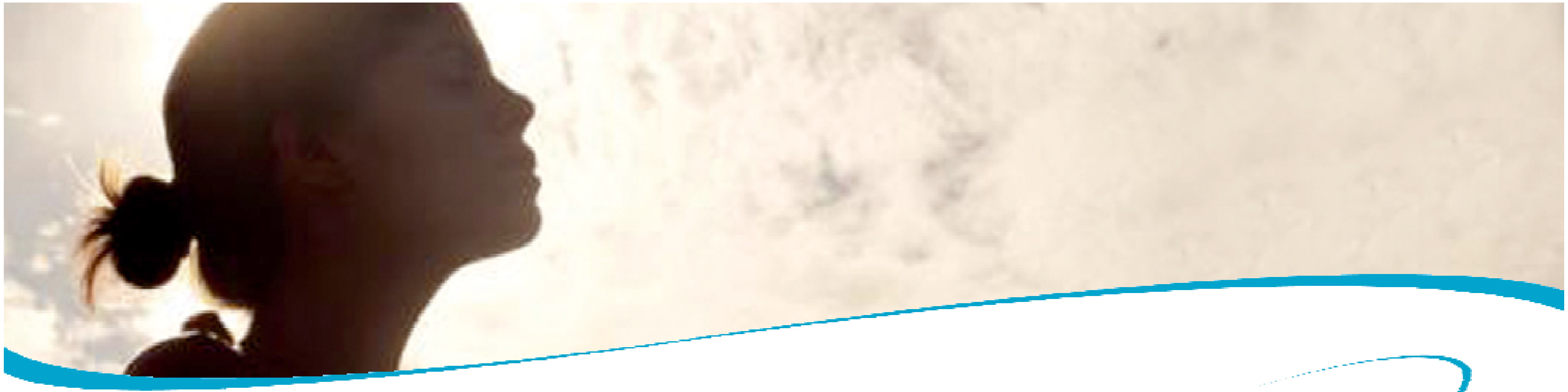


Riunione Nazionale
New Hard X-ray Mission

I risultati dello studio di fase A di NHXM/HexitSat

PRIMO Attiná

ASDC-ESRIN 12-13 Novembre 2009

New Hard X-ray Mission: Phase A references

✓ In the period June 2007 - December 2008 TAS-I was in charge of the ASI study: " New Hard X-ray Mission – Fase A (Formation Flight ed HexitSat)"

✓ NHXM phase A consisted in the study of an free-flyer observatory based on the innovative multilayer X-ray optics with imaging capability for celestial sources in the 0.5-80 keV X-ray band.

✓ The NHXM innovative optics implies a focal length over 10 meters, over the focal length of the biggest X-ray telescope built up today (XMM, Chandra FL~ 8 meters)

The present X-ray telescope generation has a focal length limit imposed by launcher firing dimension. Consequently to overcome this limit the ASI contract requested also the study of innovative satellite concepts

NHXM/HexitSat

New Hard X-ray Mission: Phase A references

Two different innovative mission concept were the references of NHXM phase A.

Simbol-X ASI/CNES mission based on two satellites launched by Soyuz-Fregat in stacked configuration. The two satellite compose a single X-ray telescope of 20 meters focal length by formation flying technique. Simbol-X was the basic reference of the NHXM phase A, in which a lot of effort was provided to the joint bi-national project context.

HexitSat ASI mission , based on a single satellite and four telescopes of 10 meters focal length each. The satellite is make compatible to the launcher height constraint (VEGA firing: ~4 m height) by the means of special extendible mechanism, able to locate the telescopes detectors and the mirrors at the correct focal length after the orbit acquisition in orbit.

NHXM Phase A study demonstrates the feasibility of both concepts.

NHXM/HexitSat

NHXM/HexitSat Legacy

HexitSat was the original concept for the NHXM, previously treated in others studies.

2003 - Alenia studies to support HexitSat initiative

2004 - Studio ASI P/L per astrofisica alte energie (INAF prime, TAS-Mi & MLT)

2005/2006 - ASI NHXM Pre-fase A study, (TAS prime, TAS-Mi, INAF, MLT, BCV)

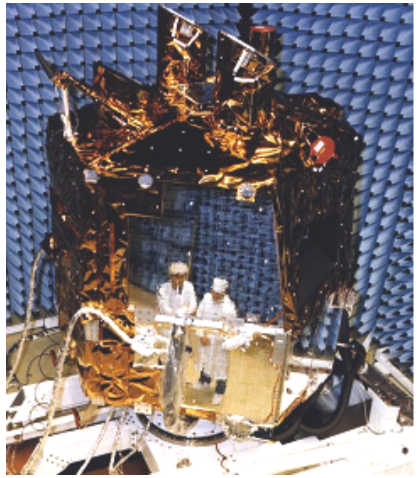
NHXM/HexitSat

Simbol-X versus HexitSat (an industrial view)

Simbol-X concept is more complex with respect HexitSat concept, because:

- it is composed by two satellites
- it needs the development of new devices for the formation flying
- it need further effort to simulate the new flying dynamics concept
- it is feasible in HEO (or LP) orbits only (achievable by launcher of Soyuz/Fregat class)

On the contrary HexitSat is based on a single satellite in LEO (achievable by the means of VEGA class launcher). The extendable mechanism, fundamental element of the mission, is an "Off-the-Shelf" technology (considered by NASA for Nustar, GEM ed IXO X-ray missions).



The NHXM Phase A study demonstrated the HexitSat feasibility, highlighting the advantages wrt a formation flying mission (e.g. mission control can be the same of others national LEO missions).

Moreover the HexitSat configuration based on four telescope allows an implicit telescope redundancy (like BeppoSAX, XMM, ASCA, SUZAKU).

NHXM/HexitSat

NHXM Mission Profile	
Orbit	600 km, circular
Orbit period	95 min
Orbit inclination	Equatorial (<5°)
Visibility (Malindi)	650 s/orbit (>150 min/day)
Launcher	Vega (compatible with Soyuz, Long-March, ...)
Launch date	2016
Mass budget (payload + spacecraft)	< 1500 kg
Power budget (payload + spacecraft)	600 W
Mission lifetime	3 (+2 goal) Years
Ground Stations	Malindi
MOCC and SOC	Fucino + ASI/ASDC in Frascati
Mission science	X-ray Observatory

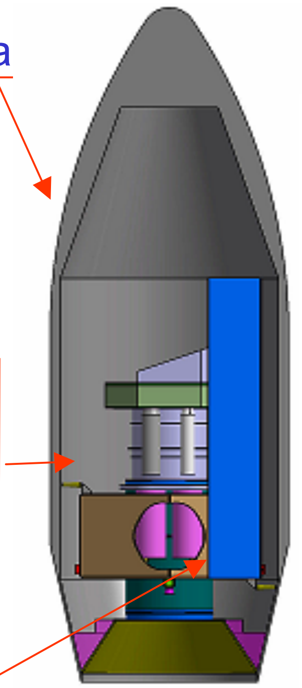
NHXM/HexitSat

NHXM/HexitSAT Overview

Vega

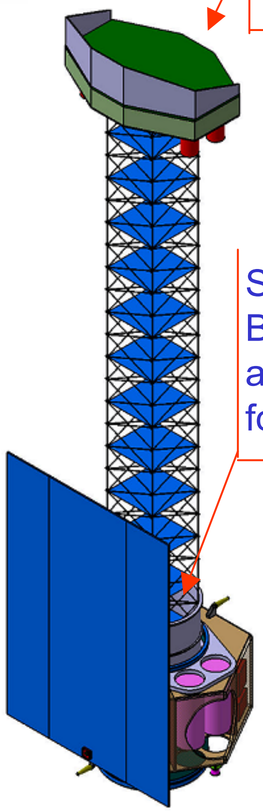
Stowed Detector Platform

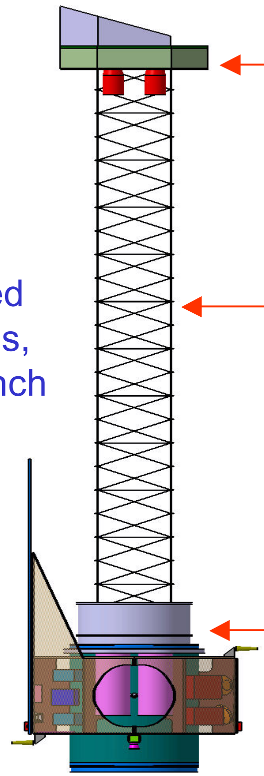
Folded Solar Array wings



Extended Detector Platform

Solar Array: Body mounted and two wings, folded at launch





Detector Platform based on
- ✓ 4 four detector,
- ✓ Strutture
- ✓ Thermal control

Extendible mechanism

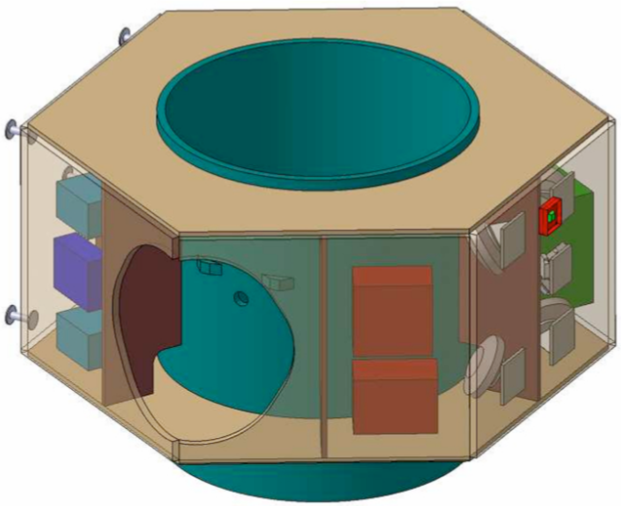
Service platform, were are allocated:
- ✓ 4 multi-layer X-ray optics
- ✓ service metrology
- ✓ satellite sub-systems
- ✓ the canister hosting with the extendible mechanism during the launch phase

The Service Platform

The NHXM phase A study has identified for HEXITSat a satellite platform (named Common Platform) common with the Simbol-X Service Modules.

The Common Platform is based on PRIMA (Piattaforma Riconfigurabile Multi-Applicazione), whose performances and reliability has been widely proven by the Cosmo-SkyMed Missions.

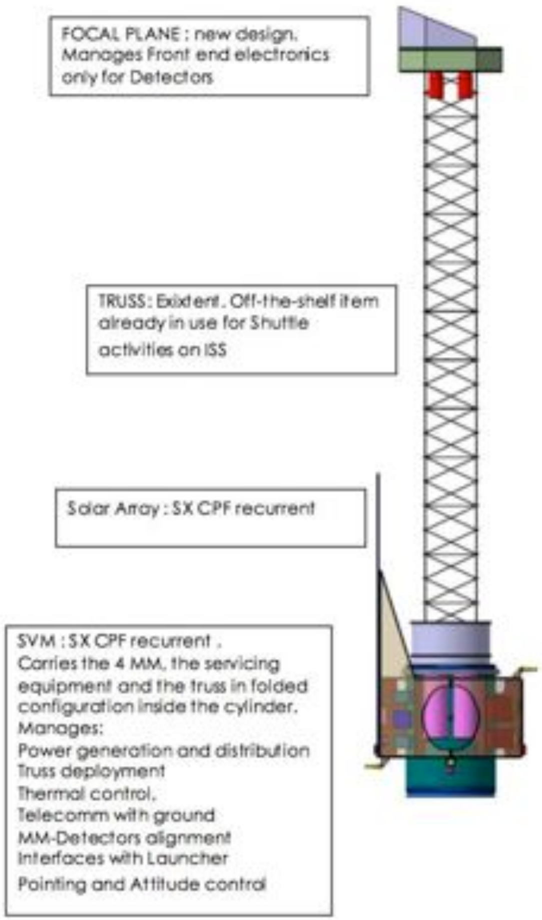
The HEXITSat Service Platform version is compatible with VEGA, the smallest and cheapest European launcher.

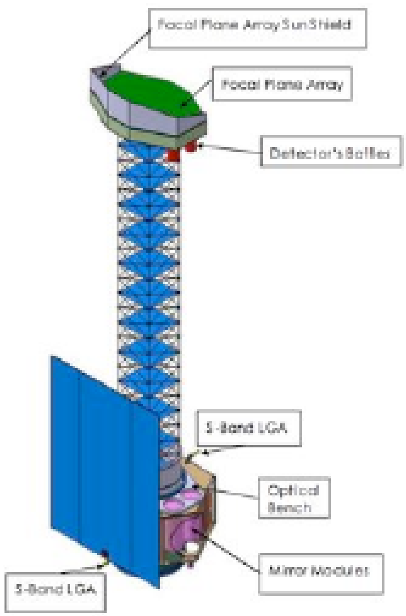


- ✓ **the central cylinder (main platform structure) hosting the extendible bench canister**
- ✓ **the extendible bench connecting the extendible platform, on which the Detector Modules are accommodate**
- ✓ **the four Mirror Modules arranged on the external wall of central cylinder**
- ✓ **the common platform is designed for a launch mass of 2300 kg (while improved-NHXM mass is 1500 kg)**

NHXM/HexitSat

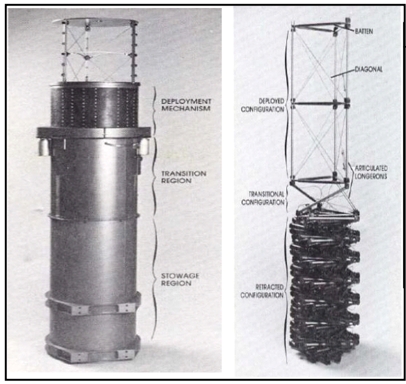
The extended X-ray telescope main features





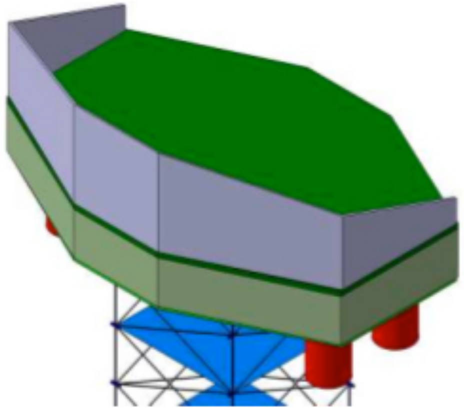
During the NHXM phase A study a trade-off considering several extendible boom concepts (inflatable structure, telescopic boom, coilable truss, circulated truss) has been performed.

The trade-off allowed the identification of the articulated truss boom for the HEXITSat implementation



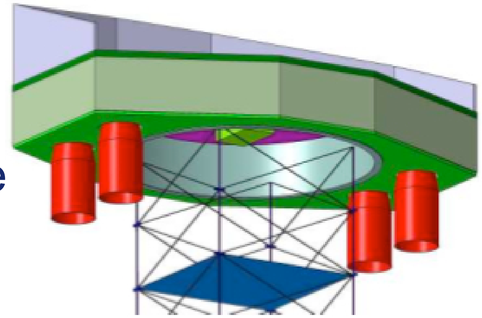
The Detector Platform

The Detector Platform provides the mechanical structure the, thermal control of FPA, the harness connecting the Detector equipment and the metrology devices.



The driving performance requirements of this architecture concerns is the stability over the timescale of an observation & under large temperature gradients .

This condition is mainly guarantee by the selection of the material, mass distribution and Detector Platform/extendable truss thermal control.



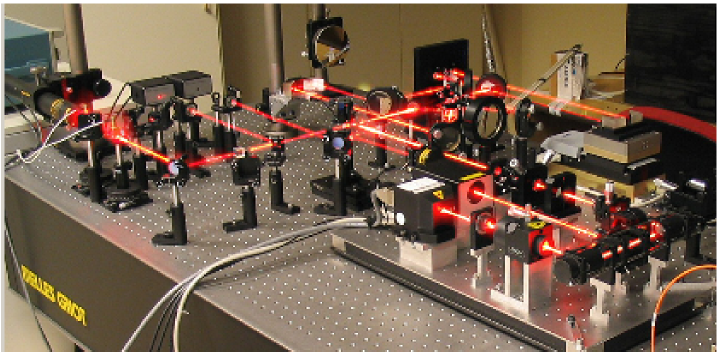
The compensation of the residual variations of the focal plane position (impacting on HEW) is operate by the Service Metrology and post facto image reconstruction.

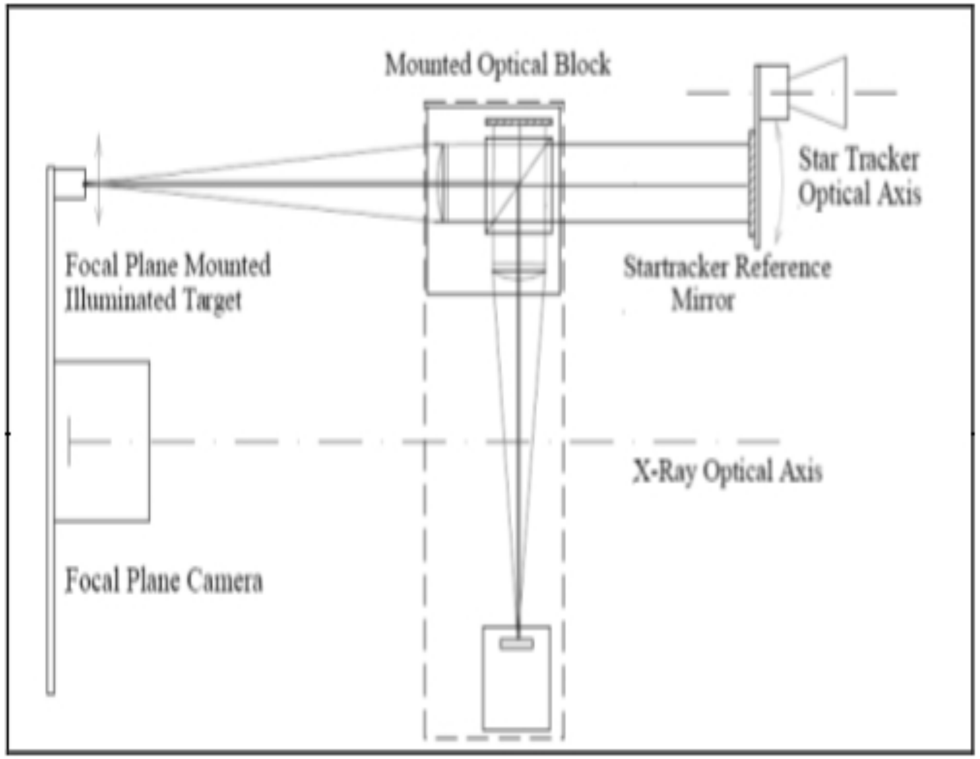
The Service Metrology & Image Reconstruction

To reach the HEW performance, the relative position of the FPA with respect to the optics will be monitored by means of an optical metrology system.

The metrology system will provide the measurement of the positional correcting factor for each detected photon.

The measurement of the alignment between each mirrors and the associated focal plane camera is like the Simbol-X formation flight concept, but the implementation is simpler.





P. Attiná

Thermal Control

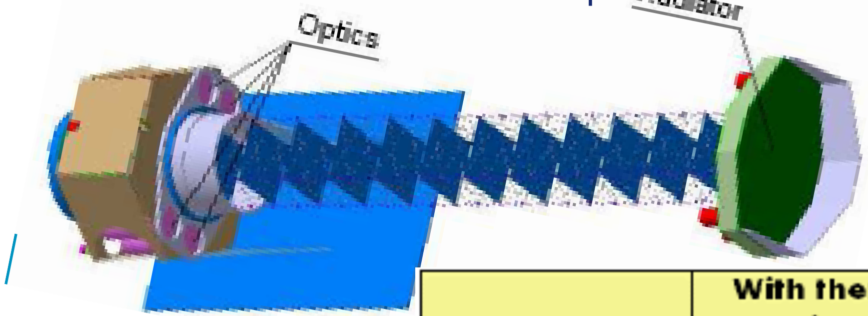
Reference for thermal control implementation:

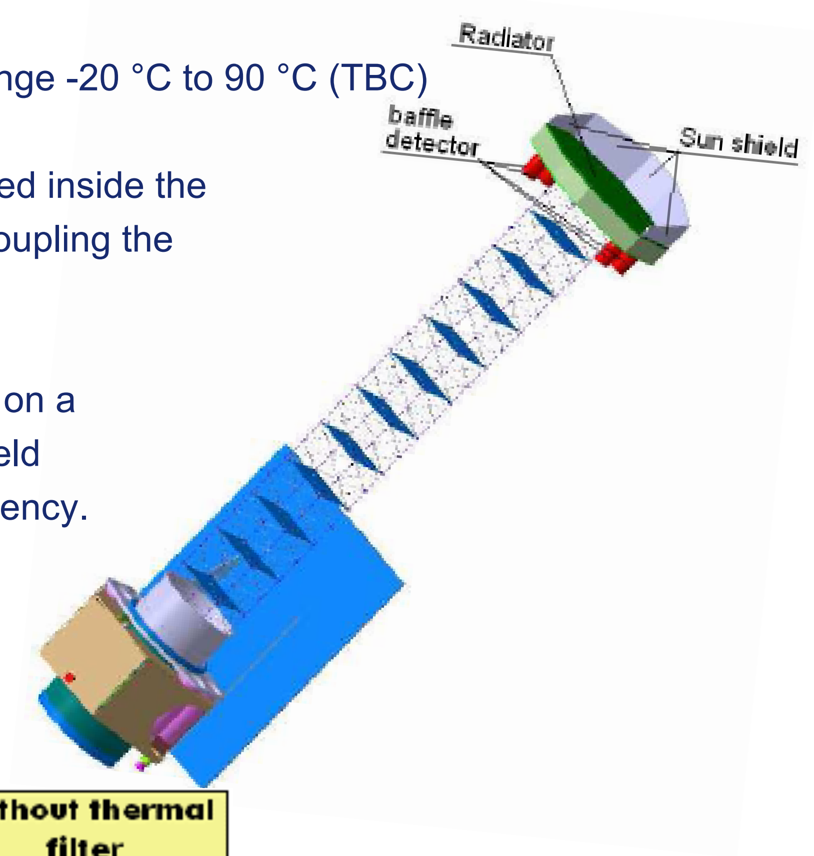
4 nested mirror modules with a working temperature in the range of 18-22 °C with a max. oscillation of +/-1 °C.

4 detectors in an external environment temperature in the range -20 °C to 90 °C (TBC)

The thermal control of the Mirror Modules. The accommodated inside the Service Platform is the best. The use of thermal filter to decoupling the Mirror Module from the environment has been considered.

The thermal control of the FPA considers the interface with a on a Common radiator. The radiator will be protected by a sun shield to avoid the direct sun flux and improves in such way its efficiency.





Module	With thermal filter		Without thermal filter	
	Eclipse	Sun	Eclipse	Sun
Mirror	244W	164W	358W	279W
Detector	150W (assuming 120W for Peltier)			

NHXM/HexitSat

Attitude and orbit control

Main reference: HEW<20" (at 30 keV)

LEO circular equatorial at 600 Km (period 5800 sec.)

AOCS	N	Note
Gyroscopes	4	Litef uFORSE-6U
Reaction Wheel	4	Goodrich TW-19B300
Sun Acquisition Sensor	2	TNO/TPD SAS
Star Tracker	3	Galileo Avionica AA-STR
Magneto Torquer	3+3	ZARM MT30-2-CGS
Magneto-meter	1+1	Billingsley Aerospace-Defense TFM100SH

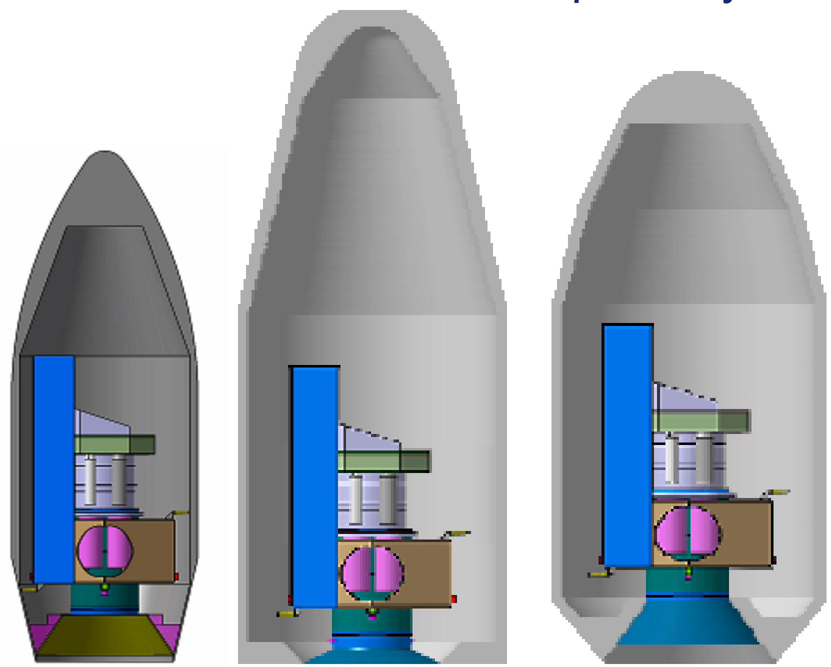
Launcher

An important output of NHXM Phase-A study is the trade-off between the scientific requirements, the mass, power budgets and the launcher choice.

The compatibility with the VEGA launcher assures also the compatibility with bigger launcher system, like the:

- ✓ Russian Soyuz/Fregat,
- ✓ Chinese Long March or
- ✓ Indian PSLV

In the improved-NHXM case the estimated launch mass is of about 1500 kg, largely above the VEGA launcher capability, i.e. 2300 kg at the chosen orbit.



VEGA

Soyuz
Fregat ST

LM-3B
4200Z

Ground Segment (GSN, MOC, SOC)

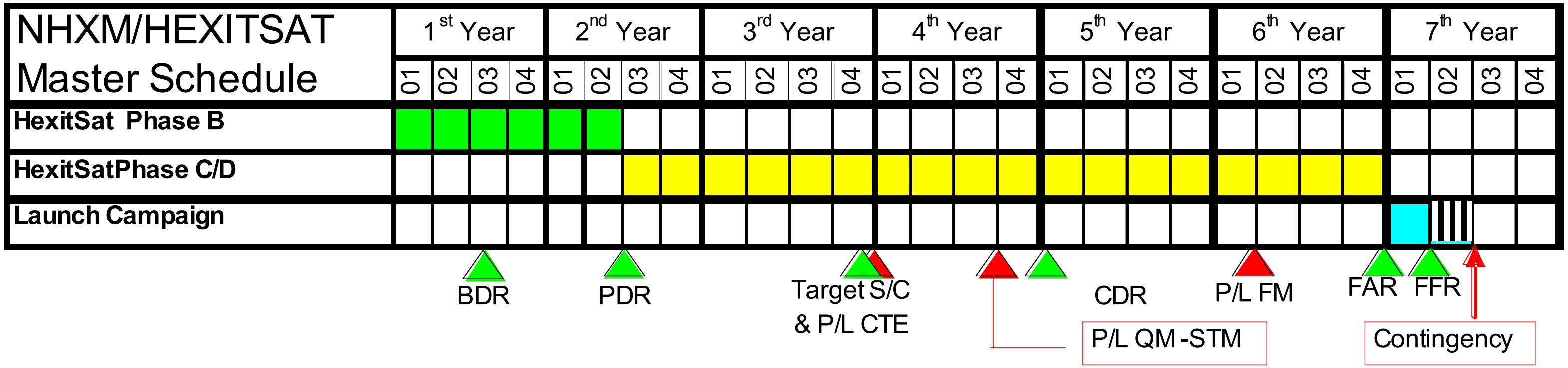
The HexitSat/NHXM flight segment will be managed by the Ground Segment which includes:

1) Ground Station Network (GSN)
The nominal Ground Station is Malindi. During LEOP, the satellite will be supported by at least a further Ground Stations (Kourou Ground Station is the best candidate)

2) Mission and Operation Control Centre (MOC)
MOC will be responsible for operating the satellite in terms of: orbit control, scheduling and planning of satellite operations, spacecraft performance control, payload functional monitoring and control. Baseline location for MOC will be at the Fucino.

3) Science Operation Centre (SOC)
The SOC constitutes the main interface between the mission and the scientific community (scientific program, opportunities, time allocation committee, processing and archiving of the data). SOC location will be the ASI Science Data Centre, in Frascati (Roma). A strong interaction of SOC with the institutes involved in the telescope development is foreseen.

The master planning



The main assumptions for a launch in the second quarter of 2016 are:

- Utilization of NHXM phase A study and of the on-going Optical Payload tech. Study
- Proto-flight approach for Service Platform and satellite system
- High modularity between scientific payload and service platform
- Phase B duration:1.5 years
- Phase C/D duration: 4.5 years
- No Critical Technology Elements (CTE): 3 years from KO
- Space Segment CDR: 4 years from KO
- Mirror Modules and Detector delivery for system integration: 5.25 years from KO
- Space Segment FAR: 6 years from KO

The satellite model philosophy

The NHXM/HexitSat Phase A model philosophy for the platform design identified:

- one Avionic Test Bench to verify avionic functionality and S/W development & test
    - one Structural/Thermal Model (STM) for structure and thermal qualification. The STM is composed by dummies/STM of the equipment
        - one Protoflight Model (PFM) – this is the model to be launched – for the completion of the qualification, satellite functional verification, flight acceptance and pre-launch certification.

The mirror and detector model philosophy

On the basis of the experience with previous X-ray missions (and in consideration of schedule the following models are foreseen.

For mirror module

- 1 QM/STM to allow an early verification of critical items (3 FS the rest are dummies)
- 1 QM to complete the qualification the (in combination with the Detector QM).
- 4 FM: these are the models to be launched

For Detector module

- 1 QM/STM to allow an early verification of critical items (FS components to be defined)
- 1 QM to complete the qualification the (in combination with the Mirror QM).
- 4 FM: these are the models to be launched

Scientific test and calibration shall be performed by the means of an X-ray test facility on QMs and FMs.

Technological Drivers to be studied

The main technology drivers to be considered for specific development are four

1st the mirrors. A dedicated ASI-Media Lario technological study was initiated in April 2009 for studying this aspect. From the NHXM phase A study and from this ongoing contract, no major issues are expected to arise for the development of these mirrors, that are therefore well on track.

2nd the detectors. The Simbol-X spectroscopic/imaging detector has been investigated in French and Germany, with only a minor involvement of Italy. However, in Italy there is a lot of expertise in the development of high-energy detectors and there is the capability to develop the detectors foreseen for NHXM in agreement with the schedule. This is a fundamental heritage to collaborate with international partners that have already expressed their interest in the mission.

3rd the extendable truss. This is a strategic technology for this class of satellites. A preliminary technology assessment has been performed by TAS-I in the NHXM Phase A study, were an off-the-shelf solution has been identified. This topic has to be further investigated, in consideration also of the partnership opportunity.

4th the service metrology. This is a strategic technology for this class of satellites and for the formation-flying satellites. Several studies with prototypes have been developed by TAS-I. This expertise is fundamental to guarantee an national autonomy in the development of this important technology.