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CORDIS Results Pack on

human-centric manufacturing

A thematic collection of innovative EU-funded research results

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How new approaches to technology design can transform European industry

Research and Innovation

Contents

Editorial

How new approaches to technology design can transform European industry

Industry 5.0 offers a transformative vision for Europe in the 21st century, putting forward a view of a resilient, sustainable and human-centric approach. This Results Pack features 10 EU-funded projects tackling key elements for the transition towards human-centric manufacturing. Through customisation of manufacturing processes, production-on-demand, artificial intelligence and enhanced human-robot collaboration, this work paves the way for a system that places core human needs and interests at the heart of industry.

From the Model T to the iPhone, mass production defined the 20th century. The economic benefits of scale, standardisation and the assembly line made products affordable and available. But industrial manufacturing also brought its own challenges: inflexible production, a one-size-fits-all consumer model, and workers too often tasked with repetitive, low-skilled and low-paid work.

In its Industry 5.0 concept, the European Commission offers a replacement: an approach that yields advantages for industry, workers, and society at large. It empowers workers, addressing their evolving skills and training requirements. It enhances industry competitiveness and facilitates the attraction of top talent. And it promotes circular production models and technologies that enhance the efficiency of natural resource utilisation. By revising existing value chains and energy-intensive consumption practices, industries can also enhance their resilience against external shocks.

Through Horizon 2020 and its successor Horizon Europe, the EU funds groundbreaking research to support the transition from traditional structured factory floors to open environments with smart systems, where humans are central to the production process chains and can closely collaborate with robots.

Collaborative technologies, including human-robot collaborations with artificial intelligence (AI) and customer-driven manufacturing, represent an important step towards complementing human capabilities. These have great potential in the European manufacturing industry, playing a significant role in the transition towards Industry 5.0.

People-centred technology

EU-funded research aims to secure effective industrial human-robot collaboration through novel human-centred design and smart mechatronic systems. This includes soft robotics, advanced machines capable of handling complex materials in industrial production environments, and novel AI technologies that enable new levels of autonomy, navigation, and cognitive perception by factory robots.

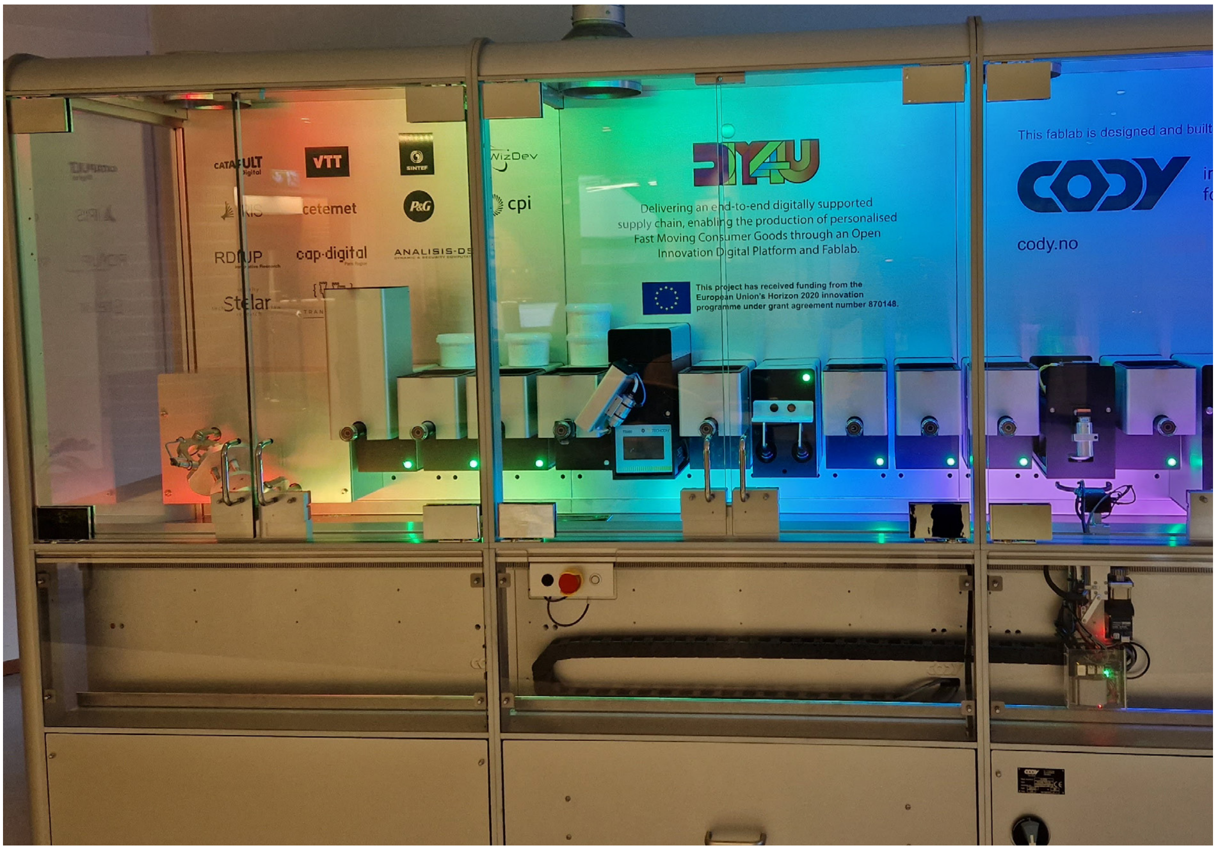
Collaborating with customers to better understand their needs also represents an important step towards a more resilient and sustainable European industry. Research supporting customer-driven manufacturing can lead to more efficient and productive manufacturing processes via innovative instruments such as collaborative Manufacturing Demonstration Facilities.

Advanced AI systems, customer-integrated manufacturing, and collaborative robotics are all technological challenges implemented by the Horizon 2020 European Factories of the Future, a EUR 1.15 billion public-private partnership for advanced manufacturing research and innovation. The partnership continues under Horizon Europe, as Made in Europe (MiE).

The projects featured in this Result Pack highlight examples of human-robot collaboration and customer-driven manufacturing that are already giving rise to safer and more skilled roles for those working in manufacturing, better economics for the industry, and a production tailored to the needs of citizens in the 21st century.

New tools to meet consumers' laundry list of demands

Combining a user-focused digital platform with modular manufacturing facilities, the EU-funded DIY4U project allows consumers to formulate their own detergent products and more.



Demand is constantly evolving for Fast-Moving Consumer Goods (FMCGs) such as food items, personal care products and clothing. Most notably, there is growing desire for customised products that address special needs and requirements.

"In the project DIY4U (Open Innovation Digital Platform and Fablabs for Collaborative Design and Production of personalised/customised FMCG), we focused on detergents – both powder-based and liquid-based – as one of the main FMCG products on the market," explains project coordinator Chandana Ratnayake from SINTEF in Norway.

Detergents are typically mass-produced, and can be difficult to formulate. Manufacturers must balance these constraints with increasing consumer demand for products that deliver specific health and wellness benefits, address sustainability and environmental concerns, and take into account allergies.

To remain competitive, manufacturers must also identify and respond quickly to changing tastes and demands, and deliver products quickly to meet these specific expectations.

Digitally enabled collaborative manufacturing

The DIY4U project addressed this manufacturing need through the use of open innovation, and the promotion of small-scale, digitally enabled collaborative manufacturing approaches.

The project team set out to build a platform where consumers could design and formulate a personalised soap or washing powder. The platform is connected to two modular, fully automated, small-scale Manufacturing Demonstration Facilities, which can produce liquid- or powder-based detergents on request.

The end result of this personalised approach is increased customer satisfaction, market differentiation and potentially higher price premiums.

"A key innovation is that both the digital platform and the hardware units are modular, which means that the concept can be adopted for other types of products and services," says Ratnayake.

The project concept was made available to SMEs through open innovation competitions. Non-consortium partners played an important role in identifying ways of fine-tuning the digital platform and providing input into market analyses and feasibility studies.

Delivering customised, personalised product design

The DIY4U project successfully demonstrated how its concept can enable manufacturers to deliver customised, personalised products quickly and efficiently. The model offers a way for brands to be receptive to individual consumer demands.

"The end result of this personalised approach is increased customer satisfaction, market differentiation and potentially higher price premiums," adds Ratnayake. "This concept could also lead to data-driven insights and improved inventory management, as the most popular ingredients can be prioritised."

Engaging non-consortium SMEs also raised market awareness of the concept, which could help with eventual market acceptance. There is also scope for expanding the DIY4U innovation to other markets such as cosmetics, food and beverages, and pet foods.

Applications in other industrial sectors

The success of the project has helped to bring the DIY4U concept closer to market.

"We recognised that further research and innovation is required to fully adapt the concept to different market sectors," notes Ratnayake. "Our plan now is to pursue new funding and support, in order to engage with end users and stakeholders, and to trial applications in specific industrial sectors."

The successes of the DIY4U project will be built upon to create an advanced system that enables FMCG product design and manufacturing to fully meet the needs of the end user.

PROJECT
DIY4U – Open Innovation Digital Platform and Fablabs for Collaborative Design and Production of personalised/customised FMCG

COORDINATED BY
SINTEF in Norway

FUNDED UNDER
Horizon 2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/870148

PROJECT WEBSITE
sintef.no/projectweb/diy4u

Some assembly required: providing tools for bespoke furniture design

A seamless digital platform from the EU-funded INEDIT project facilitates the design and manufacture of on-demand personalised furniture, heralding a new era in sustainable co-creation.

© Rithor/stock.adobe.com

European consumers increasingly look for personalised products that meet their individual needs.

This is a challenge for traditional manufacturers which rely on the scale and economics of centralised mass production. For a while, the decentralised do-it-yourself model met this need. Small companies or individuals crowdsourced design ideas, exploited low-cost design and manufacturing tools, and outsourced capital-intensive manufacturing and distribution.

Recently, the 'do-it-together' (DIT) design philosophy has attempted to marry these two approaches. The EU-funded INEDIT (open INnovation Ecosystems for Do It Together process) project sought to develop a DIT process adapted to the furniture industry, and to demonstrate this in real-life test cases.

"Open online communities that involve people with different skills and expertise have evolved," explains project coordinator Benjamin Poussard from ENSAM in France. "These forms of social collaboration have been facilitated by social media, which enables people to communicate and share ideas."

Co-creation and open manufacturing

However, co-creating a piece of furniture – from concept to manufacture – requires a deep understanding of the context, needs and constraints of what consumers are demanding, as well as necessary skills.

"This is a key challenge for the furniture industry," says Poussard. "How do we connect people, and what technologies and processes are needed? And how can we provide simple processes for local manufacturers to produce bespoke furniture, on demand and at a reasonable cost?"

We set out to demonstrate how we can produce products in innovative ways.

The INEDIT project set out to address these issues. It identified a key need to ensure the continuity of digital information, from the original idea to the manufactured product, in order that the data can be used at different stages of the process. This means, for example, being able to generate files that can be read by furniture manufacturing machines, as well as designs in PDF documents for craftspeople.

To facilitate collaboration on furniture design, the project team developed the DesignTogether platform. This includes a website, mobile app, immersive virtual reality app and other interactive and immersive technologies developed by project partners.

Next, the project sought to demonstrate the feasibility of the DIT process in four manufacturing use cases. These included: recycling and 3D-printing plastic; 3D-printing bespoke wood products; adding smart functions to furniture; and new innovations in computer numerical control (CNC) woodworking machines.

"The co-creation part of the project focused on how people meet, collaborate and use the digital platform to create design data," remarks Poussard. "In the open manufacturing phase, we set out to demonstrate how we can produce products in innovative ways."

In the CNC woodworking use case for example, a key aim was to demonstrate how technological solutions could help workers with on-demand production. Bespoke furniture requires changing the settings of the machinery every time; the integrated solution assists the operator in preparing the machine for this.

A viable do-it-together process

The project's technology partners have already been able to market some of their solutions – such as a 3D scanning module – as stand-alone products. Still, more work needs to be done before the DIT process is fully market-ready.

"These co-creation technologies need to be made widely available at home or in identified innovation spaces, and they need to be simple to use," notes Poussard. "Some technologies – such as 3D wood printing – still require further research to achieve market-ready results."

Nonetheless, the hope is that INEDIT will help to reduce wasteful mass production and promote personalised manufacturing in furniture and beyond. "For manufacturers, this process offers a new way of collaborating with customers for bespoke on-demand furniture," says Poussard.

PROJECT
INEDIT – open INnovation Ecosystems for Do It Together process

COORDINATED BY
ENSAM in France

FUNDED UNDER
Horizon 2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/869952

PROJECT WEBSITE
inedit-project.eu

A secure platform to foster co-creation in manufacturing

iPRODUCE's social manufacturing platform successfully integrates digital and human approaches to open innovation, creating new opportunities for user-led product development.

The idea of democratising innovation is increasingly popular in industrial settings. By involving a variety of stakeholders and end users in production processes, manufacturers create more commercially successful, targeted solutions. Products developed through such collaborations could be more impactful for citizens, and more useful for businesses and industry.

However, such co-creation often requires sensitive information to be shared, and issues such as health and safety and a lack of knowledge of using digital technologies securely have limited the extent to which end users have been able to provide useful input.

Uniting manufacturers and consumers

To address these challenges, the project iPRODUCE (A Social Manufacturing Framework for Streamlined Multi-stakeholder Open Innovation Missions in Consumer Goods Sectors) set out to bring manufacturers and consumers together at the local level. To do this, the project team developed an open digital platform, supported by custom-built tools, to facilitate interaction and cooperation in a safe and secure environment.

The end result is an open digital space, with a set of innovative tools that can facilitate co-creation.

This digital platform, called OpIS, was deployed in collaborative Manufacturing Demonstration Facilities (cMDFs) in Denmark, France, Germany, Greece, Italy and Spain. Each cMDF represented a specific industrial sector, including furniture, automotive, medical, electronics and microelectronics.

These cMDF ecosystems were made up of SME associations, manufacturing and specialist SMEs, as well as fablabs (small-scale digital fabrication workshops), makerspaces (a collaborative high-tech space for making, learning and sharing) and other stakeholders.

"In addition to the platform, we provided users with a set of tools to enable them to apply co-creation methodologies," explains project coordinator Manuel Sánchez from AIDIMME in Spain. "These included an augmented and virtual reality toolkit, to facilitate collaboration and shared awareness during the product design phase."

Other tools included a cMDF training platform, a data analytics and visualisation suite, and a video intelligence tool. This allows users to collect sets of videos for automatic analysis, transcription and exchange among multiple remote users.

Successful social manufacturing network

Positive experiences demonstrated how a social manufacturing framework such as OpIS can effectively integrate both digital and human/social approaches to open innovation.

The platform enabled SMEs, maker communities and consumers to tap into collective knowledge, gaining insights and support for manufacturing processes. In the Italian cMDF, participants developed an IoT-enabled irrigation system for houseplants.

"The end result is an open digital space, with a set of innovative tools that can facilitate co-creation," says Sánchez. "The idea is that this will provide operational capacity and skills for more cost-effective and sustainable production lines in the future."

Addressing evolving consumer needs

The results of the iPRODUCE project will likely contribute to the ongoing development and growing popularity of open innovation.

"We are at a time when competition in the consumer goods sector is high," adds Sánchez. "One success factor is the extent to which businesses can address evolving consumer needs. Involving users and consumers in a more proactive manner is one way of achieving this."

Moving forward, the iPRODUCE team aims to further consolidate cMDFs as local communities of open innovation manufacturing, and formalise the already functional operational procedures of these networks. Development will continue on the tools and the platform itself over the next two years, to make OpIS even more user-friendly.

PROJECT
iPRODUCE – A Social Manufacturing Framework for Streamlined Multi-stakeholder Open Innovation Missions in Consumer Goods Sectors

COORDINATED BY
AIDIMME in Spain

FUNDED UNDER
Horizon 2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/870037

PROJECT WEBSITE
iproduce-project.eu

Bringing the open-source software philosophy to hardware

Businesses could reduce development costs and bring products to market faster, thanks to collaborative design and manufacturing tools developed by the EU-funded OPEN!NEXT project.

While collaborative online software development has created a billion-euro economy, the extension of this business model to hardware has proven trickier. Nonetheless, the growing popularity of virtual design, digital manufacturing and makerspaces is creating new opportunities in this field.

“Open-source hardware OSH began in the early 2000s with the collaborative development of technologies such as 3D printers,” explains OPEN!NEXT (Company-Community Collaboration for Open Source Development of products and services) project coordinator Robert Mies from the Berlin Institute of Technology in Germany.

“Quite a few businesses today – especially in electronics – are sharing hardware designs and involving customers in this process. However, this model has not really been mainstreamed, and many businesses don’t know about the opportunities of OSH,” he says.

Making sense of open-source hardware

The OPEN!NEXT project set out to address this by encouraging and supporting small to medium-sized enterprises (SMEs) to engage in company-community collaborations. This was achieved by developing and trialling ICT infrastructure and digital tools to enable seamless collaborative engineering.

"We first of all wanted to help business to make sense of OSH," adds Mies. "All this can be a little overwhelming at the start, so we developed a business model toolkit to help companies identify the value proposition of OSH."

For organisations that signed up, the team also developed documentation templates that allow engineers and designers to foster the reuse of shared OSH designs in a structured way.

"An immediate problem we saw was that while people want to share designs and work together, they don't really know how to go about this," says Mies. "So we created a library of OSH – called LOSH – where people can visit to share designs."

OPEN!NEXT also worked on digital solutions to facilitate collaborative production, such as skill-based matchmaking, as well as tools for navigating and utilising online repositories. The aim was to provide the basics for OSH projects to conduct research, maintain documentation, and carry out manufacturing and community-building activities.

Leveraging open-source hardware designs

The success of the demonstrations illustrated the innovative potential of this digital OSH approach. The project's online repository and toolkits are now freely available in LOSH for businesses interested in developing OSH.

"These tools can be used in almost all business-to-consumer (B2C) design cases," remarks Mies. "One of the surprises was that SMEs and makerspaces proved to be a natural fit. I think that this is something that should be explored further."

Another interesting element of the project was the involvement and enthusiasm of artists. "We feel that the OSH domain could be enriching for the creative sector," notes Mies.

One of the surprises was that SMEs and makerspaces proved to be a natural fit.

The OPEN!NEXT project succeeded in encouraging design and manufacturing collaboration, and making better use of existing OSH designs. In the long term, this collaborative way of working could help SMEs to reduce development costs, improve operational efficiencies and bring customers into the loop for more user-centred designs.

Online offering and toolkits tested

The tools were designed based on the needs of six SME-led pilot projects in Amsterdam, Berlin, Copenhagen and Vienna. These pilot projects worked on real cases, such as developing open-source add-ons for solar cell electric cars, creating an air quality monitor that can be mounted on a bicycle, and co-designing new ways to minimise leftover wood waste from furniture production.

The experiences and feedback from these projects helped the OPEN!NEXT team to further define and develop the digital OSH solutions. Critical to this was the involvement of 12 voluntary SMEs, which were selected through a call for cooperation.

PROJECT
OPEN!NEXT – Company-Community Collaboration for Open Source Development of products and services

COORDINATED BY
Berlin Institute of Technology in Germany

FUNDED UNDER
Horizon 2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/869984

PROJECT WEBSITE
opennext.eu

Co-created robots to handle complex manufacturing tasks

The EU-funded REMODEL project's dual-arm robot specialises in advanced deformable component handling techniques, transforming human-intensive manufacturing processes and heralding new production environments.

© Roberto Meattini

While factories of the future are anticipated to be fully automated, current robots struggle to replicate manual tasks such as handling complex materials and objects.

"If Europe is to position itself at the forefront of complex manufacturing and stop the drift to countries with cheaper manual labour, we urgently need more adaptable robots," says Gianluca Palli, project coordinator of the EU-funded REMODEL (Robotic tEchnologies for the Manipulation of cOmplex DeformablE Linear objects) project.

Building on the previous work of WIRES (part of the EU-funded ECHORD Plus Plus project), REMODEL has developed dual-armed robotic tools with cutting-edge perception and interaction functions that can manipulate the wires and cables needed in some products.

Rethinking product design

REMODEL's robotic tools were designed to handle objects whose shapes and movements are complex and unpredictable, and require small, dexterous and repeated actions. When done manually by humans, these tasks often require long, expensive assembly lines and can lead to repetitive strain injuries.

REMODEL built on the WIRES project's lab prototype for the automated assembly of cabling inside switchgear cabinets, power systems used to manage electrical equipment. As switchgears are stand-alone products, the production line has to be adjusted every time a new version is manufactured.

Switchgear wiring for industrial plants was one of four industrial manufacturing use cases investigated by REMODEL, alongside automotive and aerospace wiring harnesses and quality inspection of manufactured tube-based medical equipment, such as catheters.

Human-inspired design

Inspired by the way humans assemble objects, REMODEL developed a dual-armed robotic solution, a relatively uncommon design on assembly lines.

"Many tasks, such as shaping cables, requires control of two points, and, even if for two separate tasks, these often need to be accomplished simultaneously. So we developed 'fingers' for dual-armed robots capable of precision grasping," explains Palli, a professor of mechatronics at the University of Bologna, the project host.

While the project sought to adapt pre-existing hardware, to ensure simple integration into current workflows, in some places it became necessary to develop new components.

"Before robots can manipulate objects, they have to be able to 'see' and 'feel' them," adds Palli. "But most 3D sensors are not sensitive enough to detect thinner objects, such as wires, and tactile sensors are not yet advanced enough, so we developed our own."

Advanced software also helped compensate for sensor limitations. Machine learning algorithms were trained through exposure to a wide range of assembly tasks, in simulated and real environments. For more complex tasks, such as fitting wiring harnesses in vehicles, algorithms were developed with autonomous installation decision-making capabilities.

The team's industrial-scale prototypes are now almost ready for testing within factory environments. Switchgear cabling will be tested at IEMA in Italy, while wiring harness manufacturing will be tested for automotive at Elvez in Slovenia and for aerospace at Elimco in Spain. Harness installation will undergo tests at Volkswagen in Poland, while catheter quality inspection will take place at ENKI in Italy.

Co-creation has been key to the project's success, says Palli. "The workers who currently perform these tasks manually will be involved in quality assurance assessments and will be consulted on how their jobs could evolve in response to automation."

Emergent production environments

Automated manufacturing not only helps reduce costs and worker injuries, but also contributes to wider EU ambitions, such as the circular economy action plan. More precise manufacturing makes more efficient use of materials, reducing the resources needed, as well as the need for remanufacturing to compensate for mistakes, while lessening pollution and waste.

"Another benefit will be customisation," adds Palli. "A highly adaptable system won't need to be reprogrammed to accommodate new tasks, making manufacturing less linear. Robots won't simply be built retrospectively to make a product, rather a product's robotic manufacturing needs will be embedded into design from the start."

This more holistic approach will generate demand for new skills, creating job opportunities, if the right training investments are made. Combining other smart systems could also revolutionise how we build our material world.

"When selecting components, designers could use internet of things technology to learn more about how they were made alongside their recycling options. This would help the circular economy by replacing 'black box' products, where it's hard to know what technology is inside," concludes Palli.

Robots won't simply be built retrospectively to make a product, rather a product's robotic manufacturing needs will be embedded into design from the start.

The team are already exploring additional areas of potential use, such as packaging involving cables, tubes or wires. As REMODEL's image sensing can detect clothes, another possible application is washing machine testing, for which the team developed a prototype.

PROJECT
REMODEL – Robotic tEchnologies for the Manipulation of cOmplex DeformablE Linear objects

COORDINATED BY
University of Bologna in Italy

FUNDED UNDER
Horizon 2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/870133

PROJECT WEBSITE
remodel-project.eu

Smart solution to support human-robot collaboration

A modular software/hardware toolbox for industrial collaborative robots enables human-like perception, human-aware dynamic planning and safe manoeuvring without safety fences.

Industry 5.0 goes beyond Industry 4.0's automation of individual robots and a focus on productivity and efficiency to an approach based on human-robot collaboration (HRC). This human-centric paradigm still contributes to industry's bottom line but also reinforces industry's ability to contribute to society.

Collaborative robots, also called cobots, are designed to work safely with human operators without conventional safety fences. They will form the foundation of Industry 5.0. The EU-funded SHAREWORK project, part of the Effective Industrial Human-Robot Collaboration cluster of projects, developed a solution to support them. It comprises 14 hardware and software modules that have been validated in four industrial manufacturing use cases.

Collaborative robots: perception, mobility, safety and communication

"SHAREWORK merged robotics, AI and the social sciences to bridge the gap between manual and fully automated tasks, combining the accuracy, repeatability and efficiency capabilities of robots with the intelligence and flexibility of humans," explains Néstor García, technical project coordinator from the Eurecat Technology Centre of Catalonia.

The consortium's modular solutions integrate perception, motion planning, safety and communication. They enable collaborative robots to 'cognitively' assess their environment and respond to it. The robots can: detect and respond to the operator's presence and movement in real time; perform human-aware dynamic planning and scheduling; and navigate their environments safely. They even adjust themselves to ensure proper workers' posture. An operator training module harnessing augmented reality develops operators' technical capabilities and fosters acceptance.

Human-robot collaboration in action: four industrial manufacturing use cases

Robots with integrated SHAREWORK modules shone in preassembly and assembly processes. One of the solutions assisted during the repetitive riveting tasks for the preassembly of tram metal door and window frames. The HRC decreased assembly time while enhancing human welfare. Another supported the multistep assembly of large, heavy, metal positioning equipment, normally done manually. It was able to understand and respond intelligently to the operator's intentions through advanced gesture recognition.

Car manufacturing received help from SHAREWORK's modules integrated into a high-payload robot that carried, positioned and held heavy car doors and hoods while an operator executed their assembly/disassembly for painting. Finally, SHAREWORK's collaborative robots worked with humans to move highly varied metal parts between storage and machining, understanding the worker's behaviour and anticipating tasks to move seamlessly about the factory floor.

A more sustainable, human-centric and resilient manufacturing industry

The key to widespread adoption of HRC is worker acceptance. SHAREWORK followed a co-creation approach including end users in early development stages. Beyond their benefits for products and companies, collaborative robotics can relieve workers of dangerous, repetitive tasks and their psychological effects and associated injuries, while opening the door to added-value jobs. Further, having robots literally share the load enhances job inclusivity by removing physical barriers.

Involving human resources in co-creation allows for smoother technology adoption and greater inclusivity and gender equality.

"The use of collaborative robotics and advanced digital technologies in industrial environments strengthens European industry, paving the way to sustainable, human-centric and resilient manufacturing production lines. Involving human resources in co-creation allows for smoother technology adoption and greater inclusivity and gender equality," concludes project coordinator Simona Neri from the Eurecat Technology Centre of Catalonia.

Anyone interested in learning more about HRC and SHAREWORK outcomes can take part in one of five open training courses created by the SHAREWORK consortium.

PROJECT
SHAREWORK

COORDINATED BY
Eurecat Technology Centre of Catalonia in Spain

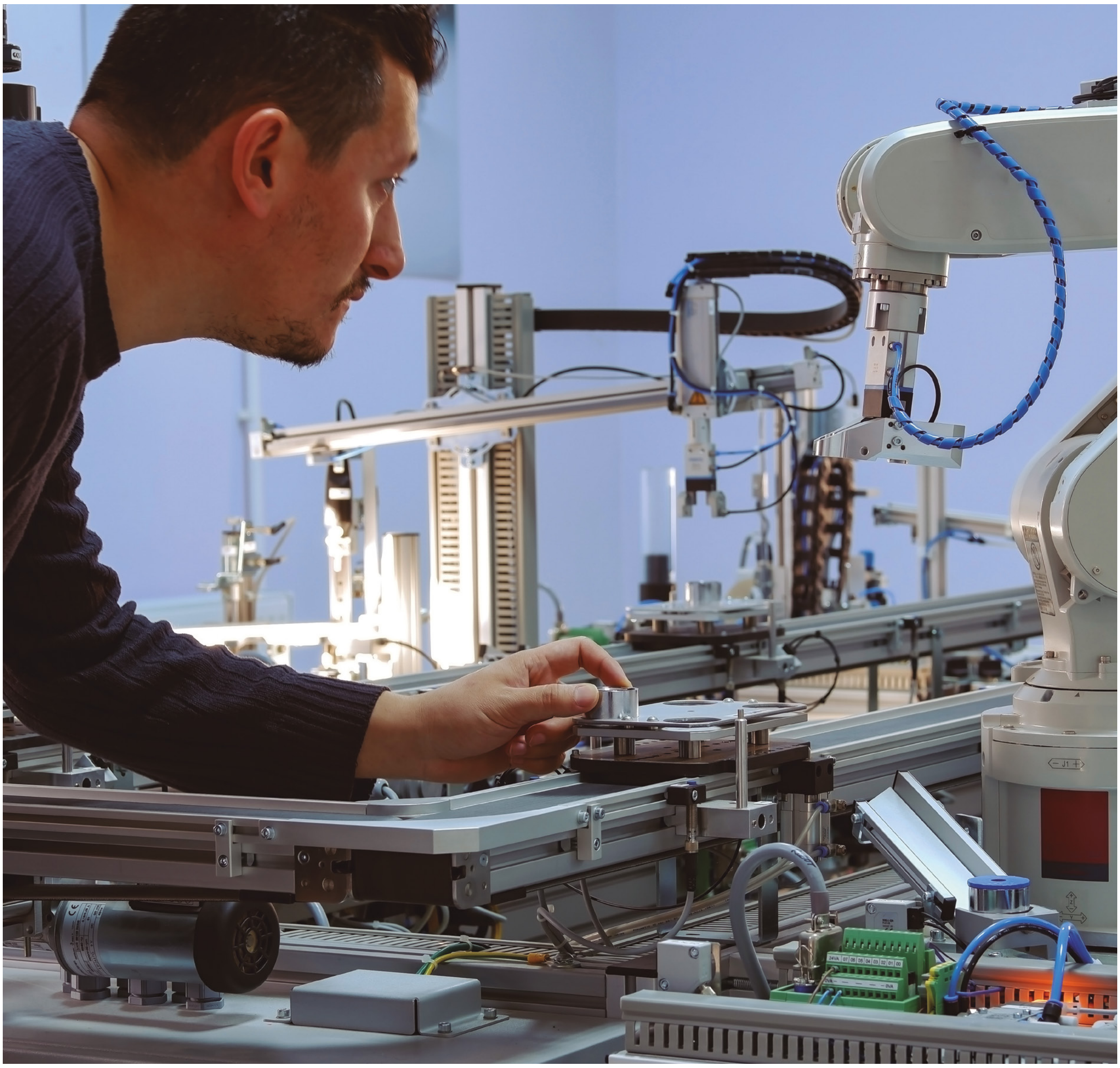
FUNDED UNDER
Horizon 2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/820807

PROJECT WEBSITE
sharework-project.eu

Collaborative robots work like humans, with humans

Seamless human-robot collaboration supported by smart mechatronics and AI-based perception exceeds performance targets and inspires team spirit.



Industry 4.0 is revolutionising manufacturing, but exploiting its full potential will only be possible when humans and robots work together, with technology actively supporting humans' leading role. The EU-funded SHERLOCK (Seamless and safe human-centred robotic applications for novel collaborative workplaces) project has overcome critical challenges to widespread deployment of human-robot collaboration (HRC). Its innovative robotic technologies with smart mechatronics and AI-based cognition make safe, efficient and highly effective HRC possible.

Human-robot collaboration: teamwork makes the dream work

No one size fits all when it comes to industrial application of HRC. Combining components of SHERLOCK's incredible toolbox of technologies enabled solutions for four industrial applications to exceed performance targets.

SHERLOCK enhanced the first-ever high-payload collaborative robot, validating the manipulation of heavy solar panels while using AI to adapt its behaviour when presenting parts to the operator.

Operators went from curious to enthusiastic, ultimately seeing the robots as valued co-workers.

"Cycle time was reduced by approximately 18 %, and the maximum weight handled by an operator went from 42 kg previously (requiring two operators) to 2 kg," explains Nikos Dimitropoulos, project coordinator from the Laboratory for Manufacturing Systems and Automation (LMS) at the University of Patras in Greece. "The high-payload robot will thus support inclusivity," he notes, "reducing employment barriers faced by operators with physical limitations."

Sotiris Makris, head of the Robots, Automation and Virtual Reality in Manufacturing group at LMS, continues: "Our low-payload collaborative robot supported by an unparalleled advanced digital twin can perform real-time task planning using integrated data from distributed sensors. Our robot undertook riveting during industrial modules assembly, with the operator working on the same piece simultaneously thanks to SHERLOCK's safety innovations." The robot's AI perception module detected about half of the most common assembly errors, and cycle time was reduced by about 40 %.

SHERLOCK's semi-active exoskeleton with AI-driven robotic perception of human actions can automatically modulate its assistance in real time. The exoskeleton provides virtual reality (VR)-based training for new operators and augmented reality (AR)-based operator instructions. Its use reduced errors in the assembly of large computer numerical control machines.

Finally, "SHERLOCK's mobile two-armed robot was employed for collaborative transport of large composite aerospace parts. Advanced impedance control and intuitive AR interfaces allowed the robot to effortlessly follow and assist the operator's movement," explains Makris. The solution reduced the number of operators required to move the large parts, freeing them to focus on other value-added activities.

AI-driven human-like robot behaviour and easy programming foster human acceptance

SHERLOCK demonstrated clear gains in performance, ergonomics and operator acceptance relative to previous HRC applications. "In four industrial scenarios, the SHERLOCK robots perceived the environment and the needs and preferences of the operators, predicted human intention and adapted their behaviour accordingly thanks to AI-driven perception and decision-making. Operators went from curious to enthusiastic, ultimately seeing the robots as valued co-workers," notes Dimitropoulos.

The robots were even easier to programme than anticipated, enabling production engineers to reconfigure systems in hours instead of days without previous knowledge or training. Ease of programming and substantial assistance to operators will reduce many age, gender, physical and training barriers to employment.

SHERLOCK has revealed the real-world potential of highly intelligent, assistive robotic systems. HRC has moved from research to application, with three products released during the project's lifetime. The team will continue maturation of key outcomes in the CONVERGING project.

PROJECT
SHERLOCK – Seamless and safe human-centred robotic applications for novel collaborative workplaces

COORDINATED BY
University of Patras in Greece

FUNDED UNDER
Horizon 2020-LEIT-ADVMANU

CORDIS FACTSHEET
cordis.europa.eu/project/id/820689

In safe hands: intelligent robots expertly manipulate soft objects

Automation is difficult for manufacturing sectors working with soft objects such as food, clothing and healthcare products. Exploiting advances in sensing capabilities, the EU-funded SoftManBot project has created an adaptable robotic solution.

While there are many robotic manufacturing systems for working with rigid objects, options remain limited for deformable materials. "The multi-fingered robots available are designed for limited applications, and have problems with durability, cost and operation," says Youcef Mezouar, project coordinator of the EU-funded project SoftManBot (Advanced RoBOTic Technology for Handling SOFT Materials in MANufacturing Sectors).

As manufacturing robots sometimes physically interact with humans, safe movement is also paramount, adding to the challenge. The SoftManBot project developed an AI-driven robotic solution based on customised grippers and multiple sensors – tactility, force, proximity and vision.

"Our robot's perception and control systems mimic the dexterity of manual operators, increasing manufacturing quality and productivity. This is more than just a technical achievement, it is a paradigm shift," explains Mohammad Alkhatib, the project's technical manager.

Mimicry to be mastered

Four pilots were run to demonstrate two key manufacturing tasks.

The first was the extraction of products from moulds. While the injection of liquids into moulds to form component parts is usually automated, removal is typically manual, due to the dexterity required.

The second task was the assembly of products made from complex multi-material components with various properties, including differences in rigidity, colour, stickiness, shape, weight and texture. This requires precise positioning, controlled deformation and different methods for joining components.

SoftManBot's solutions for the first task were demonstrated in a Spanish pilot with Plastinher Urbán, removing footwear soles from moulds, in a sporting apparel pilot with Decathlon in Albania, and in another pilot producing tyres with Michelin in France. The second task was undertaken in the Juema (website in Spanish) pilot in Spain, involving both extraction and assembly of toy parts.

This is more than just a technical achievement, it is a paradigm shift.

"Our very different pilots all benefited from each other, extending the capacities of our solutions, saving development time and money," adds Mezouar, director of the school of engineering sciences at Clermont Auvergne INP (website in French), the project host.

Toy story

To assemble a doll, individual parts are typically manually extracted from moulds using sticks and pliers. The parts are then manually fitted to each other using pre-fixed holes and joints. Both processes require fast and highly dextrous movements.

To mimic this efficiency, SoftManBot developed a robotic system capable of quickly processing the quantities, colours and textures of parts, along with two specialist grippers – a pneumatic one, capable of high forces for demoulding, and a large stroke electric gripper for assembly.

Once the raw materials were set to form the parts required, operators activated the robots. Onboard cameras helped the robots detect the moulds before the best grasping points were determined by algorithms. Next, pressure and tactile sensors enabled the robots to apply the control and force needed to extract the parts.

For assembly, the robots first separated the parts, tracking their deformation during handling, then selected the best grasping points to assemble the doll, guided by the blueprints, pressure and tactile sensors, and software-based decision-making.

"The results were impressive, with our robotic system demonstrating impressive dexterity and consistency. On average the system successfully demoulded over 120 parts (legs, heads, etc.) 96 % of the time, and successfully assembled over 40 complete dolls," notes Alkhatib.

Human-centred team players

To ensure the acceptance, comfort and trust of operators, SoftManBot has incorporated human needs into their solution's design. While the automation of physically demanding tasks already helps lessen the chance of repetitive strain injuries, the system also provides a real-time ergonomic measurement of operators' fatigue and stress. Additionally, task management algorithms include a visual sensing system that tracks human presence, enabling the robots to adjust their movements as required.

"At the beginning of the project, less than 40 % of workers/operators we asked supported our proposals, many afraid of losing their jobs. After demonstrating the technology and providing training, this rose to over 70 %, with operators seeing the robots more as assistants," remarks Mezouar.

The project has already shared their research in over 30 research papers and also plans to make a toolbox of scientific assets available to researchers interested in soft object manipulation.

PROJECT
SoftManBot – Advanced RoBOTic Technology for Handling SOFT Materials in MANufacturing Sectors

COORDINATED BY
Clermont Auvergne INP in France

FUNDED UNDER
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CORDIS FACTSHEET
cordis.europa.eu/project/id/869855

PROJECT WEBSITE
softmanbot.eu

People-first approach helps build trust in manufacturing AI

To be successfully adopted in manufacturing, AI systems need to be better understood and better trusted. The EU-funded STAR project used human-centric design to build safe and reliable technologies.

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By increasing automation and enhancing the intelligence of manufacturing processes, AI can improve production quality, while reducing costs, transitioning Europe to Industry 5.0.

Predictive algorithms can indicate the best time to service machinery, and identify product defects, avoiding costly production downtime. AI can also optimise value chains, by analysing big data to forecast supply, demand and inventory levels, benefiting logistics and production schedules.

Yet these advances also introduce significant risks, such as the introduction of biased systems due to inadequate training data or an increased vulnerability to cyberattack. But perhaps the biggest is a lack of understanding and trust from those on the production line.

"If Industry 5.0 is to fulfil its potential, it needs not only the support of these people but the benefit of their experience," says John Soldatos, technical coordinator of the EU-funded STAR (Safe and Trusted Human Centric Artificial Intelligence in Future Manufacturing Lines) project.

The STAR team collaborated with key stakeholders to develop various advanced AI technologies. In three pilots, these were evaluated and validated for both technical and social performance – in particular, their trustworthiness.

Putting AI through its paces

The Human-Robot Collaboration (cobotics) pilot took place in a Philips (website in Dutch) factory in the Netherlands. Here, STAR's active learning systems were tested in AI-driven quality inspection, and were shown to increase process efficiency without compromising cost or workflow.

"The AI consults humans when uncertain, thus avoiding errors and misclassifications while also letting the AI benefit from human knowledge, significantly improving the speed and quality of its training," explains Babis Ipektsidis, project manager at Netcompany–Intrasoft, the project host.

The AI consults humans when uncertain, thus avoiding errors and misclassifications.

The AI security pilot applied explainable AI systems to product customisation in automotive air vents. It was demonstrated at the IBER-OLEFF production facilities in Portugal. Here, variations in monthly orders make it difficult to optimise the manufacturing process.

"Explainable AI helped operators understand how automation can make production lines more flexible, while also adapting them to changes, such as the introduction of new parts or end products," notes Ipektsidis.

Lastly, the Safety with AI pilot tested cobotic operations at the German Research Center for Artificial Intelligence (DFKI). Simulated reality systems, based on reinforcement learning, trained robots to safely move around human co-workers while completing shop floor tasks. By defining dynamic safety zones for robots, the AI enhanced the safety of cobotic working, with no collisions observed.

The team applied their novel methodology for evaluating trusted AI systems, both technically and socially, to all the pilots. "The technical performance satisfied us that these robotic solutions can be used in real-life scenarios to improve production processes," explains Soldatos. "While human safety can be assured, employee training will be vital, especially on tasks such as reading dashboards and understanding data-driven results."

Navigating the wider working environment

Soldatos notes that showcasing the benefits of trust-building AI systems has not been without its challenges: "The sector is moving fast, so anticipating regulation is difficult. The AI Act emerged during the project, but we managed to align our solutions with it."

The project's ongoing collaborations help address these challenges.

STAR researchers are leading activities in the 'AI projects in manufacturing' initiative, which facilitates collaboration and knowledge sharing. STAR also contributes assets, such as information about Active Learning AI models, to the AI4EU portal.

The project has made some of its resources available through its market platform and has widely published its results, including an Open Access book about trusted AI solutions, which has already been downloaded over 40 000 times.

STAR's partners are currently working to advance the maturity of their prototypes, with the aim of launching commercial products within a few years of the project's conclusion. While several products are currently protected by proprietary licences, partners offer open-source versions of selected results.

PROJECT
STAR – Safe and Trusted Human Centric Artificial Intelligence in Future Manufacturing Lines

COORDINATED BY
Netcompany-Intrasoft in Belgium

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CORDIS FACTSHEET
cordis.europa.eu/project/id/956573

PROJECT WEBSITE
star-ai.eu

Developing AI that takes human needs into account

The EU-funded project TEACHING's machine learning models react to human operators and adapt their behaviour accordingly, offering safer, less stressful and more efficient manufacturing.

While AI has the potential to transform manufacturing processes through increased automation, it is critical that the human element is not forgotten. Humans are inevitably involved all along the production chain, and a synergistic relationship between robot and worker is essential to ensure smooth operations.

"You cannot have AI behaving irrespective of human actions," notes TEACHING (A computing toolkit for building efficient autonomous applications leveraging humanistic intelligence) project coordinator Davide Bacciu from the University of Pisa in Italy. "As humans, our reactions and well-being are influenced by our cognitive and psychological states."

In order for AI to boost operational efficiencies and lighten workloads along the production chain, it is vital that the introduction of AI does not place excessive pressures on humans.

Autonomous applications that empower humans

The EU-funded TEACHING project sought to address this challenge by developing autonomous applications that leverage human feedback. "We wanted the system to empower humans, and to be dependable and secure," says Bacciu.

To achieve this, the project brought together AI and machine learning specialists, as well as reliability engineers and software developers. "We wanted to develop safe and dependable applications in which AI is running, and then demonstrate the potential of this in end use applications," adds Bacciu.

We wanted the system to empower humans, and to be dependable and secure.

The project used autonomous cars as one test case. Just as in manufacturing, a human-centric approach is needed here, to ensure the smooth handover and takeover between vehicle and user.

A passenger's stress levels and psychological state can greatly influence comfort when being autonomously driven. AI therefore needs to take into account not only the state of the vehicle, but also that of its passengers. "Our aim here was to try to personalise the service and ensure that AI could react to the user," says Bacciu.

In TEACHING's model, data from sensors monitoring the physiological state of passengers is fed to the AI, which provides feedback to adapt the driving style of the autonomous car. "The idea was for the AI to be responsive, and eventually anticipatory of the specific user," explains Bacciu.

Methodologies and models for distributed AI

This work enabled the TEACHING project team to successfully develop new methodologies and models for distributed AI. On top of this, the AI was shown to be able to constantly learn and adapt to the reactions of a specific user. The idea is that the AI is fully responsive to the needs of the human, and not just focused on its own production task.

"We developed guidelines and a library for developers on how to structure this type of AI," adds Bacciu. "This will make life simpler for those wanting to develop autonomous distributed AI applications."

While this technology holds potential in the autonomous car sector, Bacciu sees this as a medium- to long-term aspiration, given the regulatory and technological hurdles that must still be overcome. Of more immediate interest is the manufacturing sector.

"There is major potential here because of the need for effective human-robot collaboration," he remarks. "This kind of distributed AI, which takes account of humans and learns, would allow robots to operate autonomously, while being respectful of human needs." In the long run, this could help to make the workplace safer and less stressful, and help manufacturers to make significant efficiency savings.

PROJECT
TEACHING – A computing toolkit for building efficient autonomous applications leveraging humanistic intelligence

COORDINATED BY
University of Pisa in Italy

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RESULTS PACK ON THE EUROPEAN YEAR OF SKILLS

An adequate skill offer is a precondition for well-functioning and inclusive European societies and economies. This CORDIS Results Pack showcases the work of 13 EU-funded projects working within the context of the European Year of Skills. The aim of the pack is to contribute to an evidence-based debate on the challenges associated with skills development, and to show how investing in skills not only transforms lives but also reinforces Europe's position in the world.

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