care, judgment, dexterity

CRAEFT

Innovation Management

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Executive summary

This deliverable provides a retrospective overview of the innovation management activities conducted throughout the CRAEFT project, evolving from an initial planning document into a comprehensive inventory of project-wide innovations. The Innovation Management Plan (IMP) established a structured approach to fostering a dynamic environment for research, knowledge transfer, and the development of sustainable business models for the crafts sector.

Innovation Framework and Principles

The project's strategy is grounded in the Open Innovation approach, which posits that successful outcomes arise from the interaction between diverse internal and external actors. Key principles guiding the IMP include:

- Collaborative Synergy: Leveraging a multidisciplinary team of craft practitioners, technologists, and academics to drive intellectual and organisational growth.
- User-Centric Solutions: Centring innovation on the expertise and perspectives of craftspeople to ensure recorded data and digital tools reflect real-world practices.
- Sustainability: Focusing on resource-conscious practices, such as the reduction of material and energy waste through virtual prototyping and circular economy principles.

Monitoring and Assessment Activities

Innovation monitoring was integrated into the project lifecycle through monthly workshops and plenary meetings. The project utilised structured tools to assess market readiness and technical maturity:

- Innovation Funnel: A reference model used to refine a broad range of research inputs into high-potential market outputs.
- EC Innovation Radar: A qualitative evaluation framework used to assess the maturity and commercial potential of project results.
- IPR Management: Alignment of innovation goals with intellectual property rights and exploitation strategies to ensure long-term viability.

CRAFTOUR and Policy Impact

A defining outcome of the innovation strategy is the CRAFTOUR initiative, a collaboration uniting six EU-funded projects representing 75 organisations. This initiative translated research outcomes into concrete policy recommendations presented to the European Commission and the European Parliament. These recommendations focused on reinforcing statistical knowledge of crafts, safeguarding authenticity, and empowering the transmission of skills through hybrid education models.

Innovation Inventory and WP Rationale

The deliverable documents a traceable baseline of 38 partner-identified innovations, providing a detailed record of technical and methodological advancements. These results are analysed through a WP-by-WP rationale:

WP1 & WP2: Foundational innovations including the Ethnographic Protocol, the Craft Ontology, and the Craeft Authoring Platform (CAP).

WP3 & WP4: High-impact technical outputs such as Craft-Specific Action Simulators, Haptic Interfaces, and immersive training environments like the Apprentice Studio.

WP5: Design-focused innovations, including the Design Studio and integrated Additive/Subtractive Manufacturing suites.

By merging traditional craftsmanship with cutting-edge digital technology, CRAEFT has successfully created a sustainable legacy that ensures traditional crafts thrive as living, contemporary practices.

Document history

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11/2/2026	Peiman Sichani	Khora	Combined the partners' input

Abbreviations

AR	Augmented Reality
CNC	Computer Numerical Control
FabLabs	Fabrication Labs
VR	Virtual Reality
WP	Work Package
Acronym	Expansion
AI	Artificial Intelligence
AR	Augmented Reality
CAD	Computer-Aided Design
CAP	Craeft Authoring Platform
CH / CHI	Cultural Heritage / Cultural Heritage Institutions
CIDOC-CRM	CIDOC Conceptual Reference Model
CNC	Computer Numerical Control
CrO	Crafts Ontology
DoA	Description of Action
EDM	Europeana Data Model
ECA	European Crafts Alliance
FabLabs	Fabrication Labs
FDM	Fused Deposition Modelling
GANs	Generative Adversarial Networks
ICT	Information and Communication Technologies
IMP	Innovation Management Plan
IPR	Intellectual Property Rights
MARL	Market Adoption Readiness Level
MOP	Mingei Online Platform
PBR	Physically Based Rendering
R&D	Research and Development
RCI	Representative Craft Instances
SLA	Stereolithography
SME	Small and Medium-sized Enterprise
TRL	Technology Readiness Level
VR	Virtual Reality
WP	Work Package

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1 Introduction

Traditional craftsmanship is about more than just preserving the past; it is about creating a sustainable future for crafts, where tradition and innovation walk hand in hand and where the timeless skills of practitioners are celebrated and carried forward through the power of digital technology. The Craeft project aims to redefine how we view and engage with crafts, transforming them into a vibrant, essential part of our cultural fabric. Imagine a world where the artistry of glassblowing, the precision of silversmithing, and the intricate methods of weaving are not just memories of a bygone era but thriving, evolving practices that meld seamlessly with modern digital innovations. This is the vision of Craeft, a project that stands at the crossroads of anthropology, cognitive science, and advanced digitisation, aiming to transform crafts from static heritage to dynamic, living traditions.

At its core, Craeft is an endeavour to make craftsmanship accessible and relevant in the digital age. By harnessing the power of immersive audiovisuals, haptic technology, and cutting-edge computational intelligence, we aim to create digital aids and craft-specific simulators that break down the barriers of distance and cost. This means that anyone, anywhere, should be able to learn intricate crafting skills, from the delicate shaping of porcelain to the robust carving of marble. Apart from digitising the educational process, we aim to capture the very essence of what it means to craft with care, judgment, and dexterity.

This project's innovation potential aims to reinvigorate traditional crafts' workflow by connecting craftsmanship with digital design studios, where lost techniques are resurrected through experimental archaeology and where digital techniques can facilitate material savings and energy conservation. With digital dimensions attached to each piece of work, we aim to enable certification, reputation building, and community engagement to build a vibrant, interconnected community of crafters and enthusiasts supported by a robust online portal.

The impact of Craeft will be piloted in eight representative crafts: Glass, Porcelain, Clay, Marble, Wood Carving, Silversmithing, Tapestry, and Wool Weaving, each chosen for its rich heritage and potential for innovation. These pilot projects will showcase how our integrated approach can improve craft education, design, valorisation, and community building, ensuring the crafts survive and thrive.

1.1 Scope and Objectives of the IMP

This deliverable describes the plan and guidelines for innovation management during the Craeft project. It provides supporting literature regarding innovation, describes central management tools and practices, and outlines how innovation is managed to ensure its understanding and principles for determining the innovation potential. The IMP should be seen as a dynamic document that can be adapted during the project according to the timeline and results.

1.2 Intended Audience

The dissemination level of D8.1. is sensitive (SEN). This deliverable is, therefore, intended to serve as an internal guideline for the appropriate innovation management. The main goal is for all partners to understand the procedures for innovation management and to function as an informative report for parties interested in different aspects of innovation potential.

2 Innovation Management Framework

2.1 Definition and Importance of Innovation Management

The concept of innovation must first be understood to address innovation management in collaborative environments such as the Craeft project. In the context of Horizon Europe, the IMP feeds into the European Commission's definition of innovation, which is "the use of new ideas, products or methods where they have not been used before"[1]. From this perspective, innovation offers new solutions to problems and responds to the needs of both the individual and society. Innovation leads organisations towards ambitious long-term objectives, renews structures, and fosters the emergence of new economic activity sectors. Technological advances, changes in customer behaviour, intensified competition, and changing business environments are all key factors increasing the need for innovation.[2] Innovation is also related to recognising market opportunities and establishing commercial relationships to make them economically viable. However, one of the biggest challenges is managing the innovation process.

The concept of innovation is sticky; the lack of a common definition for innovation is partly due to its multidisciplinary origin and, thus, influences the theory of innovation management. Various models of innovation break down the innovation process into various stages.[3] The innovation processes have some common basic activities that support the generation of ideas for new product and process development, as well as the management of the entire innovation process. These activities are:

- **Generation of ideas** which could become new products or processes after implementation
- **Acquisition of knowledge** on the generated ideas
- **Implementation and market monitoring** to verify customer satisfaction and after-sales service

Innovative organisations have several characteristics that can be grouped into two categories of skills: strategic skills (long-term view; ability to identify and anticipate market trends; ability to collect, process, and assimilate technological and economic information) and organisational skills (mastery of risk; internal cooperation, and external cooperation with public research, consultancies, customers, and suppliers; involvement of the whole firm in the process of change, and investment in human resources).

Innovation must be part of an organisation or a project culture: solid project management or Research and Development (R&D) are key elements for enabling innovation. Given rapid advances in information technology and a changing market environment, stakeholders need to look outside to identify new skills and knowledge. In this context, the ability to innovate by combining internal and external knowledge is becoming one of the most critical components that lead to a sustainable competitive advantage.[4] According to the literature, the stages of development and pre-development activities belong to technology management, which also includes upstream fundamental research and product and process development. Finally, innovation management includes the final product and market introduction phase.

[1] European Commission Glossary, Innovation, retrieved 2024-07-05

[2] Goffin, K., & Mitchell, R. (2010). Innovation Management. (2nd Ed.): Palgrave Macmillan.

[3] Palmberg, C. (2006). The sources and success of innovations: determinants of commercialization and break-even times. Technovation, 26, 1253-1267.

[4] Stanko, M. A., & Calantone, R. J. (2001). Controversy in innovation outsourcing research: review, synthesis and future directions. R&D Management, 41(1), 8-20.

The Craeft project aims to address all phases of innovation management, from research and planning to monitoring and assessing the final launch of the results developed.

2.2 Principles Guiding the IMP

We have chosen the Open Innovation approach. This method posits that innovation arises from the interactions between different actors rather than isolated efforts.[5] In today's interconnected world, organisations cannot remain isolated. Integrating internal and external ideas and technologies is essential. This concept of interconnectivity is supported by the European Commission's Horizon Europe program and is foundational to Craeft. Collaborative approaches in research and innovation have proven to enhance innovation outcomes and business profitability.

Open Innovation is leveraging internal and external sources of ideas and taking them to market through multiple pathways. Collaboration enables high innovation rates and efficient product development, allowing ideas to flow across organisational boundaries. This contrasts with Closed Innovation, where the entire innovation process happens internally, aiming to profit from pioneering innovations.[6]

Open Innovation has several advantages: exploring new markets, increased flexibility, access to new knowledge, shared risks and resources, and creating new value and synergies. Collaborative networks are promising in a knowledge-driven society, supported by advances in Information and Communication Technologies (ICT).

Barriers to Open Innovation include dependency on the underlying value system, difficulty identifying each partner's added value, complex income and liability distribution, and shifts from tangible to intangible assets. Key factors influencing collaboration include incentive schemes, trust relationships, management processes, organisational culture, and contract and collaboration agreement negotiation.

For Craeft, building core capabilities is crucial so that each partner can integrate sophisticated technology, test pilots coming from the project, recognise the value of external information, assimilate and apply it effectively, and maintain efficient knowledge-sharing processes. Developing strong connections with partners, including competitors and complementary entities, is essential for successful innovation management.

3 Innovation Potential

Craeft is rooted in the rich tradition of crafts, aiming to preserve and innovate within this essential aspect of cultural heritage. It is equally ambitious regarding education, digital preservation, and sustainable practices. The project's success hinges on the harmonious integration of these areas, facilitated by a multidisciplinary team of crafts experts, practitioners, technologists, and academics. This collaborative culture fosters intellectual and organisational synergy, driving innovation in the following key areas:

[5] Von Hippel, E. (1988). The Sources of Innovation. New York: Oxford University Press.

[6] Chesbrough, H. W. (2003). Open Innovation: The New Imperative for Creating and Profiting from Technology. Boston: Harvard Business School Press.

- **Technological Advancements for Preservation of Crafts for Posterity:** Craeft pilots will cover a range of Representative Craft Instances (RCIs), comparing techniques and materials across different crafts. This comparative analysis will ensure the preservation of traditional crafts, capturing them in international and open digital standards for global access. By digitally documenting and preserving these crafts, Craeft aims to safeguard them for future generations while making them accessible to a global audience.
- **Education and Training:** Craeft is dedicated to innovative craft education. By integrating digital aids such as Virtual Reality (VR) and haptics tailored to specific craft requirements, the project seeks to enhance the value of educational and training programs. This approach reduces costs and distances between instructors and students, enabling remote tutoring and informal training from traditional practitioners. Educational materials and activities will be developed for workshops and training, fostering intellectual and technical innovation. By acknowledging and documenting personal skills and contributions, Craeft aims to build a comprehensive educational curriculum that respects tradition while promoting modern techniques.
- **Sustainability through Reduction of Material and Energy Waste:** Efficiency is at the heart of Craeft's innovation strategy. The project will develop workflows that minimise resource consumption in training, testing, and prototyping of design and production. By educating participants on refurbishment and re-manufacturing and promoting designs that reuse parts, Craeft supports a circular economy. This focus on sustainability will create new products that combine traditional techniques with contemporary needs, reducing the cost of experimentation and risk through iterative planning and digitisation.
- **Crafts Creation, Production, and Development of Skills for New Products:** Craeft will cultivate design skills that leverage traditional techniques for contemporary products. By creating re-usability inventories of designs and techniques, the project will facilitate the integration of these elements into modern craftsmanship. This approach preserves traditional knowledge and adapts it to current market demands, ensuring that crafts remain relevant and economically viable.

By merging tradition with digital innovation and sustainable practices, Craeft aims to transform how we approach, learn, and preserve the art of crafting, making it an integral part of our cultural and economic lives.

4 Innovation Management Strategy

In the Craeft project, three fundamental activities are essential for driving innovation:

- **Generation of Ideas:** Identifying and developing concepts that have the potential to become new products or processes.
- **Acquisition of Knowledge:** Gathering information and insights related to these ideas.
- **Implementation and Market Monitoring:** Bringing ideas to market and continuously assessing customer satisfaction and feedback.

Innovation management within European projects requires a comprehensive understanding of market and technical challenges, aiming to successfully implement creative ideas. This involves integrating business models and process innovations often triggered by technological advancements. These advancements act as enablers and create new requirements for technology development.

The Innovation Managers (Khora, in collaboration with the Coordinator, FORTH) play a crucial role within the management structure to inform and report to partners and source feedback from the Consortium on best practices in innovation management, including:

- **Planning for Innovation Success:** Utilising innovation management techniques and processes throughout the project's lifecycle.
- **Fostering Innovation Enablers:** Identifying and promoting factors that drive innovation.
- **Performance Evaluation:** Continuously assess and improve the innovation management system.
- **Market Readiness:** Identifying the needs for market adoption of high-potential innovations.
- **Data Capture:** Systematically collecting structured data on project innovations, focusing on innovation readiness and market potential (e.g., measured by Technology Readiness Level, TRL, and Market Adoption Readiness Level, MARL).
- **Exploiting Spill-overs:** Leveraging unexpected benefits from innovations and aligning with the exploitation and strategy plan developed by the lead partners Mad'In Europe and FORTH, with input from partners.

Innovation goes beyond new technologies and products; it also seeks to develop new business models for selling and marketing craft products and designs. Production and services in the European knowledge economy rely heavily on knowledge-intensive activities, contributing to technical and scientific advancements. To support this, we look at existing business tools and strategies to:

- **Brainstorm and Quick Scan:** Utilise tools like the Business Model Canvas to discuss value propositions, branding, and market segmentation, considering resources and capabilities.
- **Test Business Models:** Evaluate business models in different scenarios to identify potential challenges and opportunities.
- **Define Roadmaps:** Create plans for transitioning to new business models when applicable.
- **Impact Analysis:** Assess the effects on business processes, applications, and IT infrastructure when implementing new business models.
- **Alignment with Partners:** Ensure new business models are aligned with relevant partners and existing IT systems, platforms, and architectures.

- **Codification and Transfer:** Facilitate the adaptation of successful business models from other sectors and countries.

This comprehensive approach ensures that Craeft fosters technological innovation and integrates innovations into sustainable and scalable business models, promoting long-term success and market adoption.

5 Innovation Monitoring & Assessment

This section informs partners about the processes and steps the Innovation Manager will follow to ensure that innovation objectives align with current market trends. Achieving this requires regular monitoring of R&D trends and market breakthroughs, and sourcing consistent input from partners. Key tasks for overall assessment include:

- **IMP Submission**: The first version of the IMP will be submitted in Month 18 and updated throughout its development until its finalisation in Month 36, when the second version of this deliverable will be submitted.
- **Updates**: Each partner is responsible for informing the rest of the consortium about events, risks, and any ideas or developments that may impact the project's Innovation Management.
- **Meetings**: A portion of selected Plenary Meetings will be dedicated to analysing the Innovation Management process and feeding input to the exploitation of results.
- **Risk Identification**: Possible risks to innovation management will be identified and classified based on their likelihood of occurrence.

5.1 Innovation Management Activities

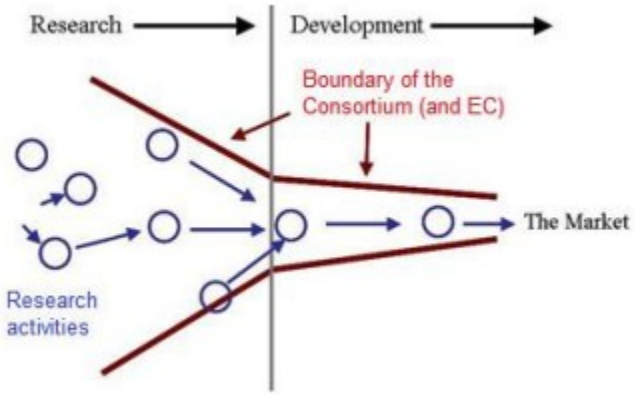
Below is an overview of the work to be carried out in each of the innovation management activities:

- **IMP and Tools Preparation:** During the development of this deliverable, the innovation management system and processes will be set up and launched. The consortium will identify and agree on relevant market and technological monitoring sources and select appropriate Innovation Management tools to be used and implemented throughout Craeft.
- **IPR Management Principles:** Any possible IPR management mechanisms will be defined in line with Exploitation Activities and IPR Management. These mechanisms will be linked with the IMP for coherence and consistency.
- **Data Gathering, Analysis, and Refinement:** During the project, the Innovation Manager will use identified tools to gather information on potential innovations developed in CRAFT from all project participants. This information will be compiled in parallel with selected plenary meetings. In each cycle, previously collected information will be reviewed and updated. Innovation and IPR results will be used to identify, assess, and prioritise ideas, establishing links between potential innovations and identified results and their market pathways.
- **Market Monitoring and Links to Exploitation Strategy:** Craeft will monitor market needs and technological evolutions in collaboration with the Exploitation Activities and Plan. It will continuously monitor market and technological data sources in identified innovation areas and filter and distribute relevant information to project stakeholders.

For efficient innovation management during the project, specific tools have been proposed to respond to the innovation management requirements. The Innovation Manager, Coordinator, and Steering Committee will be held responsible for these tools and procedures, which will be updated and implemented by all consortium members.

5.2 Innovation Funnel

A tool that can aid in identifying and understanding the pathway for technological innovations is the "Funnel" model, which has become a reference model for innovation management. The Figure below shows that the overall innovation process starts with a broad range of inputs that gradually refine and create fewer projects or outputs to be completed and introduced in the market. The funnel phases are the input of ideas, development goals, project planning, project management, execution, learning, and improved post-project. The limits of the funnel represent the organisation's boundaries; in our case, the boundaries of the consortium.



Innovation Funnel (Modified from Wheelright & Clark, 1992)[7]

5.3 Innovation Radar

The EC Innovation Radar supports innovators by recommending targeted actions that help them realise their market potential. This encompasses:

- **Assessing Innovation Maturity**: Evaluating the maturity of innovations developed within projects and identifying high-potential innovators and innovations.
- **Providing Guidance**: Offering advice on the most appropriate steps to reach the market.
- **Supporting Innovators**: Assisting innovators through entrepreneurship initiatives that address specific needs such as networking, access to finance, Intellectual Property Rights (IPR), and more.

We leverage the Innovation Radar's structured questionnaire to conduct an internal qualitative evaluation of the potential innovations developed by the end of its lifetime. This approach ensures that market potential and innovation readiness, among the strongest dimensions of ICT innovations, are thoroughly

[7] Wheelright, S. C., & Clark, K. B. (1992). Revolutionizing product development. New York: The Free Press.

assessed. By focusing on these areas, we are able to identify and nurture high-potential innovations while addressing areas where innovation can be improved.

These internal evaluation tools will help align innovations with market needs and enhance their readiness for commercialisation, ensuring that outcomes are innovative, market-ready and impactful.

5.4 Building Bridges with EC and Other Horizon Projects

Craeft has played a founding and active role in CRAFTOUR, a joint inter-project initiative coordinated by Mad'in Europe as part of the Craeft consortium, which formally unites six EU-funded projects, Craeft, HEPHAESTUS, Tracks4Crafts, Colours4Crafts, MOSAIC, and CULTURALITY, representing 75 organisations across 21 countries. CRAFTOUR operates through an interdisciplinary, bottom-up approach to strengthen, revitalise, and future-proof the European craft ecosystem, with Craeft serving as one of its four core Horizon Europe research projects alongside HEPHAESTUS, Tracks4Crafts, and Colours4Crafts.

5.4.1 Key Activities and Milestones

Launch Event – Salon International du Patrimoine Culturel, Paris (25 October 2024): The CRAFTOUR initiative was officially launched at the *Salon International du Patrimoine Culturel* in Paris on 25 October 2024. The launch conference, coordinated by Mad'in Europe, brought together representatives from all six partner projects and was attended by over 20,000 visitors and 300 exhibitors from across Europe. For the first time, six EU-funded projects jointly presented a united vision for the revitalisation of the European craft sector. Craeft was represented at the event, and the occasion marked the beginning of a sustained, structured inter-project collaboration.

Policy Round Table – European Commission, Brussels (10 December 2025): On 10 December 2025, representatives of Craeft, HEPHAESTUS, Tracks4Crafts, and Colours4Crafts met with senior officials from multiple European institutions. including DG EAC, DG MOVE, DG RTD, Creative Europe, and UNESCO, to present CRAFTOUR's first set of evidence-based policy recommendations. Craeft was represented by Madina Benvenuti and Regina Garcia Nuñez (Mad'in Europe, Craeft). The recommendations were structured around four core policy objectives:

1. Understanding, valorising, and documenting European crafts through reinforced statistical knowledge

2. Safeguarding and promoting authenticity in European crafts

3. Empowering the transmission of skills and know-how through formal and non-formal education

4. Reinforcing viable business models within the European craft sector

The discussions highlighted the transversal relevance of crafts across EU policy domains, spanning the green transition, circular economy, heritage, health and safety, trade, and tourism.

Scientific Conference – University of Antwerp (29 January 2026): CRAFTOUR held a high-level scientific conference at the University of Antwerp on 29 January 2026, serving as an anchor event for the ECA

Knowledge Exchange Programme 2026, co-hosted by Mad'in Europe. The conference translated research outcomes from across the six projects into concrete, evidence-based policy recommendations, connecting academic research with on-the-ground realities of the craft sector.

General Conference – European Parliament, Brussels (30 January 2026): On 30 January 2026, CRAFTOUR held its General Conference at the European Parliament in Brussels, further advancing its policy dialogue with European institutions and placing artisans at the centre of the discussion. The closing remarks were delivered by Kristien Van Goey, European Commission Head of Unit C.1 – Inclusive, Innovative and Reflective Societies at the Research Executive Agency.

5.4.2 Strategic Value for Craeft

Through CRAFTOUR, Craeft has extended its innovation reach beyond its own consortium by contributing to a shared European-level agenda for craft revitalisation. This inter-project collaboration has enabled Craeft to align its research outputs, including the Ethnographic Protocol, Craft Ontology, simulation tools, and educational platforms, with the broader policy needs of the European craft sector, and to co-develop recommendations now formally submitted to EU institutions. CRAFTOUR has thus become a tangible channel for translating Craeft's innovation into structural, policy-level impact, ensuring that results contribute to lasting systemic change beyond the funding period.

Craeft is committed to forging strong connections with the European Commission and other Horizon projects to enhance the sustainability and preservation of endangered crafts. As an example, Craeft will participate in international conferences and unite with 42 partners from diverse fields of expertise. A suggested tangible output of linking up with other Horizon projects on craftsmanship would be establishing a "red list" of endangered crafts at a European level, akin to the UK's approach but adapted for the broader and more complex EU landscape. Unlike the UK, which manages this manually, the EU will leverage its IT, crafts, research, and technology strengths to coordinate efforts. This initiative would lay the groundwork for creating a European Institute dedicated to endangered crafts, focusing on sustainability and the preservation of cultural heritage. Collaborations with other European partners and projects will identify and document at-risk crafts and develop innovative strategies to ensure their survival and relevance in the modern world.

6 Craeft's innovation reported by partners

This section documents the innovation input collected from Craeft partners. Its purpose is to establish a traceable baseline of partner-identified innovations and innovative results using a common reporting structure. By consolidating these inputs, the section increases transparency on the breadth of Craeft innovations, supports internal alignment across technical and dissemination Work Packages, and creates an auditable link between partner contributions and project-level reporting. The table below provides a condensed overview of the reported innovations and their key innovation dimension(s). Full partner entries are included in Annex A, while Section 7 builds on this inventory to screen overlaps, cluster innovations, and articulate Craeft's innovative results by Work Package, including the rationale and relevance to Craeft objectives.

Partner	Innovation name	Innovation dimension(s)
ARMINES	*Ethnographic protocol*	Knowledge transmission; Capacity-building; Methodological/process innovation
CERFAV	*ShellGen App*	Technical spectral rendering; Heritage reconstruction; Cost/time reduction); Democratized experimentation
	Virtual reality glassblowing simulator	Awareness-raising; Educational outreach; Cultural heritage promotion
	Ethnographic Protocol	Knowledge transmission; Capacity-building; Awareness-raising
	Instructional Methodology	Educational innovation; Methodological innovation; Accessibility
	E-learning portal	Educational innovation; Social accessibility; Cultural heritage preservation; Knowledge transmission
CETEM	*Virtual Museum of Yecla Furniture and Woodcarving*	Cultural heritage preservation; Social accessibility; Educational/dissemination; Territorial/place-based identity
	Woodcarving Online Training – E-learning portal	Educational innovation; Knowledge transmission; Skills development; Digital innovation
	Historical Documentation on Woodcarving in Yecla	Heritage/knowledge preservation; Educational; Policy/institutional support; Social identity/recognition
	Wood carving process supported by 3D printing	Not provided in partner report
CNAM	*Ethnographic Protocol*	Knowledge transmission; Capacity-building; Practitioner-centred methodology
	Plaster Simulator	Educational innovation; Cultural heritage preservation; Safe experimentation/skills acquisition
	Aubusson E-Learning Platform	Educational innovation; Cultural heritage continuity; Knowledge transmission; Community-of-practice enablement
CNR	*Craeft Ontology*	Semantic interoperability; Cultural heritage preservation; Educational/research enablement

ETH	*Haptic controller integration test track & evaluation scenarios*	Technical R&D (integration architecture and interaction design); Evaluation methodology (feasibility testing against craft-specific requirements); Human factors/ergonomics insights for sustained tool handling
ETH	*Haptic interfaces for craft training, simulation, and design*	Educational innovation (motor skill development); Technical innovation (tactile simulation of surface textures and tool resistance); Cultural heritage transmission (education of attention to material properties)
FORTH	*Digitisation of transparent, translucent, and shiny materials*	Technical innovation (polarised and structured illumination); Heritage preservation; Expanded industry applications (architecture, art, manufacturing)
FORTH	*Scene and activity monitoring*	AI-based gesture recognition; Knowledge transmission; Methodological innovation (holistic scene understanding); Educational/vocational training support
FORTH	*Craft Studio*	Educational innovation (game-engine-based immersive simulation); Technical innovation (multi-device support including VR/MR/haptics); Sustainable workflow efficiency (material/energy metrics)
FORTH	*Apprentice Studio*	Educational innovation (personalised learning); Technical innovation (adaptive performance tracking); Historical/cultural contextualisation via CAP integration
FORTH	*Design Studio and Computer-Aided Design*	Technical innovation (craft-specific 3D CAD tools with haptic integration); Efficiency/cost reduction (virtual prototyping); Bridge between digital and physical fabrication
KHORA	*Virtual reality glassblowing simulator*	Educational innovation; Technical innovation; Cultural heritage dissemination; Multiuser facilitation/UX methodology
	ETH haptic controller integration	Technical R&D; Evaluation methodology; Human factors/ergonomics
	Craeft Design Studio UX/UI framework	Technical (reusable UI shell); Educational consistency; Organisational/scalable integration
MDE	*Online Community Portal*	Social/community building; Knowledge transmission; Cross-disciplinary exchange
	Glaze rendering tool	Environmental (waste/energy reduction); Educational experimentation; Documentation/preservation; Social knowledge sharing/inclusivity
PIOP	*360 tour application (Margarites)*	Cultural heritage dissemination; Accessibility & inclusion; Audience engagement

	VR glass blowing simulator	Social innovation (social impact focus); Empowerment; Cross-sector collaboration
	Mobile app	Knowledge transmission; Informal learning; Craft heritage engagement
	Digital Contextualisation	Economic/market valorisation; Digital mediation/storytelling
	Apprentice studio	Educational innovation (learning-by-doing); Access to complex processes; Digital mediation
	E-learning platform	Educational innovation; Empowering artisans; Social inclusion
	Online community portal	Social/community building; Knowledge transmission; Cross-disciplinary exchange

7 Craeft's innovative results and rationale

This section connects the innovation management procedure with the exploitation planning and the exploitable outcomes. To this end, we present each of the identified, preliminary, exploitable outcomes from an innovation management perspective. To do so, we provide a short description of the innovation, followed by the basic innovation contributions. Each contribution addresses a specific need, which is presented together with the innovation management rationale.

7.1. WP1 - Understanding and digitalisation

7.1.1 Ethnographic strategies for craft understanding

Developing an ethnographic method tailored to the context is central to our objectives. The challenge is to create an interdisciplinary methodology combining Artificial Intelligence and Social Sciences to understand and compare technical actions in artisanal settings. To achieve this, a protocol for craft understanding has been developed and is consistently used in each craft instance, facilitating reliable data comparison. This protocol structures each dataset on a solid experimental basis, ensuring the success of other technological tasks. It involves three interrelated survey methods: (a) Collecting functional and structural data by defining actions with craftspeople, observing, and documenting operational sequences, (b) Collecting individual and professional data through life course interviews with craftspeople, and (c) Collecting verbal and emotional data via video elicitation of the operational sequences of craftspeople. This methodology helps avoid ethnographer bias and contextualises gesture recognition data with the crafts practitioner's perspective.

Implementation of an Inclusive Protocol for Craft Understanding

- **Need:** Traditional methods of craft understanding often overlook the expertise and perspectives of craftspeople.
- **Rationale:** This ethnographic strategy centres on the craftspeople's expertise, integrating their perspectives from the introduction to the conclusion of the craft analysis. By allowing craftspeople to define and contextualise their actions, this protocol ensures that the recorded data is meaningful and

reflective of real-world practices. This inclusivity fosters a deeper and more authentic understanding of crafting processes, aligning with innovation management's goal of creating user-centric solutions.

Facilitating Dialogue between Artificial Intelligence and Social Sciences

- **Need:** There is often a disconnect between the practical insights of ethnographic research and the formal methodologies of AI, hindering comprehensive understanding.
- **Rationale:** The protocol bridges the gap between ethnographic pragmatism and AI formalism, promoting interdisciplinary dialogue. This interaction challenges both social and computer sciences to refine their approaches, leading to innovative knowledge about craft practices. This interdisciplinary collaboration is essential in innovation management, as it encourages the integration of diverse perspectives and methodologies.

Generating Comparable Data

- **Need:** Heterogeneous craft instances require standardised data for effective comparison and analysis.
- **Rationale:** The protocol standardises data collection, enabling the generation of comparable datasets across different craft instances. This standardisation is crucial for action and affordance modelling and the maker-material-negotiation model. Innovation management benefits from this by ensuring that the data is consistent, reliable, and useful for comparative studies and technological advancements.

Ensuring Replicability and Transferability

- **Need:** To be widely applicable, the protocol must be replicable and adaptable to various contexts.
- **Rationale:** The protocol's flexibility allows it to adapt to local needs while maintaining a consistent identity, ensuring its applicability across different crafts and researchers. This replicability and transferability are vital for scaling the innovation, making it useful beyond the initial project scope, which is a key objective in innovation management.

Enhancing Material Knowledge Transmission

- **Need:** Effective transmission of material knowledge is essential for the sustainability of craft traditions.
- **Rationale:** Applying the protocol in educational institutions and museums promotes skill transmission to future generations. Standardised data collection for craft representation enhances the teaching and preservation of craft skills. This aligns with innovation management's focus on sustainability and long-term impact, ensuring that valuable knowledge is preserved and passed on effectively.

7.2 WP2 - Craft representation

7.2.1 Archetypal action simulators

Archetypal Action Simulators are essential for focusing on Action and Affordance Modelling by digitising practitioner motion, haptic interaction, and material transformations. This process creates Elementary Actions with specific affordances, conditions, and parameters. A comprehensive training dataset links semantic, geometric, and mechanical representations of actions and plans with multimodal execution

recordings across various materials. The simulators model Elementary Actions like knots, additive/subtractive processes, and free-form transforms computationally, geometrically, and mechanically. They predict the outcomes of these actions based on their parameters and simulated environmental conditions, offering valuable predictive insights into various crafted actions.

Enhanced Understanding through Simulation

- **Need:** Traditional crafting processes rely heavily on tacit knowledge and experiential learning, which can be slow and imprecise.
- **Rationale:** Archetypal Action Simulators provide a structured, analytical approach to understanding crafting processes. By offering a dynamic platform to simulate and visualise crafting actions, these simulators facilitate a deeper understanding of material transformations. This innovation addresses the need for a more scientific and accessible approach to craft knowledge, enabling consistent replication and transfer of expertise.

Predictive Capabilities for Crafting Outcomes

- **Need:** Craft practitioners often face uncertainty regarding the outcomes of their actions, leading to trial-and-error methods that waste time and resources.
- **Rationale:** The ability of the simulators to predict results based on parameters and environmental conditions is a breakthrough that transforms crafting from an art to a more predictable science. This predictive capability is crucial for optimising crafting processes, reducing waste, and improving efficiency, aligning with the goals of innovation management to streamline operations and enhance productivity.

Integration of Generative AI Methods

- **Need: The crafting industry lacks adaptive systems that can learn and evolve from diverse data** inputs, limiting innovation and adaptability.
- **Rationale:** By leveraging generative AI methods, the simulators continuously learn and improve from extensive datasets. This evolving intelligence ensures that the simulators remain relevant and accurate, fostering a system that adapts to new materials and techniques. This dynamic improvement aligns with innovation management principles of continuous improvement and adaptive learning.

Cross-Material Predictions

- **Need:** Craft practitioners work with a variety of materials, each with unique properties, creating a need for versatile predictive tools.
- **Rationale:** The simulators' capability to make cross-material predictions addresses the need for tools that transcend material boundaries. This versatility not only enhances the utility of the simulators but also supports innovation management objectives by promoting flexibility and broad applicability across different crafting domains.

Integration of Haptic Interaction and Practitioner Motion

- **Need:** There is a disconnect between digital simulations and real-world crafting experiences, limiting the effectiveness of virtual training tools.

- **Rationale:** By digitising practitioner motion and incorporating haptic feedback, the simulators bridge the gap between digital and physical crafting. This integration ensures that simulations are realistic and reflective of actual practices, enhancing the authenticity and applicability of the simulations. This innovation supports the goal of innovation management to create solutions that are practical and user-centric.

Application in Training and Skill Development

- **Need:** Novice craft practitioners require effective training tools to accelerate their learning curve and enhance their skills.
- **Rationale:** The simulators provide a virtual environment for practitioners to practice and refine their skills, offering a safe and resource-efficient training method. This application in training supports the development of a more skilled workforce, aligning with innovation management goals of workforce development and skill enhancement.

Transferability to Various Crafting Domains

- **Need:** Crafting industries are diverse, requiring adaptable tools that can be applied across different practices and materials.
- **Rationale:** The versatility of the simulators to model various elementary actions and materials makes them transferable across different crafting domains. This adaptability ensures that the innovation can be widely applied, maximising its impact and supporting innovation management objectives of scalability and broad application.

7.2.2 Maker-Material-Negotiation model

The ontology for maker-material negotiation, built on the CIDOC CRM-based Craft Ontology (CrO), models tools, materials, workspaces, and contextualization narratives, extending CrO to include action plans and hypotheses. Encoded in RDF Schema and OWL 2 DL, it supports computational inference, aiding decision-making in crafting. Its adaptability to diverse scenarios fosters innovation, while contextualization narratives add storytelling dimensions, enriching qualitative understanding. Aligned with computational requirements, the ontology integrates seamlessly with existing systems, offering new research and innovation possibilities in crafting.

Enhanced Understanding of Crafting Processes

- **Need:** Detailed insight into the dynamic interaction between makers and materials is essential for advancing craft knowledge.
- **Rationale:** The ontology captures the complexities of maker-material negotiation, offering structured representations of tools, materials, workspaces, and processes. This comprehensive understanding supports innovation management by providing a detailed foundation for improving and evolving crafting techniques.

Integration of Cognitive Elements

- **Need:** Traditional ontologies lack the depth to represent the cognitive processes involved in crafting.

- **Rationale:** Extending the Craft Ontology to include action plans, material effects, hypotheses, conditions, and parameters integrates cognitive aspects, reflecting the decision-making processes of makers. This integration enriches the representation, aligning with innovation management's goal of enhancing system intelligence and usability.

Support for Computational Inference

- **Need: Automated reasoning and decision support are crucial for efficient crafting processes.**
- **Rationale:** Encoding the model in RDF Schema and OWL 2 DL introduces computational inference capabilities, enabling automated reasoning and prediction. This functionality supports innovation management by facilitating smarter decision-making and optimising crafting workflows.

Facilitation of Action Plans and Hypotheses

- **Need:** Structured frameworks are necessary for planning and exploring crafting activities systematically.
- **Rationale:** The ontology's inclusion of action plans and hypotheses provides a framework for makers to plan and execute their activities. This structured approach encourages systematic exploration and innovation in crafting methodologies, supporting innovation management by fostering organised and efficient practice.

Adaptability and Flexibility

- **Need:** Crafting involves diverse scenarios and materials, requiring adaptable systems.
- **Rationale:** The extended Craft Ontology's adaptability to various elements and scenarios ensures it can accommodate the diversity within the crafting domain. This flexibility is crucial for innovation management, as it supports a wide range of practices and materials, promoting broad applicability and fostering innovation.

Contextualization Narratives

- **Need:** Understanding the contextual factors influencing decision-making is vital for comprehensive craft analysis.
- **Rationale:** The ontology's ability to represent narratives adds a storytelling dimension, providing insights into contextual factors affecting crafting decisions. This narrative aspect enhances qualitative understanding and aligns with innovation management's objective of integrating human-centric perspectives into technological solutions.

Alignment with Computational Requirements

- **Need:** Compatibility with existing computational systems ensures seamless integration and usability.
- **Rationale:** Using RDF Schema and OWL 2 DL aligns the ontology with computational requirements, ensuring effective use in computational environments. This compatibility supports innovation management by enabling smooth integration with existing systems, facilitating seamless interactions between the crafted model and computational tools.

7.2.3 Craeft Authoring Platform

The Craeft Authoring Platform (CAP) extends the Craft Ontology (CrO) and enhances the Craft Authoring process, building on the Mingei Online Platform (MOP). CAP facilitates the instantiation of entities from the extended ontology and provides additional services to streamline craft authoring. It associates semantics and signals with new entities, enabling a nuanced representation of crafting concepts. CAP integrates with CrO to manage diverse crafting knowledge and aligns with CIDOC-CRM and EDM for compatibility and interoperability. It links knowledge entities with digital assets, enhancing documentation and preservation of craft processes, and supports broader dissemination through the Semantic Web and Europeana.

Holistic Craft Authoring Experience

- **Need:** A comprehensive and nuanced representation of crafting activities is essential for a deeper understanding of the craft domain.
- **Rationale:** CAP extends the Craft Ontology (CrO) with enriched entities, including hypotheses and affordances, creating a holistic craft authoring experience. This contributes to a more thorough understanding of crafting processes, aligning with innovation management's goal of enhancing knowledge representation and user engagement.

Semantic Enrichment and Signal Association

- **Need:** Craft practitioners require tools that capture the subtleties and context of crafting processes.
- **Rationale:** CAP associates semantics and signals with new entities, surpassing conventional authoring platforms. This innovation allows practitioners to express and document the intricate details of crafting, fostering a richer and more context-aware representation. This aligns with innovation management's objective of creating expressive and comprehensive tools.

Integration with Mingei Online Platform (MOP)

- **Need:** Interoperability of craft-related data is crucial for unified information management.
- **Rationale:** CAP integrates seamlessly with MOP, ensuring background compatibility with CRAFT and innovative extensions through the Craft Ontology. This integration enhances data interoperability, supporting innovation management by creating a unified framework for managing diverse crafting information.

Dynamic Entity Instantiation Services

- **Need:** Efficient management of diverse crafting-related entities is essential for flexible authoring workflows.
- **Rationale:** CAP offers services for dynamically instantiating entities from the extended ontology, streamlining the craft authoring workflow. This empowers users to manage and manipulate a wide range of entities efficiently, fostering flexibility and adaptability. This capability aligns with innovation management's focus on optimising workflows and user empowerment.

CIDOC-CRM and EDM Compatibility

- **Need:** Compatibility with widely accepted standards is essential for broader dissemination and collaboration.
- **Rationale:** CAP's alignment with CIDOC-CRM and EDM ensures compatibility and interoperability with standard models. This enhances the accessibility of craft-related entities and assets on the Semantic Web and Europeana, supporting innovation management's goals of broader knowledge dissemination and cross-platform collaboration.

Digital Asset Linking and Reconstruction

- **Need:** Dynamic and interactive connections between crafted entities and their digital representations are essential for comprehensive documentation.
- **Rationale:** CAP's novel approach to linking knowledge entities with digital assets, including object reconstruction and action recording, enriches documentation and preservation. This innovation provides valuable resources for practitioners, researchers, and enthusiasts, aligning with innovation management's objective of enhancing documentation and accessibility.

Facilitation of Interdisciplinary Collaboration

- **Need:** A collaborative space for interdisciplinary engagement is crucial for fostering innovation.
- **Rationale:** CAP's extended ontology and digital asset-linking mechanisms create a platform for interdisciplinary collaboration. Craft practitioners, researchers, and experts can share, annotate, and explore knowledge, driving innovation through cross-disciplinary engagement. This supports innovation management's aim of promoting collaborative innovation.

Enhanced Educational and Training Opportunities

- **Need:** Comprehensive and interactive tools are necessary for effective education and training in crafting.
- **Rationale:** CAP's rich semantics and dynamic entity instantiation provide an immersive environment for students to learn crafting skills. This enhances educational and training programs, contributing to the development of skilled practitioners. This aligns with innovation management's focus on fostering the next generation of skilled professionals.

7.3 WP3 - Digital reenactment

7.3.1 Craft-specific action simulators

Craft-specific action simulators refine archetypal simulators using Generative Adversarial Networks (GANs) within generative AI. Trained on craft representations and third-party materials, these simulators are fine-tuned with craft-specific data for accuracy and customisation. They integrate insights from scene understanding methods for enhanced 3D visualisation of challenging materials, showcasing intricate crafting processes. The simulators generate realistic 3D previews, aiding practitioners in understanding and decision-making in crafting workflows.

Customisation through Craft-Specific Simulations

- **Need:** High customisation is essential for accurately representing diverse crafting processes.
- **Rationale:** Utilising GANs to refine archetypal simulators into craft-specific ones introduces significant customisation. This tailored approach provides practitioners with simulations that reflect the unique intricacies of their specific crafting processes, enhancing realism and user experience. This aligns with innovation management's goal of creating personalised and effective tools.

Integration of Generative AI in Crafting Workflows

- **Need:** Modernising crafting workflows with advanced technologies is crucial for progress. **Innovation**
- **Management Rationale:** The application of generative AI, specifically GANs, in crafting simulations is a pioneering approach. This innovation generates dynamic and realistic crafting scenarios, bridging traditional methods with advanced technologies, thus modernising workflows. This integration supports innovation management's objective of incorporating cutting-edge technologies into established practices.

Fine-Tuning with Craft-Specific Data

- **Need:** Accurate representation of different crafting processes requires detailed data.
- **Rationale:** Fine-tuning GANs with craft-specific data ensures simulations capture the nuances of various crafting processes. This precision is crucial for creating visually realistic simulations aligned with the specific characteristics of different craft domains. This aligns with innovation management's focus on achieving high accuracy and relevancy in tool development.

Incorporation of Diverse Materials and Third-Party Data

- **Need:** Broadening the scope of materials used in simulations enhances applicability and innovation.
- **Rationale:** Including third-party materials enriches the diversity of materials in crafting simulations. This broadens the scope of scenarios, making simulations applicable to a wide range of materials and fostering cross-disciplinary insights. This innovation aligns to enhance flexibility and adaptability in innovation management.

Enhanced Simulation through 3D Visualisation

- **Need:** Realistic and detailed visualisation is key for understanding complex crafting processes.
- **Rationale:** Emphasising the visualisation of challenging materials in 3D enhances simulation realism. Practitioners can better visualise and understand complex crafting processes, improving decision-making and skill development. This innovation aligns to provide comprehensive and immersive tools in innovation management.

Mental Imagery for Craft Practitioners

- **Need:** Providing practitioners with visual and immersive understanding aids in decision-making.
- **Rationale:** Generating 3D previews as mental imagery offers practitioners a ground-breaking feature. This innovation provides a visual and immersive understanding of the production process, aiding in decision-making, skill development, and creative exploration. This aligns with innovation management's focus on enhancing user experience and effectiveness.

Compatibility with the Semantic Web and Europeana

- **Need:** Ensuring compatibility with modern standards enhances accessibility and knowledge dissemination.
- **Rationale:** Encoding simulations in CIDOC-CRM and EDM ensures compatibility with the Semantic Web and Europeana. This enhances accessibility and contributes to the broader dissemination of craft-related knowledge, aligning with modern digital preservation standards and supporting innovation management's goal of enhancing knowledge sharing.

Interdisciplinary Collaboration and Research Opportunities

- **Need:** Encouraging interdisciplinary collaboration fosters innovation and new research avenues.
- **Rationale:** The integration of diverse data sources and customizable simulations encourages interdisciplinary collaboration. Researchers can study material behaviours, crafting methodologies, and various parameters, opening new research opportunities. This aligns with innovation management's objective of promoting collaborative innovation and advancing research.

7.3.2 Digitisation of material treatment and deformation

Leveraging computer vision, graphics, and machine learning, this innovation simplifies modelling how practitioner actions impact materials. Understanding the context of actions, such as subtractive, additive, or interlocking processes, streamlines computational learning, enhancing efficiency. It uses 3D sensing to narrow down action parameters and integrates machine learning to explain material transformations. Trained on a large dataset of real and synthetic data, this adaptive simulation tool visualises material deformations, aiding in understanding material responses to various crafting actions.

Context-Aware Modelling

- **Need:** Accurate simulation of intricate crafting actions requires understanding the specific context of each action.
- **Rationale:** Emphasising the 'context' of practitioner actions, such as distinguishing between subtractive, additive, and interlocking processes, introduces a sophisticated approach to computational modelling. This context-aware modelling ensures accurate simulation and understanding of crafting actions, aligning with innovation management's goal of developing precise and context-sensitive tools.

Efficient Computational Learning

- **Need:** Simplifying complex training processes enhances efficiency and adaptability in modelling.
- **Rationale:** Simplifying the training space for computational models significantly improves efficiency, which is particularly valuable in crafting scenarios with high geometric complexity. This streamlined learning process enhances the product’s adaptability to various crafting contexts, supporting innovation management’s objective of creating efficient and adaptable technological solutions.

3D Sensing for Precision

- **Need:** High precision in modelling material effects is crucial for realistic simulations.

- **Rationale:** Utilising 3D sensing to narrow down the search space for action parameters enhances precision. This innovation enables more accurate modelling of material effects, allowing practitioners to visualise and anticipate outcomes with high fidelity. This aligns with innovation management's focus on precision and accuracy in tool development.

Diverse Material Transformations

- **Need:** Versatility in modelling various material transformations is essential for broad applicability.
- **Rationale:** The ability to model diverse material transformations, such as plastic transforms, knot mechanics, weaving algebras, and subtractive/additive processes, showcases the product's versatility. This adaptability makes it applicable across various industries and domains, supporting innovation management's goal of creating versatile and widely applicable tools.

Explanatory Machine Learning

- **Need:** Providing insights into material transformations enhances user understanding and decision-making.
- **Rationale:** Integrating machine learning to instantiate models and explain material transformations adds an explanatory layer. This innovation goes beyond simulation, offering users insights into why certain material effects occur based on observed actions, fostering a deeper understanding of the crafting process. This aligns with innovation management's objective of enhancing user knowledge and decision-making.

Large Dataset for Robust Training

- **Need:** Robust training datasets ensure models handle diverse crafting scenarios effectively.
- **Rationale:** Using a large dataset of real and synthetic, photorealistic data enhances training robustness. This ensures the models are well-equipped to handle diverse crafting scenarios, contributing to the product's adaptability and reliability. This innovation supports innovation management's focus on robust and comprehensive data utilisation.

Integration with Scene Understanding

- **Need:** Incorporating real-world motion data enhances the realism and accuracy of simulations.
- **Rationale:** Integrating scene understanding for hand and tool motion estimates enhances realism by incorporating real-world motion data. This strategic innovation makes simulations more accurate and reflective of actual crafting scenarios, aligning with innovation management's goal of creating realistic and practical simulation tools.

Adaptive Simulation for Material Deformations

- **Need:** Dynamic and user-centric simulation experiences enhance practitioner interaction and control.
- **Rationale:** The product's ability to adaptively "playback" material deformations provides a dynamic user experience. This innovation allows practitioners to visualise, interact with, and adaptively control material transformations, offering a user-centric crafting experience. This aligns with innovation management's objective of enhancing user interaction and control in technological solutions.

7.3.3 High-resolution 2D and 2½D surface scanning

The High-Resolution Scanner is an advanced tool for digitising heritage objects, capturing intricate details and textures with resolutions exceeding 1 gigapixel per square centimetre. It introduces 2½D scanning through photogrammetry, providing depth to the digital representation and capturing surface structures that influence tactile sensations. This innovation aids in cultural heritage preservation by creating detailed digital archives, enhancing the understanding and appreciation of heritage objects.

High Resolution

- **Need:** Capturing minute details and textures of heritage objects is crucial for accurate digital representation.
- **Rationale:** The scanner's resolution, surpassing 1 gigapixel per square centimetre, marks a significant advancement in heritage object digitisation. This high level of precision ensures even the smallest features are faithfully captured, aligning with innovation management's goal of developing cutting-edge tools that push the boundaries of current technology.

Integration of 2½D Scanning

- **Need:** Adding depth to digitised images enhances the realism and comprehensiveness of digital representations.
- **Rationale:** Introducing 2½D scanning through photogrammetry represents a breakthrough in digitisation technology. This integration provides a more lifelike representation of artefact surfaces, enhancing the realism of digital reproductions and supporting innovation management's focus on creating advanced and realistic technological solutions.

Tactile Sensation Capture

- **Need:** Capturing surface structures that influence tactile sensations adds a sensory dimension to digital archives.
- **Rationale:** Beyond visual reproduction, capturing tactile qualities like smoothness and coarseness enriches the understanding of heritage objects. This feature enhances the immersive experience for researchers and the general audience, aligning with innovation management's objective of developing multi-sensory and immersive technological solutions.

Holistic Preservation Approach

- **Need:** A comprehensive preservation approach ensures a richer engagement with heritage objects.
- **Rationale:** The scanner's holistic approach, capturing both visual and tactile aspects, contributes to a more complete digital archive. This ensures future generations can engage with artefacts more effectively, supporting innovation management's goal of comprehensive and meaningful preservation of cultural heritage.

Interdisciplinary Collaboration

- **Need:** Combining expertise from multiple fields ensures the development of advanced and robust technologies.

- **Rationale:** The innovation results from interdisciplinary collaboration, integrating surface scanning, photogrammetry, and heritage preservation expertise. This collaborative effort ensures the scanner meets rigorous standards and incorporates cutting-edge technology, aligning with innovation management's emphasis on leveraging interdisciplinary knowledge for technological advancement.

Cultural Heritage Accessibility

- **Need:** Increasing accessibility to cultural heritage democratizes knowledge and education.
- **Rationale:** Creating a detailed digital archive addresses the growing need for accessibility to cultural heritage. This innovation democratizes access, allowing researchers, educators, and the public to explore and study objects remotely with unprecedented clarity, aligning with innovation management's focus on expanding access to cultural and educational resources.

Technological Advancement in Photogrammetry

- **Need:** Advancing photogrammetry techniques enhances the depth and realism of digitised images.
- **Rationale:** The introduction of 2½D scanning through photogrammetry showcases a significant technological advancement. This approach leverages photogrammetric techniques to create depth-enhanced digitisations, marking a milestone in heritage object scanning methodologies and aligning with innovation management's goal of driving technological innovation.

Fostering Appreciation for Craftsmanship

- **Need:** Engaging users with the intricate details and historical context of artefacts enhances cultural appreciation.
- **Rationale:** Capturing intricate details and tactile qualities of heritage objects fosters a deeper appreciation for craftsmanship and historical context. This innovation invites users to engage with artefacts in a sensory and educational manner, supporting innovation management's objective of enriching cultural understanding and appreciation through advanced technological solutions.

7.3.4 Digitisation of transparent, translucent, and shiny materials

The initiative to digitise transparent, translucent, and shiny materials employs innovative, non-contact 3D reconstruction methods using polarised and structured illumination techniques. This approach captures the intricate details of challenging materials like clear and frosted glass, tinted stained glass, amber, and metal. The process integrates Augmented Reality (AR) to enhance precision and efficiency, building upon insights from the Transparent3D project. This initiative holds significance beyond heritage preservation, impacting industries such as architecture, art, and manufacturing by providing accurate 3D visualisations of materials with complex optical properties.

Inherent Optical Complexity

- **Need:** Traditional scanning methods struggle to capture the nuances of transparent and semi-transparent materials, including variations in transparency, refraction, and reflection.
- **Rationale:** The specialised scanner addresses the inherent optical complexity of transparent objects, providing a tailored solution. This innovation ensures accurate digitisation of materials with complex

optical properties, aligning with innovation management's goal of developing specialised technologies that overcome specific challenges.

Surface Detail Preservation

- **Need:** Transparent and semi-transparent objects often have intricate surface details that are crucial for heritage preservation, art restoration, and material analysis.
- **Rationale:** The scanner's ability to preserve and accurately digitise fine engravings, textures, and subtle colour variations represents a significant advancement. This capability supports innovation management's focus on enhancing the precision and fidelity of digital reproductions for critical applications.

Mitigating Reflection and Glare

- **Need:** Shiny and reflective surfaces can cause unwanted glare and reflections during scanning, leading to inaccurate representations.
- **Rationale:** The incorporation of polarised and structured illumination techniques mitigates glare and reflections, ensuring accurate capture of surface features. This innovation addresses a common challenge in digitising reflective materials, aligning with innovation management's objective of improving scanning accuracy and reliability.

Expanded Applications in Diverse Industries

- **Need:** Accurate digitisation of transparent and semi-transparent materials is beneficial for various industries, including architecture, design, manufacturing, and art.
- **Rationale:** The scanner's versatility opens new possibilities for digitising these materials across multiple sectors. This innovation facilitates advancements in design workflows, material analysis, and virtual prototyping, supporting innovation management's goal of broadening the application and impact of technological solutions.

Streamlined Operator Guidance with AR

- **Need:** Transparent and shiny surfaces can be challenging to position accurately during scanning, necessitating a more intuitive process for operators.
- **Rationale:** Integrating Augmented Reality (AR) provides real-time guidance, simplifying the scanning process and enhancing efficiency. This innovation improves user-friendliness and operational precision, aligning with innovation management's focus on developing intuitive and efficient technological tools.

Learnings from the Previous Transparent3D Project

- **Need:** Building on the outcomes of the Transparent3D project ensures that past insights inform current technological advancements.
- **Rationale:** Leveraging the knowledge and lessons learned from Transparent3D demonstrates a strategic approach to innovation. This ensures a more informed and effective implementation of the specialised scanner, supporting innovation management's emphasis on continuous improvement and learning from previous projects.

Advancements in Material Visualisation

- **Need:** Accurate and comprehensive visualisation of transparent and semi-transparent objects is crucial for fields like art conservation.
- **Rationale:** The innovation enhances material visualisation, providing faithful reproductions essential for documentation and analysis. This supports innovation management's goal of advancing visualisation technologies to meet the needs of specialised fields.

Industry and Research Collaboration

- **Need:** Collaboration between industries and research institutions is essential for developing technologies that meet evolving sector needs.
- **Rationale:** The development of the specialised scanner involves industry and research collaboration, ensuring alignment with real-world applications. This collaborative approach fosters innovation by combining expertise and insights from multiple disciplines, supporting innovation management's objective of fostering interdisciplinary collaboration for technological advancement.

7.3.5 Scene and activity monitoring

The Scene and Activity Monitoring initiative for the partners captures and analyses the multifaceted elements of the craft scene, including the craftsmen, their actions, tools, materials, and resulting sounds. Through extensive recordings in environments such as marble carving, glassblowing, silversmithing, and porcelain creation, the initiative employs two cameras and two microphones to gather comprehensive data. The process involves interviews, recordings, and video elicitation to deeply understand and document the craft processes. This methodology integrates advanced AI to create a detailed hierarchy schema for professional gestures, aiding in the preservation and training of craft techniques. The project extends its impact to other manual professions and industries, enhancing vocational training and knowledge sharing.

Complexity of Crafting Activities

- **Need:** Crafting involves intricate actions requiring manual dexterity, material manipulation, and creative decision-making.
- **Rationale:** Scene and Activity Monitoring provides an intelligent solution to analyse and interpret crafting actions in real-time. This innovation addresses the complexity of crafting activities, ensuring that detailed and accurate monitoring is essential for improving craft techniques.

Holistic Scene Understanding

- **Need:** Accurate and insightful analysis of the crafting environment requires recognising nuanced interactions between practitioners, materials, and tools.
- **Rationale:** The product's holistic approach to scene understanding goes beyond simplistic monitoring, capturing the full context of the crafting process. This comprehensive analysis supports innovation management’s goal of providing deeper insights and fostering a thorough understanding of professional craft environments.

Multifaceted Implementation

- **Need:** Comprehensive capture of crafting processes requires body and hand tracking, object recognition, haptic interaction, and material deformation tracking.
- **Rationale:** The multifaceted implementation ensures that all aspects of the crafting process are monitored. This innovation aligns with innovation management's focus on developing robust, versatile tools that enhance the understanding and documentation of craft techniques.

Integration with Craft-Specific Simulators

- **Need:** Enhancing the accuracy of monitoring results and creating a feedback loop for continuous improvement.
- **Rationale:** Integrating with craft-specific simulators introduces sensory imagery validation, improving monitoring accuracy and providing dynamic feedback. This forward-thinking approach supports innovation management's aim of leveraging technology to refine and enhance craft practices.

Adaptability with Third-Party Resources

- **Need:** Enriching the dataset and improving recognition accuracy through diverse crafting techniques.
- **Rationale:** The product's adaptability in incorporating third-party resources ensures versatility across various crafting styles. This innovation enhances the dataset's richness and supports innovation management's goal of creating adaptable, comprehensive solutions.

Efficiency in Craft Training

- **Need:** Making the learning process accessible and efficient for practitioners at all skill levels.
- **Rationale:** By capturing and streamlining crafting techniques, the product significantly improves training efficiency. This innovation addresses the need for accessible learning tools, aligning with innovation management's objective of fostering skill development and continuous improvement in the crafting community.

Documentation and Knowledge Sharing

- **Need:** Preserving traditional crafting methods and facilitating collaboration within the crafting community.
- **Rationale:** Scene and Activity Monitoring serves as a valuable documentation tool, preserving traditional techniques and promoting knowledge sharing. This innovation supports innovation management's focus on fostering collaboration and ensuring the longevity of craft knowledge.

Comparative Analysis and Community Building

- **Need:** Promoting the exchange of insights and techniques within the crafting community.
- **Rationale:** Enabling practitioners to compare techniques fosters a collaborative learning environment. This innovation contributes to community building, aligning with innovation management's goal of creating dynamic, evolving communities of practice.

Real-Time Feedback for Skill Development

- **Need:** Providing personalised insights to support dynamic skill development.

- **Rationale:** The product's real-time feedback and analysis accelerate the learning curve, empowering practitioners to refine their skills. This innovation supports innovation management's aim of enhancing skill development through immediate, actionable insights.

7.4 WP4 - Education and training

7.4.1 Craft Studio

The Craft Studio is an advanced authoring environment that revolutionises crafting simulations using 3D and immersive rendering powered by a game engine pipeline. Integrated with the Craft Authoring Platform (CAP), it offers realistic, dynamic simulations for various crafting scenarios, supporting generic and craft-specific procedures. The tool allows crafters to visualise and interact with crafted objects in an immersive setting, utilising digitisations and action simulators for designing customised simulations. It adapts to user-selected variables, providing a personalised experience and supports various visualisation devices. Additionally, it offers metrics on material and energy usage to promote efficient workflows.

Enhanced Realism through Game Engine Rendering

- **Need:** Crafters require a realistic and immersive environment to enhance the authenticity and visual appeal of the crafting experience.
- **Rationale:** Craft Studio leverages a game engine rendering pipeline to create highly realistic 3D simulations. This innovation aligns to provide an immersive environment that enhances the simulation experience, ensuring crafters are engaged and can interact with simulations in a lifelike manner.

Versatile Support for Craft-Specific Simulations

- **Need:** Address the diverse landscape of crafting procedures, materials, techniques, and artistic styles.
- **Rationale:** The tool supports both generic and craft-specific simulations, catering to a wide range of crafting scenarios. This versatility ensures that crafters from various domains can benefit from the tool, aligning with innovation management's objective of creating inclusive and adaptable solutions.

Seamless Integration with Craft Authoring Platform (CAP)

- **Need:** Enhance crafting simulations with semantic content, action plans, and schemas for a more contextual experience.
- **Rationale:** By integrating with CAP, Craft Studio accesses and incorporates semantic content, adding depth to simulations. This integration ensures that simulations are aligned with real-world crafting processes, promoting a more meaningful and context-rich simulation experience.

Intuitive Authoring of Simulation Scenarios

- **Need:** Provide a user-friendly approach for designing crafting experiences.
- **Rationale:** Crafters can leverage digitisation and action simulators to design simulations intuitively. This user-friendly approach promotes accessibility and creativity, ensuring that even novice users can design and customise their simulation experiences effectively.

Dynamic Instantiation for Simulations

- **Need:** Ensure simulations accurately reflect user-selected variables for a personalised crafting environment.
- **Rationale:** During simulation execution, Craft Studio dynamically instantiates schema components based on selected variables. This adaptability ensures that simulations are personalised and realistic, aligning with innovation management's goal of creating user-centric and responsive tools.

Flexible Bindings to Visualisation and Interaction Devices

- **Need:** Cater to diverse user preferences for visualisation and interaction.
- **Rationale:** The tool supports various visualisation devices, such as screens, MR glasses, VR headsets, and interaction devices like tactile and haptic feedback. This flexibility enriches the simulation experience, ensuring that users can interact with simulations in their preferred manner, enhancing user engagement and satisfaction.

Data-Driven Insights for Efficient Workflows

- **Need:** Provide metrics on material and energy usage to promote sustainable and efficient crafting processes.
- **Rationale:** Craft Studio includes metrics on material and energy usage in all simulations, offering data-driven insights for efficient workflow planning. This innovation supports sustainability and efficiency, aligning with innovation management's objective of promoting resource-conscious practices in crafting.

7.4.2 Apprentice Studio

The Apprentice Studio is a cutting-edge extension of the Craft Studio designed specifically for educational and training purposes. It emphasizes personalized learning through a user interface tailored to each learner's needs. The Studio features a conventional desktop application for basic simulations, a web-based UI for educational materials, and an immersive 3D GUI compatible with haptic, VR, and AR devices. It tracks performance metrics and adapts to individual progress, offering open-ended problems to address real-world issues like health and safety. Unique problem-solving scenarios link to historical contexts via the Craft Authoring Platform (CAP), enriching the learning experience with a historical and cultural perspective.

Personalised Learning Approach

- **Need:** Traditional education often fails to address individual differences in learning styles and progress.
- **Rationale:** The Apprentice Studio innovates by offering a personalised learning experience. By tailoring content, exercises, and success metrics to each trainee's unique needs, it enhances engagement and effectiveness. This approach aligns with innovation management's goal of fostering more effective and individualised training solutions.

Integration of Diverse Learning Modalities

- **Need:** Diverse learners benefit from different methods and formats of instruction.
- **Rationale:** The Apprentice Studio integrates various learning modalities, including conventional desktop applications, web-based UIs, and immersive 3D GUIs. By supporting haptic, VR, and AR devices, it caters to multiple learning preferences and enhances the versatility of the training experience. This innovation aligns with the modern approach to multimodal learning, addressing diverse trainee needs effectively.

Performance Tracking and Adaptability

- **Need:** Effective training requires real-time feedback and adaptation to individual progress.
- **Rationale:** The Studio's sophisticated tracking mechanisms, including performance logs and simulated resource metrics, allow for dynamic adaptation to each trainee's progress. This data-driven approach ensures targeted support and personalised guidance, aligning with innovation management's objective of optimising learning outcomes through adaptive technologies.

Creative Problem-Solving Dimension

- **Need:** Traditional training methods often focus on theoretical knowledge without practical application.
- **Rationale:** By incorporating open-ended problems related to health, safety, and experimental archaeology, the Apprentice Studio fosters critical thinking and real-world problem-solving. This creative dimension encourages practical skill development and holistic learning, supporting innovation management's goal of enhancing educational methodologies with practical applications.

Historical and Cultural Contextualization

- **Need:** Training can benefit from contextualising knowledge within historical and cultural frameworks.
- **Rationale:** The Studio's integration of experimental archaeology scenarios and historical context through CAP adds depth to the learning experience. This contextualization enriches trainees' understanding and appreciation of the historical significance of tools and techniques, aligning with innovation management's goal of incorporating cultural and historical perspectives into educational tools.

7.4.3. Haptic interfaces for craft training, simulation, and design

The Interactive Haptic Apparatuses are designed to simulate the tactile sensations associated with tool use during various craft actions, emphasising the nuanced "feeling" of surfaces during manipulation. This innovation aims to provide hands-on practice and enhance skill development in a virtual environment, focusing on dexterous actuation skills and the "education of attention" to tactile features of materials. By offering realistic tactile experiences, the system enables craft practitioners to refine their skills and build confidence before entering a physical workshop.

Realistic Tactile Simulation

- **Need:** Traditional craftsmanship education often lacks realistic tactile experiences, which are critical for skill development.

- **Rationale:** The Haptic Craft Learning System bridges this gap by providing authentic tactile simulations. This innovation enhances the learning experience by replicating the sense of touch, a fundamental aspect of crafting. It aligns with innovation management's goal of improving educational methods through advanced technologies.

Dexterous Actuation Skill Development

- **Need:** Craft practitioners require hands-on practice to develop precise motor skills and muscle memory.
- **Rationale:** The system facilitates the development of dexterous actuation skills by allowing practitioners to practice in a virtual environment before entering the workshop. This innovation supports skill refinement and builds confidence, aligning with innovation management's focus on enhancing practical training and skill acquisition.

Exercisability Enhancement

- **Need:** Effective skill development benefits from repetitive and deliberate practice.
- **Rationale:** The Haptic Craft Learning System increases exercisability by providing a platform for repeated practice of craft actions. By engaging with haptic interfaces, practitioners can improve muscle memory and precision, which supports innovation management's goal of promoting effective skill-building practices.

Pre-Workshop Preparation

- **Need:** Practitioners need to be familiar with tools, materials, and surfaces before engaging in physical crafting.
- **Rationale:** The system offers a virtual environment for tactile training, reducing the learning curve and enhancing confidence. This pre-workshop preparation aligns with innovation management's objective of preparing individuals effectively for real-world applications.

Education of Attention to Tactile Features

- **Need:** Craft practitioners must develop a heightened sensitivity to material properties and textures.
- **Rationale:** The system's focus on educating practitioners about tactile features fosters a deeper understanding of materials. This "education of attention" enhances material sensitivity and comprehension, which supports innovation management's goal of enriching educational content with practical insights.

Integration with Craft Simulators

- **Need:** A cohesive training experience requires integration across various simulation tools.
- **Rationale:** The system's integration with craft simulators creates a seamless learning experience by combining haptic feedback with virtual environments. This alignment enhances the authenticity of the training process, supporting innovation management's goal of creating integrated and effective training solutions.

Contribution to Craft Studios

- **Need:** A holistic crafting ecosystem benefits from advanced training components.
- **Rationale:** The Haptic Craft Learning System contributes to a comprehensive crafting ecosystem by integrating with Craft Studio, Apprentice Studio, and Design Studio. This holistic approach enhances the overall crafting experience and supports innovation management's goal of developing interconnected and versatile training tools.

7.4.4. Games and toys

The project aims to make crafting accessible and enjoyable for all age groups through creative digital games and physical toys. By simplifying complex crafting techniques into engaging experiences, users can explore and develop their skills in a fun and structured manner. The digital games, available for desktop and mobile devices, offer a guided journey with scripted training, rewards, and nudges, making learning enjoyable. The physical toys, made from recyclable plastic and designed as 3D-printed "tools," provide hands-on crafting experiences. This initiative, supported by Craft Studio and Apprentice Studio, combines digital and physical elements to create an immersive and inclusive crafting adventure.

Simplified Learning Approach

- **Need:** Traditional crafting techniques can be complex and daunting for beginners.
- **Rationale:** By distilling these techniques into simplified, engaging formats through games and toys, we make learning more approachable. This innovation addresses the need to lower barriers to entry, fostering a positive introduction to crafting and aligning with innovation management's focus on user-friendly educational solutions.

Engagement Through Play

- **Need:** Effective learning often requires motivation and engagement.
- **Rationale:** The use of games and toys leverages the motivational power of play. By integrating playful elements into the learning process, we encourage users to engage actively, experiment, and persist in developing their skills. This approach supports innovation management's goal of enhancing user engagement through enjoyable experiences.

Structured Learning Journeys

- **Need:** A structured approach helps users progress systematically through learning experiences.
- **Rationale:** The digital games offer scripted training with built-in rewards, warnings, and sanctions, providing a clear progression path. This structured approach ensures users experience a balanced journey of challenge and achievement, aligning with innovation management's focus on effective and organised educational tools.

Accessible Digital Platforms

- **Need:** Broad access to educational resources enhances learning opportunities.
- **Rationale:** Making the digital games available online for both desktop and mobile devices ensures widespread accessibility. By leveraging the ubiquity of digital platforms, we maximise reach and convenience, supporting innovation management's objective of broadening access to educational content.

Tangible Hands-On Experience

- **Need:** Hands-on practice is crucial for skill development and a deeper understanding.
- **Rationale:** The physical toys provide a tangible crafting experience, allowing users to interact with materials and tools in a real-world context. This tactile engagement complements digital learning and supports innovation management's focus on creating comprehensive and immersive learning experiences.

Inclusivity and Adaptability

- **Need:** Educational tools must cater to a diverse range of skill levels and backgrounds.
- **Rationale:** The range of difficulty levels and adaptable instructions in both the digital and physical components ensures inclusivity. By accommodating various skill levels, we promote widespread participation and support innovation management's goal of creating versatile and inclusive educational solutions.

Eco-Friendly Design

- **Need:** Sustainability is increasingly important in product design and manufacturing.
- **Rationale:** Using recyclable plastic for the 3D-printed tools aligns with environmental sustainability goals. This eco-friendly approach not only supports responsible manufacturing but also introduces users to crafting with an environmental conscience, reflecting innovation management's commitment to sustainable practices.

Joyful Learning Experience

- **Need:** Learning should be engaging and enjoyable to maximise effectiveness.
- **Rationale:** The project's emphasis on creating a joyful learning experience through play, simplicity, and accessibility ensures that users discover the pleasure of crafting without feeling overwhelmed. This aligns with innovation management's focus on making educational experiences enjoyable and impactful.

7.5. WP5 - Design

7.5.1 Design Studio & Computer-aided design

The Design Studio is a virtual workspace designed to enhance the creative design process by integrating advanced computer-aided design (CAD) tools, AI-based design capabilities, and workflow planning support. This virtual studio offers a simulation environment that reduces experimentation costs and supports exploration, training, and the creation of pre-defined craft forms. It incorporates craft-specific 3D tools, haptic interfaces, and realistic artefact previews to provide a comprehensive and immersive design experience. The Design Studio bridges the gap between digital and physical realms, facilitating the transition from virtual designs to tangible creations through various fabrication methods.

Efficiency and Cost Reduction

- **Need:** Traditional design processes can be costly and time-consuming due to extensive physical experimentation.
- **Rationale:** The Design Studio's simulation environment minimises the need for physical trials, thereby reducing costs and accelerating the design cycle. By focusing on virtual experimentation, the innovation addresses the need for efficient and cost-effective design processes, aligning with the goals of innovation management to optimise resources and streamline workflows.

Craft-Specific Precision

- **Need:** Crafting techniques often require specialised tools for precision and accuracy.
- **Rationale:** The integration of craft-specific 3D tools allows designers to work with instruments tailored to the nuances of various craft forms, such as glassblowing, marble cutting, and wood carving. This precision enhances the ability to create detailed and customised designs, supporting innovation management's focus on specialised, high-quality design solutions.

Tactile Engagement for Enhanced Design Experience

- **Need:** A deeper connection with digital creations can improve the design experience.
- **Rationale:** The inclusion of haptic interfaces introduces a tactile dimension to the virtual workspace, enhancing physical engagement and fostering a stronger connection between designers and their digital artefacts. This innovation promotes a more intuitive and immersive design process, aligning with innovation management's objective of enhancing user experience through interactive technologies.

Versatile Computer-Aided Design Functionality

- **Need:** Designers require versatile tools to accommodate diverse design requirements.
- **Rationale:** The Design Studio's integration of CAD tools provides a comprehensive toolkit for conceptualisation and refinement. This functionality ensures that designers can efficiently manage various design needs, supporting innovation management's focus on providing adaptable and effective design tools.

Transition to Physical Creations

- **Need:** Bridging the gap between digital designs and physical products is crucial for practical implementation.
- **Rationale:** The Design Studio's ability to interface with digital fabrication methods facilitates the transition from virtual designs to tangible creations. This feature streamlines the realisation of digital concepts, aligning with innovation management's goal of integrating digital and physical processes to bring designs to life effectively.

Immersive Artefact Previews

- **Need:** Designers benefit from realistic previews to evaluate designs in context.
- **Rationale:** The provision of realistic artefact previews in virtual and mixed-reality environments allows designers to visualise and assess their creations in real-world contexts. This immersive capability

provides dynamic insights and enhances the design process, supporting innovation management's emphasis on providing comprehensive and contextual design evaluation tools.

7.5.2 Additive and subtractive manufacturing

The Craft Manufacturing Integration Suite is designed to integrate both additive and subtractive manufacturing tools within the Design Studio, enhancing craft training capabilities. By incorporating a range of advanced manufacturing technologies into a unified software toolchain, the suite aims to streamline educational and production processes, offering craft professionals and students versatile and practical solutions for their creative endeavours.

Holistic Technological Analysis

- **Need:** Understanding and integrating a diverse range of manufacturing technologies is crucial for relevance and adaptability.
- **Rationale:** The suite's comprehensive analysis of both additive (e.g., FDM, SLA) and subtractive (e.g., laser cutting, milling) technologies ensures that it accommodates various tools and techniques. This holistic approach aligns with innovation management's focus on thorough technological understanding and adaptability, ensuring the suite remains relevant and useful across different craft settings.

Real-world Collaboration with Craft Training Organizations

- **Need:** Practical application and user relevance are enhanced through collaboration with industry stakeholders.
- **Rationale:** Engaging craft training organisations in the development of the suite grounds its features in real-world applications. This collaboration ensures that the suite addresses actual needs and challenges in educational and production contexts, aligning with innovation management's emphasis on real-world applicability and user-driven design.

Tailored Integration for Craft Education

- **Need:** Simplifying the integration of manufacturing technologies in educational settings is essential for effective learning and application.
- **Rationale:** By focusing on a software toolchain specifically designed for the Design Studio, the suite streamlines the integration of additive and subtractive manufacturing tools into craft education. This tailored approach supports innovation management's goal of simplifying and enhancing the educational process, making advanced manufacturing techniques more accessible to students and practitioners.

Versatile Evaluation of Manufacturing Technologies

- **Need:** Offering a range of manufacturing technologies expands utility and relevance across different craft disciplines.
- **Rationale:** The suite's evaluation of various additive and subtractive technologies demonstrates versatility and adaptability. By allowing craft professionals to explore and adopt the most relevant

technologies for their applications, the suite supports innovation management's focus on providing flexible and comprehensive solutions that meet diverse user needs.

Empowerment of Craft Professionals

- **Need:** Advanced manufacturing capabilities can significantly enhance creative processes and experimentation.
- **Rationale:** The suite's primary goal is to empower craft professionals by providing access to advanced manufacturing technologies. This empowerment aligns with innovation management's objective of enhancing user capabilities and enabling experimentation, pushing the boundaries of traditional craftsmanship and fostering creativity.

User-Friendly Simplified Integration

- **Need:** The integration of advanced manufacturing tools can be complex and challenging.
- **Rationale:** The suite emphasises user-friendly design to simplify the integration of additive and subtractive manufacturing tools into the Design Studio. By providing an accessible and intuitive interface, the suite supports innovation management's focus on reducing complexity and enhancing user experience, ensuring that advanced technologies are easily incorporated into creative workflows.

7.5.3 Community portal

The community portal is designed to facilitate creative exchange among stakeholders in the crafting domain. The portal integrates standard web-based community features with advanced tools to support activities such as craft education and training, valorisation and branding of crafts, online sales, and the promotion of European crafts and heritage. By offering a comprehensive digital ecosystem, the Craft Exchange Hub aims to enrich the crafting community and foster collaboration, education, and preservation.

Facilitating Creative Exchange

- **Need:** A centralised platform for diverse stakeholders to share ideas and techniques.
- **Rationale:** The Craft Exchange Hub addresses the need for a vibrant community space where craftsmen, educators, enthusiasts, and businesses can connect and collaborate. By fostering a creative exchange, the platform enriches the crafting domain, aligning with innovation management's goal of promoting collaborative environments and knowledge sharing.

Enhancing User Experience with Advanced Tools

- **Need:** To provide a dynamic and interactive user experience beyond traditional community portals.
- **Rationale:** Incorporating advanced web-based tools elevates the user experience, offering a sophisticated yet accessible environment for content presentation, interaction, and engagement. This approach reflects innovation management's emphasis on creating user-centric solutions that enhance interaction and engagement with digital content.

Supporting Craft Education and Training

- **Need:** Continuous learning and access to educational resources are crucial for the crafting community.
- **Rationale:** The Craft Exchange Hub serves as a virtual classroom, providing access to educational resources and training programs. This focus on education aligns with innovation management's objective of addressing evolving needs within the community, supporting ongoing learning and skill development.

Empowering Craftspersons and Micro-Businesses

- **Need:** An integrated platform for valorisation, branding, and sales of crafts.
- **Rationale:** The portal empowers individual craftsmen and micro-businesses by offering tools for product valorisation, online sales, and brand-building. This centralised hub facilitates not only showcasing work but also engaging in commercial activities, reflecting innovation management's focus on supporting entrepreneurial growth and market access.

Preserving Craft Heritage and Identity

- **Need:** To highlight and preserve cultural heritage and traditional techniques.
- **Rationale:** By promoting European crafts, history, and identity, the platform contributes to the preservation of cultural heritage. This commitment aligns with innovation management's goal of sustaining traditional practices and integrating them into contemporary contexts, ensuring that craft heritage remains relevant and valued.

Facilitating New Entrepreneurship and Skills Development

- **Need:** Encouragement of new entrepreneurship and skills acquisition within the crafting sector.
- **Rationale:** The Craft Exchange Hub fosters new entrepreneurship and skills development by creating a space for exploring entrepreneurial opportunities and acquiring new skills. This approach supports innovation management's emphasis on adapting to changing dynamics and encouraging growth and innovation within the crafting community.

Creating a Comprehensive Digital Ecosystem

- **Need:** Integration of community-building, education, promotion, and commerce into a cohesive platform.
- **Rationale:** The creation of a comprehensive digital ecosystem that seamlessly integrates various functions reflects innovation management's goal of providing a holistic and multifunctional platform. The Craft Exchange Hub serves as a one-stop destination, addressing diverse needs and interests within the crafting community, thereby enhancing overall user experience and engagement.

8 Conclusion

Innovation management is a dynamic process that requires a comprehensive understanding of market and technical issues to implement creative ideas.

Recognising the importance of integrating business models and process innovations, we defined an IMP and strategy from Craeft's inception. This strategy is designed to foster advancements in the preservation of crafts, education and training, reduction of material and energy waste, and the development of new products.

Throughout the project, our multidisciplinary team will leverage advanced digitisation, immersive technologies, and sustainable practices to transform traditional crafts into thriving, contemporary practices. By building strong connections with the European Commission and other Horizon projects, to create a robust network that supports the identification and preservation of endangered crafts across Europe.

This report provides a detailed overview of the innovation management approach. It serves as a guide for consortium members and will be updated to adapt to the evolving needs and phases. The IMP is thus considered a living document, ensuring that we remain responsive to emerging trends and market demands.

Craeft is poised to create a vibrant future for crafts by fostering collaboration, leveraging technology, and promoting sustainability. This project aims to preserve cultural heritage, innovate and adapt, ensuring that traditional crafts continue to enrich our society and economy in the years to come.

Annex A. Partner-reported innovation fiches

This annex provides the full partner-reported innovation fiches collected using the common reporting structure. The fiches underpin the consolidated inventory presented in Section 6 and provide traceability from partner input to project-level reporting. Each fiche contains the innovation name, a short product description, a description of the innovation, and the partner's reported innovation dimension(s).

A.1 ARMINES

A.1.1 Ethnographic protocol

Short description of the product: The ethnographic protocol is a guideline on the capturing of human movement gestures and consists of three steps, the initial interview with the expert, the main motion capturing process and concludes with the video elicitation, a process where the respective crafts person follows his own egocentric recordings and unveils their thoughts, actions, working process, also understanding things themselves on how they work.

Description of the innovation: Most, if not all, motion capturing processes include only the second step described, thus the technical part of motion capturing, where different sensors are installed in the working environment and capture the movements of the human operator for a few hours and for a few repetitions. However, this process brings together the technicality of the research, tech word and the ethnographic analysis that takes place both during the initial interview and the video elicitation.

INNOVATION DIMENSIONS: The protocol has proven to have also been useful to the crafts people that were captured, since they all expressed that the third step of the video elicitation gives them an extra perspective of their work, as well as the way that they performed the process of teaching right after that process, proving its innovation dimensions, not only for the research community and the motion capturing process, but also the expert crafts people in the further discovery of their craftsmanship.

A.2 CERFAV

A.2.1 E-learning portal

Short description of the product: The e-learning portal makes it possible to open up learning about craft trades to a wider audience. There are several expectations for this tool:

- To raise awareness and increase the attractiveness of craft trades
- To enable interested individuals to acquire a basic level of knowledge
- To provide a complementary learning tool to the workshop, which covers basic knowledge and allows participants to practise problem solving, to emphasise the anchorage of skills.

In addition, the e-learning platform opens up new educational opportunities by enabling independent learning for several concepts.

Description of the innovation: Description of innovations:

- Integration of Cognitive Load Theory (Sweller 1988) principles and establishment of guidelines, providing a methodological and practical framework for developing user-oriented training modules that are more efficient in terms of learning.
- Combines a multimodal and scaffolding approach adapted to the expertise levels of participants/learners, taking into account pedagogical progression.
- Use of Moodle as an e-learning platform, not the only one available, but widely used for training, recognised and stable, allowing the implementation of varied multimedia content, such as video quizzes with H5P tools. Moodle, customised for manual trades, allows for a structured, accessible and scalable approach, while preserving the authenticity of gestures and cultural contexts, which are often absent from traditional online training courses.

INNOVATION DIMENSIONS: Craeft uses multimodal content (interactive comics, annotated videos) to create an attractive training environment and draws on Cognitive Load Theory to facilitate learning. Socially, it democratises access to craft professions by breaking down geographical and generational barriers, while promoting artisan communities. Culturally, it preserves endangered skills by documenting them digitally (ethnography, 3D archives) and anchoring them in their historical context. The collaborative approach (forums, feedback) also reinforces interpersonal transmission, which is essential in the crafts.

A.2.2. Ethnographic Protocol

Short description of the product: The Ethnographic Protocol is a methodology for documenting craft practices that merges computer science and anthropology. It relies, among other methods, on egocentric recording and video elicitation techniques. By capturing the craftsperson’s perspective and combining it with interviews and contextual analysis, the protocol documents the embedded knowledge of craft professionals.

Description of the innovation: Even though egocentric recording has been used across many disciplines, including cooking, dance, and sports, it has not yet been applied in crafts, and its potential for self-recognition, self-improvement, and teaching remains largely unexplored. Moreover, video elicitation following egocentric recording allows craft professionals to become aware of the embedded, often unconscious body knowledge involved in their practice, fostering self-appreciation and respect for their skills. Combined, video elicitation and egocentric recording, though not new tools, have been given a new, innovative purpose through this methodology. Together, they serve as a powerful tool for self-recognition and the transmission of craft knowledge and skills.

INNOVATION DIMENSIONS: Knowledge/Transmission: Serves as a powerful tool for teaching, learning, and transmitting craft knowledge across generations and disciplines. Capacity-building: Helps craft practitioners become more self-aware of their own skills and processes, encouraging them to value and respect their knowledge. Communication and awareness-raising: The gestures recorded with the eco-centric camera can be used to raise awareness among the general public by demonstrating the complexity of the craft skills. Resulting in the wider appreciation of the craft sector and the consumers' awareness.

A.2.3. Instructional Methodology

Short description of the product: The instructional methodology describes how digital tools can be integrated into traditional craftsmanship curricula to optimise their impact.

This methodology is based on the concept of a hybrid mode, in which the use of traditional and digital tools is interwoven within learning scenarios developed according to the specific characteristics of each tool and the constraints of the RCIs.

Description of the innovation: As part of the objectives to promote and broaden access to craftsmanship training, two areas of innovation have been developed.

Firstly, innovation in digital tools, including simulators that enable initial learning in a controlled and secure environment, saves time in often costly workshops. Examples include a 3D modelling wheel for porcelain and a virtual reality glassblowing workshop simulator.

Secondly, innovation in educational methods thanks to the hybrid mode, which optimises the effectiveness of digital tools integrated into the traditional learning programme. The hybrid mode aims to define a specific role for each tool, whether digital or traditional, to avoid confusion or interference between tools when their scope of action is not specified. Another innovative aspect of the hybrid mode is its emphasis on creating links between the various basic concepts learned in order to help build a complex cognitive image of skills, with the support of complementary tools, like a 3D printing demonstrator.

INNOVATION DIMENSIONS: The innovative aspect consists of exploring alternative learning methods in order to facilitate access to and/or optimise the acquisition of skills in the craft trades.

The proposed learning methodology is grounded on recognised and proven theories, such as Cognitive Load Theory or Active Method. The aim is to place the learner/knowledge/skills relationship at the centre of the learning process. The core of innovation lies in using these recognised methods and adapting them to integrate the use of digital tools into traditional learning. Not forgetting to take into account geographical, economic and socio-cultural environments.

The second area of innovation is hybrid learning, where the role of each tool, whether traditional or digital, is clearly defined in close interaction through scenarios and comes into play at the right moment in the educational journey to create bridges between concepts, facilitating the acquisition and consolidation of complex skills.

A.2.5. ShellGen App

Short description of the product: ShellGen is a spectral volumetric rendering system specialised in accurately representing the appearance of artisanal and heritage glass, as well as other materials. Built on the Mitsuba 3 engine, it incorporates real optical data characterising glass to generate accurate, physically based renderings.

Description of the innovation: ShellGen is the first spectral volumetric rendering tool bridging scientific rendering and craft accessibility. Developed and validated through glass as a case study, the system generalises to any translucent or transparent material by integrating measured optical data into physically-based volumetric rendering. While architectural visualisation tools lack spectral precision and scientific rendering software remains inaccessible to non-programmers, ShellGen combines physics-based accuracy with an intuitive interface that allows craftspeople, conservators, and designers to simulate how specific material compositions will appear in finished objects, directly addressing a market gap in craft and heritage sectors seeking accessible tools for material appearance prediction and digital preservation.

INNOVATION DIMENSIONS: ShellGen allows users to visualise and explore glass compositions that have never been physically produced: rediscovering the exact appearance of a lost historical formula by recalculating its chemical composition, or exploring artisanal innovations without conducting costly trials. Socially, this means reviving lost skills and making experimentation accessible to artisans, allowing them to "see before they do", thus democratizing innovation and the restoration of glassmaking heritage by reducing economic and material barriers.

A.2.6. Virtual reality glassblowing simulator

Short description of the product: The virtual reality glassblowing simulator is an application that simulates the environment of a glassblowing workshop, featuring several interactions that realistically reflect certain tools and skills used in the glassblowing profession.

Description of the innovation: The VR simulation of a glassblowing workshop is a possible first step for novice learners, particularly those who may be apprehensive about the heat of the furnace or fire. It provides an initial introduction to the layout of the glassblowing workshop and the tools used, with the option to pick up the tools and view a short explanatory text and video about how each one is used. Furthermore, this virtual reality simulator prototype offers an opportunity to democratize access to the glassblowing experience for the general public. Transposing the environment of a workshop into an interactive virtual environment, it allows visitors and curious individuals with no prior experience to explore some of the fundamental techniques of the craft in an accessible and immersive way.

INNOVATION DIMENSIONS: It is a valuable tool for raising awareness: it makes a craft that is often misunderstood or perceived as being reserved for insiders accessible and tangible, by making it accessible, fun and experimental. Beyond being a simple attraction, this type of prototype helps to promote arts and crafts by making them concrete and appealing, potentially inspiring vocations or, at the very least, enabling a better understanding and recognition of traditional skills among a novice audience.

A.3 CETEM

A.3.1 Historical Documentation on Woodcarving in Yecla

Short description of the product: A structured historical documentation compiling the evolution, techniques, actors, and cultural relevance of woodcarving within the furniture tradition of Yecla. The documentation gathers contextual, historical, and technical information to support educational, heritage, and policy-related activities.

Description of the innovation: While Yecla's furniture industry is widely recognised, its woodcarving tradition has largely remained undocumented in a systematic and accessible way. Existing references are fragmented, informal, or embedded within broader industrial narratives without a specific focus on carving practices.

This documentation is innovative in that it consolidates dispersed knowledge into a single, structured resource explicitly linking woodcarving to Yecla's industrial and craft identity. It bridges heritage research, vocational education, and policy support by serving multiple purposes: educational content, cultural documentation, and evidence base for institutional processes such as Geographical Indications for crafts.

INNOVATION DIMENSIONS: Knowledge and heritage innovation: Systematises and preserves historical and technical knowledge related to an under-documented craft tradition.

Educational innovation: Provides contextual content that enhances learning materials and training programmes.

Policy and institutional innovation: Supports evidence-based applications for heritage recognition and Geographical Indications for crafts.

Social innovation: Reinforces local identity and recognition of craft communities linked to Yecla's furniture sector.

A.3.2 Virtual Museum of Yecla Furniture and Woodcarving

Short description of the product: An immersive 360° virtual museum designed to document, communicate, and promote the historical evolution of Yecla's furniture industry and its associated woodcarving tradition. The virtual environment allows users to explore spaces, objects, and narratives related to Yecla's industrial and craft heritage in an accessible digital format.

Description of the innovation: Yecla has been recognised by the European Commission as a candidate area for Geographical Indications for crafts due to its long-standing furniture tradition. Despite this relevance, no physical museum or consolidated exhibition space currently exists to present the full historical evolution of its main industry, including woodcarving.

The Virtual Museum addresses this structural gap by offering a digital alternative that combines heritage documentation, storytelling, and immersive technologies. Unlike conventional heritage websites or static archives, the 360° environment enables spatial exploration and contextual understanding of furniture manufacturing and woodcarving as interconnected practices.

INNOVATION DIMENSIONS: Cultural and heritage innovation: Digitally preserves and communicates both tangible and intangible heritage linked to furniture making and woodcarving in Yecla.

Social innovation: Improves public access to local industrial heritage, including audiences who cannot visit Yecla physically.

Educational innovation: Provides a reusable learning and dissemination resource for training, awareness-raising, and vocational education related to crafts and furniture traditions.

Territorial innovation: Supports place-based identity and visibility of Yecla as a craft and furniture cluster at the European level.

A.3.3 Wood carving process supported by 3D printing

Short description of the product: A new and reinforced process of woodcarving, supported by 3D printing. This creates a new and more efficient workflow based on a plastic and cheap 3D printing prototype of the piece to carve. This improves and facilitates the artisan's work and reduces the communication gap between designer and woodcarver.

Description of the innovation: This new process is based on using different techniques and technologies: CAD modelling, FDM 3D printing technology and even (if needed) CNC machining. Traditional woodcarving doesn't use such technologies. With this new process, communication and collaboration between designers and artisans are improved.

The new solution has been proven to be very useful, minimising errors and misinterpretations.

Combining CAD modelling, FDM 3D printing, and CNC machining creates a more efficient workflow in which the carver can begin working from a prepared and precisely shaped wooden base, and using the 3D printed prototype for reproducing its shape is highly innovative.

INNOVATION DIMENSIONS:

A.3.4 Woodcarving Online Training - E-learning portal

Short description of the product: An online training programme on woodcarving designed as a self-training course or as supportive material for face-to-face courses.

It consists of structured digital content, including explanatory texts, images, and instructional videos, covering tools, materials, safety considerations, and the main stages of the woodcarving process, complemented by guided practical exercises.

Description of the innovation: Woodcarving training is traditionally delivered almost exclusively through in-person, workshop-based formats, with limited structured digital support. The Woodcarving Online Training introduces a digital learning approach by integrating interactive resources with hands-on practice.

Unlike generic online tutorials or isolated video content commonly found on open platforms, this training programme is pedagogically structured and tailored to complete beginners and woodworking professionals with little or no experience in woodcarving.

The innovation lies in that it can be used as a supportive learning tool or as a complete online course, ensuring a strong practice experience with complete and real videos of face-to-face training.

INNOVATION DIMENSIONS: Educational innovation: Possibility of introducing a hybrid learning model that combines face-to-face training with structured digital support materials.

Knowledge transmission: Facilitates the documentation and transfer of tacit craft knowledge through step-by-step videos and guided exercises.

Skills development: Supports beginners in consolidating practical skills beyond the limited duration of in-person workshops.

Digital innovation: Applies e-learning methodologies to a craft discipline that is rarely addressed through formal digital training tools.

A.4. CNAM

A.4.1 Aubusson E-Learning Platform

Short description of the product: The E-learning platform for Aubusson tapestry translates workshop-based apprenticeship knowledge into a structured, accessible digital curriculum. It offers modular learning paths combining historical and cultural context with technical foundations, loom set-up, and step-by-step practical techniques. Through enriched visuals, bilingual terminology support, and interactive learning materials, the platform enables learners with different levels of experience to engage with the craft remotely while complementing in-person training.

Description of the innovation: The platform is innovative in that it is purpose-built for the specificities of Aubusson low-warp tapestry and its gesture-based know-how, rather than providing generic textile or craft instruction. It converts an apprentice's detailed documentation into a cohesive digital learning experience validated and supplemented by master weavers and historical sources. Its approach also preserves linguistic and cultural precision by retaining key French technical terms and embedding them into a bilingual glossary with contextual explanations, while transforming archival visual material into labelled diagrams and interactive resources that make complex procedures readable and teachable at a distance.

INNOVATION DIMENSIONS: The platform innovates through its pedagogical and heritage-oriented strategy, making an apprenticeship tradition transmissible through modular, learner-centric pathways. It supports cultural continuity by documenting and archiving techniques, terminology, and context in a durable and shareable form, while also enabling new communities of practice through global access. Its translation and glossary strategy constitutes a methodological contribution in itself, balancing accessibility with fidelity to a culturally specific vocabulary and worldview embedded in the craft.

A.4.2 Ethnographic Protocol

Short description of the product: Conceived through an interdisciplinary approach, the ethnographic protocol seeks to document the gestural dimension of human activities, particularly within craft practices. It is structured around three main stages: first, an initial interview with the practitioner focusing on their life history and training, during which they select the gestures to be documented according to predefined criteria; second, the gesture capture phase, which combines multiple recording technologies; and third, a final interview known as video elicitation, in which the practitioner watches recordings of their own activity and is guided by questions to articulate less explicit aspects of their practice.

Description of the innovation: The central role assigned to the social sciences in this protocol, involving the integration of several disciplinary approaches and traditions (such as anthropology of techniques, sociology of work, and ethnomethodology), enables a richer, more nuanced, and more comprehensive use of motion capture technologies in the recording process. This approach foregrounds the situated, embodied, and sensory character of the practices under study while restoring dimensions that are essential for a detailed understanding of human activity.

INNOVATION DIMENSIONS: The protocol was designed to place practitioners at its core and, in this respect, also generated substantial interest among the professionals involved. Many reported that the recording process, particularly the final stage involving guided viewing of egocentric recordings, encouraged them to reassess their practice from a fresh perspective. This reflexive engagement proved highly valuable for fostering renewed connections to specific skills, refining technical performance, and supporting processes of archiving and transmission.

A.4.3 Plaster Simulator

Short description of the product: The Plaster Simulator is an interactive digital environment designed to model the craft process of plaster turning for porcelain slip casting. Developed through a user-centred and ethnographically informed approach, it reproduces the workflow of the workshop, from preparing the plaster blank to shaping it on the turning wheel. By combining real-time interaction, multimodal feedback, and geometrically accurate modelling, the system supports both the transmission of tacit craft knowledge and the generation of digital models suitable for design and visualisation.

Description of the innovation: The Plaster Simulator is distinguished by its focus on subtractive plaster shaping rather than clay deformation, a process largely absent from existing virtual craft tools. Its innovation lies in coupling ethnographic insight with interactive simulation to faithfully represent professional workflows, sensory cues, and decision-making processes. Unlike entertainment-oriented craft applications, it prioritises procedural realism, expert-informed interaction, and compatibility with professional rendering pipelines, positioning it as both a training and documentation tool.

INNOVATION DIMENSIONS: The Plaster Simulator contributes to the preservation and transmission of intangible cultural heritage by transforming tacit knowledge into observable and discussable processes. Pedagogically, it supports experiential and perceptual learning by training attention to sensory cues and enabling safe experimentation, thereby bridging the gap between embodied practice and digital representation.

A.5. CNR

A.5.1 Craft Ontology

Short description of the product: The Craft Ontology formally represents the knowledge about crafts that Craeft is to describe and preserve.

Description of the innovation: The Craft ontology is a formal and multi-level framework for representing traditional craft practices and their contexts. The ontology encompasses not only materials, tools, actions, and products, but also the social, economic, and historical factors that shape craft production. Its three-

tier activity structure - schema, virtual, and real levels - allows detailed analysis from planning to execution, while integrated semantic networks and narratives connect events and entities into a comprehensive knowledge system.

INNOVATION DIMENSIONS: The Craft ontology enables cultural institutions, educators, and digital heritage platforms to preserve, teach, and analyse crafts in ways not previously possible. By bridging technical practice and contextual knowledge, the Craft ontology provides a reusable, interoperable, and extensible framework that can be exploited for research, education, and digital heritage applications.

A.6 ETH ZURICH

A.6.1 Haptic Interfaces for Craft Training, Simulation, and Design

Short description of the product: The Haptic Craft Interfaces are interactive apparatuses that authentically simulate the tactile sensations of craft tool use, enabling practitioners to develop dexterous actuation skills and heightened material sensitivity in a controlled virtual environment before entering the physical workshop.

Description of the innovation: The system focuses on the "education of attention" to the tactile features inherent in different materials and products, training users to discern subtle differences in surface texture, resistance, and material response. By providing pre-workshop tactile preparation, the haptic interfaces reduce the learning curve and build muscle memory and confidence in a risk-free virtual setting. They integrate with the Craft Studio, Apprentice Studio, and Design Studio, serving as a cohesive tactile layer across the Craeft training ecosystem.

INNOVATION DIMENSIONS: Haptic interfaces address a fundamental gap in craft education by making the sense of touch, the most essential yet hardest-to-transmit aspect of craftsmanship, digitally accessible and trainable. This has significant implications for craftsmanship education institutions, VR/AR developers, manufacturing industries producing handcrafted products, and healthcare and rehabilitation programmes targeting fine motor recovery. Their integration across multiple platforms makes them a cross-cutting enabling technology for the entire training ecosystem.

A.7. FORTH

A.7.1 Archetypal Action Simulators

Short description of the product: Archetypal Action Simulators are computational tools that model Elementary Actions, such as knots, additive/subtractive processes, and free-form transforms, with specified affordances, conditions, and parameters drawn from digitised practitioner motion and haptic interaction.

Description of the innovation: The simulators combine geometric, mechanical, and semantic representations of crafting actions with multimodal execution recordings across diverse materials, producing a comprehensive training dataset. Using generative AI methods, the simulators learn from this dataset and predict the outcomes of crafting actions based on environmental conditions and input

parameters. The integration of haptic interaction and practitioner motion bridges the gap between digital simulation and real-world craftsmanship.

INNOVATION DIMENSIONS: The predictive capability of the Archetypal Action Simulators represents a step-change in crafting workflow planning, enabling practitioners, students, and researchers to test and refine actions before executing them on physical materials. Their transferability across crafting domains and materials, combined with compatibility with Semantic Web and Europeana standards, makes them applicable in education, manufacturing prototyping, materials science, VR/AR development, and crafting software tools.

A.7.2 Maker-Material-Negotiation Model

Short description of the product: The Maker-Material-Negotiation (MMN) Model is a formal ontological model, built upon the CIDOC CRM-based Craft Ontology (CrO), that represents the dynamic interaction between makers and materials, including tools, workspaces, action plans, hypotheses, and contextualisation narratives.

Description of the innovation: Encoded in RDF Schema and transcribed to OWL 2 DL, the MMN model extends the Craft Ontology to integrate cognitive elements such as action hypotheses, material effects, conditions, and parameters. This encoding enables computational inference, allowing the system to perform automated reasoning and support decision-making in crafting. The model further incorporates contextualisation narratives, a storytelling dimension that documents the qualitative factors influencing a maker's decisions, and aligns with computational requirements for downstream tasks in digital re-enactment.

INNOVATION DIMENSIONS: The MMN Model goes beyond traditional ontologies by capturing the cognitive and procedural dynamics of the maker's decision-making process, making it a unique resource for research in cognitive science, human-computer interaction, and material science. Its interoperability with existing Semantic Web standards and adaptability to diverse making scenarios make it valuable for industry adoption, crafting software development, educational platforms, VR/AR applications, and artisan communities seeking collaborative design frameworks.

A.7.3 Craeft Authoring Platform

Short description of the product: The Craeft Authoring Platform (CAP) is a comprehensive software system that extends the Craft Ontology (CrO) and facilitates the authoring, management, and dissemination of craft-related knowledge entities and digital assets by building upon the existing Museum Object Platform (MOP).

Description of the innovation: CAP enables users to associate semantics and multimodal signals with crafting entities such as elementary actions and affordances, and to dynamically instantiate these entities from the extended ontology. A distinctive feature is its novel approach to linking knowledge entities with digital assets, including 3D object reconstructions and action recordings, creating an interactive connection between crafted entities and their representations. Its strategic alignment with CIDOC-CRM and the Europeana Data Model (EDM) orients all content around the central "Event" class, ensuring compatibility with the Semantic Web and Europeana.

INNOVATION DIMENSIONS: CAP transforms the authoring of craft knowledge from a static documentation task into a dynamic, interoperable, and semantically rich process. Museums, cultural heritage institutions, educators, and VR/AR developers can leverage CAP to document, preserve, and share crafting processes with global accessibility. Its Europeana compatibility positions it as a bridge between local craft expertise and international digital heritage platforms, while its open architecture supports start-ups and software companies seeking advanced craft-tech solutions.

A.7.4 Craft-Specific Action Simulators

Short description of the product: Craft-Specific Action Simulators are a software method that refines general archetypal simulators into highly customised, craft-specific simulation tools using Generative Adversarial Networks (GANs), trained on ethnographic craft data and third-party materials, to produce realistic 3D previews of crafting processes.

Description of the innovation: GANs are first trained on craft representations acquired during ethnographic research, then fine-tuned using craft-specific data to ensure accuracy and nuance for each particular craft domain. The method integrates scene understanding outputs to model challenging materials in 3D, generating immersive previews that serve as mental imagery for practitioners. The simulations are encoded in CIDOC-CRM and EDM formats, ensuring compatibility with Semantic Web and Europeana platforms.

INNOVATION DIMENSIONS: The application of generative AI to crafting simulation represents a pioneering fusion of advanced machine learning with intangible cultural heritage. The craft-specific simulators empower practitioners with a visual, decision-supporting tool that reduces uncertainty before physical execution, while providing educational institutions and VR/AR developers with a customisable, realistic environment for skill training. Their compatibility with global digital archives extends their reach to heritage preservation, materials science research, and consulting services for craftsmanship optimisation.

A.7.5 Digitisation of Material Treatment and Deformation

Short description of the product: The Digitisation of Material Treatment and Deformation is an adaptive simulation tool that uses computer vision, machine learning, and 3D sensing to model and visualise how practitioner actions, whether subtractive, additive, or interlocking, transform materials during crafting.

Description of the innovation: The tool simplifies the computational learning problem by contextualising the type of action being performed, reducing geometric complexity and degrees of freedom. Machine learning is integrated not only to instantiate deformation models but also to explain observed material transformations, offering an interpretive layer that reveals why specific material effects occur. The models are trained on a large dataset of both real annotated craft data and synthetic photorealistic data, while 3D sensing narrows down the action parameter space for precision.

INNOVATION DIMENSIONS: The tool's context-aware and explanatory approach to material modelling advances the state of the art in craft digitisation and adaptive simulation. Its ability to model diverse transformations, plastic deformations, knot mechanics, weaving algebras, and additive/subtractive processes across a wide range of materials makes it applicable in crafting industries, manufacturing,

material science R&D, and VR/AR development. Compatibility with Semantic Web platforms ensures global accessibility and contribution to digital craft preservation.

A.7.6 High-Resolution 2D and 2½D Surface Scanning

Short description of the product: The High-Resolution Surface Scanner is a heritage digitisation product that achieves resolutions exceeding 1 gigapixel per square centimetre, combining 2D imaging with 2½D photogrammetric depth capture to produce comprehensive and tactile-quality-preserving digital representations of artefact surfaces.

Description of the innovation: Building on established 2D scanning techniques, the scanner introduces depth through photogrammetry, generating anaglyph-quality surface maps that capture not only visual details but also surface structures influencing tactile sensations such as smoothness and coarseness. This goes beyond conventional digitisation by incorporating the tactile dimension of heritage objects into the digital archive, enabling future generations to engage with artefacts with unprecedented fidelity. The technology brings together expertise in surface scanning, photogrammetry, and heritage preservation in an interdisciplinary workflow.

INNOVATION DIMENSIONS: The scanner sets a new technological standard for heritage digitisation by capturing both the visual and tactile dimensions of artefacts, advancing beyond the limitations of traditional 2D scanning. Its unprecedented resolution and photogrammetric depth make it invaluable for cultural institutions, museums, archaeological research, and VR/AR content development. It also enables cross-industry applications in manufacturing, design, and material science, where detailed 3D surface representations are critical for quality control and innovation.

A.7.8 Digitisation of Transparent, Translucent, and Shiny Materials

Short description of the product: The Transparent Materials Digitisation system is an innovative, non-contact 3D reconstruction tool that uses polarised and structured illumination techniques, guided by Augmented Reality (AR), to accurately capture the geometry and surface details of optically challenging materials such as clear and frosted glass, stained glass, amber, and metal.

Description of the innovation: Traditional scanning methods fail with transparent and reflective surfaces due to inherent optical properties, including refraction, highlights, and reflections. This system addresses those challenges through specialised illumination techniques that mitigate glare and reflection, while AR overlays provide real-time operator guidance to ensure correct positioning and data capture. The approach builds on insights from the prior Transparent3D project and extends its capabilities to a broader range of materials and application contexts.

INNOVATION DIMENSIONS: By solving a long-standing challenge in 3D digitisation, this system opens entirely new possibilities for the preservation of heritage artefacts made of glass and metal, and for industries working with transparent materials in architecture, art, manufacturing, and product design. The integration of AR for operator guidance lowers the technical barrier for adoption, while the non-contact method ensures the safety of delicate artefacts. Its cross-sector potential, from medical imaging to virtual reality content creation, positions it as a broadly applicable digitisation innovation.

A.7.9 Craft Studio

Short description of the product: The Craft Studio is a novel, game-engine-powered 3D authoring and simulation environment that enables craft practitioners, students, and designers to visualise, plan, and interact with crafting processes through immersive rendering and dynamic integration with the Craeft Authoring Platform (CAP).

Description of the innovation: The Craft Studio supports both generic and craft-specific simulations, dynamically instantiating schema components based on user-selected devices, tools, materials, and crafts. It is interoperable with a range of visualisation and interaction devices, screens, MR glasses, VR headsets, and haptic/tactile interfaces, ensuring a personalised and adaptive simulation experience. All simulations generate metrics on material and energy usage, providing a data-driven foundation for planning efficient crafting workflows. Integration with CAP ensures access to semantic content, including action plans and schemas.

INNOVATION DIMENSIONS: The Craft Studio transforms craft simulation from a passive viewing experience into an active, contextualised, and device-flexible environment. By combining game-engine realism with semantic content from CAP, it enables crafters to practise, plan, and evaluate their work before committing to physical materials, reducing waste and accelerating skill development. Its potential markets span crafting enthusiasts, vocational schools, heritage preservation organisations, online crafting platforms, and manufacturing industries that incorporate handmade elements.

A.7.10 Apprentice Studio

Short description of the product: The Apprentice Studio is a personalised educational and training extension of the Craft Studio, designed to deliver bespoke learning journeys for craft trainees through multi-modal interfaces, including desktop, web-based, VR, AR, and haptic, combined with performance tracking and open-ended problem-solving scenarios.

Description of the innovation: The Apprentice Studio tailors courses, exercises, and success metrics to each learner's progress, adapting dynamically based on performance logs, simulated material quantities, and energy usage. It introduces a creative problem-solving dimension through open-ended challenges related to health, safety, and fatigue in workshop environments, and incorporates experimental archaeology scenarios that link with the Craft Authoring Platform's historical knowledge sources. This contextualises training within the historical and cultural significance of the tools and materials used.

INNOVATION DIMENSIONS: The Apprentice Studio redefines craft training by merging personalised learning with immersive technology and critical thinking challenges. Its experimental archaeology scenarios are particularly innovative, connecting practical skill development with historical and cultural heritage knowledge. The system is applicable in universities, vocational training centres, corporate training programmes, online learning platforms, and heritage institutions, as well as in health and safety training and therapeutic rehabilitation settings that require fine motor skill development.

A.7.11 Games and Toys

Short description of the product: The Games and Toys exploitable outcome encompasses a suite of digital crafting games (accessible online for desktop and mobile) and physical 3D-printed toys made from recyclable plastic, designed to introduce diverse age groups to craft skills through play, structured learning journeys, and hands-on physical creation.

Description of the innovation: The digital games guide users through crafting techniques via scripted training courses with built-in rewards, warnings, and sanctions, making the learning process structured yet enjoyable. The physical toys replicate craft tools at a miniature scale, enabling users to follow craft instructions at their own pace and physically interact with crafting processes. Both components draw from the Craft Studio and Apprentice Studio, simplifying complex craft techniques into approachable experiences that blend digital and physical elements. The use of recyclable plastic aligns the product with sustainability goals.

INNOVATION DIMENSIONS: Games and Toys lower the entry barrier to craft learning by packaging complex skills into joyful, accessible formats for all ages and skill levels. The combination of digital interactivity and tangible physical experience is a unique innovation that bridges screen-based learning with hands-on craft engagement. Markets include crafting enthusiasts, schools, online learning platforms, toy and game retailers, eco-conscious brands, community organisations, and healthcare/therapeutic settings, leveraging the tactile and cognitive benefits of play-based craft activities.

A.7.12 Additive and Subtractive Manufacturing Suite

Short description of the product: The Craft Manufacturing Integration Suite is a software toolchain designed to integrate additive manufacturing (e.g. FDM, SLA) and subtractive manufacturing (e.g. laser cutting, milling) tools directly within the Design Studio, enabling craft professionals and educators to evaluate and adopt advanced manufacturing technologies in their creative and training workflows.

Description of the innovation: Developed in real-world collaboration with craft training organisations, the suite provides a user-friendly interface that simplifies the integration of diverse manufacturing technologies into craft education and production contexts. It evaluates a broad range of additive and subtractive processes, providing craftspeople and institutions with a comprehensive toolkit to explore new techniques without requiring deep technical expertise. The emphasis on simplified integration ensures that even SMEs and individual craftspeople can adopt advanced manufacturing capabilities.

INNOVATION DIMENSIONS: The suite empowers craft professionals to cross the boundary between traditional craftsmanship and advanced manufacturing, enabling experimentation, diversification, and innovation in both training and production settings. Its broad technology coverage and user-friendly design make it accessible to craft training institutions, artisan communities, manufacturing and fabrication industries, technology companies specialising in advanced manufacturing, and global craft and maker communities seeking to push the boundaries of what is traditionally achievable by hand.

A.8 KHORA

A.8.1 Craeft Design Studio UX/UI framework

Short description of the product: A reusable UX/UI framework and navigation flow for the Craeft Design Studio (dashboard → area selection → module selection → workspace), implemented in Unity and designed to host multiple craft simulation modules (Plaster turning, wood carving Simulations and Photo booth, all created by FORTH) and utilities under a consistent interface shell.

Description of the innovation: Rather than building each craft simulation as a stand-alone prototype, the Design Studio is structured as a modular environment with a shared user journey and a consistent workspace grammar (top bar plus tool panel and workflow/output panel). This supports cross-module consistency, reduces per-module UI redesign, and makes it easier for new craft capabilities to be integrated without reworking navigation, layout, or basic interaction patterns. The approach also supports iterative exploration by keeping persistence and output actions consistent across modules.

INNOVATION DIMENSIONS: Technical: reusable UI shell and routing enabling scalable module integration. Educational: consistent interaction patterns that support iterative learning and critique workflows. Organisational: reduces per-module UI redesign and integration overhead across partners.

A.8.2 ETH haptic controller integration evaluation scenarios

Short description of the product: Separated haptics entry point and test area with scenarios for spring-like tool handling (jacks/tweezers), aligned with ETH-confirmed controller modes and protected from main scenario interference.

Description of the innovation: A safe integration architecture and feasibility evaluation approach for experimental haptic hardware within a complex VR training application. Haptics are isolated to a dedicated track (separate lobby entry, isolated test space, and disabling non-haptic session functions) to prevent interaction conflicts and protect the main scenarios. Test scenarios map directly to confirmed device capabilities (Grabbing and Touch) and provide criteria tied to real workshop demands (precision grip, repeatable open/close tool behaviour, stable contact feedback, and alignment between visual and tactile cues). The resulting documentation captures both integration design and the scope conclusion on what additional R&D would be required for workshop-grade training.

INNOVATION DIMENSIONS: Technical R&D (integration architecture and interaction design); evaluation methodology (feasibility testing against craft-specific requirements); human factors/ergonomics insights for sustained tool handling.

A.8.3 Virtual reality glassblowing simulator

Short description of the product: Unity-based single-user and multi-user VR glass workshop prototype with a waiting room/lobby, two learning modes (Knowledge and Know-how), controller interaction mapping, zone-triggered media for process steps, and an isolated haptics test track.

Description of the innovation: An immersive VR training environment for glassblowing that separates contextual exploration (Knowledge) from procedural learning (Know-how) while keeping interactions consistent across the user journey. The prototype introduces a stable lobby for scenario selection and recovery, robust highlight/selection rules, and a pragmatic hybrid learning model in which the Glass making with a blowpipe is practised from the first step, discovering tools, gathering glass from the furnace, and shaping in the Block is practised hands-on, and subsequent steps are delivered as zone-triggered egocentric video. It is designed for iterative improvement, with documented constraints for all aspects of the prototype development.

INNOVATION DIMENSIONS: Educational innovation (mode-based learning design); technical innovation (interaction specification and Unity implementation patterns); cultural heritage and craft skills dissemination; multiplayer facilitation concept (teacher/student roles) for guided learning; iterative UX improvement methodology.

A.9 MDE

A.9.2 Glaze rendering tool

Short description of the product: The glaze rendering tool is an online module within the Craeft Design Studio that enables craft professionals working with clay to test different glazing parameters in a virtual environment. It allows users to explore how variations in mineral composition, firing temperature, cooling rate, and other subtle factors influence the final appearance of a glaze, all without the need for physical firing. Additionally, the tool supports knowledge exchange by enabling craft professionals to share glazing information, compare results, and learn from one another.

Description of the innovation: Traditionally, glazing represents one of the most unpredictable stages of ceramic creation. A glaze, a thin, glassy film, transforms a fired clay body with depth, luminosity, and subtle optical effects that arise from how light refracts, reflects, and scatters through its microscopic structures. Capturing this dual nature of glaze, at once artistic and material, is one of the most challenging tasks in digitisation. In craft practice, glaze behaves like a volume rather than a surface; its appearance is shaped by mineral composition, firing temperature, cooling rate, and countless small variations that are difficult to articulate, let alone simulate. The Craeft glaze rendering tool addresses this challenge by applying Physically Based Rendering (PBR) to model light as the craftsperson experiences it. Drawing on high-resolution surface scans and optical measurements, the system simulates how photons travel through the glaze, interact with the underlying clay, and create the unique glow that artisans recognise. This approach transcends conventional 3D digitisation, which often reduces glaze to a flat shine, not being like real life.

INNOVATION DIMENSIONS:

A.9.3 Community Portal

Short description of the product: The Community Portal is an online platform designed as a dynamic forum-like online space for the crafts sector. It enables registered users to post content, comment, share knowledge, and exchange ideas, fostering dialogue and collaboration across diverse craft communities and a wide range of topics.

Description of the innovation: Although emerging heritage-focused platforms such as the European Heritage Hub Social Forum exist, the topic of crafts is often overlooked. These types of heritage-related forums tend to focus primarily on built heritage and tangible assets, rather than intangible cultural heritage as crafts. The Craeft Community, however, is unique in that it bridges multiple disciplines around the common theme of crafts, ranging from academic research in social sciences to computer science, and practical tools such as GIS for craft products. This interdisciplinary approach offers a distinctive, comprehensive platform for knowledge exchange, collaboration, and innovation in the crafts sector, setting it apart from existing solutions.

INNOVATION DIMENSIONS:

A.10 PIOP

A.10.1 360 tour application

Short description of the product: An immersive 360° tour developed to document, communicate, and promote the ceramic heritage of Margarites, a traditional pottery village in Rethymno, Crete.

Description of the innovation: Unlike institution-centred museum applications, the Margarites case focuses on a living craft settlement, where multiple workshops coexist within a shared public space and where everyday production remains visible and active. The application, therefore, adopts a spatial and place-based perspective, aiming to represent not only individual craft environments but also their relationships within the village fabric, providing an accessible and high-quality environment for exploring real craft spaces.

INNOVATION DIMENSIONS: By enabling remote exploration through immersive 360° documentation, the experience supports both pre-visit discovery and post-visit reflection, while remaining accessible to diverse audiences.

A.10.2 Apprentice studio

Short description of the product: The Apprentice Studio is an advanced, immersive training platform designed to facilitate the learning and mastering of traditional crafts

Description of the innovation: It is part of a comprehensive ecosystem that includes the Craft Studio, which authors and exports lessons that are then imported and executed within the Apprentice Studio. This innovative application is geared towards providing apprentices with a personalised, interactive, and hands-on learning experience, utilising cutting-edge technology to replicate real-world crafting processes. It is based on a simplification of the represented crafts and techniques, and both will have a digital and a physical component.

INNOVATION DIMENSIONS: Innovation lies in the use of digital tools (e.g. immersive experiences, digital documentation, and mediated environments) as supports for learning-by-doing, enabling apprentices and learners to access complex or inaccessible craft processes. The approach reframes digital technologies as mediators of craft knowledge rather than substitutes for hands-on practice, enhancing understanding, contextualisation, and engagement.

A.10.3 Digital contextualisation

Short description of the product: Digital narratives linked to physical craft products to enhance meaning, learning, and emotional engagement.

Description of the innovation: Digital narratives are attached to physical craft products through QR codes, enabling visitors and customers to access layered multimedia content directly on their mobile devices. These narratives combine text, images, audio, and video to communicate the object's origin, making process, material qualities, and the craftsperson's perspective. By framing each object as a biographical artefact rather than a standalone commodity, the tool deepens understanding of craftsmanship, strengthens emotional attachment, and supports informal learning. The approach enhances the perceived cultural and experiential value of craft products while remaining non-intrusive within museum shops and exhibition contexts. It also allows institutions to update, reuse, and adapt narratives over time, ensuring long-term relevance and sustainability.

INNOVATION DIMENSIONS: Digital tools can support the valorisation of craft products in market contexts.

A.10.5 Mobile app

Short description of the product: An application which includes texts, images, and interactive learning material (connected through Craeft's e-learning platform)

Description of the innovation: The app provides structured educational content, including vocabulary, material preparation recipes, and technique principles. Users can explore high-resolution multimedia content, such as super-zoomable images and videos that explain complex historical contexts or specific manual techniques. The app provides access to craft-specific simulators (via the Apprentice Studio) that allow users to virtually practice actions, helping them understand "tacit knowledge" through digital reenactment. Beyond text, the app leverages Augmented Reality (AR), enabling 3D exploration from perspectives usually restricted in galleries. It features interactive quizzes and challenges that turn a passive visit into an active, educational adventure.

INNOVATION DIMENSIONS: The App documents and recovers lost techniques through simulations, supports informal learning and allows users to engage with craft heritage.