XMM-Newton mission operations – preparing for the third decade

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Fuel saving extends life time to >2030+

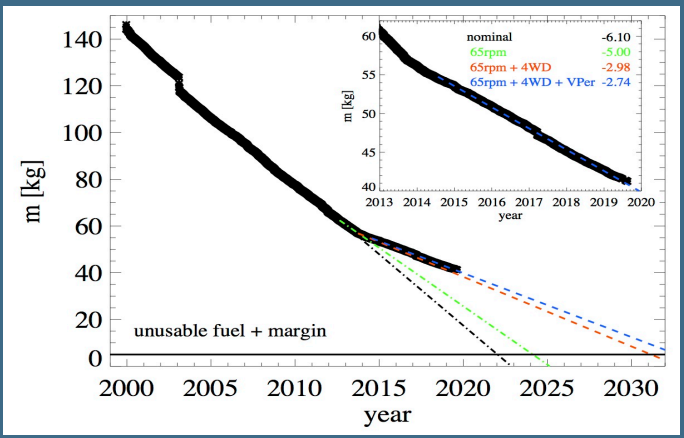


Figure 1
Fuel consumption of XMM-Newton. The coloured numbers show various steps of the improvements in operations where the most important factor is the operations with 4 reaction wheels (4WD)

- XMM-Newton uses hydrazine thrusters - mainly to unload its reaction wheels every orbit, but also for orbit stabilization
- Reaction wheels are the primary actuators for attitude control.
- The fuel usage after launch was of the order of 6 kg/year
- Changed in 2013 the onboard attitude control software to use 4 reaction wheels instead of 3 before (use the back up wheel)
- The degree of freedom that is introduced by this change, allows to reduce the fuel consumption and to change wheel speeds without changing the S/C total momentum (null space operation)

→ **The operations with 4 wheels in combination with some other operational improvements of wheel usage reduced the fuel consumption to < 3 kg/year, i.e. less than the half.**

XMM Mission status is very stable

Money	Funded until	End 2020/2022
Fuel	remaining Use per year Mileage	**~42.0 Kg** < 3.0 kg/year 2030+
Thruster pulses	Remaining use per year Mileage	13 000 (200000 qualified) <6 000 2021 (B-system with full redundancy available, industry recommends to stay on A)
Solar array power	Maximum required Current margin	**~ 1350 W** **~ 430 W**
Battery	According to industry	15+ y
Gyros/(IMUs)	Usage	< 31 %
Reaction wheels	Usage	< 52 %
Optocouplers	Mileage	~ 2028 +
RF switches **Transponder switches**	Usage	Stuck at one position Back up not used instead transponders are switched TX A LCL switches <1700 TX B LCL switches <1700 (Qualified to 25000)

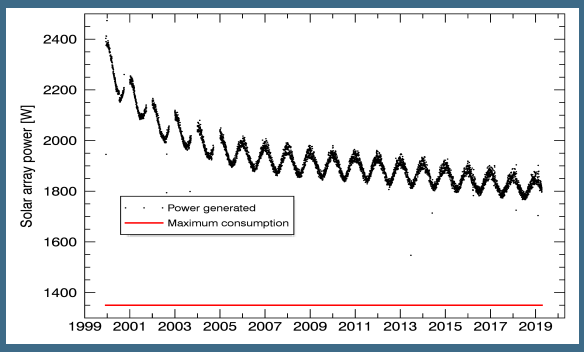
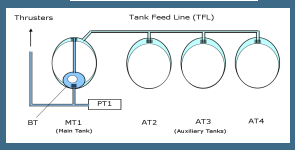


Figure 2
Power generation aboard XMM-Newton (normalised to 28.14V, Solar Aspect Angle: 0° .)
Power is healthy with a margin of currently more than 400 Watt for a maximum consumption of 1350 Watt.

- All XMM-Newton subsystems are in good shape
- Margins lead into late 20ties
- Lifetime currently limited only by fuel to 2030 +

Fuel migration and replenishment will provide fuel until 2030+

- **The XMM Tank system**
  - Uses hydrazine as propellant, helium as pressurant
  - Two types of tanks are used: three Auxiliary Tanks are feeding into one Main Tank, which in turn feeds the thruster branches
  - By design and filling conditions at launch the Main Tank will run dry first while there is still some fuel available in the Auxiliary Tanks



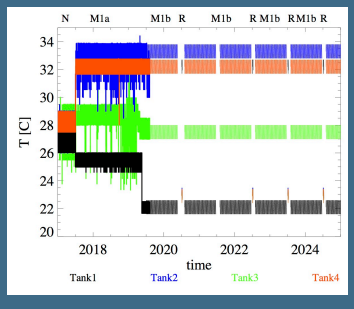


Figure 3: Tank temperatures during various phases.
N: Nominal, M1a M1b migration phases, R: Replenishment. Note: data in the future (light coulours) are simulated.

- **How to get the fuel from the AUX to the Main tank?**
  - Command thermal excursions to mop up the remaining propellant inside the Auxiliary Tanks and to replenish the Main Tank
  - Migration phase: 2017-2020 (thermo-dynamical fuel balance)
  - Replenishment phase (2020+) (thermo-dynamical fuel and gas exchange)
  - Tight control of the tank heater loops is required meanwhile - now provided by an elegant solution via open and closed loop temperature control by the CDMU

- 4 wheel operations in combination with fuel migration and replenishment operations should provide fuel up to 2030+
- This number contains margins for extra fuel usage in Safe Mode. If this is not used it extends per safe mode of the order of ~500g.
- → 10 years without safe mode buy an other 2 years of operations
- Working on automation systems that can prevent (faster than a human being) a safe mode (e.g. Single Event upset on wheel electronics)

Ground Segment is being made ready for next decade

- Remember: XMM is a "live" mission (very limited on board storage)
- Migration of Ground Infrastructure to state of the art systems where possible
  - Emulated Simulator and integration into modern SIMSAT environment
  - Using GMMS for automated monitoring and MOIS for commanding
  - Mission control system will be migrated to until 2030+ sustainable H/W solution

→ Introduction of automated systems to monitor and command improves safety and efficiency

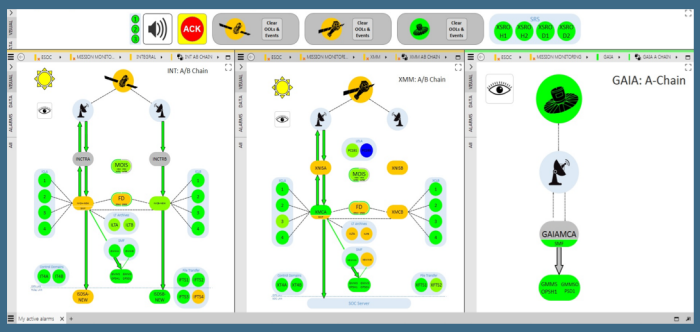


Figure 4: The new monitoring system GMMS that monitors all ground system components and critical S/C alarms for the three ESA astronomy missions XMM INTEGRAL and Gaia

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