# Concept for IXO operations by ESA

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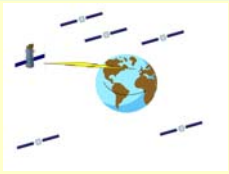
## A standard ESA ground segment



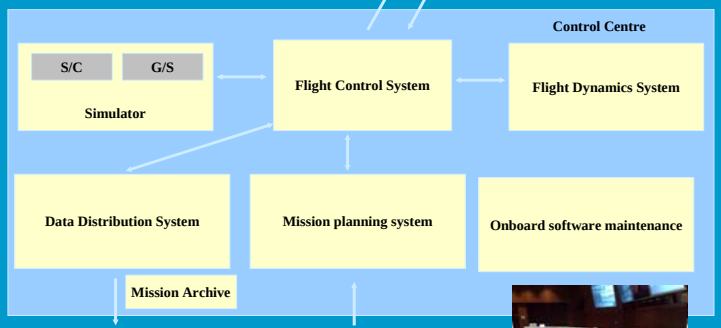
**Standard RF link concept:**

**small High Gain Antenna (HGA) coding/modulation as for Gaia (8.7 Mbit/s max), science and control/ monitoring combined**

**Note: constraint for IXO: ground antenna booked for several missions 1 pass / day for IXO → dead time for ToO uplink ~24 h**

Spacecraft (S/C)

Ground Station Network (GS)




**Note: Nominal control centre availability**
- **8 h / day manning**
- **24 h / day automated processes**

## IXO specialities

For this study we assume that the IXO mission is designed and operated under responsibility of ESA.

- **Launch 2020** (Ariane-5 ECA from Kourou)
- 5 year science mission
- communications link: **X-band**

- Control of the spacecraft based on **timeline uplinked in advance** → IXO provides **on-board capabilities and autonomy** such that the satellite is able to perform corrective actions in case of on-board anomalies → anomalies will be detected on ground with a typical delay of approximately 1 day
- **autonomous slews** according to target quaternions, changing of instruments, initialization of instruments and thermal control settings.
- **low complexity is assumed for the Mission Planning** because of serial operations of the instruments → no attitude constraints within the pitch: ±20°, roll: ±10° , yaw: ±180° envelope
- science data volume: compatible with **1.5h/day science pass** plus 20 preplanned passes/year of 5h duration for bright sources
- average HK TM generation rate is 5 kbps
- omnidirectional coverage with LGAs under contingency conditions
- required ground station and network availability is 95 %.

- **spacecraft autonomy** design is safe with ground reaction times **larger than 5 days** during nominal operations phase→ spacecraft continues mission product generation for a minimum period of 5 days without ground contact

- **Targets of Opportunity** (ToO) requirement: within 24h after their detection, since processing of the ToO commands and repointing take time → less than 24h are available to uplink the respective commands → **additional passes on demand needed**

## IXO ground segment baseline

- Only **one ground station** for nominal operations (New Norcia, Cebreros, Malarguè available. **New Norcia prime station** for IXO, because it provides daytime operations at ESA/ESOC)
- science downlink with short daily X-band passes
- **downlink data rate of 8.7 Mbit/s** has been assumed, as implemented for GAIA but with a small High Gain Antenna. With a 10% overhead for packet headers and housekeeping data (equivalent to a science data rate of 8 Mbit/s) (The maximum achievable data rate for X-band according to the ECSS standard is slightly higher, albeit still limited by a maximum bandwidth requirement of 10 MHz.)
- Ranging (required for tracking): **1/2h per pass (**no high data rate for science downlink during this time)
- Doppler tracking to guarantee **timing accuracy: 1h/day Doppler**, gaps longer than 2 days should be avoided
- The **proposed coverage concept are daily 2h passes with 20 passes of 5h duration distributed over the year** as required by the data volume calculated from the operational plan.

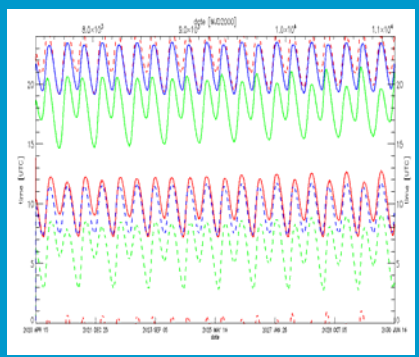


Figure 1 Ground Station Visibility **New Norcia: red**, **Cebreros: green**, **Kourou: blue**, AOS: solid, LOS: dashed (nearly continuous ground station visibility is provided with partial double coverage, the period without visibility is in the order of magnitude of 1h to 3h)

## IXO Target of Opportunity (ToO) trade offs

- **XMM-Newton** is since 10 years operating a **very successful and efficient ToO system** (240 ToO in the last 10 years) We took this system as baseline and tailored it for the IXO case.
- To satisfy the reaction time to a ToO of 24h less than 12h are available for the MOC to uplink commands

Concepts for ToO:

- Concept 1: To guarantee the availability of an uplink, **2 additional passes** would have to be scheduled each day which would not be of use in case of no ToO, but still charged

- Concept 2: ToO concept on a **best effort basis**, i.e. the earliest possibility for a free uplink slot with any available ESTRACK X-band antenna is scheduled in real time:
  - The SOC provides a ToO operations request according to a respective ICD to the MOC.
  - ECC staff (manned 24h /day) alarms the IXO operations engineer on call and schedules the uplink as early as possible with the ESTRACK X-band ground stations. A respective tool at the MOC generates the Flight Dynamics and operations commands for the spacecraft timeline and calculates the ground station contact data.
  - The spacecraft is capable of performing the respective actions autonomously and provides flexible handling of the Mission Timeline on-board (e.g. manipulation at sub-schedule level decoupling individual operations).

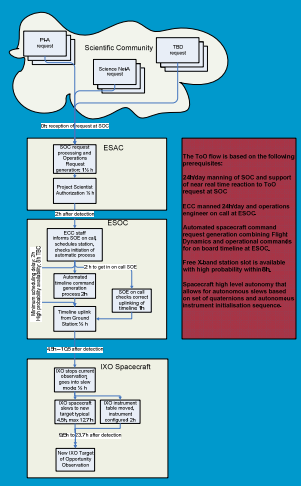



Figure 2: Target of Opportunity Flow

| ESTRACK X-Band Station Availability for ToO Uplink | | | |
|---|---|---|---|
| | Cebreros | New Norcia | Kourou |
| Average visibility [h/day] | 11 | 11 | 11 |
| No other passes scheduled (1st to 3rd quarter 2008) | 91% | 63% | 28% |
| If initially occupied: chance of 0.5 h gap with no passes within 7.5 h | 86% | 68% | 9% |

Table 1: ToO Uplink Scheduling Success Rate for L2 calculated based on availability of G/S in 2008

Concept 3: Alternative solution

- **very small stations at existing sites** (e.g. 3 m diameter and 100 W RF power) dedicated to IXO ToO uplink commanding. (The uplink and downlink link margins are roughly similar for: LGA on board - 35m antenna on ground or HGA on board – 3 m antenna on ground.)

- IXO science meeting -
April 27 - 29, 2010 Cité Universitaire Paris

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