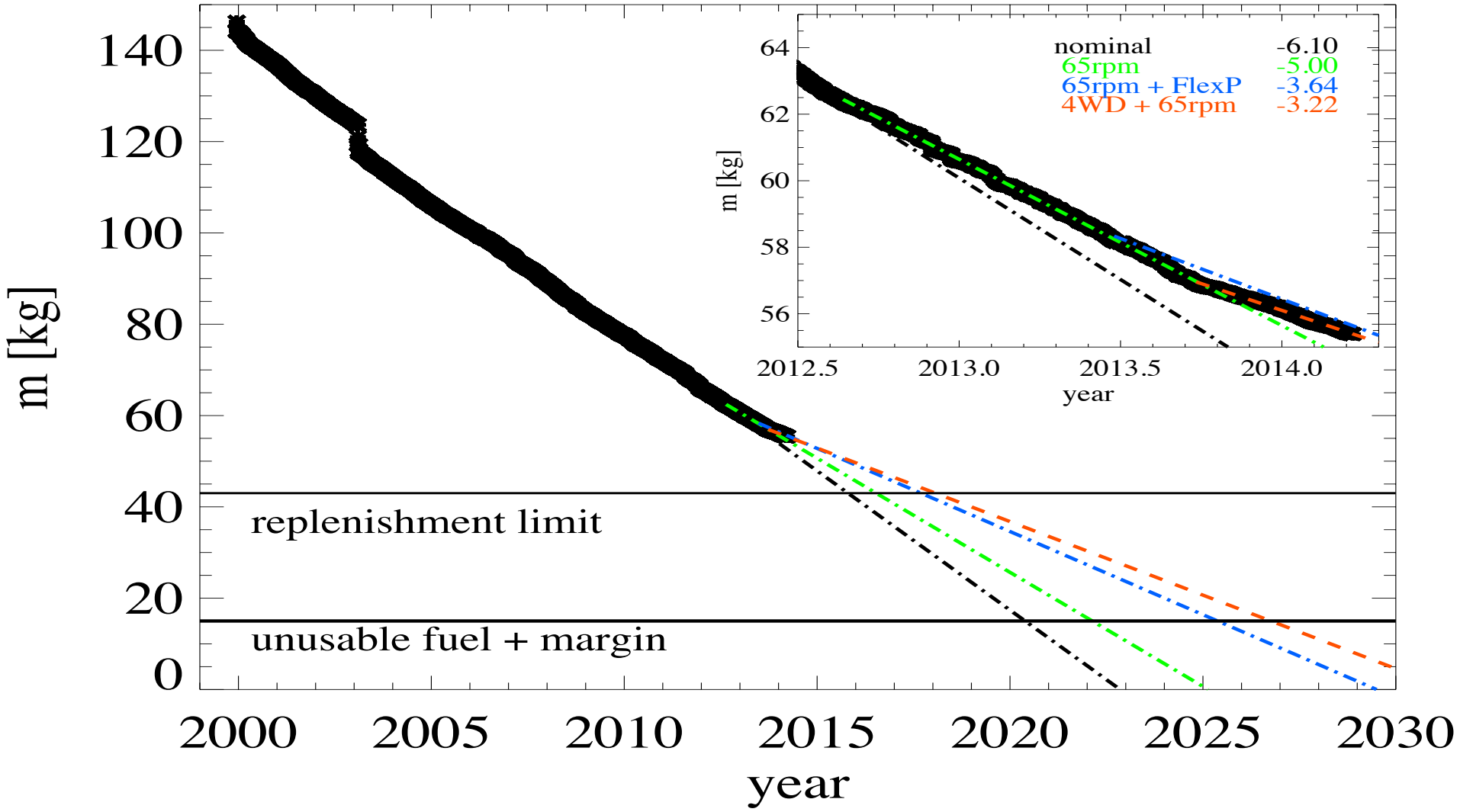
- operationally implemented additional null space operations for every stable pointing
- pointing stability not effected

- reducing the wheel speed to low speeds is the best way of reducing caging on a wheel that suffers already from cage instability and cannot be cured anymore using re-lubrication.

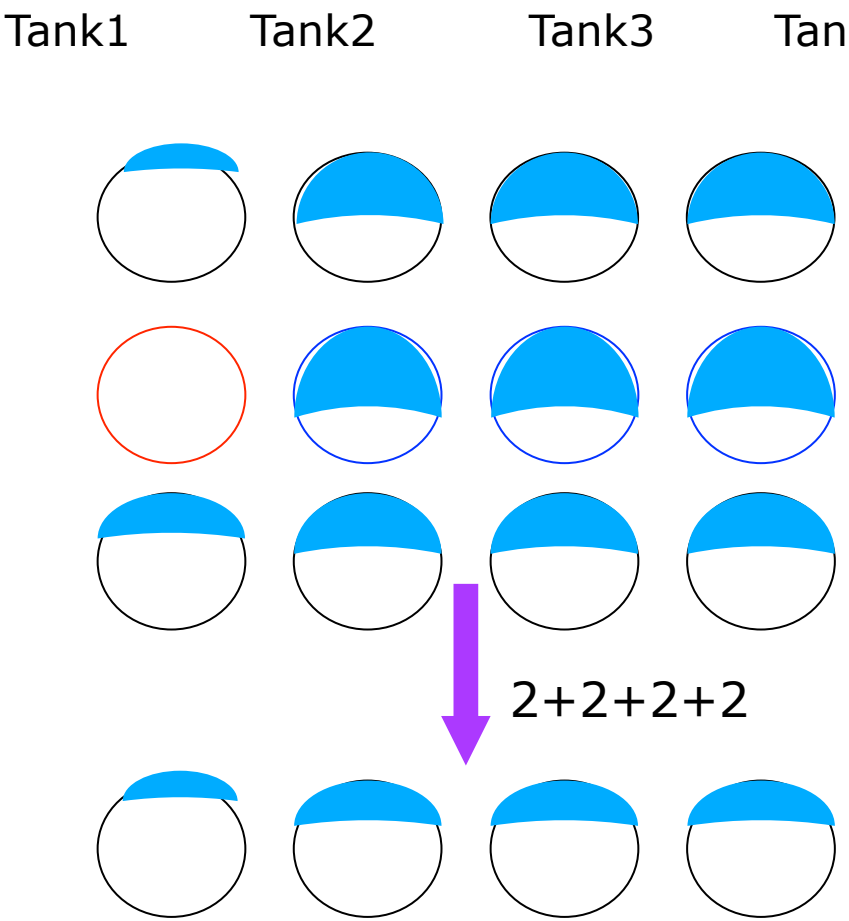


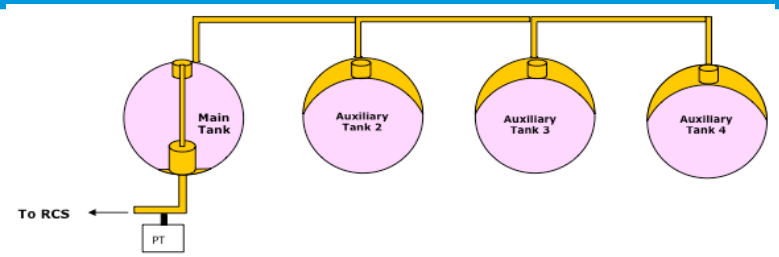


What was the effect on fuel usage ?



Fuel Migration





- propellant actuation system
  (He: pressurizer and liquid Hydrazine sharing the volume of the storage system)
- three Auxiliary Tanks which feed into the Main Tank (Tank 1), that in turn feeds the Thruster Lines
- main Tank will be the first to run dry (at this stage still up to 43 litres of hydrazine inside the tank system)
- commanded thermal excursions to migrate up the remaining propellant inside the Auxiliary Tanks and to replenish the Main Tank.
- close control of the tank heater loops is required currently only possible via time tagged commands that cycle the switches of the heater loops → Better solution required

CDMU update

- Temperature control currently is only possible via time-tagged commands
  - Tank replenishment requires a better solution
  - Antenna coverage gaps at pericenter – in eclipse season – require active temperature control of a number of elements
  - Only solution would be an update of the CDMU software
- CDMU software update
  - Has been designed and developed
  - Has been extensively tested at ESOC and by industry
  - Implementation delayed because of unavailability of person critical to this activity
  - Will continue after-September – update required for tank replenishment test in summer 2015 – tank replenishment itself required in 1-2 years time

The rest .....

- XMM-Newton's success can be attributed to:
  - Instruments and mirrors
  - Quality of the Calibration
  - Pipeline products in the archive
  - Point source catalogues
  - SAS
- Looking forward to the post-operations phase and the post mission phase, the following will have to be achieved:
  - Best possible products in the archive
  - Final mission catalogue
  - Consolidate the calibration
  - Post-mission data processing capability
    - Can't be the SAS as it is today – no budget available
    - Work has started to look at this – very significant effort required
- Overall resources available at SOC and MOC require prioritising activities and executing in sequence rather than in parallel

The end

- Thanks for your support
- Thanks to MOC and industry for their support to the material presented
- Thanks to the SOC for their continued dedication in support of the mission
- Thanks to the PI teams and the SSC for their support to the mission
- Thanks to the project scientist – Norbert Schartel

- Looking forward to many more years of XMM-Newton science !