Demonstration of VERT-X Critical Items

Product Assurance Plan

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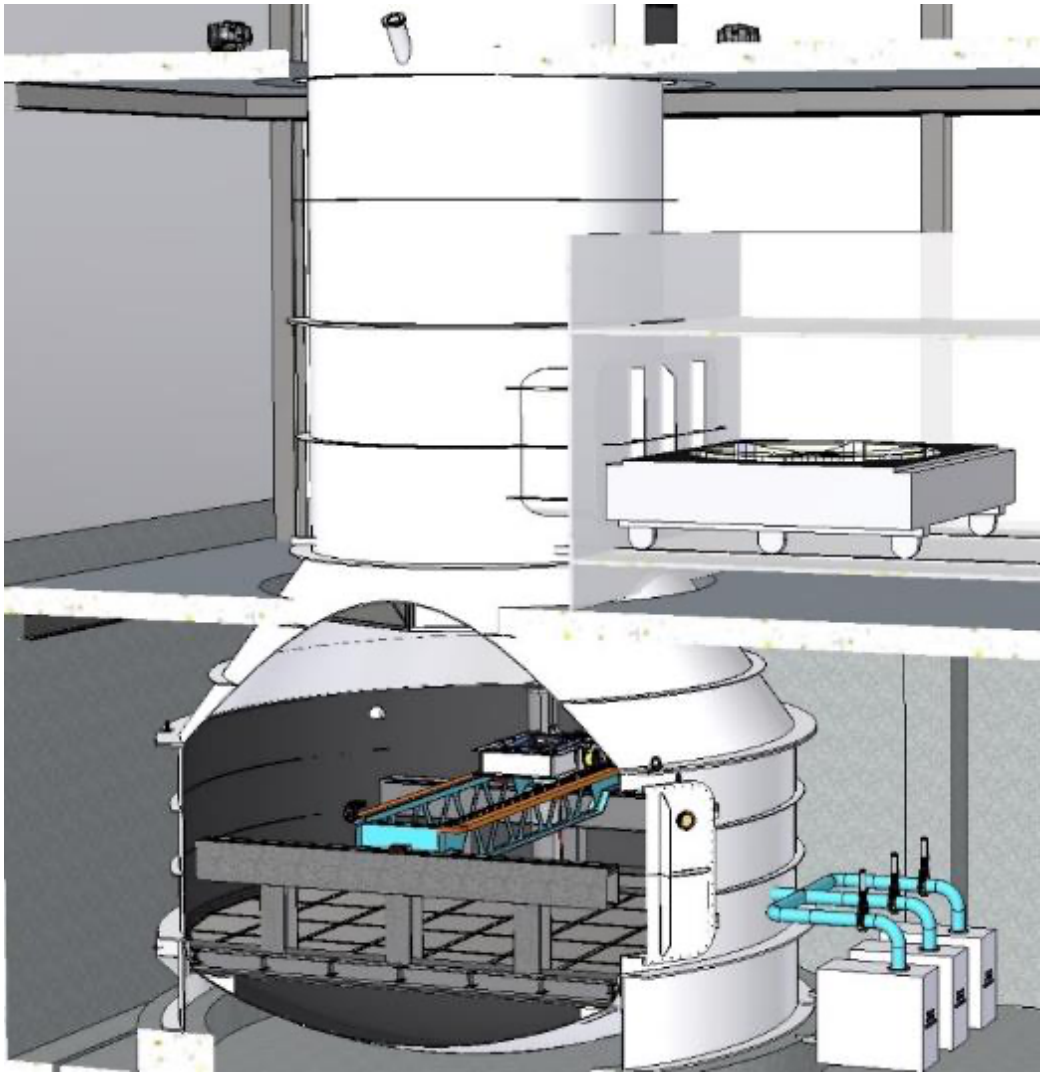

Demonstration of VERT-X Critical Items

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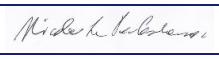
Prepared by:	N. La Palombara	Signed by:	
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1. INTRODUCTION

1.1. OVERVIEW

Vert-X is an innovative facility proposed by the Italian National Institute for Astrophysics (INAF) to the European Space Agency (ESA) for the calibration of the entire mirror assembly (MA) of the ATHENA X-ray telescope. The VERT-X facility design [AD1] consists of several parts: the source, the collimator, the raster-scan mechanism, the metrology, the ATHENA mirror support, and the detector with its positioning system, all included in a vacuum chamber.

In order to estimate the performance and the functionality of the whole system, the most critical parts have been defined: they are the X-ray source assembly (XSA), including both the X-ray source and the mirror, and the raster scan mechanism (RS), including the tip/tilt metrology.

The XSA and the RS are considered the most critical parts of the whole system, not only because they are the most innovative but also because they are the main contributors to the final error budgets in the calibration of the ATHENA mirror assembly. This means that their performance is expected to determine the final performance of the VERT-X facility, in terms of the ATHENA MA calibration accuracy. Therefore, ESA has funded the Demonstration of VERT-X Critical Items (DVTX) to prove that the XSA and the RS are suitable for the aims of the Vert-X facility.

The aim of the DVTX project is to build both the items and to test their performance and functionality. In the VERT-X facility the XSA will be integrated on the RS. Testing the whole integrated system would have required the realization of the designed vacuum chamber, which is well beyond the goal of the present phase of the ATHENA project. An accurate estimate of the final performance of the VERT-X facility can be achieved by separately testing the two core systems XSA and RS.

1.2. SCOPE

This Product Assurance Plan (PAP) describes rules and procedures to be followed to assure the performance and reliability of the critical items of Vert-X.

This PAP will provide assurance that:

- The XSA and RS in all their parts are compliant with the specifications
- The risks are identified, assessed and controlled
- The traceability and quality of deliverables are accessible at all times
- Non-conformances are identified and addressed

This PAP is:

- Written and updated by the Product Assurance Manager (PAM)
- Approved by the Project Office (PO)
- Implemented, with the help of the PAM, by the coordinators of the Work Packages (WPs) described in the DVTX Managerial and Administration Proposal [AD4]

1.3. APPLICABILITY

This document is applicable to all the phases of the project, i.e. design, construction, integration, test, and verification.

1.4. ROADMAP

Document section	Content description
2 Applicable and reference documents	List of the applicable, reference, and standard documents, and of the acronyms and abbreviations used in the document
3 Product Assurance programme	Overview of the Product Assurance programme for the Critical Item Demonstration Project
4 General Quality Assurance requirements	Description of the general Quality Assurance requirements, regarding both hardware and software items
5 Quality Assurance requirements for acceptance	Description of the Quality Assurance requirements regarding the acceptance process
6 Quality Assurance programme for Hardware	Description of the specific Quality Assurance requirements regarding hardware items
7 Quality Assurance programme for Software	Description of the specific Quality Assurance requirements regarding software items
8 Non-conformances	Description of the management process of the non-conformances

Table 1-1: Roadmap of the document

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1. APPLICABLE DOCUMENTS

AD1	ESA-TECMMO-SOW-017462 - Demonstration of critical items for X-ray scanning facility
AD2	DVTX-OAB-PRO-TEC-001 - DVTX Technical Proposal
AD3	DVTX-OAB-PRO-TEC-002 - DVTX Implementation Proposal
AD4	DVTX-OAB-PRO-TEC-003 - DVTX Managerial and Administration Proposal
AD5	DVTX-OAB-PRO-TEC-004 - DVTX Financial Proposal
AD6	DVTX-OAB-PRO-TEC-005 - DVTX Contractual Proposal
AD7	DVTX-OAB-IPM-MIN-001 - DVTX Negotiation Meeting Minutes
AD8	ESA-TECMMO-RS-014713 - Updated Requirements for the ATHENA VERT-X following the System Requirements Review
AD9	ESA-ATH-SP-2016-001 - ATHENA Calibration Requirements Document
AD10	ESA-ATHENA-ESTEC-SYS-RS-0003 – ATHENA Mirror Calibration facility URD&IRD

2.2. REFERENCE DOCUMENTS

RD1	VTX-MLT-ISE-TEC-001 - TN2 - X-ray Source and Collimator System
RD2	VTX-EIE-ISE-TEC-002 - TN3 - Raster Scan System
RD3	VTX-GPAP-INT-TEC-001 - VERT-X Configuration and data management document

2.3. GENERAL SPECIFICATIONS AND STANDARD DOCUMENTS

SD1	ECSS-M-40 - Configuration management

SD2	ECSS-M-50 - Information/documentation management
SD3	ECSS-Q-ST-10C - Product assurance management
SD4	ECSS-Q-ST-20C - Quality assurance
SD5	ECSS-Q-ST-80C - Software product assurance

2.4. LIST OF ACRONYMS

ACP	Assembly check point
AD	Applicable Document
AIT	Assembly, Integration, and Tests
AIV	Assembly, Integration, and Verification
COTS	Commercial Off-The-Shelf
DR	Design Review
DVTX	Demonstration of VERT-X Critical Items
EA	Effective Area
EIE	European Industrial Engineering
ESA	European Space Agency
FE	Finite Elements
FEM	Finite Elements Model
FP	Final Presentation
FR	Final Review
GPAP	GP Advanced Projects
GSE	Ground Support Equipment
I/F	Interface
IASF	Istituto di AstroFisica Spaziale (INAF, Milano)
ICD	Interface Control Document
INAF	Istituto Nazionale di AstroFisica
ITT	Invitation To Tender
LLI	Long Lead Item(s)
MA	Mirror Assembly
MLS	Media Lario S.r.l.
MPE	Max-Planck-Institut für extraterrestrische Physik
OAB	Osservatorio Astronomico di Brera (INAF, Milano)
PA	Product Assurance
QA	Quality Assurance
RD	Reference Document
RFQ	Request For Quotation
RMS	Root Mean Squared
RS	Raster-Scan
SD	Standard Document
SOW	Statement of Work
TAR	Test Acceptance Review
TBA	To Be Assessed
TBC	To Be Controlled

TBD	To Be Defined
TN	Technical Note
TRR	Test Readiness Review
TVC	Thermal Vacuum Chamber
VERT-X	VERTICAL X-Ray
VTX	VERT-X
XSA	X-ray Source Assembly (including collimator and X-ray source)
XTA	X-ray Tube Assembly (including tube, collimator and X-ray source)

3. PRODUCT ASSURANCE PROGRAMME

3.1. Product Assurance organization and responsibilities

According to the DVTX Managerial and Administration Proposal [AD4], all the Product Assurance (PA) activities described in this PA Plan will be managed by the PA Manager (PAM). The PAM shall report to the Project Manager (PM) the status of the PA activities and shall have organizational authority to establish and implement the applicable PA programme.

3.2. Product Assurance interfaces

The PAM shall interface with the responsible of each WP to manage all the PA matters.

3.3. Product Assurance management

3.3.1. Product Assurance tasks

The PAM shall ensure that the inputs to perform the PA activities are consistent and complete, and available in line with the project schedule, and that the outputs produced by the PA activities are consistent and complete, and delivered in line with the project schedule. Moreover, the PAM shall ensure that all the tasks described in this PA Plan are performed in line with the project schedule.
The PAM shall control the quality of products provided by each WP by issuing applicable PA requirements and ensuring their implementation.
The PAM shall be involved in the preparation and completion of the project reviews.

3.3.2. Product Assurance reporting

The responsible of each WP shall report on the status and progress of the PA programme implementation. The PA report shall include at least the following items for the reporting period:

- Progress and accomplishment of each major PA task, including resolved and new problems, future planning of major activities and events
- Status of PA reviews, Waiver requests, Non-conformances (minor and major), Critical items (including mitigation action plan status)

The PA progress report may be part of the project progress report.

3.3.3. Documentation and data control

The documentation and data management shall be performed according to the DVTX Configuration and data management document [RD3].
The PAM shall ensure that the applicable issues of all documents and data are available at all locations where activities required for the implementation of the PA programme are performed.
The PAM shall ensure that invalid or obsolete documents and data are removed from all points of issue or use, or that they are assured against unintended use.
The Documentation Manager shall ensure that obsolete documents and data retained for legal or knowledge preservation purposes are identified as such.
The PAM, in collaboration with the PM, shall identify the project documents requiring approval, including those requiring approval by PA.

3.3.4. Product Assurance contribution to configuration management

The PAM shall ensure that:

1) the as-designed status is defined and released prior to manufacturing;
2) the as-built documentation is properly defined, identified and maintained in order to reflect approved modifications;
3) the delivered items comply with the as-built documentation.

3.3.5. Non-conformance control

The PAM shall establish and maintain a non-conformance control system, as described in Section 8 of this document.

4. GENERAL QUALITY ASSURANCE REQUIREMENTS

4.1. QA requirements for design and verification

4.1.1. Design rules

Any product shall be designed such that it can be produced with the specified level of quality, it can be inspected and tested under conditions representative of the operational environment, and it can be operated in accordance with programme constraints and requirements, throughout its whole life cycle (including handling, storage, transportation, integration and operations).

4.1.2. Verification rules

The requirement verification shall be performed progressively, as each stage of the project is completed, and shall provide the organized base of data upon which qualification and acceptance is incrementally declared.
The top-down requirement allocations and bottom-up requirement verifications shall be complete and consistent.
A system for tracking requirements and verification of results shall be established and maintained during the whole project life cycle.
The verification methods shall be adequate and consistent with the type and criticality of the requirements.
Depending on the level and the product, five different verification methods can be envisaged:

- Test (T). The requirement shall be verified by a dedicated test. This is the preferable option. A Test Report shall be requested to pass the verification step.
- Analysis (A). The requirement shall be verified by a dedicated analysis. If, for any reason, a requirement cannot be verified by test, an analysis is requested as alternative. An Analysis Report shall be requested to pass the verification step.
- Review of Design (ROD). The requirement shall be verified by reviewing the design by a board of experts. A reference to a Minute of Meeting (MOM) of the board shall be requested to consider the verification passed.
- Inspection (I). The requirement shall be verified by inspecting the hardware. A Technical Report shall be requested to consider the verification process passed.
- Certification (C). The requirement shall be certified by a third part. Usually this method is applied to COTS components and to those components that are procured from an external supplier.

Appropriate reference to the verification documentation shall be recorded and updated at project reviews up to final acceptance.

4.1.3. Verification matrix

As result of the verification strategy, a verification matrix showing all requirements and their selected verification methods shall follow the progress in the project development in all its phases, from design to the acceptance.

4.1.4. Design review

The Design Review (DR) will be the only technical review of the DVTX project. The DR shall assess that:

- The output of the VERT-X design activity have been updated and optimized
- Test plans for XSA and RS have been defined, together with the necessary ground support equipment (GSE) for the test set-ups
- Quality requirements and criteria for design, feasibility, standardization of parts and interfaces (if possible), repeatability, testability, and operability are adequately considered in design documentation.
- Methods and data required for procurement, manufacturing, inspection and test are available and validated.

- Risks of not achieving requirements are highlighted and adequately controlled.

4.1.5. Documentation control

The following documents shall be recorded and stored by the responsible of each WP:

- Technical Specifications
- Technical Design reports
- Detailed designs
- Manufacturing dossier
- Inventory list
- Interface Control Documents
- AIT/AIV plan
- Test plans
- Test procedures
- Test results in form of a Test Report
- Logbooks
- Non-conformance reports and corrective action plans

In addition, a resume of the performed activities should be sent regularly to the DVTX PO.
The Raw Data obtained from tests, controls, and inspections shall be recorded in such a way that they can be easily retrieved at any time.

4.2. QA requirements for Assembly, Integration, and Tests (AIT)

4.2.1. Assembly, Integration, and Test control

The Assembly, Integration, and Test (AIT) activities of the items provided by the DVTX project shall be outlined in a detailed AIT plan. The test plan shall state the type of the test, the test approach, the configuration of the assembly under test and the pass/fail criteria. A test report shall describe the obtained results.
An AIT/AIV responsible shall follow these processes assuring an updated version of the document.
For each test the AIT plan has to discuss in detail the following items:

- Test objectives
- Test description
- Hardware and Software configuration
- Test pre-requirements
- Test equipment
- Required manpower
- Test responsible
- Safety precautions
- Acceptance/rejection criteria
- Cleanliness and environmental conditions of integration/test facility

Tests and assembly operations shall be reported in a logbook containing the most important data (applicable procedures, responsible of the operation, date, cleanliness, environment, etc.). This logbook shall be made available for verification to the DVTX PO.

4.2.2. Test facilities, equipment, and tools

The supplier shall ensure that test facilities, equipment, and tools conform to specified requirements.

4.2.3. Test documentation

4.2.3.1. Test procedures

The tests shall be performed in accordance with documented step-by-step procedures, where acceptance criteria are clearly indicated. For each step the following items shall be reported:

- sequential ID number of the performed action
- summary description of the performed action
- name of parameter to be checked
- expected parameter value
- measured parameter value
- action result (PASSED/FAILED)
- additional notes

The WP responsible and the PAM shall review and approve test procedures.

4.2.3.2. Test reports

The supplier shall ensure that all tests are comprehensively documented in test reports, and that they include, as a minimum:

1) reference to the applicable test procedure, and description of the deviations from it during the actual testing,
2) test data records and evaluation, and
3) summary of test results.

The WP responsible and the PAM shall review and approve test reports.

4.2.4. Test reviews

Once the XSA and the RS have been assembled, and before the execution of any test on them, the test readiness shall be verified with a Test Readiness Review (TRR). The TRR shall verify:

- the conformance between the as-built configuration status of the test sample and the design baseline;
- the status of non-conformances / failures, requests for waivers, requests for deviations and open work;
- the availability of the finally assembled XSA and RS;
- the availability of the GSE;
- the availability and the approval status of the test procedures;
- the calibration status of the test facility;
- the responsibilities during the test.

The DVTX PO shall be informed in advance of the test execution and a PO representative shall be invited to attend it. The DVTX PAM shall monitor that all the quality assurance activities are followed and, in particular, that:

- the approved procedures are applied during the test;
- no errors arise during the execution of the procedures;
- record and logbook of the activities are taken;
- non conformances are traced following rules reported in Section 8.

The analysis of the test data and the results will be reviewed at the Test Acceptance Review (TAR).

4.3. Quality Assurance requirements for procurement

4.3.1. Selection of procurement sources

The WP coordinators (hereafter purchasers) are responsible not only for the quality of their own products but also for the quality of the products procured by them. The selection of manufacturers and suppliers shall be

driven by proven ability in procurement of materials, parts, and components needed by the project. They must guarantee their capability concerning the quality control and traceability.
It is responsibility of each purchaser to define criteria for evaluating and selecting its suppliers from a quality point of view, and to apply this PA Plan also to its suppliers.

4.3.2. Quality Agreement with Suppliers

A quality agreement with the selected external suppliers should be included in all procurement contracts. The only exception is for commercial products off the shelf (COTS), for which documentation and configuration management will be subject to manufacturer definition.
The quality agreement establishes:

- the quality requirements applicable to the supplier
- the need of a supplier's quality plan and control plan
- the tests, inspection and controls before, during and after production which the supplier has to implement
- the file format which should be used for exchanging technical drawings between the purchaser and the supplier
- the warranty conditions
- the procedure for solving non-conformances (see Section 8)
- the packaging requirements
- the requirements for product identification, marking and labelling
- the documentation which the supplier shall attach to each delivery, for example:
  - as-built configuration with product number, revision index, production date and serial numbers of components and sub-components
  - test results and inspection logs
  - material certificates

4.3.3. Procurement contracts

Each DVTX contract shall include a Statement-of-Work (SoW) and Applicable and Reference documents.
The DVTX contracts shall include all the technical requirements applicable to the purchasing contract.
This PA Plan is applicable to all the DVTX contracts.

4.3.4. Surveillance of procurement sources

The purchaser shall exercise surveillance over all the activities carried out by its suppliers.
The surveillance programme shall address audits, reviews, mandatory inspection points, as well as direct supervision at the suppliers' facilities and source inspection.

4.3.5. Documentation for Procurement

All the documentation related to procurements shall follow PA rules and shall report the requirements for quality control, the traceability and the appropriate standard.
Conformance documentation shall be requested and act as an entry point into the manufacturer's traceability system.
It is responsibility of the WP responsible to verify that all inspections and tests are performed and that the necessary documentation is provided.
The documentation related to quality that the supplier shall prepare is:

- Check lists for incoming inspection
- Check lists for final inspection before delivery
- Material certificates
- Certificate of conformance
- As-Built Configuration List
- As-Designed Configuration List

- Detailed Assembly Drawings and Part Lists
- Non-Conformance Reports
- Requests for deviation/waiver (if a non-conforming product needs to be delivered)
- Acceptance Test Report, including test data sheets with acceptance signature

5. QUALITY ASSURANCE REQUIREMENTS FOR ACCEPTANCE

5.1. Acceptance process

The formal acceptance process for all deliverable items, to ensure that conformance of the items to be delivered is fully assessed and documented, is establish according to the DVTX Implementation Plan [AD3].
The Final Review (FR) is the milestone for the acceptance of the deliverable HW and SW items, together with the updated technical and programmatic documentation.

5.2. Acceptance Data Package

The DVTX Collaboration shall provide an Acceptance Data Package (ADP) for the deliverable items. The ADP shall be composed of all documents regarding the deliverable item (as listed in Table 5-1 of [AD3]) and shall include a 'Summary Report' of the overall test campaign performed. This Summary shall provide:

- the list of the performed tests
- the list of the produced NCRs
- an overall evaluation of the test results
- a declaration about the item compliance to applicable specifications

User manual, commissioning report, and transport procedures will be part of the ADP.
The ADP shall constitute the basis for the formal acceptance review.

6. QUALITY ASSURANCE PROGRAMME FOR HARDWARE

6.1. Product Identification

Product identification is fundamental for proper control of the system configuration and for future maintenance activities and product upgrades. All parts and components produced or purchased shall be clearly identified with a product number and a serial number. This information shall be engraved or placed in such a way that it cannot be removed or deleted accidentally. The identification data of the delivered items shall be recorded and stored in a proper document. For electronic components with firmware, there shall be the possibility to know the firmware used version by means of a specific command. The firmware should be password protected in order to avoid accidental or unauthorized changes.

6.2. Traceability

Each supplier shall be capable to trace data, personnel and equipment related to procurement, manufacturing, inspection, test, assembly, integration, and operations activities.
The supplier shall be capable to trace backward the locations of materials, parts, sub-assemblies, and to trace forward the locations of materials from raw stock.

6.3. Metrology and calibration

The supplier shall control, calibrate, and maintain inspection, measuring, and test equipment at prescribed intervals, or prior to use.
The supplier shall maintain calibration records for inspection, measuring, and test equipment, and shall make them available to the DVTX PAM upon request.
The supplier shall use equipment in a manner which ensures that measurement uncertainty is known and is consistent with the specified measurement capability.
The supplier shall include in the calculations of all measurements the total error in the measurement process attributable to the cumulative error from the calibration chain, measuring equipment, and those contributed by personnel, procedures, and the environment.
The supplier shall select inspection, measuring, and test equipment in conformance with the required measurement accuracy and precision.
The supplier shall establish, document, and maintain calibration procedures, including details of equipment type, identification number, location, frequency of checks, check method, acceptance criteria, and the action to be taken when results exceed the specified accuracy.
The supplier shall ensure that the environmental conditions are suitable for the calibrations, inspections, measurements, and tests being carried out.

6.4. Storage

The supplier shall place in secure storage areas incoming materials, intermediate items needing temporary storage, and end items before shipping. These areas shall guarantee the storage conditions applicable to the involved items. Each storage area shall be identified and labelled for its intended use.
The supplier shall maintain control over acceptance into and withdrawal from storage areas.

6.5. Material Certificate

A material certificate proves that the quality and properties of the material correspond to the applicable standards. It can either just confirm the compliance with an international norm or it can contain the results of a chemical analysis and/or physical test made by a certified laboratory together with a statement that the required specifications are met. The suppliers should be requested to attach a material certificate to each delivered item. All electrical items shall be CE marked.

6.6. Receiving inspection

6.6.1. Receiving inspection planning

In case of incoming items, the involved QA responsible shall perform inspections of all incoming supplies in accordance with established procedures and instructions, to ensure that quality level is properly determined. He/she shall ensure that all incoming supplies, including documentation and packaging, whether delivered on his/her own premises or elsewhere, conform to the requirements of the procurement documents.
Receiving inspectors shall have available the procurement documents, specifications, drawings and any other document relevant to incoming supplies as required in the procurement documents.

6.6.2. Receiving inspection activities

Receiving inspection activities shall include:

- verification that the packaging meets the requirements and is not damaged
- verification that the environmental sensors and the shock and tilt indicators (if any) are not damaged
- visual inspection of the delivered items, in order to assess that product looks OK at a first glance (no loose parts, dents, cracks, etc.)
- verification that the product corresponds to the type, model and characteristics that had been ordered
- verification of correct identification and, where appropriate, configuration identification for conformance to the ordering data
- verification that the quantity of pieces, batch number and serial numbers match with the packing list and with the purchase order
- verification that the required documentation is attached to the delivery (packing list, as-built configuration, level of engineering, handling and safety instructions, conformance certifications, documentation on tests, etc.)
- identification of the inspection status and physical separation of the supplies in the receiving inspection area according to the following categories:
  a) items for which the receiving inspection has not been completed
  b) conforming items
  c) non-conforming items
- prevention of unauthorized use of uninspected and non-conforming items
- identification of the items to be released for production with conformance status and traceability data to be recorded in manufacturing documents

In case any of the inspected parameters shows a non-conformance, the entire batch shall be put immediately in quarantine and clearly labelled to prevent that it arrives to the assembly line (see Section 8). The next step is to prepare a non-conformance report describing the problem and to inform the responsible of the involved WP, in order to decide if the batch can be accepted after a full inspection of all parts, can be reworked, or if it must be rejected and sent back to the supplier (see Section 8).

6.6.3. Receiving inspection records

The WP responsible shall maintain receiving inspection records to ensure the traceability and the availability of historical data, to monitor supplier performance and quality trends.

6.7. Product manufacturing

6.7.1. Workmanship standards

The supplier shall employ workmanship standards throughout all phases of manufacturing, assembly and integration, to ensure acceptable and consistent workmanship quality levels.
Workmanship standards shall identify acceptance or rejection criteria.

Tools shall be checked for accuracy during the production life at adequate intervals.

6.7.2. Cleanliness and contamination control

6.7.2.1. Cleanliness control

Each supplier shall establish controls for cleanliness of manufacturing, integration, and test facilities, and the limitation of sources of contamination.

6.7.2.2. Cleanliness levels

Contamination-sensitive items shall be cleaned, controlled and maintained to the required cleanliness levels. The required cleanliness levels for the deliverable items shall be indicated on drawings, specifications, procedures, or other documents controlling the manufacture, assembly, integration, and test of the items.

6.7.2.3. Cleaning materials and methods

The supplier shall develop detailed methods for attaining the cleanliness levels specified for the hardware.

6.7.2.4. Contamination control

Contamination shall be minimized by operating in clean working areas and by proper handling, preservation, packaging and storage.
Contamination-sensitive items fabricated or processed in contamination-controlled environments shall be inspected, tested, modified or repaired in identical or cleaner environments, unless specific precautions are taken to protect the items concerned from contamination.

6.7.2.5. Cleanliness of facilities

Fabrication, assembly and integration of contamination-sensitive items shall be conducted in facilities that provide cleanliness levels compatible with the specified product cleanliness.

6.7.3. Logbooks

The supplier shall prepare and maintain system, subsystem and equipment logbooks for all operations and tests performed on the item.
The logbooks shall be made available to the DVTX PAM upon request.

6.7.4. Manufacturing, assembly and integration records

The supplier shall establish and maintain manufacturing, assembly and integration records to provide all manufacturing, assembly, integration and inspection data required for traceability.

6.8. Preparation for delivery

6.8.1. Packaging

Each supplier shall ensure that packaging materials, methods, procedures, and instructions are adequate for protection of items while at the supplier's plant, during transportation, and after their arrival at destination. If necessary, quality representative will prepare a specific test plan for verifying that the packaging of especially delicate parts is adequate for the transport conditions. For critical and costly products, packaged items shall be protected against shocks, dust, water, and temperature gradients. Therefore, the use of shock and tilt indicators as well as humidity and temperature sensors could be taken into consideration, especially when a verification of the integrity of the product upon arrival to the site is technically not feasible or very complex. In such cases, it is necessary to define a threshold of humidity, temperature or shocks/accelerations and to design an appropriate packaging. Items (for example electronic components) which can be damaged by condensed water that may appear inside the packaging during transport due to large temperature and pressure changes should be protected additionally (with humidity absorbers, waterproof sealing, etc.).

6.8.2. Marking and labelling

The supplier shall ensure that appropriate marking and labelling for packaging, storage, transportation and shipping of items are performed in accordance with the applicable specifications.

6.9. Delivery

6.9.1. Shipping control

The supplier shall ensure that the items to be shipped from its plant are inspected before release and found to be complete, adequately preserved and packaged, correctly marked and accompanied by all the required documentation.
Accompanying documentation shall include the ADP and, attached to the outside of the shipping container, the handling and packing or unpacking procedure and any relevant safety procedure.

6.9.2. Transportation

The supplier shall make provisions for the prevention of damages to items during transportation.
If necessary, transportation boxes shall be equipped with shock and temperature indicators.

7. QUALITY ASSURANCE PROGRAMME FOR SOFTWARE

The objective of software quality procedures is to provide adequate confidence that all the DVTX developed or procured/reused software, satisfies the quality requirements throughout the product lifetime. In particular, that the software design, controls, methods, and techniques result in a satisfactory level of quality in the delivered product.
This requires the measurement and control of the quality of:

- development processes (SW Process Quality Assurance)
- products (SW Product Quality Assurance)

These activities are based on the principles of the standard ECSS-Q-ST-80C [SD 5].

7.1. Software Process Quality Assurance

The software process quality assurance looks at the process used to create the final software product. The scope is to ensure that an appropriate development plan for the specific product is followed, and that the software standards described in SD5 are applied.

7.1.1. Software Dependability and Safety

Software components shall be object of the dependability and safety analyses in order to identify the severity of the associated possible failures.

7.1.2. Software configuration management

Software configuration control will be performed, assuring traceability of the developed software configuration items, until final acceptance and utilization. The PAM shall verify that the Configuration management system defined in the DVTX Configuration and data management document [RD3] is used.
Software problems shall be handled since the start of code unit tests, by reporting them following appropriate procedures. Software Problem reports shall be issued and maintained in a dedicated database. Methods and tools to protect the supplied software, checksum type key calculation for the delivered operational software, and labelling method for the delivered media shall be defined.

7.1.3. Process metrics

Metrics shall be used to manage the development and to assess the quality of the development processes.
Process metrics shall be used by the development team, including number of problems detected during verification and number of problems detected during integration and validation testing and use.

7.1.4. Coding

Before coding activities start, specific tools to be used in implementing and checking conformance with coding standards shall be identified.

7.1.5. Testing

Testing shall be performed in accordance with a specific strategy for each testing level (i.e. unit integration, verification against the technical specification, validation against the requirements baseline, acceptance). Each planned test shall be performed following a clear procedure and its results shall be described in a report.
In case of retesting, all test-related documentation (test procedures, data and reports) shall be updated accordingly. This activity should be carried out in case of a major change in the software.

7.2. Software Product Quality Assurance

The SW development team shall describe how metrication of the software product quality will be performed, to verify the implementation of the relevant quality requirements. Such metrication activity will give a figure of the product quality involving requirements, design, code, and testing activities as well as software documentation quality.
The SW development team shall describe how testing and validation activities will be performed in accordance to the strategy defined for each testing level and adequately documented in related plans and procedures.
In order to verify these activities, the Test documentation shall cover all the specific aspects including the test environment, the hardware and software configuration, the exploited tools and the possible test software necessary.
Test definition shall include the expected results and in any case the criteria for pass/fail determination.
Contingency steps for the fail case shall be specified. For the requirements not covered by a test activity, verification reports shall be produced by documenting (or referring to) the verification activities performed. The defined set of metrics shall furnish also a valid assessment tool to verify whether the test coverage goal has been reached.
All the software documentation produced during design, implementation, test, and verification phases shall be subject to DVTX configuration management, assuring so the development and implementation traceability and permitting to maintain the software product during the operational phase.

7.3. Software Verification

Verification is a software process to confirm that adequate specifications and inputs exist for any activity, and that the outputs of the activities are correct and consistent with the specifications and input. Verification tests are performed by the development team. These tests cover the requirements identified within the specification document to show that expected functions are effectively performed by the resulting product.
Most, but not all, software requirements are traceable to executable tests, but all requirements are verified using one or more of the five System Engineering Verification methods: review of design, inspection, demonstration, test, data analysis. However, for most if not for all software codes, the Testing Verification Method shall be used to verify the requirements.
At the TAR a Verification Report shall be produced to illustrate the results of the Verification Procedures.

8. NON-CONFORMANCES

8.1. Definition

A non-conformance (NC) is defined as a failure to meet the requirements and may be detected in the product itself or in the process used for its realization. It can be detected in internal or external audits, tests, incoming inspections, during production, after production or even after delivery to the WP to whom it is intended.

8.2. Classification

NCs can be classified as MAJOR or MINOR.
A NC is classified as MAJOR if it affects the form, fit or function of a deliverable HW/SW item, or if it can have an impact on the following areas and cases:

- safety of people or equipment
- operational, functional or any technical requirements
- reliability, maintainability, availability, lifetime
- functional or dimensional interchangeability
- changes to or deviations from approved qualification or acceptance test procedures
- approved HW/SW Interface Control Documents

A NC is classified as MINOR if, by definition, it cannot be classified as major, i.e. it does not affect the form, fit or function of a deliverable HW/SW item and have no impact on the items listed above. Examples of minor NCs are random failures, where no risk for a lot-related reliability or quality problem exists, and minor inconsistencies in the accompanying documentation.

8.3. Responsibilities related to non-conformances

It is the responsibility of any person involved in the project who detects any product that does not meet the requirements, to report the problem immediately to the responsible for his/her WP.
In case the product affected by the detected non-conformance is provided by an external supplier, the WP responsible shall report the problem to the involved supplier. It is the responsibility of the supplier of the non-conforming item to ensure that the causes are investigated and solved in a satisfactory manner. The supplier nominates the Non-conformance Review Board (NRB), which shall be the sole technical authority for the treatment of non-conformances. The NRB shall include the responsible for the involved WP and at least one representative for the Engineering area.

8.4. Non-conformance reporting

Non-conformances shall be identified and recorded in a report (NCR), which has to be prepared and managed by the WP responsible. Each NCR shall be uniquely identified with a reference code, which shall be assigned according to the rules described in the DVTX Configuration and data management document [RD3]. The NCR shall report at least the following items:

- revision and date
- NC classification (major/minor)
- name or serial number of the NC item
- procedure or activity in execution when the NC is detected
- problem description
- originator of the reported problem
- test set-up
- environmental conditions at problem occurring
- configuration of the equipment under test (operating modes, connections, …)
- remedial actions adopted in order to proceed with the on-going activity
- preventive actions adopted in order to avoid the problem repetition on similar items
- corrective actions adopted in order to remover the causes(s) of the problem

- name and signature of person who has verified the effectiveness of the adopted solution

In order to close the NCR, it shall be signed by all the members of the NRB. The template to be used for the NCRs of the DVTX is reported in Appendix A.
Remedial/Corrective actions will be planned, initiated and carried out. In case no corrective actions are practicable, a request for deviation (RFD) or waiver (RFW) must be advanced.
Subcontractors and external suppliers will be requested to follow the same principles.

8.5. Procedure for handling non-conformances

For reporting and solving NCs within a WP or with an external suppliers, a non-conformance procedure shall be implemented. This non-conformance procedure shall be applicable to all approved parts, software, services, systems, subsystems and infrastructure of the DVTX project.
The process model reported in Fig. 1 shows the steps for detecting, reporting, solving, and closing non-conformances regarding items provided by an internal supplier of the DVTX project. An equivalent model shall be applied by external suppliers.
The objective of this procedure is to respond to the unintended delivery of non-conforming products and to prevent undesired consequences. Furthermore, the causes of all non-conformances should be investigated and a Corrective Action Plan should be implemented, in order to avoid whenever possible a repeat of the same non-conformance.
This procedure should be mandatory for all external suppliers and, then, it should be included as a requirement in all procurement contracts.

8.5.1. Non-conformance management

Any NC detection is reported to the WP responsible, who prepares a NCR which describes in detail the detected NC. In the case of items provided by an external supplier, a NC detected during an inspection of the procured items at the supplier facility (before the item is delivered to a DVTX WP) is managed by the supplier PA responsible; if, on the other hand, a NC is detected on the procured items at the facility of a DVTX WP (after the item is delivered), it is managed by the WP responsible.
The WP responsible nominates a NRB, which is responsible to classify the detected NC and to identify its causes and consequences. The NRB determines the corrective actions to eliminate the causes of the NCs, and the preventive actions to avoid the occurrence of the NC on similar items. These tasks shall form an Action plan, which shall be written down in the NCR, together with the due dates and the final fate of the nonconforming product. The NCR is then stored with the status ‘Action Plan’. In order to allow a fast response, a detailed Corrective Action plan should be written and implemented. If the corrective actions are effective, the NCR is closed, otherwise the causes of the nonconformity are investigated again and a new solution to eradicate the problem is designed.

8.5.2. Management of NC items

In Fig. 2 the flow chart to manage the NC items is reported.
If the NC item is internally produced, if possible it is reworked or repaired. If, on the other hand, no rework or fixing is possible, but the NC item can be used as it is, a RFW is sent to the PO. The PO can either accept the RFW, update the configuration data sheet of the affected products, label them with the corresponding waiver reference and deliver them for further integration, or reject the waiver and scrap the NC item. A NC item which cannot be used as it is shall be scrapped as well. It is expected that this last possibility is applicable only to HW items, since in the SW case any NC item can be repaired or reworked.
If the NC item is provided by an external supplier, the same procedure is adopted to agree with the supplier the fate of the affected items.

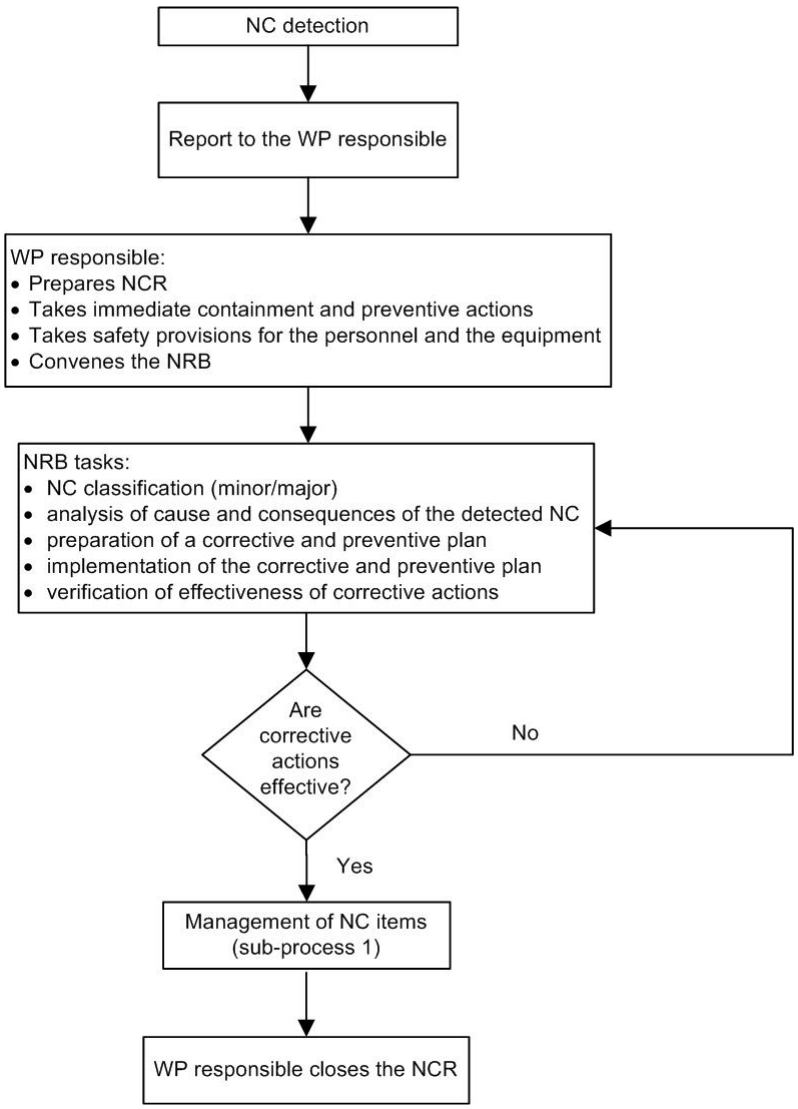

Figure 8-1: Flow-chart of the procedure adopted for the NC management

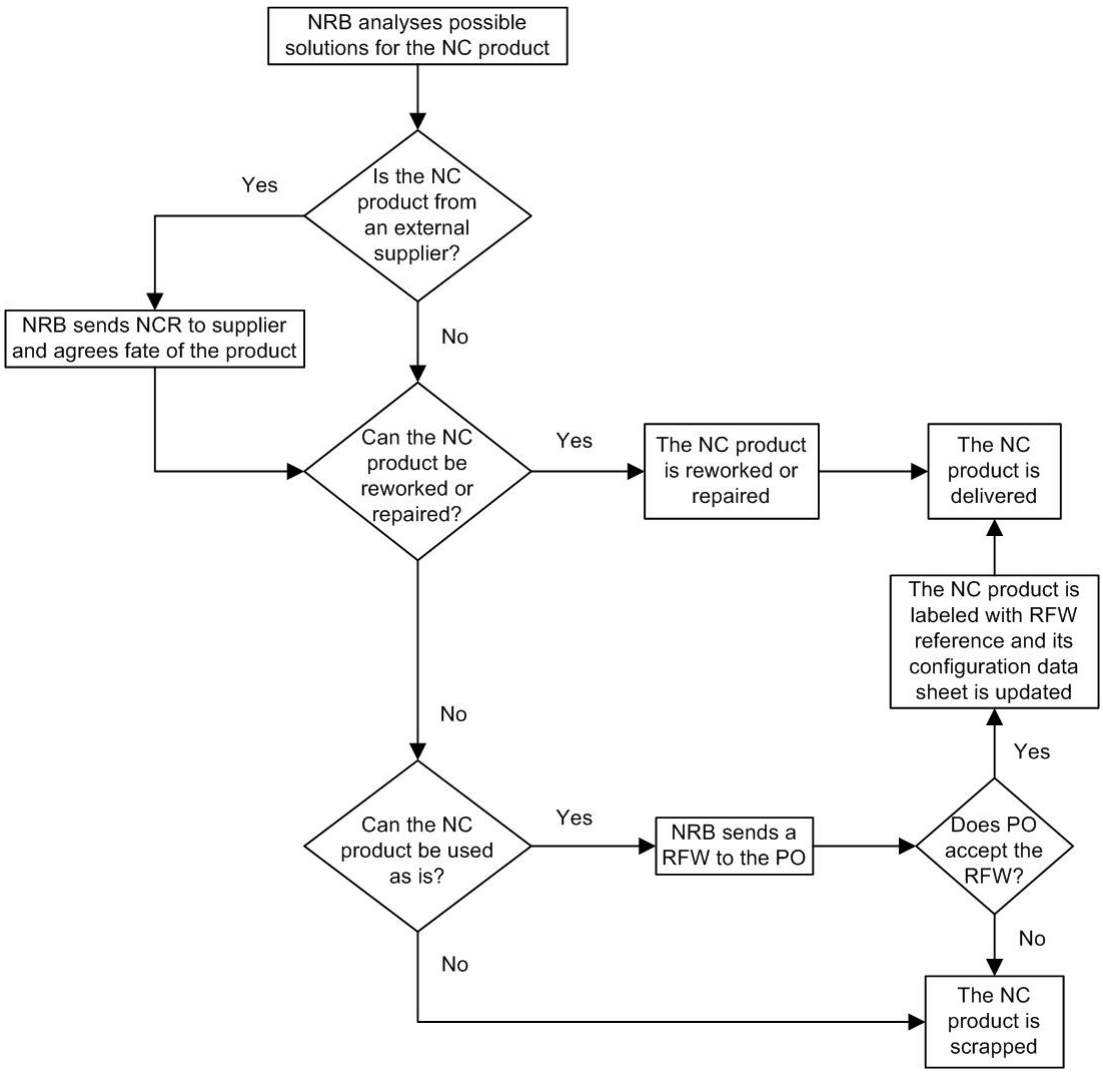

Figure 8-2: Flow-chart for the management of NC items (sub-process 1 of Fig. 1)

9. APPENDIX A

The following template shall be used to track NCRs:

NCR No.: DVTX-NCR-XXXX-YYY (see RD3) Revision: NCR type: Major/Minor Date:
NCR Title:
NC item (name/serial number):
Procedure (with code) or activity in execution when NC occurs:
Description of Non-conformance: Description of the problem and of the occurrence conditions (HW/SW configurations, environmental conditions, test set-up, …) Reported by: Requirements violated (if any):
Cause of NC:
Remedial Action: Description of possible solutions adopted to proceed with the on-going activity Action by: action responsible To be completed by: due date
Action to Prevent Recurrence: Description of possible solutions adopted to avoid repetition of the same problem on similar items Action by: action responsible To be completed by: due date
Corrective Action: Description of the solution adopted to remove the problem causes Action by: action responsibleTo be completed by: due date Verified by: who verifies the action effectiveness name signature

NCR close-out			
Name	Position	Signature	Date
	WP Responsible		
	WP Engineer(s)		
	DVTX PAM		
	DVTX System Engineer		
	DVTX PM		

Table 9-1: Template for the Non-Conformance Reports

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