Intelligent Reconfigurable Machines for Smart Plug&Produce Production

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I-RAMP³

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Final Report Summary - I-RAMP³ (Intelligent Reconfigurable Machines for Smart Plug&Produce Production)

Executive Summary:
The vision of I-RAMP³ is to enable the European industry towards smart manufacturing systems in conventional production. The project aims at creating innovative solutions in order to improve the competitiveness for this industry sector. This goal will be reached by a new concept for fast and optimized ramp-up and operation of production lines with heterogeneous devices. By this, significant reduction of time and efforts during the setup and re-configuration of production will be reached. At the same time, production costs will be reduced by increasing the efficiency of manufacturing.
This challenge will be tackled by the introduction of the so called NETDEVs. This new kind of agent-based production devices is equipped with standardized interfaces and standardized communication protocols as well as self-descriptive capabilities. Furthermore, NETDEVs are able to optimize themselves to varying setup of production and production conditions by negotiating with each other. A plug-in concept of different models allows for easy extension of NETDEVs for maintenance and re-use purposes. By revealing hidden features I-RAMP³ technology is able to multiply the usability of conventional devices.
The I-RAMP³ concept covers also new approaches for the smart introduction of intelligent sensors and actuators as they play a significant role in future smart factories. Such systems will be equipped with standardized interfaces and advanced communication skills in order to improve plug&work.
The holistic concept of I-RAMP³ for enabling future smart factories is completed by the introduction of knowledge-based modules for Manufacturing Execution Systems. The additional features of the I-RAMP³ approach allow for increasing flexibility and fault-tolerance during production.
Having I-RAMP³ technology available, a significant step towards plug&produce technology as well as better modularity, maintainability and reusability will be made.

I-RAMP³ successfully implemented those objectives in a number of individual exploitable results having a high TRL as well as three industrial Demonstrators. Various devices such as welding controls, servo presses or robots have been equipped with I-RAMP³ technology which allows for fast discovery in a production network, self-description and rapid parametrization. Sensors and actuators have also been featured with enhanced communication capabilities which support fast plug and produce, dynamic sensor

group formation and much more. Additional modules for a MES allow for workflow optimization and for easy interfacing with ERP systems.
The I-RAMP^3 results and Demonstrators have successfully been shown during a public event. The very positive feedback by project externals complemented the more than satisfying results.

By this, I-RAMP^3 achieved its overall goal: Contribute to the transition of the European manufacturing industry and especially SMEs into knowledge-based business.

Project Context and Objectives:
European industry is facing many new challenges. Cost pressure from emerging countries in Asia and South America forces the European industry to think over the costs of their products while keeping and leveraging the high quality standards at the same time. Customization and make to order needs lead to smaller lot sizes and requires highly flexible production systems and intelligent, self-adaptive devices, which can be brought to operation by just inserting them into the production network.
To make machine and component self-adaptive and to avoid or shorten the setup of machine configuration and parameterization, specific knowledge needs to be implemented in machines and components. Only machines, which are capable to understand their process, can support the fast ramp-up of chains or networks, where they co-operate by themselves based on standardized information exchange. Intelligent and flexible production devices are needed which are able to interpret data coming from other processes in order to perform process optimization by the usage of proactive models. Sensors need to be faster deployed and provide complex data. Advanced data analysis and decision-making tools are needed in order to guarantee process optimization also for small batch series. Processes need to align with each other in order to find the best controls settings.

The vision of I-RAMP^3 is to enable zero ramp-up time integration of additional capabilities in existing and new production networks by task-driven “on the fly” cooperation of plug&produce devices. To do so, I-RAMP^3 proposes the transformation of production equipment into Network-enabled Device Structures (NETDEVs), which form the plug&produce building blocks of a heterogeneous production network. NETDEVS allow the flexible creation of production networks, which operate by intra-device and global optimization mechanisms.

To achieve the transformation of production equipment into NETDEVs, the I-RAMP^3 approach as a whole will be based on three main ideas. First, I-RAMP^3 will develop the NETDEVs concepts as well as real-life joining, automation and sensor Plug&Produce devices, which are wrapped in a NETDEV shell. Due to their built-in intelligence, these devices will provide to production system integrators and end users a direct benefit for integration and configuration. This has full impact also in “conventional” manufacturing systems, without dependencies on any other of I-RAMP^3 developments. However, the full potential of the I-RAMP^{3}approach will only be realized, if (1) these NETDEVs are embedded in the I-RAMP^3 Plug&Produce Communication Framework, which allow them to interact with each other based on standardized documents, and (2) they are equipped and supported by cross-device configuration, validation & optimization modules.

In order to realize the main ideas of I-RAMP^{3}described above, the project will target five S&T objectives:

S/T (1) Plug&Produce devices with built-in intelligence (NETDEVs agents) for fast exchange of components

Target of this S/T objective is to establish agent-based plug&produce devices for smart factories, which can be exchanged and adapt with at least 50% less configuration and customization effort. To do so, these NETDEVs shall describe and optimize themselves towards their environment by providing knowledge and models about their properties, abilities, constraints and re-use abilities (device self-description). Furthermore, they shall have the ability to (1) perform condition monitoring and maintain a device history, (2) interpret and execute tasks (process model), (3) optimize process and expose abilities (optimization model) and to (4) predict its maintenance requirements (maintenance model). The NETDEV concept will therefore allow component and system integrators suppliers to built-in expertise into their devices.

S/T (2) Sensor and Actuator Middleware for rapid factory integration

Target of this S/T objective is to incorporate sensors as ‘special’ NETDEVs, which transform measurement data or higher-level information to higher quality level and are easier to integrate and exchange due to their built-in intelligence. This makes deployment and integration of complex or autonomous sensors more efficient, and will reduce the integration and configuration effort by up to 50%. In addition, the flexible creation of “virtual sensor” will be enabled, which can be configured from a number of sensor NETDEVs (representing dedicated sensor devices or sensor components of existing equipment). These virtual sensors shall expose a complete overview of all its sensed data, and enrich it with inherent knowledge (e.g. interrelationships of measurement data). This will allow to assembly intelligent and complex sensor units based on (1) simple, low-cost sensors and (2) existing sensors, which are integrated in equipment. As a consequence, hidden system capabilities can be revealed and utilized without any additional cost. This will allow more performing process monitoring, root cause reasoning and further analysis (e.g. for maintenance).

S/T (3) Plug&Produce Communication Framework for heterogeneous devices

Target of this S/T objective is to transform the interaction between devices towards a real-time and document-based communication. This communication between devices will cover documents for task description, self-description and result description. A standardized communication protocol, the Device Integration Language (DIL) based on XML schemes, will be developed. This language will be extensible and flexible and covers all mentioned document types. As a consequence, the inter-device communication will be human-understandable, based on standards (XML) and easier to adapt and extend by device manufacturers and system integrators. Therefore, this S/T objective will reduce the adaption effort for devices to specific production systems towards zero.

In addition, the communication framework will support the constant negotiation between devices during ramp-up and operation phase. This enables information exchange and adaption of devices in case of changing process conditions, without requiring an interruption of the production process. This will lead to a reduction of productions downtime during ramp-up by approx. 20-40%. Furthermore, the Plug&Produce Communication Framework will contain end user interfaces as integrated modules, which supports the engineer to perform their work for configuration and optimization of production systems.

S/T (4) Intra-device and global optimization models for automated device configuration

Target of this S/T objective is develop optimization models, which are applied inside NETDEVs for local optimization as well as global optimization models, which can be applied across the entire process-chain.

This will lead to a fully automated device configuration considering the entire process chain.
The intra-device optimization approach follows either a general cost minimization objective or can follows specific cost function based on a cost function document, which shall be provided via the communication framework. In the latter case NETDEVs need to control the process in a way to minimize the total cost, which is the sum of process and result cost. A global optimization engine “Workflow Optimizer” will manage this process wide optimization. The optimization shall be commenced with the latest NETDEV in the workflow. This device will perform an optimization and then provide input to the predecessor until the first process is reached.
Hereby, the S/T objective will achieve that devices can be automatically optimized based on built-in intelligence (intra-device optimization models) as well as towards process-chain wide optimization criteria. This will strongly reduce the expertise and time required for system configuration and customization by approx. 50%, and will lead to higher process efficiency in versatile production systems.

S/T (5) Enabling commercial Manufacturing Execution Systems to optimize workflow during ramp-up
Target of this S/T objective is to enable the optimization of workflow during the ramp-up of new production systems and in case of fast changing production systems. This shall not be done by replacing existing Manufacturing Execution Systems and SPC solutions, which are performing well in stable production settings. Instead I-RAMP^3 will complement the capabilities of MES for ramp-up and re-configuration phases, when no sufficient production data is available to perform conventional workflow optimization.
This S/T objective shall be achieved by introducing Process Analyzers and Workflow Optimizers between the NETDEVs at the MES layer. I-RAMP^3 will supply the Process Analyzers with the capabilities to interpret the result description documents of the NETDEVs and to analyze them according to rules, which classify the results. The classification results will be forwarded to the Workflow Optimizer, where they are assessed by a rule-based knowledge system. The latter decides on re-configuration, modification of workflow and maintenance. The optimized workflow configuration is forwarded to the MES. I-RAMP^3 will create the according interpretation and knowledge systems. Hereby, the workflow can be optimized already in the early phase of the ramp-up as well as during the operation phase of highly volatile production systems. This will reduce the time to full production output by approx. 30%.
Project Results:
The main S & T results and foregrounds have been developed within a set of 9 workpackages. In the following sections, the workpackage contents and the respective results are described.

In WP1, the industrial requirements and use cases for fast ramp-up and flexible production have been gathered. To do so, this work package established but also continuously supported the I-RAMP^3 developments by providing a solid base of industrial motivation and business regulation of the invented I-RAMP^3 methodologies and instruments.To do so, questionnaires have been developed and intensive bilateral discussions with all industry partners have been initiated by partner IPA. Even though the I-RAMP3 partners are situated in quite different (industrial) branches, a good alignment of the general scope of the project’s activities and goals has been reached. The results of those activities are documented in Deliverable 1.1 “Industrial requirements and use-case description”. After the finalization of the requirements, the basic concepts and the I-RAMP architecture has been defined. Standards have been reviewed and the best-fitting have been used and adapted according to the needs. The results of those activities are documented in Deliverable 1.2 “I-RAMP^3 architecture document”. In order to guarantee a smooth take-up of the technology in the project and in order to involve all partners during the concept’s

finding phase, activities on constant knowledge transfer (Task 1.3) have also been carried out. This task aimed for fostering a constant exchange of ideas and best practices between the partners, developing best possible implementation concepts for different topics of common interest, leveraging I-RAMP^3 S/T objectives by creating a common sense and joint understanding of approaches and methodologies, and developing implementation policies for transferring the best-practices to other fields of application. After significant progress in conception, definition, and fixing of content which has been executed and fostered by the partner SEZ, the activities concentrated on the execution and evaluation of three workshops.

Main results:
D1.1 Industrial requirements and use-case description
D1.2 I-RAMP^3 architecture document
D1.3 Report on Best Practices and implementation policies

WP2 was dedicated to Standardization, Knowledge Management, Exploitation, Dissemination. Furthermore, this work package provided an active management of intellectual property (IP) as a basis for mutual trust within the consortium in order to perform any exploitation and dissemination activities.
Main activities performed concentrated on the creation of a project corporate identity and all related promotional material. Furthermore, the I-Ramp3 partners participated to a number of national and international events. During the first project period I-RAMP3 started to actively network with other related EC funded projects in order to explore the potential of future common activities and the exploitation of synergies. In addition, activities were initiated through formalities, first awareness raising among the consortium on IP issues and the correct handling of delicate information. An Exploitation seminar has been performed in parallel to the 12 month meeting. A first list of Exploitable Results has been compiled. By month 18, the list has been revised and refined.
The dissemination of project activities and progress (2.1) was consequently continued by several activities (project networking, newsletters, 5+6, press releases, fairs + conferences visits, monitoring of performed activities, Industry contacts, organization and implementation of final event (D2.7) give-aways, Video, PUDF update) in the second period. Especially the planning and preparation of the final public event was a central activity within the last month. From the very beginning, the event was planned as an industry event with the main goals for results dissemination and exploitation. Further to this, the management of IP issues (2.2) was also continued and exploitation activities have been enhanced (by the activities Monitoring of IP interests, revision of publications, IP issues for cross-project dialogue and 3rd + 4th IPR/exploitation workshop. 3rd + 4th IPR/exploitation workshop, results characterization, observe relevant technologies & project activities, assess exploitation plans of non-owners or co-owners, Exploitation plans for high TRL results, PUDF update). Training material has been prepared and internal as well as external training sessions (e.g. with students of the University of Applied Science, Karlsruhe Germany) have been performed. In T 2.5 Standardization of I-RAMP^3 technologies, several discussions on ways of harmonization of technological approach as used in I-Ramp^3 through an open license scheme, the definition of the content, elaboration of brand visuals (in collaboration with 2.1) and assess further potential ways towards standardization (potentially through cluster) have been done.

Main results
D2.1 I-RAMP^3 Corporate Identity
D2.2 IPR Report

D2.3 Technology Implementation Plan
D2.4 Report on training activities
D2.5 a, b Report on standards (a) used and (b) generated in I-RAMP^3

In WP3 the communication framework for heterogeneous devices. Has been developed. It aimed on realizing an IT infrastructure, which is complementing existing factory backbones and machine concepts in the industries. It shall build on top of the strengths of existing standards for factory automation such as Ethercat, Profibus, Open Process Connectivity (OPC) and shall interface manufacturing execution systems (MES). It will realize a layer-oriented communication scheme allowing interfacing heterogeneous devices having different communication capabilities. In addition to this, it shall enable negotiation between devices in order to find optimal device setup during the ramp-up phase of production. Furthermore, it realizes a model-driven communication. The link to the grid of sensors will be established.

As the communication framework is a central activity within the project, the requirements from almost all partners have to be taken into account. Further major activities concentrated on the definition of the communication mechanisms for the I-RAMP devices (NETDEVs). Standards for communication have been reviewed and UPnP has been selected to serve as a basis for future developments. The UPnP technology was tested and approved, and implementation of NETDEV templates and communication interfaces were started. After analysing existing Device Description Languages, NETDEV communication generic structure was defined, and the DIL was implemented. NETDEV Self-description Document (NSD), Task Description Document (TDD), Task Fulfilment Document (TFD) and Quality Result Document (QRD) structures were created, and are used. Negotiation requirements were collected, process chain optimization was analysed, communication and negotiation requirements were identified and formalized, and implementation is included in the NETDEVs with specific requirements. An extended NETDEV categories list was defined for further use. For the HMI, requirements were gathered, and the implementation of HMI was started with C# WPF technology. A prototype was presented showing the statuses of the NETDEVs, using the DIL as communication language, and the first tasks were executed successfully.

Main results:
D3.1 Device communication layers and communication protocol definition
D3.2 Device Integration Language definition
D3.3 Negotiation mechanisms definition for highly adaptable devices
D3.4 Graphical wizard for device integration

WP4 concentrated on the development of Plug&Produce devices for fast ramp-up and flexible production. To do so, a model of the NETDEVs and its components will be developed and checked against the overall requirements gathered in WP 1. At the end of the first step, a template for a NETDEV will be available. After that, a NETDEV based on a Harms&Wende welding device and a NETDEV based on IEF automation component will be developed.
The main activities within the first period concentrated on comprising the analysis of requirements, the definition of a commonly usable software architecture, the definition of general software components and the specification of hardware platform for prototype implementation. The activities are good in time. Deliverable 4.1 “Architecture Framework for NETDEVs” has been submitted without delay and also

Milestone MS5 “Architecture framework finalized” has successfully been reached. Implementation templates have been developed which serve as a basis for the NETDEV development. An easy to use graphical editor is available which makes it easy to instantiate NETDEVs for different purposes. The results are documented in Deliverable D 4.2 “Implementation template for NETDEVs”. The work is very good in time first prototypes of dedicated NETDEV devices of different partners are already available. Milestones MS5 and MS6, which are related to the NETDEV development, have successfully been reached.
In the second period, HWH defined a storage process for multiple storage devices in the network and created a first prototype of the Storage NETDEV. In addition to that, the prototype of the Welding NETDEV which was presented during the 18 month meeting was further improved. AWL finished implementing the required communication between the Siemens PLC and the Cell NETDEV. By implementing the NETDEV template from task 4.2 the Cell NETDEV can now set configuration items and execute task in the PLC. In September 2014 AWL organized the 3rd Hackfest in Harderwijk. On this Hackfest AWL supported the development of the NETDEV template and updated the Cell NETDEV implementation. AWL also started working on the Robot NETDEV for an ABB Handling and Welding robots. TNX developed its own NETDEV which main aim consists in the retrieval of a big amount of data during the welding process. IEF is responsible to develop and build up a NETDEV for a servo press for which a first demonstrator has been implemented. To do so, a new servo press was built especially for the test and validation of automatic ramp up and auto tune function. During the period INOS has worked on implementing the NETDEV interface (INOS NETDEV gateway) to its machine vision and factory automation integration framework. INOS has also developed a NETDEV client for getting photometry data from the FEUP sensor gateway and computing an exposure setting to supply to the INOS NETDEV gateway. The IAF main activities concentrated on the contribution of optimization components to the NETDEVs such as specifications of user interfaces or delivery of software and documentation to partners.

Main results:
D4.1 Architecture framework for NETDEVs
D4.2 Implementation template for NETDEVs
D4.3 NETDEV implementation for Harms & Wende and IEF Werner applications

In WP5, the Plug&Produce sensors for fast ramp-up and flexible production have been realized by implementing a Sensor & Actuator Abstraction Middleware (SAAM) which is complementing and extending existing factory automation solutions and concepts in the industries. Having the SAAM, sensors and actuators can be integrated in the I-RAMP^3 approach for factory automation as the SAAM implements the same interface as the NETDEVs do.
In addition to that, a Sensor & Actuator Abstraction Language will be developed. This aims to connect such sensor and sensor grids to the SAAM, which resources allow for more sophisticated interface implementation as low-level sensors and actuators do.
The WP5 will follow up the gathering of industrial requirements and overall architecture and data model definitions (WP1) and the initial definitions of the communication approach (WP3). It will realize new IT systems, which will be compatible with existing installations in the factory.
The objectives of the first reporting period comprised the specification of the Sensor and Actuator Abstraction Middleware (SAAM) overall concept and internal building blocks, the specification and documentation of the SAAM interfaces as well as the implementation of SAAM. Those objectives were

fully met and led to the main achievements of a sensor & actuator architecture and a software demonstrator. An improved version of the software demonstrator and hardware demonstrator has been shown at the 12 month meeting. Further development concentrates on the definition and implementation of the Sensor and Actuator Abstraction Language (SAAL). Specifications and example implementations are available.
The major objective of the second period was the implementation of sensors for metrology applications based on I-RAMP3 technology. Besides this, the exploration of sensor inclusion on the I-RAMP3 Demonstrators has been worked out partially. Furthermore, a refinement of the Sensor & Actuator NETDEV Template – turn sensors I-RAMP3 compliant, implementation of the Sensor & Actuator Group Formation and investigation of Sensor Data Validation techniques and the development of a Graphical User Interface for the Sensor & Actuator NETDEV Group Formation has been done

Main results:
D5.1 Sensor and Actuator Abstraction Middleware
D5.2 Sensor and Actuator Abstraction Language
D5.3 Sensor for metrology applications based on I-RAMP^3 technology

WP6 was dedicated to the enhancement of Manufacturing execution system for fast ramp-up and flexible production. In I-RAMP^3 a new integrating approach for collection, matching, weighting and combination of the different “ingredients for knowledge creation” shall provide a new quality in flexibility and an increase of efficiency. An approach will be developed that allows collecting the different resources of knowledge in a highly flexible manner as well as to assess and validate knowledge, and subsequently draw conclusions on possible required reactions on it. Reactions might be re-organization of production flow, introduction of new devices/NETDEVs, maintaining of equipment, etc. It is expected that the process of creating, combination and internalization of information will run quite similar to the iterative methodology being introduced in WP 4 (according to the Spiral model by Garry Boehm in 1988).
From the technological point of view this work package is dedicated to the development of building blocks and the set-up of an integrated Intelligent manufacturing support system. A plug-in concept for the Process Analyser and the Workflow Optimizer and the interfaces to the MES systems has been developed. The WP6 partners decided to implement also an interface to an ERP system.

Main results:
D6.1 I-RAMP^3 Workflow Engine
D6.2 I-RAMP^3 Process Analyzer
D6.3 I-RAMP^3 Workflow Optimizer

In WP7, methods for Configuration & Optimization for fast production ramp-up were developed. The methods will integrate in the NETDEVs (WP4). A novel approach will decompose nowadays complex and non-modular algorithms into sets of individual models; which in turn will increase reusability of existing models for various aspects the control. A coordination of these models will allow for solution finding and distributed optimization of process parameters of one NETDEV and also along the whole process chain. The models will be able to work independently from each other. According to the definition of the NETDEVs, the following models will be developed:
(i) Parameter optimization model, (ii) Process model, (iii) Sensor models, (iv) Quality model, (v)

Maintenance model, (vi) Task-interpretation model, (vii) Internal state representation, (viii) Condition monitoring model and (ix) Visualization.
This workpackage started with the design of a plug-in architecture for model integration. During this phase, also the requirements and expectations of the partners related to the optimization opportunities in production ramp-up have been gathered. In this context it has been realized, that covering all potential tasks will be very challenging. For that it was agreed to concentrate first on a sub-set of potential objectives in order to minimize the risk of a too wide scope. The main activities and results in the second period concentrated on the industrial realization of the objectives mentioned above.

Main results:
D7.1 Design of plug-in architecture for model integration
D7.2 Basic process and quality models
D7.3 Ramp-up optimization model
D7.4 NETDEV downstream optimization

The Demonstration and validation activities were performed within WP8. This work package takes up the efforts of all developments and convey them to well-defined added values for European manufacturing industry. In order to focus the activities and goals of the several developments, task 8.1 has been executed which deals with the definition of potential scenarios and use-cases for the final demonstrators as well as with the definition of quality goals for the demonstration activities. In order to include the requirements and expectations of the industrial partners on the I-RAMP3 technology, a very detailed survey and analysis of the quality goals has been done. After that, the planning for the demonstrators in a professional, industry-driven manner. For the coordination of the planning, the Hackfests and the general project meetings to establish the definition and scope of the demonstrators have been used. The Demonstrators will be located at AWL (Harderwijk, Netherlands), TECHNAX (Lyon, France) and IEF Werner (Furtwangen, Germany). For all Demonstrators, detailed mechanical and electrical drawings are available. Furthermore, timings for the integration of the several prototypes for the partners into the physical demonstrator setups have been worked out. The final activity of this workpackage was the finalization of the basic hardware and software of the Demonstrators and the integration of the tools developed within the RTD workpackages. In addition to those technical preparations, also a story board has been developed in order to explain the goals and benefits of the I-RAMP technology to a broad audience.

Main results:
D8.1 Definition of quality goals for demonstration scenarios
D8.2 Demonstration towards set-up and ramp-up of a new E-Vehicle assembly line
D8.3 Demonstration towards Component exchange in E-Vehicle subassembly unit
D8.4 Demonstration towards Enhancing device with re-use and predictive maintenance capabilities
D8.5 Report on results of validation against internal and external end-users and the Industrial Advisory group

WP 9 is the management workpackage which aims on ensuring an efficient and pro-active coordination of the project by administration, organisation and monitoring of the technical, administrative and financial components of the project. A common set of rules and structures for the communication inside (project management tool, intranet) and outside the consortium will enable the flow of information and knowledge

needed to implement a robust monitoring process. Thus, the following objectives were envisaged:

• Smooth and effective collaboration within the consortium
• Delivery of deliverables and milestones in time
• High quality of the project results
• Tracking and effective mitigation of risks
• Anticipation of unexpected developments or new opportunities
• Prevention and resolution of problems and conflicts
• Effective management of project budget and expenditure

Main results:
D9.1 Consortium Agreement
D9.2 Intranet and data repository
D9.3 Midterm Report
D9.4 Final Report
D9.5a,b,c,d Interim Progress Reports

Potential Impact:

The I-RAMP^3 project will strongly reduce the required time, cost and expertise for ramp-up and reconfiguration of assembly systems. This will be achieved by developing (1) Network-enabled Device Structures (“NETDEV”), (2) a Plug&Produce Communication Framework, as well as (3) Configuration and Optimization methods and tools, which will be the main enablers to achieve a knowledge-based business approach for SMEs in the manufacturing sector.

The project will address the ramp-up phase for new assembly systems and the recurring installation & configurations of new elements during the operation phase as well as the maintenance of these elements. With respect to the ramp-up phase, I-RAMP^3 supports a fast integration of a high variety of components into specialized assembly systems and its commissioning and ramp-up, while strongly reducing effort and expertise required. With respect to the operating phase, the project’s developments will support a faster integration and configuration of new elements such as components and sensors into assembly systems. Furthermore a continuous monitoring of the production parameters and context through the communication framework and the NETDEVs will permit to achieve an intelligent maintenance plan and an optimal re-usability of the production systems and components. As a consequence, the project will also allow end users to adapt and optimize their assembly systems with less effort and expertise. Thereby a more cost-efficient operation mode of assembly lines under changing conditions is enabled by I-RAMP^3.

In addition, the I-RAMP^3 project will contribute to the transition of the European machinery industry and especially SMEs into a knowledge-based business, and thereby generating added value and a competitive advantage with respect to Asia, USA and new emerging economies. This will be supported by:
• Allowing component suppliers & system integrators to integrate knowledge in NETDEVs
• Making hidden knowledge of NETDEVs available for factory optimization / reconfiguration
• Allowing component suppliers & integrators to provide optimization services to end users

The NETDEVs possess the latest available expert knowledge about incorporated components and sensors, which will be (logically or physically) stored at the NETDEV. The added value generated by the inclusion of “expert knowledge” in the system improves the competitiveness especially of specialized SMEs, which turn from component producers to knowledge suppliers offering services and providing benefits (→Achievement 6).
European manufactures need to provide higher-quality products to their customers to compete with low cost competitors. While hardware is still an important factor, it offers limited potential for market differentiation in the future. In contrast, the I-RAMP^3 approach to “embed knowledge” in component and systems offers a big potential for European manufactures to keep and extend their market share, which will then lead to maintain or increase employment in Europe.

Regarding the safety of working staff and the human-machine interface, I-RAMP^3 means another important step ahead. The I-RAMP^3 support for ramp-up and integration of new elements in systems will significantly reduce the need for manual operations at the machine and thereby reduce the risk of safety issues and improve the ergonomy. The risk of entering wrong data items, causing erroneous system behavior during ramp-up will be mitigated by the optimization and configuration capabilities of the NETDEV concept. In addition, all interfaces of the I-RAMP^3 software tools, especially the wizard for component integration will be designed for user-friendliness and include error indications.

I-RAMP^3 will increase the re-usability and maintainability of components by their capability of process history storing and condition monitoring. Therefore, the life-time of components and machine will be increased, which leads to less waste. The self-description of the NETDEVs will include recycling guidelines to ensure that this information is always directly accessible and can therefore be following by end users. In addition to that, the process optimization capabilities of the NETDEVs allow for environmental-related optimization goals such as minimum energy consumption or minimum pollution generation.

In order to stimulate the partners to take an active role in the dissemination activities, they will be involved in the creation of a Roadmap for Dissemination. For the first half of the project the overall objective of the dissemination activities will be to create interest in the project within the scientific community and in the manufacturing industry. Thus in the first version of the roadmap the partners will define when and how they will engage in general dissemination activities such as presenting the project on their websites, in in-house and external fairs, newsletters and annual reports. Later on in the project the Roadmap for Dissemination will be updated taking into account the publication of scientific publications, presentations at conferences, dedicated presentation for the industry alongside of in-house fairs.
For the last year dedicated workshops alongside in-house fairs and training courses for students will be incorporated in the dissemination strategy.

The Roadmap to Dissemination will include the following means with respect to the different target groups of the dissemination activities:
At the Industrial level: An Industrial Advisory Group will be created at an early stage in the project to disseminate the results and to provide early commercial uptake. In addition, general information on the project will be available via the project website, flyers and articles in partners’ newsletters. As soon as specific (intermediate) results are available which are of interest for exploitation, targeted dissemination

activities will be performed. Stakeholders and potential customers will be invited to participate in dedicated events alongside in-house fairs and general exhibitions and conferences, thus being able to address a large number of specialists.

At the Scientific and Academic level: The scientific breakthroughs will be communicated via publications in peer reviewed journals and world-class conferences. The university partners FEUP and IAF will integrate the I-RAMP^3 results into university courses in the field of manufacturing. This will enable the immediate involvement of the next generation of engineers into the latest technologies of modern manufacturing. IPA, FEUP and IAF are planning to have doctoral thesis on the research topics.

At the Public level: General information on the project will be disseminated by the partners in order to promote the technology to the wider community by engaging the attention of the professional media, press, radio and TV.

Web site: The I-RAMP^3 web site will be a major dissemination vehicle for project, technology and product announcements. A part of the website will be available for public access. It will contain information on the project partners, an outline of current research activities, and a calendar of events. In addition, a secure section of the site will enhance inter-working between the project partners.

Co-operation between the partners during and after the end of the project plays an essential role in the successful exploitation of the technology innovations. It is necessary to show for each partner and especially for the SMEs, how they will benefit from the innovative results of the I-RAMP^3 project and how they can integrate these results in their future commercial products.
In a first step, the rules for the distribution of the Industrial Properties Rights (IPR) were elaborated in a consortium agreement in order to define a first Exploitation Strategy for the consortium, which will be the basis for the development of an exploitation plan. A knowledge database will be established and updated with the knowledge generated, used and disseminated in the course of the project. This will form an essential input in the Exploitation Plan.
In a series of exploitation workshops (official EC session will be requested for M12; further sessions by SEZ) the partners will identify which results they are interested in to exploit. This foreground will be analysed in detail with respect to the holders of the included background IP as well as the partners' contributions and different exploitation interests. Based on this the partners will prepare separate agreements considering access rights to knowledge for use outside the project by defining the terms and conditions of this use. However, when inventors are unable themselves to exploit knowledge they have generated in the project, they will be encouraged to license the knowledge more widely to ensure maximum exploitation of the project's results. The consortium is very aware of the need that the maximum amount of information generated during the project will be disseminated to the appropriate stakeholders, provided that this does not damage partners' industrial competitiveness or harm any intellectual property applications.
List of Websites:
I-Ramp3 website: www.i-ramp3.eu/
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