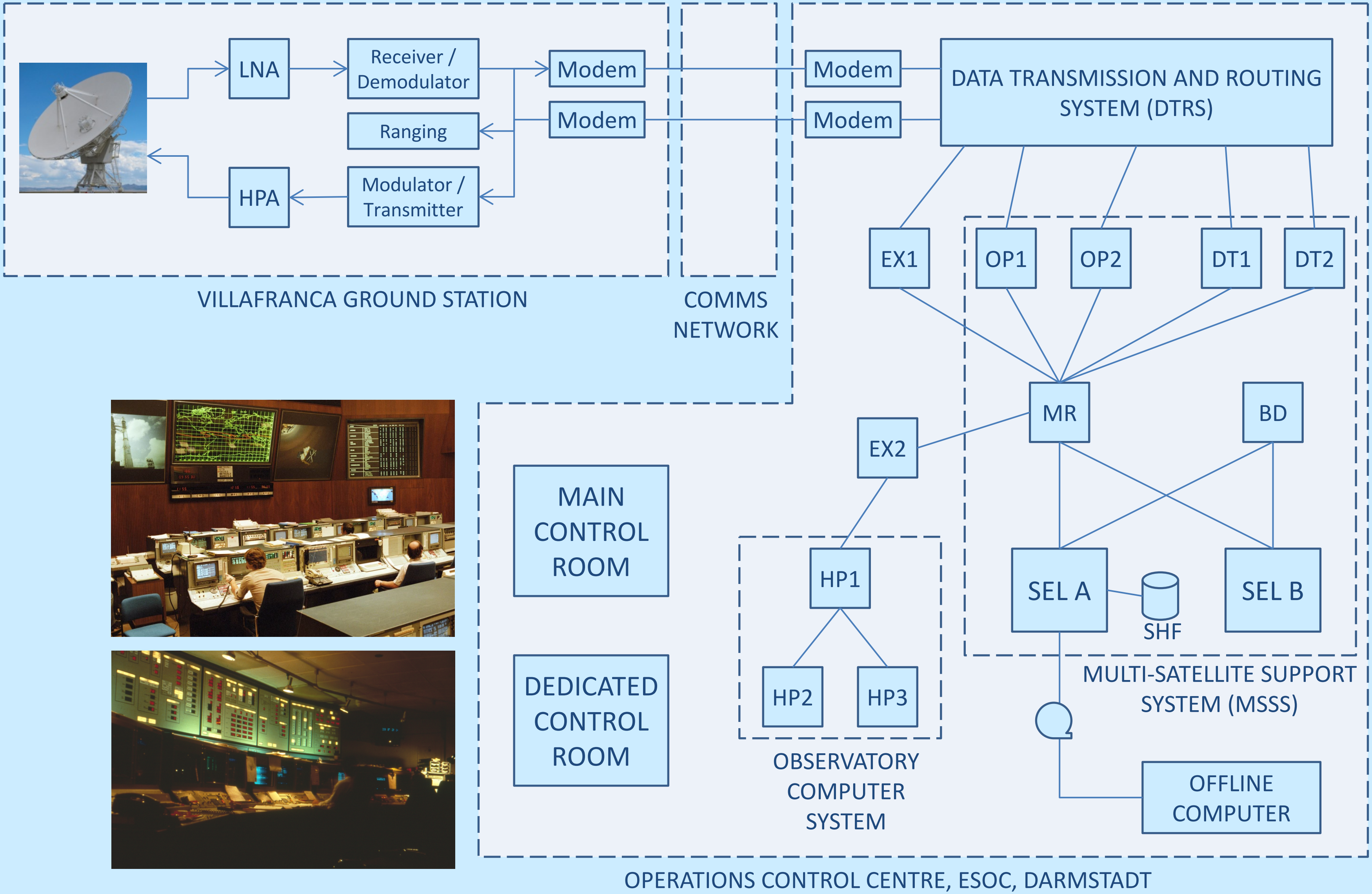
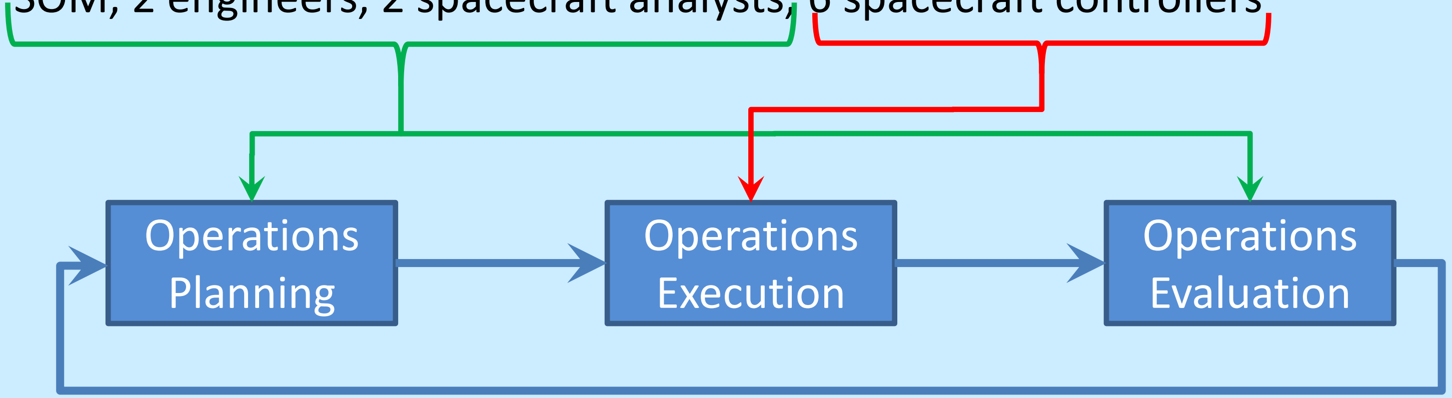
The EXOSAT Ground Segment



Routine Phase Spacecraft Operations

Spacecraft Operations Team:
SOM, 2 engineers, 2 spacecraft analysts, 6 spacecraft controllers



Support teams:

- Flight dynamics (orbit and attitude)
- Facilities scheduling including routine orbit determination
- Network and computer operations (24/7 support)
- Software support (MSSS & Exosat-specific software)
- OBC Software Maintenance (Observatory Team)
- Post-launch Spacecraft Support Team (Industry and ESTEC)

Routine Phase Spacecraft Operations

Operations planning:

Orbit predictions, based on the latest orbit determination, were used to:

- generate antenna pointing predictions which were sent automatically to VILSPA on a weekly basis
- prepare routine orbit-based operations such as perigee configuration, eclipse operations etc.

The Planned Observation File (POF) generated on the Observatory computers defined the nominal sequence and duration of observations (inertial pointings) with associated payload and OBC configuration.
POF was used to generate a merged spacecraft operations timeline of activities

Operations evaluation:

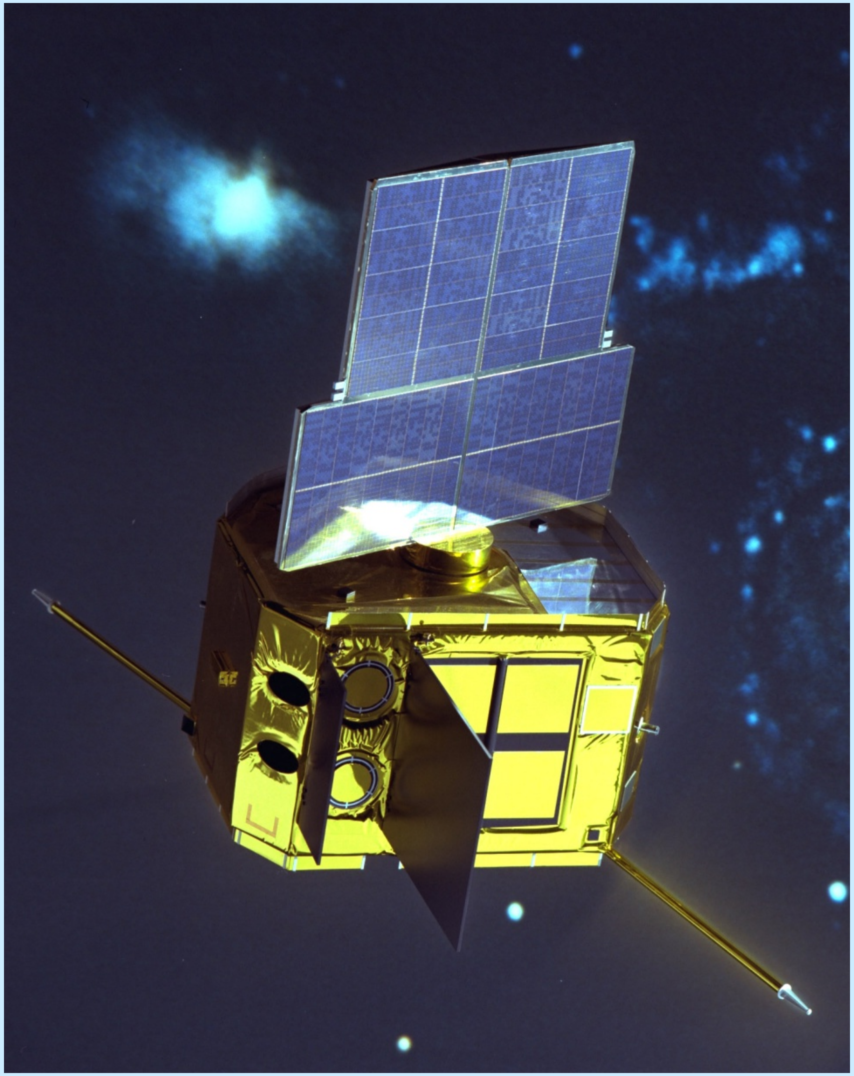
- Subsystem performance analysis
- Anomaly investigation
- Refinement of procedures (nominal, contingency)
- In-orbit incentive scheme for Industry

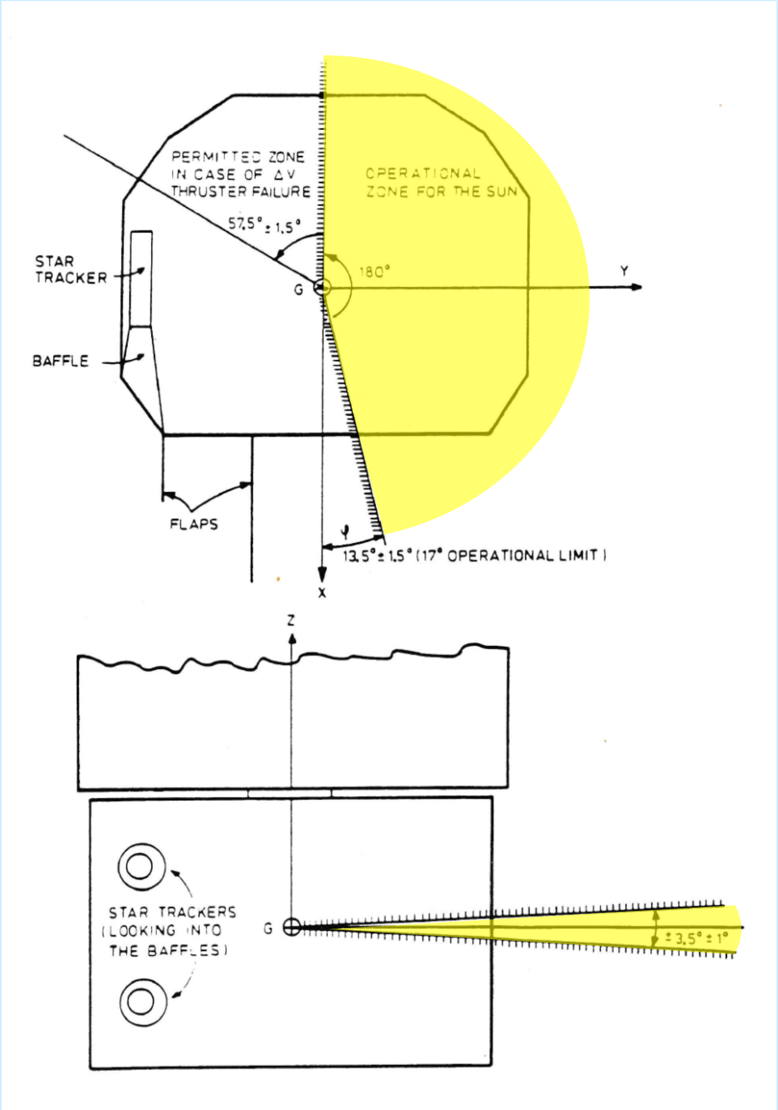
Routine Phase Spacecraft Operations

Operations execution:

- Real-time spacecraft monitoring and control was performed by the Spacecraft Controller (SPACON)
- All incoming telemetry was automatically monitored in real time by MSSS (limit-checking, status consistency checking) and any inconsistency was flagged for the SPACON to take appropriate action according to predefined procedures
- Timelined spacecraft activities implemented by SPACON
- Manoeuvre preparation, execution and monitoring undertaken by SPACON using manoeuvre support software (running on the back-end SEL computer with a terminal in the DCR)
- Payload and OBC configuration for each observation implemented by SPACON on request of the Duty Scientist
- If a spacecraft anomaly occurred that was not covered by procedure, this would trigger a call-out to analyst/engineering support staff and potentially lead to a suspension of planned real-time operations

Allowable operational zone for the Sun





Spacecraft Subsystem Performance in orbit

"Villains of the Piece"

AOCS:

- Safety Mode design:
  - no provision to enable/disable individual inputs
  - no preserved information about what had triggered a Safety Mode
  - early failure of Safety Mode B
- +Y thruster stuck open condition
- Inability to use highest slew rate
- Progressive gyro failures
- Plenum chamber1 control valve failure
- No direct measurement of remaining propane for attitude control

Transmitters powered from the Sun Bus

Spurious events (especially around perigee)

"Stars of the Show"

OBC:

Provision of interchangeable AP slots allowing upload of new/modification of existing APs for both payload and subsystems

AOCS:

Star trackers

Attitude stability during observations

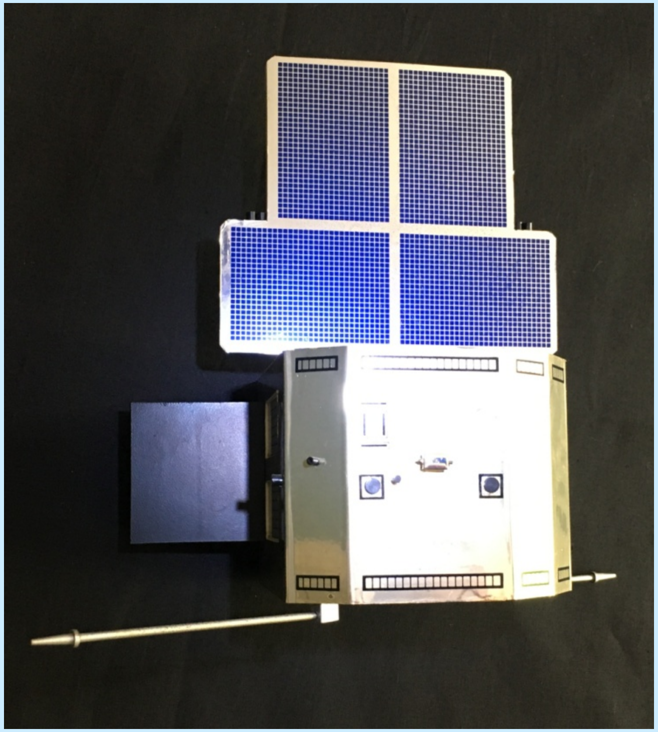
Scientific Data Sequencer (SDS):

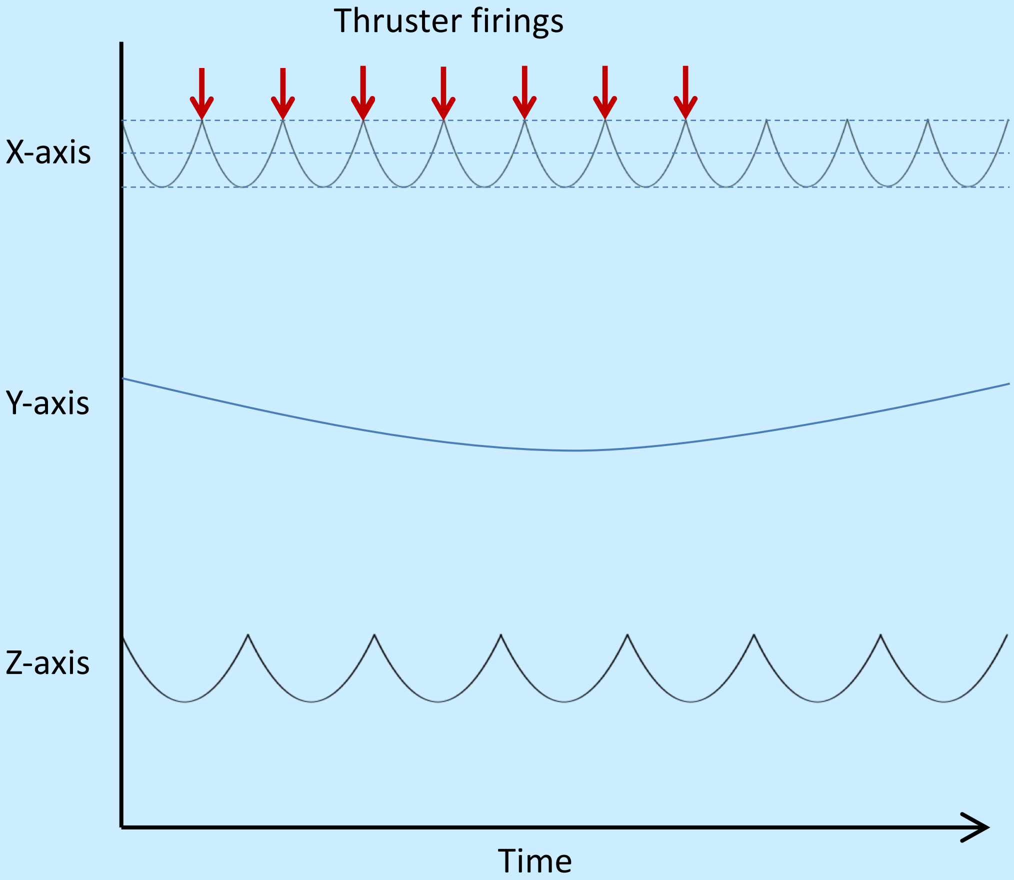
Provided flexibility in high speed data sampling from payload to OBC

PSS, Data Handling, TT&C, Thermal

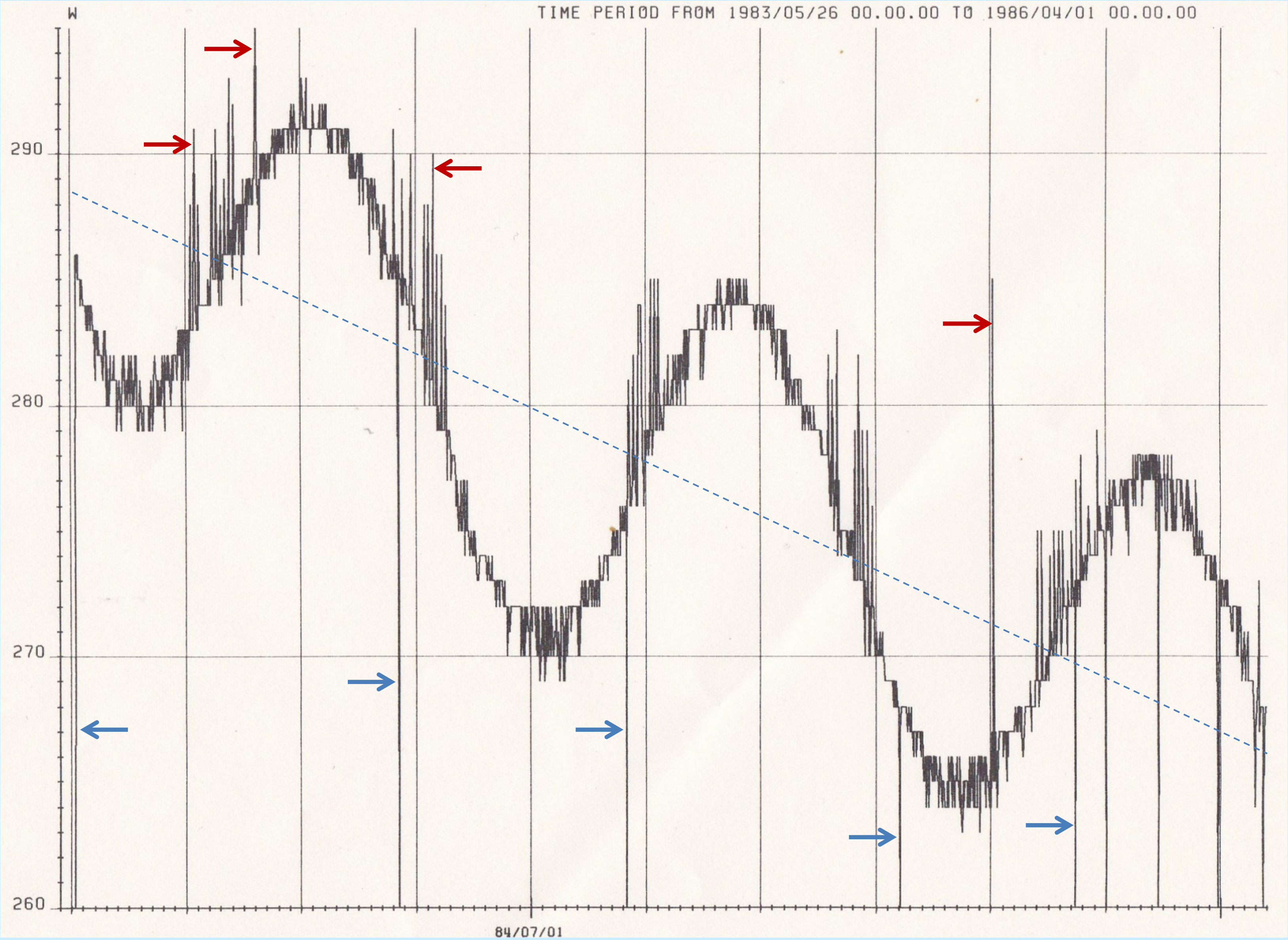
Performed (almost) flawlessly

Typical limit-cycle pattern in pointing mode





Solar array output power over the EXOSAT lifetime



EXOSAT End-of-life

- Lifetime extension activities had been planned, consisting of perigee-raising manoeuvres using the 14-Newton hydrazine system . 45kg of hydrazine was loaded at launch corresponding to a total velocity increment of 173 m/s
- Test burn was undertaken in April 1984. This showed that propane used to stabilise spacecraft during a burn of 1.8 m/s (enough to extend the lifetime by 1 orbit) would consume the same as during 2 orbits worth of normal operations i.e. effective propane usage rate would triple after perigee raising
- Since the amount of remaining propane was highly uncertain, the optimum strategy was a sequence of small burns executed as late as possible
- **HOWEVER**, this plan was overtaken by events:
- Plenum chamber 1 control valve started to fail in Feb 1986 and failed completely in March 1986
- Thereafter, RCE2 had to be used with its known proclivity for a stuck-open +Y thruster
- Observatory operations continued for a short time with degraded attitude pointing
- On April 9th 1986, an attitude instability resulted in Safety Mode triggering, followed by an incomplete Sun reacquisition and intermittent telemetry indicating +Y thruster stuck-open. No more Exosat data was ever received.

Marconi Space & Defence Systems (MSDS) post-launch support for AOCS