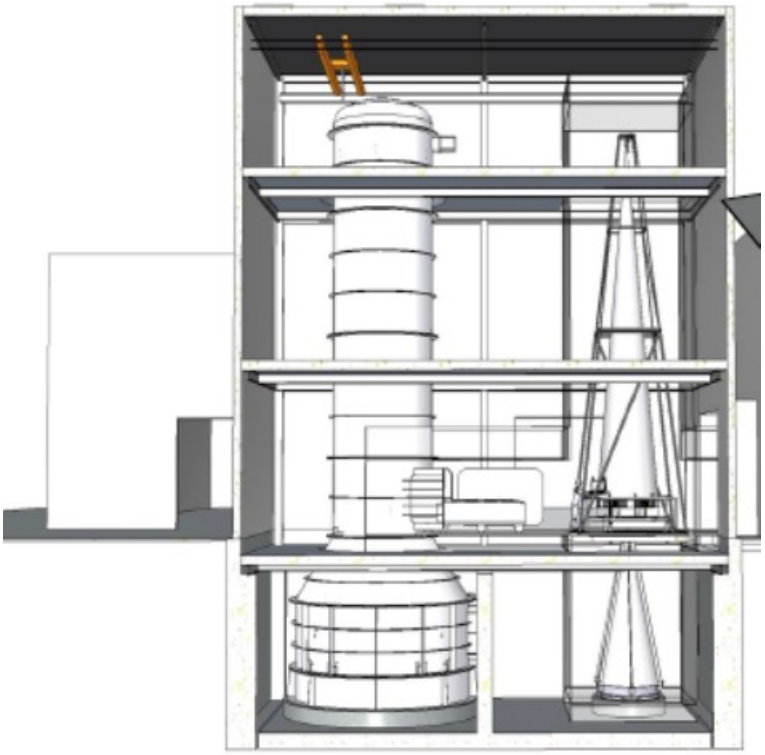
VERT-X Design of Vertical X-Ray Test Facility for ATHENA

TN14 PRODUCT TREE

Doc: VTX-OAB-IPA-TRE-001

Date: 18 / 09 / 2020



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

CHANGE RECORDS						
ISSUE	**DATE**	**AUTHOR**	**APPROVED**	**QA/QC**	**SECTION / PARAGRAPH AFFECTED**	**REASON/INITIATION Documents/Remarks**
I01p00	30/01/2020				All	First Issue
I01p01	16/04/2020				Section 3	Facility design updates involving review of some Product Tree elements
I01p02	18/09/2020				Par. 1.1 and 1.2 Par. 2.4 Section 3	Update of the contents. Update of acronyms list New Product Tree structure

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Issue:	I01p02		
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TABLE OF CONTENTS

LIST OF TABLES

1. INTRODUCTION

1.1. SCOPE

The scope of the present document is the illustration of VERT-X Product Tree (PT), following the outcomes of the System Requirements Review (SRR) and of the Preliminary Design Review (PDR), as well as the results of the design activities performed for the Detailed Design Review (DDR) and the Final Review (FR).

1.2. APPLICABILITY

The present document is one of the deliverables related to the PDR milestone outcomes. The current revision aims to present the PT as derived from VERT-X design activities for the DDR and the FR.

In particular, following the issue of an ITT for a future study to demonstrate X-ray vertical scanning facility critical items, an update of the original VERT-X PT structure has been implemented for the FR. The goal is to achieve consistency with the PT definition that has been reported in the proposal for the new study, while providing a more faithful characterisation of planned VERT-X architecture as resulting from the design activities after the DDR.

1.3. ROADMAP

Document section	Content description
Section 2 (Applicable and reference documents)	List of applicable documents and reference documents.
Section 3 (VERT-X Product Tree)	Overview of Product Tree concept and illustration of its configuration.

Table 1.3-1: 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-M-40°	Configuration management
SD2	ECSS-M-50°	Information/documentation management

2.4. LIST OF ACRONYMS

AD	Applicable Document
AIT	Assembly, Integration & Testing
DDR	Detailed Design Review
EIE	European Industrial Engineering
ESA	European Space Agency
FR	Final Review
GPAP	GP Advanced Projects
GSE	Ground Segment Equipment
HVAC	Heating, Ventilation and Air Conditioning
I/F	Interface
IASF	Istituto di AstroFisica Spaziale (INAF, Milano)
INAF	Istituto Nazionale di AstroFisica
ITT	Invitation To Tender
MA	Mirror Assembly
MCS	Master Control System
MLS	Media Lario S.r.l.
MM	Mirror Module
OAB	Osservatorio Astronomico di Brera (INAF, Milano)
PDR	Preliminary Design Review
PT	Product Tree
RD	Reference Document
SD	Standard Document
SIM	Science Instrument Module
SOW	Statement of Work
SRR	System Requirements Review
TBA	To Be Assessed
TBC	To Be Controlled
TBD	To Be Defined
TCS	Thermal Control Subsystem
TVC	Thermal Vacuum Chamber
VERT-X	VERTICAL X-Ray
VTX	VERT-X
XRD	X-Ray Detector
XRS	X-Ray Raster Scanner
XYZS	(x, y, z) stage
WBS	Work Breakdown Structure

3. VERT-X PRODUCT TREE

3.1. OVERVIEW

The Product Tree provides the hierarchical product breakdown of the VERT-X facility. It does not include the support functional activities, like the Project Management tasks, that are defined by the Work Breakdown Structure (WBS). It includes as a minimum the items under configuration control and those which are subject of technical specification.

Each item of the Product Tree is identified by a unique identification code in accordance with the hierarchical position of the item in the Product Tree. The identification shall remain unchanged during the product lifetime, unless a modification causes discontinuation of interchangeability.

The Product Tree will be used within the Program as the reference for the generation of the deliverable items list, where for each items of the Product Tree the foreseen models and quantity are identified.

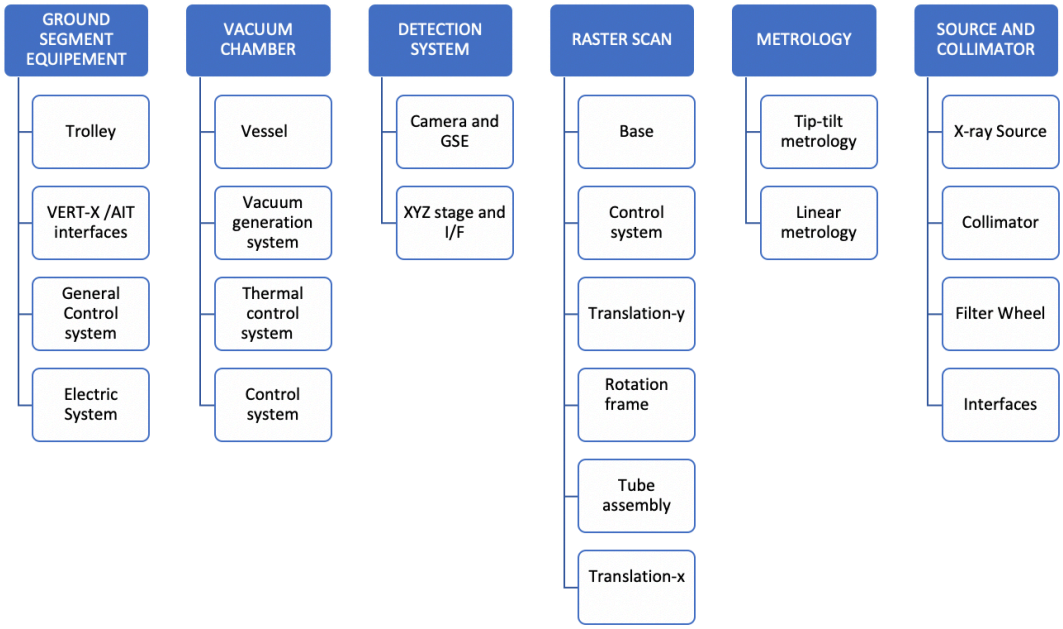
3.2. PRODUCT TREE ELEMENTS DEFINITIONS

The characterization of the Product Tree elements is done by applying the definitions of Table 3.2-1.

Item code	Product tree group	Definition
10	Ground Segment Equipment	It includes any element related to the VERT-X ground segment, taking in account the integration with the AIT facility and the related design aspects like the trolley and the interfaces.
20	Thermal Vacuum Chamber	It includes as sub-elements all the mechanical parts, equipment, sensors, etc. that are necessary to generate the required environment inside the vessel and including the vessel itself. It also includes the thermal shroud and the associated hardware and software (temperature sensors, piping, control units, control system).
30	Detection system	It includes all the hardware and software elements that allow to properly operate the X-ray detection assembly.
40	Raster Scan	It includes all the hardware and software elements that allow to properly operate the Raster Scan system.
50	Metrology	It includes all the hardware and software elements that allow to properly operate the VERT-X facility metrology system.
60	Source and collimator	It includes all the hardware and software elements that allow to properly operate the X-ray source assembly, including the X-ray beam collimator.
70	Spare	It includes the spare elements for the facility components and subsystems, to provide the needed reliability.

Table 3.2-1: Product Tree elements identifiers and definitions

3.3. PRODUCT TREE GENERAL STRUCTURE



Level 1	Level 2	Description	
0	0	VERT-X	
1	0	Ground Segment Equipment	
1	1		Trolley
1	2		VERT-X / AIT interfaces
1	3		General Control System
1	4		Electric System
2	0	Thermal Vacuum Chamber	
2	1		Vacuum Vessel
2	2		Vacuum Generation System
2	3		Thermal Control System
2	4		Control System
3	0	Detection System	
3	1		Camera and GSE
3	2		XYZ Stage and I/F
4	0	Raster Scan	
4	1		Base
4	2		Control system
4	3		Translation X
4	4		Translation Y
4	5		Rotation frame
4	6		Tube Assembly

5	0	Metrology	
5	1		Tip-tilt metrology
5	2		Linear metrology
6	0	Source and collimator	
6	1		X-ray source
6	2		Collimator
6	3		Filter wheel
6	4		Interfaces
7	0	Spare parts	

Table 3.3-1: VERT-X general Product Tree elements

3.4. PRODUCT TREE ELEMENTS DESCRIPTION

3.4.1. Ground segment equipment

In the current design the VERT-X facility will be integrated with the ATHENA AIT facility.

The ground segment equipment is hence defined accordingly.

Part number	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
10-00-00-00-00	Ground segment equipment						
11-00-00-00-00		Trolley					
11-10-00-00-00			Guiding trolley				
11-20-00-00-00			Handling trolley				
12-00-00-00-00		VERT-X / AIT interfaces					
12-10-00-00-00			Thermal control system				
12-11-00-00-00				Chiller units			
12-12-00-00-00				Pipelines			
13-00-00-00-00		General Control System					
13-10-00-00-00			Mission Control Center				
13-20-00-00-00			Supervisor				
13-30-00-00-00			Monitoring System				
13-40-00-00-00			Safety System				
14-00-00-00-00		Electric System					
14-10-00-00-00			Electrical power distribution				
14-11-00-00-00				Block diagrams			
14-12-00-00-00				Single line diagrams			
14-20-00-00-00			Cabling and routing				
14-30-00-00-00			Lighting system				

Table 3.4-1: Ground segment equipment elements

3.4.2. Thermal Vacuum Chamber

Part number	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
20-00-00-00-00	TVC						
21-00-00-00-00	Vacuum vessel						
21-10-00-00-00	Skirt assembly						
21-11-00-00-00	Welded assembly						
21-20-00-00-00	RS segment assembly						
21-21-00-00-00	Welded assembly						
21-22-00-00-00	Door assembly						
21-22-10-00-00	Door welded assembly						
21-30-00-00-00	MA segment assembly						
21-31-00-00-00	Welded assembly						
21-32-00-00-00	Door assembly						
21-32-10-00-00	Door welded assembly						
21-40-00-00-00	Detector segment assembly						
21-41-00-00-00	Welded assembly						
21-42-00-00-00	Door assembly						
21-42-10-00-00	Door welded assembly						
21-50-00-00-00	Top segment assembly						
21-51-00-00-00	Welded assembly						
21-52-00-00-00	Electrical Feedthroughs						
21-53-00-00-00	Fluid feedthroughs						
21-54-00-00-00	Viewports						
22-00-00-00-00	Vacuum generation system						
22-10-00-00-00	Primary vacuum pumps						
22-20-00-00-00	Turbo-pumps						
22-30-00-00-00	Cryo-pumps						
22-40-00-00-00	Vacuum sensors						
22-50-00-00-00	Compressor unit						
22-60-00-00-00	Cooling chillers						
22-70-00-00-00	Pre-vacuum pumps						
22-80-00-00-00	Pipelines & connectors						
22-90-00-00-00	Vacuum Control Unit						
23-00-00-00-00	Thermal Control System						
23-10-00-00-00	Thermal Shroud						
23-20-00-00-00	Pipelines						
23-30-00-00-00	Thermal Sensors						
23-40-00-00-00	Control Unit						
24-00-00-00-00	Control System						

Table 3.4-2: TVC elements

3.4.3. Detection system

Part number	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
30-00-00-00-00	X-Ray Detection System						
31-00-00-00-00		Camera and GSE					
31-10-00-00-00			X-ray sensor				
31-20-00-00-00			Camera electronics				
31-30-00-00-00			Cooling system				
31-40-00-00-00			Data acquisition system				
31-50-00-00-00			Detector control system				
32-00-00-00-00		XYZ stage and I/F					
32-10-00-00-00			Translation equipment				
32-20-00-00-00			XYZS I/F				

Table 3.4-3: Detection system elements

3.4.4. Raster scan

Part number	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
40-00-00-00-00	Raster scan						
41-00-00-00-00		Base					
41-10-00-00-00			Welded assembly				
42-00-00-00-00		Control system					
42-10-00-00-00			Control system HW				
42-11-00-00-00				PLC			
42-12-00-00-00				Goniometer motion controller			
42-13-00-00-00				Linear motion controller			
42-14-00-00-00				Angular motion controller			
43-00-00-00-00		Translation X					
43-10-00-00-00			Frame welded assembly				
43-20-00-00-00			Linear encoder				
43-30-00-00-00			Linear motor				
43-40-00-00-00			Guiding rail				
43-50-00-00-00			Braking rail				
43-60-00-00-00			Trolleys				
43-70-00-00-00			Brake				
43-80-00-00-00			Cable wrap X				
44-00-00-00-00		Translation Y					
44-10-00-00-00			Frame welded assembly				

Part number	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
44-20-00-00-00	Linear encoder						
44-30-00-00-00	Linear motor						
44-40-00-00-00	Guiding rail						
44-50-00-00-00	Braking rail						
44-60-00-00-00	Trolleys						
44-70-00-00-00	Brake						
44-80-00-00-00	Cable wrap Y						
45-00-00-00-00	Rotation frame						
45-10-00-00-00	Welded assembly						
45-20-00-00-00	Brake						
45-30-00-00-00	Bearings						
45-40-00-00-00	Encoder						
45-50-00-00-00	Torque motor						
45-60-00-00-00	Bearing housing						
46-00-00-00-00	X-ray tube assembly						
46-10-00-00-00	X-ray source interface						
46-20-00-00-00	Collimator interface						
46-30-00-00-00	Axis welded assembly						
46-40-00-00-00	Carbon fiber tube						
46-50-00-00-00	Torque motor (incl. Housing)						
46-60-00-00-00	Brake						
46-70-00-00-00	Bearings						
46-80-00-00-00	Bearing housing						
46-90-00-00-00	Encoder						

Table 3.4-4: Raster scan system elements

3.4.5. Metrology

Part number	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
50-00-00-00-00	Metrology						
51-00-00-00-00	Tip-Tilt metrology						
51-10-00-00-00	Optical Tip-Tilt metrology						
51-11-00-00-00	Rotation X detection system						
51-11-10-00-00	External station						
51-11-11-00-00	Metal case						
51-11-12-00-00	Baseplate						
51-11-13-00-00	Autocollimator + alignment base						
51-11-14-00-00	Tilt-meter (incl. Electronics)						
51-11-20-00-00	Vacuum optical train						
51-11-21-00-00	Mounting structure						

Part number	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
51-11-22-00-00			Pentaprism				
51-11-23-00-00			Pp mechanical assembly				
51-11-24-00-00			Goniometer 1				
51-11-25-00-00			Goniometer 2				
51-11-30-00-00			Reference mirror system				
51-11-31-00-00			Roof prism				
51-11-32-00-00			Tip-tilt unit				
51-12-00-00-00			Rotation Y detection system				
51-12-10-00-00			External station				
51-12-11-00-00			Metal case				
51-12-12-00-00			Baseplate				
51-12-13-00-00			Autocollimator + alignment base				
51-12-14-00-00			Tilt-meter (incl. Electronics)				
51-12-20-00-00			Vacuum optical train				
51-12-21-00-00			Mounting structure				
51-12-22-00-00			Pentaprism				
51-12-23-00-00			Pp mechanical assembly				
51-12-24-00-00			Goniometer 1				
51-12-25-00-00			Goniometer 2				
51-12-30-00-00			Reference mirror system				
51-12-31-00-00			Roof prism				
51-12-32-00-00			Tip-tilt unit				
51-13-00-00-00			Tilt meters				
52-00-00-00-00			Linear displacement metrology				
52-10-00-00-00			Internal displacement metrology				
52-11-00-00-00			Z-displacement Air Unit				
52-12-00-00-00			XY-displacement Air Unit				
52-12-10-00-00			Mounting structure				
52-12-20-00-00			Components				
52-13-00-00-00			XRD Station				
52-14-00-00-00			MA Station				
52-14-10-00-00			Z-displacement target				
52-14-20-00-00			XY-displacement detector				
52-15-00-00-00			XY-displacement Stabilization Vacuum Unit				
52-15-10-00-00			Mounting structure				
52-15-20-00-00			Components				

Table 3.4-5: Metrology system elements

3.4.6. Source and collimator

Part number	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
60-00-00-00-00	Source and collimator						
61-00-00-00-00		Source					
61-10-00-00-00			X-ray source				
61-20-00-00-00			Ionic pump				
61-30-00-00-00			Cooling system				
61-40-00-00-00			Source mechanical interfaces				
61-50-00-00-00			Harness (electrical, control, coolant pipes, etc.)				
62-00-00-00-00		Collimator					
62-10-00-00-00			Collimator mirror				
62-20-00-00-00			Collimator mechanical interfaces				
63-00-00-00-00		Filter wheel					
64-00-00-00-00		Interfaces					

Table 3.4-6: Source and collimator elements

3.4.7. Spare

A detailed definition of spare elements for the Product Tree will be implemented in the following phases of the study, following an extensive analysis of VERT-X facility equipment to individuate what is needed to achieve reliability.

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