CRAEFT

care, judgment, dexterity

Innovation Management

Project Acronym	Craeft
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Executive summary

This report aims to provide a clear and structured approach to managing innovation within the CRAEFT project, ensuring that all partners are aligned and equipped to contribute effectively to the project's success.

The Innovation Management Plan outlines the strategies and processes to cultivate a dynamic environment for research, innovation, and knowledge transfer within the CRAEFT project. It utilises open innovation meetings held in conjunction with plenary sessions and monthly workshops to identify and develop strategies, products, services, and processes and ensure they materialise effectively.

The Innovation Manager, with support from the project Coordinator and WP Leads, sources input from all partners and relevant stakeholders to monitor end-user needs and the state-of-the-art products and services available in the market to ensure that the planned work is aligned and includes links to exploitation management strategies where relevant.

Key objectives of the Innovation Management Plan include generally defining innovation in the context of the CRAEFT project, outlining guiding principles and coordination of CRAEFT innovation activities and partner interactions, ensuring the quality of results, and assessing innovation potential for further exploitation.

Document history

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Abbreviations

AR	Augmented Reality
CNC	Computer Numerical Control
FabLabs	Fabrication Labs
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 a bold 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 CRAFT 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 Innovation Management Plan

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 in the project to ensure its understanding and principles for determining the innovation potential. The CRAEFT innovation management plan 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 of the project. 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 the project's 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 CRAEFT Innovation Management Plan 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

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 leads 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. 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 in the project.

2.2. Principles Guiding the Innovation Management Plan

For the CRAEFT project, 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. CRAEFT's Innovation Potential

CRAEFT is deeply 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:

- **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.

In CRAEFT, 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:** Utilizing 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 in CRAEFT 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, CRAEFT will look at existing business tools and strategies to:

- **Brainstorm and Quick Scan:** Utilize 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 CRAEFT's 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 in the project. Key tasks for overall assessment include:

- **Innovation Management Plan Submission**: The first version of the CRAEFT Innovation Management Plan 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.
- **Consortium 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.
- **Consortium Meetings**: A portion of selected Plenary Meetings will be dedicated to analysing the Innovation Management process and feed 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:

- **Innovation Management Plan 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 Innovation Management Plan 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 CRAEFT from all project participants. This information will be compiled in parallel with selected Consortium 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 the case of CRAEFT, they represent the boundaries of the project's consortium.
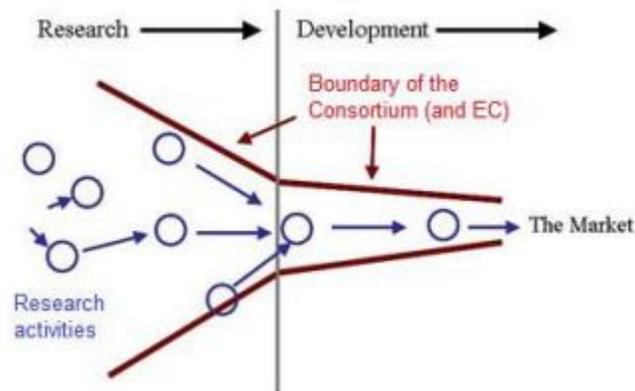
Innovation Funnel (Modified from [7]).

5.3. Innovation Radar

The Innovation Radar initiative by the European Commission is designed to support innovators by recommending targeted actions that help them realise their market potential. This initiative encompasses several key activities:

- **Assessing Innovation Maturity**: Evaluating the maturity of innovations developed within projects and identifying high-potential innovators and innovations.
- **Providing Guidance**: Offering advice throughout the project 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.

In the context of CRAEFT, we will leverage the Innovation Radar's structured questionnaire to conduct an internal qualitative evaluation of the potential innovations developed within the project by the end of its lifetime. This approach ensures that market potential and innovation readiness, among the strongest dimensions of ICT innovations, are thoroughly assessed. By focusing on these areas, CRAEFT aims to

identify and nurture high-potential innovations while addressing areas where innovation can be improved.

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

5.4. Building Bridges with EC and Other Horizon Projects

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 innovative results and rationale

This section connects the innovation management procedure with the exploitation planning and the exploitable outcomes of the project. To this end, we present each of the identified, preliminary, exploitable outcomes of the project 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.

6.1. WP1 - Understanding and digitalisation

Developing an ethnographic method tailored to the project's 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 contextualizes gesture recognition data from the crafts practitioner's perspective.

Justification for Innovation in the Context of Innovation Management:

Implementation of an Inclusive Protocol for Craft Understanding

- **Need:** Traditional methods of craft understanding often overlook the expertise and perspectives of craftspeople.
- **Innovation Management 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 contextualize 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.
- **Innovation Management 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 standardized data for effective comparison and analysis.
- **Innovation Management Rationale:** The protocol standardizes data collection, enabling the generation of comparable datasets across different craft instances. This standardization 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:** For the project to be widely applicable, the protocol must be replicable and adaptable to various contexts.
- **Innovation Management 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.
- **Innovation Management Rationale:** Applying the protocol in educational institutions and museums promotes skill transmission to future generations. By using standardized data collection for craft representation, the project 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.

6.2. WP2 - Craft representation

6.2.1. Archetypal action simulators

Archetypal Action Simulators are essential for the project's goals, focusing on Action and Affordance Modelling by digitizing 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.

Justification for Innovation in the Context of Innovation Management:

Enhanced Understanding through Simulation

- **Need:** Traditional crafting processes rely heavily on tacit knowledge and experiential learning, which can be slow and imprecise.

- **Innovation Management Rationale:** Archetypal Action Simulators provide a structured, analytical approach to understanding crafting processes. By offering a dynamic platform to simulate and visualize 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.
- **Innovation Management 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 optimizing 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.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management Rationale:** By digitizing 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.
- **Innovation Management 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.
- **Innovation Management 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, maximizing its impact and supporting innovation management objectives of scalability and broad application.

6.2.2. 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.

Justification for Innovation in the Context of Innovation Management:

Enhanced Understanding of Crafting Processes

- **Need:** Detailed insight into the dynamic interaction between makers and materials is essential for advancing craft knowledge.
- **Innovation Management 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.
- **Innovation Management 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.**
- **Innovation Management 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 optimizing crafting workflows.

Facilitation of Action Plans and Hypotheses

- **Need:** Structured frameworks are necessary for planning and exploring crafting activities systematically.
- **Innovation Management 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 organized and efficient practice.

Adaptability and Flexibility

- **Need:** Crafting involves diverse scenarios and materials, requiring adaptable systems.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management 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 and facilitating seamless interactions between the crafted model and computational tools.

6.2.3. CRAEFT Authoring Platform

The Craft Authoring Platform (CAP) extends the Craft Ontology (CrO) and enhances the Craft Authoring process, building on the Craeft 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.

Justification for Innovation in the Context of Innovation Management

Holistic Craft Authoring Experience

- **Need:** A comprehensive and nuanced representation of crafting activities is essential for a deeper understanding of the craft domain.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management Rationale:** CAP integrates seamlessly with MOP, ensuring background compatibility with Craeft 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.
- **Innovation Management 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 optimizing workflows and user empowerment.

CIDOC-CRM and EDM Compatibility

- **Need:** Compatibility with widely accepted standards is essential for broader dissemination and collaboration.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management 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.

6.3. WP3 - Digital reenactment

6.3.1. 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 customization. They integrate insights from scene understanding methods for enhanced 3D visualization of challenging materials, showcasing intricate crafting processes. The simulators generate realistic 3D previews, aiding practitioners in understanding and decision-making in crafting workflows.

Justification for Innovation in the Context of Innovation Management

Customization through Craft-Specific Simulations

- **Need:** High customization is essential for accurately representing diverse crafting processes.
- **Innovation Management Rationale:** Utilizing GANs to refine archetypal simulators into craft-specific ones introduces significant customization. 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 personalized and effective tools.

Integration of Generative AI in Crafting Workflows

- **Need:** Modernizing 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 modernizing 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.
- **Innovation Management 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.
- **Innovation Management 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 Visualization

- **Need:** Realistic and detailed visualization is key for understanding complex crafting processes.
- **Innovation Management Rationale:** Emphasizing the visualization of challenging materials in 3D enhances simulation realism. Practitioners can better visualize 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.
- **Innovation Management 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 Semantic Web and Europeana

- **Need:** Ensuring compatibility with modern standards enhances accessibility and knowledge dissemination.
- **Innovation Management Rationale:** Encoding simulations in CIDOC-CRM and EDM ensures compatibility with 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.
- **Innovation Management 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.

6.3.2. 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 visualizes material deformations, aiding in understanding material responses to various crafting actions.

Justification for Innovation in the Context of Innovation Management

Context-Aware Modelling

- **Need:** Accurate simulation of intricate crafting actions requires understanding the specific context of each action.
- **Innovation Management Rationale:** Emphasizing 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.
- **Innovation Management 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.
- **Innovation Management Rationale:** Utilizing 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 visualize 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.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management 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 utilization.

Integration with Scene Understanding

- **Need:** Incorporating real-world motion data enhances the realism and accuracy of simulations.
- **Innovation Management 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.
- **Innovation Management Rationale:** The product's ability to adaptively "playback" material deformations provides a dynamic user experience. This innovation allows practitioners to visualize, 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.

6.3.3. High-resolution 2D and 2½D surface scanning

The High-Resolution Scanner is an advanced tool for digitizing 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.

Justification for Innovation in the Context of Innovation Management

High Resolution

- **Need:** Capturing minute details and textures of heritage objects is crucial for accurate digital representation.
- **Innovation Management Rationale:** The scanner's resolution, surpassing 1 gigapixel per square centimetre, marks a significant advancement in heritage object digitization. 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 digitized images enhances the realism and comprehensiveness of digital representations.
- **Innovation Management Rationale:** Introducing 2½D scanning through photogrammetry represents a breakthrough in digitization 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.

● **Innovation Management 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.
● **Innovation Management 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.
● **Innovation Management 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.
● **Innovation Management 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 digitized images.
● **Innovation Management 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 artifacts enhances cultural appreciation.
- **Innovation Management 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 artifacts in a sensory and educational manner, supporting innovation management's objective of enriching cultural understanding and appreciation through advanced technological solutions.

6.3.4. Digitisation of transparent, translucent, and shiny materials

The initiative to digitize transparent, translucent, and shiny materials employs innovative, non-contact 3D reconstruction methods using polarized 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 visualizations of materials with complex optical properties.

Justification for Innovation in the Context of Innovation Management

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.
- **Innovation Management Rationale:** The specialized scanner addresses the inherent optical complexity of transparent objects, providing a tailored solution. This innovation ensures accurate digitization of materials with complex optical properties, aligning with innovation management's goal of developing specialized 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.
- **Innovation Management Rationale:** The scanner's ability to preserve and accurately digitize 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.
- **Innovation Management Rationale:** The incorporation of polarized and structured illumination techniques mitigates glare and reflections, ensuring accurate capture of surface features. This innovation addresses a common challenge in digitizing reflective materials, aligning with innovation management's objective of improving scanning accuracy and reliability.

Expanded Applications in Diverse Industries

- **Need:** Accurate digitization of transparent and semi-transparent materials is beneficial for various industries, including architecture, design, manufacturing, and art.
- **Innovation Management Rationale:** The scanner's versatility opens new possibilities for digitizing 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.
- **Innovation Management 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 Previous Transparent3D Project

- **Need:** Building on the outcomes of the Transparent3D project ensures that past insights inform current technological advancements.
- **Innovation Management 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 specialized scanner, supporting innovation management's emphasis on continuous improvement and learning from previous projects

Advancements in Material Visualization

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

Industry and Research Collaboration

- **Need:** Collaboration between industries and research institutions is essential for developing technologies that meet evolving sector needs.
- **Innovation Management Rationale:** The development of the specialized 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.

6.3.5. Scene and activity monitoring

The Scene and Activity Monitoring initiative for the CRAEFT partners captures and analyzes 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.

Justification for Innovation in the Context of Innovation Management

Complexity of Crafting Activities

- **Need:** Crafting involves intricate actions requiring manual dexterity, material manipulation, and creative decision-making.
- **Innovation Management 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 detailed and accurate monitoring essential for improving craft techniques.

Holistic Scene Understanding

- **Need:** Accurate and insightful analysis of the crafting environment requires recognizing nuanced interactions between practitioners, materials, and tools.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management 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 personalized insights to support dynamic skill development.
- **Innovation Management 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.

6.4. WP4 - Education and training

6.4.1. Craft Studio

The Craft Studio is an advanced authoring environment that revolutionizes 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 visualize and interact with crafted objects in an immersive setting, utilizing digitizations and action simulators for designing customized simulations. It adapts to user-selected variables, providing a personalized experience and supports various visualization devices. Additionally, it offers metrics on material and energy usage to promote efficient workflows.

Justification for Innovation in the Context of Innovation Management

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.
- **Innovation Management Rationale:** Craft Studio leverages a game engine rendering pipeline to create highly realistic 3D simulations. This innovation aligns with the goal of providing 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.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management Rationale:** Crafters can leverage digitisations and action simulators to design simulations intuitively. This user-friendly approach promotes accessibility and creativity, ensuring that even novice users can design and customize their simulation experiences effectively.

Dynamic Instantiation for Simulations

- **Need:** Ensure simulations accurately reflect user-selected variables for a personalized crafting environment.

- **Innovation Management Rationale:** During simulation execution, Craft Studio dynamically instantiates schema components based on selected variables. This adaptability ensures that simulations are personalized and realistic, aligning with innovation management's goal of creating user-centric and responsive tools.

Flexible Bindings to Visualization and Interaction Devices

- **Need:** Cater to diverse user preferences for visualization and interaction.
- **Innovation Management Rationale:** The tool supports various visualization 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.
- **Innovation Management 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.

6.4.2. 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.

Justification for Innovation in the Context of Innovation Management

Personalized Learning Approach

- **Need:** Traditional education often fails to address individual differences in learning styles and progress.
- **Innovation Management Rationale:** The Apprentice Studio innovates by offering a personalized 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 individualized training solutions.

Integration of Diverse Learning Modalities

- **Need:** Diverse learners benefit from different methods and formats of instruction.

● **Innovation Management 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.
● **Innovation Management 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 personalized guidance, aligning with innovation management's objective of optimizing learning outcomes through adaptive technologies.

Creative Problem-Solving Dimension

● **Need:** Traditional training methods often focus on theoretical knowledge without practical application.
● **Innovation Management 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 contextualizing knowledge within historical and cultural frameworks.
● **Innovation Management 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.

6.4.3. 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, emphasizing 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.

Justification for Innovation in the Context of Innovation Management

Realistic Tactile Simulation

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

6.4.4. 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.

Justification for Innovation in the Context of Innovation Management

Simplified Learning Approach

- **Need:** Traditional crafting techniques can be complex and daunting for beginners.
- **Innovation Management Rationale:** By distilling these techniques into simplified, engaging formats through games and toys, the project makes 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.
- **Innovation Management Rationale:** The use of games and toys leverages the motivational power of play. By integrating playful elements into the learning process, the project encourages 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.
- **Innovation Management 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 organized educational tools.

Accessible Digital Platforms

- **Need:** Broad access to educational resources enhances learning opportunities.
- **Innovation Management Rationale:** Making digital games available online for both desktop and mobile devices ensures widespread accessibility. By leveraging the ubiquity of digital platforms, the project maximizes 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 deeper understanding.
- **Innovation Management 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.
- **Innovation Management Rationale:** The range of difficulty levels and adaptable instructions in both the digital and physical components ensures inclusivity. By accommodating various skill levels, the project promotes widespread participation and supports innovation management's goal of creating versatile and inclusive educational solutions.

Eco-Friendly Design

- **Need:** Sustainability is increasingly important in product design and manufacturing.
- **Innovation Management 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 maximize effectiveness.
- **Innovation Management 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.

6.5. WP5 – Design

6.5.1. 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.

Justification for Innovation in the Context of Innovation Management

Efficiency and Cost Reduction

- **Need:** Traditional design processes can be costly and time-consuming due to extensive physical experimentation.
- **Innovation Management Rationale:** The Design Studio's simulation environment minimizes 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 optimize resources and streamline workflows.

Craft-Specific Precision

- **Need:** Crafting techniques often require specialized tools for precision and accuracy.
- **Innovation Management 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 customized designs, supporting innovation management's focus on specialized, high-quality design solutions.

Tactile Engagement for Enhanced Design Experience

- **Need:** A deeper connection with digital creations can improve the design experience.
- **Innovation Management 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.
- **Innovation Management Rationale:** The Design Studio's integration of CAD tools provides a comprehensive toolkit for conceptualization 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.

- **Innovation Management 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 realization 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.
- **Innovation Management Rationale:** The provision of realistic artefact previews in virtual and mixed-reality environments allows designers to visualize 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.

6.5.2. 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.

Justification for Innovation in the Context of Innovation Management

Holistic Technological Analysis

- **Need:** Understanding and integrating a diverse range of manufacturing technologies is crucial for relevance and adaptability.
- **Innovation Management 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.
- **Innovation Management Rationale:** Engaging craft training organizations 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.

- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management Rationale:** The suite emphasizes 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.

6.5.3. 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.

Justification for Innovation in the Context of Innovation Management

Facilitating Creative Exchange

- **Need:** A centralized platform for diverse stakeholders to share ideas and techniques.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management Rationale:** The portal empowers individual craftsmen and micro-businesses by offering tools for product valorisation, online sales, and brand-building. This centralized 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.
- **Innovation Management 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.
- **Innovation Management 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.
- **Innovation Management 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.

7. Conclusion

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

Recognising the importance of integrating business models and process innovations, CRAEFT has defined an innovation management plan and strategy from the project'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 CRAEFT 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, CRAEFT aims 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 CRAEFT has chosen. It serves as a guide for consortium members and will be updated to adapt to the evolving needs and phases of the project. The Innovation Management Plan is thus considered a living document, ensuring that CRAEFT remains 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 years to come.

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