VERT-X Design of Vertical X-Ray Test Facility for ATHENA

TN15 CRITICAL ITEMS LIST

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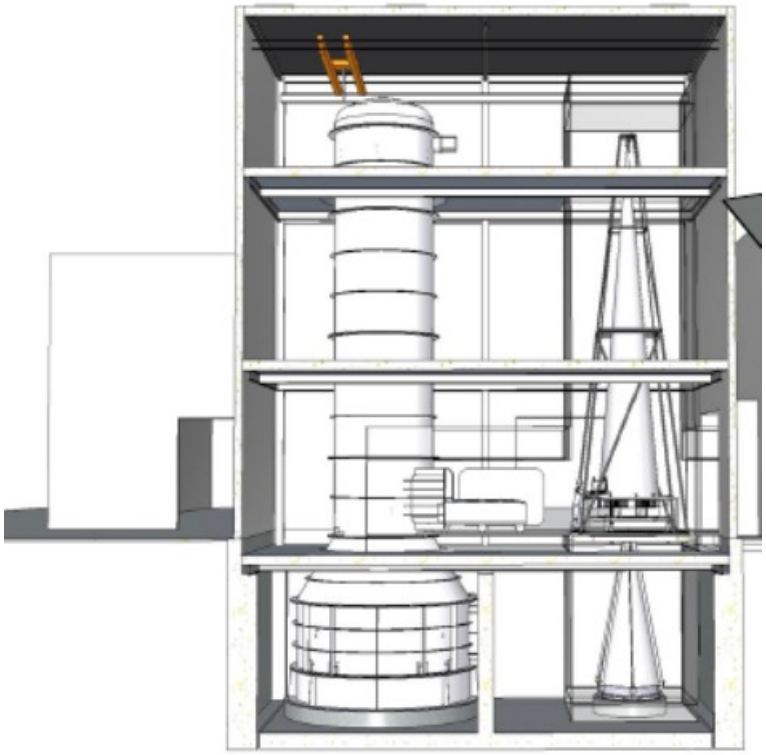

VERT-X Design of Vertical X-Ray Test Facility for ATHENA

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1. INTRODUCTION

1.1. SCOPE

The present document deals with the VERT-X critical items, following the outcomes of the System Requirements Review (SRR) and the Preliminary Design Review (PDR).

The scope is to define a reference document for the reporting of the critical items individuated in VERT-X preliminary design and the implementation of a management strategy, aimed to control and reduce them.

1.2. APPLICABILITY

The present document is one of the deliverables related to the PDR milestone outcomes. It is intended to be an input to VERT-X preliminary design and a driver for the identification of critical items in the next phases of the study.

1.3. ROADMAP

Document section	Content description
Section 2 (Applicable and reference documents)	List of applicable documents and reference documents.
Section 3 (Critical items definition and control)	Classification of critical items and definition of criticality levels.
Section 4 (Critical item list)	Identification and review of critical items in the VERT-X facility design.

Table 1-1: Roadmap of the document

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1. APPLICABLE DOCUMENTS

AD1	AO/1-9549/18/NL/AR - SOW	X-ray Raster Scan Facility for the ATHENA Mirror Assembly SOW
AD2	VERT-INAFOAB-001	VERTICAL X-Ray (VERT-X) Technical Proposal
AD3	ESA-TECMMO-RS-014713	Updated Requirements for the ATHENA VERT-X following the System Requirements Review

2.2. REFERENCE DOCUMENTS

RD1	VTX-EIE-ISE-TEC-001	TN1 Vacuum Chamber
RD2	VTX-MLS-ISE-TEC-001	TN2 X-ray Source and Collimator System
RD3	VTX-EIE-ISE-TEC-002	TN3 Raster Scan System
RD4	VTX-EIE-ISE-TEC-003	TN4 MA mechanical support and thermal system
RD5	VTX-OAB-ISE-TEC-002	TN5 X-ray detector and (x, y, z) stage
RD6	VTX-OAB-ISE-TEC-003	TN6 Gravity Release Structure/Mechanism
RD7	VTX-EIE-ISE-TEC-004	TN7 Metrology System
RD8	VTX-EIE-ISE-TEC-005	TN8 Ground Segment Equipment
RD10	VTX-EIE-IFF-SPC-001	TN10 Interface Specifications
RD11	VTX-OAB-IOP-TEC-001	TN11 Concept of Operation
RD12	VTX-OAB-ISE-TEC-001	TN12 Technical Budgets
RD13	VTX-OAB-ISE-REP-003	D4 Preliminary design document
RD14	VTX-OAB-ISE-REP-001	D2 Conceptual Design Report
RD15	VTX-OAB-ISE-REP-002	D3 Trade-off Report

2.3. GENERAL SPECIFICATIONS AND STANDARD DOCUMENTS

SD1	ECSS-Q-ST-10-04C	Space Product Assurance – Critical Items Control
SD2	ECSS-M-40A	Configuration management
SD3	ECSS-M-50A	Information/documentation management

2.4. LIST OF ACRONYMS

AD	Applicable Document
CIL	Critical Items List
CON	Contamination
EIE	European Industrial Engineering
ESA	European Space Agency
EUT	Equipment Under Test
FCI	Fracture Critical Item
GPAP	GP Advanced Projects
I/F	Interface
IASF	Istituto di AstroFisica Spaziale (INAF, Milano)
INAF	Istituto Nazionale di AstroFisica
ITT	Invitation To Tender
LLI	Long Lead Item
MA	Mirror Assembly
MLS	Media Lario S.r.l.
OAB	Osservatorio Astronomico di Brera (INAF, Milano)
PA	Product Assurance
PDR	Preliminary Design Review
PMP	Program Management Planning
QUA	Qualification
RAD	Radiation
RD	Reference Document
SD	Standard Document
SIM	Science Instrument Module
SOW	Statement of Work
SPF	Single Point Failure
SRR	System Requirements Review
TBA	To Be Assessed
TBC	To Be Controlled
TBD	To Be Defined
VERT-X	VERTICAL X-Ray
VTX	VERT-X
XRD	X-Ray Detector
XRS	X-Ray Raster Scanner
XYZS	(x, y, z) stage

3. CRITICAL ITEMS DEFINITION AND CONTROL

3.1. OVERVIEW

According to SD1, critical items are potential threats to the performance, quality, dependability and safety of a system. To mitigate the related risks and prevent negative effects on the system, a specific action plan will be needed to manage them.

Critical items control will include the following activities:

- identification of critical items through program management planning (PMP), reliability and safety analysis.
- issue of a consolidated critical item list (CIL) which will be maintained, as items are added to the list or closed-out when the criticality is mitigated, or additional control is satisfactorily completed.
- inclusion of critical items in the list of potential projects risks.
- definition of CIL risk reduction or prevention actions.
- closure of the CIL risk reduction or prevention actions.

The critical items will be identified and selected according to the following criteria, which form a category within the CIL:

CIL	Item definition
Safety/Reliability and Qualification Critical Items	
SPF	Single point failures, referring to the elements whose isolate failure could stop the entire system or impact the performance of the tested article.
QUA	Items not qualified or critical technologies involving a sensitive manufacturing process.
CON	Items requiring precautions to avoid contamination.
Fracture Critical Items	
FCI	Structural items whose failure can result in catastrophic or critical hazards. In VERT-X this is especially relevant for the safety of the Mirror Assembly (MA) or other equipment under test.
Items with long supply or manufacturing time	
LLI	Long lead items, referring to the equipment identified at the beginning of the project to have a delivery time so long that it could directly affect the facility lead time.

Table 3-1: Critical items classification

For the characterization of the critical items some details shall be collected. To this aim, an identification form may be used for each critical item. Accordingly, a control sheet can be used for the monitoring of the critical item risk control and mitigation actions. Examples of these forms are reported as an Annex in Section **Error! Reference source not found.**.

3.2. CRITICALITY LEVEL

A ranking process is defined to list and order the critical items. Each critical item will be associated to a criticality level. Criticality levels are defined as follows:

1. Catastrophic
   - Loss of life or life-threatening, permanent disabling injury to personnel or occupational illness.
   - Loss or major damage to the ATHENA MA or other future equipment under test in the VERT-X facility.
   - Loss of the facility.
   - Long term detrimental environmental effects.

2. Critical
   - Temporary disabling but not life-threatening injury, or temporary occupational illness.
   - Major damage to the facility.
   - Loss or major damage to private or public property.
   - Short term detrimental environmental effects.

3. Major
   - Minor injury, minor disability, minor occupational illness.
   - Facility degradation or minor system damage.
   - Minor environmental damage.

4. Negligible
   - Events not categorised above.

Critical Items will be listed and ordered in accordance with the ranking process.

4. CRITICAL ITEMS LIST

4.1. CRITICAL ITEMS IDENTIFICATION

4.1.1. X-ray Source and Collimator

Collimator

Given the dimension (about 1.1 m) and the required accuracy (0.5 arcsec), the collimator is definitely a critical item. Moreover, it is also a long lead item and its procurement should be triggered at the earliest possible time.

Source

The source is also a long lead item. Since it is a complex system, requiring a number of supporting pieces of equipment (high voltage power supply, ionic pump, cooling and temperature control) and since some level of customization may be required, in particular with reference to the X-ray window required to keep the source at ultra-high vacuum (10^{-9} mTorr), it is advisable to test the source before finalizing the design of the VERT-X facility.

4.1.2. X-ray Detector and Positioner

Detachment of mechanic items from XYZS translation equipment

Accidental detachment of screws or other mechanical items and their fall could damage the MA during the calibration phase. This would damage the XYZS performance and would make the X-ray source calibration impossible. However, the most critical impact would be the severe harm to ATHENA mission, because of the damage to a critical and expensive element like the MA.

This may be classified as a single point failure, with a catastrophic criticality level. Possible causes may be the unforeseen supply of lesser quality components for the manufacturing of the translation equipment.

However, this event is considered a low probability one, provided that appropriate care is dedicated to the procurement and inspection of components before their assembly.

XYZS translation equipment qualification

Use of an ad-hoc, newly designed equipment needing qualification may affect the XYZS functionality. The most severe impact would be the unavailability of reliable data from X-ray source calibration.

This may be classified as a single point failure, with a major criticality level. Possible cause is the development of an ad-hoc equipment not formerly tested in analogous systems.

Indeed, this event is considered a low probability one, provided that an appropriate qualification process of newly designed equipment is in place on time.

4.1.3. Raster Scan

Tilt-meter

The noise of the measurement provided by the selected tilt-meter can be larger than the rated values, because the tilt-meter can be subject to vibrations during the transportation along the XY translation stage of the raster scan.

This can be classified as an item needing qualification, with a major effect on the performances of the facility.

This event can be considered a significant probability one, as documented activities on a similar system identified the problem.

Indeed, the resulting noise is strictly related to the motion system over which the system is installed, and a qualification process is absolutely necessary to measure the real-life performances of the component. Measurements of the mechanical vibrations occurring at the tilt-meter interface with the raster scan can also provide the necessary data for the design of a vibration dumping support (negative stiffness isolator).

As this qualification activity implies the acquisition of a significant amount of experimental data and possibly the development of suitable solutions, the system is a long lead item and its procurement shall start as soon as possible.

XRS rotation / translation equipment

Use of an ad-hoc, newly designed equipment needing qualification may affect the XRS functionality. The most severe impact would be the unavailability of reliable data from X-ray source calibration.

This may be classified as a single point failure, with a major criticality level. Possible cause is the development of an ad-hoc equipment not formerly tested in analogous systems.

Indeed, this event is considered a low probability one, provided that an appropriate qualification process of newly designed equipment is in place on time.

This system is definitively a long lead item, due to the complexity of its fabrication and assembly, and the number of verifications and tests that must be performed to demonstrate its performances. Therefore, its procurement shall be considered a priority for the qualification of the entire facility.

XRS Linear Metrology

The proposed linear metrology system includes the integration of a new opto-mechanical system. Use of an ad-hoc, newly designed equipment needing qualification may affect the XRS functionality. The most severe impact would be the unavailability of reliable data from X-ray source calibration.

This may be classified as a single point failure, with a major criticality level. Possible cause is the development of an ad-hoc equipment not formerly tested in analogous systems.

Indeed, this event is considered a low probability one, provided that an appropriate qualification process of newly designed equipment is in place on time.

XRS Optical Tip-tilt metrology

The optical set up of the tip-tilt optical metrology includes the integration of several systems that must properly aligned and operated in order to provide the required accuracy.

Furthermore, the optical beam emitted by a commercial autocollimator shall pass through a viewport and undergoes several reflections, along a path several meters long. Even if the selected autocollimator performances, available from the data sheet, are compliant with the required values, even by considering a rather high margin of safety, the novelty of the design requires a qualification, since this equipment can affect the XRS functionality.

This can be classified as a single point of failure and despite the associated probability can be considered low, an appropriate qualification process must be performed.

4.1.4. MA mechanical support system and gravity release

MA mechanical support system

The system must be designed and built to provide the safe support of the MA. A failure of this element of VERT-X facility could severely damage the MA, hence catastrophically affecting the ATHENA mission.

This can be classified as a single point of failure. Nevertheless, the possible failures of this system must be analyzed considering the choice of an integration between VERT-X calibration facility and AIT facility. Possible problems related to MA mechanical support system failure may hence be addressed by the design solutions adopted for the interfaces in the AIT facility. As further measure, inspection of the support system conditions may improve the safety of the MA.

Gravity release

Gravity release equipment must be designed to avoid support problems for the MA. As for the general mechanical support system, a failure of this element could severely damage the MA, hence catastrophically affecting the ATHENA mission.

This can be classified as a single point failure. Nevertheless, the same considerations for the MA mechanical support system, related to the VERT-X facility configuration as integrated with the AIT facility, may apply here. As further measure, inspection of the gravity release equipment conditions may improve the safety of the MA.

4.2. SUMMARY TABLE

As previously reported, in the definition of VERT-X facility design some items have been identified having potentially critical issues.

A summary of the critical items and the related details like the associated risk, criticality level, cause, control activities and status, is reported in Table 4-1.

The fields of the table have the following meaning:

- **No.**: unique identifier of the critical item.
- **Description**: description of the critical item.
- **Risk associated**: description of the potential damage or risk related to the critical item.
- **Ref. doc.**: document where the critical item is addressed, if any.
- **CIL code**: critical item classification as from Table 3-1.
- **Criticality level**: numerical code describing the criticality level of the critical item, according to the definition in par. 3.2.
- **Control activities**: list of planned activities to reduce or control the risk associated to the critical item.
- **Due date**: expected date for the completion of control activities.
- **Status**: status of the action related to criticality control, that may be “Open” or “Closed” whether the problem is still present or has been solved.

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No.	Description	Risk associated	Ref. doc.	CIL code	Criticality level	Control activities	Due date	Status
CI001	Collimator	Performances	RD2	LLI	2	Design, procurement	TBD	Open
CI002	Source	Performances	RD2	LLI	2	Procurement, qualification	TBD	Open
CI003	Detachment of mechanic items from XYZS translation equipment	Damages to the MA	RD5	SPF	1	Procurement, inspection	TBD	Open
CI004	XYZS translation equipment qualification	Performances	RD5	QUA	3	Procurement, qualification	TBD	Open
CI005	Tilt meter	Performances	RD7	QUA	3	Procurement, qualification	TBD	Open
CI006	XRS rotation / translation equipment	Performances	RD3	QUA	3	Procurement, qualification	TBD	Open
CI007	XRS Linear Metrology	Performances	RD7	QUA	3	Procurement, qualification	TBD	Open
CI008	XRS Optical Tip-tilt metrology	Performances	RD7	QUA	3	Procurement, qualification	TBD	Open
CI009	MA mechanical support system failures	Damages to the MA	RD4	SPF	1	Design, inspection	TBD	Open
CI010	Gravity release failure	Damages to the MA	RD6	SPF	1	Design, inspection	TBD	Open

Table 4-1: Critical Items List

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