TRINITY Use Cases

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www.trinityrobotics.eu

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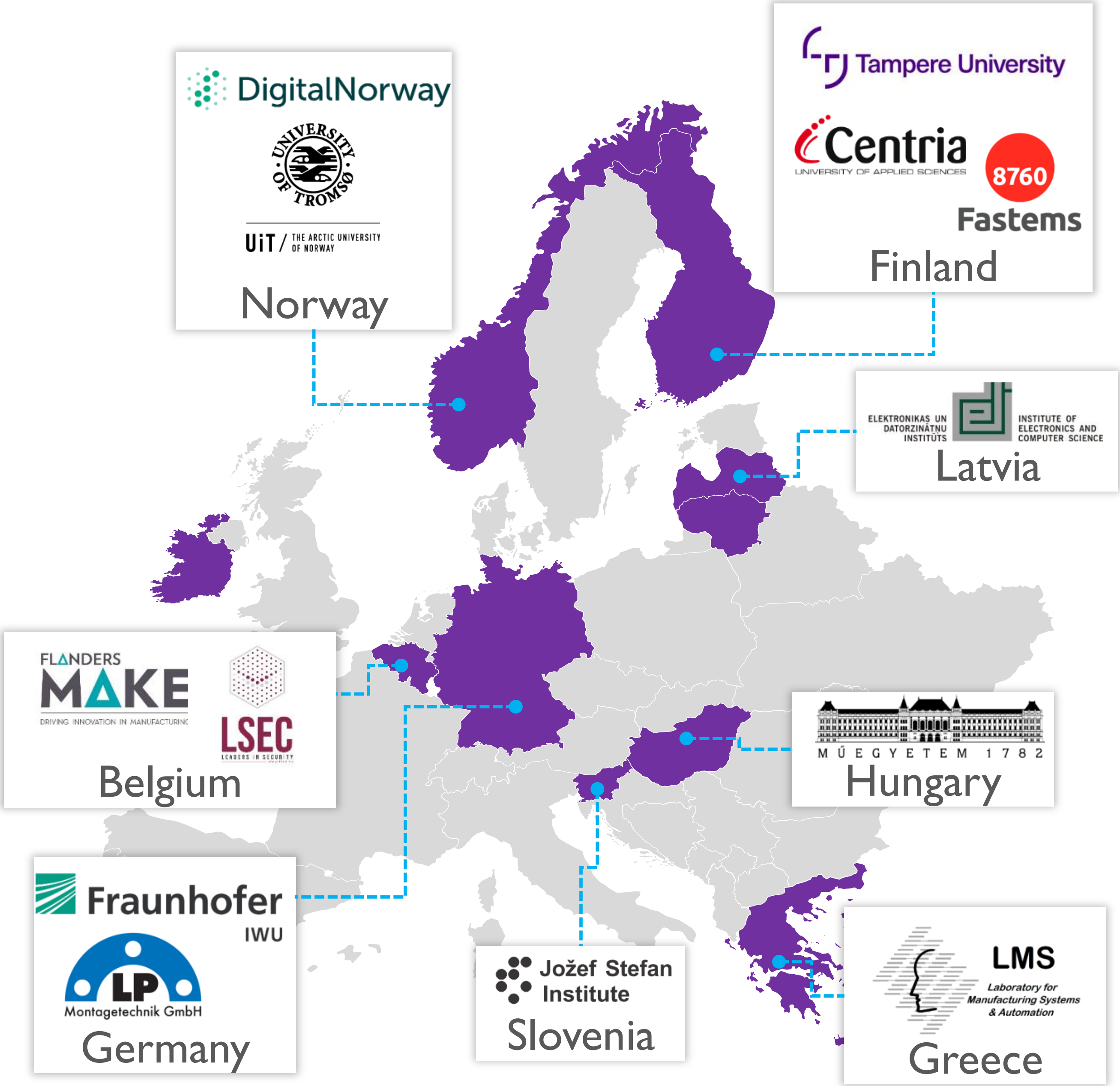
TRINITY demonstrators

- The TRINITY consortium has developed demonstrators in the areas of robotics we identified as the most promising to advance agile production, e.g. collaborative robotics including sensory systems to ensure safety, effective user interfaces based on augmented reality and speech, reconfigurable robot workcells and peripheral equipment (fixtures, jigs, grippers, …), programming by demonstration, IoT, secure wireless networks, etc.
- The demonstrators presented in this document will serve as reference implementation for two rounds of open calls for application experiments, where companies with agile production needs and sound business plans will be supported by TRINITY DIHs to advance their manufacturing processes.
- Besides technology-centered services, primarily laboratories with advanced robot technologies and know-how to develop innovative application experiments, TRINITY network of DIHS will also offer training and consulting services, including support for business planning and access to financing.



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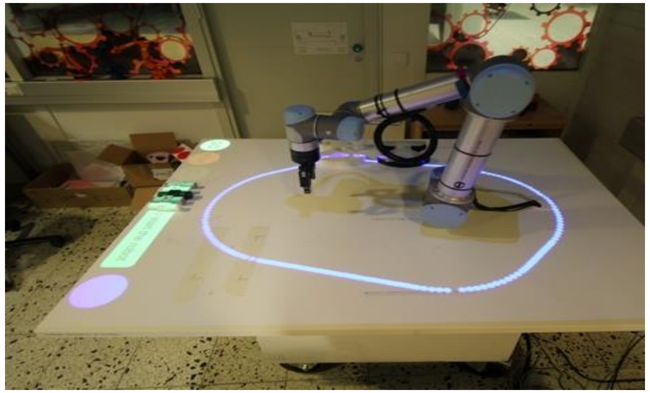
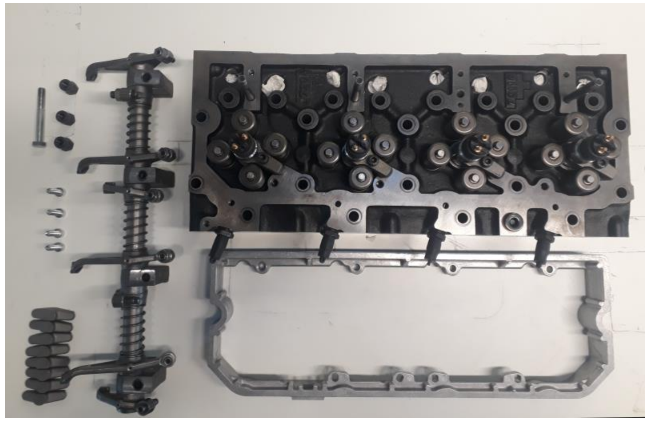
Use Case 1: Collaborative assembly with vision-based safety system

Problem/goal	Utilization of safe and intuitive robotics in human-robot collaboration.
Potential users	SMEs for novel safety systems and co-bot potential in assembly.
NACE	29.3 Manufacture of parts and accessories for motor vehicles
Description	Demonstration of a vision-based safety system for human-robot collaborative assembly of diesel engine components. A dynamic 3D map of the working environment (robot, components + human) is continuously updated and used for safety and interaction (virtual GUI). This robot working zone is projected onto a flat surface via projection.
Hardware	Universal Robots (UR5), Robotiq gripper, Kinect, Intel Realsense, projector
Software	Open source software (ROS, MoveIt)
Standards	Considered: ISO/TS 15066:2016, ISO 10218-1/2
Possible benefits	Studies with collaborative robots, human-robot interaction, pose recognition and handling of complex objects (engine block components), dynamic 3D safety zone in shared workspace
Partners	Tampere University (Finland), LMS (Greece), EDI (Latvia)
More info	https://www.dropbox.com/s/xlatmas4w6r2rx7/user_studies_grid.mp4?dl=0 Antti Hietanen, antti.hietanen@tuni.fi



Projection-based safety zone around robot



Diesel engine components for assembly

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Use Case 2: Collaborative disassembly with augmented reality interaction

Problem/goal	Utilization of human-robot collaboration with larger robots
Potential users	SMEs for augmented reality interaction and industrial disassembly
NACE	33.1 Repair of fabricated metal products, machinery and equipment
Description	Disassembly of an industrial product. The vision system scans the product and recognizes its type, position and orientation. The cell control system will make a task allocation between robot and operator. Operator can see the instructions to disassembly and the robot safety zones in 3D with a MS HoloLens AR headset . The operator notifies the robot via gestures. The sensor system is supervising the work space.
Hardware	ABB IRB4600, Kinect, Intel Realsense, DLP projector, MS HoloLens
Software	Open source software (ROS, MoveIt)
Standards	Considered: ISO/TS 15066:2016
Possible benefits	Applications with large robots for disassembly and AR interaction. Object and pose recognition of complex objects (engine block components)
Partners	Tampere University (Finland), LMS (Greece), EDI (Latvia)
More info	Antti Hietanen, antti.hietanen@tuni.fi

3D Diesel engine model for disassembly

MS Hololens for augmented reality interaction

Use case 3: Collaborative robotics in large scale assembly, material handling and processing

Problem/goal	Utilization of agile human robot collaboration in large scale material handling, processing or assembly tasks, which are needed e.g. in the prefabrication of a wall element
Potential users	Intergrators of robotic applications and companies carrying out large-scale material handling, processing or component prefabrication
NACE	33.20 Installation of industrial machinery and equipment
Description	Demonstration of agile industrial robotization of a large-scale material handling, processing or prefabrication where robots and people will process components collaboratively. The working zone will be monitored dynamically and provided to the worker and robot together with the task plans and situation aware information. In the use case different multimodal human-computer interaction methods are evaluated.
Hardware	ABB/KUKA robots, Universal Robots (UR3/10), Robotiq gripper, Pilz Safety Eye, 3D Kinect, RF tracking and local positioning systems, LIDARs, PhotoXi 3D Scanner, Sick S300 safety scanner
Software	Commercial (Visual Components/ ABB Robot Studio/ RoboDK/ AUTOMAPPPS), and open source software (ROS, CloudCompare)
Standards	Considered: ISO/TS 15066:2016, ISO 10218-1/2
Possible benefits	Studies with collaborative robots, human-robot interaction, dynamic 3D safety
Partners	Centria, Tampere University (Finland), FhG (Germany), UiT (Norway), LMS (Greece)
More info	Sakari Pieskä, Email sakari.pieska@centria.fi

Agile large-scale prefabrication can benefit from collaborative robotics

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Use Case 4: Integrating digital context (e.g. BIM) to the digital twin with AR/VR of the robotized production

Problem/goal	Utilization of digital context and digital twins for the robotized production with AR/VR
Potential users	Intergrators of industrial robotic applications, manufacturing companies and SMEs providing or utilizing augmented reality interaction
NACE	28.29 Manufacture of other general-purpose machinery
Description	Demonstrate how companies carrying out prefabrication can utilize robotized manufacturing to get their production more agile by integrating BIM, digital twin and VR/AR technology. They can utilize these agile concepts for more flexible monitoring, operational support, training, safety and maintenance purposes of the production cell.
Hardware	ABB/KUKA/UR robots, MS HoloLens, HTC Vive, 3D Kinect, LIDARs, NDI Optotrack, Leica long range scanner, SICK encoders
Software	Commercial (Dassault 3DExperience, Visual Components/ ABB Robot Studio/ RoboDK) and open source software (Unity, Vuforia, Blender, ROS, Linux)
Standards	Considered: ISO/TS 15066:2016
Possible benefits	Studies with digital twins, BIM and AR/VR technology for collaborative robotics in industrial environments for better human-robot interaction, and dynamic 3D safety
Partners	Centria, Tampere University (Finland), FhG (Germany), UiT (Norway)
More info	Jorma Hintikka, jorma.hintikka@centria.fi

BIM, digital twins and AR/VR (e.g. MS Hololens) can be utililized in agile production

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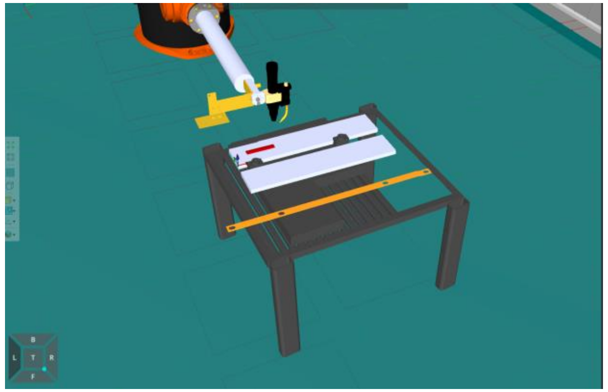
Use Case 5: Wire arc additive manufacturing with industrial robots

Problem/goal	Increase production rate with additive manufacturing of metal parts
Potential users	SMEs who manufacture complex geometries with welding
NACE	25.11 Manufacture of metal structures and parts of structures
Description	The industrial robot has an important role in the automation of the manufacturing industry and has considerably contributed to the improvement of profitability and working environment. However, there are still many tasks in industry that require heavy work, e.g. in additive manufacturing based on welding.
Hardware	KUKA KR30-3, Fronius MagicWave 5000
Software	Open source software (ROS) and commercial (Visual Components)
Standards	Considered: ISO 10303, ISO 6983, NS-EN 1011-1:2009, ROS-I.
Possible benefits	This use-case represents a new conceptual solution for additive manufacturing. The solutions contains the required level of intelligence and flexibility to apply robotized TIG welding in manufacturing and construction. The system and setup will be assessed against different Cybersecurity vulnerabilities identified, issues coming out of a quick scan self test) and known challenges.
Partners	UiT The Arctic University of Norway (Norway), LSEC (Belgium)
More info	Lazar Sibul, lazar.sibul@uit.no

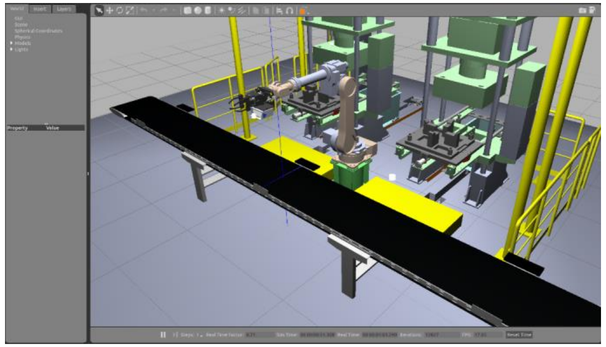


Planning of work in 3D simulation

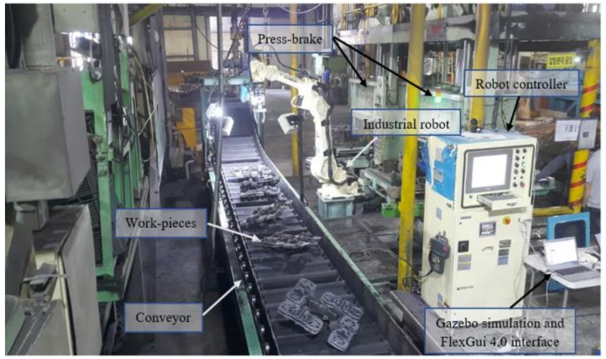
Some of the executed work

Use Case 6: Production flow simulation/supervision

Problem/goal	Visualization of production, along with distant monitoring/control of production flow
Potential users	SMEs who are carrying out commissioning, system integration
NACE	33.20 Installation of industrial machinery and equipment
Description	Factories of the future will face increasing demands for a non-stop production, accompanied with high flexibility and safety requirements. This implies an important future market for instant services dealing with support, error diagnostics and reconfiguration of industrial robot systems. These advances can be achieved by utilizing IoT in every stage of the production process in a factory. Based on the collected data, decisions can be made even from distant locations.
Hardware	Raspberry Pi, PLCs, Industrial robots
Software	Open source software (ROS, MoveIt, Gazebo) and FlexGUI
Standards	Considered: ISO 10303
Possible benefits	This use-case demonstrates the usability of IoT (PLCs, robot cells, sensors, actuators) in a production flow, where data is continuously monitored, collected and actions can be carried out through a simulation environment (e.g. Gazebo) or automatically. Transmission of data amongst various components, increases the number of specific security issues that could be derive. The data is distributed with ROS components.
Partners	UiT The Arctic University of Norway (Norway), LSEC (Belgium)
More info	Beibei Shu, beibei.shu@uit.no



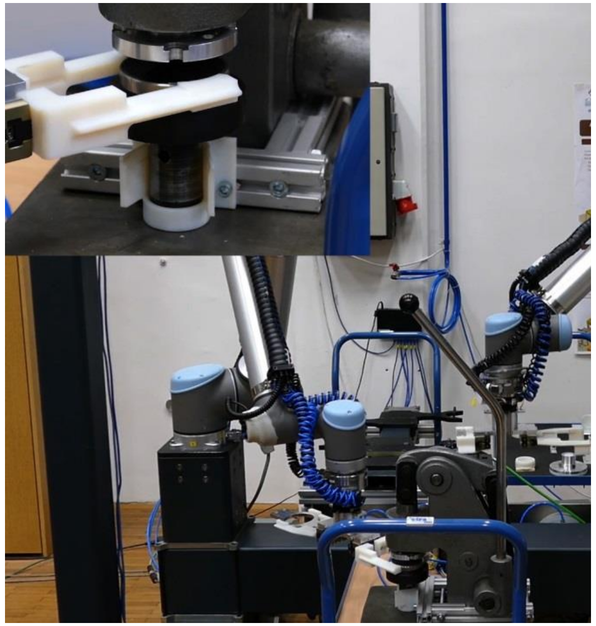
Supervision in Gazebo

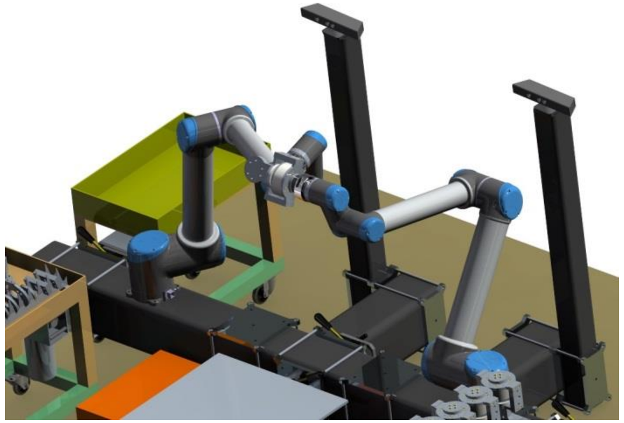


Factory setup

Use case 7: Robot workcell reconfiguration

Problem/goal	Partly autonomous reconfiguration of a robotic workcell for automated robot assembly.
Potential users	Manufacturing companies that need to automate their assembly production processes
NACE	C26.1 Manufacture of electronic components and boards, C27.1 Manufacture of electric motors, … 29.3 Manufacture of parts and accessories for motor vehicles
Description	Demonstration of quick robot workcell reconfiguration for automated assembly of parts in different manufacturing industries. This is accomplished using innovative technologies such as passively reconfigurable fixtures, passive linear units, plug-and-produce trolleys, 3-D printing for gripper and fixture design, tool changers, etc.
Hardware	2 Universal Robots (UR10), DESTACO tool changers, reconfigurable passive hardware (linear guides, hexapods), 3-D printing of gripper fingers and fixtures
Software	Open source software (ROS), MATLAB Simulink
Standards	Considered: ISO/TS 15066:2016, ISO 10218-1/2
Possible benefits	Minimize the time needed to change production from one product to another with a minimum amount of human intervention. The aim is to provide to manufacturing companies (including SMEs) a reconfigurable robot workcell, which is attractive for small batch production.
Partners	JSI – Jožef Stefan Institute, Slovenia
More info	https://www.dropbox.com/s/b0kcjcsdfi1rg9o/housing_assembly.mp4?dl=0 Ales Ude, ales.ude@ijs.si





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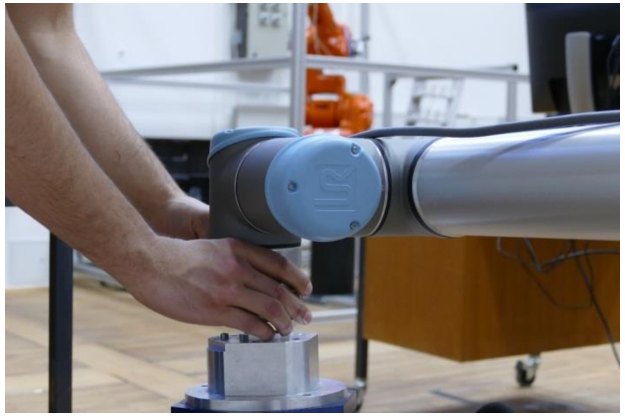
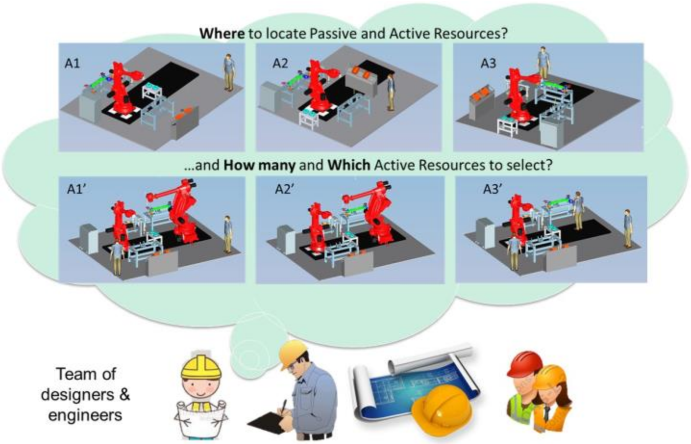
Use case 8: Quick programming and calibration by kinesthetic teaching

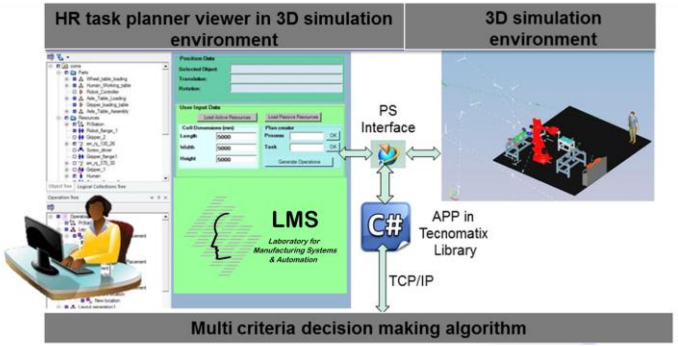
Problem/goal	Utilization of kinesthetic teaching for user-friendly programming of assembly tasks
Potential users	Manufacturing companies that need to automate their assembly production processes
NACE	C26.1 Manufacture of electronic components and boards, C27.1 Manufacture of electric motors, … 29.3 Manufacture of parts and accessories for motor vehicles
Description	Traditional programming of industrial robots based on either teach pendants or off-line programming in a simulation environment is rather unintuitive, tedious, and requires significant expert knowledge. We address these challenges by providing a software framework that includes both front-end and back-end solutions that facilitate the integration of kinesthetic guidance for teaching robot assembly skills.
Hardware	Universal Robots (UR10)
Software	Open source software (ROS), MATLAB Simulink
Standards	Considered: ISO/TS 15066:2016, ISO 10218-1/2
Possible benefits	Operators without expert knowledge in robotics will be able to efficiently calibrate and program new automated assembly tasks.
Partners	JSI – Jožef Stefan Institute, Slovenia
More info	Ales Ude, ales.ude@ijs.si



Use Case 9: Dynamic task planning & work re-organization

Problem/goal	Support production designers during the manufacturing system design process
Potential users	SMEs that need novel solutions for optimizing their production while automating the design process.
NACE	29.3 Manufacture of parts and accessories for motor vehicles
Description	Demonstration of an intelligent decision-making framework for active and passive resources allocation in a workcell, rough motion planning of human and robot operations and initial task planning. Multi criteria decision making modules integrating 3D graphical representation, simulation and embedded motion planning is used to validate alternative workplaces layouts and task plans.
Hardware	High performance computer
Software	Open source software (ROS), Siemens - Process Simulate
Standards	Considered: ISO/TS 15066:2016, ISO 10218-1/2
Possible benefits	Minimize the time required as well as the effort for multiple iterations between the designers, process engineers and system integrators. The solution will address the issue by gathering in a tool all this knowledge and providing feedback to the human within a short time frame (some minutes instead of 1-month work).
Partners	LMS – University of Patras, Greece
More info	https://www.youtube.com/watch?v=0asQ5HYwe2g Niki Kousi, kousi@lms.mech.upatras.gr

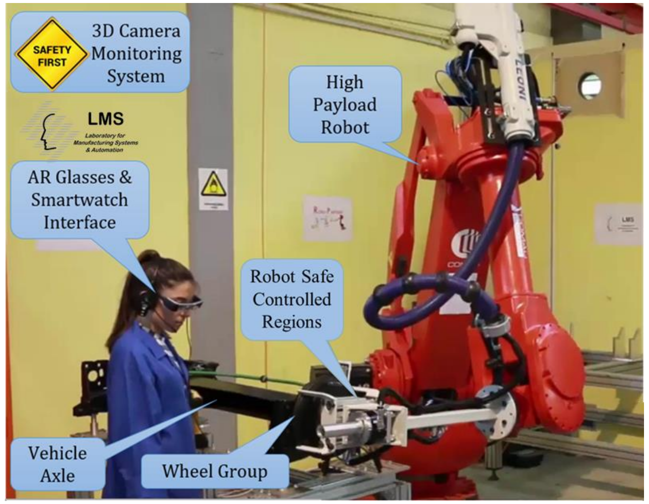




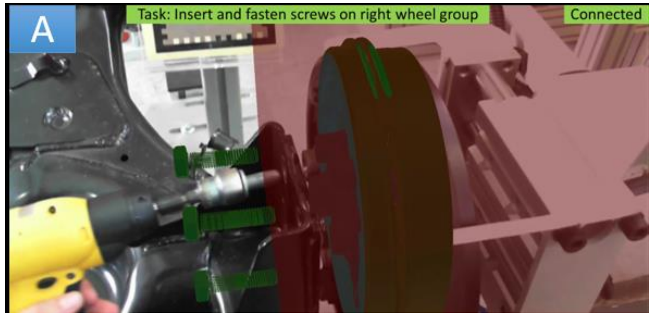
Intelligent heuristics integrated with 3D simulation tools

Use Case 10: HRI framework for operator support in human robot collaborative operations

Problem/goal	Support and increase human operator's safety feeling during collaborative applications
Potential users	SMEs interested on exploiting the synergy effect of humans and robots in assembly
NACE	29.3 Manufacture of parts and accessories for motor vehicles
Description	Demonstration of an Augmented Reality (AR) based application providing to the human operators: a) assembly instructions, b) robot behaviour information for increasing safety awareness, c) safe working volumes, d) production status information. Interfaces on smart wearable devices enable the easy and direct human robot interaction while the HRC execution is orchestrated and monitored through a service – based controller.
Hardware	Industrial robots, , Augmented Reality glasses, Smartwatch
Software	Open source software (ROS, RosBridge, ROS Java, Unity, Vuforia)
Standards	Considered: ISO/TS 15066:2016, ISO 10218-1/2
Possible benefits	Unexperienced operators can be allocated to work in HRC cells and new processes limiting the training requirements thus providing agility in the system on re-allocating human resources according to the production needs
Partners	LMS – University of Patras, Greece
More info	https://www.youtube.com/watch?v=FsYA26SowVk Niki Kousi, kousi@lms.mech.upatras.gr



HRC assembly cell

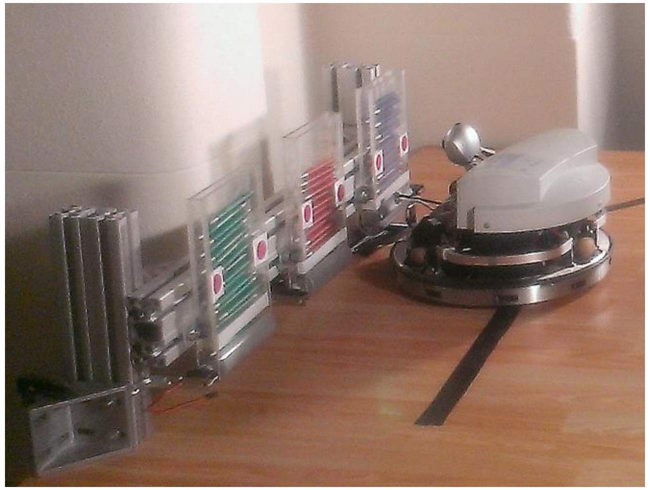


AR based application – Operator's field of view

Use Case 11: Robotized serving of automated warehouse

Problem/goal	Demonstrate the feasibility of using mobile robots in intralogistics.
Potential users	SMEs for novel safety systems and co-bot potential in assembly
NACE	63.12 Storage and warehousing
Description	The demonstration is based on a mobile robot equipped with three omni-wheels. The automated warehouse in the demonstration is a pen wending machine operated by a microcontroller. The wending machine has 3 slots for holding 3 differently coloured pens and serving 1 pen at a time. The robot recognizes the task by a label coded card shown to its camera using optical character recognition (OCR).
Hardware	Festo Robotino
Software	NI LabVIEW
Standards	Considered: IROS, ISO 10303, ISO 6983
Possible benefits	Applications with mobile robots, optical character recognition, target detection and controlled manoeuvring, path tracking without compromising safety
Partners	Budapest University of Technology and Economics (BME)
More info	Levente Raj, raj@mogi.bme.hu

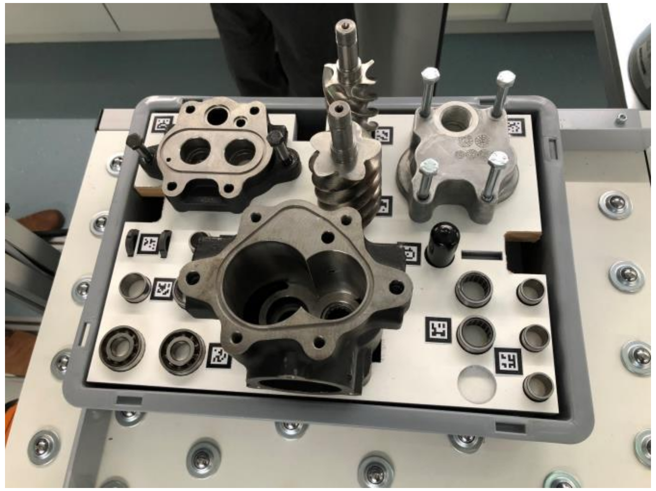
Line following of a mobile robot



Approaching the target

Use Case 12: Reconfigurable human-robot collaborative tasks scheduling for assembly of product variants.

Problem/goal	Easy reconfiguration of assembly scheduling and allocation between agents based on product specifications and generation of adequate work instructions for operators.
Potential users	SME‘s and large scale industry that need flexible assembly solutions
NACE	C27 - Manufacture of electrical equipment; C26 - Manufacture of computer, electronic and optical products; C28 - Manufacture of machinery and equipment n.e.c.
Description	Demonstratea that the assembly steps can be easily (re)configured for the assembly of product variants. The digitization and novel robotics solutions allow to realize flexible assembly work cells. Once a product order is placed, the optimal assembly sequence and allocation are scheduled using planning software tools, vision and available resources. Digital work instructions are generated to support the operator and displayed on screens or smart glasses.
Hardware	Kuka iiwa, Arkite, Robotiq grippers
Software	ROS, Automappps, Unity, OpenCV
Standards	ISO/TS 15066:2016, ISO 10218-1/2, ISA-95
Possible benefits	When an assembly allocation and scheduling can be easily (re)configured for the assembly of product variants, it will allow companies to deal with mass-customization demand of the market
Partners	Flanders Make (Belgium)
More info	Asad Tirmizi, asad.tirmizi@flandersmake.be

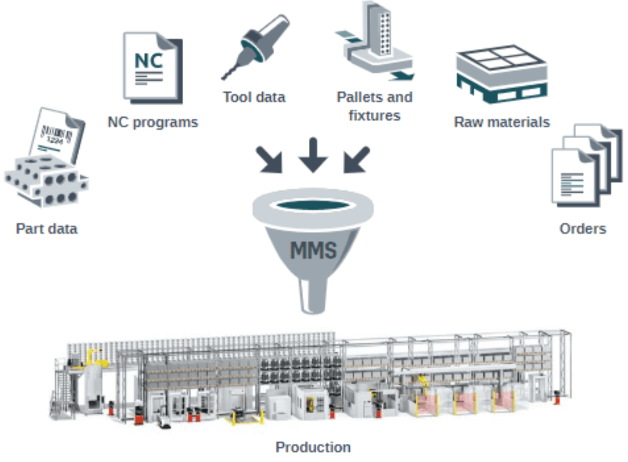


Use Case 13: Deployment of mobile robots in collaborative work cell for assembly of product variants.

Problem/goal	Collaborative mobile manipulators in shared work places to perform assembly operations.
Potential users	SME's and large scale industry that need flexible mobile robotic solutions
NACE	C27 - Manufacture of electrical equipment; C26 - Manufacture of computer, electronic and optical products; C28 - Manufacture of machinery and equipment n.e.c.
Description	The aim is to demonstrate the capabilities of mobile manipulators in work places shared by humans. The robot needs to localize itself accurately using sensor fusion techniques in the indoor working environment during its motions. Next, the mobile manipulator movements are planned, avoiding obstacles, by solving a numeric optimization problem which takes into account a continuously updated digital representation of the environment. A Kuka KMR robot will perform in a collaborative work space, a kitting application of C40 compressor parts.
Hardware	Kuka KMR, Ultra Wide Band for localization
Software	ROS, CaSaDi, OpenCV
Standards	ISO/TS 15066:2016
Possible benefits	Mobile collaborative robots allows to deploy robotics in manufacturing operations beyond the reach of current robots. Their required sensing systems allow to realize autonomous and agile production systems which are able to cope with variability.
Partners	Flanders Make (Belgium)
More info	Asad Tirmizi, asad.tirmizi@flandersmake.be

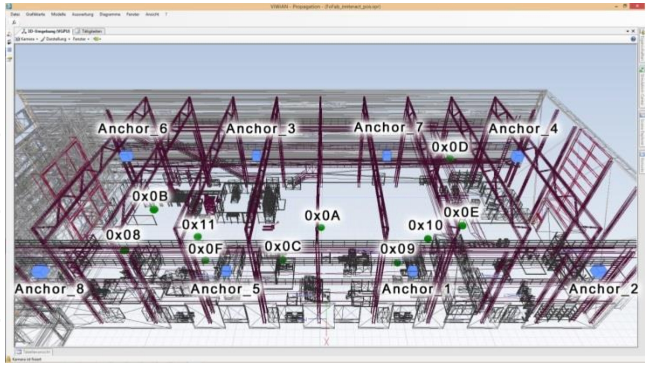
Use Case 14: Agile Manufacturing System (AMS)

Problem/goal	Development of system level solutions for more agile production. Core: manufacturing intelligence. Context: metal cutting processes
Potential users	SME- and large metalworking manufacturers dealing with challenges related to economically feasible manufacturing of lot-size-one.
NACE	C28, C29, C30
Description	Building enablers for economically feasible lot-size-one manufacturing, case: robotized manufacturing cells and –systems. Ability to adapt automatically to manufactured products and production lot-sizes: • HW: Adaptability and flexibility of physical elements • SW: Mfg. Intelligence for part handling applications (process plans, process control parametres, resource capability and scheduling management) • Interfaces: Interface like process parameter transfer from CAD/CAM and Digital Twin (mfg.) Ability to reconfigure and extend delivered automation solution: • Solution HW modularity • Possibility to adapt the control SW to the current HW configuration Human aspect: • Human-robot/system collaboration in mfg. context • Attractive working place of the future
Hardware	Fastems automation HW, integrated HW from third parties according Fastems' open integrator policy
Software	MMS
Standards	Directive 2006/42/EC, ISO 10218-1/2, TS-15066, ISA-95
Possible benefits	Solution blocks to be developed are enablers for economically feasible lot-size-one manufacturing
Partners	Fastems Oy Ab (Finland), Tampere University (Tampere)
More info	Harri Nieminen, harri.nieminen@fastems.com

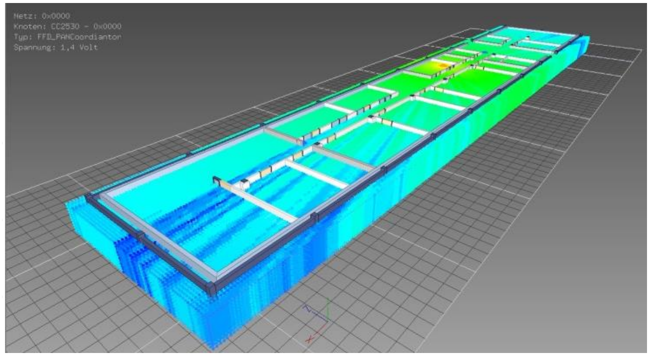


Use Case 15: IIoT Robustness Simulation

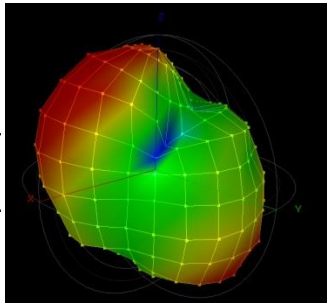
Problem/goal	• Increase robustness of wireless networks in production/IIoT environments • Put wireless networks faster into service • Enable SMEs to build up robust, reliable, cost- and time-efficient IIoT infrastructure
Potential users	Integrators of wireless networks in IIoT environments, IIoT manufacturers, researchers
NACE	C33.2 Installation of industrial machinery and equipment J61.2 Wireless telecommunications activities
Description	Wireless networks (WN) are essential in production/IIoT environments. Mobile robots, edge devices, or Automated Guided Vehicles need to communicate. Such networks are prone to physical changes of the environment and cyber attacks. This use case simulates the WN behaviour in IIoT infrastructure and validates it against real environments. The simulation results in an optimal positioning of the network devices and evaluates fallback strategies for cyber attacks.
Hardware	Wireless Sensor Network (IIoT devices)
Software	Software *d3vs1m*
Standards	IEEE 802.15.4 (LR-WPAN), IEEE 802.11 (WLAN), CUDA, OpenCL, web standards (WebGL , HTML5, CSS3)
Possible benefits	Reduction of setup time of WSNs in IIoT infrastructures, Simulation of robustness against wireless communication failures (unwanted system behavior or criminal attacks), Optimization of positioning the network devices (node distribution)
Partners	**Fraunhofer IWU**, LSEC (Belgium), Centria (Finland), EDI (Latvia)
	Jan Reimann, jan.reimann@iwu.fraunhofer.de https://github.com/adriansinger87/d3vs1m



Radio simulation with 18 nodes inside E³ Research Factory



3D radio map in office environment



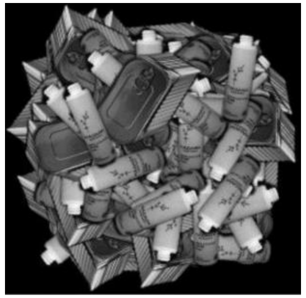
3D simulation of 868MHz PCB antenna

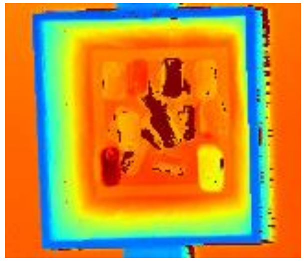
Use Case 16: Flexible automation for agile production

Problem/goal	Plan, design and test flexible devices for fixing, grasping and assembling
Potential users	Integrators of wireless networks in IIoT environments, IIoT manufacturers, researcher
NACE	C26.1 Manufacture of electronic components and boards
Description	Highly flexible solutions for handling and clamping parts during the assembly process are needed to realize small lot sizes with a high variety. Flexible grippers and jigs are a possible solution. Requirements of different product types must be considered while planning, designing and constructing such systems. The main idea is to develop methods for planning and designing such tools and jigs. The use case is demonstrated for the LED-lamp production.
Hardware	Industrial robot arm, vision system (hardware), gripper
Software	Vision system (software)
Standards	C# (ISO/IEC 23270:2006); Computer graphics and image processing - The Virtual Reality Modeling Language (ISO/IEC 14772-1:1997; ISO/IEC 14772-2:2004)
Possible benefits	method to identify and rate automation potential of different work places, solution for creating a highly flexible production system for products in small lot sizes and high variety will be shown, summary of design rules for manual work place design
Partners	Fraunhofer IWU, LP-Montagetechnik (Germany), LSEC (Belgium)
More info	Marcel Todtermuschke, Marcel.Todtermuschke@iwu.fraunhofer.de


Use case at LED-lamp producer

Use Case 17: AI based vision system for object detection, recognition, classification and pick-up by a robotic arm



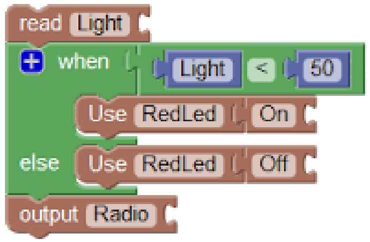


Problem/goal	Automation of industrial processes involving large number of objects with unpredictable positions.
Potential users	SMEs willing to optimize the production process by using AI based robotic arms.
NACE	C32 - Other manufacturing
Description	A lot of industrial processes involve operation with large number of different objects. It is hard to automate these kinds of processes because sometimes it is impossible to predetermine the positions for these objects. To overcome this issue, we integrate 3D and 2D computer vision solutions with AI and robotic systems for object detection, localization and classification
Hardware	RealSense, Microsoft Kinect V2, Bumblebee, Proximity sensor, Universal Robots UR5
Software	Open source software (ROS, TensorFlow)
Standards	Considered: Python, OpenCV
Possible benefits	Provided algorithms and methods, which are based on AI, will allow to generate labelled data for various objects a lot faster with reduced amount of manual work allowing faster adaption of system which is capable of randomly dropped object detection, recognition, classification and pick-up by a robotic arm for different scenarios.
Partners	EDI (Latvia)
More info	https://www.youtube.com/watch?v=aovhtCX4aiM&t Kaspars Ozols, kaspars.ozols@edi.lv

Use Case 18: Rapid development, testing and validation of large scale wireless sensor networks for production environment

Problem/goal	To decrease time to market for large scale WSN implementation in production environment.
Potential users	SMEs willing to increase the performance of their production/manufacturing equipment by using wireless sensor networs (WSN).
NACE	C32 - Other manufacturing, J61.2 - Wireless telecommunications activities
Description	EDI testbed will allow to smoothly pass from one development stage to another (e.g. from lab to industrial environment). EDI TestBed is located in EDI premises in Riga, it consist of 2 parts: 1. EDI Indoor WSN TestBed (100 nodes) and 2. EDI mobile WSN TestBed (50 nodes) EDI Indoor WSN TestBed. EDI indoor WSN TestBed is a 100+ node heterogeneous WSN testbed. EDI mobile WSN TestBed has the same capabilities as EDI Indoor WSN TestBed only it is not “tied” to one location and can be moved to actual factory, to perform the tests in real productionenvironment.
Hardware	EDI TestBed, EDI mobile TestBed
Software	Custom EDI SW (OpenWRT, MansOS)
Standards	Considered: IEEE 802.11a/b/g/n/p, IEEE 802.15.4,
Possible benefits	The experiment contributes to reduce time to market for large scale wireless sensor networks envisioned for use in production environment. It is expected to reduce development time by 20-30% and testing/validation time by 60-70%.
Partners	EDI (Latvia)
More info	https://www.dropbox.com/s/nz2ehraxieuz7ed/EDI_TestBed_leaf.pdf?dl=0 Kaspars Ozols, kaspars.ozols@edi.lv

MansOS
Portable and easy-to-use WSN operating system



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