XMM-Newton Future Operational Ground Segment

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Introduction

- XMM-Newton is one of the European Space Agency's Cornerstone mission launched in December 1999 from Kourou
- XMM-Newton has an approximately 48 hour highly elliptical orbit inclined at approximately 65 degrees with the majority of visibility from the southern hemisphere
- XMM requires constant ground station contact as:
  - No on-board data storage, as a result data must be relayed continuously to ground
  - Thermal sensitivity of Instruments may require immediate reaction to on-board event
- Currently XMM is supported routinely by 6 fifteen metre antennas located in Australia (Perth and Dongara), South America (Kourou and Santiago de Chile) and Spain (Villafranca and Maspalomas)
- The 35 metre deep space station at New Norcia, Australia can provide additional support in the case of unavailability of Perth or Dongara due to LEOPs or outages

Figure 1 : ESTRACK Network

Operational Ground Segment Evolution

- XMM-Newton has undertaken a number of lifetime enhancing measures in the last few years
  - 4 Wheel Drive : Slews are now performed using all four instead of three reaction wheels on-board. This has resulted in fuel savings of approximately 50%
  - Anti-Reaction Wheel Caging Strategies
  - Upgrade of the Mission Control System to modern virtual machines running on Solaris 10
  - Wheel Re-lubrication to decrease caging and avoid wheel failure
  - Fleixible-Perigee passage optimizing the spacecraft attitude to allow more efficient slewing to first scientific target

The end result is a dramatic improvement in fuel consumption (~50%) and reduced exposure to obsolescence and/or catastrophic failure extending mission life to potentially ~2028

- These achievements have lead to a new set of challenges:
  - Orbital evolution during the next 6 years leads to the opening of a large gap in visibility
  - Mission extension past end-of-2015 decommissioning of Perth

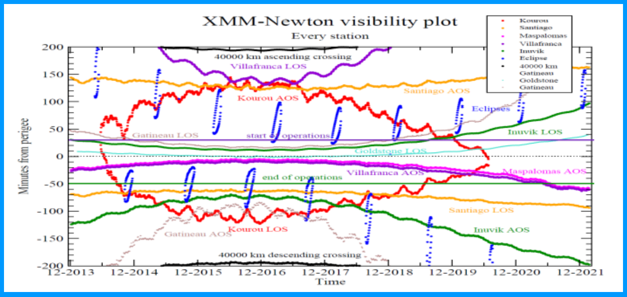

Figure 2 : XMM Perigee Visibility

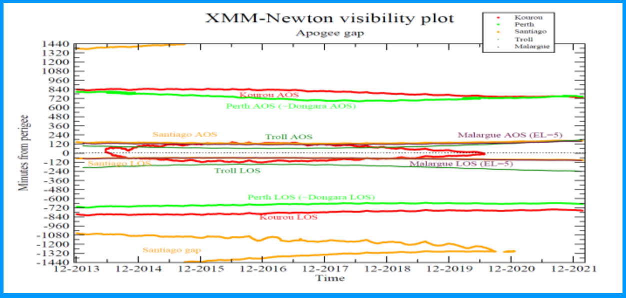

Figure 3 : XMM Apogee Visibility

Ground Station Requirements

Several key points to consider when defining the requirements for the new ground stations

- Antenna Sensitivity: -170dBW/sqm
- Antenna EIRP : Minimum of 68 dBm
- Antenna Max Tracking Rate
- Radiometric Capability (Ranging and Doppler)

Station	RR(km/s)	R (km)	Pnt-r(mdeg/s)	Azr(mdeg/s)	Elr(mdeg/s)
DONGARA (13m)	1.2	118000	2	3	3
PERTH (15m)	1.4	117000	3	3	3
SANTIAGO (13m)	2.9	121000	17	12	12
KOUROU (15m)	3.5	111000	35	40	3
VILLA2 (15m)	4.7	60000	70	200	55
GOLDSTNE (34m)	4.2	66000	59	2000	45

Table 1 : Antenna Tracking Characteristics

If the tracking rate is too high key-holing can occur effectively limiting the tracking capability of the antenna

Another key concern is the availability of the station. XMM requires continuous uninterrupted coverage from its ground stations without which valuable observation time is lost. For example Santiago has a high availability rate (~99%) whereas Villafranca2 has a higher loading due to utilization by Cluster and INTEGRAL

Ground Segment Requirements

The final ground station(s) should meet the following Technical Specifications:

- RX/TX frequency ratio 240/221 in coherent mode
- Polarisation predominantly RHC
- Pointing accuracy sufficient for search pattern
- Timing critical for science observations (order of magnitude less than millsecs required)
- Ranging critical for orbit determination
- Data fidelity key mission perform figure

Requirement	Value
RX/TX Frequency	2225/2049 MHz ±100kHz
Uplink Transmission Rate	2 kbps
Downlink Transmission Rate	70.3 kbps
Modulation Type	BPSK
Polarisation	RHC/LHC
EIRP	> 68 dBm
Ranging Tone	645.3 kHz
Pointing Accuracy	< 0.1 degrees
Station Time Accuracy (wrt to UTC)	< 3 microsecs
TC&TM Fidelity	>99.5%

Table 2 : Station Specifications

The final ground station(s) should meet the following Visibility Specifications while continuous coverage must be guaranteed to maximise scientific return :

CASE	Coverage	2016	2017	2018	2019
1	Full Orbit Support	44:00 hours	44:00 hours	44:00 hours	44:00 hours
2	Full Perth Replacement	24:00 hours	24:24 hours	24:36 hours	23:40 hours
3	Partial Perth Replacement (NNO available)	15:00 hours	14:00 hours	16:30 hours	12:20 hours

Table 3 : Station Coverage

Ground Segment Architecture Overview

- MOC – Mission Operation Centre (ESOC)
- NCTRS – Network Controller and Telemetry Router
- WAN – Single Redundant Communication Lines (MPLS)
- PSS – Portable Satellite Simulator
- TMTCS - Handles TC & TM frames across the SLE
- IFMS – Modulates TC onto carrier and demodulates TM from carrier.

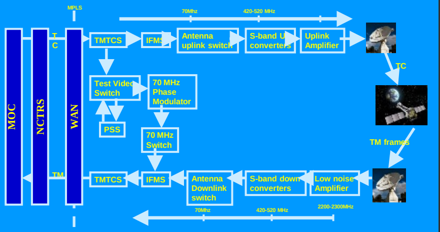

Figure 4 : ESTRACK Station Overview

Conclusions

- XMM-Newton in excellent shape with all units both payload and service module operating on prime units
- Successful implementation of 4WD greatly extends potential operational life
- MCS migration to Solaris 10 avoids legacy issues with hardware obsolescence
- Wheel Lubrication and 4WD reduce likelihood of reaction wheel failure
- Robust Requirement defined for Public Tender
- Further refinements to operational ground segment will further optimize routine operation and reduce mission overheads
- Cross-Support Agreement with NASA foresees Goldstone support pre-perigee during the Winter eclipse season
- Successful execution will ensure continuance of XMM-Newton well into next decade

Figure 5 : Santiago de Chile Station

Figure 6 : New Norcia Deep Space Network Station

Figure 7 : Kourou Diane Station

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