

## Technical Annex

**STEP – I&D&I Empresarial – Digital e Biotecnologia - Operações em Copromoção**

**STEP – Business R&D&I – Digital and Biotechnology - Collaborative  
Projects**

**CALL    MPr-2026-2**

## Index

|                                                                                                                                                                             |    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| Project Acronym and title:                                                                                                                                                  | 3  |
| Executive Summary                                                                                                                                                           | 3  |
| 1. Project Description                                                                                                                                                      | 5  |
| 1.1. Rationale and context                                                                                                                                                  | 5  |
| 1.2. Objectives and methodology                                                                                                                                             | 10 |
| 1.3. Technical and Financial Maturity                                                                                                                                       | 13 |
| 2. Implementation Capacity                                                                                                                                                  | 14 |
| 2.1. Consortium description                                                                                                                                                 | 14 |
| 2.2. Identification of Activities                                                                                                                                           | 20 |
| 2.3. Description of Activities                                                                                                                                              | 21 |
| 2.4. Summary table of deliverables                                                                                                                                          | 33 |
| 2.5. Summary table of milestones                                                                                                                                            | 36 |
| 2.6. Description of critical risks for Project Management                                                                                                                   | 37 |
| 2.7. Project Management                                                                                                                                                     | 39 |
| 3. Impact                                                                                                                                                                   | 39 |
| 3.1. Economic and/or business impact                                                                                                                                        | 39 |
| 3.2. If applicable, justify (quantifying) the project's contribution to reducing or preventing strategic dependencies of the EU in one or more of the following dimensions: | 41 |
| ANNEX 1 - List of risk events                                                                                                                                               | 43 |

**Project Acronym and title:** SHOE.AI: AI-driven Cyber-Physical Factory for Flexible Footwear Manufacturing

**Executive Summary**

SHOE.AI - AI-driven Cyber-Physical Factory for Flexible Footwear Manufacturing - is a 36-month collaborative R&D&I project that develops and validates an integrated set of AI, robotics, laser and digital-twin technologies to transform leather footwear production into a smart, flexible and sustainable cyber-physical manufacturing system.

The project addresses a critical gap: while Portugal is the world's third-largest footwear exporter by value, factories rely heavily on manual operations for quality inspection, handling, assembly and roughing - processes that are labour-intensive, quality-variable and difficult to scale for short production runs. The EU also faces growing strategic dependencies on Asian manufacturing capacity.

SHOE.AI proposes a single, coherent development line - the AI-powered cyber-physical footwear factory - structured around four Product and Process Systems (PPS):

PPS1 - Cognitive Design and Deep Vision (led by MIND): AI algorithms for computer vision, generative design, defect detection, augmented reality and nesting optimisation, advancing from TRL 3 to TRL 6.

PPS2 - AI Robotics, Vision and Laser (led by DCSI PRO): three AI-branded factory facilities - DCSI AI Vision Factory (industrial vision systems and inspection software), DCSI AI Robotic Factory (tooling, manipulation and assembly for flexible materials) and DCSI AI Laser Lab (3D roughing, engraving and parameter validation) - advancing from TRL 3 to TRL 6.

PPS3 - Quality Gates and System Integration (led by DCSI PRO): integration of all PPS outputs into Quality Gate stations and full validation at two industrial sites - CARITÉ (leading beneficiary, full demonstrator site, project management) and RODIRO (modular QG on existing lines) - advancing from TRL 6 to TRL 8.

PPS4 - Digital Twin and Factory Optimisation (led by OLIFEL): development of FOOTWEAR TWIN (operational digital twin of the upper-injection line) and OPTIMIZE (AI engine for planning, re-planning and industrial optimisation), integrated into the OLIFEL ERP - advancing from TRL 3 to TRL 6, with industrial validation at TRL 7–8.

The consortium brings seven complementary partners: CTCP (coordination, state of the art, AI and computer vision research, robotics experimentation, digital twin validation, materials testing, dissemination), MIND (AI/CV/AR software), DCSI PRO (robotics, vision, laser), OLIFEL (digital twin, ERP), INESC TEC (research support), CARITÉ (leading beneficiary, full demonstrator, management) and RODIRO (modular demonstrator with productive innovation).

The project comprises 9 activities and 41 tasks across five phases: (1) foundation (A1), (2) research and development (A2-A4, TRL 3→6), (3) integration and validation (A5-A6, TRL 6→8), (4) productive innovation (A7), and (5) dissemination and management (A8-A9).

SHOE.AI targets the STEP domains of AI technologies, robotics and autonomous systems, and advanced digital technologies, directly contributing to the EU's strategic autonomy in manufacturing and to the safeguarding of the European footwear value chain.

|                                     |                                   |
|-------------------------------------|-----------------------------------|
| <b>Leading project beneficiary:</b> | CARITÉ - Fábrica de Calçado, Lda. |
|-------------------------------------|-----------------------------------|

|                                                         |   |
|---------------------------------------------------------|---|
| <b>1 – Total number of project beneficiaries (2+3):</b> | 7 |
| <b>2 - Companies</b>                                    | 5 |
| <b>3 – Research Performing Organisations (RPO's)</b>    | 2 |
| <b>4 - Partners:</b>                                    | 0 |

|                           |            |
|---------------------------|------------|
| <b>Start Date:</b>        | 01/01/2027 |
| <b>End Date:</b>          | 31/12/2029 |
| <b>Duration (months):</b> | 36         |

|                             |                 |
|-----------------------------|-----------------|
| <b>Eligible Investment:</b> | 18.374.486,10 € |
|-----------------------------|-----------------|

#### List of project beneficiaries

| No. | Legal designation                                                                    | Abbrev.  | Entity Profile | RPO | Public/<br>Private |
|-----|--------------------------------------------------------------------------------------|----------|----------------|-----|--------------------|
| 1   | CARITÉ - Fábrica de Calçado, Lda                                                     | CARITÉ   | Company        | No  | Private            |
| 2   | RODIRO - Fábrica de Calçado, S.A.                                                    | RODIRO   | Company        | No  | Private            |
| 3   | DCSI PRO, Lda.                                                                       | DCSI PRO | Company        | No  | Private            |
| 4   | OLIFEL - Software & IT Solutions, Lda.                                               | OLIFEL   | Company        | No  | Private            |
| 5   | MIND - Software Multimédia e Industrial, S.A.                                        | MIND     | Company        | No  | Private            |
| 6   | INESC TEC - INSTITUTO DE ENGENHARIA DE SISTEMAS E COMPUTADORES, TECNOLOGIA E CIÊNCIA | INESCTEC | Entity         | Yes | Private            |

|   |                                           |      |                                     |     |         |
|---|-------------------------------------------|------|-------------------------------------|-----|---------|
| 7 | Centro Tecnológico do Calçado de Portugal | CTCP | Centre of Technology and Innovation | Yes | Private |
|---|-------------------------------------------|------|-------------------------------------|-----|---------|

## 1. Project Description

### 1.1. Rationale and context

(relevant information for the assessment of sub-criteria A1, D2 and D3)

SHOE.AI addresses a single development line: the AI-powered cyber-physical factory for flexible footwear manufacturing. The footwear sector remains one of the least automated in European manufacturing because natural leather is a non-rigid, anisotropic material with variable thickness, grain, elasticity and surface characteristics. This variability defeats conventional automation: critical operations - quality inspection, colour classification, part nesting, component handling, roughing and assembly - remain manual, limited by operator fatigue, subjectivity and lack of digital traceability.

AI and computer vision bridge this gap: trained models interpret leather variability as structured information - distinguishing defects from acceptable grain variation, classifying colour zones and generating optimal nesting layouts. Coupled with industrial vision hardware, AI transforms sensor data into production intelligence. Vision-guided robotics enables adaptive manipulation of flexible materials, compensating for deformation in real time. AI-assisted laser processing enables precise roughing via automatic 3D path generation and surface analysis, replacing manual methods.

The project targets the transformation of labour-intensive leather footwear production into a smart manufacturing system through integrated development of AI, computer vision, robotics, laser and digital twin technologies within a single cyber-physical architecture.

The Portuguese footwear sector exported 90% of production to 170 countries (67 million pairs in 2024), with leather goods reaching an all-time high of €350M (+8.5%). Despite world-class product quality, the sector must adopt digital tools and flexible production technologies to maintain competitiveness against emerging markets, overcome labour shortages and respond to dynamic market demands.

The APICCAPS 2030 Strategic Plan defines the sector strategy through 4 Axes. Axis 3 - Flexibility and Speed of Response - is directly relevant, with measures on process

modernisation, automation, new methods and digitalisation, and actions including virtual models, co-creation tools, rapid prototyping, quality control systems, cutting systems and shop-floor digitalisation. The project also aligns with Norte RIS3 priorities for advanced manufacturing and digital transformation of traditional industries.

The specific industrial needs driving SHOE.AI are: (i) quality inspection - currently visual, achieving ~85% defect detection with inter-operator variability, fatigue effects and no piece-level traceability; physical ink markings cause waste and prevent digital integration; (ii) material handling - no commercial robotic solution exists for autonomous pick-and-place of post-cutting leather parts; the research challenge lies in grippers, vacuum systems and vision-guided adaptive manipulation compensating for deformation while preserving surface quality; (iii) roughing - mechanical or basic laser systems requiring manual path programming per model; AI-assisted laser roughing with automatic 3D path generation is unavailable in current systems, and laser safety (exhaust, purification, emission characterisation) requires dedicated validation; (iv) production planning - small-batch, high-mix production exceeds traditional ERP capabilities; current systems are transactional, cannot simulate scenarios, anticipate bottlenecks or dynamically re-plan; generic AI/DT platforms lack footwear-specific domain knowledge. Moreover, the footwear data ecosystem is characterised by ERP and MES data silos and disconnected legacy systems [Pystina], limiting the availability of high-fidelity data required for advanced AI training. An industrial Digital Twin emerges as the necessary enabler - a 'Single Source of Truth' filling the void where a consistent digital counterpart does not yet exist, establishing a continuous feedback loop between design and manufacturing data [Ramos et al., 2026; Qiang et al., 2023]; (v) system integration - no interoperable digital backbone connects inspection, assembly and planning processes.

These needs align with the APICCAPS 2030 Strategic Plan (Axis 3), and the European Commission's priorities for manufacturing sovereignty in critical technology sectors.

SHOE.AI aligns with STEP under 'Digital technologies and deep technology innovation', operating across three technology domains:

1. AI Technologies - CV algorithms for leather defect detection (T2.1, T2.3), generative AI for design (T2.2), AI-optimised nesting (T2.6), predictive quality models (T4.6), and OPTIMIZE AI engine for production planning (T4.5). Corresponds to 'Algoritmos de IA; visão computacional; tecnologias de análise de dados' in Annex E.
2. Robotics and Autonomous Systems - Robotic tooling for flexible material handling (T3.2), robotic assembly (T3.2), and integrated robotic cells for Quality Gates (T5.1, T5.2). Corresponds to 'Robôs e sistemas de precisão controlados por robôs' in Annex E.

3. Advanced Digital Technologies - FOOTWEAR TWIN operational digital twin (T4.3, T4.4), IoT synchronisation, AR for design validation and part picking (T2.4, T2.5), and laser systems with AI kinematics (T3.3). Corresponds to 'Internet das Coisas e realidade virtual' in Annex E.

The project qualifies as deep technology innovation (Annex D point (f)): it creates transformative solutions combining advances in the physical sphere (robotics, laser, sensors), digital sphere (AI, digital twins, AR) applied to traditional manufacturing (leather footwear). The integration of these three pillars into a single cyber-physical factory system defines the project.

SHOE.AI aligns with STEP under 'Digital technologies and deep technology innovation', operating across three technology domains:

1. AI Technologies - CV algorithms for leather defect detection (T2.1, T2.3), generative AI for design (T2.2), AI-optimised nesting (T2.6), predictive quality models (T4.6), and OPTIMIZE AI engine for production planning (T4.5). Corresponds to 'Algoritmos de IA; visão computacional; tecnologias de análise de dados' in Annex E.

2. Robotics and Autonomous Systems - Robotic tooling for flexible material handling (T3.2), robotic assembly (T3.2), and integrated robotic cells for Quality Gates (T5.1, T5.2). Corresponds to 'Robôs e sistemas de precisão controlados por robôs' in Annex E.

3. Advanced Digital Technologies - FOOTWEAR TWIN operational digital twin (T4.3, T4.4), IoT synchronisation, AR for design validation and part picking (T2.4, T2.5), and laser systems with AI kinematics (T3.3). Corresponds to 'Internet das Coisas e realidade virtual' in Annex E.

The project qualifies as deep technology innovation (Annex D point (f)): it creates transformative solutions combining advances in the physical sphere (robotics, laser, sensors), digital sphere (AI, digital twins, AR) applied to traditional manufacturing (leather footwear). The integration of these three pillars into a single cyber-physical factory system defines the project.

SHOE.AI contributes to both STEP objectives:

Objective 1 - Strengthening EU strategic autonomy: The project develops an end-to-end suite of AI, robotics and digital twin technologies from TRL 3 to TRL 8, enabling European manufacturers to compete on flexibility and quality without dependence on non-EU automation suppliers. All key components are developed by EU-based

consortium members, ensuring IP and know-how remain in Europe. This directly supports the EU Digital Decade 2030 target of 75% of European businesses adopting advanced digital technologies, and addresses Europe's significant private funding gap in AI and robotics compared to the US and China [Curry et al., 2026]. Productive innovations by RODIRO (robotic lines, QC lab, software - T7.2) and CARITÉ (laser robot, roughing line, injection machine - T7.2) demonstrate the scalability pathway.

Objective 2 - Safeguarding the value chain: European footwear production faces structural pressure from low-cost competitors and shorter production cycles. SHOE.AI strengthens the value chain at three intervention points: (a) upstream quality control (AI vision + Quality Gates), (b) core assembly (robotic cells + laser roughing), and (c) factory orchestration (digital twin + OPTIMIZE). CARITÉ and RODIRO serve as demonstrators for full and modular integration respectively.

Summarise the information described above on the table below:

| Development Line                                                      | Value Chain intervention                                                                                          | Type of intervention (per Annex D (a) of the Call)                              | R&D actions                                            | Innovative Productive Investment Assets                                                                                                                |
|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| AI-powered cyber-physical factory for flexible footwear manufacturing | Upstream quality control (AI vision);<br>Core assembly (robotics, laser);<br>Factory orchestration (digital twin) | Development and manufacturing of critical technologies (Art. 2 STEP Regulation) | A1–A6 (Industrial Research + Experimental Development) | A7: T7.1 (DCSI PRO - AI factory construction); T7.2 (RODIRO - robotic lines, QC lab, software; CARITÉ - laser robot, roughing line, injection machine) |

SHOE.AI meets both STEP criticality conditions:

Condition 1 - Innovative, emerging and cutting-edge technologies: The project introduces to the EU market an integrated set of technologies unavailable at industrial scale for footwear: (a) AI-powered inline defect detection for natural leather, (b) robotic manipulation of non-rigid, variable-thickness materials, (c) laser roughing with 3D AI-assisted path generation, (d) FOOTWEAR TWIN - first operational digital twin for footwear. Economic potential: €30B+ European footwear market, €2.5B+ Portuguese exports, replication potential across 1,300+ Portuguese factories and broader EU manufacturing.

Condition 2 - Reducing strategic dependencies: SHOE.AI develops EU-sovereign technology solutions (all IP within EU consortium members) reducing dependence on: (a) manual labour for quality-critical operations, (b) imported non-EU automation systems, (c) foreign factory management software. The project strengthens EU manufacturing sovereignty in a sector employing 250,000+ workers across Europe.

References:

[Ramos et al., 2026] V. A. Ramos et al., "Digital Twins in Europe: Driving Sustainable Innovation and Sovereignty", in Artificial Intelligence, Data and Robotics, Springer, 2026, pp. 51–76. doi: 10.1007/978-3-032-10561-5\_4.

[Curry et al., 2026] E. Curry et al., Eds., Artificial Intelligence, Data and Robotics: Foundations, Transformations and Future Directions, Springer, 2026. doi: 10.1007/978-3-032-10561-5.

[Qiang et al., 2023] W. Qiang, P. K., and X. Luo, "Research on integrated Development of Footwear Design and Manufacturing based on Digital Twin", in 4th International Conference on Intelligent Design (ICID), IEEE, 2023, pp. 26–32. doi: 10.1109/ICID60307.2023.10396721.

[Pystina] X. Pystina, "Digital Twin systems for production systems: Application on the manufacturing lab".

[Marin] T. F. Marin, "Footwear under the impact of digital technologies: A review".

Summarize the information described above, regarding the STEP criticality conditions, in the table below:

| STEP technology domain / Technology                                  | Value Chain intervention                                       | Development and manufacturing critical technologies? (Y/N)                        | Contributing to the safeguarding and strengthening of their respective value chains (Y/N)                                              | Innovative, emerging, cutting-edge with significant economic potential? (Y/N)                     | Reducing or preventing strategic dependencies? (S/N)                                     |
|----------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| AI Technologies - Algorithms, computer vision, data analytics        | Quality inspection, design, nesting, production planning       | Yes - AI vision software, defect detection, generative design, OPTIMIZE AI engine | Yes - AI enables autonomous quality control and factory orchestration , reducing EU dependence on manual labour and foreign automation | Yes - innovative integration of AI/CV in footwear manufacturing, no comparable EU solution exists | Yes - reduces dependency on Asian manufacturing capacity for quality footwear production |
| Robotics and Autonomous Systems - Precision robots, AI-based systems | Material handling, assembly, glue application, laser roughing  | Yes - robotic tooling for flexible materials, adaptive assembly cells             | Yes - EU-developed robotic systems for leather handling replace manual operations                                                      | Yes - manipulation of non-rigid natural materials is unsolved at industrial scale                 | Yes - autonomous assembly reduces reliance on labour-cost arbitrage with Asia            |
| Advanced Digital Technologies - IoT, AR, digital twins               | Factory orchestration , production planning, design validation | Yes - FOOTWEAR TWIN digital twin, OPTIMIZE planning engine, AR visualisation      | Yes - operational digital twin integrates full production line                                                                         | Yes - first operational DT for injected footwear                                                  | Yes - EU-sourced DT platform                                                             |

## 1.2. Objectives and methodology

(relevant information for the assessment of sub-criteria B1 e D2)

| Value Chain intervention              | Innovative Characteristics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Unit of measurement / Technical specification                                                                                                                                                                                                                 | Current Market performance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Project Objective                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Weight (%) |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| AI-powered quality inspection         | Inline AI defect detection for natural leather with real-time traceability                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Defect detection accuracy (%); False positive rate (%); Inspection speed (parts/min)                                                                                                                                                                          | Manual visual inspection: ~85% accuracy, no traceability, 3-5 sec/part                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | ≥95% detection accuracy; <5% false positives; ≥10 parts/min; full traceability                                                                                                                                                                                                                                                                                                                                                                                                                 | 30%        |
| Robotic handling and assembly         | Autonomous manipulation, glue application and assembly for non-rigid leather materials                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Gripping success rate (%); Surface damage rate (%); Assembly cycle time (s)                                                                                                                                                                                   | Manual assembly: variable quality, ~60 sec/operation, surface damage risk                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | ≥90% gripping success; <1% surface damage; ≤45 sec/operation                                                                                                                                                                                                                                                                                                                                                                                                                                   | 25%        |
| AI-assisted laser roughing            | 3D laser roughing/engraving with AI path generation replacing manual/mechanical roughing                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Adhesion strength (N/mm <sup>2</sup> ); 3D path accuracy (mm); Processing time per pair (s)                                                                                                                                                                   | Mechanical roughing: inconsistent adhesion, no 3D capability, manual path programming                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Adhesion ≥ manual baseline; ±0.5mm path accuracy; ≤30 sec/pair                                                                                                                                                                                                                                                                                                                                                                                                                                 | 20%        |
| Digital twin and factory optimisation | Operational DT (FOOTWEAR TWIN) + AI planning engine (OPTIMIZE) for small-batch injected footwear production. FOOTWEAR TWIN creates a dynamic digital representation of the upper-injection line integrating production orders, footwear models, sizes, colours, uppers, soles, moulds, machines, cycle times, setups, production states, internal flows, quality events, maintenance and operational traceability - a sector-specific digital component that no generic DT platform currently provides. OPTIMIZE transforms ERP and twin data into | Planning horizon accuracy (%); Re-planning response time (min); OEE improvement (%); Number of validated operational decision scenarios supported by FOOTWEAR TWIN (No.); Number of validated AI/optimisation decision modules integrated into OPTIMIZE (No.) | Traditional ERP/MES: static planning, no real-time sync, 2-4h re-planning cycle. Existing systems are mainly transactional - they record what has been planned or produced but do not dynamically represent the real behaviour of the production line, simulate scenarios, anticipate bottlenecks, evaluate alternative sequencing, optimise machine-mould allocation, or integrate predictive models for quality and maintenance. Generic DT/AI platforms exist but are insufficiently adapted to the specific constraints of injected footwear (model families, sizes, colours, | ≥85% planning accuracy; ≤15 min re-planning; ≥10% OEE improvement; ≥5 validated operational decision scenarios supported by FOOTWEAR TWIN (incl. production sequencing, machine-mould allocation, capacity/bottleneck analysis, stoppage simulation, traceability reconstruction); ≥5 validated OPTIMIZE decision modules integrated with OLIFEL ERP (incl. advanced planning, dynamic re-planning, setup reduction, delay-risk prediction, preventive maintenance or quality-risk prediction) | 25%        |

|  |                                                                                                                                                                                                                                                                   |  |                                                                                                                                                                                                      |  |  |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
|  | prescriptive recommendations for planning, re-planning, setup reduction, machine-mould allocation, delay-risk prediction, quality-risk prediction and preventive maintenance, moving beyond descriptive monitoring towards actionable AI-driven decision support. |  | moulds, machine-mould compatibility, setups). 0 validated industrial decision scenarios currently supported by an integrated DT; 0 AI-based optimisation modules embedded in footwear ERP workflows. |  |  |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|

#### Innovative characteristics compared to market state-of-the-art:

AI-powered quality inspection: Current manual inspection achieves ~85% defect detection with significant variability and no digital traceability. Existing machine vision (textile sector) cannot handle natural leather variability. Competitors (MindHive, Corium, Dr. Schenk, Homiro) focus on automotive upholstery with limited footwear adaptation. SHOE.AI develops AI algorithms trained specifically on footwear leather (T2.1, T2.3) with DCSI PRO vision hardware (T3.1), targeting  $\geq 95\%$  accuracy, full traceability and  $\geq 50\%$  inspection time reduction.

Robotic handling of flexible materials: No commercial solution (ABB, KUKA, Fanuc, Universal Robots) handles autonomous pick-and-place of post-cutting leather - all target rigid materials. SHOE.AI develops specialised grippers, vacuum systems and vision-guided manipulation (T3.2) with AI-driven adaptive control integrating visual feedback, force sensing and material behaviour models for complete handling and assembly cycles including glue application, component placement and roughing.

AI-assisted laser roughing: Current roughing uses mechanical methods or basic laser systems requiring manual path programming per model. No industrial system offers automatic 3D path generation from CAD with AI compensation for surface curvature. SHOE.AI develops AI-driven software that derives laser trajectories from CAD models, optimises parameters per material type (T3.3), includes adhesion testing validation and dedicated exhaust/purification systems with emission characterisation.

Operational digital twin and AI planning: Current ERP/MES systems are transactional - they cannot simulate scenarios, anticipate bottlenecks, optimise machine-mould allocation or re-plan dynamically. Generic DT/AI platforms lack footwear-specific knowledge (model families, sizes, moulds, compatibility matrices, setup rules). Academic research confirms this gap: there are notably few studies or commercial solutions focusing on the deep integration of footwear product design and manufacturing based on Digital Twin technology [Qiang et al., 2023], and the sector's reliance on traditional empirical production processes has resulted in a fragmented data landscape with low commonality of design information [Qiang et al., 2023]. SHOE.AI creates FOOTWEAR TWIN - the first operational DT for the upper-injection line - coupled with OPTIMIZE, an AI engine for

planning, sequencing, setup reduction and predictive quality (T4.3-T4.7). The solution integrates into OLIFEL's ERP and will be industrially validated at CARITÉ.

SMART characteristics of project objectives:

Specific: Each intervention targets a defined industrial process with quantified performance targets. Measurable: All objectives are expressed as measurable KPIs - detection accuracy (%), gripping success rate (%), adhesion strength (N/mm<sup>2</sup>), planning accuracy (%), OEE improvement (%) - verified through standardised protocols at two demonstrator sites.

Achievable: The consortium combines necessary competencies - MIND's AI/CV expertise, DCSI PRO's robotics/vision experience, OLIFEL/INESC TEC's digital twin capabilities, CTCP's materials testing infrastructure - with TRL 3-4 starting points supported by prior experience. Relevant: Objectives address APICCAPS 2030 (Axis 3) and EU STEP priorities for digital manufacturing.

Time-bound: 36-month structured timeline - foundation (M1-M12), research (M4-M28), integration (M16-M34), industrialisation (M18-M36) - with milestones at M12, M18, M28 and M34.

Technical challenges and methodological approach:

Challenge 1 - Natural material variability: Leather's variable thickness, colour, grain and mechanical properties confound vision algorithms and robotic manipulation. Methodology: MIND develops AI models with transfer learning and data augmentation trained on leather datasets from CARITÉ/RODIRO; DCSI PRO designs adaptive grippers with force-torque sensing and real-time vision feedback.

Challenge 2 - Real-time integration of heterogeneous systems: The cyber-physical factory requires communication between vision, robotics, laser and digital twin subsystems, integrated into existing industrial software. Generic approaches fail because they lack the footwear-specific data model. Within the EU, digital transformation progresses at disparate speeds across Member States, and the industrial SME network often lacks the resources and expertise to navigate this complexity [Ramos et al., 2026]. Methodology: OLIFEL develops FOOTWEAR TWIN as integration backbone; INESC TEC designs functional architecture with standardised interfaces (OPC-UA, MQTT). Progressive integration: T4.7 → T6.1 → T6.2 with validation in ≥5 real scenarios.

Challenge 3 - Industrial-grade reliability: Lab-validated prototypes must perform under production conditions. Methodology: structured TRL progression - lab development (A2-A4, TRL 3→6) followed by integration and industrial validation (A5-A6, TRL 6→8) at two complementary demonstrator sites.

Integration of fields of knowledge:

SHOE.AI integrates: (a) computer science and AI (MIND, INESC TEC), (b) mechatronics and robotics (DCSI PRO), (c) laser physics and materials science (DCSI PRO, CTCP), (d) industrial engineering and operations research (OLIFEL), and (e) leather science, footwear technology, and applied AI/robotics research (CTCP - computer vision, deep learning, robotic manipulation). Activities A5-A6 serve as the convergence point where all disciplines integrate into a working factory system.

### 1.3. Technical and Financial Maturity

Technology Readiness Levels:

The project progresses through two TRL bands:

Phase 2 - Research and solution development (A2-A4), TRL 3 → TRL 6: Starting from proof-of-concept (MIND's validated AI/CV algorithms, DCSI PRO's demonstrated vision/robotic/laser components, OLIFEL's operational ERP with industrial data, INESC TEC's published DT research), each PPS delivers validated prototypes at TRL 6.

Phase 3 - Integration and industrial validation (A5-A6), TRL 6 → TRL 8: A5 integrates PPS outputs into Quality Gate stations validated at CARITÉ (full end-to-end) and RODIRO (modular). A6 performs DT integration, validates in real scenarios, measures impact and prepares productisation of the OLIFEL ERP module and cross-border replication package.

The emphasis on Experimental Development (higher TRL) is consistent with the call requirement for minority weight of Industrial Research in R&D actions.

Productive Innovation (A7):

Two companies make complementary productive innovation investments incorporating R&D results:

RODIRO (T7.2): 2 robotic assembly lines, QC laboratory equipment (35 items), software licenses. These enable transition from manual to automated AI-assisted production validated in the modular demonstrator (T5.6).

CARITÉ (T7.2): Laser roughing robot (incorporating T3.3/T5.5 validated parameters), mechanical roughing line with integrated logistics, heavy outsole injection machine, plus smart factory systems — intelligent automated mould warehouse, AMRs for internal

logistics, robotised mould washing, AI-vision thread-burning robot, and robotic glue/shank positioning cell with 3D vision. These complete the full demonstrator installation enabling industrial-scale cyber-physical production. These complete the full demonstrator installation enabling industrial-scale cyber-physical production.

Complementarity: Both investments are directly linked to R&D results - RODIRO's robotic lines use T3.2 tooling and T3.1 vision; CARITÉ's laser robot incorporates T3.3 software. Both qualify as 'Alteration of the global production process', targeting respectively the high-volume mocassin segment (automated assembly) and the full-process luxury segment (laser roughing, end-to-end traceability).

## 2. Implementation Capacity

(relevant information for the assessment of sub-criteria C1)

### 2.1. Consortium description

The SHOE.AI consortium comprises seven partners with complementary expertise spanning the full innovation chain from fundamental AI research to industrial deployment. Below, each partner is described with its role in the project, relevant experience and critical human resources.

#### **CARITÉ** - Fábrica de Calçado, Lda. (Leading beneficiary, and full demonstrator)

Founded in 1990 in Felgueiras (with origins dating to 1986), CARITÉ is one of the main promoters of innovation in the Portuguese footwear sector, leading the introduction of automation and advanced manufacturing technologies and acting as a sectoral reference. The company combines in-house product design with vertically integrated production - cutting, stitching, upper injection and finishing -using its own moulds and a dedicated design studio. CARITÉ's production methodology centres on injected footwear, where automated injection lines, CAD-based cutting and stitching operate alongside processes that remain manual: quality inspection, roughing, glue application and component assembly. These manual operations are precisely the bottlenecks that SHOE.AI targets for AI-powered automation.

As leading beneficiary, CARITÉ assumes overall project management (A9), hosts the full-chain demonstrator site for end-to-end validation (T5.5) -from leather scanning through laser roughing, injection to Quality Gate inspection -and drives the productive innovation investments: a laser roughing robot, a mechanical roughing line, a heavy injection machine, and smart adaptive factory systems including an intelligent mould warehouse, AMRs, robotised mould washing, AI-vision finishing robot and robotic glue/shank cell (T7.2). CARITÉ also leads the industrial mapping of use cases (T4.1) and the industrial validation of FOOTWEAR TWIN and OPTIMIZE (T6.2, T6.3).

The contribution is through production management, factory access and industrial validation capacity - the essential real-world testbed without which the consortium's technologies cannot be validated at TRL 7–8.

Critical HR:

**Carlos Araújo** is a footwear designer with more than 20 years of experience, specialized in the creative and technical development of collections. He has a solid command of digital design tools, such as MindCAD 2D/3D and Procreate, fundamental skills for immersive 3D visualization and design validation. Throughout his career in companies such as Shea and Everest, he was responsible for the integral development of several brands, including Creation of Minds, demonstrating a strong ability to align aesthetic design and technical production requirements. At CARITÉ he is responsible for the footwear design for CARITÉ own brands and also for other brands of reference in the market. He is also strongly involved in R&D projects such as the Mobilizing Agenda for the Footwear Industry – FAIST. His experience in footwear styling and leather goods makes him a key resource specially for the development of AI models applied to conceptual design and Augmented Reality (AR) for 3D visualization.

**Ventura Correia** is a senior specialist in moulds and shoe lasts, with a career marked by leading innovation and industrial automation projects in the footwear sector. His participation in the strategic project "F25" at ECCO and "FAIST" at CARITÉ stands out, where he was part of a multidisciplinary team focused on the creation of a fully automatic production line, from raw material to the final product, with minimal human intervention. This experience is directly relevant to the development of Augmented Reality (AR)-assisted mould placement and part picking solutions. With advanced training in CAD/CAM (PowerShape/PowerMill) and a Bachelor of Science degree in Mechanical Engineering, Ventura has the technical knowledge necessary to optimize manufacturing processes and integrate complex hardware and software systems to maximize material yield

**RODIRO** -Fábrica de Calçado, S.A. (Modular demonstrator)

It was founded in 1991 in Felgueiras by three entrepreneurial brothers. Following restructuring in 2010 under the ownership of Ana Marques and Daniel Cerqueira, the company modernised progressively, investing in new production methods. RODIRO currently produces approximately 600 pairs/day with 70 workers, exporting over 95% to the EU market, specialising in mocassins and men's casual/classic shoes. A key innovation is the '3D Scanner' production method -a differentiated technique with exclusive moulds requiring mechanical or laser roughing, gluing, sole washing, re-gluing and pressing -which is the process to be robotised through the project.

As modular demonstrator, RODIRO validates the scalability of Quality Gate deployment on existing production lines (T5.6), demonstrating that SHOE.AI technology adapts to different factory configurations without full redesign. RODIRO's productive innovation investments include two robotised assembly lines, a quality-control laboratory (dynamometer, flexometer, abrasion testers, Martindale, crockmeter, colour chamber, durometer) and software platforms for AI administrative automation and ESG management (T7.2).

Critical HR: **Pedro Costa, Daniel Pacheco, Mariline Peixoto, António Sampaio** - production technicians working daily with the equipment targeted by this project, combining hands-on experience with knowledge of digitisation processes. Pedro Costa, is the head of Process Digitalization for about 10 years, will contribute to the development and implementation of the robotic systems and software; Daniel Pacheco is the Head of Operations, will contribute with overall technical and company's strategy in adopting and implementing the results of the project; Mariline is the head of continuous improvement at RODIRO and will guarantee the positive impact in terms of production efficiency, workflow, lean manufacturing and lean robotics when adopting and implementing the innovative solutions; António Sampaio is the head of R&D and will contribute to the overall I&D tasks in the project including the specifications definition, state-of-the-art, support the development with MIND and DCSI PRO and also on the implementation of the innovative solutions.

#### **DCSI PRO, Lda. (PPS2 leader)**

Founded in 2012 in Estarreja (Aveiro district), DCSI PRO is an industrial technology company specialising in turnkey automation and robotics projects. With a team of 32 professionals, DCSI PRO develops customised industrial solutions across mechanics, robotics and electrical engineering. The company invests heavily in R&D (70% of turnover in 2023) and is creating three AI-branded factory facilities within SHOE.AI: DCSI AI Vision Factory, DCSI AI Robotic Factory and DCSI AI Laser Lab - dedicated spaces where the vision, robotic and laser systems developed in A3 will be permanently housed and operated.

As PPS2 leader, DCSI PRO is responsible for all robotics, industrial vision hardware and laser developments (A3), including: vision systems with cameras, scanners and profilometers for leather inspection (T3.1), robotic tooling for flexible material handling and assembly (T3.2), and AI-driven laser roughing/engraving systems (T3.3). DCSI PRO also leads the integration of these systems into Quality Gate stations (T5.1, T5.2, T5.4) and the construction of the three factory facilities (T7.1). The company's unique combination of hardware engineering, robotics and industrial vision makes it indispensable for translating AI algorithms into production-grade equipment.

Critical HR:

**Edgar Ferro** has a degree in Business Management from ISAG European Business School, currently at DCSI PRO, LDA, where he works in the planning and coordination of projects, monitoring their execution and managing the relationship with clients. Also responsible for the preparation of performance reports, contributing to operational efficiency and continuous improvement.

José Duarte is a Mechanical Engineer graduated from the University of Aveiro, with experience in design and development of industrial machinery. He works in all phases of the process, from the survey of needs to production and assembly, with a strong command of tools such as SolidWorks and AutoCAD. It stands out for its ability to manage projects, organization and technical monitoring in an industrial environment.

**Ricardo Aguiar** is an Electrotechnician and Computer Technician Engineer, graduated from the Faculty of Engineering of the University of Porto, with specialization in industrial

automation. Experience in automata programming (Siemens and Omron), robotics and supervision systems, standing out for its organization, critical sense and work capacity

**Fernado Silva** is a Mechanical Engineer specialized in Industrial Automation, graduated from the Faculty of Engineering of the University of Porto, with 9 years of experience in machine programming projects for different industrial sectors. He has skills in robotics, PLCs, HMI and development in C# .NET, standing out for his problem-solving skills, proactivity and focus on continuous improvement.

#### **OLIFEL** - Software & IT Solutions, Lda. (PPS4 leader)

Founded in 1988 in Felgueiras and certified as one of the Top 5% Best SMEs in Portugal (2023), OLIFEL is a software house developing ERP and digital management solutions for the footwear sector. OLIFEL's ERP is installed in 100+ Portuguese footwear factories, covering production planning, inventory, logistics and quality management. With a deeply innovative DNA, the company specialises in transforming complex requirements into high-performance architectures using AI, cloud computing and custom software development. As PPS4 leader, OLIFEL is responsible for integrating FOOTWEAR TWIN and OPTIMIZE into its ERP platform as a new intelligent module (T4.7), for deploying the industrial pilot at CARITÉ (T6.1), and for defining the commercial exploitation strategy, licensing model and replication package (T6.4, T6.5). OLIFEL's existing ERP client base of 100+ footwear manufacturers provides an immediate commercialisation channel for the project results.

Critical HR:

Nuno Fonseca (Tech Lead, leads software innovation), Mário Macedo (Product Owner, translates domain knowledge into product value), Dev Team (agile execution), António Moreira (support and user experience), Rui Mendes (strategy and partnerships for project sustainability).

#### **MIND** - Software Multimédia e Industrial, S.A. (PPS1 leader)

MIND was established in 1997, incubated at INESC TEC's AITEC centre. The company operates in two business areas: Industrial Systems (CAD/CAM for footwear, automatic cutting, nesting optimisation - its MindCAD platform is the leading footwear design/cutting software in Portugal) and Information Management Systems (multimedia, decision-support). MIND has 25+ years of continuous R&D and international presence through an exclusive ZÜND partnership for global distribution. Prior R&D projects with CTCP on AI/CV for leather inspection and defect detection provide the direct technological foundation for SHOE.AI.

As PPS1 leader, MIND is responsible for all AI, computer vision and AR developments (A2): colour-tone detection (T2.1), generative AI design (T2.2), defect identification (T2.3), AR mould placement and 3D visualisation (T2.4, T2.5), and AI-optimised nesting (T2.6). MIND also leads CAD/CAM integration in A5 (T5.3). The company's deep domain expertise - combining footwear manufacturing knowledge with AI/CV capabilities - is the critical differentiator that general-purpose AI providers cannot replicate.

Critical HR:

**Tiago Talhada** - Product Owner for automatic cutting, industrial automation and computer vision, MSc Mechanical Engineering / Robotics and Artificial Vision (University of Aveiro), 10+ years at MIND. **Nuno Gonçalves** - Senior programmer, MindCAD and nesting algorithms, BSc Computer Engineering (IST), 20+ years at MIND, expert in geometric modelling and optimised fitting algorithms. **Ágata Barros** - Software Development Engineer specialising in Computer Vision, ML, Deep Learning and Optimisation, MSc Mechanical Engineering / Systems (IST), 4+ years R&D at MIND, starting PhD in Electrical and Computer Engineering at IST in collaboration with MIND. Expert in CNNs, YOLO, TensorFlow, image segmentation and industrial defect detection. **Nuno Rosa** - Programmer specialising in advanced algorithms for nonlinear programming and AI, MSc Electrical and Computer Engineering / Systems, Decision and Control (IST), expert in ML, reinforcement learning and image processing for nesting and cutting optimisation.

**INESC TEC** - Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência (RPO)

INESC TEC is one of Portugal's leading research performing organisations (RPO), with internationally recognised expertise in AI, data science, optimisation and digital systems. As the consortium's RPO, INESC TEC provides the scientific backbone for the digital twin and AI planning components, contributing research capacity in digital twins, AI, optimisation, production planning and data integration from manufacturing, logistics and smart cities contexts.

INESC TEC participates in A1, A4, A6 and A9, with particular relevance in: data modelling and solution architecture (T4.2), FOOTWEAR TWIN core development - digital modelling, simulation, real-data synchronisation (T4.3, T4.4), OPTIMIZE AI engine - planning, sequencing and re-planning algorithms (T4.5), predictive models for quality, delay and maintenance (T4.6), and industrial validation support (A6). INESC TEC's advanced research capacity addresses the project's non-routine technical challenges, ensuring novel Digital Twin, AI and optimisation capabilities beyond standard ERP integration.

Critical HR: **Cristóvão Dinis Polido Sousa** - Researcher, Computer Engineering background. Expertise in digital architectures, knowledge-based systems, interoperability and applied AI. Experience in advanced technologies for production and logistics (IoT/CPS, Digital Twins, MBSE, data analytics). Participates in A1, A4 and A6. **Rui Diogo Rebelo** - Senior Researcher, Electrical and Computer Engineering degree, PhD in progress (Industrial Engineering). Expertise in manufacturing systems, production planning/scheduling, decision-support and industrial optimisation. Experience in automotive and manufacturing contexts. Participates in A1, A4 and A6.

**CTCP** - Centro Tecnológico do Calçado de Portugal (Technical coordinator)

CTCP is a private, non-profit entity founded in 1986, providing technological support to the footwear and leather goods sector (~1,900 companies). Recognised as a European Digital Innovation Hub (EDIH-PT / one.stop.shoe.hub), related to R&D&I, CTCP operates in three key areas: Laboratory (materials testing, environmental compliance), Innovation and

Digital Manufacturing (FABLAB, automation, robotics, AI) and Technology Transfer. CTCP has led or participated in 100+ R&D projects, coordinates the FAIST mobilising agenda for industrial transformation of the footwear sector, BIOSHOES4ALL and manages the Digi4Fashion digital innovation hub and Missão Interface SHOEDIGINOV.

As technical coordinator, CTCP leads state-of-the-art analysis (A1) and actively contributes to R&D activities across multiple technology domains: computer vision and AI research for defect detection and robotic grasp prediction (A2, A3), robotics experimentation and 3D vision integration on its pilot units (A3, A5), and digital twin testing and validation at the industrial demonstrator sites (A6). CTCP's team includes researchers with backgrounds in CV, deep learning and robotics (see shortbios below), who participate directly in the development and testing of SHOE.AI solutions. CTCP further contributes materials testing and laser parameter validation (A3, A5), conducts environmental sustainability assessment (T5.7), and coordinates dissemination through its European network and FAIST Pilot Units (A8). CTCP's unique combination of sectoral reach, laboratory infrastructure, applied R&D capability and technology transfer experience ensures that project results are validated, disseminated and adopted across the Portuguese and European footwear industry.

Critical HR: **Florbela Silva** - Director of Innovation and Digital Manufacturing Unit and FABLAB, PhD University of Bath (Materials Engineering), coordinator of FAIST mobilising agenda, 17 scientific publications (over 120 citations, h-index 4). Expert in sustainable materials, advanced manufacturing and Industry 4.0 strategy. **Cristiano Figueiredo** - PhD University of Bath, team leader for Digitalisation, Automation and Robotics at CTCP, postgraduate in Industry 4.0 (INESC TEC/INEGI). Expert in 3D scanning, point cloud processing, photogrammetry and industrial robotics. 14 publications, h-index 8. Participates in FAIST, Digi4Fashion and international projects. **Pedro Tavares** - MSc Robotics and Intelligent Systems (University of Aveiro). Experience with robotic arms, 3D vision, feeding systems and mixed reality across semiconductor and automotive industries. Currently developing robotic arm + 3D vision solution for footwear sole handling at CTCP. **Raquel Pinto** - MSc Computer and Telematics Engineering (University of Aveiro). Experience in industrial computer vision, OpenCV, PLC-controlled environments. Currently developing deep learning-based CV system integrating object detection and keypoint estimation for footwear sole identification and robotic grasp prediction.

Consortium complementarity (complete consortium): The seven partners form a complete consortium covering: (a) AI and software development (MIND), (b) hardware, robotics and laser systems (DCSI PRO), (c) digital twin software, ERP integration and factory orchestration (OLIFEL), (d) scientific research and advanced computational methods (INESC TEC), (e) applied R&D in AI, computer vision and robotics, materials testing, laser parameter validation, digital twin validation, technical coordination and dissemination (CTCP), (f) industrial demonstration - full chain (CARITÉ) and modular (RODIRO). Each partner contributes unique, non-overlapping expertise essential for the integrated SHOE.AI solution. The consortium covers the complete innovation chain from fundamental research (INESC TEC) through applied R&D (MIND, DCSI PRO) and software productization

(OLIFEL) to industrial validation and deployment (CARITÉ, RODIRO), with CTCP providing the sectoral bridge for technology transfer and dissemination.

External critical competencies: The consortium does not anticipate the need for external critical competencies, as the seven partners collectively cover all required disciplines (AI, robotics, laser, digital twin, materials science, footwear manufacturing). Specific equipment suppliers are engaged as suppliers under the Productive innovation tasks, not as R&D subcontractors.

## 2.2. Identification of Activities

| Activity No. | Activity Title                                       | Classification              | Responsible beneficiary |          |
|--------------|------------------------------------------------------|-----------------------------|-------------------------|----------|
|              |                                                      |                             | Nº                      | Abbrev   |
| 1            | State of the art and technological surveillance      | Industrial Research         | 7                       | CTCP     |
| 2            | AI, computer vision and AR solutions                 | Industrial Research         | 5                       | MIND     |
| 3            | Robotics, industrial vision and laser                | Industrial Research         | 3                       | DCSI PRO |
| 4            | Digital twin development                             | Industrial Research         | 4                       | OLIFEL   |
| 5            | Integration and validation in industrial environment | Experimental Development    | 3                       | DCSI PRO |
| 6            | Digital twin industrial integration                  | Experimental Development    | 4                       | OLIFEL   |
| 7            | Productive innovation                                | Productive Innovation       | 1                       | CARITÉ   |
| 8            | Promotion and dissemination of the results           | Dissemination and Promotion | 7                       | CTCP     |
| 9            | Project management and implementation                | Technical Management        | 1                       | CARITÉ   |

The SHOE.AI work plan is organised into 9 activities and 41 tasks, structured across 5 phases that follow the TRL progression from foundation to industrial deployment:

Phase 1 - Foundation and Specification (A1, M1–M12): State of the art review and technical requirements specification across all technology domains.

Phase 2 - Research and Solution Development (A2–A4, M4–M28): Parallel development of the three technology pillars - AI/CV/AR (A2, PPS1, led by MIND), robotics/vision/laser (A3, PPS2, led by DCSI PRO), and digital twin (A4, PPS4, led by OLIFEL) - from TRL 3 to TRL 6.

Phase 3 - Integration and Industrial Validation (A5–A6, M16–M34): System integration and validation (A5, PPS3, led by DCSI PRO) at two sites - CARITÉ (full demonstrator) and RODIRO (modular demonstrator) - from TRL 6 to TRL 8. Digital twin industrial integration (A6, PPS4, led by OLIFEL) deploys FOOTWEAR TWIN and OPTIMIZE at CARITÉ, validates in real scenarios, measures impact, defines the ERP product architecture and go-to-market strategy, and prepares a replication package for sectoral dissemination.

Phase 4 - Productive Innovation (A7, M6–M36): Physical facility construction at DCSI PRO (AI Vision Factory, AI Robotic Factory, AI Laser Lab) and technology acquisition by CARITÉ (laser robot, roughing line, injection machine, intelligent mould warehouse, AMRs,

robotised washing, AI-vision finishing robot, robotic glue/shank cell) and RODIRO (robotic assembly lines, QC laboratory, software).

Phase 5 - Dissemination and Management (A8–A9, M1–M36): Transversal activities for promotion, dissemination, and project management.

Key interdependencies: A2–A4 produce components that feed into A5–A6 for integration. A6 (digital twin) provides the data backbone, validates the solution industrially, and prepares its productization and replication - A5 integrates and validates the full system. A5 validates the technologies that A7 industrialises. A1 feeds all subsequent activities with state-of-the-art requirements. A8 disseminates results progressively as milestones are achieved.

### 2.3. Description of Activities

| Activity No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Activity Title                                  |                      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|----------------------|
| A1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | State of the art and technological surveillance |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Start date: 01/01/2027                          | End date: 31/12/2027 |
| <b>Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                 |                      |
| <p>This activity characterises the scientific and technological landscape across the project's three domains: (i) AI, computer vision and AR applied to footwear; (ii) adaptive robotics and laser processing for flexible materials; (iii) digital twins and intelligent factory orchestration. It also maps developments across Lead Users to identify emerging technologies, trends and innovation opportunities.</p> <p>Objectives: deepen and update the state of the art throughout the project; identify technical needs and market trends; conduct technology surveillance of the target market. The output defines reference specifications guiding Activities 2–4 and their integration in Activity 6. The three domains are led respectively by MIND (AI/CV/AR), DCSI PRO (robotics/laser) and OLIFEL/INESC TEC (digital twin/ERP).</p>                                                        |                                                 |                      |
| <b>Description of the activity</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                 |                      |
| <p><b>T1.1 - AI, computer vision and AR applied to footwear (M1–M10)</b></p> <p>Review of the state of the art in AR, CV and AI, progressing from broad cross-sector applications to industrial use cases and then footwear/leather goods. Focus areas: defect detection, colour-tone detection, generative design, 3D visualisation and interactive mould placement. All partners contribute domain-specific knowledge; CTCP leads information consolidation.</p> <p><b>Leader:</b> CTCP   <b>Participants:</b> CARITÉ, DCSI PRO, INESC TEC, MIND, RODIRO</p> <p>Methods: systematic literature review, patent analysis, technology scouting, benchmarking, Lead User identification</p> <p>Main output: State-of-the-art report on AI/CV/AR for footwear (D1.1 contribution)</p>                                                                                                                        |                                                 |                      |
| <p><b>T1.2 - Adaptive robotics and laser for flexible materials (M1–M10)</b></p> <p>Review of robotic manipulation for flexible materials (grippers, vacuum, soft-grip, pick-and-place for post-cutting leather), glue application robotics and component placement for cemented and injection-moulded construction. Review of laser technologies for roughing and 3D engraving, including laser types, power configurations and their effect on bonding quality, plus exhaust and air purification systems. Reflects DCSI PRO's robotics and laser expertise.</p> <p><b>Leader:</b> CTCP   <b>Participants:</b> CARITÉ, DCSI PRO, INESC TEC, RODIRO</p> <p>Methods: literature review, technology scouting, supplier benchmarking, analysis of existing robotic cells and laser systems</p> <p>Main output: State-of-the-art report on robotics and laser for flexible materials (D1.1 contribution)</p> |                                                 |                      |
| <p><b>T1.3 - Digital twins and intelligent factory orchestration (M1–M10)</b></p> <p>Review of Digital Twin platforms, AI-based planning/optimisation tools, industrial analytics and ERP/MES integration for SME manufacturing. Analysis of current ERP/MRP/MES limitations: these systems are transactional and do not dynamically represent production-line behaviour, simulate scenarios, anticipate bottlenecks, optimise sequencing or integrate predictive models. Existing Digital Twin platforms lack adaptation to injected footwear constraints and are difficult to operationalise in industrial SMEs.</p>                                                                                                                                                                                                                                                                                    |                                                 |                      |

**Leader:** CTCP | **Participants:** CARITÉ, INESC TEC, OLIFEL, RODIRO  
**Methods:** literature review, commercial platform analysis, ERP/MES capability mapping, gap analysis  
**Main output:** State-of-the-art report on digital twins and orchestration for footwear (D1.1 contribution)

#### T1.4 - Technical requirements specification (M3–M12)

Based on T1.1–T1.3 and T1.5, a technical reference framework will be established covering all three technology domains. Includes: functional requirements for AI/CV/AR modules (accuracy, speed, robustness), robotic cell specifications (payload, reach, precision), laser system requirements (power, wavelength, beam quality) and digital twin architecture (data model, integration points, simulation fidelity, ERP integration). CTCP consolidates cross-partner inputs; architecture aligned with OLIFEL/INESC TEC specifications.

**Leader:** CTCP | **Participants:** CARITÉ, DCSI PRO, INESC TEC, MIND, OLIFEL, RODIRO  
**Methods:** requirements engineering, technical interviews, cross-partner workshops, MoSCoW prioritisation  
**Main output:** Technical reference framework and requirements specification (D1.2)

#### T1.5 - Technological surveillance of the target market (M1–M12)

Monitoring of technological innovation in footwear through product benchmarking, trade fairs (SIMAC, A+A, Messe), specialised publications and industry networking. Supports alignment of project objectives with market reality and future trends for Activities 2–7.

**Leader:** CTCP | **Participants:** DCSI PRO, INESC TEC, MIND, OLIFEL  
**Methods:** trade fair participation, publication monitoring, industry networking, periodic benchmarking reports  
**Main output:** Technology watch reports (D1.3)

#### Effort in FTEs and investments (per beneficiary)

FTE:  
 CARITÉ: 12,1; RODIRO: 10,7; DCSI PRO: 67,7; OLIFEL: 38,0; MIND: 78,9; INESC TEC: 15,6; CTCP: 13,6  
 Investment (non FTE):  
 CTCP: 6.400 €

#### Description of deliverables and milestones

D1.1 - State-of-the-art report covering AI/CV/AR, robotics/laser, and digital twins for footwear (Month 10) - Document - Confidential

D1.2 - Technical requirements specification framework (Month 12) - Document - Confidential

D1.3 - Technology watch reports (Month 6, Month 12) - Report - Confidential

M1.1 - State-of-the-art review completed (Month 10) - Verified by delivery of D1.1

M1.2 - Requirements specification approved by consortium (Month 12) - Verified by sign-off from all partners on D1.2

| Activity No.                                                                                                                                                                                                                                                                                                                                                                                                       | Activity Title                       |                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|----------------------|
| A2                                                                                                                                                                                                                                                                                                                                                                                                                 | AI, computer vision and AR solutions |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                    | Start date: 01/04/2027               | End date: 30/04/2029 |
| <b>Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                   |                                      |                      |
| This activity develops AI algorithms, computer vision models and AR applications targeting: automatic colour-tone detection in natural leather, AI-assisted conceptual footwear design, automatic defect identification in leather, interactive AR-assisted mould placement and part picking, immersive 3D visualisation for design validation, and AI-optimised nesting for material yield maximisation.          |                                      |                      |
| The six development lines build on MIND's prior AI/CV experience for footwear. The nesting engine (T2.6) integrates outputs from colour detection (T2.1) and defect mapping (T2.3) to maximise material yield on irregular leather hides.                                                                                                                                                                          |                                      |                      |
| <b>Description of the activity</b>                                                                                                                                                                                                                                                                                                                                                                                 |                                      |                      |
| <b>T2.1 - CV algorithms for colour-tone detection in leathers (M4–M16)</b>                                                                                                                                                                                                                                                                                                                                         |                                      |                      |
| Development of CV algorithms for automatic, precise colour-tone detection in natural leather, ensuring chromatic uniformity and traceability. Techniques include colour correction, illumination normalisation and dataset curation. Prototypes will be validated with industrial cameras and sensors in production conditions. Output feeds the nesting engine (T2.6) with zone-level colour classification data. |                                      |                      |

**Leader:** MIND | **Participants:** CARITÉ, CTCP, RODIRO

**Methods:** image processing, colour correction, illumination normalisation, dataset curation, sensor integration, software prototyping

**Main output:** Colour-tone detection algorithms validated with industrial cameras, targeting  $\geq 30\%$  reduction in nesting preparation time and  $\geq 10\%$  chromatic homogeneity increase

## **T2.2 - Generative AI for conceptual footwear design (M4–M20)**

Development of a generative AI solution for conceptual footwear design. Models trained on visual and descriptive data (catalogues, patterns, textures, styles) generate design proposals aligned with market trends and stylistic preferences. Enables exploration of new material, shape and colour combinations, accelerating the creative phase. Iterative testing with designers and product technicians ensures relevant, original and production-viable output.

**Leader:** MIND | **Participants:** CARITÉ, CTCP, RODIRO

**Methods:** generative AI (GANs, diffusion models), transfer learning, designer co-creation workshops, iterative validation

**Main output:** Generative AI platform for footwear design, targeting design cycle reduction from 5 to 2 days and  $\geq 25\%$  increase in approved concepts per collection

## **T2.3 - AI for digitisation and defect identification in leathers (M6–M22)**

AI and CV systems for digitisation and automatic detection of leather defects - texture irregularities, cuts, holes, stains and colour variations. Deep learning models trained on high-resolution images recognise and classify defect types. Automates quality control, reducing human error. Defect mapping integrates with the nesting engine (T2.6) to exclude or downgrade defective zones during part placement.

**Leader:** MIND | **Participants:** CARITÉ, CTCP, RODIRO

**Methods:** deep learning (CNNs, transformers), high-resolution acquisition, data augmentation, transfer learning, defect taxonomy

**Main output:** Defect detection system validated on representative leather types, targeting  $\geq 50\%$  reduction in inspection time and elimination of  $\geq 90\%$  of physical ink markings

## **T2.4 - AR for interactive mould placement and piece collection (M8–M24)**

AR application supporting cutting and component picking in footwear production. Enables interactive visualisation and positioning of virtual moulds over physical leather, guiding operators on optimal placement and picking sequence. Uses spatial tracking, surface recognition and camera calibration for millimetre-precision overlay. Testing in industrial environments with operators from partner companies ensures usability and workflow integration.

**Leader:** MIND | **Participants:** CARITÉ, CTCP, RODIRO

**Methods:** spatial tracking, surface recognition, camera calibration, AR rendering, operator testing in industrial settings

**Main output:** AR mould placement application validated by operators, targeting millimetric precision and measurable material waste reduction

## **T2.5 - AR for immersive 3D visualisation and design validation (M8–M26)**

AR solution enabling real-time 3D visualisation of virtual footwear models via mobile devices or AR glasses. Users explore models at different angles, materials and chromatic variations, simulating product integration in real contexts. Optimised rendering engines with realistic textures and dynamic lighting ensure visual quality and fluid interaction. Validated with designers and brand partners.

**Leader:** MIND | **Participants:** CARITÉ, CTCP, RODIRO

**Methods:** 3D rendering optimisation, texture mapping, dynamic lighting, AR device integration, designer and brand validation

**Main output:** AR 3D visualisation platform, targeting  $\geq 40\%$  reduction in physical samples and  $\geq 30\%$  faster design validation

## **T2.6 - AI-optimised nesting engine (chromatic variations) (M10–M28)**

AI-powered nesting engine leveraging colour-tone data (T2.1) and defect mapping (T2.3) to maximise material yield on irregular leather hides. Combines zone-level quality and colour classification with advanced layout algorithms considering shape constraints, grain direction, colour matching and defect avoidance. Targets significant reduction in leather waste - one of the largest cost and environmental factors in footwear production.

**Leader:** MIND | **Participants:** CARITÉ, CTCP, RODIRO

**Methods:** combinatorial optimisation, constraint satisfaction, ML zone classification, irregular shape packing, integration with T2.1/T2.3

**Main output:** Nesting engine integrated with colour and defect data, validated on representative hides, targeting measurable yield improvement

| Effort in FTEs and investments (per beneficiary)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>FTE:<br/>CARITÉ: 28,7; RODIRO: 29,0; MIND: 222,6; CTCP: 21,8<br/>Investment (non FTE):<br/>CARITÉ: 18.000 €; RODIRO: 7.000 €; MIND: 540.000 €; CTCP: 118.000 €</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Description of deliverables and milestones                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <p>D2.1 - Colour-tone detection system prototype (Month 18) - Prototype - Confidential<br/>D2.2 - Generative AI design platform prototype (Month 24) - Prototype - Confidential<br/>D2.3 - Leather defect detection and classification system (Month 24) - Prototype - Confidential<br/>D2.4 - AR mould placement and part picking application (Month 24) - Prototype - Confidential<br/>D2.5 - AR 3D visualisation platform (Month 24) - Prototype - Confidential<br/>D2.6 - AI-optimised nesting engine (chromatic variations) (Month 28) - Prototype - Confidential</p> <p>M2.1 - First functional prototypes of CV and AI modules (Month 18) - Verified by demonstration of T2.1 and T2.3 prototypes<br/>M2.2 - All A2 prototypes ready for integration testing (Month 28) - Verified by standalone validation of all six outputs</p> |

| Activity No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Activity Title                        |                      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|----------------------|
| A3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Robotics, industrial vision and laser |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Start date: 01/04/2027                | End date: 30/04/2029 |
| Objective                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                       |                      |
| <p>This activity develops industrial vision systems, robotic tooling and laser technologies for footwear assembly on flexible materials (leather), organised around DCSI PRO's three focus areas:</p> <ol style="list-style-type: none"> <li>1. Artificial vision and AI - creation of the DCSI Vision Factory for vision systems incorporating cameras, scanners, profilometers, illumination studies and bespoke software;</li> <li>2. Robotics and manipulation - tooling for cemented and injection-moulded footwear assembly: glue application, component placement, grippers for flexible materials, pick-and-place, roughing systems, and identification via RFID and CV;</li> <li>3. Laser for footwear - software and testing of different lasers for roughing and 3D engraving, with exhaust and air purification systems.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                       |                      |
| Description of the activity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                       |                      |
| <p><b>T3.1 - DCSI AI Vision Factory: vision systems and AI inspection software (M4–M28)</b><br/>Creation of an artificial vision and AI department at DCSI PRO. Hardware: systems with cameras (2D/3D), scanners, profilometers and optimised lighting for leather/footwear inspection. Software: tailored machine vision software integrating DCSI PRO hardware with MIND's AI defect-detection algorithms (A2), calibrated for leather-specific defects under production-line conditions (variable lighting, positioning, throughput). The vision systems handle leather inspection challenges: variable surface reflectance, grain pattern diversity and the distinction between defects and natural features. Current manual inspection achieves ~85% accuracy with inter-operator variability; target is ≥95% with full digital traceability.<br/><b>Leader:</b> DCSI PRO   <b>Participants:</b> CARITÉ, CTCP, RODIRO<br/><b>Methods:</b> sensor benchmarking, structured illumination design, camera calibration, machine vision software development, hardware–software co-design, AI adaptation to production conditions<br/><b>Main output:</b> Industrial vision platform with AI inspection software, targeting ≥95% defect detection accuracy and ≥50% inspection time reduction</p> <p><b>T3.2 - DCSI AI Robotic Factory: tooling, manipulation and assembly (M4–M28)</b><br/>Robotic tools and systems for the complete handling and assembly cycle of flexible leather - a domain lacking commercial solutions due to the challenge of manipulating non-rigid, anisotropic materials that deform under gripping forces. Tooling: specialised grippers (vacuum, soft-grip, force-limited), pick-and-place for post-cutting leather of varying thickness, RFID and CV-based part tracking. Multiple gripping strategies evaluated against leather types measuring reliability, cycle time and surface damage. Assembly: robotic glue application on irregular 3D surfaces, component placement, roughing systems. AI and CV provide real-time adaptive control - compensating for material variability through visual feedback, force-torque sensing and deformation models.</p> |                                       |                      |

**Leader:** DCSI PRO | **Participants:** CARITÉ, CTCP, RODIRO

**Methods:** gripper design/prototyping, force analysis, deformation testing, RFID integration, vision-based tracking, AI path planning, force-torque sensing, deformation compensation

**Main output:** Robotic tooling and assembly cell validated for leather handling, glue application and component manipulation

### T3.3 - DCSI AI Laser Lab: 3D roughing, engraving and parameter validation (M4–M28)

Software and laser systems for roughing and 3D engraving on footwear (cemented and direct-injection). Current systems require manual path programming per shoe model, limiting flexibility. No industrial laser system offers automatic 3D path generation from CAD models with AI compensation for surface curvature. Software: AI-driven 3D path generation from CAD shoe models, compensating for curvature and thickness variation, optimising laser parameters (power, speed, focal distance, pulse pattern) per material and construction method. Laser validation: systematic testing of laser types (CO<sub>2</sub>, fibre, diode) with peel/shear adhesion testing (CTCP), creating a parameter database linking settings to adhesion across leather types. Safety: exhaust and air purification systems with emission characterisation (PM, VOCs) and occupational safety assessment.

**Leader:** DCSI PRO | **Participants:** CARITÉ, CTCP, RODIRO

**Methods:** laser–material modelling, kinematic simulation, 3D path generation, laser parameter optimisation, adhesion testing, parameter database construction, emission characterisation, safety certification

**Main output:** Laser roughing/engraving system with AI-driven 3D path software, parameter database and validated exhaust system

### Effort in FTEs and investments (per beneficiary)

FTE:

CARITÉ: 26,7; RODIRO: 23,1; DCSI PRO: 203,5; INESC TEC: 15,6; CTCP: 15,7

Investment (non FTE):

CARITÉ: 3.000 €; RODIRO: 40.000 €; DCSI PRO: 2.102.500 €; CTCP: 175.000 €

### Description of deliverables and milestones

D3.1 - DCSI AI Vision Factory: integrated vision platform with AI inspection software (Month 24) - Prototype - Confidential

D3.2 - DCSI AI Robotic Factory: robotic tooling and assembly cell for flexible materials (Month 24) - Prototype - Confidential

D3.3 - DCSI AI Laser Lab: laser roughing/engraving system with 3D software and safety assessment (Month 28) - Report + Prototype – Confidential

M3.1 - AI Vision Factory hardware and software platform operational (Month 18) - Verified by image acquisition, calibration and defect detection on leather samples

M3.2 - All robotic and laser prototypes ready for integration (Month 28) - Verified by standalone validation of each system

| Activity No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Activity Title           |                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------|
| A4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Digital twin development |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Start date: 01/04/2027   | End date: 30/04/2029 |
| <b>Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                          |                      |
| <p>This activity develops two complementary digital products for injected footwear: FOOTWEAR TWIN - an operational Digital Twin creating a dynamic digital representation of CARITÉ's upper-injection line (production orders, moulds, machines, times, states, quality events, maintenance, constraints) - and OPTIMIZE - an AI engine for advanced planning, prescriptive decision-making and operational optimisation that transforms ERP and production data into actionable recommendations.</p> <p>Together they constitute a sector-specific digital component enabling simulation, monitoring and AI-driven optimisation of injected footwear production, forming a new intelligent module within OLIFEL's ERP - validated at CARITÉ and prepared for replication. The activity progresses from industrial mapping (T4.1) through architecture (T4.2), development (T4.3–T4.6) to ERP integration (T4.7), from TRL 3 to TRL 6.</p> |                          |                      |

#### Description of the activity

##### T4.1 - Industrial mapping and definition of priority use cases (M4–M10)

Strategic diagnosis of the upper-injection line to identify critical data and decision points. Identifies sector-specific manual bottlenecks (machine–mould compatibility, setup constraints) that caused previous high-tech initiatives to fail. Output: prioritised use-case matrix for FOOTWEAR TWIN and OPTIMIZE.

**Leader:** CARITÉ | **Participants:** OLIFEL, INESC TEC, CTC

**Methods:** site survey, workflow mapping, technical interviews, value stream mapping, constraint analysis

**Main output:** Operational map, industrial constraints matrix and prioritised use cases

##### T4.2 - Functional architecture, data model and technical validation (M6–M14)

Defines the solution's functional and technical architecture, data requirements, ERP integration specifications and validation indicators. Establishes the industrial baseline for comparison of project results.

**Leader:** INESC TEC | **Participants:** OLIFEL, CARITÉ, CTC

**Methods:** requirements engineering, data model design, ERP data analysis, KPI definition, validation protocol design

**Main output:** Solution architecture, data model, validation KPIs and baseline

##### T4.3 - Development of the digital model of the upper-injection line (FOOTWEAR TWIN) (M8–M22)

Develops FOOTWEAR TWIN as a dynamic digital representation integrating production orders, products, moulds, machines, times, states, flows, quality events, maintenance and constraints that generic market twins ignore. Virtualises the physical environment enabling simulation and rapid response to market shifts.

**Leader:** INESC TEC | **Participants:** OLIFEL, CARITÉ, CTC

**Methods:** digital twin modelling, discrete-event simulation, constraint modelling, machine–mould compatibility analysis

**Main output:** Functional FOOTWEAR TWIN prototype

##### T4.4 - Simulation, synchronisation with real data and technical validation (M14–M26)

Synchronises FOOTWEAR TWIN with physical reality (ERP, production records, industrial equipment). Validation focuses on high-impact scenarios - stoppages, urgent orders, material shortages - ensuring the twin serves as a resilient decision-support hub.

**Leader:** INESC TEC | **Participants:** OLIFEL, CARITÉ, CTC

**Methods:** OT-IT data integration, simulation modelling, scenario testing, ERP synchronisation, traceability modelling

**Main output:** FOOTWEAR TWIN synchronised with real data, validated in representative scenarios

##### T4.5 - Development of planning, sequencing and re-planning algorithms (OPTIMIZE) (M10–M24)

Develops the optimisation core: algorithms for planning, order sequencing, machine–mould allocation, setup reduction, capacity management and dynamic re-planning. Moves beyond reporting to a recommendation-based approach solving the "manual setup bottleneck" that previously broke smart factory flow, ensuring European production remains cost-competitive.

**Leader:** INESC TEC | **Participants:** OLIFEL, CARITÉ, CTC

**Methods:** mathematical optimisation, constraint programming, scheduling algorithms, heuristics/metaheuristics, multi-objective optimisation

**Main output:** Planning, sequencing and dynamic re-planning engine

##### T4.6 - Development of predictive models for quality, delay and preventive maintenance (M12–M26)

AI models predicting operational risks: delays, defects, performance degradation, machine anomalies. Integrated into OPTIMIZE as risk indicators and recommendation mechanisms, increasing supply security and safeguarding the value chain against unplanned disruptions.

**Leader:** INESC TEC | **Participants:** OLIFEL, CARITÉ, CTC

**Methods:** machine learning, anomaly detection, time-series analysis, predictive modelling, feature engineering

**Main output:** Predictive models for delay, quality and maintenance, ready for OPTIMIZE integration

##### T4.7 - Integration of FOOTWEAR TWIN and OPTIMIZE into the OLIFEL ERP (M20–M28)

Converts R&D results into a new intelligent commercial module embedded in the OLIFEL ERP. Uses APIs and microservices for natural integration into production teams' daily routines, preventing "technological rejection" seen in previous industry attempts.

**Leader:** OLIFEL | **Participants:** INESC TEC, CARITÉ, CTC

**Methods:** ERP integration, API development, microservices, database integration, UI prototyping

**Main output:** Intelligent OLIFEL ERP module with FOOTWEAR TWIN and OPTIMIZE

#### Effort in FTEs and investments (per beneficiary)

FTE:  
CARITÉ: 25,1; OLIFEL: 91,3; INESC TEC: 74,0; CTCP: 11,9  
Investment (non FTE):  
OLIFEL: 138.250 €;

#### Description of deliverables and milestones

D4.1 - Industrial mapping report and use-case prioritisation (Month 12) - Document - Confidential  
D4.2 - Solution architecture and data model (Month 14) - Document - Confidential  
D4.3 - FOOTWEAR TWIN functional prototype (Month 22) - Prototype - Confidential  
D4.4 - FOOTWEAR TWIN validated with real data (Month 26) - Demonstrator - Confidential  
D4.5 - OPTIMIZE engine (Month 24) - Prototype - Confidential  
D4.6 - Predictive models (Month 26) - Prototype - Confidential  
D4.7 - Integrated OLIFEL ERP module (Month 28) - Prototype - Confidential

M4.1 - Use cases defined and baseline established (Month 12)  
M4.2 - FOOTWEAR TWIN technically validated (Month 26) - ≥3 scenarios within defined tolerance  
M4.3 - OPTIMIZE engine operational (Month 24) - planning recommendations on real data  
M4.4 - ERP integration complete (Month 28) - functional demonstration

| Activity No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Activity Title                                       |                      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|----------------------|
| A5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Integration and validation in industrial environment |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Start date: 01/04/2028                               | End date: 31/10/2029 |
| <b>Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                      |
| <p>This activity integrates all PPS outputs - AI/CV/AR (PPS1, MIND), robotics/laser (PPS2, DCSI PRO) and digital twin (PPS4, OLIFEL/INESC TEC) - into a coherent cyber-physical production system, demonstrating industrial implementation potential with existing shop-floor technologies and digital tools.</p> <p>Validation occurs through: (i) full-chain demonstration at CARITÉ (leather scanning → laser → injection → Quality Gate); (ii) modular Quality Gate deployment at RODIRO; (iii) environmental sustainability assessment. Pilot tests evaluate detection precision, algorithm response time, AR effectiveness, robotic-cell/digital-twin integration and end-user acceptance, confirming TRL maturity.</p> |                                                      |                      |
| <b>Description of the activity</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                      |                      |
| <p><b>T5.1 - Vision HW and AI algorithms in Quality Gates (QG) (M16–M26)</b><br/>Integration of DCSI PRO vision hardware (cameras, scanners, lighting from T3.1) with MIND AI algorithms (defect detection from T2.3, colour classification from T2.1) into unified Quality Gate stations. Covers calibration, data-flow orchestration and real-time inference for inline inspection at production-line speed.<br/><b>Leader:</b> DCSI PRO   <b>Participants:</b> CARITÉ, CTCP, MIND, RODIRO<br/><b>Methods:</b> system integration, hardware-software interface design, real-time inference, calibration, production-speed testing<br/><b>Main output:</b> Integrated Quality Gate stations</p>                              |                                                      |                      |
| <p><b>T5.2 - Adaptive robotic cell for uppers: assembly and calibration (M16–M28)</b><br/>Assembly of the adaptive robotic cell integrating grippers for flexible materials (T3.2) and laser roughing/engraving (T3.3), with digital twin feedback for adaptive path control on flexible upper materials.<br/><b>Leader:</b> DCSI PRO   <b>Participants:</b> CARITÉ, CTCP, RODIRO<br/><b>Methods:</b> robotic cell assembly, sensor fusion, adaptive control, digital twin integration<br/><b>Main output:</b> Adaptive robotic cell calibrated and tested</p>                                                                                                                                                                |                                                      |                      |
| <p><b>T5.3 - AI/CV/AR integration into CAD systems and cutting machines (M18–M28)</b><br/>Integration of A2 solutions with existing CAD systems and automatic cutting machines. MIND develops software interfaces and communication protocols for interoperability between digital tools and industrial equipment.</p>                                                                                                                                                                                                                                                                                                                                                                                                        |                                                      |                      |

Includes adaptation of AI/AR modules to CAD/CAM specifications, integration components for different cutting machine brands, and automatic calibration mechanisms. Partners provide test infrastructure (CAD workstations, cutting lines) for real-environment validation. Integration leverages CTCP's FAIST Pilot Units (Prototyping, Advanced Production Technologies, Digitisation, Automation/Robotics).

**Leader:** MIND | **Participants:** CARITÉ, CTCP, DCSI PRO, RODIRO

**Methods:** CAD/CAM integration, communication protocol development, automatic calibration, cutting machine interfacing, FAIST pilot testing

**Main output:** AI/CV/AR modules integrated with industrial CAD/CAM and cutting systems

#### T5.4 - Closed-loop quality control implementation (M20–M30)

Closed-loop quality control linking Quality Gates (T5.1), digital twin (A4) and robotic cell (T5.2). Real-time feedback from inspection triggers automatic process adjustments - laser power correction, robotic path adaptation based on QG rejection patterns.

**Leader:** DCSI PRO | **Participants:** CARITÉ, CTCP, INESC TEC, MIND, OLIFEL, RODIRO

**Methods:** feedback loop design, real-time data integration, process parameter optimisation, control system implementation

**Main output:** Closed-loop quality control demonstrated in production conditions

#### T5.5 - Full validation at CARITÉ (scan > laser > injection > QG) (M24–M34)

End-to-end validation of the complete integrated production chain at CARITÉ. Assesses robustness, reliability and usability, evaluating: colour/defect detection precision, algorithm response time, AR effectiveness, robotic cell and laser integration with digital twin, and end-user acceptance. Results validate TRL, provide optimisation data and confirm impact on efficiency, quality and sustainability.

**Leader:** CARITÉ | **Participants:** CTCP, DCSI PRO, OLIFEL

**Methods:** end-to-end production testing, multi-shift validation, TRL assessment, KPI monitoring, user acceptance testing

**Main output:** Full-chain demonstration report at CARITÉ

#### T5.6 - Modular validation at RODIRO (QG on existing lines) (M24–M32)

Deployment and validation of modular Quality Gate stations on RODIRO's existing lines, demonstrating scalability and adaptability to different factory configurations.

**Leader:** RODIRO | **Participants:** CTCP, DCSI PRO, OLIFEL

**Methods:** modular deployment, production-line integration, operator training, performance comparison

**Main output:** Modular QG demonstration report at RODIRO

#### T5.7 - Environmental impact and sustainability assessment (M28–M34)

Environmental sustainability evaluation of each solution using LCA methodology. Data typologies defined, data collected across A2–A5 for impact analysis against conventional footwear-sector tools. Essential for framing within sustainability and circular economy principles.

**Leader:** CTCP | **Participants:** CARITÉ, DCSI PRO, MIND, OLIFEL, RODIRO

**Methods:** life-cycle assessment (LCA), energy efficiency measurement, waste characterisation, environmental impact modelling

**Main output:** Environmental sustainability assessment report

#### Effort in FTEs and investments (per beneficiary)

FTE:

CARITÉ: 29,0; RODIRO: 28,8; DCSI PRO: 134,8; OLIFEL: 53,9; MIND: 206,8; INESC TEC: 14,8; CTCP: 14,8

Investment (non FTE):

CARITÉ: 3.000 €; RODIRO: 15.000 €; CTCP: 1.000 €

#### Description of deliverables and milestones

D5.1 - Integrated Quality Gate system report (Month 28) - Report - Confidential

D5.2 - Adaptive robotic cell integration report (Month 28) - Report - Confidential

D5.3 - CAD/CAM integration report (Month 30) - Report - Confidential

D5.4 - Closed-loop quality control implementation demonstration (Month 32) - Report - Confidential

D5.5 - Full-chain validation report at CARITÉ (Month 34) - Report - Confidential

D5.6 - Modular QG validation report at RODIRO (Month 34) - Report - Confidential

D5.7 - Environmental sustainability assessment (Month 34) - Report - Public

M5.1 - QG and robotic cell integrated (Month 28) - joint operation of vision, robotics and DT  
M5.2 - Full-chain validation at CARITÉ (Month 34) - end-to-end production run  
M5.3 - Modular QG validated at RODIRO (Month 34) - operator acceptance and QC data

| Activity No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Activity Title                      |                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|----------------------|
| A6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Digital twin industrial integration |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Start date: 01/04/2028              | End date: 30/06/2029 |
| <b>Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                     |                      |
| <p>This activity deploys the industrial pilot at CARITÉ, validates FOOTWEAR TWIN and OPTIMIZE in real operational scenarios and measures impact on production performance and OLIFEL's commercial exploitation potential. It marks transition from lab development (TRL 5–6) to industrial validation (TRL 7–8), confirming performance under real conditions - weekly planning, stoppages, urgent orders, mould changes, capacity constraints, multi-shift operation. Validation establishes before/after comparison against the T4.2 baseline, quantifying impact on planning time, plan adherence, setups, resource utilisation, delays, traceability and equipment availability. Results inform OLIFEL's productization strategy and replication package for the EU footwear sector.</p> |                                     |                      |
| <b>Description of the activity</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                     |                      |
| <p><b>T6.1 - Pilot implementation at CARITÉ and adaptation to industrial users (M16–M24)</b><br/> Industrial pilot implementation connecting ERP, line data, FOOTWEAR TWIN and OPTIMIZE. Development of dashboards, reports and interfaces for planning, production, quality, maintenance and management roles.<br/> <b>Leader:</b> OLIFEL   <b>Participants:</b> CARITÉ, INESC TEC, CTCP<br/> <b>Methods:</b> pilot deployment, ERP parametrisation, UI testing, dashboard development, user training, feedback collection<br/> <b>Main output:</b> Functional pilot installed and used at CARITÉ by industrial users</p>                                                                                                                                                                   |                                     |                      |
| <p><b>T6.2 - Industrial validation of FOOTWEAR TWIN and OPTIMIZE in real scenarios (M20–M28)</b><br/> Industrial validation in real CARITÉ scenarios: weekly planning, re-planning after stoppages, urgent orders, mould availability changes, capacity simulation, delay prediction and preventive maintenance.<br/> <b>Leader:</b> CARITÉ   <b>Participants:</b> OLIFEL, INESC TEC, CTCP<br/> <b>Methods:</b> industrial validation, real-case testing, before/after comparison, KPI monitoring, user acceptance testing<br/> <b>Main output:</b> Industrial validation report (≥5 validated scenarios per product)</p>                                                                                                                                                                    |                                     |                      |
| <p><b>T6.3 - Measurement of operational, economic and strategic impact (M24–M30)</b><br/> Measures solution impact on CARITÉ's operation and OLIFEL's commercial exploitation: planning time, plan adherence, setups, resource utilisation, delays, traceability, rework, equipment availability and market potential.<br/> <b>Leader:</b> CARITÉ   <b>Participants:</b> OLIFEL, INESC TEC, CTCP<br/> <b>Methods:</b> KPI analysis, operational/economic assessment, cost-benefit analysis, market-exploitation assessment<br/> <b>Main output:</b> Operational, economic and strategic impact report</p>                                                                                                                                                                                    |                                     |                      |
| <p><b>T6.4 - ERP product, business model and exploitation strategy (M24–M34)</b><br/> Transforms validated results into a new OLIFEL ERP commercial module: functionalities, product architecture, licensing model, services, support, maintenance and market strategy. Prepares a productised, market-ready offering for sustainable business and sectoral replication.<br/> <b>Leader:</b> OLIFEL   <b>Participants:</b> CARITÉ, INESC TEC<br/> <b>Methods:</b> product roadmap, business model design, go-to-market strategy, software productisation, pricing/licensing analysis<br/> <b>Main output:</b> Industrialisation and commercial exploitation plan for the OLIFEL ERP module</p>                                                                                               |                                     |                      |
| <p><b>T6.5 - Replication package, intellectual property and sectoral dissemination (M28–M36)</b><br/> Prepares solution replication in other footwear companies: minimum data requirements, implementation methodology, parametrisation, documentation, training, IP mapping, data-use rules and dissemination actions. Aims to facilitate rapid cross-border adoption within the EU internal market.<br/> <b>Leader:</b> OLIFEL   <b>Participants:</b> CARITÉ, INESC TEC, CTCP</p>                                                                                                                                                                                                                                                                                                          |                                     |                      |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Methods:</b> replication methodology, implementation playbook, IP mapping, data-governance, documentation, sectoral dissemination                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Main output:</b> Replication package, IP matrix and dissemination/exploitation plan.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Effort in FTEs and investments (per beneficiary)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| FTE:<br>CARITÉ: 18,7; OLIFEL: 48,4; INESC TEC: 18,4; CTCP: 13,0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Description of deliverables and milestones</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <p>D6.1 - Pilot deployment report (Month 26) - Report - Confidential</p> <p>D6.2 - Industrial validation report with ≥5 scenarios per product (Month 30) - Report - Confidential</p> <p>D6.3 - Impact report (Month 30) - Report - Confidential</p> <p>D6.4 - OLIFEL ERP module industrialisation and commercial exploitation plan (T6.4, M34): Product roadmap, licensing model, pricing strategy, service design and go-to-market plan for the new intelligent ERP module.</p> <p>D6.5 - Replication package and IP matrix (T6.5, M36): Minimum data requirements, implementation methodology, parametrisation guide, technical documentation, training materials, intellectual-property matrix, data-governance rules and sectoral dissemination plan.</p> <p>M6.1 - Pilot operational at CARITÉ (Month 26) - daily use by ≥3 user roles</p> <p>M6.2 - ≥5 FOOTWEAR TWIN + ≥5 OPTIMIZE scenarios validated (Month 30) - before/after KPI comparison</p> <p>M6.3 - ERP product and replication strategy complete (T6.4+T6.5, M36): Commercial exploitation plan approved by OLIFEL management and replication package validated with at least one external footwear company assessment.</p> |

| Activity No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Activity Title         |                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|----------------------|
| A7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Productive innovation  |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Start date: 01/06/2027 | End date: 31/12/2029 |
| <b>Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                        |                      |
| <p>This activity encompasses productive innovations incorporating R&amp;D results into industrial operations:</p> <p>(a) Physical facility construction - DCSI PRO creates the three AI-branded facilities (AI Vision Factory, AI Robotic Factory, AI Laser Lab) housing the robotics, vision and laser systems developed in A3.</p> <p>(b) Technology acquisition - CARITÉ acquires a laser roughing robot, a mechanical roughing line, a heavy injection machine, and a suite of smart adaptive systems: an intelligent automated mould warehouse (AI-driven storage and retrieval), autonomous mobile robots (AMRs) for internal logistics, a robotised mould washing station, an AI-vision robot for thread-burning finishing, and a robotic cell for glue application and shank positioning with 3D vision; RODIRO acquires robotised assembly lines, a quality-control laboratory and supporting software. These investments are linked to R&amp;D activities (A2–A6) and essential for transition from validated prototypes (TRL 6–8) to permanent industrial deployment.</p> |                        |                      |
| <b>Description of the activity</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                        |                      |
| <p><b>T7.1 - Creation of the AI, Artificial Vision and Laser Factories at DCSI PRO (M6–M36)</b></p> <p>Construction and fitting-out of three specialised facilities: (a) DCSI AI Vision Factory - space for vision systems, camera arrays, lighting and AI inspection stations; (b) DCSI AI Robotic Factory - floor space, safety enclosures, power/pneumatic infrastructure for robotic cells and grippers; (c) DCSI AI Laser Lab - controlled environment for laser equipment including extraction and purification systems. Works include civil, electrical and mechanical installations, environmental controls and safety infrastructure for A3 equipment operation.</p> <p><b>Leader:</b> DCSI PRO   <b>Participants:</b> —</p> <p><b>Methods:</b> architectural design, civil construction, mechanical/electrical installation, safety certification, environmental compliance</p> <p><b>Main output:</b> Three operational factory facilities ready to house SHOE.AI technology</p> <p><b>T7.2 - Acquisition of technologies (M6–M36)</b></p>                                |                        |                      |

Productive innovation by CARITÉ and RODIRO:

RODIRO: (a) two robotised assembly lines for the new production method (3D scanner with AI-driven roughing/glue adjustment, robotic roughing/glue stations, sole washing/glue robot, injection equipment); (b) quality-control laboratory (dynamometer, flexometer, abrasion testers, Martindale, crockmeter, colour chamber, durometer, light-exposure tester, thickness gauge); (c) software platforms for HR competence mapping, AI administrative automation and ESG/energy management.

CARITÉ: (a) laser robot for automated upper roughing; (b) production line with mechanical roughing and logistics; (c) heavy injection machine for outsole production; (d) intelligent automated mould warehouse with AI-driven location, availability checking and maintenance tracking (capacity 300-500 moulds); (e) demoulding-agent application robot integrated into the injection cycle for uniform dosing and reduced waste; (f) two autonomous mobile robots (AMRs) with 20 load/unload stations for mould, material and finished-goods transport; (g) robotised ultrasonic mould-washing station with controlled jet and automatic drying; (h) AI-vision thread-burning robot using camera-based identification and controlled flame for consistent finishing; (i) robotic cell with 3D vision (Photoneo-class) for automatic glue-path generation and precision shank positioning in injection moulds

**Leader:** CARITÉ | **Participants:** RODIRO

**Methods:** equipment procurement, factory layout adaptation, installation, commissioning, process validation

**Main output:** Industrial equipment operational at CARITÉ and RODIRO

#### Effort in FTEs and investments (per beneficiary)

Investment (non FTE):

CARITÉ: 4.050.000 €; RODIRO: 2.946.002,00 €; DCSI PRO: 762.500,00 €;

#### Description of deliverables and milestones

D7.1 - DCSI PRO factory facilities commissioning report (Month 36) - Report - Confidential

D7.2 - RODIRO productive innovation commissioning report (Month 36) - Report - Confidential

D7.3 - CARITÉ productive innovation commissioning report (Month 36) - Report - Confidential

M7.1 - DCSI PRO AI Vision Factory, Robotic Factory and Laser Lab operational (Month 30)

M7.2 - RODIRO robotic lines and QC laboratory operational (Month 34)

M7.3 - CARITÉ automated roughing line, injection machine and smart factory systems operational (Month 34)

| Activity No.                                                                                                                                                                                                                                                                                                                             | Activity Title                             |                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|----------------------|
| A8                                                                                                                                                                                                                                                                                                                                       | Promotion and dissemination of the results |                      |
|                                                                                                                                                                                                                                                                                                                                          | Start date: 01/01/2027                     | End date: 31/12/2029 |
| <b>Objective</b>                                                                                                                                                                                                                                                                                                                         |                                            |                      |
| Disseminate project results and communicate their relevance to stakeholders, the scientific community and the general public. Maximise commercial and industrial exploitation of results for consortium partners and improve the competitiveness of the Portuguese footwear ecosystem.                                                   |                                            |                      |
| <b>Description of the activity</b>                                                                                                                                                                                                                                                                                                       |                                            |                      |
| <b>T8.1 - Promotional material and project identity (M1–M12)</b>                                                                                                                                                                                                                                                                         |                                            |                      |
| Definition of the project logo and development of promotional materials (roll-ups, posters, brochures, identification cards) reflecting the project's innovation and competitive advantages, for distribution at events and communication actions.                                                                                       |                                            |                      |
| <b>Leader:</b> CTCP   <b>Participants:</b> CARITÉ, DCSI PRO, INESC TEC, MIND, OLIFEL, RODIRO                                                                                                                                                                                                                                             |                                            |                      |
| <b>Methods:</b> graphic design, brand development, digital communication strategy                                                                                                                                                                                                                                                        |                                            |                      |
| <b>Main output:</b> Project visual identity and promotional material suite                                                                                                                                                                                                                                                               |                                            |                      |
| <b>T8.2 - Technical-scientific publications (M6–M36)</b>                                                                                                                                                                                                                                                                                 |                                            |                      |
| Approximately 4 articles planned for recognised journals (International Journal of Computer Vision, IAES International Journal of AI, IEEE Transactions on PAMI). Target conferences: IEEE/CVF CVPR, ECCV, WACV, BMVC, 3DV. Industry publications: World Footwear, CTCP INOVA, Just Style. A doctoral thesis in AI/CV is also envisaged. |                                            |                      |
| <b>Leader:</b> INESC TEC   <b>Participants:</b> CARITÉ, CTCP, DCSI PRO, MIND, OLIFEL, RODIRO                                                                                                                                                                                                                                             |                                            |                      |
| <b>Methods:</b> scientific writing, peer-review submission, open-access strategy, industry publication outreach                                                                                                                                                                                                                          |                                            |                      |

**Main output:** ≥4 scientific articles published or submitted

### T8.3 - Participation in scientific and specialist events (M6–M36)

Participation in: (i) scientific conferences (IJCAI, AI Applications, ECCV, 3DV, UITIC Congress); (ii) technology fairs (SIMAC, A+A, Messe). Consortium-organised Open Days at demonstrator sites (CARITÉ, RODIRO). Webinars and podcasts building on CTCP's 'Um Café com' programme (FAIST). Collaboration with higher education institutions and design schools for student experimentation.

**Leader:** CTCP | **Participants:** DCSI PRO, INESC TEC, MIND, OLIFEL

**Methods:** conference presentation, exhibition, live demonstration, Open Days, webinars, podcasts, university collaboration

**Main output:** Participation in ≥6 events with demonstration of results

### T8.4 - Valorisation and commercial exploitation strategy (M18–M36)

Commercial exploitation strategy for the footwear technology market: minimum data requirements, implementation methodology, documentation, training, IP mapping and data-use rules. CTCP contributes national/international sectoral perspective leveraging FAIST Pilot Units for result demonstration. Digital dissemination: social media, short videos, storytelling, infographics and cross-promotion with other R&D&I initiatives.

**Leader:** OLIFEL | **Participants:** CARITÉ, CTCP, DCSI PRO, INESC TEC, MIND, RODIRO

**Methods:** replication methodology, IP mapping, data-governance, sectoral demonstration, FAIST leveraging, social media, video storytelling

**Main output:** Exploitation strategy, IP matrix and digital dissemination plan

### Effort in FTEs and investments (per beneficiary)

FTE:

CARITÉ: 17,6; RODIRO: 12,1; DCSI PRO: 44,0; OLIFEL: 17,6; MIND: 26,3; INESC TEC: 8,3; CTCP: 31,9

Investment (non FTE):

DCSI PRO: 47.500 €; OLIFEL: 19.500 €; MIND: 108.000 €; CTCP: 190.500 €

### Description of deliverables and milestones

D8.1 - Project identity and promotional materials (Month 6) - Website/Materials - Public

D8.2 - Scientific publications (Month 18, 24, 30, 36) - Publications - Public

D8.3 - Event participation reports (Month 12, 24, 36) - Report - Public

D8.4 - Replication package and IP matrix (Month 36) - Document - Confidential

M8.1 - Project identity launched (Month 6)

M8.2 - ≥2 scientific articles submitted (Month 30)

M8.3 - Replication package completed (Month 36)

| Activity No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Activity Title                        |                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|----------------------|
| A9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Project management and implementation |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Start date: 01/01/2027                | End date: 31/12/2029 |
| <b>Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                       |                      |
| This activity ensures the technical, scientific, administrative and financial management of the project, guaranteeing the work plan and proposed objectives.                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                       |                      |
| <b>Description of the activity</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                       |                      |
| <b>T9.1 - Technical, administrative and financial management (M1–M36)</b><br>Overall project coordination through communication and cooperation among all partners. A Steering and Oversight Committee (senior representative per partner + Project Coordinator) will: (i) manage the project across technical, administrative and financial dimensions; (ii) schedule monthly meetings; (iii) prepare deliverable and milestone plans; (iv) define KPIs for progress and efficiency assessment.<br><b>Leader:</b> CARITÉ   <b>Participants:</b> CTCP, DCSI PRO, INESC TEC, MIND, OLIFEL, RODIRO |                                       |                      |

**Methods:** project management methodology, monthly meetings, financial reporting, progress tracking, risk management

**Main output:** Project governance operational; interim and final reports

#### T9.2 - Quality management and indicator monitoring (M1–M36)

Quality control across: (i) developed solutions - evaluation by all partners; (ii) project deliverables - ensuring contributions and evaluation as project documents; (iii) monitoring of each partner's contribution to tasks and activities. R&D quality indicators: concordance with A1 requirements; stakeholder consultation through post-event surveys. Deliverable indicators: compliance with deadlines and objectives.

**Leader:** CARITÉ | Participants: CTCP, DCSI PRO, INESC TEC, MIND, OLIFEL, RODIRO

**Methods:** quality management framework, KPI monitoring, partner evaluation, solution testing, stakeholder feedback

**Main output:** Quality monitoring reports (quarterly); final quality assessment report

#### Effort in FTEs and investments (per beneficiary)

FTE:

CARITÉ: 9,9; RODIRO: 17,2; DCSI PRO: 3,3; OLIFEL: 3,3; MIND: 45,0; INESC TEC: 2,75; CTCP: 15,4

Investment (non FTE):

CARITÉ: 6.750 €; RODIRO: 4.500 €; DCSI PRO: 4.800 €; OLIFEL: 4.500 €; MIND: 3.000 €; CTCP: 4.500 €

#### Description of deliverables and milestones

D9.1 - Interim progress reports (Month 12, Month 24) - Report - Confidential

D9.2 - Final project report (Month 36) - Report - Confidential

D9.3 - Quality monitoring reports (quarterly) - Report - Confidential

M9.1 - Governance structure operational (Month 1)

M9.2 - Interim report approved (Month 12)

M9.3 - Final report delivered (Month 36)

## 2.4. summary table of deliverables

Identify and classify the project deliverables and the corresponding activities associated with them.

| Deliverable No. | Activity No. | Deliverable title                                                | Delivery date (Month 0+N) | Responsible beneficiary |         | Deliverable type | Dissemination level |
|-----------------|--------------|------------------------------------------------------------------|---------------------------|-------------------------|---------|------------------|---------------------|
|                 |              |                                                                  |                           | No.                     | Abbrev. |                  |                     |
| D1.1            | A1           | State-of-the-art report: AI/CV/AR, robotics/laser, digital twins | Month 10                  | 7                       | CTCP    | Report           | Confidential        |
| D1.2            | A1           | Technical requirements specification framework                   | Month 12                  | 7                       | CTCP    | Report           | Confidential        |
| D1.3            | A1           | Technology watch reports                                         | Month 12                  | 7                       | CTCP    | Report           | Confidential        |
| D2.1            | A2           | Colour-tone detection system prototype                           | Month 18                  | 5                       | MIND    | Prototype        | Confidential        |
| D2.2            | A2           | Generative AI design                                             | Month 24                  | 5                       | MIND    | Prototype        | Confidential        |

|      |    |                                                       |          |   |          |              |              |
|------|----|-------------------------------------------------------|----------|---|----------|--------------|--------------|
|      |    | platform prototype                                    |          |   |          |              |              |
| D2.3 | A2 | Leather defect detection and classification system    | Month 24 | 5 | MIND     | Prototype    | Confidential |
| D2.4 | A2 | AR mould placement and part picking application       | Month 24 | 5 | MIND     | Prototype    | Confidential |
| D2.5 | A2 | AR 3D visualisation platform                          | Month 24 | 5 | MIND     | Prototype    | Confidential |
| D2.6 | A2 | AI-optimised nesting engine (chromatic variations)    | Month 28 | 5 | MIND     | Prototype    | Confidential |
| D3.1 | A3 | DCSI AI Vision Factory: integrated vision platform    | Month 24 | 3 | DCSI PRO | Prototype    | Confidential |
| D3.2 | A3 | DCSI AI Robotic Factory: tooling and assembly cell    | Month 24 | 3 | DCSI PRO | Prototype    | Confidential |
| D3.3 | A3 | DCSI AI Laser Lab: roughing/en graving system         | Month 28 | 3 | DCSI PRO | Prototype    | Confidential |
| D4.1 | A4 | Industrial mapping report and use-case prioritisation | Month 12 | 4 | OLIFEL   | Report       | Confidential |
| D4.2 | A4 | Solution architecture and data model                  | Month 14 | 4 | OLIFEL   | Report       | Confidential |
| D4.3 | A4 | FOOTWEAR TWIN functional prototype                    | Month 22 | 4 | OLIFEL   | Prototype    | Confidential |
| D4.4 | A4 | FOOTWEAR TWIN validated with real data                | Month 26 | 4 | OLIFEL   | Demonstrator | Confidential |
| D4.5 | A4 | OPTIMIZE AI planning engine                           | Month 24 | 4 | OLIFEL   | Prototype    | Confidential |
| D4.6 | A4 | Predictive models                                     | Month 26 | 4 | OLIFEL   | Prototype    | Confidential |

|      |    |                                                               |          |   |          |           |              |
|------|----|---------------------------------------------------------------|----------|---|----------|-----------|--------------|
| D4.7 | A4 | Integrated OLIFEL ERP module                                  | Month 28 | 4 | OLIFEL   | Prototype | Confidential |
| D5.1 | A5 | Integrated Quality Gate system report                         | Month 28 | 4 | OLIFEL   | Report    | Confidential |
| D5.2 | A5 | Adaptive robotic cell integration report                      | Month 28 | 4 | OLIFEL   | Report    | Confidential |
| D5.3 | A5 | CAD/CAM integration report                                    | Month 30 | 5 | MIND     | Report    | Confidential |
| D5.4 | A5 | Closed-loop quality control implementation demonstration      | Month 32 | 4 | OLIFEL   | Report    | Confidential |
| D5.5 | A5 | Full-chain validation report at CARITÉ                        | Month 34 | 1 | CARITÉ   | Report    | Confidential |
| D5.6 | A5 | Modular QG validation report at RODIRO                        | Month 34 | 2 | RODIRO   | Report    | Confidential |
| D5.7 | A5 | Environmental sustainability assessment                       | Month 34 | 7 | CTCP     | Report    | Public       |
| D6.1 | A6 | Pilot deployment report                                       | Month 26 | 4 | OLIFEL   | Report    | Confidential |
| D6.2 | A6 | Industrial validation report (≥5 scenarios per product)       | Month 30 | 1 | CARITÉ   | Report    | Confidential |
| D6.3 | A6 | Impact report                                                 | Month 30 | 1 | CARITÉ   | Report    | Confidential |
| D6.4 | A6 | ERP module industrialisation and commercial exploitation plan | Month 34 | 4 | OLIFEL   | Report    | Confidential |
| D6.5 | A6 | Replication package and IP matrix                             | Month 36 | 4 | OLIFEL   | Report    | Confidential |
| D7.1 | A7 | DCSI PRO factory facilities commissioning report              | Month 36 | 3 | DCSI PRO | Report    | Confidential |
| D7.2 | A7 | RODIRO productive innovation                                  | Month 36 | 2 | RODIRO   | Report    | Confidential |

|      |    |                                                   |          |   |        |                   |              |
|------|----|---------------------------------------------------|----------|---|--------|-------------------|--------------|
|      |    | commissioning report                              |          |   |        |                   |              |
| D7.3 | A7 | CARITÉ productive innovation commissioning report | Month 36 | 1 | CARITÉ | Report            | Confidential |
| D8.1 | A8 | Project identity and promotional materials        | Month 6  | 7 | CTCP   | Website/Materials | Public       |
| D8.2 | A8 | Scientific publications                           | Month 36 | 7 | CTCP   | Publications      | Public       |
| D8.3 | A8 | Event participation reports                       | Month 36 | 7 | CTCP   | Report            | Public       |
| D8.4 | A8 | Replication package and IP matrix                 | Month 36 | 7 | CTCP   | Report            | Confidential |
| D9.1 | A9 | Interim progress reports                          | Month 24 | 1 | CARITÉ | Report            | Confidential |
| D9.2 | A9 | Final project report                              | Month 36 | 1 | CARITÉ | Report            | Confidential |
| D9.3 | A9 | Quality monitoring reports (quarterly)            | Month 36 | 1 | CARITÉ | Report            | Confidential |

(\*) **Confidential**: dissemination restricted to the consortium and to the evaluation and monitoring teams /

**Public**: unrestricted dissemination (e.g., on the project website or the lead beneficiary's website).

## 2.5. summary table of milestones

| Milestone No. | Activity No. | Delivery date (Month 0+N) | Milestone title                                              | Means of verification ( <i>must be quantifiable</i> )         |
|---------------|--------------|---------------------------|--------------------------------------------------------------|---------------------------------------------------------------|
| M1.1          | A1           | Month 10                  | State-of-the-art review completed                            | Published SoA report (D1.1) delivered                         |
| M1.2          | A1           | Month 12                  | Requirements specification approved by consortium            | Sign-off from all partners on D1.2                            |
| M2.1          | A2           | Month 18                  | First functional prototypes of CV and AI modules             | Demonstration of T2.1 and T2.3 prototypes                     |
| M2.2          | A2           | Month 28                  | All A2 prototypes ready for integration testing              | Standalone validation of all 6 deliverables                   |
| M3.1          | A3           | Month 18                  | AI Vision Factory hardware and software platform operational | Image acquisition and calibration verified on leather samples |
| M3.2          | A3           | Month 28                  | All robotic and laser prototypes ready for integration       | Standalone validation of each system completed                |
| M4.1          | A4           | Month 12                  | Use cases defined and baseline established                   | Industrial mapping report (D4.1) approved                     |
| M4.2          | A4           | Month 26                  | FOOTWEAR TWIN technically validated                          | ≥3 scenarios within defined tolerance                         |
| M4.3          | A4           | Month 24                  | OPTIMIZE engine operational                                  | Planning recommendations generated on real data               |

|      |    |          |                                                                                         |                                                                                                                                                     |
|------|----|----------|-----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| M4.4 | A4 | Month 28 | ERP integration complete                                                                | Functional demonstration of integrated module                                                                                                       |
| M5.1 | A5 | Month 28 | QG and robotic cell integrated                                                          | Joint operation of vision, robotics and AI as integrated station                                                                                    |
| M5.2 | A5 | Month 34 | Full-chain validation at CARITÉ complete                                                | All validation test protocols executed and documented                                                                                               |
| M5.3 | A5 | Month 34 | Modular QG validated at RODIRO                                                          | Operator acceptance and QC data documented                                                                                                          |
| M6.1 | A6 | Month 26 | Pilot operational at CARITÉ                                                             | Daily use by ≥3 user roles                                                                                                                          |
| M6.2 | A6 | Month 30 | ≥5 FOOTWEAR TWIN + ≥5 OPTIMIZE scenarios validated                                      | Before/after KPI comparison documented                                                                                                              |
| M6.3 | A6 | Month 36 | ERP product and replication strategy complete                                           | Commercial exploitation plan approved by OLIFEL management and replication package validated with at least one external footwear company assessment |
| M7.1 | A7 | Month 30 | DCSI PRO AI Vision Factory, Robotic Factory and Laser Lab operational                   | Facilities inspection certificate and equipment installation sign-off                                                                               |
| M7.2 | A7 | Month 34 | RODIRO robotic lines and QC laboratory operational                                      | Equipment commissioning report and first production run                                                                                             |
| M7.3 | A7 | Month 34 | CARITÉ automated roughing line, injection machine and smart factory systems operational | Equipment commissioning report and first production run                                                                                             |
| M8.1 | A8 | Month 6  | Project identity launched                                                               | Website live and promotional materials distributed                                                                                                  |
| M8.2 | A8 | Month 30 | ≥2 scientific articles submitted                                                        | Submission confirmations from journals/conferences                                                                                                  |
| M8.3 | A8 | Month 36 | Replication package completed                                                           | Document approved by consortium                                                                                                                     |
| M9.1 | A9 | Month 1  | Governance structure operational                                                        | Steering Committee constituted and first meeting held                                                                                               |
| M9.2 | A9 | Month 12 | Interim report approved                                                                 | Report submitted and accepted                                                                                                                       |
| M9.3 | A9 | Month 36 | Final report delivered                                                                  | Report submitted to funding agency                                                                                                                  |

## 2.6. Description of critical risks for Project Management

| Project management risk event                                        | Event description                                                                                                                                             | Probability of occurrence (1 = Low to 5 = High) | Impact on project delivery | Planned mitigation measures                                                                                                                                                                                                                                   |
|----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Delays by a beneficiary in providing a deliverable                   | A partner falls behind schedule on a critical deliverable, potentially blocking dependent activities (e.g., A2/A3/A4 prototypes needed for A6/A5 integration) | 3                                               | High                       | Monthly Management Committee meetings monitor progress against Gantt milestones. Buffer periods built into Phase 3 activities (A6 starts M16 while A2-A4 run until M28). Re-allocation of tasks within the consortium if needed.                              |
| Communication and coordination issues among beneficiaries            | Misalignment between the parallel PPS development streams (PPS1-MIND, PPS2-DCSI PRO, PPS4-OLIFEL) leading to integration difficulties in Phase 3              | 2                                               | High                       | Technical-Scientific Committee with representatives from all partners meets quarterly. Interface specifications defined in A1 (T1.4). Joint integration checkpoints at M12, M18, M24.                                                                         |
| The effort required to deliver is significantly larger than expected | Technical challenges in manipulating flexible materials or training AI models on natural leather variability prove more complex than anticipated              | 3                                               | Medium                     | TRL starting points are conservative (TRL 3). MIND's prior experience in AI/CV for footwear de-risks AI algorithms. Iterative development methodology with intermediate milestones allows early detection. Scope can be narrowed to core use cases if needed. |
| Lack of qualified human resources                                    | Difficulty recruiting or retaining AI/robotics specialists during the 36-month project period                                                                 | 2                                               | Medium                     | Key researchers identified and committed at proposal stage (CVs attached). INESC TEC provides research backup capacity. CTCP and MIND have stable, experienced teams in footwear technology.                                                                  |
| Deviations from the defined budget                                   | Cost overruns on equipment, materials or HR due to inflation or supply chain disruptions                                                                      | 2                                               | Medium                     | Budget includes contingency margins. Productive Innovation quotes obtained from identified suppliers. Management Committee reviews financial execution quarterly against budget forecast.                                                                     |

## 2.7. Project Management

The consortium will define a Management Committee, led by a representative of each element of the consortium, together with a Technical-Scientific Committee, consisting of a researcher from the technical-scientific area of each entity, in order to ensure an efficient management of the project.

The Management Committee is responsible for the general administration of the project, including the technical, administrative and financial aspects, ensuring the financial execution and compliance with the plan of activities aligned with the contracted objectives. This Committee will meet monthly to evaluate the evolution of the work plan, focusing on meeting the proposed objectives and milestones according to the proposed schedule. It is also the responsibility of the Management Committee to timely communicate to the Project Manager and the responsible intermediary entities all contractual changes, ensuring compliance with the conditions established both pre- and post-contractual, as defined at the time of signing the Term of Acceptance.

## 3. Impact

(relevant information for the scoring of sub-criteria A1, D1 and D3)

### 3.1. Economic and/or business impact

Describe the **strategy** for the **economic valorisation** of project results, **per beneficiary (company)**, associating it with the project's development lines, and identifying:

Economic valorisation strategy per beneficiary:

MIND - 5 technology products (AI/CV/AR software): AI leather defect detection, generative AI design, AR visualisation/mould placement, AI nesting optimisation, integrated AI quality platform. Target: European footwear manufacturers (primary), leather goods/automotive/textile (secondary). International commercialisation via ZÜND global distribution partnership. Geographic: Portugal, Italy, France, Spain, then Turkey, Vietnam, China through ZÜND channels.

DCSI PRO - Integrated hardware+software systems: AI Vision Factory (vision + inspection), AI Robotic Factory (tooling + assembly cells), AI Laser Lab (roughing/engraving + 3D software). Target: footwear machinery sector, extending to leather goods and flexible material manufacturing. Turn-key solution model.

OLIFEL - New ERP module integrating FOOTWEAR TWIN and OPTIMIZE, productised with defined functionalities, licensing model and support services. Exploitation includes: replication package (minimum data requirements, implementation methodology, training

materials), IP/data governance framework, and sectoral dissemination via CTCP network. Target: injection footwear manufacturers (200+ PT, 1,500+ EU), expanding via SaaS/license. Competitive advantage: sector-specific knowledge natively embedded, unlike generic DT/AI platforms.

CARITÉ - Valorisation through increased production capacity, quality and efficiency enabled by the full demonstrator installation. Competitive advantage in the luxury footwear segment through AI-verified quality, laser roughing precision, smart adaptive factory infrastructure (intelligent mould logistics, autonomous transport, AI-driven finishing and assembly robotics) and full digital traceability.

RODIRO - Valorisation through automated robotic assembly and AI quality control, enabling higher throughput and consistent quality in the high-volume mocassin segment. The productive innovation in robotic lines and QC laboratory positions RODIRO as one of the most technologically advanced footwear factories in Europe.

Market characterisation: European footwear manufacturing represents €30B+ production value; Portugal exports €2.5B+ from 1,300+ factories (40,000 workers). Addressable market: AI/CV inspection (800+ PT, 5,000+ EU factories), robotic handling (200+), laser roughing (400+), digital twin/planning (300+). SHOE.AI produces high technology-intensive goods and knowledge-intensive services that are complementary - the integrated system generates more value than individual components.

Competitors: No integrated solution comparable to SHOE.AI exists in EU footwear. Individual components face competition from general-purpose machine vision (Cognex, Keyence), industrial robots (ABB, KUKA) and ERP systems (SAP, Infor) - none specialised for natural leather variability and footwear domain constraints. SHOE.AI's advantage lies in domain-specific integration.

Market entry: Phase 1 (M18-M36): validation with CARITÉ/RODIRO as references. Phase 2 (Year 1 post-project): Portuguese market via CTCP network and MIND's customer base. Phase 3 (Years 2-3): EU expansion via MIND's ZÜND partnership and CTCP's European network.

Export channels: MIND - ZÜND global distribution + subsidiaries in USA/China. DCSI PRO - international sales via trade fairs. OLIFEL - international ERP client base. CTCP - European technology centre network across EU footwear clusters.

Value chain positioning: SHOE.AI positions the consortium as technology provider to footwear manufacturers - a high-value position currently dominated by non-EU general-purpose automation players. The project creates an EU-sovereign alternative optimised for footwear's unique requirements.

Market objectives for the 'Ano Cruzeiro' (Consolidation Year, Year 3 post-project): Technology providers — forecast turnover from technology product sales: MIND: VN of €10.0M (+26.7% vs 2024), driven by commercialisation of the five AI-powered software solutions (colour-tone detection, defect digitalisation, AI nesting, AR design, intelligent cut) through the ZÜND global distribution network and own subsidiaries (USA, China). DCSI

PRO: VN of €13.7M (+247.6% vs 2024), reflecting the scaling of robotic systems and AI factory solutions developed in A3, with the three branded facilities (AI Vision Factory, AI Robotic Factory, AI Laser Lab) serving as permanent demonstration and production centres. OLIFEL: VN of €0.83M (+60.9% vs 2024), driven by AI-enhanced ERP modules (Visualgest.web) sold as SaaS subscriptions to the existing client base (~50 footwear firms) and expansion to adjacent sectors.

Productive innovators — production volume and efficiency improvements: CARITÉ: VN of €58.2M (+34.8% vs 2024), with VAB growth of +40.1% reflecting higher value-added production enabled by the full AI-integrated demonstrator line (laser roughing, intelligent mould logistics, robotic assembly, smart factory systems, Quality Gate inspection). RODIRO: VN of €73.7M (+80.2% vs 2024), with VAB growth of +76.7%, driven by the robotised assembly lines, AI-driven quality control laboratory and new production methods enabling higher throughput and reduced waste.

Consortium-level impact: Total VN grows from €96.4M (2024) to €156.4M (2032), a +62.2% increase. Total VAB rises from €27.7M to €37.5M (+35.3%), demonstrating that SHOE.AI generates not just volume growth but structural improvement in value creation across the consortium.

### 3.2. If applicable, justify (quantifying) the project's contribution to reducing or preventing strategic dependencies of the EU in one or more of the following dimensions:

EU industrial and technological leadership: SHOE.AI develops EU-sovereign AI, robotics and digital twin technologies demonstrated at TRL 8, strengthening EU leadership in AI-for-manufacturing and reducing the gap with Asian/US competitors in factory automation.

Critical infrastructures: The manufacturing automation technologies (AI vision, robotic handling, digital twins) are transferable to critical sectors (medical devices, automotive, aerospace) where EU sovereignty is paramount.

Manufacturing capacity: By enabling competitiveness through automation rather than offshoring, SHOE.AI preserves EU manufacturing capacity. Two demonstrators and CTCP replication strategy target 1,300+ Portuguese and broader EU footwear factories (250,000+ workers).

Security of supply: All key components - AI algorithms (MIND), vision/robotic tooling (DCSI PRO), digital twin (OLIFEL) - are developed by EU entities, ensuring IP, maintenance and upgrade paths remain within the EU.

Cross-border effects: CTCP's European network, MIND's ZÜND partnership and multilingual dissemination (A8) ensure cross-border impact across EU footwear clusters (Italy, Spain, France, Romania).

| Market risk event                         | Event description                                                                                                 | Probability of occurrence (1 = Low to 5 = High) | Planned mitigation measures                                                                                                                                                                                                                                                                             |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Low acceptance of the solution            | Footwear manufacturers are resistant to adopting AI/robotic solutions due to cost, complexity or cultural inertia | 2                                               | Two demonstrator sites (CARITÉ full, RODIRO modular) provide concrete proof of value. RODIRO's brownfield deployment proves incremental adoption path. CTCP's sectoral network ensures dissemination to 1,300+ factories.                                                                               |
| Competing solutions already on the market | Alternative automation solutions from non-EU providers enter the footwear market during the project period        | 2                                               | SHOE.AI's differentiator is the integration of all technologies into a single cyber-physical system, not individual components. The leather/flexible materials specialisation creates a defensible niche. EU-sovereign IP ensures long-term competitiveness.                                            |
| High time-to-market                       | The 36-month project period is insufficient to achieve full market readiness for all technology products          | 3                                               | Phased commercialisation strategy: Productive Innovations (A7) begin from M6 in parallel with R&D, ensuring factory facilities and equipment are ready for validation. Early-adopter deployment at CARITÉ/RODIRO generates reference cases. Replication package (T8.4) accelerates post-project uptake. |
| Rapid technological evolution             | Fast advances in general-purpose AI or robotics make project-specific developments less competitive               | 2                                               | Modular architecture allows integration of newer AI models/algorithms as they emerge. Domain-specific knowledge (leather characterisation, footwear processes) is the lasting competitive advantage, not the underlying AI framework.                                                                   |
| Insufficient value proposition            | The productivity/quality improvements do not justify the investment for SME footwear manufacturers                | 2                                               | Quantified KPIs (defect detection ≥95%, gripping ≥90%, OEE +10%) target measurable ROI. Modular deployment at RODIRO demonstrates that partial adoption already delivers value. CTCP's replication package includes cost-benefit analysis for different factory sizes.                                  |

## ANNEX 1 - List of risk events

| Market                                                           | Project Management                                                                                 |
|------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| Low acceptance of the solution                                   | Changes in Activity leaders and/or tasks                                                           |
| Low adoption of the solution                                     | Withdrawal of beneficiaries from the consortium                                                    |
| High time-to-market                                              | Delays by a beneficiary in providing a deliverable                                                 |
| Legal constraints (e.g., certification, licensing, patent, etc.) | Communication and coordination issues among beneficiaries                                          |
| Competing solutions already on the market                        | The effort required to deliver is significantly different from what was planned in the application |
| High solution costs                                              | Deviations from the defined budget                                                                 |
| Cultural and social factors                                      | Difficulty in engaging end-users                                                                   |
| Rapid technological evolution                                    | Lack of qualified human resources                                                                  |
| Challenges in protecting intellectual property                   | Lack of own funds to carry out the activities                                                      |
| Insufficient value proposition                                   | Deliverables do not reach the expected quality                                                     |
| Other risks                                                      | Other risks                                                                                        |