



DEFENCE AND SPACE

SWARM satellites 10 years in orbit

Status and Forecast

The Swarm mission provides the best ever survey of the geomagnetic field and its temporal evolution. The Swarm system design is based on the long standing experience of Airbus in building magnetically clean satellites for missions like ISEE-B, Ulysses, Cluster and Champ. The satellite shape is driven by instrument (VFM, ASM, ACC, EFI) arrangement and single launcher requirements.

Scientists want to measure with 5 instruments

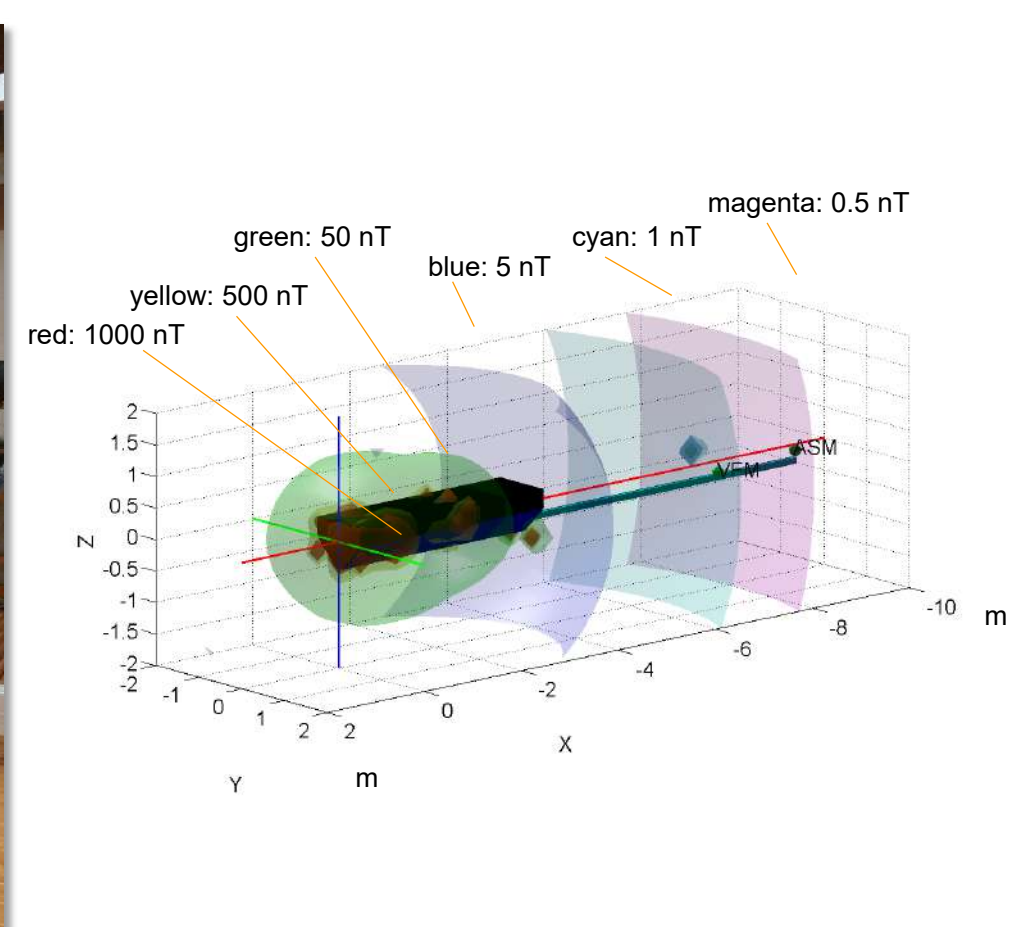
- ✓ simultaneously magnetic field, electrical field, air drag
- ✓ magnetic signature of earth, not of satellite
- ✓ undisturbed for long time in low altitudes
- ✓ at the same point of time at different locations

Airbus engineers ensure this by

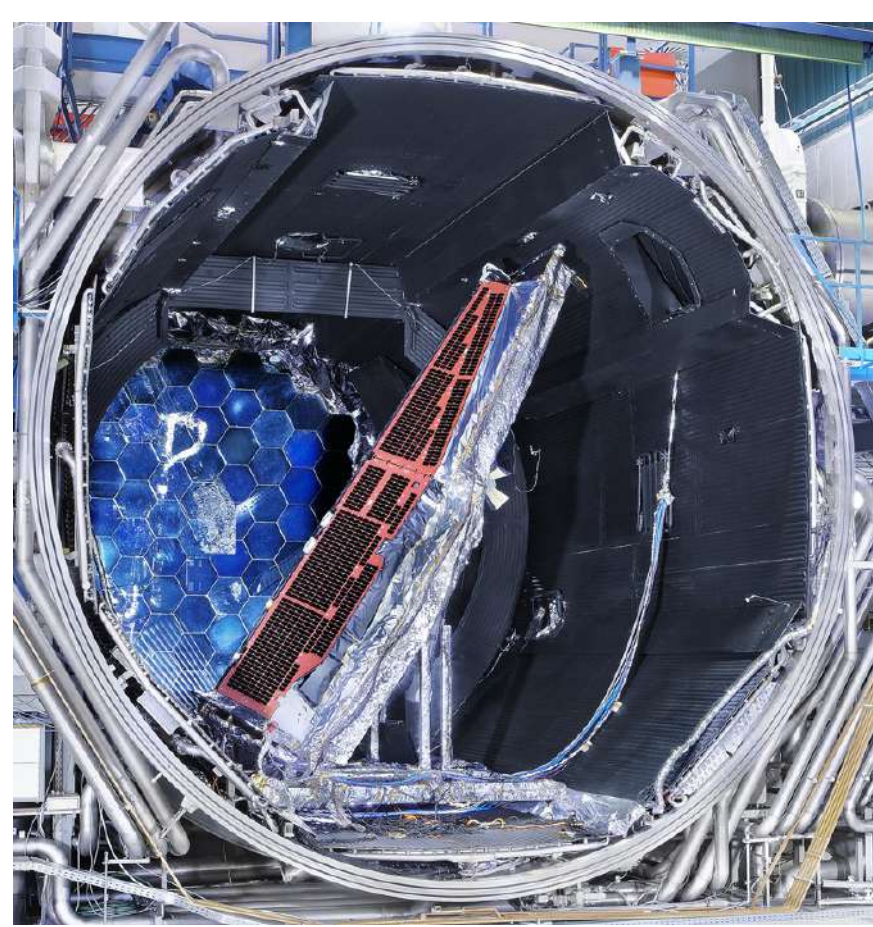
- ✓ 1m² x 5 m slim trapezoidal body with body mounted solar arrays and a
- ✓ 4.3 m long boom carrying science magnetometers and star trackers
- ✓ inverted electrical grounding scheme to limit S/C charging to 1 V
- ✓ very stable CFRP structure/boom; ultra-stable SiC/CFRP optical bench
- ✓ 473 kg satellite mass including 105 kg high density CF₄ propellant gas



System Magnetic Test



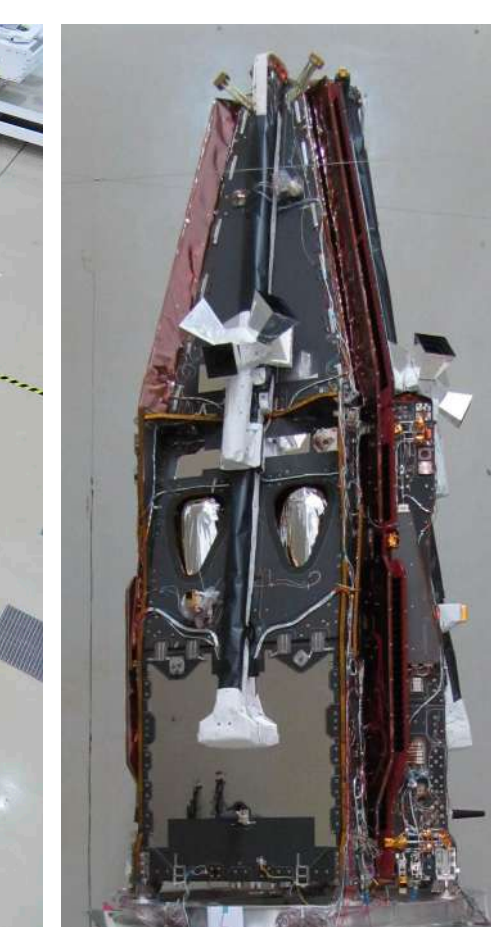
Magnetic Noise Levels



System TB/TV Test



Satellites in Cleanroom



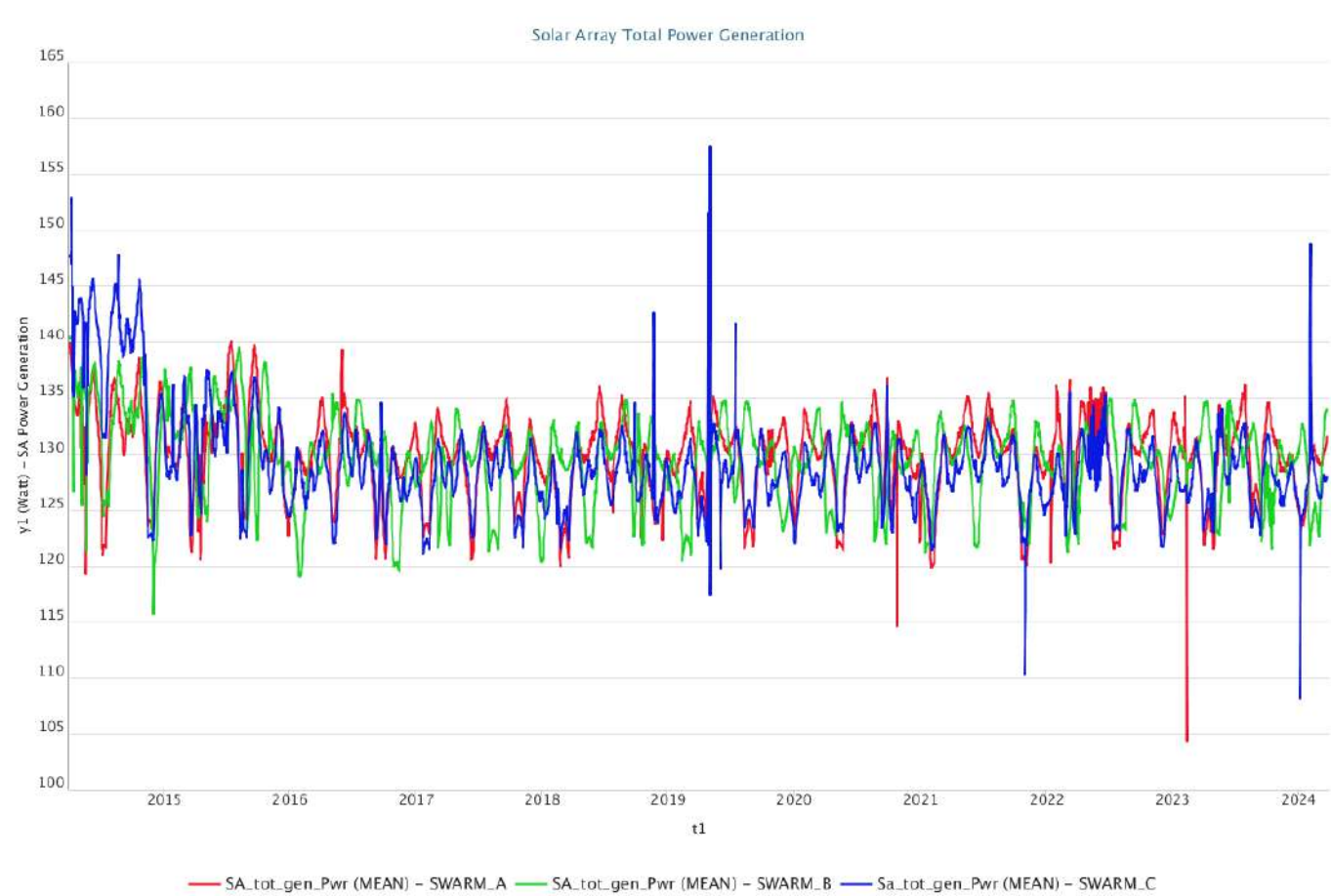
S/C Stack



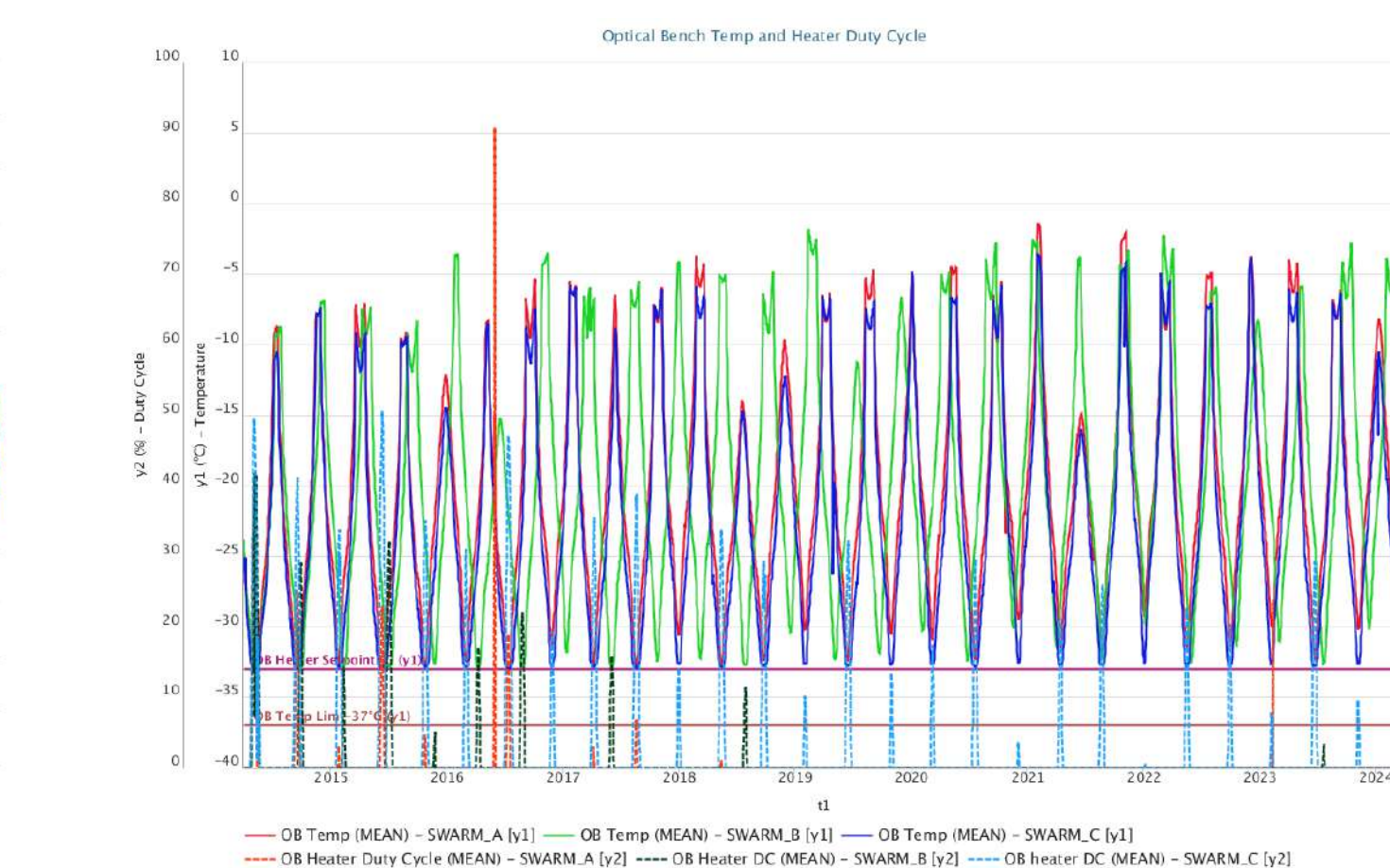
Launch

The three Swarm satellites have been launched on 22 November 2013 and are operating in excellent health since more than 10 years. The mission performance is better than specified and all platform subsystems are performing as predicted or even better.

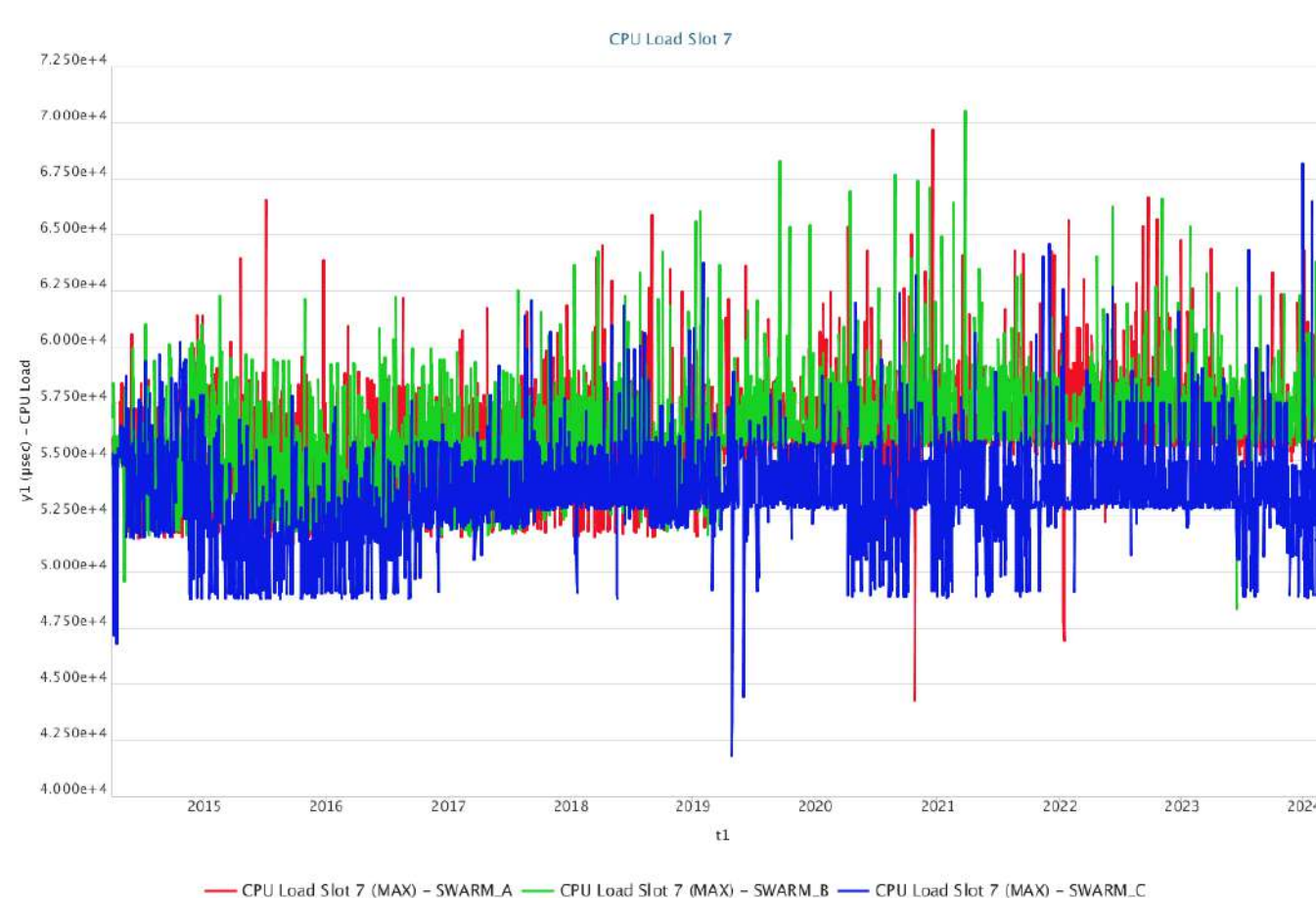
- ✓ Accuracy of magnetic field measurement better than 0.3 nT
- ✓ 99.8% of mission time in science operation mode since begin of operations, only 9(A)/2(B)/11(C) days in other AOCS modes
- ✓ 248(A)/157(B)/204(C) orbit control manoeuvres of up to 3 hours duration performed since launch
- ✓ Less than 3 sec/orbit thruster pair on-time to maintain attitude control performance in support of air coil torquers
- ✓ 135 W mean power consumption vs. 221 W power budget
- ✓ More than 65% margin wrt. 235 W EoL power capability
- ✓ No long term variation of on-board temperatures
- ✓ Less than 0.6 Am² satellite residual magnetic moment
- ✓ On-Board Software has not been modified since launch
- ✓ More than 44% margin wrt. maximum processor run-time load
- ✓ All platform redundancies available on all three satellites



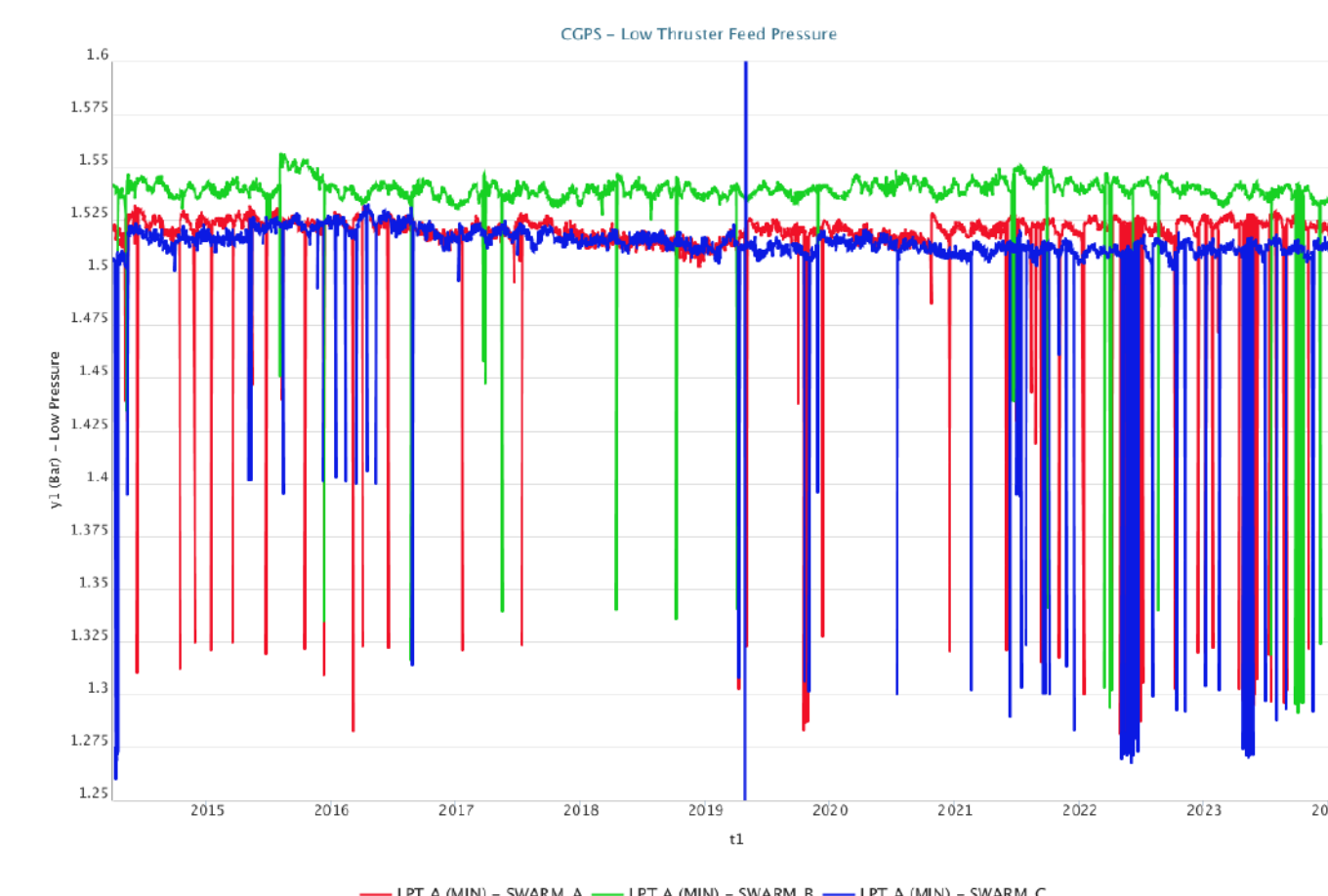
Solar Array Power
(> 65% margin wrt. EoL power capability)



Optical Bench Temp. & Heater Duty Cycle
(temp. kept above -33°C by <50% heater duty cycle)



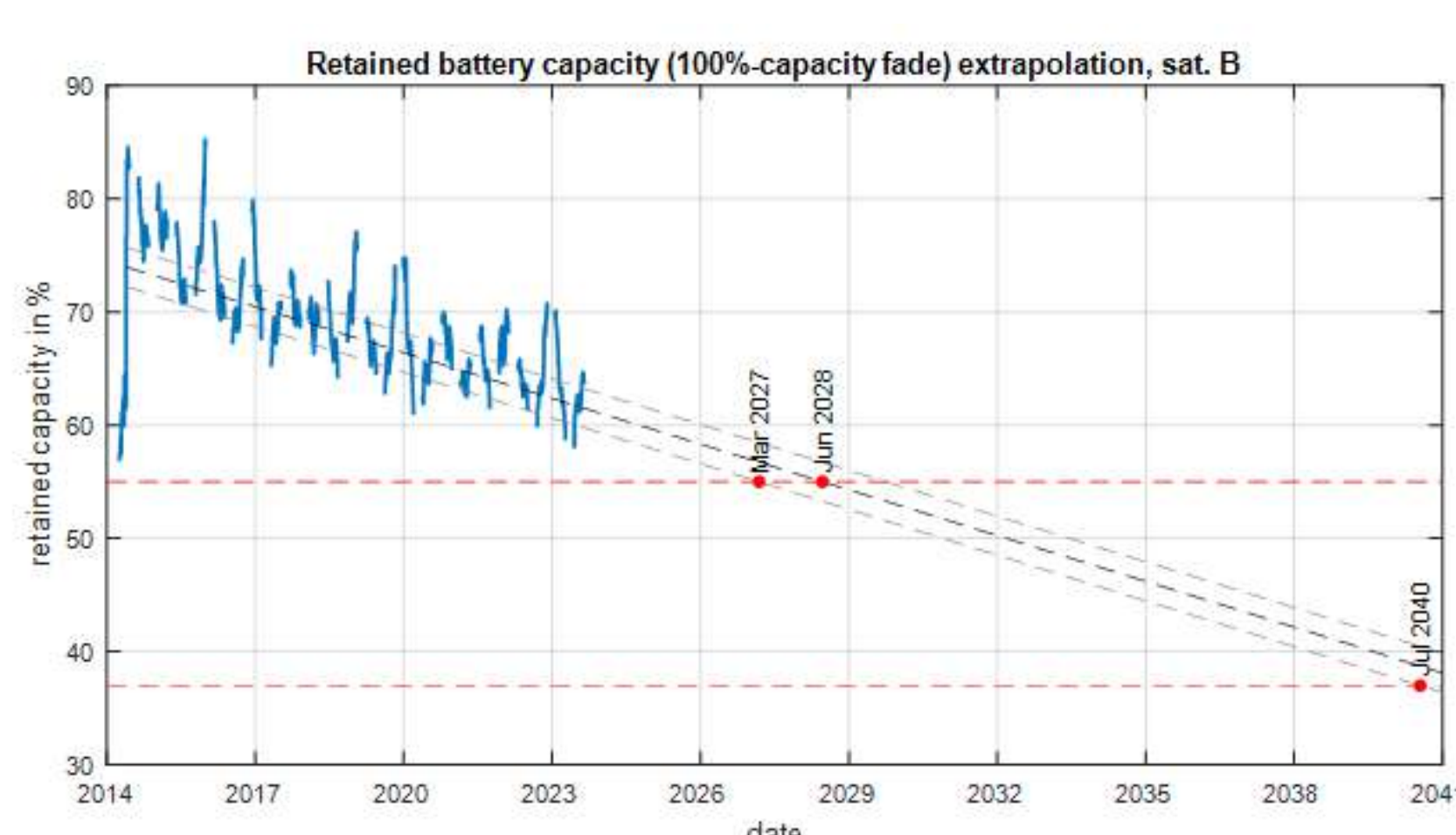
OBC S/W Processor Load
(> 44% margin wrt. 125 ms slot length)



AC & OC Thruster Feed Pressure
(lower pressure during orbit control manoeuvres)

The Swarm platform consumables and life limited items have sufficient margin to extend the mission through the current solar cycle until deorbit of Swarm A and C during next solar minimum in ~2033 timeframe and to operate Swarm B well beyond 2040.

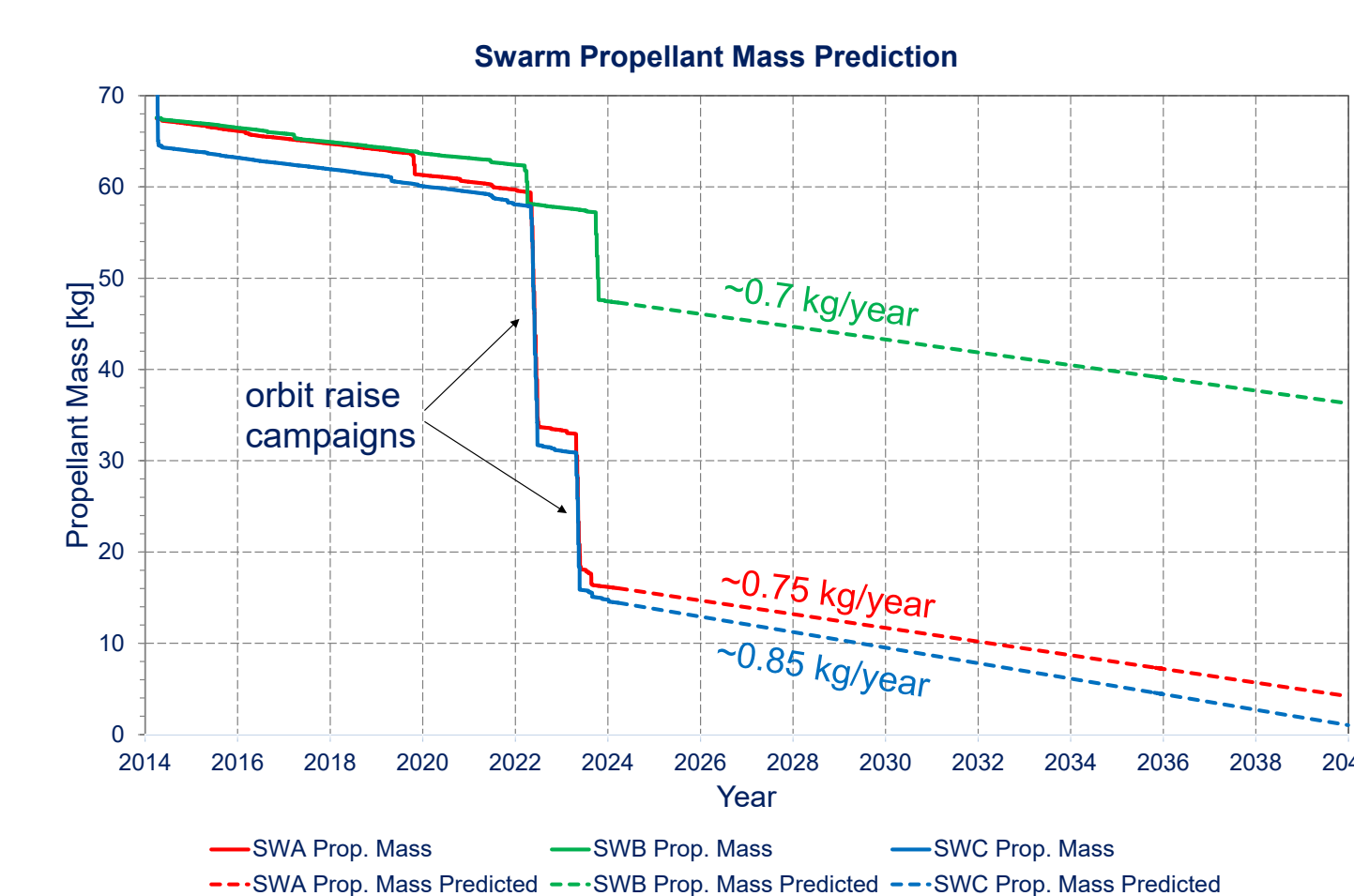
- ✓ Battery capacity fade ~1.3 % per year
- ✓ 37 % minimum required capacity to survive safe mode transition will be reached in 2040/41 for all three satellites



Swarm B Battery Degradation Prediction

Date	Swarm A	Swarm B	Swarm C
Begin of Life (Launch)			
22.11.2013	105.5	105.2	102.8
Begin of Operational Phase			
17.04.2014	68.5	67.7	64.9
End of Nominal Lifetime			
22.02.2018	65.2	64.7	61.8
Right Now			
22.03.2024	16.5	47.0	14.0

Propellant Mass Consumption [kg]



Propellant Mass Prediction