FORGING

INDUSTRY-ACADEMIA FORUM
TO UNCOVER THE POTENTIAL OF
EMERGING ENABLING TECHNOLOGIES

CO-CREATION WORKSHOP PRELIMINARY RESULTS

Novel Enabling Technologies for a Sustainable Future: Human-centric Solutions & Human-machine Interaction

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Use-case: SEAMLESS (**S**ocial, **E**nvironment, **A**daptative, **M**utiple modalities **L**ow-x **E**rgonomics for **S**afety and **S**ustainability)

Facilitators: Marina Dias (INL), Marta Martorell Camps (i2CAT)

Human diversity was central to the group's discussions, focusing on manufacturing lines where human involvement is crucial due to technological challenges in adapting to various sensitivities needed for handling different components and product state uncertainties. The group identified seamless human-machine collaboration as a key issue, stemming from the low cost of human labour, the lengthy time robots require for precise assembly, and the monotony of repetitive, low-cognition tasks. The group proposes a shift to a seamless human-machine operations model, emphasizing ergonomic support and enhancing worker environments. This approach involves 'user-friendly learning and teaching factories,' where robots, acting as personal twins, are trained through human interaction. This setup aims for operations that are more dynamic and comfortable, with humans retaining ultimate decision-making authority.

The main issue addressed by the group is optimizing processes that cannot be fully automated, particularly in assembling and disassembling flexible, high-dexterity components. The proposed solution involves a personal digital twin that integrates adaptive, learning robotics. This solution will merge various technologies including Natural Language Processing to simplify process awareness, personal digital twins for worker recognition and diversity, e-skin sensors to enhance robot dexterity, and haptics and computer vision for improved interaction. The focus is putting workers at the centre of the solution, with leaders and decision-makers playing a crucial role in adopting these technologies. Key participants will include mechanical and electronic engineers, and AI experts, with essential support from financial sources, research and innovation, and training programs for worker upskilling and reskilling. Challenges such as worker acceptance, the low readiness level of technologies, the need for new standards, and GDPR compliance are identified as major obstacles to implementing personalized production lines that maintain a motivated, safe, and inclusive workforce while potentially increasing company profits.

The final use case co-created by the group, named SEAMLESS: Social, Environmental, Adaptive, Multi-modal, Low-x Ergonomics for Safety and Sustainability. Its primary aim is to automate processes that are difficult to mechanize, to reduce production costs, simplify complexity, and enhance worker motivation and well-being. The proposed solution centres on seamless human-robot collaboration in manufacturing processes. Key technologies include digital twins to maintain machine context awareness on the shop floor and natural language processing to reduce complexity. This technology suite will be integrated directly into production lines where humans and machines collaborate. Full technology adoption could take 5 to 10 years, depending on R&I investment, though some group members anticipate up to 20 years, considering social factors. The target groups includes production workers and the broader manufacturing sector. Expected benefits include improved workforce skills, increased worker engagement, and fewer product defects. Long-term, the group foresees reductions in healthcare costs and shifts in labour division. This solution aims to contribute to several Sustainable Development Goals (SDGs), specifically numbers 3, 8, 9, and 12.

Group 2: Davide De Tommaso, Jordi Picas, Luca Carbonari, Patrizio Pelliccione, Pol Torrent Torros, Sophie Rutter, Xinyi Tu

Use-case: TECHCARE

Facilitators: Brigita Jurisic (INL), Viviana Perez Clausen (i2CAT)

The primary issue targeted is the well-being and decision-making support for caregivers and care receivers in high-stress and critical situations, particularly in the context of elder care and care workers. Specific needs include addressing loneliness, ensuring individuals feel "safe" and "acknowledged," and managing workload stress for caregivers. Challenges like cybersecurity, privacy concerns, and the inclusion of ethical considerations are also highlighted.

The proposed solution involves developing a robust infrastructure that collects and analyses information about the care environment in real-time. This infrastructure supports decision-making protocols tailored for critical and stressful scenarios, enabling care to be delivered efficiently and empathetically.

The target groups and stakeholders are care workers and caregivers (to enhance their workload management and reduce stress); elderly individuals: To improve their sense of safety, connection, and well-being); families of care receivers (to mitigate family conflicts and improve engagement with care processes); and broader stakeholders that includes hospitals, residential care facilities, and home care providers.

Key Technologies we want to use to solve the challenge:

- Digital Twins: For knowledge representation and modeling of real-life care environments, enabling predictive insights.
- Artificial Intelligence (AI): To analyze data and provide actionable recommendations.
- Internet of Things (IoT): To collect real-time data on care environments and the state of care receivers and caregivers.

We expect to have impact in these fields:

- Social: Improved decision-making, better well-being of caregivers and care receivers, and conflict resolution within families.
- Environmental: Optimized resource utilization and reduced energy use.
- Technological: Enhanced privacy controls and cybersecurity measures.

This use case demonstrates the potential of integrating innovative technologies with a human-centric approach to meet the demands of Industry 5.0 while addressing the ethical and societal aspects of caregiving.

Group 3: Alexandru Roja, Ana Martins, Carlos Molina, Ensieh Iranmehr, Fabio Della Valle, Henrikki Salo-Pöntinen, Roberto Venditti

Use-case: You'll Never Fly Alone

Facilitator: Francesca Foliti (APRE)

The initial input for this group discussion came from a participant working in the aviation sector, who highlighted some issues related to operational communication processes in safety-critical environments such as aircrafts and healthcare facilities. A debate followed about several problems that may arise in such environments. More specifically, participants mentioned difficulties in protocol implementation (with special regards to checklists), in communication processes between system operators, in maintaining good situational awareness, and in operational scaling when it comes to balancing efficiency and safety. These difficulties are caused by a variety of factors, for instance noisy environments, different dialects or accents, and disturbed or interfered signals. As a result, a series of negative effects are produced, from operational inefficiency to unexpected and potentially dangerous events (e.g., accidents).

The group embraced an approach based on human-machine teaming design that could help address the identified difficulties and develop a solution enhancing safety, reducing unexpected events, and refining human-machine interaction mechanisms in safety-intensive contexts. The discussion was then narrowed down to the specific context of aircrafts, entailing all phases of the aircraft journey – from pre-flight to landing. However, the proposed solution has potential to be adaptable to other environments as well (e.g., hospitals).

The final use-case co-created by the group was titled *You'll Never Fly Alone*, as it consists of a multisensorial, NLP-powered intelligent support system to enhance operational communication and refine human-machine-human interaction. The system represents a valid assistance tool for pilots in the implementation of protocols and for the purposes of situational awareness (both collective and within the cockpit). It uses different state-of-the-art sensors, collects data with Internet of Things, uses signal processing and Machine Learning techniques, and relies on large language models and Natural Language Processing to improve communication and summarize conditions.

Although the proposed solution may negatively impact the environment (due to the ecological footprint of LLM's production and usage) and increase cybersecurity risks, it may also be beneficial from a social perspective, as a better situational awareness would be a boost for better decision-making and for new safety standard, and it would ultimately increase the overall safety in the aviation sector (even by a very small percentage). Additional downsides mentioned are the possible reduction in human-human interaction and in employment rates, while an environmental advantage would be the decrease of waste and e-waste thanks to predictive maintenance systems.

Group 4: Alessandro Mengarelli, Ana Ribeiro, Elisa Prati, Gilberto Burgio, Greg Agriopoulos, Jose Arco Martín de Rosales, Pol Aixas Martinez

Use-case: AIMS (**A**ircraft **I**ntelligent **M**aintenance **S**ystem)

Facilitator: Livia Di Bernardini (APRE)

The group chose to focus on aviation, identifying the aircraft maintenance process as a critical issue, particularly due to its high level of complexity. Key causes include the low level of automation in procedures, limited adoption of solutions despite strict regulations, and inadequate design specifications. The most evident consequences are the high cost of maintenance, operator stress, lengthy operations, and resulting delays in aircraft operations.

The group aims at reducing the complexity of the sector. To achieve this goal, identified needs include training and education for personnel, improved operator safety, greater adoption of technology, enhanced infrastructure, better design specifications, and timelier implementation of regulations. Expected outcomes include improved working conditions for operators (resulting in a lower risk of accidents), reduced downtime, lower maintenance costs, and faster, more efficient processes.

As the discussion progressed, the group recognized that the complexity of the maintenance process is actually a symptom of a broader issue: limited efficiency. The proposed solution seeks to enhance operational safety, improve working conditions for operators by reducing risks of failures and unexpected issues, and generally increase the efficiency of the process, making it smarter and more streamlined. The technologies identified as most suitable to address these needs are a combination of IoT systems and Digital Twins. IoT would facilitate data collection, while Digital Twins would enable predictive maintenance. Specifically, the group envisions an aircraft scanning system capable of promptly assessing the aircraft's health and identifying the maintenance tasks to be performed.

Key stakeholders affected by the problem and thus integral to the solution include aviation authorities, airport operators, airlines, and their boards of directors/management teams. Essential resources for implementing the solution include hardware and software components, technical equipment (such as the scanning device), technical experts, trainers, and an updated regulatory framework. Potential limitations or obstacles to the solution include low investment levels, the cost of technical equipment, and resistance from airlines and operators to adopt new technologies.

In conclusion, the group proposes AIMS - Aircraft Intelligent Maintenance System as an intelligent check-and-maintenance system designed to enhance the efficiency of maintenance processes. The system integrates IoT and Digital Twin technologies, includes robust data security measures, and is intended as a tool to support operators, who remain in control of its operation.

The anticipated benefits include greater reliability of the maintenance process, easier task management for operators (resulting in reduced stress), and improved flight scheduling. From an environmental perspective, the system is expected to promote greater reuse of components, prevent unnecessary replacements, and reduce waste overall. Expected impacts include changes in workers' conditions, improved safety for both operators and passengers, and shorter wait times for takeoff. Considerations must also include the energy consumption associated with implementing these new technologies and a potential increase in the overall number of flights.