Management of End of Life for Airbus LEO satellites: the example of MetOp A

2022 Clean Space Industry days

DEFENCE AND SPACE

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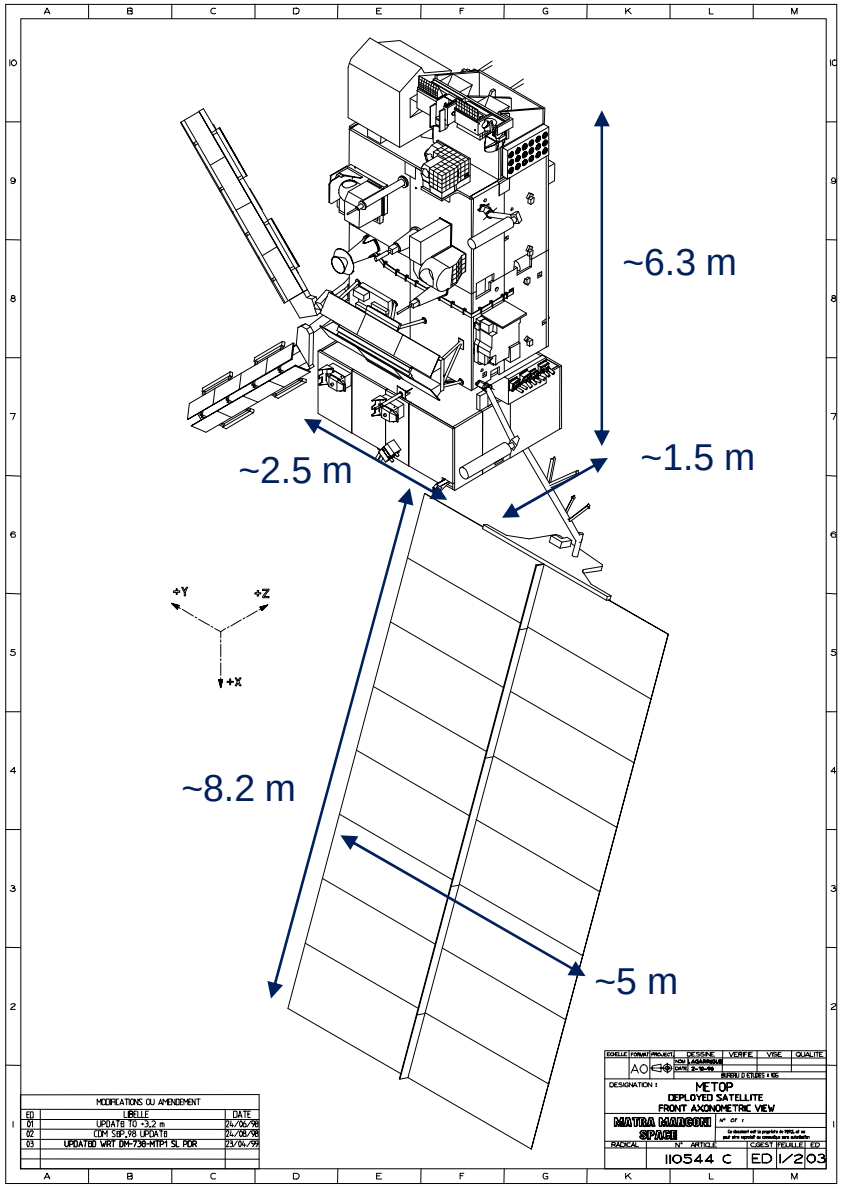
MetOp A introduction

MetOp A
- Platform inherited from 11 satellites of the SPOT-ERS-ENVISAT family, with some improvements
- Development phase with EUMETSAT and ESA
- Final customer and operator: EUMETSAT

SRR of MetOp A before 2014
➔ the ESA policy was not applicable to MetOp A

MetOp A shared its orbit mission with MetOp B and C
- Sun synchronous orbit
- Mean altitude = 820 km ± 20km
- Mean local time of ascending node = 21.5h ±2min

➔ **need to deorbit MetOp A**



S/C wet mass ~4100 kg at BOL
Propellant mass ~ 315 kg

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MetOp A lifetime extension

Lifetime extension

All redundancies

Drift of the Local Time of Ascending Node

19/10/2006: LEOP
- Hydrazine=300 kg
- LTAN=21.5h ±2'

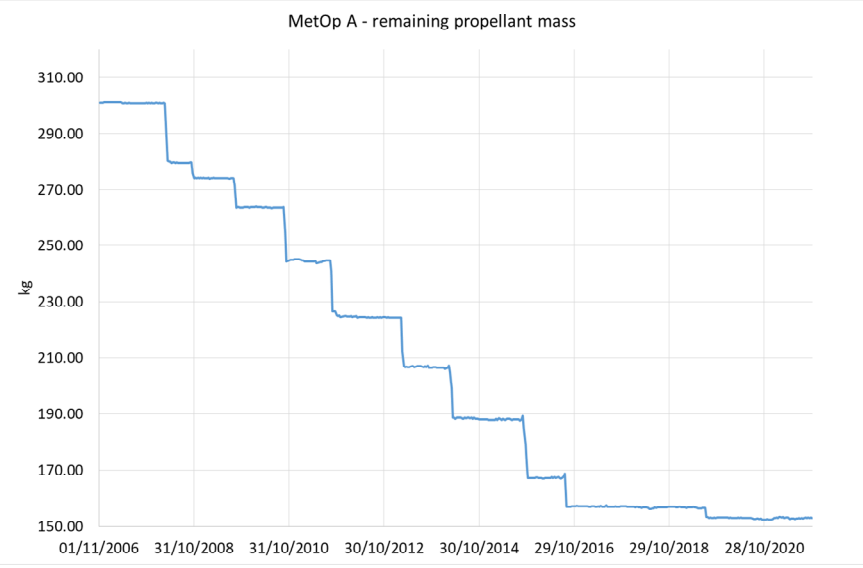
19/10/2011: contractual EOL
- Hydrazine=225 kg
- LTAN=21.5h ±2'
- All redundancies ☺

17/09/2012
MetOp B launch

31/08/2016: start of LTAN drift
- Hydrazine=157 kg
- LTAN=21.5h

07/11/2018
MetOp C launch

15/11/2021: end of mission
- Hydrazine=153 kg
- LTAN=19.9h
- All redundancies ☺



Drift of Local Time of Ascending Node:
- Rationale: to save propellant for EOL operations
- Heritage on other S/C of the same family
- EUMETSAT & ESA analyses performed in 2015:
  - No impact on the power budget neither batteries
  - Thermal design robust down to LTAN ~20h
  - Minor AOCS impacts (Earth and Sun sensors) easily managed

MetOp A EOL operations: main overview

Date	15 Nov	16 Nov	17 Nov	18 Nov	19 Nov	20 Nov	21 Nov	22 Nov	23 Nov	24 Nov	25 Nov	26 Nov	27 No	28 Nov	29 Nov	30 Nov
Phase 1	SC prep															
Phase 2		Decrease of the				*break*	perigee altitude									
Phases 3&4													EOL IOT	Propulsion and electrical passivation		

Phase 1: de-orbiting preparation - switch off of useless units, loading of S/W patches, FDIR management.
Phase 2: de-orbiting - decrease of the perigee altitude with long orbit corrections.
Phase 3: propulsion passivation – short orbit corrections to empty the tanks.
Phase 4: electrical passivation.

Remark: EOL IOT = in-orbit tests during the End Of Life operations

MetOp A: phase 2 - decrease of the perigee altitude

OCM = Orbit Control Mode,

- Same OCM as the OCM for the mission

1 cycle of orbit correction:

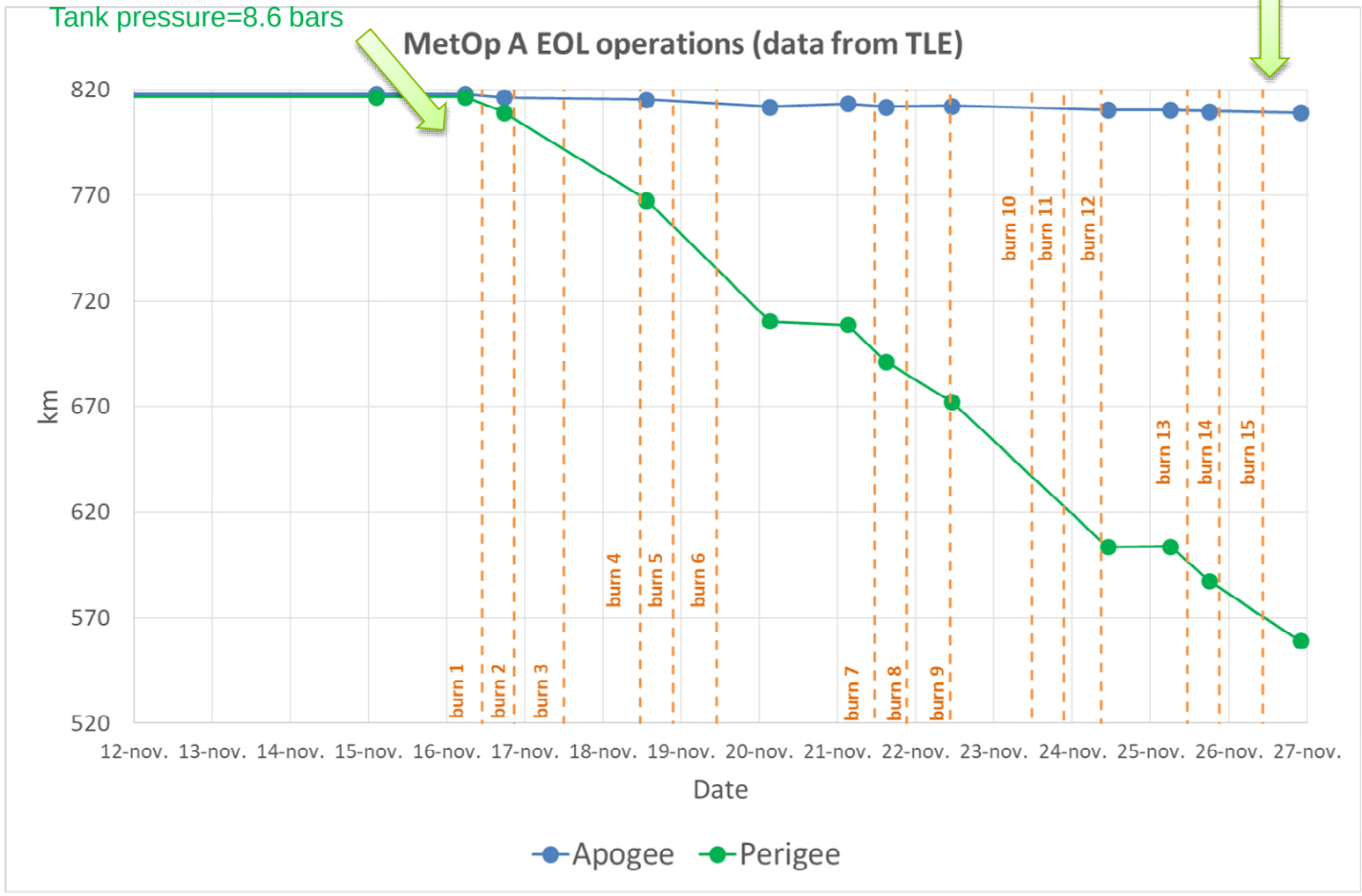
- Day 1:
  - Orbit Control Mode on the morning
  - OCM on the afternoon
- Day 2
  - OCM on the morning
  - FDS activities on the afternoon
- 3 axes wheel control between OCM

For all OCMs:

- 2 off-modulated thrusters (#13 and #15)
- Thrust duration of 1065 s (excepted the 1st one=400 s and the last one=702 s)

Start of phase 2
Remaining propellant=152.6 kg
Tank pressure=8.6 bars

End of phase 2
Remaining propellant=21.8 kg
Tank pressure = 6 bars



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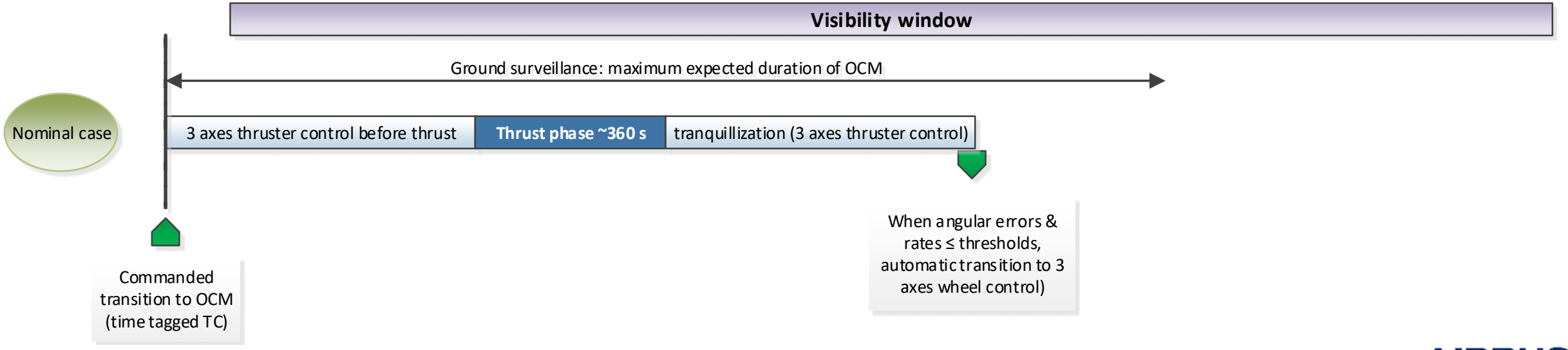
MetOp A – phase 3: propulsion passivation

Principle

- At phase 3 entry, payload switch OFF and removal of the constant yaw bias (in wheel control mode)
- Several short in-plane maneuvers with expected end during ground station visibility
- Short in-plane maneuvers identical to the ones performed for the mission

Contingency case: see the phase 4

- Contingency case = on-board FDIR triggering or S/C stuck in the tranquillization phase after the thrust



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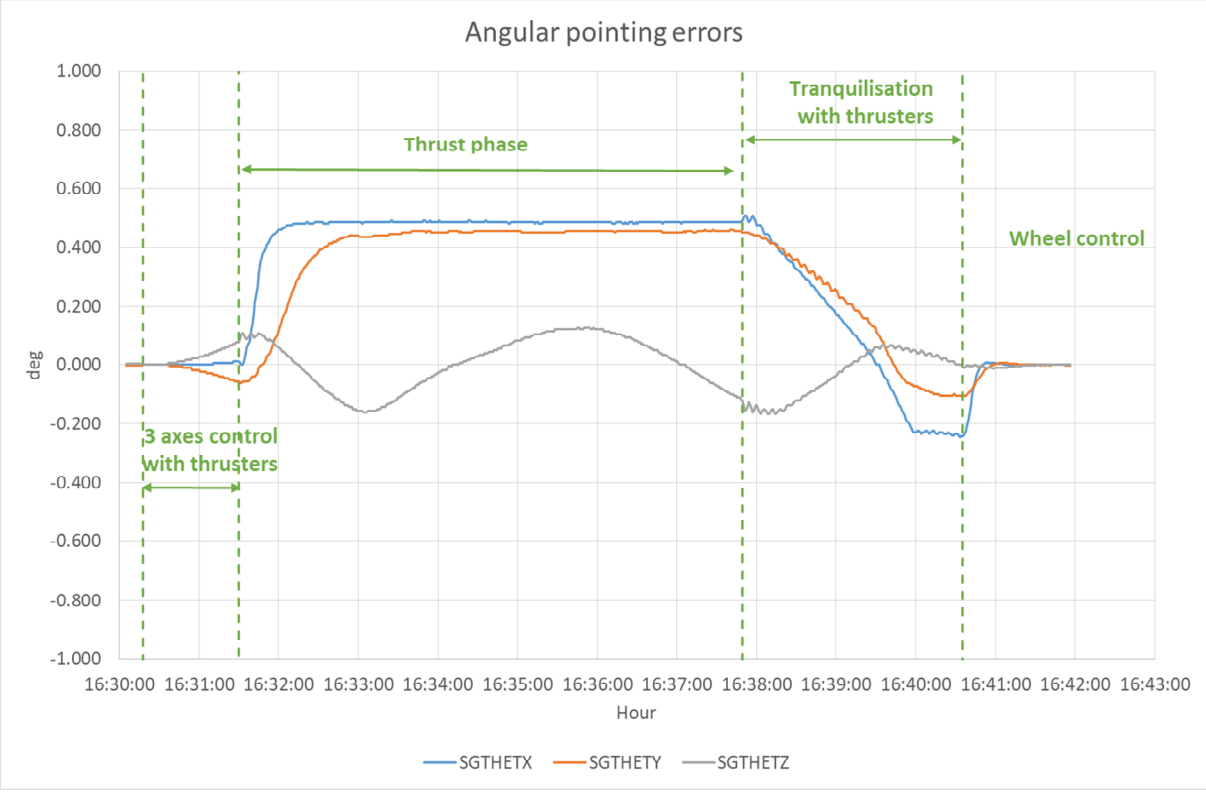
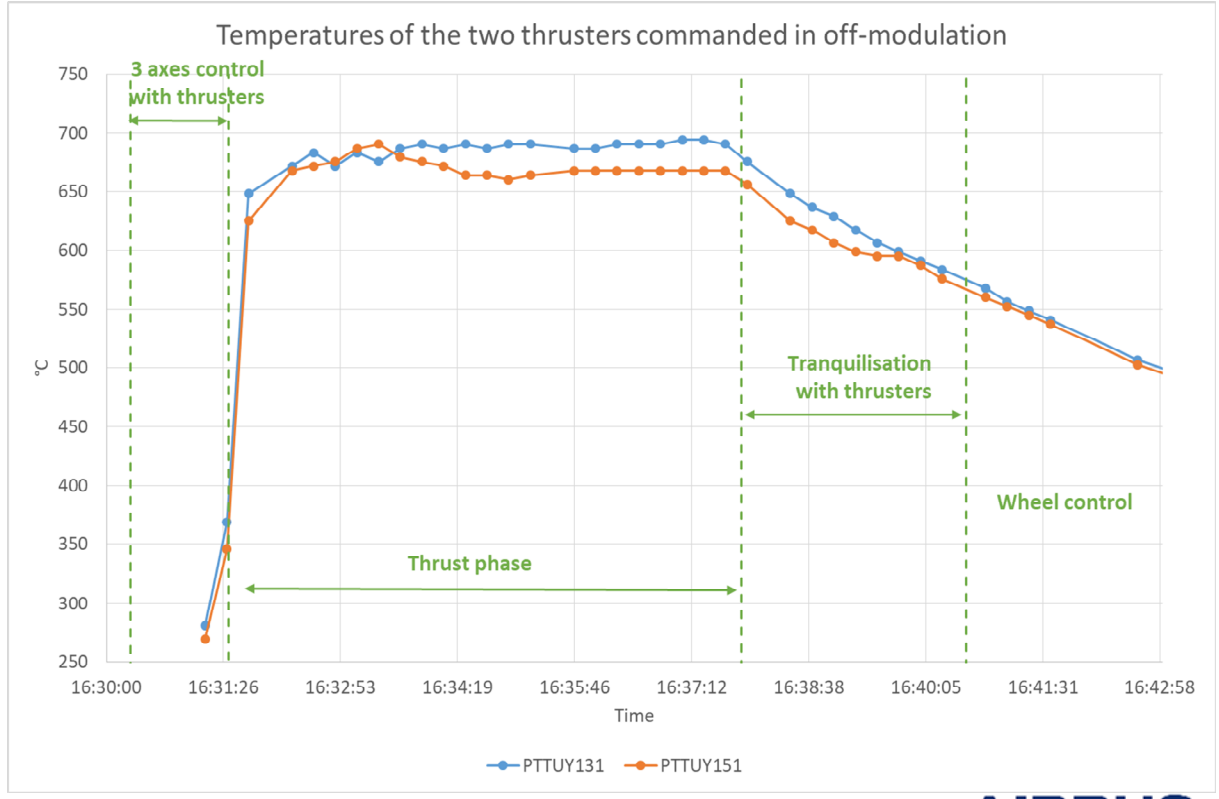
MetOp A – phase 3: example of nominal small thrust

The time evolutions of the angular pointing errors are nominal: X and Y stuck to positive limit cycle, Z around 0

The temperatures of the thruster chamber assembly of the two main thrusters are stable during thrust phase





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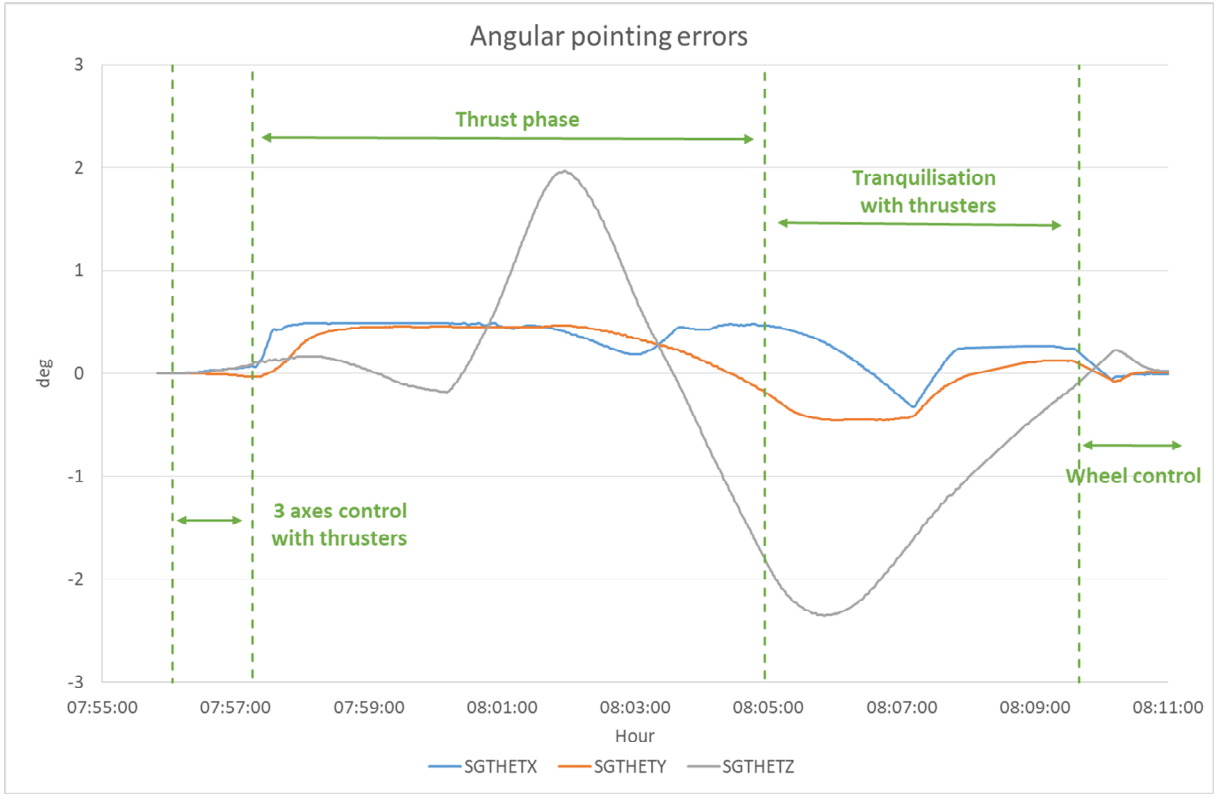
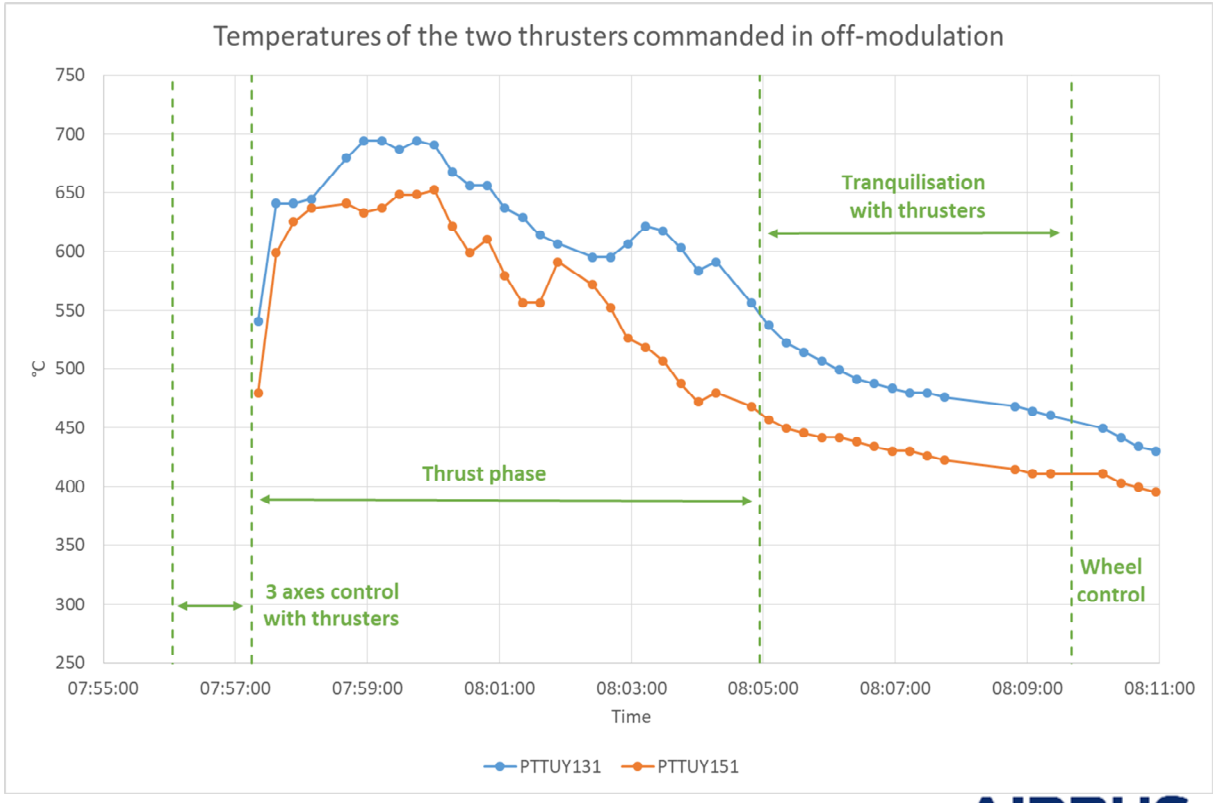
MetOp A – phase 3: example of small thrust with bubbles

The angular pointing error around Z axis has important variations within ±2 deg

The temperatures of the off-modulated thrusters decreased during the thrust

The thruster control during the tranquillization damps correctly the attitude, but with longer duration

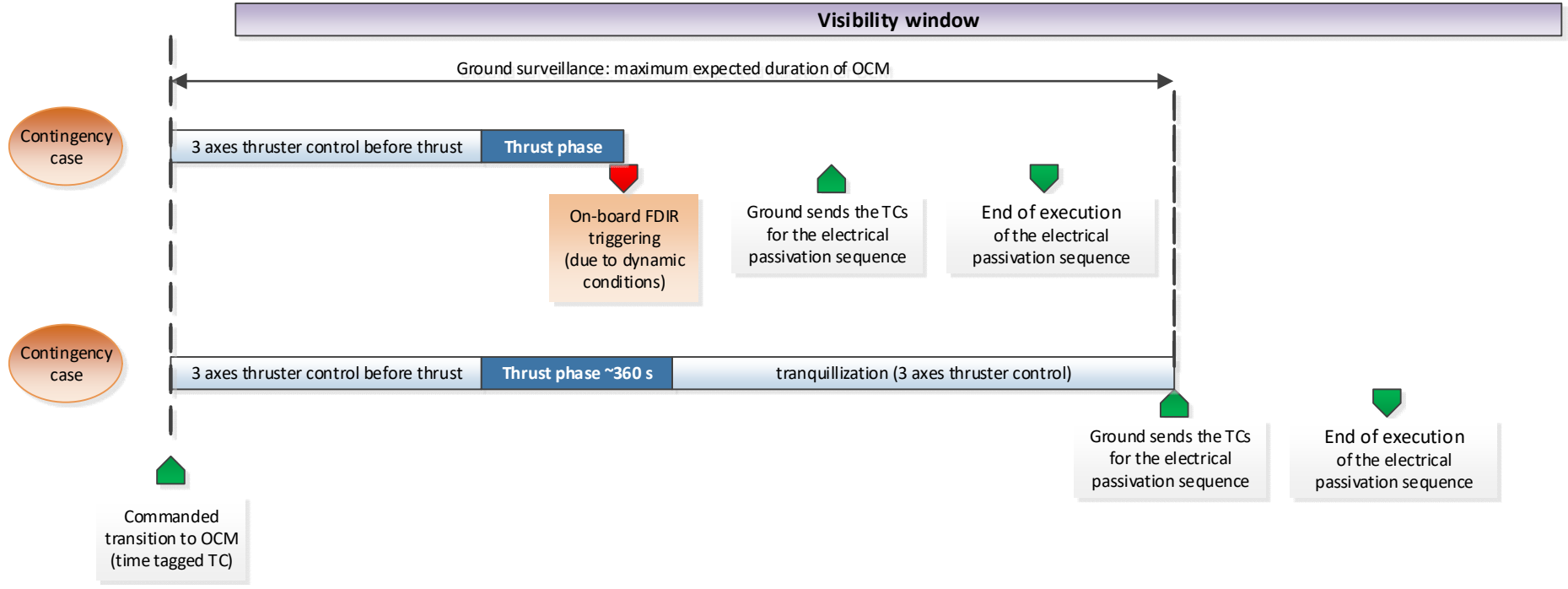




MetOp A – phase 4: electrical passivation sequence, commanded by ground

Electrical passivation sequence (inherited from other previous electrical passivations of the same S/C family)

- Inhibition of the on-board hardware FDIR
- Disconnection of all the batteries (disconnection of both charge and discharge capability on the power bus)
- Transponder emitters switch OFF



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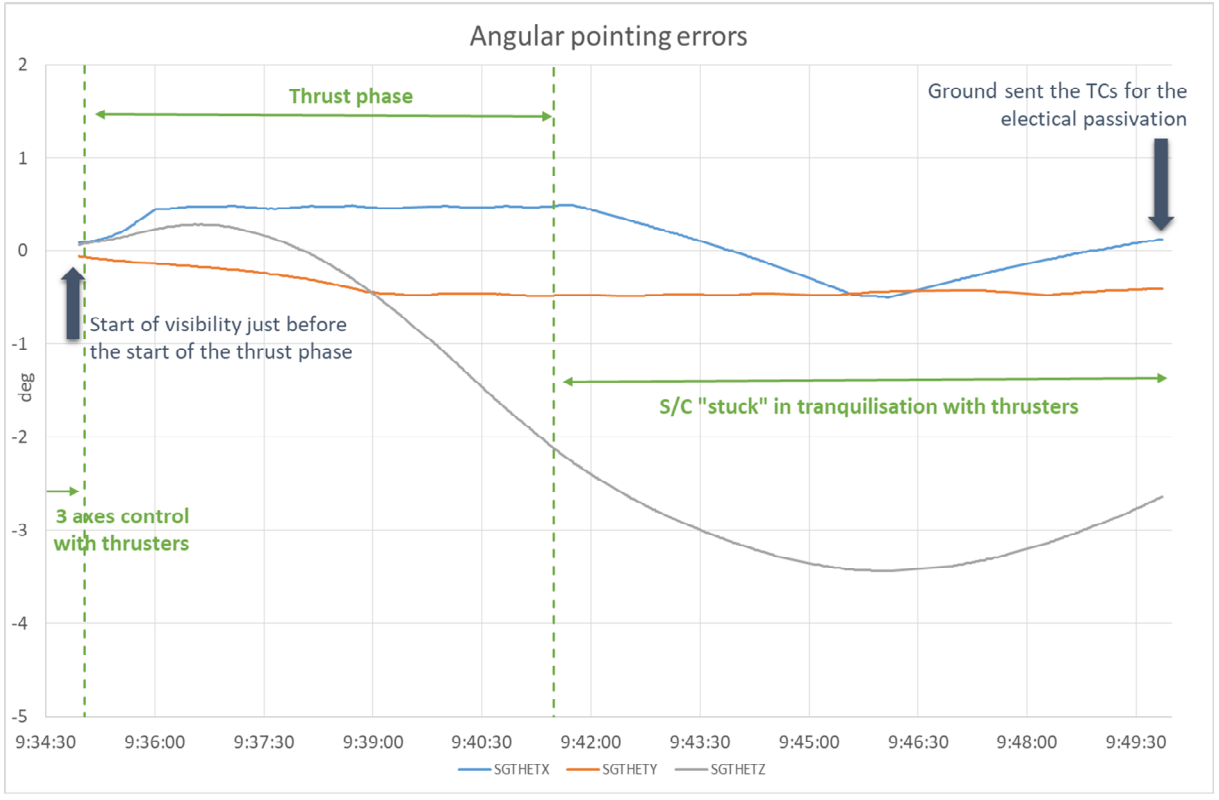
Phase 4: electrical passivation during the 8th small OCM

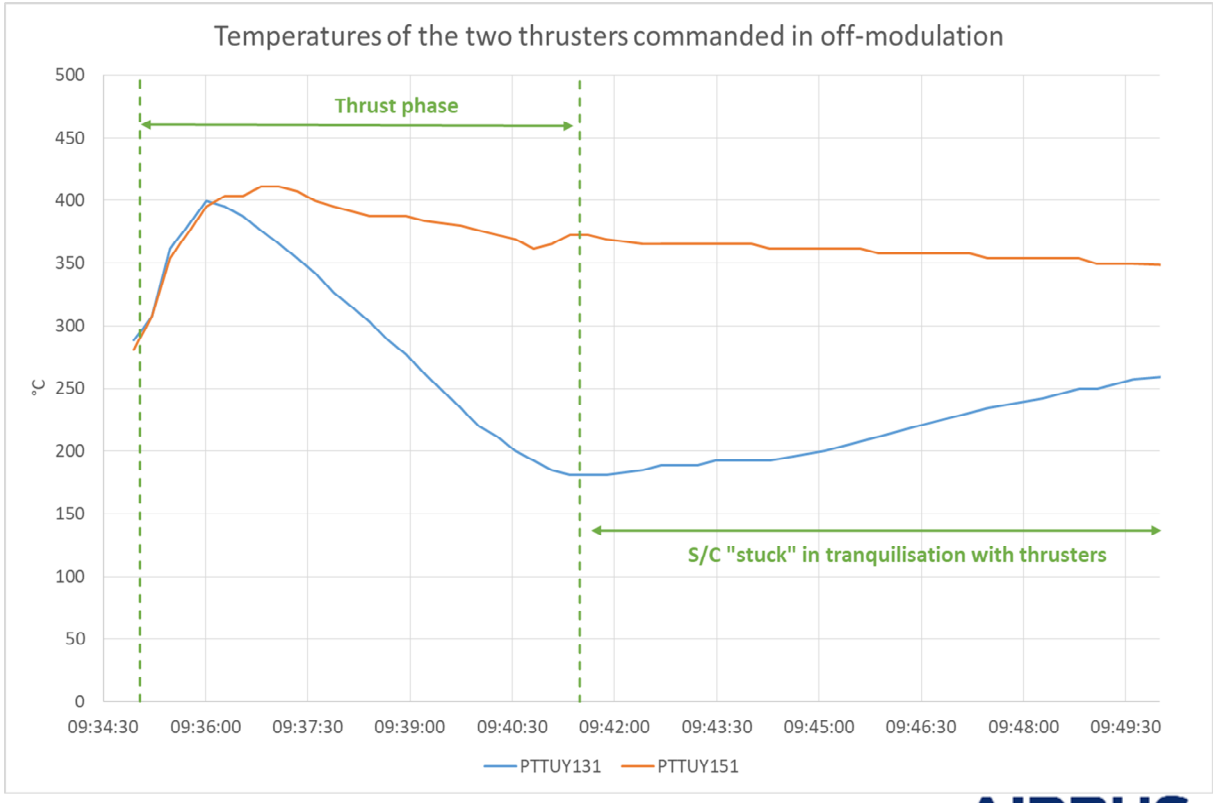
5 small in-plane maneuvers with nominal AOCS and propulsion behavior

2 small in-plane maneuvers with some minor AOCS disturbances and bubbles, with come back in wheel control

Last maneuver with important yaw pointing error and bubbles at the start of the thrust

- The max expected OCM duration was reached → ground commanded the electrical passivation





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Conclusions

Final S/C state at the end of the End Of Life operations

- Perigee altitude ~530 km
- Last tank pressure measurement: 4.2 bars
- Re-entry time estimated to 21.5 years (EUMETSAT's estimation)
- Solar array is still connected to the power bus
- Transponders A and B passivated: emitters OFF
- The batteries are disconnected (disconnection of both charge and discharge capability on the power bus)

In-orbit experience return

- No observable impact of the drag torque on the wheel rates
- Correct coarse 3 axes pointing attitude with thrusters with hydrazine & bubbles and cold gas only
- Successful operations because of
  - Co engineering between EUMETSAT and Airbus DS to define and validate the operations
  - EUMETSAT managed the End Of Life operations like a LEOP

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Thank you

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