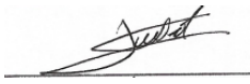




PROJECT: RF SUBSYSTEMS FOR AIRBORNE RADAR - MUSE

TECHNICAL SPECIFICATION & SETTING OF WORK

	Rédacteur	Approbateur
Fonction	Responsable technique	Chef d'unité DEMR/SERA
Nom	G. DUTEIL	N. CASTET
Visa		

GEN-F24-3 (GEN-SCI-003)

HISTORIQUE

Version Révision	Date de mise en application	Cause et/ou nature de l'évolution
1.0	10/06/2026	Création

TABLE OF CONTENTS

1	INTRODUCTION	6
2	APPLICABLE DOCUMENTS	6
3	LOT SPLITTING	7
4	SCOPE OF WORK DEFINITION.....	7
4.1	SCOPE OF WORK PEREMITER	7
4.2	LOT 1: 1T2R MODULE: TECHNICAL REQUIREMENTS	8
4.3	LOT 2: OL DISTRIBUTION MODULE: TECHNICAL REQUIREMENTS	14
4.4	LOT 3: CALIBRATION SELECTION MODULE: TECHNICAL REQUIREMENTS	16
4.5	DESCRIPTION OF OPERATIONAL REQUIREMENTS.....	20
4.6	DESCRIPTION OF NON-TECHNICAL REQUIREMENTS.....	22
4.7	OPTIONAL ADDITIONAL SERVICES.....	23

SUMMARY OF FIGURES

Figure 1 : Synoptic of 1T2R Module in RX & TX Mode8

Figure 2 : Electrical routing connection to backplane12

Figure 3 : Calibration Selection Module synoptic.....16

Figure 4 : Calibration Module electrical routing inside the connector18

SUMMARY OF TABLES

Table 1 : Control table for TX1 mode13

Table 2 : Control table for TX2 mode13

Table 3 : Control table for RX mode13

Table 4 : Calibration Selection module control table18

1 INTRODUCTION

Within the framework of the development of a new airborne platform dedicated to experiment in radar and optical sensors called MUSE, ONERA is developing a new X-band radar sensor.

This document outlines the technical and administrative specifications related to the design and production of radiofrequency circuits to be integrated in the radar sensor currently in development.

2 APPLICABLE DOCUMENTS

Reference documents:

[DR1]	01-000 - MODULE 1T2R (GABARITS).STEP
[DR2]	02-000 - MODULE DIV-OL (GABARITS).STEP
[DR3]	03-000 - MODULE CAL SELEC (GABARITS).STEP

3 LOT SPLITTING

This contract is divided in three (3) Lots

- Lot n°1 : 1T2R Module
- Lot n°2 : OL Distribution Module
- Lot n°3 : Calibration Selection Module

Technical and administrative requirements specific to each Lot are clearly defined within this document.

4 SCOPE OF WORK DEFINITION

4.1 SCOPE OF WORK PEREMITER

This contract includes study, manufacture and delivery of the radiofrequency sub-systems to be integrated in the airborne radar developed by ONERA.

In the first phase, the contractor shall conduct the study and simulations required for the design sub-system(s) to ensure compliance with the requirement specified in this document.

In the second phase, the contractor shall manufacture and deliver the subsystem(s) following their validation by ONERA.

4.2 LOT 1: 1T2R MODULE: TECHNICAL REQUIREMENTS

4.2.1 LOT1-EX-TS-001: Generalities (EI)

The 1T2R Module is made of four main parts:

- RF TX Chain path
- RF RX Chain path
- OL distribution path
- Calibration path

The synoptic in Figure 1 depicts the schematic principle of this module.

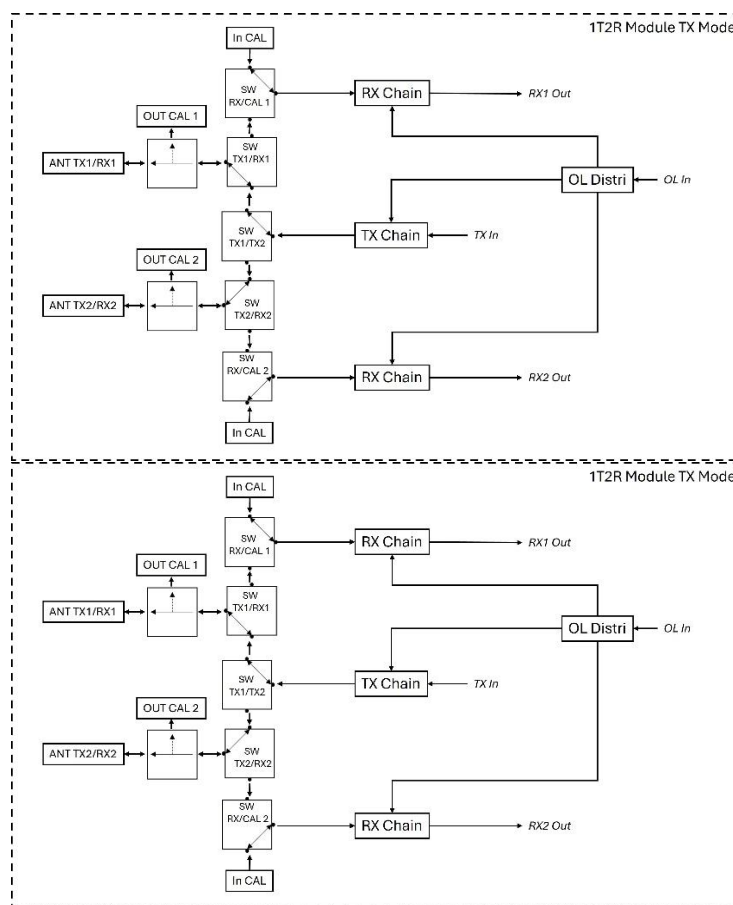


Figure 1 : Synoptic of 1T2R Module in RX & TX Mode

4.2.2 LOT1-EX-TS-002 : TX Chain path (EI min)

The TX chain path must be at least built with:

- one input connector
- two output connectors

4.2.3 LOT1-EX-TS-003: Input TX Frequency Range (EI max)

The input TX Frequency range must be included within [0,1 - 1,5 GHz].

4.2.4 LOT1-EX-TS-004: Input TX power (El max)

The typical input TX power must be less than 0 dBm.

4.2.5 LOT1-EX-TS-005: Maximum rated input TX power (El min)

The maximum rated TX input power must be at least greater or equal than +5dBm with no damage and no degradation.

4.2.6 LOT1-EX-TS-006: Input TX VSWR (El)

The TX input VSWR must be at least less than or equal to 2:1 (50 ohms impedance) across the entire input TX frequency range defined by LOT1-EX-TS-003.

4.2.7 LOT1-EX-TS-007: Output TX Frequency Range (El min)

The output Tx frequency range must be at least included inside [8,8 - 10,8 GHz].

4.2.8 LOT1-EX-TS-008: Output TX Chirp Bandwidth (El min)

The output TX chirp bandwidth must be at least better than or equal to 1.2 GHz.

4.2.9 LOT1-EX-TS-009: P1dB Output TX power (El min)

The P1dB output TX power must be at least better than 1 W (i.e. 30 dBm) at the central chirp frequency.

4.2.10 LOT1-EX-TS-010: Output TX Chirp power variation (El max)

The TX chirp power variation must be at least less than 3 dB over the output TX chirp bandwidth described in LOT1-EX-TS-008.

4.2.11 LOT1-EX-TS-011: Output TX power linearity (El min)

The output TX power linearity must cover an input TX power variation of at least 7 dB.

4.2.12 LOT1-EX-TS-012: Output TX chirp spurious level (El min)

The output TX chirp spurious level must be better than 30 dBc at the P1dB Output TX power described in LOT1-EX-TS-009.

4.2.13 LOT1-EX-TS-013: TX path selection (El)

Output TX chain path must be selectable via at least one RF switch.

4.2.14 LOT1-EX-TS-014: TX patch calibration output (El min)

Output TX chain path must include at least one calibration output close of the TX output connector. The coupling factor between TX Output and TX Calibration Output must be equal to 20 dB across the entire TX output frequency range describe LOT1-EX-TS-007.

4.2.15 LOT1-EX-TS-015: RX Chain path (EI min)

The RX chain path must be at least made of:

- two input connectors: one dedicated to calibration input / one dedicated to RX input
- one output connector

4.2.16 LOT1-EX-TS-016: Input RX Frequency Range (EI min)

The input RX Frequency range must be at least included inside [8,8 - 10,8 GHz].

4.2.17 LOT1-EX-TS-017: Input RX VSWR (EI max)

The RX input VSWR must be at least less than or equal to 2:1 (50 ohms impedance) across the entire input RX frequency range defined in LOT1-EX-TS-016.

4.2.18 LOT1-EX-TS-018: Output RX Frequency Range (EI max)

The output RX frequency range must be at least included inside [1,76 - 2,96 GHz] with a variation less than 3 dB.

4.2.19 LOT1-EX-TS-019: Output RX Rejection level (EI min)

The output RX rejection must be better than 25 dBc for the following frequency ranges:

- < [0,01 – 1,44 GHz]
- > [3,44 – 6,5 GHz]

4.2.20 LOT1-EX-TS-020: Input P1dB RX power (EI min)

The input P1dB RX must be better than -30 dBm across the entire frequency range described in LOT1-EX-TS-016.

4.2.21 LOT1-EX-TS-021: RX linear gain (EI min)

The RF linear gain of the RX path must be equal at 34 dB @ 25°C across the entire frequency range described in LOT1-EX-TS-016.

4.2.22 LOT1-EX-TS-022: RX NF input (EI max)

The RX NF input must be less than 6 dB @ 25°C across the entire frequency range described in LOT1-EX-TS-016.

4.2.23 LOT1-EX-TS-023: Maximum RX output power (EI max)

The maximum RX output power must be less than 10 dBm across the entire frequency range described in LOT1-EX-TS-016.

4.2.24 LOT1-EX-TS-024: RX path selection (EI)

Both RX path must be available in the same time.

4.2.25 LOT1-EX-TS-025: Switching speed (EI max)

The switching speed (i.e. On and Off Time 50% Vctrl to 90% of RF output) must be less than 300 ns.

4.2.26 LOT1-EX-TS-026: RX Calibration input selection (EI)

RX chain must include an input calibration port that is selectable via an RF switch. The calibration must be available during TX emission flow.

4.2.27 LOT1-EX-TS-027: TX/RX Isolation (EI min)

Over the TX emission, RX chain must be in calibration mode. The isolation (conducted and radiated) between TX path and RX path must be better than or equal to 100 dB.

4.2.28 LOT1-EX-TS-028: RX1/RX2 Isolation (EI min)

The isolation (conducted and radiated) between both RX chain must be better than 50 dB.

4.2.29 LOT1-EX-TS-029: OL Input power (EI max)

The OL Input power must be at least less than or equal to 0 dBm.

4.2.30 LOT1-EX-TS-030: Prime Power (EI)

The 1T2R must be connected to a backplane via a connector MOLEX 45985-1413 or equivalent. The backplane provides the following electrical primary voltage / powers:

- -12V /
- +12V / 24W
- +15V / 10W
- +28V / 35W

The electrical routing inside the connector is described in Figure 2.

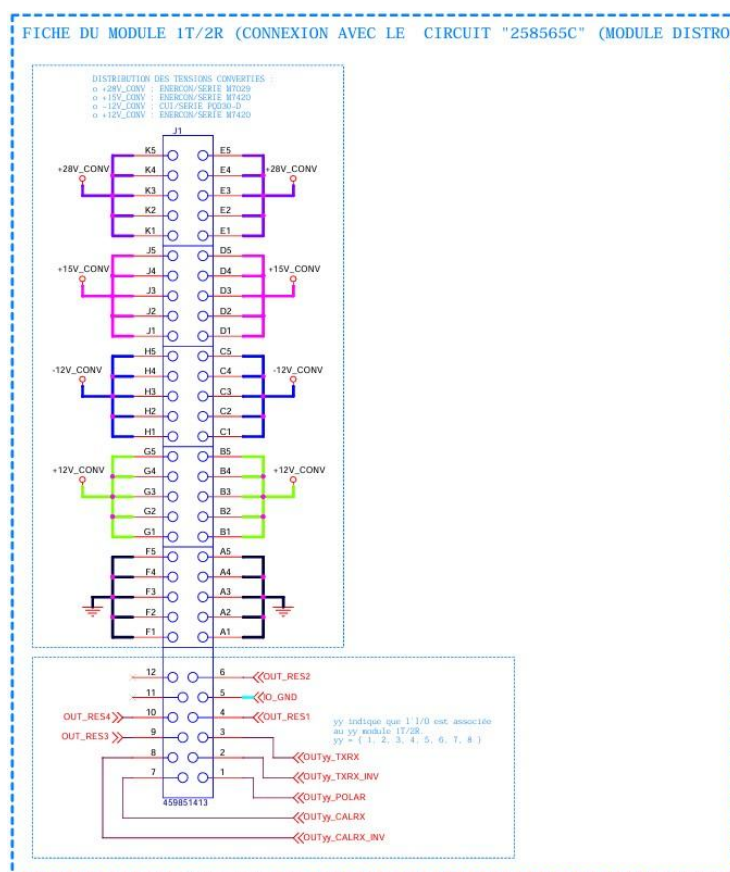


Figure 2 : Electrical routing connection to backplane

4.2.31 LOT1-EX-TS-031: I/Os (EI)

The 1T2R must be connected to a backplane via a connector MOLEX 45985-1413 or equivalent. The backplane provides the following I/Os (TTL 3.3V signal i.e. Low = < 0,8V / High = > 2.5V) that controls and commands the 1T2R Module:

- OUTyy_TXRX: Connected to SW TX2/RX2
- OUTyy_TXRX Inv: Connected to SW TX1/RX1
- OUTyy_Polar: Connected to SW TX1/TX2
- OUTyy_CALRX: Connected to SW RX/CAL2
- OUTyy_CALRX_INV: Connected to SW RX/CAL1

Module 1T2R must fulfill the control tables described in Table 1 (for TX1 mode), Table 2 (for TX2 mode) and Table 3 (for RX mode).

The electrical routing inside the connector is described in Figure 2.

Table 1 : Control table for TX1 mode

I/Os	State	Connected to
OUTyy_TXRX	Low	SW TX2/RX2
OUTyy_TXRX Inv	High	SW TX1/RX1
OUTyy_Polar	High	SW TX1/TX2
OUTyy_CALRX	Low	SW RX/CAL2
OUTyy_CALRX_INV	High	SW RX/CAL1

Table 2 : Control table for TX2 mode

I/Os	State	Connected to
OUTyy_TXRX	Low	SW TX2/RX2
OUTyy_TXRX Inv	High	SW TX1/RX1
OUTyy_Polar	Low	SW TX1/TX2
OUTyy_CALRX	Low	SW RX/CAL2
OUTyy_CALRX_INV	High	SW RX/CAL1

Table 3 : Control table for RX mode

I/Os	State	Connected to
OUTyy_TXRX	High	SW TX2/RX2
OUTyy_TXRX Inv	Low	SW TX1/RX1
OUTyy_Polar	Low	SW TX1/TX2
OUTyy_CALRX	High	SW RX/CAL2
OUTyy_CALRX_INV	Low	SW RX/CAL1

4.2.32 LOT1-EX-TS-032: RF Connectors type (Em)

All RF connectors must be the following SMP Male Limited detent type. The final type will be discussed with ONERA.

4.2.33 LOT1-EX-TS-033: Mechanical dimension (El max)

The maximum mechanical dimensions of the 1T2R module system (connectors included) must be less than or equal to the dimensions of the cavity volume that is drafted in 01-000 - MODULE 1T2R (GABARITS).STEP [DR1].

4.2.34 LOT1-EX-TS-034: Weight (El max)

The total mass of the equipment must be about 0,30 kg ($\pm 10\%$).

4.2.35 LOT1-EX-TS-035: Quantity (El)

The supplier must deliver 12 quantity of Module 1T2R.

4.3 LOT 2: OL DISTRIBUTION MODULE: TECHNICAL REQUIREMENTS

4.3.1 LOT2-EX-TS-001: Generalities (EI)

The OL Distribution Module play the role of RF splitter 1 to 8.

4.3.2 LOT2-EX-TS-002: Frequency Range (EI)

The splitter must operate at least over the following frequency range: [11 - 13 GHz].

4.3.3 LOT2-EX-TS-003: Maximum rated input power (EI min)

The maximum rated input power must be at least higher or equal to +15dBm with no damage and no degradation.

4.3.4 LOT2-EX-TS-004: Input VSWR (EI max)

The input VSWR must be at least less than or equal to 2:1 (50 ohms impedance) over the all-frequency range defined in LOT2-EX-TS-002.

4.3.5 LOT2-EX-TS-005: Output VSWR (EI max)

Output VSWR must be at least less than or equal to 2:1 (50 ohms impedance) over the all-frequency range defined in LOT2-EX-TS-002.

4.3.6 LOT2-EX-TS-006: Insertion Loss (EI max)

The insertion loss (above the theoretical 9,0 dB) must be at least less than or equal to 1.5 dB over the all-frequency range described in LOT2-EX-TS-002.

4.3.7 LOT2-EX-TS-007: Isolation (EI min)

Isolation between outputs must be better than 10 dB over the all-frequency range described in LOT2-EX-TS-002.

4.3.8 LOT2-EX-TS-008: Phase unbalance (EI max)

Phase unbalance between output must be less than 5° over the all-frequency range described in LOT2-EX-TS-002.

4.3.9 LOT2-EX-TS-009: Amplitude unbalance (EI max)

Amplitude unbalance between output must be less than 1 dB over the all-frequency range described in LOT2-EX-TS-002.

4.3.10 LOT2-EX-TS-010: RF Connectors type (Em)

All RF connectors must be the following SMP Male Limited detent type. The final type will be discussed with ONERA.

4.3.11 LOT2-EX-TS-011: Mechanical dimension (EI max)

The maximum mechanical dimensions of the OL Distribution module system (connectors included) must be less than or equal to the dimensions of the cavity volume that is drafted in 02-000 - MODULE DIV-OL (GABARITS).STEP [DR2] i.e. 242x82x16mm³.

4.3.12 LOT2-EX-TS-012: Weight (*EI max*)

The total mass of the equipment must be about 0,5 kg ($\pm 10\%$).

4.3.13 LOT2-EX-TS-013: Quantity (*EI*)

The supplier must deliver 2 quantity of OL distribution module.

4.4 LOT 3: CALIBRATION SELECTION MODULE: TECHNICAL REQUIREMENTS

4.4.1 LOT3-EX-TS-001: Generalities (EI)

The Calibration Selection Module must be made of two main parts:

- Switch matrix 16 to 1
- RF Splitter 1 to 8

The synoptic describe in Figure 3 shows the schematic principle of this module.

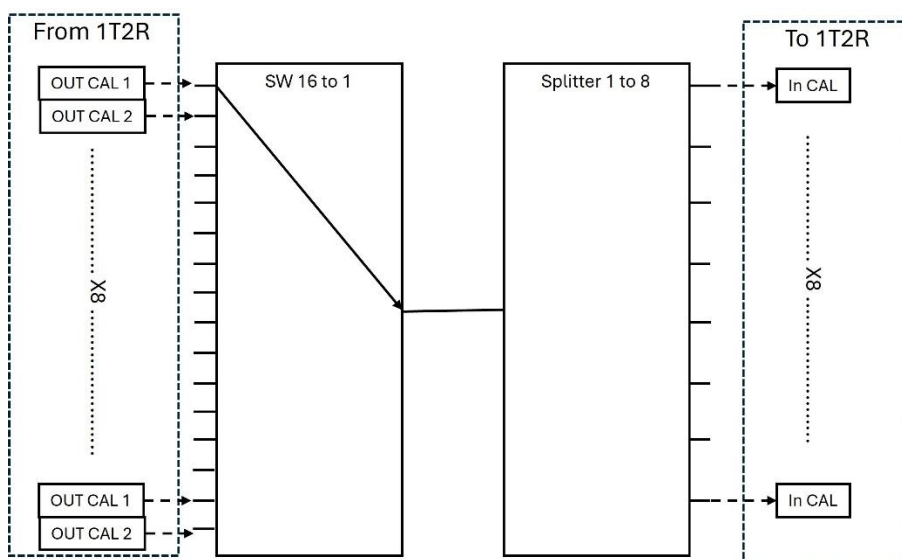


Figure 3 : Calibration Selection Module synoptic

4.4.2 LOT3-EX-TS-002: Frequency Range (EI min)

The Calibration Selection Module must operate over at least [8,8 - 10,8 GHz] frequency range.

4.4.3 LOT3-EX-TS-003: Input VSWR (EI max)

The input VSWR must be less than or equal to 2:1 (50 ohms impedance) over the all-frequency range described in LOT3-EX-TS-002.

4.4.4 LOT3-EX-TS-004: Output VSWR (EI max)

Output VSWR must be at least less than or equal to 2:1 (50 ohms impedance) over the all-frequency range defined in LOT3-EX-TS-002.

4.4.5 LOT3-EX-TS-005: Insertion loss (EI min)

The total insertion loss, for one path of the Calibration Selection Module, must be better than 48 dB. Without exceed 55 dB.

4.4.6 LOT3-EX-TS-006: Maximum rated input power (*EI min*)

The maximum rated input power must be at least higher than or equal to +15dBm with no damage and no degradation.

4.4.7 LOT3-EX-TS-007: Input Isolation (*EI min*)

Isolation between inputs must be better than 40 dB.

4.4.8 LOT3-EX-TS-008: Output isolation (*EI min*)

Isolation between outputs must be better than 20 dB.

4.4.9 LOT3-EX-TS-009: Switching speed (*EI max*)

The switching speed (i.e. On and Off Time 50% Vctrl to 90% of RF output) must be less than 300 ns.

4.4.10 LOT3-EX-TS-010: Prime Power (*EI*)

The Calibration Selection module must be interconnected to the radar prime power via a connector MOLEX 43650-0304 or equivalent. Electrical prime power available are:

- -12V /
- +12V / 24W

The electrical routing inside the connector is described in Figure 4.

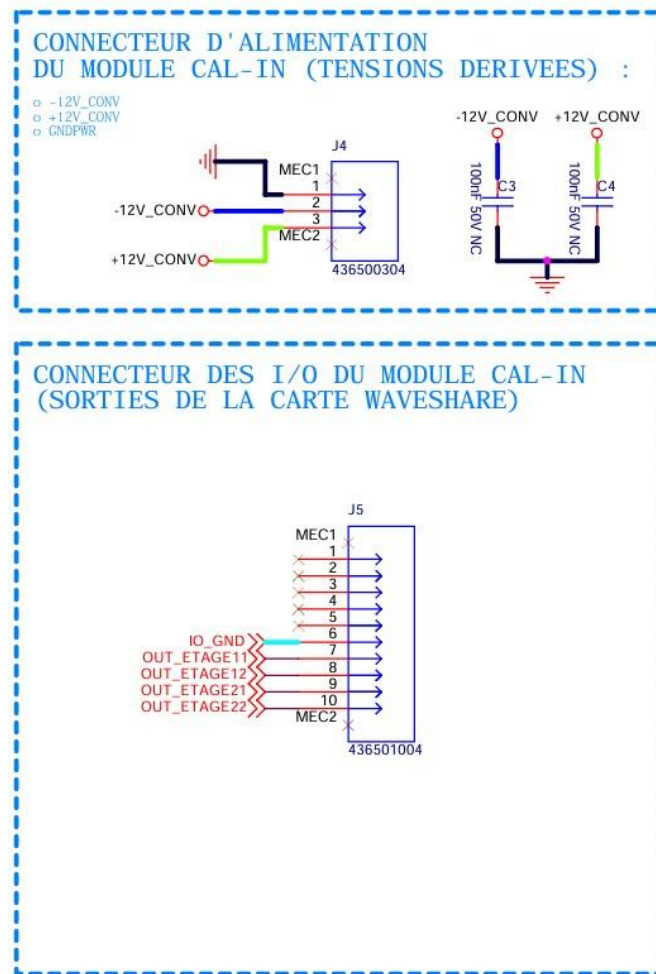


Figure 4 : Calibration Module electrical routing inside the connector

4.4.11 LOT3-EX-TS-011: I/Os (EI)

The Calibration Selection module must be connected to the radar control and command via a connector MOLEX 436501004 or equivalent. The radar provides the following I/Os (TTL 3.3V signal i.e. Low = < 0,8V / High = > 2.5V) to control and command the Calibration Selection module:

- OUT_ETAGE11
- OUT_ETAGE12
- OUT_ETAGE21
- OUT_ETAGE22

Calibration Selection module must be respecting control table described in Table 4.

The electrical routing inside the connector is described in Figure 4.

Table 4 : Calibration Selection module control table

I/Os	IN 1	IN 2	IN 3	IN 4	IN 5	IN 6	IN 7	IN 8	IN 9	IN 10	IN 11	IN 12	IN 13	IN 14	IN 15	IN 16
OUT_ETAGE11	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
OUT_ETAGE12	High	High	Low	Low	High	High	Low	Low	High	High	Low	Low	High	High	Low	Low
OUT_ETAGE21	High	High	High	High	Low	Low	Low	Low	High	High	High	High	Low	Low	Low	Low
OUT_ETAGE22	High	High	High	High	High	High	High	High	Low	Low	Low	Low	Low	Low	Low	Low

4.4.12 LOT3-EX-TS-012: RF Connectors type (*Em*)

All RF connectors must be the following SMP Male Limited detent type. The final type will be discussed with ONERA.

4.4.13 LOT3-EX-TS-013: Mechanical dimension (*EI max*)

The maximum mechanical dimensions of the Calibration Selection module system (connectors included) must be less than or equal to the dimensions of the cavity volume that is drafted in 03-000 - MODULE CAL-SELEC (GABARITS).STEP [DR3] i.e. 242x82x16mm³.

4.4.14 LOT3-EX-TS-014: Weight (*EI max*)

The total mass of the equipment must be about 0,5 kg ($\pm 10\%$).

4.4.15 LOT3-EX-TS-015: Quantity (*EI*)

The supplier must deliver 2 quantity of Calibration selection module.

4.5 DESCRIPTION OF OPERATIONAL REQUIREMENTS

This chapter describes the mechanical constraint, environmental, and identification requirements for each Lot of the contract.

4.5.1 Mechanical constraint

4.5.1.1 EX-MEC-001: Mass budget (EI)

A detailed mass budget of the equipment must be established. It draws up exhaustive tables of the MCI (Masses, Centerings and Inertias) with the assumed margins of safety, of every equipment part and fastener that are listed in the BOM.

4.5.1.2 EX-MEC-002: Acceleration, Shock & Vibration (EI)

The equipment supplied must comply, at least, with the following mechanical stresses:

- Withstand permanent deformation with static accelerations of 1.33g along its lateral axis
- Support without rupture a punctual acceleration of 2g along the lateral axis
- Support without permanent deformation, a punctual acceleration of 5.2g along the longitudinal axis
- Support without rupture a punctual acceleration of 7.8g along the longitudinal axis

Two alternatives can be used by the supplier:

Alternative 1 (basis offer – mandatory): The supplier must collaborate with the mechanical engineer of ONERA to demonstrate by calculation note that the equipment is compliant. This alternative involves the supply of the mechanical plans and materials of the mechanical envelope of the equipment.

Alternative 2 (variant – optional): The equipment provided must be compliant with the acceleration, shock, and vibration requirements for equipment used under the wing of an aircraft, described in the MIL-STD-810H standard.

4.5.1.3 EX-MEC-003: REACH (EI)

The materials and substances chosen for the design and manufacture (including surface treatments) must comply with the REACH regulations.

The supplier must provide a certificate attesting to the absence of asbestos and ionizing sources.

4.5.1.4 EX-MEC-004: Material Certificate (EI)

The supplier agrees to supply the material certificate for every material that is a part of the manufactured equipment.

4.5.1.5 EX-MEC-005: Specific tools (EI)

The supplier agrees to supply the material certificate for every material that is a part of the manufactured equipment.

4.5.2 Environmental constraint (EI)

4.5.2.1 EX-ENV-001: Ambient operating temperature and thermal control

The equipment must be fully functional (in nominal mode) without any degradation or damage with an ambient temperature included between -40°C to +65°C.

In the event that a thermal control be strongly recommended, parts such as heat pipes, blowers or any other onboard dissipating devices have to be proposed. Such thermal devices must also match with the cavity volume that is drafted by the CAD files. The power supply of such devices, and their control as well, must be considered.

4.5.2.2 EX-ENV-002: Operating altitude (EI)

The equipment must be fully functional (in nominal mode) without any damage or degradation up to 12 000 ft in an unpressurized environment.

4.5.2.3 EX-ENV-003: Humidity (EI)

The equipment must be fully functional (in nominal mode) without any damage or degradation with a 95% humidity (non-condensing).

4.5.3 Identification

4.5.3.1 EX-ID-001: Identification (EI)

A unique identification number engraved on the structure of the equipment must identify each of the antennas supplied. Similarly, each function of the equipment connectors must be engraved on the top of the connector concerned.

The identification must be defined in agreement with ONERA.

4.6 DESCRIPTION OF NON-TECHNICAL REQUIREMENTS

This chapter describe the non-technical requirements for each Lot of the contract.

4.6.1 Delivery

4.6.1.1 EX-SOW-001: Delivery conditions (EI)

Each piece of equipment must be packed in a dedicated box, with suitable protection such as bubble wrap, shockproof foam, and an impact/overturn indicator.

ONERA does not require the production of custom-made transport and storage boxes. In any case, the supplier commits that the equipment is under his responsibility until the delivery into the ONERA building.

4.6.2 Documents delivery:

4.6.2.1 EX-SOW-002 : Deliverable documents (EI)

The supplier commits to provide, at least, the following deliverable documents:

- Detailed mechanical plans of the equipment are provided in pdf format
- Detailed list of all component includes in the system
- The 3D mechanical CAD of the equipment is provided in a format usable by the SolidWorks software i.e. .step or .sat.
- The results of the validation measurements of each piece of equipment provided are required as proof of the technical requirements described above.
- The various certificates of conformity required as well as a weight certificate for each piece of equipment delivered and mechanical resistance calculation notes requested EX-TS-MEC-001.
- A recipe book for acceptance to describe the methods and results that will be used to formally demonstrate to ONERA that each product delivered meets the requirements of the STB.

4.6.2.2 EX-SOW-003 : ITAR Restriction (EI)

The supplier commits that the provided equipment is not ITAR restricted.

The supplier agrees to provide an ITAR Free certificate.

4.6.3 Acceptance test

4.6.3.1 EX-SOW-004 : Acceptance test client site (EI)

A FAT must be performed on the supplier site. This acceptance test must prove the compliance of the equipment with all technical specifications described in this document.

This test must be performed on the first piece of equipment. This test must be validated by ONERA before the full production of the equipment.

4.6.3.2 EX-SOW-005 : Acceptance test before delivery (EI)

Equipment can not be delivered without ONERA validation of acceptance test reports of each piece of equipment.

4.7 **POTENTIAL ADDITIONAL SERVICES**

This chapter describe additional services called PAS.

4.7.1 Potential Additional Services (mandatory response)

4.7.1.1 EX-PASF-001: warranty extension

ONERA requests a two-year warranty extension for all the equipment supplied.