



ESCC HYBRID PROCESS CAPABILITY APPROVAL LIST (HPCL)

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DOCUMENTATION CHANGE NOTICE

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DCR No.	CHANGE DESCRIPTION
1422	<p>Extension: 351B, 3D+ (France), Non Hermetic 3D Stacking Assembly Technology</p> <p>Editorial: 346A, Safran (France) Insertion of Safran listing which was omitted in previous issue 5 of the HPCL.</p>

FOREWORD

This document contains a list of suppliers of EEE manufacturing, assembly or test services that have been certified by the European Space Agency for Process Capability Approval (PCA) to the rules of the ESCC system with principle reference to ESCC Basic Specification no 25600.

The certification given to a supplier for Process Capability Approval does not include nor enable the ESCC Qualification of his products. Therefore, this listing of a PCA in the this report just confirms the validity of the ESCC certification of approval within the limits of the applicable domain as described in a Process Identification Document (PID), but does not imply any declaration of individual product(s) qualification.

The electronic components produced within the domain described in the approved PID may need individual type (component) approval if intended for use in ESA and other spacecraft and associated equipment, in accordance with the requirements of the ECSS standard ECSS-Q-ST-60C.

Each PCA and its subsequent maintenance is monitored and overseen by the ESCC Executive. ESA certifies the PCA upon receipt of a formal recommendation raised by the ESCC Executive to state that all applicable ESCC requirements have been met by the pertinent manufacturer. The achieved PCA status is noted by an entry in this document, a corresponding entry in the European space components information exchange system, ESCIES, and the issue of a certificate to the qualified manufacturer.

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1 PROMOTION

It is permitted to advertise the ESCC PCA status of a component supplier provided such publicity or advertisement does not state or imply that the related domain is the only approved one of that particular type, range or family.

2 PROCURER'S RESPONSIBILITY

When procuring EEE components produced within the limits of a certified PCA, the procurer is responsible for ensuring that the certification status is valid and that delivered components fulfil the specified contractual requirements in addition to those of the applicable ESCC specifications. The procurer is advised to utilise the ESCC non-conformance system, per ESCC Basic Specification No. [22800](#), in the event that a PCA-approved supplier delivers non-conforming components.

3 HPCL ORGANISATION

3.1 HYBRID PROCESS CAPABILITY APPROVALS (PCA)

The individual HPCA are listed in this document by manufacturer in alphabetical order. They may also be found on the ESCIES web site, <https://escies.org>. A PCA Abstract is provided to describe the main features of the certified domain.

3.2 MANUFACTURER

Contact information and plant locations are indicated in the individual PCA listings. Contact information may also be found in the ESCC PCL section of the ESCIES web site, <https://escies.org>.

4 TABLE OF PROCESS CAPABILITY TECHNOLOGIES

Domain	Technology	Specification	Supplier	Cert. No.
40- Hybrid and modules: Hermetic Hybrid lines	Thick Film Hermetic Hybrid Integrated Circuits and HTCC Hermetic Hybrid Integrated Circuits	ESCC 2566000	Airbus Defense and Space, F	345A
40- Hybrid and modules: Hermetic Hybrid lines	Thick Film Hermetic Hybrid Integrated Circuits and HTCC Hermetic Hybrid Integrated Circuits	ESCC 2566000	Safran Electronics and Defense, F	346A
40- Hybrid and modules: Hermetic Hybrid lines	Microwave Hybrid Integrated Circuits (MHIC) and High Density Integrated (HDI) RF Systems in Package (RF-SiP) using LTCC multilayer technology	ESCC 2566000	Tesat Spacecom, G	341B
40- Hybrid and modules: Hermetic Hybrid lines	Low Frequency and Power Hybrid Line	ESCC 2566000	Thales Alenia Space, B	349
40- Hybrid and modules: Hermetic Hybrid lines	High Frequency Hybrid Line	ESCC 2566000	Thales Alenia Space, F	332B
40- Hybrid and modules: Hermetic Hybrid lines	Hybrid Integrated Circuits (MHIC) product line and LTCC Integral Substrate Package (ISP) Hybrid Integrated Circuits	ESCC 2566000	Thales Alenia Space, I	343A
40- Hybrid and modules: Non-hermetic modules lines	3D Stacking Technology Modules	ESCC 2566000	3Dplus, F	351B

5 CERTIFIED PROCESS CAPABILITY APPROVALS

The following Process Capability Approvals are certified.

5.1 HERMETIC HYBRID LINES

5.1.1 AIRBUS DEFENCE & SPACE, FRANCE

The Process Capability Approval (PCA) of the Hybrid Line of Airbus Defence & Space in Elancourt, France, has been certified by ESA in accordance with the requirements of ESCC Basic specification No. [2566000](#).

The associated PID includes Airbus’ manufacturing, assembly and test operations which have been approved for the supply of Hermetic Hybrid products for use in ESA space systems as a Category1, Option 1 Manufacturer, in accordance with ECSS-Q-ST-60-05C Rev.1

5.1.1.1 Contact Information

Address	ESCC Chief Inspector
Airbus Defence & Space 1, Boulevard Jean Moulin ZAC de la Clef Saint Pierre 78990 Elancourt, France	Mr. Dominique Mahasoro dominique.mahasoro@airbus.com

5.1.1.2 Process Capability Approval

Certificate No.	Certified since:	Type Designation
345A	Dec. 2016	Thick Film Hermetic Hybrid Integrated Circuits and HTCC Hermetic Hybrid Integrated Circuits
346A	Dec. 2016	Thick Film, Hermetic and HTCC Hermetic, low power, single cavity, Hybrids

5.1.1.3 Capability Abstract

5.1.1.3.1 Capability Abstract Thick Film Hybrids

The PCA associated to the PID GM.HYBR.NT.220.V.MMS Ed.20 Rev.00 covers the ADS-Elancourt activities on manufacturing, testing, inspection and Quality Assurance of Thick Film Hermetic Hybrid microcircuits used for Space application (internal ADS equipment and external customers). Electronic functions performed by thick film hybrids are digital, analog, 1553 Bus (couplers, transceivers), low frequency and low power.

ADS-Elancourt is category 1 hybrid manufacturer and applies Lot Acceptance Tests Option1 Production lot control according to the PID and as defined in ECSS-Q-ST-60-05C Rev.1.

Active and passive chips (ASICs, Integrated circuits, Transistors, Diodes, Capacitors and Resistors) are adhesive attached on screen printed thick film alumina.

Interconnections between dice and substrate are performed by ultrasonic wire bonding.

Substrate is adhesive attached onto metal-based package.

Interconnections between substrate and package are performed by thermosonic wire bonding. Metallic Flat Package (up to 40mm x 51mm) is hermetically sealed with lid under inert gas atmosphere.

The repair provisions (element replacement, wire re-bonding, delidding-relidding) are given in the PID.

Hybrid microcircuits are screened, according to the PID in conformance to the generic procurement specification ECSS-Q-ST-60-05C Rev.1.

Manufacturing and screening operations are performed according to procedures listed in the PID. The procurement of passive and active parts, materials and piece parts are performed according to procurement specifications and incoming procedures, as detailed in PID.

5.1.1.3.2 Capability Approval HTCC MCM

The PCA associated to the PID GM.HYBR.NT.879.V.ASTR Ed.09 Rev.00 covers the ADS-Elancourt activities on manufacturing, testing, inspection and Quality Assurance of HTCC Hermetic Hybrid microcircuits used for Space application (internal ADS equipment and external customers). Electronic functions performed by HTCC hybrid microcircuits are digital, analog, 1553 Bus (couplers, transceivers), low frequency and low power.

ADS-Elancourt is a Category 1 hybrids manufacturer and applies Screening tests and Lot acceptance Tests Option1 Production lot control according to the PID and as defined in ECSS-QST-60-05C Rev.1.

Active and passive chips (ASICs, Integrated circuits, Transistors, Diodes, Capacitors and Resistors) are adhesive attached onto Multilayer HTCC Aluminium Nitride package.

Interconnections between dice and HTCC package are performed by ultrasonic wire bonding. Ceramic Flat package (up to 43mm x 30 mm) is hermetically sealed with lid under inert gas atmosphere.

Then hybrid microcircuits are screened, according to the PID in conformance to the generic procurement specification ECSS-Q-ST-60-05C Rev.1.

Manufacturing and screening operations are performed according to procedures listed in the PID. The repair provisions (element replacement, wire re-bonding, delidding-relidding) are given in the PID.

The procurement of passive and active parts, materials and piece parts are performed according to procurement specifications and incoming procedures, as detailed in PID.

5.1.2 TESAT SPACECOM, GERMANY

The Process Capability Approval (PCA) of the Hybrid Line of Tesat Spacecom, Backnang, Germany, has been certified by ESA in accordance with the requirements of ESCC Basic specification No. [2566000](#).

The associated PID includes Tesat’s manufacturing, assembly and test operations which have been approved for the supply of Hermetic Hybrid products for use in ESA space systems as a Category1, Option 1 Manufacturer, in accordance with ECSS-Q-ST-60-05C Rev.1

5.1.2.1 *Contact Information*

Address	ESCC Chief Inspector
Tesat-Spacecom GmbH & Co. KG Gerberstraße 49 D-71522 Backnang Germany	Dr. – Ing. Jens Werner

5.1.2.2 *Process Capability Approval*

Certificate No.	Certified since:	Type Designation
341B	July 2016	Microwave Hybrid Integrated Circuits (MHIC) and High Density Integrated (HDI) RF Systems in Package (RF-SiP) using LTCC multilayer technology

5.1.2.3 *Capability Abstract*

TESAT’s microwave hybrid manufacturing line capabilities are defined within the associated Process Identification Document (PID) 63.0200.005.00PID, Issue J.

This PID describes hybrid assembly, packaging, production screening, test and quality assurance processes for Microwave Hybrid Integrated Circuits (MHIC) and for High Density Integrated (HDI) RF-Systems in Package (RF-SiP) using LTCC multilayer technology. The manufacturing and screening lines are highly automated and provide up to man-less 24/7 operation mode.

The TESAT buried microwave technology offers the highest possible degree of circuit integration at extreme electromagnetic shielding levels.

The packaging standard is hermetic sealing but non-hermetic packaging has also been evaluated. Sealed packages are metal-ceramic based and apply thin-film, or LTCC technology.

Such hybrids are applied in various TESAT space equipment like linearizers, channel amplifiers, frequency converters, low noise amplifiers, SSPAs, modulators, data link electronics, DC-controllers and optical communication systems (likely the hermetic variants) but also in commercial terrestrial applications (non-hermetic variants). The frequency range reaches up to V-band.

TESAT hybrids are suited for radar applications (T/R-modules, TRX-modules for satellite constellations or high throughput satellites) or SSPA building blocks for beam-forming antennas.

TESAT's microwave hybrid manufacturing services are offered in-house and also externally (<http://tesat.de/en/services/microwave-hybrid-manufacturing>).

All space modules are screened according to ECSS-Q-ST-60-05C including burn-in and life test monitoring

5.1.3 **SAFRAN ELECTRONICS & DEFENSE, FRANCE**

The Process Capability Approval (PCA) of the Hybrid Line of Safran Electronics & Defense in Valence, France, has been certified by ESA in accordance with the requirements of ESCC Basic specification No. [2566000](#).

The associated PID includes Safran Electronics & Defense’s manufacturing, assembly and test operations which have been approved for the supply of Hermetic Hybrid products for use in ESA space systems as a Category1, Option 1 Manufacturer, in accordance with ECSS-Q-ST-60-05C Rev.1

5.1.3.1 *Contact Information*

Address	ESCC Chief Inspector
Safran Electronics & Defense 95 route de Montélier BP234 26002 VALENCE FRANCE	Mr. Stephane BLACHE stephane.blache@safrangroup.com

5.1.3.2 *Process Capability Approval*

Certificate No.	Certified since:	Type Designation
346A	Dec. 2016	Thick Film Hermetic Hybrid Integrated Circuits and HTCC Hermetic Hybrid Integrated Circuits

5.1.3.3 *Capability Abstract*

SAFRAN ELECTRONICS & DEFENSE’s hybrid manufacturing line capabilities are defined within the associated Process Identification Document (PID) AQA 511 rev AA.

This PID describes hybrid assembly, packaging, production screening, test and quality assurance processes for Medium and Low power Hybrids Circuits using multilayer Thick film and HTCC (High Temperature Cofired Ceramics) technology.

Hybrids are used in equipment like power supplies, Video treatment, low noise amplifiers, data link electronics for telecom or scientific systems...

The hybrids are screened in house according to the PID. Regarding the Lot Acceptance Test SAFRAN ELECTRONICS & DEFENSE is compliant to Option 1 as default, but under customer agreement also the Option 2 can be applied (TRB, SPC, SEC).

According to the PID, the hybrids circuits are manufactured by encapsulation, of several types of active and passive components reported inside customized hermetic package: ASICs and digital/analog ICs, Transistors, Diodes, Capacitors, Resistors networks, Optocouplers, Magnetic devices, Thermistors ...

The choice, definition and procurement of active and passive chips, material and mechanical parts, the incoming inspection and the User-LAT test are performed according to custom specifications or PID procedures.

In-house process capabilities:

- •Multilayer thick film printing
- •Static and dynamic thick film resistors trimming.
- •Single or double-sided hybrids
- •Bare dices and SMT components: automatic pick-and-place assembly
- •Automatic Wire bonding.
- •Seam sealing
- •Mix technologies on same hybrid circuit (HTCC+Thick film+Reflow soldering)
- •Internal Expertise Laboratory: Destructive Physical Analysis (DPA), Elements characterizations, Failure analysis

5.1.4 THALES ALENIA SPACE, BELGIUM

The Process Capability Approval (PCA) of the Hybrid Line of Thales Alenia Space (TAS), Charleroi, Belgium, has been certified by ESA in accordance with the requirements of ESCC Basic specification No. 2566000.

The associated PID includes TAS' production flow (manufacturing, assembly and test operations which has been approved for the supply of Hermetic Hybrid products for use in ESA space systems as a Category1, Option 1 Manufacturer, in accordance with ECSS-Q-ST-60-05C Rev.1

Restrictions (ref. ESCC 25600, Para. 8.6):

The ultra-sound bonding of Al wire on pins of hermetic connectors supplied by SRI/US is subject to an ESCC Non Conformance Review Board (ref. ESCC 22800 Para. 7.2) with ref. NCR No. 2EETC801. An alternative sequence of operations related to the wire bonding, currently not included in the approved PID, foresees the wire bonding on Ni under-plate of the mentioned pins, upon the pins' gold-plating removal. This can be implemented in agreement with individual customers and needs to be performed with the additional use of a pin-locking device. In addition, a non-destructive shear test has to be implemented after wire bonding

5.1.4.1 *Contact Information*

Address	ESCC Chief Inspector
Thales Alenia Space Rue Chapelle Beaussart 101 B-6032 Mont-sur-Marchienne (Charleroi) Belgium	Mr. P. Delporte Tel. +32 71 44 27 66

5.1.4.2 *Process Capability Approval*

Certificate No.	Certified since:	Type Designation
349	April 2018	Low Frequency and Power Hybrid Line

5.1.4.3 *Capability Abstract*

The associated Process Identification Document (PID) is referenced 9100.0683 Issue 7.2

The PCA covers the TAS-Be activities in the field of manufacturing, testing, screening and Quality Assurance of Low-Frequency and Power Hermetic Hybrid technologies, produced to be embedded in modules assembled on TAS space equipment and sub-systems. TAS-B also delivers hybrids in direct to external customers (DC/DC converters,...).

According to the PID, the hermetic modules are designed and manufactured for the integration of function as "thick film" MCMs. These hybrids integrate several types of active and passive add-on parts, inside customized hermetic package : analogic and digital ICs, ASICs, bare chips (transistors & diodes), Capacitors, Resistors, Inductors and transformers, Thermistors, Thin-Film and Thick-Film circuits.

Various types of wires are used for interconnection on dies and substrates or package (Al, Au, Cu).

Various types of sealing are available to obtain a hermetic cavity under inert gas atmosphere. Depending on the application, the hermetic package is made of metal (Kovar or Aluminium) with glass or ceramic feedthroughs. The use of ceramic HTCC package is also part of the PCA.

At the final step of production, hybrid modules are screened, according to the PID and to the generic procurement specification ECSS-Q-ST-60-05C Rev. 1.

The repair provision conditions (element replacement, re-bonding, de-lidding ...), as well as the criteria for lot rejection are also given in the PID, in accordance with ECSS-Q-ST-60-05C Rev. 1.

The procurement of passive and active components, materials and mechanical parts are assured according to internal procurement specifications and incoming instructions, as detailed in PID. The associated internal tests namely include bondability/ shear tests , and user-LAT carried out per ECSS-Q-ST-60-05C Rev. 1.

In matter of LAT, TAS-B validates the hybrid lots produced according to "Option 1" of ECSS-Q-ST60-05C Rev. 1.

5.1.5 THALES ALENIA SPACE, FRANCE

The Process Capability Approval (PCA) of the Hybrid Line of Thales Alenia Space (TAS), Toulouse, France has been certified by ESA in accordance with the requirements of ESCC Basic specification No. [2566000](#).

The associated PID includes TAS' manufacturing, assembly and test operations which have been approved for the supply of Hermetic Hybrid products for use in ESA space systems as a Category1, Option 2 Manufacturer, in accordance with ECSS-Q-ST-60-05C Rev.1

5.1.5.1 *Contact Information*

Address	ESCC Chief Inspector
Thales Alenia Space 26, Av. J.-F. Champollion BP33787 31037 Toulouse Cedex 1 France	Mr. M. Lambert Tel. +33 5 3435 6338

5.1.5.2 *Process Capability Approval*

Certificate No.	Certified since:	Type Designation
332B	May 2015	High Frequency Hybrid Line

5.1.5.3 *Capability Abstract*

The Process Capability Approval (PCA) of the Hybrid Line of Thales Alenia Space (Toulouse) has been renewed in accordance with ESCC Basic Specification n° 2566000 requirements. The associated Process Identification Document (PID) is Ref. 39.731.284/924, Issue 10/-.

This PCA covers the TAS-Toulouse activities on manufacturing, tuning, testing, inspection and Quality Assurance of High-Frequency Hermetic Hybrid technologies, used for high power and low power modules of TAS space equipment and sub-systems.

According to the PID, the hermetic modules are manufactured by encapsulation, of several types of active and passive components, inside customized hermetic package:

- MMICs,
- ASICs and digital/analog ICs
- Bare transistors,
- Diodes,
- Capacitors,
- Resistors,
- Inductors and transformers,
- Thermistors.
- Thin-Film and Thick-Film circuits

Wires and ribbons are used for interconnection between the dies, and between dies and substrates or package.

Hermetic cavities are generated with lid sealing under inert gas atmosphere.

Depending of the application, the hermetic package is metal-based or HTCC-based, with glass or ceramic for DC or RF feedthroughs.

Then, modules are screened, according to the PID and to the generic procurement specification ECSS-Q-ST-60-05C Rev. 1.

The repair provision conditions (element replacement, re-bonding, delidding ...), as well as the criteria for lot rejection are also given in the PID, in accordance with ECSS-Q-ST-6005C Rev. 1.

5.1.6 THALES ALENIA SPACE, ITALY

The Process Capability Approval (PCA) of the Hybrid Line of Thales Alenia Space (TAS), L'Aquila, Italy, has been certified by ESA in accordance with the requirements of ESCC Basic specification No. [2566000](#).

The associated PID includes TAS' manufacturing, assembly and test operations which have been approved for the supply of Hermetic Hybrid products for use in ESA space systems as a Category1, Option 2 Manufacturer, in accordance with ECSS-Q-ST-60-05C Rev.1

5.1.6.1 *Contact Information*

Address	ESCC Chief Inspector
Thales Alenia Space Zona Industriale Frazione di Pile (snc), 67100 L'Aquila Italy	Mr. F. Vasarelli Tel. +39 0862 707 313

5.1.6.2 *Process Capability Approval*

Certificate No.	Certified since:	Type Designation
343A	October 2016	Hybrid Integrated Circuits (MHIC) product line and LTCC Integral Substrate Package (ISP) Hybrid Integrated Circuits

5.1.6.3 *Capability Abstract*

The PID PCP-14-60-013 Iss.F covers the TAS-I L'Aquila activities on manufacturing, tuning, testing, inspection and quality assurance of Microwave Hybrid Integrated Circuits (MHIC's) and LTCC Integral Substrate Package (I.S.P.) Hybrid Integrated Circuits, installed on space Units Hardware for TAS Equipment, Sub-System and Antennas.

The MHICs manufactured in L'Aquila have customized packages and they can be made by means different technologies, according specific need and performances, as mechanical housing with brazed glass or ceramic feed-through or connectors or as Integral Substrate Package (ISP) based on Low Temperature Ceramic Cofired (LTCC) or High Temperature Ceramic Cofired (HTCC).

The MHICs housing can be populated by Thin Film Al₂O₃ or LTCC or Thick Film on multilayer Al₂O₃ (Ref. proper PID 14-40-001) ceramic substrates, manufactured, on a dedicated line in TAS-I L'Aquila as reported in the PID, glued or brazed on the MHIC housing.

The MHICs are populated with a lot of active and passive components selected to meet specific functions and performances : MMICs , ASICs, SRAMs, Digital Analog and RF ICs, Transistors, Diodes, Capacitors, Resistors, Inductors, Circulators and Thermistors. These components are mounted on the substrates by dispensing of different epoxy adhesive or by brazing process.

The interconnections among parts and substrates are made by wiring or ribbons in different materials and size and using different techniques.

The thermal dissipation for the most critical devices is managed by the use of heat spreader glued with high thermal conductive adhesive or brazed onto metal carrier.

Hermetic cavity is generated by lid sealing process, Seam or Laser Welding techniques, in inert gas atmosphere.

The procurement of active and passive chips, material and mechanical parts , the incoming inspection and the User-LAT test are performed according to dedicated procurement specifications or procedures reported in the PID and in conformance to ECSS-Q-ST-60-05C.

The MHICs are screened in house according to the PID and in conformance to ECSS-Q-ST-60-05C, as well the rework provisions and the Lot Acceptance Criteria. Regarding the MHIC Lot Acceptance Test TAS-I L'Aquila is compliant to Option 2 as default, but under customer agreement also the Option 1 can be applied. In addition for the Option 2 TAS-I L'Aquila defined a Technology Review Board (TRB) which supervises the Statistical Process Control (SPC) on manufacturing line processes, and implemented Standard Evaluation Circuit (SEC) policy for LAT acceptance. The SECs, coming from different Flight Model and taken from the manufacturing line, are able to cover the whole MHIC Technology Domain, and they are submitted to Destructive Physical Analysis (DPA) according to PID and ECSS-Q-ST-60-05C.

5.2 NON-HERMETIC MODULES LINES

5.2.1 3D plus

The Process Capability Approval (PCA) of the Production and Test Line of 3D PLUS in Buc, France, has been certified by ESA in accordance with the requirements of ESCC Basic specification No. [2566001](#).

The associated PID No. 3300-0546 issue 13 includes 3D PLUS' manufacturing, assembly and test operations which have been approved for the supply of non-hermetic modules for use in ESA space systems.

5.2.1.1 *Contact Information*

Address	ESCC Chief Inspector
3D plus 408, rue Hélène Boucher – Z.I. 78532 BUC Cedex France	Mr. Loïc LE ROY loic.le.roy@3d-plus.com

5.2.1.2 *Process Capability Approval*

Certificate No.	Certified since:	Type Designation
351B	Nov. 2017	3D Stacking Technology Modules

5.2.1.3 *Capability Abstract*

The associated Process Identification Document (PID) is Ref. 3300-0546-13 (PID Rev.13).

Since the Rev.11 of the PID, ESCC N°2566001 standard is the reference for the definition and evolution of the Process Capability Approval (PCA). This PCA covers the 3D PLUS Buc activities on manufacturing, tuning, testing, inspection and Quality Assurance of 3D stacked products used for 3D PLUS catalogue and custom products.

According to the PID, the 3D PLUS modules are manufactured by stacking several layers of active and passive components. Two manufacturing flows are defined as follows:

- Flow 1 for the stacking of memories with TSOP packages.
- Flow 2 for the stacking of thin PCBs (Flex) populated with EEE components. These components are assembled by soldering when used in packages or by wire bonding when used in dice form.

Flow 2 allows a large diversity of packages (TSOP, PQFP, FBGA...) enabling the design and manufacturing of complex products.

Then, modules are screened, according to the PID, and to the generic procurement specification ECSS-Q-ST-60-05C.

The repair provision conditions as well as the criteria for lot rejection are also given in the PID.

The procurement of passive and active components, materials and mechanical parts are performed following internal procurement specifications and incoming instructions, as detailed in PID. Commercial EEE Active components

Evaluation is in conformance with ECSS-Q-ST-60-13C standard.

For Module Lot Acceptance Test (Module LAT), 3D PLUS follows the ECSS-Q-ST-60-05C adapted to non-hermetic and cavity free modules.