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PROCAMIDA project - Special tender specifications for the supply of an Automated Fiber Placement (AFP) Robotic Cell


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PROCAMIDA project - Special tender specifications for the supply of an Automated Fiber Placement (AFP) Robotic Cell

ABSTRACT:

AUTHORS: De Nicola Felice

APPROVAL REVIEWERS:

APPROVER:


De Nicola Felice

AUTHORIZATION REVIEWERS:

Notarnicola Lorenzo; Baldascino Francesco; Esposito Gennaro; Menzani Monica

AUTHORIZER:

Fusco Francesco

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## o General

### o.1 Scope of the present document

This document defines the special tender specifications for the supply of an Automated Fiber Placement Robotic Cell for thermoset and thermoplastic prepreg materials, to be installed at CIRA.

This document is the technical *reference* for the submission of technical and economic proposals of *bidding* candidates, for their *evaluation* aimed at the selection of the supplier, and for the *purchasing contract*.

### o.2 Applicability of the present document

This document is applicable to the CIRA project named PROCAMIDA – “laboratori per la PROtotipizzazione e CARatterizzazione di Materiali ed Integrazione di Dimostratori Aerospaziali” (laboratories for the Prototyping and Characterization of Materials and Integration of Aerospace Demonstrators), funded by the a National Complementary Plan (PNC) of the National Recovery and Resilience Plan (PNRR) through the public notice for the candidacy of project ideas “Decreto del Direttore Generale dell’Agenzia per la Coesione Territoriale n. 204/2021”, CUP n° E49D22000570001.

### o.3 List of acronyms

A.D.	Applicable Document
AFP	Automated Fiber Placement
CEPROCAM	Centro di PROtotipizzazione strutture in Composito e cAratterizzazione Materiali
CIRA	Centro Italiano Ricerche Aerospaziali
DNSH	Do No Significant Harm
FEM	Finite Element Method
HVAC	Heating, Ventilation and Air Conditioning
ILSS	Interlaminar shear strength
PAEK	Polyaryl ether ketone
PEEK	Polyether ether ketone
PROCAMIDA	laboratori per la PROtotipizzazione e CARatterizzazione di Materiali ed Integrazione di Dimostratori Aerospaziali
Req	Requirement
Rpm	Revolutions per minute



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## 0.4 Glossary

AFP Cell	Automated Fiber Placement Robotic Cell for thermoset and thermoplastic prepreg materials
In situ	Thermoplastic material laminates, laid up by the AFP, can be <i>in situ consolidated</i> , not requiring a post processing by autoclave or by hot press. This possibility is related to the processing capabilities of AFP in terms of temperature, pressure and deposition speed.

## 0.5 Applicable regulations

The supplier is obliged to comply with all the current regulations in Europe and in Italy concerning design, installation and operation of machinery.

## 0.6 Annex

Annex 1	General layout of the hangar hosting the laser safety room reserved to the Robotic Cell
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## 1 Supply Overview

The main object to be supplied, specified in this document, is a complete “Robotic Cell for Automated Fiber Placement”, AFP, enclosed in a “laser safety room” included in the supply, too.

The basic AFP consists in an industrial robotic system with an attached head which enables multiple slit tapes of prepreg material – with thermoset, thermoplastic or binder matrices - to be laid onto a tool surface under a compaction roller.

A series of slit tapes are laid up in parallel by the head, forming a course; courses are then combined to create a complete ply on the surface; multiple plies, overlaid on each other, create a laminate.

Adhesion between the incoming slit tapes and substrate on the tool is ensured by using appropriate process conditions such as heating, compaction pressure, and tensioning.

Thermoset material laminates, laid up by the AFP, require a post process in autoclave or in oven to be cured and consolidated.

Thermoplastic material laminates, laid up by the AFP, can be *in situ consolidated*, not requiring a post processing by autoclave or by hot press. This possibility is related to the processing capabilities of AFP in terms of temperature, pressure and deposition speed.

The Robotic Cell for AFP described in this document includes:

- an industrial anthropomorphic robot on a linear track unit.
- a horizontal positioner with an external rotating mandrel axis.
- a fiber placement head, with a fiber delivering system.
- a real time parameter monitoring system.
- a full software package to simulate and control the process.

Moreover, the supply includes:

- a laser safety room
- factory pre - acceptance tests
- transportation and full installation at CIRA site
- acceptance tests on site at CIRA
- training for the use of software and hardware on site
- a full warranty including on line assistance and programmed maintenance

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## 2 Requirements

### 2.1 Feasible reference mock-ups

The following *reference mock-ups* are defined to help the definition of some requirements and to demonstrate, by simulation or by experiments, the achievement of performances both in the technical proposal and in the testing of the supply.

Mock-ups represent objects which are feasible in terms of laying up capability of the proposed AFP Cell

- The *reference fixed on the floor **flat surface*** (*reference flat surface* later in this document) is a rectangular flat surface, 8 meters long, 2.4 meters large, on a reference tool plane fixed with respect to the floor. The reference plane to be considered will not be necessarily horizontal.
- The *reference rotating **mandrel*** (*reference mandrel* later in this document) is a cylinder closed by two peripheral spherical domes with polar bosses. The admissible diameter range is variable from 0.1 to 2.4 meters. The admissible overall length range, included domes, is variable from 1 to 8 meters. The minimum polar boss diameter is 0.3 meters. The maximum mass is 8 Tons. The surface has to be considered feasible with the combined movement of the robot and the rotation of the external axis.
- The *reference fixed on the floor **convex surface*** (*reference convex surface* later in this document) is a portion of the reference mandrel surface, 2.4 meters diameter, corresponding to an arch of 75° along the rotation coordinate. The surface, being fixed with respect to the floor, has to be considered feasible with the movement of the only robot with linear track unit, without rotating the external axis.
- The *reference fixed on the floor **concave surface*** (*reference concave surface* later in this document) is a 180° portion of a concave cylinder with 2 meters diameter. The surface is considered fixed on the floor.

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## 2.2 Requirement types

Several types of requirements are specified in this document.

The *functional* requirements describe parts and their role in the supply.

The *performance* requirements describe physical measurable values to be achieved by the proposed supply.

A statement for the fulfilment of all the *mandatory* requirements is necessary to be admitted to the next phases of tender technical evaluation for the selection of the supplier. No score is assigned in the technical offer ranking to the fulfilment of these requirements, but **failure to declare compliance with even one of these requirements will result in the exclusion of the offer.**

The herein called *scoring* requirements will receive a score in the technical offer ranking, aimed to the definition of the supplier. The evaluation criteria of technical proposal are described in chapter 6.1 *Method for evaluation of the technical offer*.

The *scoring performance* requirements describe performance enhancements with respect to mandatory minimum threshold levels.

For each of these requirements the bidder shall explicitly declare in the technical offer the level of performance achieved by the proposed supply. The bidder is obliged to declare the achieved values, whatever they are.

The values declared by the bidders will be compared to assign a score in the ranking. The selected supplier will demonstrate the achieving of these levels of performance during testing phase.

The *scoring functional add-on* describe requirements of facultative added functions of the supply which are not mandatory: the bidders can decide freely to fulfil them or not in the technical proposal.

In case the bidder includes a functional add-on, fulfilling any of these requirements, it will gain a corresponding score in the technical evaluation for the selection of the supplier. **Failure to satisfy the *scoring functional add on* requirements does not imply the exclusion of the proposal.**

**The economical values of the proposed *functional add-on* have to be included in the unique price stated in the economical offer of the overall supply.** No extra optional cost, nor specific value indication has to be declared in the proposal.

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## 2.3 AFP Robotic Cell Technical Requirements

The Robotic Cell for AFP includes:

- an industrial anthropomorphic robot, on a linear track unit.
- a horizontal positioner with an external rotating mandrel axis.
- a fiber placement head, with a fiber delivering system.
- a real time parameter monitoring system.
- a full software package to simulate and control the process.

The bidder shall propose each and all the parts of the AFP robotic cell satisfying the requirements and harmonized to concur to the achieving of required layup performances.

### 2.3.1 Robotic Cell Configuration

Req 2-1 Robot and linear track unit.	mandatory, functional
--------------------------------------	-----------------------

The robotic cell shall have an industrial KUKA *anthropomorphic* robot arm to move the placement head.

The robot shall be mounted on an actuated linear track unit, moved on a rail.

Dimensions, load capacity and all other performances of robot and linear track unit shall be compatible with the fulfilment of all operativity and layup performance requirements specified in this document.

The overall length of rails will depend on the cell configuration (robot, head and creel) and on the feasible layup requirements, specifically on the reachability of domes of reference mandrel. All the above factors require an amount of extra length other than 8 meters.

The bidder shall clearly indicate in the proposal the model and the technical data of the proposed KUKA robot. The bidder shall indicate among other robot data:

1. the accuracy
2. the repeatability
3. the loading capacity (mass and momentum on the wrist).

The bidder shall clearly indicate in the proposal the manufacturer, the model and the technical data of the proposed linear track unit. The bidder shall indicate among other linear track unit data:

1. the accuracy

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2. the repeatability
3. the linearity
4. the loading capacity (mass and momentum on the track unit)
5. the overall length of rail under the linear track unit
6. the net length of linear movement of the robot on the rail
7. the required floor characteristics (concrete quality, thickness, flatness under linear axis and positioner and on the room total surface).

Req 2-2 External horizontal positioner	mandatory, functional
--	-----------------------

The robotic cell shall have an external *horizontal positioner with an interpolated, infinitely rotating axis*, to operate on a rotating mandrel tool.

The horizontal positioner *headstock* shall be combined with a *tailstock mounted on a sliding rail*, not actuated.

The headstock can be mounted on the floor or on the sliding rail.

The horizontal positioner and the sliding rail under the tailstock shall be aligned with linear track unit rail under the robot.

The sliding rail shall be mounted in a *recessed configuration in the floor, adequately covered to allow trolley and forklift movements (12 tons max load)* in the area, without obstacles.

Dimensions, load capacity and all other performances of horizontal positioner shall be compatible with the fulfilment of all operativity and layup performance requirements (specifically with **8 meters long, 8 tons reference mandrel**, defined in chapter 2.1).

The overall length of rails will depend on the cell configuration (robot, head and creel) and on the feasible layup requirements, specifically on the reachability of domes of reference mandrel. All the above factors require an amount of extra length other than 8 meters.

The bidder shall clearly indicate for the horizontal positioner in the proposal

1. the manufacturer
2. the model
3. the accuracy
4. the repeatability
5. the loading capacity
6. the electric power
7. the maximum acceleration with the max reference mandrel
8. the clamping mechanism

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9. the length of sliding rail
10. the mandatory and the maximum distance achievable between headstock and tailstock
11. the linearity of sliding rail under the tailstock
12. the expected parallelism error of sliding rail under the tailstock with respect to the rail under the robot
13. the required floor characteristics
14. the proposed recessed configuration of the rail in the floor

Req 2-3 <i>Stand-alone</i> positioner performances	mandatory, performance
--	------------------------

The horizontal positioner shall be capable to clamp, hold and move the max *reference mandrel* defined in chapter 2.1 at a maximum rotational speed of **5 rpm**.

This maximum speed requirement does not refer to a layup performance, but it is supposed to be satisfied in *stand-alone* condition.

Req 2-4 Possibility of extension of rails	mandatory, functional
---	-----------------------

The robotic cell linear track rail and the sliding rail under the tailstock shall be *extendable* by adding *modular* parts, without compromising the basic installation foreseen by the supply.

To simplify the possible extension of rails, in the basic supply configuration the headstock position shall be already chosen as opposite to the extendable end of rails.

No fixed obstacle on the floor shall be mounted at the extendable end of rails.

Req 2-5 Possible extended rails	scoring functional add on
---------------------------------	---------------------------

The bidder can include in the proposed supply an extension of length for **6 meters**, *both for the rail of linear track unit, under the robot, and for the sliding rail under the positioner tailstock*, with respect to the basic mandatory configuration proposed to satisfy the *Req 2-1 and Req 2-2*.

This improvement shall be equivalent to an extension of *reference mandrel* maximum length from 8 to 14 meters, included domes.

The overall length of rails will depend on the cell configuration (robot, head and creel) and on the feasible layup requirements, specifically on the reachability of domes of reference mandrel. All the above factors require an amount of extra length other than 14 meters.

The bidder shall clearly indicate the length of rails under the robot and under the positioner tailstock.

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The score assigned to the presence of the extended rails in the tender evaluation for the selection of supplier is described in chapter 6.1 *Method for evaluation of the technical offer*.

Req 2-6 Possible two-axis positioner	scoring functional add on
--------------------------------------	---------------------------

*This improvement requires the rails extension defined in the Req 2-5 Possible extended rails.*

*The bidder can include in the proposal this add on only in combination with the fulfilment of Req 2-5 Possible extended rails.*

The bidder can include in the proposed supply an extension of cell capability, adding to the basic configuration the two-axis KUKA positioner KP2-SV HW 5000 – with one rotational and one swivel axis – capable of supporting and moving an object weighing 5 tons.

The possible two-axis positioner to be considered shall be fixed on a platform moveable on the extended sliding rail used for the tailstock. The platform shall be not actuated and shall slide on the rail like the tailstock.

The sliding position of the two-axis positioner on the rail shall be external to the space between the headstock and the tailstock.

The possible two-axis positioner shall be alternatively used with respect to the horizontal positioner (headstock+tailstock), to layup complex shapes.

The possible two-axis positioner shall not be supposed to interfere physically with horizontal positioner basic performance included in the supply.

The possible two-axis positioner shall be controlled by the robotic cell controller, included in the supply.

The programming of the two-axis positioner shall be perfectly integrated in the software package of the basic supply.

The score assigned to the presence of the two-axis positioner in the tender evaluation for the selection of supplier is described in chapter 6.1 *Method for evaluation of the technical offer*.

### 2.3.2 Fiber Placement head

Req 2-7 Fiber Placement Head	mandatory, functional
------------------------------	-----------------------



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The bidder shall clearly describe the Fiber Placement Head configured for thermosets and thermoplastics by using pictures and drawings showing wherever possible detailed numerical quotes.

The bidder can propose a single physical device (head) with the two configurations (thermoset/thermoplastic), or even two separate physical devices (two interchangeable heads), each one for a single configuration (thermoset/thermoplastic).

The bidder shall clearly indicate, among other data,

1. the head parts
2. the dimensions
3. the volumes
4. the weight.

The description shall clearly cover *the different configurations* - if any - depending for example on:

1. the possible heating source selected for the thermoset/thermoplastic materials
2. the possible modularity of bobbins on board
3. the modularity of roller dimension in case of reduced number of tapes

showing the different quotes, volumes and derived limitations or advantages for the movement of the head.

Req 2-8 Number and size of tapes	mandatory, performance
----------------------------------	------------------------

The Fiber Placement Head shall be capable to place at least **8 prepreg slit tapes 1/4 inch large**, in parallel, both for thermoset and thermoplastic materials.

Req 2-9 Processable Materials	mandatory, performance
-------------------------------	------------------------

The head shall be capable to process

1. thermoset slit tape preregs
2. thermoplastic slit tape preregs:
  - a. PEEK thermoplastic carbon fiber preregs (for example APC2-PEEK (Solvay product), CETEX TC1200 PEEK (Toray))
  - b. PAEK thermoplastic carbon fiber preregs (for example CETEX TC1225 LM-PAEK (Toray))

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### 3. bindered dry fibers

The head shall be capable to process, by *in situ* consolidation, thermoplastic laminates in PEEK reaching a minimum required performance:

1. minimum porosity: 2.5 % in volume
2. minimum ILSS (InterLaminar Shear Strength): 40% less than nominal data sheet value (depending on the material supplier)

The bidder shall declare in the proposal the achievable performances of a laminate with PEEK obtained by in situ consolidation with the proposed head, without any postprocessing in oven or in autoclave.

The bidder shall declare in the proposal:

1. the temperature
2. the pressure
3. the layup max velocity
4. ILSS value
5. porosity

used for *in situ consolidation* of laminate with PEEK.

The bidder shall support this declaration of the achievable performance values by means of *available testing results from previous installation experiences*. In case no evidence will be provided, the requirement will be considered not met and the offer will be excluded from the competition.

Req 2-10 Compaction Roller	mandatory, functional
----------------------------	-----------------------

To have adhesion between the incoming slit tapes and substrate - tool surface or already laid down plies - the head shall be capable to compact locally the contact region by means of *a roller* acting on the tapes.

Short compaction slides can be added to the configuration with the roller.

The roller can be internally *segmented* to be more conformable.

The roller can contain metal interior parts, but the roller external part shall be polymeric, to be conformable as specified in *Req 2-15 Roller Conformability*.

The bidder shall clearly describe the compaction rollers used by the head, indicating

1. the internal structure
2. the different rollers choice - if any - for different materials to be laid up
3. the dimensions

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#### 4. the materials

Req 2-11 Possible modularity of roller dimension	scoring functional add on
--	---------------------------

The bidder can include in the proposed supply a modularity of roller dimension (width, along the meridian) in accordance with a possible reduction of number of tapes used in a process, aimed at the reduction as much as possible of lateral extra clutter with respect to the course band.

The additional score assigned to the presence of a modular roller dimension (width, along the meridian) in the tender evaluation for the selection of supplier is described in chapter 6.1 *Method for evaluation of the technical offer*.

Req 2-12 Roller refrigeration	mandatory, functional
-------------------------------	-----------------------

The roller shall be locally refrigerated by actively controlled systems.

The bidder shall describe:

1. the refrigerating system,
2. the actuators aimed at refrigeration
3. the sensors used to monitor the area involved in the refrigeration, declaring
  - a. the temperature range
  - b. the tolerances guaranteed by the controlled system.

Req 2-13 Possible tooling free maintenance	scoring functional add on
--	---------------------------

The bidder shall indicate clearly if the procedures for the ordinary operations of

1. inspection,
2. material loading and unloading,
3. blade substitution,
4. roller substitution,

can be done without any tooling (tool free maintenance).

The score assigned to the presence of Tooling free maintenance in the tender evaluation for the selection of supplier is described in chapter 6.1 *Method for evaluation of the technical offer*.

Req 2-14 Compaction Forces and Dynamic Compliance	mandatory, performance
---	------------------------

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The compaction force on the roller during layup shall be controlled and modulated at least up to 1200 N for a course with 8 slit tapes in parallel, within a dynamic compliance of  $\pm 5$  mm.

Req 2-15 Roller Conformability	scoring, performance
--------------------------------	----------------------

The roller shall be sufficiently conformable to apply a uniform pressure on each of the 8 parallel slit tapes of a course when placing the tapes along a meridian path on a cylindrical surface having a diameter of 300 mm.

The bidder shall describe the technical characteristics of roller and declare the expected pressure variation tolerance among the slit tapes in the above case, supporting this declaration of the achievable performance values by means of available testing results from previous installation experiences, or validated studies based on FEM simulations.

The additional score assigned to the *Roller Conformability* in the tender evaluation for the selection of supplier is described in chapter 6.1 *Method for evaluation of the technical offer*.

Req 2-16 Spare rollers	mandatory, functional
------------------------	-----------------------

**Ten** spare rollers, other than the basic set of rollers necessary to process thermoset and thermoplastics materials, shall be included in the supply.

The bidder shall describe the different spare rollers offered in terms of characteristics of the polymeric cover (material, shore A).

Req 2-17 Heating and temperature control	mandatory, functional
--	-----------------------

To have adhesion between the incoming slit tapes and substrate - tool or already laid up laminates - the head shall be capable to heat locally the contact region between them in a controlled way.

All the performances of heating and temperature field control around the nip point shall be compatible with the fulfilment of all mandatory functional and performance requirements, in particular with thermoset/thermoplastic material choice and maximum layup performance requirements.

*The heating system shall be able to produce (by radiation) at least 400°C temperature at nip point, at the maximum deposition speed, on a full 8 tapes course of thermoplastic prepregs slit tapes.*

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The heating system *cannot* include hot gas torch.

The heating system can include infrared and/or pulsed light and/or laser sources.

The bidder shall clearly describe

1. the heating system
2. the sensors and the sources used to control the area involved in the heating
3. the temperature range at the nip point vs placement velocity
4. the tolerances guaranteed by the control system
5. the power of sources
6. the necessity to mount/dismount heat sources, depending on the material choice.

Req 2-18 Heated area Modulation	mandatory, functional
---------------------------------	-----------------------

The heating system shall be capable to dynamically modulate the heating intensity and the width of the heated region, depending on the number of tapes involved in the deposition, from 1 to 8.

The bidder shall describe the system evidencing the modulation capability.

Req 2-19 Temperature field and other parameters monitoring system	mandatory, functional
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The cell shall have, included in the supply, a monitoring system to monitor the temperature field and other parameters during placement, in real time.

The monitoring system shall include all the necessary hardware and software to

1. acquire,
2. elaborate,
3. display and
4. store data

describing the temperature field on the placement area and other parameters, like velocity and pressure.

The bidder shall clearly describe the technical characteristics of the proposed temperature monitoring system with respect to the above functions.

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Req 2-20 Head Feeding	mandatory, functional
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The prepreg slit tapes shall be delivered to the head coming from a dedicated creel, under thermal control, through twist-free feeding tubes.

The creel cannot be in a fixed position on the floor.

The creel can be on board, on the head or on a link of the robot arm, or off board with respect to the robot, but following the robot on the track rail.

The creel system shall give to the operator the possibility to trace material data through bar code readers, storing information related to the length, the expiry date, the loading date, the real time residual length of single bobbin.

The bobbin packaging dimensions allowed in the creel shall include at the minimum

1. cardboard core inner diameter 76mm
2. cardboard core length range from 182 to 297 mm

The bidder shall clearly indicate the allowed packaging formats including

1. max bobbin diameter
2. max bobbin weight

Req 2-21 Creel temperature control	mandatory, functional
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The creel, the feeding tubes and the head parts hosting prepregs shall be under thermal control to maintain the prepreg refrigerated at constant temperature, adjustable at lower value than 15°C.

The temperature history in the creel shall be recorded and stored.

The bidder shall describe the refrigerating system, declaring

1. the maximum temperature range.
2. the tolerances guaranteed by the system.

### 2.3.3 Layup performances and monitoring

Req 2-22 Cut and restart	mandatory, performance
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The minimum deposition length for each fiber tape, placed on a flat surface, shall be less or equal to **105 mm**.

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The minimum distance between cutting and feeding for each fiber tape shall be less or equal to **10 mm**.

The bidder shall support this declaration of the achievable performance values by means of *available testing results from previous installation experiences*. In case no evidence will be provided, the requirement will be considered not met and the offer will be excluded from the competition.

Req 2-23 Possible angled cut	scoring functional add on
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The bidder can include in the proposed supply the possibility to have a variable angle of cut of tapes course (at least 4 tapes in parallel), during placement, from 90° to 10°.

It is supposed that the same angle used for a cut is taken on the material at the following restart.

It is supposed that the angle is continuously selectable from 90° to 10°.

The score assigned to the presence of an angled cut in the tender evaluation for the selection of supplier is described in chapter 6.1 *Method for evaluation of the technical offer*.

Req 2-24 Cut and restart improvement	scoring, performance
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A reduction of the minimum length between cuts and restarts has to be considered a performance improvement.

The bidder shall declare:

- the achievable minimum deposition length for thermoset fiber tape, placed on a flat surface at the velocity of 0.5 m/s
- the achievable minimum distance between cutting and feeding thermoset fiber tape at the velocity of 0.5 m/s

The additional score assigned to the *cut and restart improvement* in the tender evaluation for the selection of supplier is described in chapter 6.1 *Method for evaluation of the technical offer*.

The bidder shall support this declaration of the achievable performance values by means of *available testing results from previous installation experiences*. In case no evidence will be provided, the requirement will be considered not met.

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Req 2-25 Cutting blades – durability	mandatory, performance
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The bidder shall describe the cutting mechanism, explicitly declaring the *durability* of blades in terms of number of cuts before substitution, and the procedure to substitute them.

The number of cuts before substitution of a blade cannot be less than 20000.

The bidder shall support this declaration of the achievable performance values by means *of available maintenance or testing documentation from previous installation experiences*. In case no evidence will be provided, the requirement will be considered not met and the offer will be excluded from the competition.

Req 2-26 Cutting blades - durability improvement	scoring, performance
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The bidder shall declare the achievable number of cuts before blades substitution.

The additional score assigned to the *cutting blades improvement* in the tender evaluation for the selection of supplier is described in chapter 6.1 *Method for evaluation of the technical offer*.

The bidder shall support this declaration of the achievable performance values by means *of available maintenance or testing documentation from previous installation experiences*. In case no evidence will be provided, the requirement will be considered not met.

Req 2-27 Speed	mandatory, performance
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The maximum linear deposition speed possible while *starting the feeding* of fibers shall be not be less than 50 cm/s (with thermoset preregs).

The maximum linear deposition speed possible while *cutting* fibers shall not be less than 50 cm/s (with thermoset preregs).

The maximum linear deposition speed possible while *placing* shall not be less than 50 cm/s (with thermoset preregs).

The bidder shall support this declaration of the achievable performance values by means *of available testing results from previous installation experiences*. In case no evidence will be provided, the requirement will be considered not met and the offer will be excluded from the competition.



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Req 2-28 Speed improvement	scoring, performance
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The bidder shall declare the achievable value of linear deposition speed.

The additional score assigned to the speed improvement in the tender evaluation for the selection of supplier is described in chapter 6.1 *Method for evaluation of the technical offer*.

The bidder shall support this declaration of the achievable performance values by means of *available testing results from previous installation experiences*. In case no evidence will be provided, the requirement will be considered not met.

Req 2-29 Accuracy and repeatability	mandatory, performance
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The repeatability of cutting and feeding fibers on a flat surface at 50 cm/s shall be less than or equal to  $\pm 2\text{mm}$  for all the placed materials thermosets or thermoplastics.

The accuracy of cutting and feeding fibers on a flat surface at 50 cm/s shall be less than or equal to  $\pm 2.5\text{mm}$ .

The tolerance between parallel courses on a flat surface at 50 cm/s deposition speed for all the placed materials shall be less than  $+2.5/-0\text{ mm}$ .

The bidder shall support this declaration of the achievable performance values by means of *available testing results from previous installation experiences*. In case no evidence will be provided, the requirement will be considered not met and the offer will be excluded from the competition.

Req 2-30 Accuracy and repeatability improvement	scoring, performance
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The bidder shall declare the value of achievable:

1. repeatability of cutting and feeding fibers at 25 cm/s for all the placed materials.
2. accuracy of cutting and feeding fibers at 25 cm/s.
3. tolerance between parallel courses at 25 cm/s.

The additional score assigned to the accuracy and repeatability improvement in the tender evaluation for the selection of supplier is described in chapter 6.1 *Method for evaluation of the technical offer*.

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The bidder shall support this declaration of the achievable performance values by means *of available testing results from previous installation experiences*.

Req 2-31 Laying up on the <i>reference flat surface</i>	mandatory, performance
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The AFP Robotic Cell, as a whole, shall be capable to fully operate, laying up the thermoset and thermoplastic materials in optimal conditions at the maximum speed, on the *reference **flat** surface*, defined in chapter 2.1.

The bidder shall clearly describe in the proposal this operativity condition on the overall reference surface, by using off line simulations, pictures and drawings showing numerical quotes.

The supplier shall use the software referred in *Req 2-37 Path Planning, Req 2-38 Generation of programs, Req 2-39 Verification of programs*, to produce the offline simulations required.

The bidder shall support the declaration by means *of available testing results from previous installation experiences* showing experimental test cases as much as possible near to the required reference surface. In case no evidence will be provided, the requirement will be considered not met and the offer will be excluded from the competition.

Req 2-32 Laying up on the reference mandrel	mandatory, performance
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The AFP Robotic Cell, as a whole, shall be capable to fully operate, laying up the thermoset and thermoplastic materials in optimal conditions, at the maximum speed, on the *reference mandrel*, including domes and polar bosses, defined in chapter 2.1.

The bidder shall clearly describe in the proposal this operativity condition on the overall reference surface at the maximum dimensions defined in 2.1 (2.4 m diameter, 8 meters long, included domes with 0.3 meters polar bosses) by using off line simulations, pictures and drawings showing numerical quotes.

The bidder shall clearly describe in the proposal this operativity condition on the overall reference surface at the minimum dimensions defined in 2.1 (0.1 m diameter cylinder, without domes) by using off line simulations, pictures and drawings showing numerical quotes.

The supplier shall use the software referred in *Req 2-37 Path Planning, Req 2-38 Generation of programs, Req 2-39 Verification of programs* to produce the offline simulations required.

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The bidder shall support the declaration by means of *available testing results from previous installation experiences* showing experimental test cases as much as possible near to the required reference surface. In case no evidence will be provided, the requirement will be considered not met and the offer will be excluded from the competition.

Req 2-33 Laying up on the reference concave surface	mandatory, performance
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The AFP Robotic Cell, as a whole, shall be capable to fully operate, laying up the thermoset and thermoplastic materials in optimal conditions at the maximum speed, on the *reference concave surface*, defined in chapter 2.1.

The bidder shall clearly describe in the proposal this operativity condition on the overall reference surface, by using off line simulations, pictures and drawings showing numerical quotes.

The supplier shall use the software referred in *Req 2-37 Path Planning, Req 2-38 Generation of programs, Req 2-39 Verification of programs* to produce the offline simulations required.

The bidder shall support the declaration by means of *available testing results from previous installation experiences* showing experimental test cases as much as possible near to the required reference surface. In case no evidence will be provided, the requirement will be considered not met and the offer will be excluded from the competition.

Req 2-34 Laying up on the reference convex surface	mandatory, performance
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The AFP Robotic Cell, as a whole, shall be capable to fully operate, laying up the thermoset and thermoplastic materials in optimal conditions at the maximum speed, on the *reference convex surface*, defined in chapter 2.1.

The bidder shall clearly describe in the proposal this operativity condition on the overall reference surface, by using off line simulations, pictures, drawings showing numerical quotes.

The supplier shall use the software referred in *Req 2-37 Path Planning, Req 2-38 Generation of programs, Req 2-39 Verification of programs* to produce the offline simulations required.

The bidder shall support the declaration by means of *available testing results from previous installation experiences* showing experimental test cases as much as possible near to the required reference surface. In case no evidence will

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be provided, the requirement will be considered not met and the offer will be excluded from the competition.

Req 2-35 Possible quality monitoring system	scoring functional add on
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The bidder can include in the proposal a monitoring system to monitor the *quality of placement during layup*.

The monitoring system shall include all the necessary hardware and software to get, elaborate, show and store data *describing spatially the quality of layup placed on the surface, layer by layer*.

The hardware shall be completely integrated in the cell and shall not interfere with the functionality of the cell and movement of the AFP Head, mainly during the lay-up on the reference surfaces defined in chapter 2.1.

The bidder shall describe the technical characteristics of the proposed monitoring system, the sensors used and the collected data.

The bidder shall support where possible the description by means of *available testing results from previous installation experiences* showing experimental test cases monitored by the software.

The score assigned to the presence of the *quality monitoring system* in the tender evaluation for the selection of supplier is described in chapter 6.1 *Method for evaluation of the technical offer*.

#### 2.3.4 Control

Req 2-36 Control System	mandatory, functional
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The AFP Robotic Cell shall be controlled by a SIEMENS or Rockwell Automation system controller.

The bidder shall clearly indicate in the proposal

1. the model
2. the technical data of the proposed control system.

#### 2.3.5 Simulation, programming and quality monitoring software

Req 2-37 Path Planning	mandatory, functional
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The software package in the supply shall include an off-line optimal planning software for the definition of deposition paths on the tool surface, starting from the geometry of the surface given by a CATIA V model.

The bidder shall use the reference surfaces described in chapter 2.1 as indicated in Req 2-31, Req 2-32, Req 2-33, Req 2-34, to clearly describe in details the functionalities of the proposed software.

Req 2-38 Generation of programs	mandatory, functional
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The software package in the supply shall include a software for the automated generation of placement and movement programs to be executed by the overall robotic system included in the supply – contemporary movement of head, robot arm, linear track unit and horizontal positioner.

The bidder shall use the reference surfaces described in chapter 2.1 as indicated in Req 2-31, Req 2-32, Req 2-33, Req 2-34, to clearly describe in details the functionalities of the proposed software.

Req 2-39 Verification of programs	mandatory, functional
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The software package in the supply shall include a simulation software for the off-line verification of generated programs, before execution.

The bidder shall use the surfaces described in chapter 2.1 as indicated in Req 2-31, Req 2-32, Req 2-33, Req 2-34, to clearly describe in details the functionalities of the proposed software.

Req 2-40 Software capability to manage optional hardware	mandatory, functional
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The software of Req 2-38 Generation of programs, and Req 2-39 Verification of programs shall be able, without additional packages, to generate programs and to verify them applied to the complete cell configured with *the two-axis positioner included in the improvement described in Req 2-6 Possible two-axis positioner, even if those improvements were not included in the proposal.*

The bidder shall present a simulation case of placement on a spherical surface moved on a two-axis positioner (configuration equivalent to the one described in Req 2-6 Possible two-axis positioner) to clearly describe in details the software capability.

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## 2.4 Laser safety room

The Robotic Cell shall be integrated in a laser safety room, included in the supply.

This enclosure room is required as part of the supply even if the power source proposed for the heating (see Req 2-17 Heating and temperature control) were not a laser.

The laser safety room will be hosted in the hangar of a building called CEPROCAM.

In annex 1, the general layout of the hangar with the dimensions of the laser safety room reserved to the Robotic Cell are given.

The floor dimensions of the laser safety room will be 24m x 9,3 m.  
The room shall cover the entire floor.

CIRA will have in charge (not included in the supply):

- The concrete floor construction, under supplier declared characteristics (see *Req 2-1 Robot and linear track unit.* and *Req 2-2 External horizontal positioner*)
- HVAC unit for ventilation and air conditioning system, to be connected to the ducts in the safety room.

Air ducts and ventilation grids in the laser safety room are included in the supply, in charge of the supplier.

Req 2-41 Room Layout	mandatory, functional
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The bidder shall include a preliminary design of the laser safety room structure, including walls, roof, openings and doors, compliant to quotes referred in annex 1.

The bidder shall describe in the proposal the room layout, with all the parts included in the supply:

1. Control room, including an access to the AFP cell
2. Robotic Cell, with 6 meters rail extension
3. Openings, doors and windows

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- a. Door for loading 8m x 3,5m from the hangar
- b. Personnel access from the hangar in the safety room
- c. Personnel access from the hangar to the control room
- d. Personnel access from the control room to the safety room
- e. Windows on the hangar and control room
4. The characteristics of the floor (the floor construction is in charge to CIRA)
5. All boxes and utilities (lighting/laser power source cooler, air, electrical cabinet, etc.).

The layout shall be optimized, including possible rail extension and possible two-axis positioner (even if not necessarily included in the offer, see Req 2-6 Possible two-axis positioner, Req 2-4 Possibility of extension of rails).

Moreover, the layout shall include

1. Position of ventilation grids
2. Positioning of the split for air conditioner

Req 2-42 Laser Safety Room Characteristics	mandatory, functional
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The bidder shall describe in the proposal the technical characteristics of the room aimed at Laser Safety conditions, to shield operators acting outside the room from the radiation of **a high-power laser (class 4)**.

This protection is required as part of the supply even if the power source proposed for the heating (see Req 2-17 Heating and temperature control) is not a laser.

The description shall include safety characteristics of:

1. Walls and ceilings of the room (included sandwich panel and materials description)
2. Openings and doors (access, loading, section, swinging)
3. Windows (Specific laser protective)
4. Joints sealing (Lap joint, Baseboard, roof)
5. Ventilation Grids (folded sheets or baffle)
6. Holes sealing
7. Laser Safety system (laser source shutdown in case of open door or any other emergency)

Req 2-43 Roof	mandatory, functional
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The bidder shall describe in the proposal the technical characteristics of the roof of the laser safety room.

The roof shall have a walkable area only if necessary for the maintenance of possible equipment and ducts specific of the present supply such as the lighting, air ventilation and conditioning systems and/or any other utilities of laser safety room. A walkable area is not necessary for reasons other than that.

Req 2-44 Utilities	mandatory, functional
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The Laser Safety Room shall be equipped with the following services with delivery points in a position to be defined.

All the “service points” shall be completed with any needed connection (piping or cabling) to the CIRA utilities access points.

- Lighting of the room: minimum 500lux
- Adequate air ducts and ventilation grids for the ventilation and air conditioning system to connect to the HVAC unit located outside the hangar.
- N. 6 electrical wall mounted socket groups, each one including:
  - o N.1 wall socket single phase 16A
  - o N.1 wall socket three-phase 32A
  - o At least 4 wall sockets single phase 10A, including Schuko
- N. 6 compressed air wall mounted connection (Max 12 bar), derived from the compressed air line of CIRA, each one including:
  - o pressure regulator
  - o pneumatic lubricator
  - o female connector
- N. 6 wall mounted connection to vacuum line derived from the vacuum system of CIRA

The ventilation and air conditioning system HVAC unit shall be in charge to CIRA.

The air ducts and ventilation grids in the laser safety room shall be included in the supply.

Piping for air ventilation and vacuum as well as the terminations of the internal electrical distribution system, shall arrive at the battery limit just outside the laser safety room in positions to be agreed.



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## 2.5 Compliance to regulations

All the equipment as well as the Laser Safety Room have to be compliant with all the applicable regulations for safety and protection of the workers.

Req 2-45 CE certification and compliance with EU directives	mandatory, functional
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All devices must have the CE marking and the necessary declarations of compliance with EU directives.

Declarations of conformity must be provided, where applicable, for both the instrument and for any other component relating to it as well as for the AFP as a whole.

Req 2-46 Compliance with regulations on safety and protection of workers	mandatory, functional
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Laser Safety Room and AFP installations shall be done in compliance with all accident-prevention and safety regulations applicable. In this regard, the Contractor shall provide the Staff with the technical means, clothing and equipment required to work safely, paying particular attention to Personal Protective Equipment.

Req 2-47 Do No Significant Harm	mandatory, functional
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In compliance with the European principle of Do No Significant Harm to the environment (so-called DNSH), the components of any supplied computer shall be marked with the ISO type I eco-label, according to UNI EN ISO 14024 (e.g.: TCO Certified, EPEAT 2018, Blue Angel, TÜV Green Product Mark, or equivalent).

In the absence of this label, EnergyStar<sup>1</sup> certification and a declaration of conformity to the following regulations are required: Reach (Regulation (EC) n.1907/2006); RoHS (Directive 2011/65/EU and subsequent amendments) and electromagnetic compatibility (Directive 2014/30/EU).

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<sup>1</sup> As an alternative to EnergyStar certification, a declaration from the manufacturer certifying that the typical electricity consumption (Etec), calculated for each device offered, does not exceed the maximum necessary TEC (Etec-max) in line with what is described in Annex III of the EU GPP criteria.

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## 2.6 Transport, Installation and General Planning

### 2.6.1 Transport

Req 2-48 Transport	mandatory, functional
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The transport at CIRA and all the corresponding costs, including downloading on site at CIRA, shall be included in the supply.

The transport at CIRA installation site shall be under the full responsibility of the supplier.

All the tools, trolley, forklifts necessary to unload the parts at CIRA are in charge of the supplier.

Req 2-49 Transport Plan	mandatory, functional
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The bidder shall define and propose, as included in the supply, a detailed transportation schedule.

### 2.6.2 Installation at CIRA

Req 2-50 Installation	mandatory, functional
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The overall cell installation at CIRA, including the laser safety room and all the necessary utilities, shall be included in the supply.

The installation shall be under the full responsibility of the supplier.

All the corresponding installation costs are in charge of the supplier, included in the overall offer.

All the costs - for instruments, tools, manpower, travel and accommodation, permission and authorization from civil authority, safety - necessary for the installation shall be in full charge of the supplier, included in the overall offer.

Req 2-51 General planning	mandatory, functional
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The bidder shall define and propose, as included in the supply, a detailed supply schedule.

The supply, installation and acceptance shall be completed in **14 months**, from the reception of the purchase order and subject to CIRA final acceptance.

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**The overall time above mentioned is linked to the fundings constraints. For this reason, it is very important to respect this deadline.**

The bidder shall include in the proposed schedule at least the following phases:

- Final Design of the laser safety room structure and of the AFP cell, the lay-out definition, the utilities (electrical energy, pneumatic energy, HVAC unit, etc.)
- Pre-acceptance in-factory verifications
- Installation of the laser safety room
- AFP installation and final acceptance test at CIRA
- Training

## **2.7 Training**

Req 2-52 Training course contents	mandatory, functional
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The bidder shall describe contents proposed in the training course on site to be transferred to CIRA personnel.

Among the contents, the bidder shall include the procedures for

- the manoeuvre of robotic cell in manual mode by teach pendant
- the uploading and downloading of mandrel on the horizontal positioner
- the acquisition of tool surfaces for calibration
- the ordinary operations for the use of the head, uploading of materials in the creel, maintenance on blades, verification of fiber paths to the roller, maintenance on the rollers
- the use of software (simulation, generation and verification of programs, uploading and execution of programs)

Req 2-53 Training plan	mandatory, functional
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The bidder shall define, included in the supply, a detailed training plan on site at CIRA personnel for not less than 5 lesson days.

## **2.8 Warranty and Maintenance**

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Req 2-54 Warranty	mandatory, functional
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A full warranty, including on line assistance and programmed maintenance, both for hardware and software, for two years, shall be included in the supply.

The full warranty for two years shall cover, in case of failure not due to the user negligence, the costs of on-site maintenance for the full repairing, including personnel, travel, substitution of parts and parts costs.

Req 2-55 Maintenance plan	mandatory, functional
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The bidder shall define and propose, as included in the supply, a detailed ordinary maintenance plan for two years.

## 2.9 Documentation

Req 2-56 Documentation	mandatory, functional
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The bidder shall define and propose, as included in the supply, a detailed list of documents for

- the technical description of the full cell, including technical drawings
- the CE certification,
- DNSH documentation (for each possible computer),
- the warranty certificate,
- the safety certifications,
- the use and the ordinary maintenance of the cell,
- the installation and deinstallation procedures,
- the software user and reference manuals,
- the spare part list

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### 3 Acceptance Tests

To demonstrate compliance with the requirements and values stated in the proposal, the bidder shall implement, included in the supply, the verification matrix proposed by CIRA (see Table 1 - Pre-Acceptance and Acceptance Verification Matrix) to be carried out *partly in-factory*, on the preassembled AFP cell, and *partly on site* at CIRA, on the installed AFP cell.

For all the tests, the bidder shall define and propose an implementation method. *For some tests, CIRA test matrix in Table 1 includes some mandatory recommendations to be adopted in the implementation method.*

In many cases a simple verification (visual or documental) is required.

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**Table 1 - Pre-Acceptance and Acceptance Verification Matrix**

pre acceptance  type of verification	acceptance  type of verification	req type	Requirement	Parameters to be verified by check or test	Implementation recommendations
verification by document/inspection		mandatory, functional	Req 2-1 Robot and linear track unit.	Industrial KUKA anthropomorphic robot arm -the accuracy (declared in proposal) -the repeatability (declared in proposal) -the loading capacity (mass and momentum)	
verification by document	verification by test			Linear track unit - declared manufacturer and model - the accuracy (declared in proposal) - the repeatability (declared in proposal) - the linearity (declared in proposal) - the loading capacity (declared in proposal) the loading capacity (mass and momentum on the track unit) - the overall length of rail under the linear track unit - the net length of linear movement of the robot on the rail	test shall demonstrate at the minimum  - the accuracy (declared in proposal) - the repeatability (declared in proposal) - the linearity (declared in proposal) - the overall length of rail under the linear track unit - the net length of linear movement of the robot on the rail
verification by document	verification by test	mandatory, functional	Req 2-2 External horizontal positioner	Horizontal Positioner  -the manufacturer -the model -the accuracy -the repeatability -the loading capacity -the electric power -the maximum acceleration with the max reference mandrel -the clamping mechanism -the length of sliding rail -the minimum and the maximum distance achievable between headstock and tailstock -the linearity of sliding rail under the tailstock -the expected parallelism error of sliding rail under the tailstock with respect to the rail under the robot -the recessed configuration of the rail in the floor	test shall demonstrate at the minimum  - the accuracy (declared in proposal) - the repeatability (declared in proposal) - the linearity of sliding rail under the tailstock (declared in proposal) -the minimum and the maximum distance achievable between headstock and tailstock -the expected parallelism error of sliding rail under the tailstock with respect to the rail under the robot

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verification by document		mandatory, performance	Req 2-3 Stand-alone positioner performances	Maximum rotational speed of horizontal positioner 5 rpm (with mounted reference mandrel)	check shall be done on datasheet
verification by document		mandatory, functional	Req 2-4 Possibility of extension of rails	Possibility to extend the linear track rail (under robotic cell) without compromising the basic installation	
verification by document/inspection	verification by test	scoring functional add on	Req 2-5 Possible extended rails	Possible Extension of rails length for 6 meters, both for the linear track unit and for the sliding tailstock (extension of reference mandrel length from 8 to 14 meters).  - the overall length of rails under the robot and under the positioner tailstock in the basic configuration and in the extended one	test shall demonstrate at the minimum - the linearity of extended sliding rail under the tailstock (declared in proposal) - the minimum and the maximum distance achievable between headstock and tailstock - the expected parallelism error of sliding rail under the tailstock with respect to the rail under the robot
verification by document/inspection		scoring functional add on	Req 2-6 Possible two-axis positioner	Model KUKA positioner KP2-SV HW 5000  - controlled by the robotic cell controller - programming of the two-axis positioner perfectly integrated in the software package of the basic supply	
verification by document		mandatory, functional	Req 2-7 Fiber Placement Head	the head parts, -the dimensions, -the volumes, -the weight -the configurations: the possible heating source selected for the thermoset/thermoplastic materials the possible modularity of bobbins on board the modularity of roller dimension in case of reduced number of tapes	
verification by inspection		mandatory, functional	Req 2-8 Number and size of tapes	8 prepreg slit tapes 1/4 inch large, in parallel	
verification by test		mandatory, functional	Req 2-9 Processable Materials	The head shall be capable to process -thermoset slit tape prepregs -thermoplastic slit tape prepregs -bindered dry fibers  In situ consolidation of thermoplastic PEEK prepregs - interlaminar shear minimum (declared in the proposal) - minimum porosity (declared in the proposal)	Test  manufacturing trials of in situ consolidated samples of PEEK, tested for the interlaminar shear and porosity  other manufacturing trials with thermoset and bindered dry fibers
verification by inspection				- the temperature, - the pressure - the layup velocity used for in situ consolidation of laminate with the above materials	Check during manufacturing of trials

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verification by document/inspection		mandatory, functional	Req 2-10 Compaction Roller	<p>roller acting on the tapes.</p> <ul style="list-style-type: none"> <li>- possible short compaction slides can be added to the roller.</li> <li>- possible metal interior parts</li> <li>- polymeric external part</li> <li>- possible internal segmentation</li> <li>- possible different rollers choice for different materials to be laid up</li> <li>- dimensions</li> <li>- materials</li> </ul>	
verification by document/inspection		scoring functional add on	Req 2-11 Possible modularity of roller dimension	modularity of roller dimension (width, along the meridian) in accordance with a possible reduction of number of tapes	during manufacturing of trials
verification by document/inspection		mandatory, functional	Req 2-12 Roller refrigeration	<p>- roller locally refrigerated by actively controlled systems.</p> <ul style="list-style-type: none"> <li>-the refrigerating system,</li> <li>-the actuators aimed at refrigeration</li> <li>-the sensors</li> <li>-the temperature range</li> <li>-the tolerances</li> </ul>	during manufacturing of trials
verification by document/inspection		scoring functional add on	Req 2-13 Possible tooling free maintenance	<p>tool free maintenance ordinary operations of</p> <ul style="list-style-type: none"> <li>-inspection,</li> <li>-material loading and unloading,</li> <li>-blade substitution,</li> <li>-roller substitution</li> </ul>	
verification by test		mandatory, performance	Req 2-14 Compaction Forces and Dynamic Compliance	compaction force up to 1200 N for a course with 8 slit tapes dynamic compliance of $\pm 5$ mm.	testing results from previous installation experiences or, in alternative, test execution
	verification by test	scoring performance	Req 2-15 Roller Conformability	<p>uniform pressure on 8 parallel tapes placed on a meridian path on a 300 mm diameter cylinder</p> <p>the expected pressure variation tolerance among the slit tapes in the above case, as declared in the proposal.</p>	<p>Test</p> <p>test shall demonstrate at the minimum the variation of thickness on a thin elastic substrate between the roller and a cylindrical mandrel or on a pressure sensitive tape.</p>
verification by inspection		mandatory, functional	Req 2-16 Spare rollers	Ten spare rollers included in the supply	
verification by test		mandatory, functional	Req 2-17 Heating and temperature control	<p>infrared and/or pulsed light and/or laser sources</p> <ul style="list-style-type: none"> <li>-the sensors and the sources used to control the area involved in the heating</li> <li>-the temperature range at the nip point</li> <li>-tolerances</li> <li>-power of sources</li> <li>-the necessity to mount/dismount them, depending on the material</li> </ul>	during manufacturing of trials



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				<p>choice.</p> <p>capability to produce by radiation 400°C temperature at nip point, at the maximum deposition speed, on a full 8 tapes course of thermoplastic prepregs slit tapes</p>	
verification by test		mandatory, functional	Req 2-18 Heated area Modulation	-modulation of the heating intensity and the largeness of the heated region, depending on the number of tapes involved in the deposition, from 1 to 8.	during manufacturing of trials
verification by inspection		mandatory, functional	Req 2-19 Temperature field and other parameters monitoring system	<p>a monitoring system to monitor the temperature field and other parameters during placement.</p> <p>Capability to</p> <ul style="list-style-type: none"> <li>-acquire,</li> <li>-elaborate,</li> <li>-display and</li> <li>-store data</li> </ul> <p>describing the temperature field on the placement area</p>	during manufacturing of trials
verification by inspection		mandatory, functional	Req 2-20 Head Feeding	<p>creel:</p> <ul style="list-style-type: none"> <li>-thermal control</li> <li>-creel on board, on the head or on a link of the robot arm, or off board following the robot on the track rail.</li> <li>- the possibility to trace material data through bar code readers, storing information related to the length, the expiry date, the loading date, the real time residual length of single bobbin.</li> </ul> <p>- bobbin packaging dimensions allowed in the creel shall include at the minimum</p> <p>cardborad core inner diameter 76mm</p> <p>cardborad core length range from 182 to 297 mm</p> <p>- max bobbin diameter</p> <p>- max bobbin weight</p>	during manufacturing of trials
verification by inspection		mandatory, functional	Req 2-21 Creel temperature control	<p>The creel, the feeding tubes and the head parts hosting prepregs refrigerated at constant temperature, adjustable at lower value than 15°C.</p> <p>Recording of temperature history in the creel</p> <p>The maximum temperature range (declared in proposal)</p> <p>The tolerances guaranteed by the system (declared in proposal)</p>	during manufacturing of trials

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verification by test		mandatory, performance	Req 2-22 Cut and restart	The minimum length of individual thermoset fiber tape placed after a single cut less or equal to 105 mm.  The minimum distance between cutting and feeding of an individual thermoset fiber tape less or equal to 10 mm.	during manufacturing of trials
verification by test		scoring functional add on	Req 2-23 Possible angled cut	a variable angle of cut of tapes course (up to 8 tapes in parallel), during placement, from 90° to 10°, applied to each tape of the course and to the course itself	Manufacturing of specific trials to demonstrate the variable angle cut on a flat surface
verification by test		scoring, performance	Req 2-24 Cut and restart improvement	the achievable minimum length of individual thermoset fiber tape placed on a flat surface, after a single cut, at the velocity of 0.5 m/s (declared in proposal)	Manufacturing of specific trials to demonstrate the variable angle cut on a flat surface
				the achievable minimum distance between cutting and feeding thermoset fiber tape at the velocity of 0.5 m/s (declared in proposal)	
verification by document /inspection		mandatory, performance	Req 2-25 Cutting blades – durability	number of cuts before substitution of blade cannot be less than 20000	testing results from previous installation experiences or, in alternative, test execution
verification by document/ inspection		scoring, performance	Req 2-26 Cutting blades - durability improvement	achievable number of cuts before blades substitution (declared)	testing results from previous installation experiences or, in alternative, test execution
verification by test		mandatory, performance	Req 2-27 Speed	The maximum linear deposition speed while starting the feeding of fibers not less than 50 cm/s (with thermoset prepregs).	during manufacturing of trials
				The maximum linear deposition speed while cutting fibers not less than 50 cm/s (with thermoset prepregs).	
				The maximum linear deposition speed shall not less than 50 cm/s (with thermoset prepregs).	
verification by test		scoring, performance	Req 2-28 Speed improvement	linear deposition speed (declared in proposal)	during manufacturing of trials
verification by test		mandatory, performance	Req 2-29 Accuracy and repeatability	The repeatability of cutting and feeding fibers on a flat surface at 50 cm/s less than or equal to ±2mm for all the placed materials.	during manufacturing of trials
				The accuracy of cutting and feeding fibers on a flat surface at 50 cm/s less than or equal to ±2.5mm.	
				The tolerance between parallel courses on a flat surface at 50 cm/s deposition speed for all the placed materials less than +2.5/0 mm	
verification by test		scoring, performance		repeatability of cutting and feeding fibers at 25 cm/s for all the placed materials (declared in proposal)	Manufacturing of specific trials

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			Req 2-30 Accuracy and repeatability improvement	accuracy of cutting and feeding fibers at 25 cm/s (declared in proposal)	Manufacturing of specific trials
				tolerance between parallel courses at 25 cm/s. (declared in proposal)	Manufacturing of specific trials
verification by test	verification by test	mandatory, performance	Req 2-31 Laying up on the reference flat surface	The AFP Robotic Cell, as a whole, shall be capable to fully operate, laying up the thermoset and thermoplastic materials in optimal conditions at the maximum speed, on the reference flat surface, defined in 5.1 Reference feasible objects.	The experimental in pre-acceptance test shall be as much as possible near to the required in terms of surface dimensions.  The acceptance test shall verify the correct installation by means of accuracy and linearity measurements on the overall cell, with the fiber placement head mounted on it, in the full operative space.  If possible, CIRA will make available a flat surface
verification by test	verification by test	mandatory, performance	Req 2-32 Laying up on the reference mandrel	The AFP Robotic Cell, as a whole, shall be capable to fully operate, laying up the thermoset and thermoplastic materials in optimal conditions, at the maximum speed, on the reference mandrel, defined in 5.1 Reference feasible objects.	The experimental test in pre-acceptance shall be as much as possible near to the required in terms of surface dimensions  For acceptance tests CIRA will make available some mandrels.
verification by test		mandatory, performance	Req 2-33 Laying up on the reference concave surface	The AFP Robotic Cell, as a whole, shall be capable to fully operate, laying up the thermoset and thermoplastic materials in optimal conditions at the maximum speed, on the reference concave surface, defined in 5.1 Reference feasible objects.	The experimental test shall be as much as possible near to the required in terms of surface dimensions
verification by test	verification by test	mandatory, performance	Req 2-34 Laying up on the reference convex surface	The AFP Robotic Cell, as a whole, shall be capable to fully operate, laying up the thermoset and thermoplastic materials in optimal conditions at the maximum speed, on the reference convex surface, defined in 5.1 Reference feasible objects.	The experimental test in pre-acceptance shall be as much as possible near to the required in terms of surface dimensions  For acceptance tests CIRA will make available some mandrels.
verification by test		scoring functional add on	Req 2-35 Possible quality monitoring system	monitoring system hardware and software capability to - Acquire - Elaborate - display - store data describing spatially the quality of layup placed on the surface, layer by layer.	during manufacturing of trials
verification by document/inspection		mandatory, functional	Req 2-36 Control System	unique SIEMENS controller.  The bidder shall clearly indicate in the proposal the model the technical data of the proposed control system.	
Verification by inspection		mandatory, functional	Req 2-37 Path Planning	The software package in the supply shall include an off line optimal planning software for the definition of deposition paths on the tool	Check shall be done during manufacturing tests.

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				surface, starting from the geometry of the surface given by a CATIA V model.	
Verification by inspection		mandatory, functional	Req 2-38 Generation of programs	The software package in the supply shall include a software for the automated generation of placement and movement programs to be executed by the robotic system included in the supply - consisting of head, robot arm, linear track unit and horizontal positioner – supposed to be active in case of rotating mandrel.	Check shall be done during manufacturing tests.
Verification by inspection		mandatory, functional	Req 2-39 Verification of programs	The software package in the supply shall include a simulation software for the off line verification of generated programs, before execution.	Check shall be done during manufacturing tests.
Verification by document/ inspection		mandatory, functional	Req 2-40 Software capability to manage optional hardware	The software of Req 6 34 Generation of programs, and Req 6 35 Verification of programs shall be able, without additional packages and costs, to generate programs and to verify them applied to the complete cell configured with the two-axis positioner included in the improvement described in Req 6 15 Possible two-axis positioner	Check shall be done during manufacturing tests.
Verification by document	Verification by document/ inspection	mandatory, functional	Req 2-41 Room Layout	<p>The bidder shall include a preliminary design of the laser safety room structure, including walls, roof, opening on the roof, openings and doors, compliant to quotes referred in annex 1.</p> <p>the room layout described in the proposal, with all the parts included in the supply:</p> <ul style="list-style-type: none"> <li>- Control room, including an access to the AFP cell</li> <li>- Robotic Cell, with rail extension (even if optional)</li> <li>- Openings, doors and windows</li> </ul> <p>door for loading 8m x 3,5m from the hangar Door for access from the hangar in the safety room Door for access from the hangar to the control room</p> <ul style="list-style-type: none"> <li>- Door for access from the control room to the safety room</li> </ul> <ul style="list-style-type: none"> <li>- All boxes and utilities (lighting/laser power source cooler, air, electrical cabinet, etc..).</li> <li>- Position of ventilation grids</li> <li>- Positioning of the split for air conditioner</li> </ul>	<p>In pre-acceptance Check of matching between the executive project and what declared in the proposal</p> <p>In acceptance Check of matching between the real installed room and the executive project</p>
Verification by document	Verification by document/ inspection	mandatory, functional	Req 2-42 Laser Safety Room Characteristics	<p>Class 4 laser safety room characteristics of:</p> <ul style="list-style-type: none"> <li>- Walls and ceilings of the room (included sandwich panel and materials description)</li> <li>- Openings and doors (access, loading, section, swinging)</li> </ul>	<p>In pre-acceptance Check of matching between the executive project and what declared in the proposal</p> <p>In acceptance</p>

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				<ul style="list-style-type: none"> <li>- Windows (Specific laser protective)</li> <li>- Opening on the roof (motorized hatch)</li> <li>- Joints sealing (Lap joint, Baseboard, roof)</li> <li>- Ventilation Grids (folded sheets or baffle)</li> <li>- Holes sealing</li> <li>- Laser Safety system (laser source shutdown in case of open door or any other emergency)</li> </ul>	Check of matching between the real installed room and the executive project
Verification by document	Verification by document/ inspection	mandatory, functional	Req 2-43 Roof	<p>The roof shall have:</p> <ul style="list-style-type: none"> <li>- A motorized hatch (on the roof) - access area from the roof corresponding to the positioner area (between headstock and tailstock)</li> <li>- Dimension of the hatch in the roof shall be at least 8m x 3m.</li> <li>- Configuration with a rollable, or foldable, or sliding roof.</li> </ul> <p>Walkable area if necessary for the maintenance</p>	<p>In pre-acceptance Check of matching between the executive project and what declared in the proposal</p> <p>In acceptance Check of matching between the real installed room and the executive project</p>
Verification by document	Verification by document/ inspection	mandatory, functional	Req 2-44 Utilities	<ul style="list-style-type: none"> <li>- Lighting of the room: minimum 500lux</li> <li>- Adequate air ducts and ventilation grids</li> <li>- N. 6 electrical wall mounted socket groups</li> <li>- N. 6 compressed air wall mounted connection</li> <li>- N. 6 wall mounted connection</li> </ul>	<p>In pre-acceptance Check of matching between the executive project and preliminary design declared in the proposal</p> <p>In acceptance Check of matching between the real installed room and the executive project</p>

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### 3.1 In-factory pre-acceptance Tests

Req 3-1 Pre-acceptance verifications	mandatory, functional
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The bidder shall define and propose, included in the supply, the implementation methods corresponding to the pre-acceptance tests in the Test Matrix in Table 1, accepting CIRA recommendations where expressed.

The tests and checks shall be *executed in factory* on the preassembled AFP cell which will then be installed at CIRA.

All the costs of testing execution in factory shall be included in the supply.

CIRA personnel will be free to witness testing phase in factory.  
Travel and accommodation costs for CIRA personnel will not be included in the supply.

Once the tests and checks will have been executed, the supplier shall submit to CIRA test reports for acceptance.

### 3.2 Acceptance verifications at CIRA site

Req 3-2 Acceptance verifications	mandatory, functional
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The bidder shall define and propose, included in the supply, the implementation methods corresponding to the acceptance tests in the Test Matrix in Table 1, accepting CIRA recommendations where expressed.

The tests and checks shall be *executed on site at CIRA* on the installed AFP cell, to verify the proper installation and to complete the demonstration of achievement of stated performances.

CIRA will make available some *test mandrels with characteristics compatible with reference feasible objects defined in chapter 2.1*.

The test matrix proposed by the bidder shall include manufacturing tests on CIRA test mandrels.

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The bidder shall define in the technical proposal all the instruments and other tools to be used for testing in case of selection as a supplier. All the costs of testing on site at CIRA shall be included in the supply.

CIRA personnel will witness the testing activities.  
Once the tests and checks have been completed, within 10 (ten) working days the supplier shall submit the test reports to CIRA for acceptance.

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## 4 Administrative aspects

All administrative documentation towards CIRA must explicitly contain the following applicability:

*laboratori per la PROtotipizzazione e CARatterizzazione di Materiali ed Integrazione di Dimostratori Aerospaziali”, finanziato dal Piano Nazionale di fondi Complementari (PNC) al Piano Nazionale di Ripresa e Resilienza (PNRR) a valere sull’Avviso pubblico per la candidatura di idee progettuali Decreto del Direttore Generale dell’Agenzia per la Coesione Territoriale n. 204/2021, CUP n° E49D22000570001.*

### 4.1 Milestone and payments for work progress

Payments will be made based on the achievement of the following milestones.

Layout studies acceptance – 20%	The layout will be defined along with all the dimensions, interfaces (mechanical, electrical, etc) and any further detail needed for the proper installation of the Fiber placement system and related laser proof room. The milestone will be achieved when CIRA has accepted the "layout study report".
In-factory pre-acceptance – 30%	The milestone will be achieved when CIRA has accepted: 1. the “In-factory verifications report”; 2. the detailed GANTT chart planning and scheduling the installation activities.
Delivery – 20%	The milestone will be achieved when all the components have reached the CIRA premise where the system shall be installed.
Final Acceptance at CIRA – 30%	The milestone will be achieved when CIRA has accepted the “Final verifications report”.

### 4.2 Subcontracting

Subcontracting is allowed.

The contractor remains in any case responsible towards CIRA for the execution of the subcontracted works, relieving CIRA itself from any claims from the subcontractors or from requests for compensation for damages made by third parties as a result of the execution of subcontracted works.



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#### **4.3 Penalties**

In case of failure to respect the deadline established for completing the works, for each consecutive natural day of delay a penalty equal to 1 ‰ (one per thousand) of the contractual amount will be applied.

The application of penalties does not prejudice the compensation of any damages or further costs incurred by CIRA due to delays.

#### **4.4 Termination of the contract**

Any delay attributable to the contractor in respecting the deadlines for completing the supply, installation and acceptance exceeding 45 (forty-five) consecutive calendar days results in the termination of the contract at the discretion of CIRA and without the obligation of further motivation, pursuant to article 122 of the Italian Legislative Decree n. 36/2023.

#### **4.5 Revision of the valuable consideration**

If increases or decreases in the cost of materials and/or labor occur such as to determine an increase or decrease in the expected considerations exceeding 5% of the total amount, the price revision will be applied to the extent of 80% of the variation itself.

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## 5 ANNEX 1 – General layout of the hangar hosting the laser safety room reserved to the Robotic Cell

