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Project acronym: I-RAMP[3]

Project title:

Intelligent Reconfigurable Machines for Smart Plug&Produce Production

Instrument: Collaborative Project

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Deliverable 1.1

I-RAMP[3] - Industrial requirements and use-case description

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Change Control

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1. Introduction

1.1 General description of the project

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. Additionally, a plug-in concept of different models allows for easy extension of NETDEVs for maintenance and re-using 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 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.

1.2 Purpose of this document

This document aims to establish a solid base for industrial motivation in context to invented I-Ramp³ methodologies and instruments. Considering practicable use cases, scenarios, and constrains it provides a solid foundation for research and evaluation of applicable solutions which strongly comply with industrial needs.

Focussing on constant improvement of concept it enables continual exchange of ideas and best practices between all participants within the project.

The range of requirements contains SMART (see chapter 5.4) requirements from all partners of the consortium which participate in the development of methodologies, devices, and solutions. This includes industrial partners, software providers, academic partners, as well as experienced external technical advisories with a strong industrial background.

By using a formalized requirement engineering process according to IREB (**I**nternational **R**equirements **E**ngineering **B**oard)-Standards, requirements will be gathered, consolidated, prioritized, documented and assigned to work packages. All requirements will be communicated, discussed and evaluated with all partners to ensure a common acceptance within the consortium of the I-Ramp³ project.

In order to keep requirements up-to-date and additionally to constantly increase the level of detail, the process of requirement engineering is being executed and maintained over the period of the project.

1.3 Motivation of project partners

1.3.1 Industrial partners

Harms & Wende expects to exploit a welding control unit based on I-Ramp³ technology after further efforts for industrial application.

AWL-Technieks goal is to equip the respective equipment with I-Ramp³ technology in order to gain full benefit of the I-Ramp³ approach.

For **Technax** highly self-adaptive devices for flexible task execution and devices having plug&produce capabilities for fast ramp-up are highly required in order to decrease lot sizes and by that increase numbers of product variations.

The major goal of **IEF Werner** within I-Ramp³ is to enhance their moulding equipment with intelligent features, especially for maintenance and plug&produce issues.

For **INOS** the I-Ramp³ project provides an excellent basis to further improve their software and hardware sensor systems by adding various features and standard interfaces enabling plug&produce for automation environment. Furthermore, INOS is interested in widening their application markets for their products.

1.3.2 Partners for software & sensors

GAMAX plans to enhance the company’s product range and competitiveness in the field of software for production processes.

For **Critical Manufacturing** the I-Ramp³ project will increase their knowledge in system optimization, planning and control systems, development of applications for technical statistics, yield reporting product data analysis, reliability control, and critical applications. Furthermore Critical Manufacturing the I-Ramp³ project provides the opportunity to enhance their MES with additional, intelligent features such as process data gathering, quality control and other features required by industrial customers. This will strengthen its position in the market.

Freedom Grow is very motivated to join the I-Ramp³ project because of the strongly increasing market shares of wireless sensor and actuators. A major challenge is to embed and to ramp-up such sensors in complex manufacturing system with a minimum of time efforts.

1.3.3 Research partners

The innovative I-Ramp³ approach will significantly contribute to the reputation of **Fraunhofer IPA** of being the link between research and industry, especially for SME's.

With the I-Ramp³ approach, Hochschule Karlsruhe Technik und Wirtschaft (**IAF)** intends to extent its role as one of the leading institutes for research in process modelling and process chain optimization in manufacturing systems.

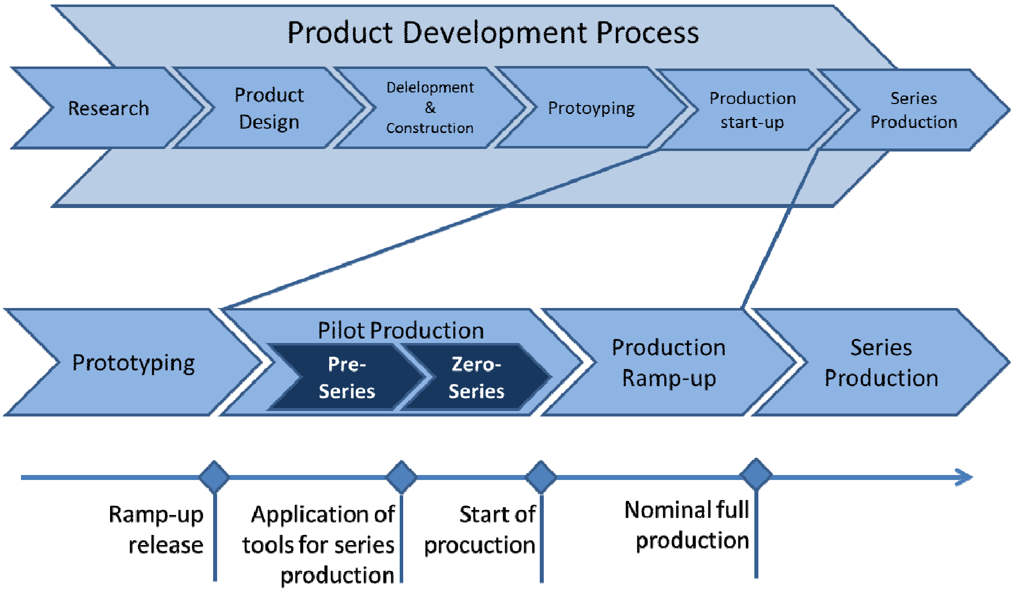
The Faculty of Engineering at Proto University (**FEUP**) – University of Porto aims to strongly extend its experience in the fields of discrete-event systems, hierarchical control theory, and development of advanced information infrastructures for cooperation, as well as in its application to manufacturing systems.

2. Ramp-up – State-of-the-art

2.1 Initial Ramp-up - Definition

A wide accepted definition for ramp-up is to be found in [Terwiesch 2001]: "*The period between the end of product development and full capacity production is known as* production ramp-up*"*.

Graph 1 depicts this definition more detailed. It shows that the process of pilot production, considering pre-series and zero-series might also be an integrated part of the production ramp-up.



Graph 1 – Product Development Process according [Bruns 2001, Page 16]

However, this description does only cover the first ramp-up which follows after the prototype phase. The definition stated by [Terwiesch 2001] does not include ramp-ups which become necessary due to interruptions during full production mode. All scenarios are described in chapter 3.

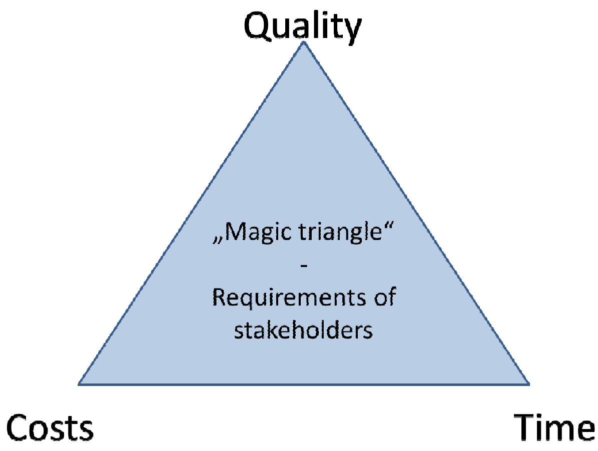
The detailed definition of "Production Ramp-up" is essential as it allows to deduct a clear scope of deliverables, documentations and sub sequentially pre-defined responsibilities. Additionally, previous phases provide pre-requirements to the milestone "Ramp-up release" and by that to the start of production ramp-up. Existing dependencies within single phases but also dependencies beyond the boundaries of single phases have to be considered in the planning and execution of the production ramp-up.

Graph 1 illustrates that Production Ramp-up is an integrated part of the Product Development Process which finishes at the start of series production. However, the process of ramp-up is also executed after the initial installation of the production line. Interruptions at single equipment within the production line e.g. in case of product exchange, tool exchange, or maintenance require a ramp-up procedure in order to return to series production mode. Also temporary suspensions of single equipment or entire production line require a ramp-up in the time has come to re-activate the system.

2.2 Key-Performance-Indicators

Key-Performance-Indicators (KPI's) are essential for defining "SMART" requirements as this information reflect stakeholder's targets and requirements to a production line, or in general to a project.

Additionally to this, KPI's facilitate the definition of assessment criteria during the Acceptance Test and enable effective measurement of the level of achievement of single requirements.



Graph 2 – "Magic triangle" of Stakeholder Requirements [Romberg, Haas 2005, Page 36]

Applicable examples for cost, time, and quality are listed as follows.

For **Costs** in general all relevant types are applicable which are also used for production, e.g. costs for material, personal, logistic, spare- and ware parts, yield, financing etc. Additional type of costs shall be considered in order to response to additional expenses during the ramp-up phase, such as for quality loss, additional travel expenses, lost marginal profit due to lost sales, contractual penalties, etc.

"**Time"** is considered as the period of time needed from "Ramp-up release" to "Nominal full production" is essential. However, additional to the duration of the ramp-up, also an on schedule of milestones within the project plan is essential to avoid potential delays of the ramp-up. In the context of the Product Development Process a differentiation between "time-to-market" and "time-to-customer" has to be done (see Glossary).

Key-performance-indicator covering **Quality** aspects, shall consider as well as the product itself, but also process, service, risk management [Romberg, Haas 2005, Page 44] to achieve Zero-Error-Quality.

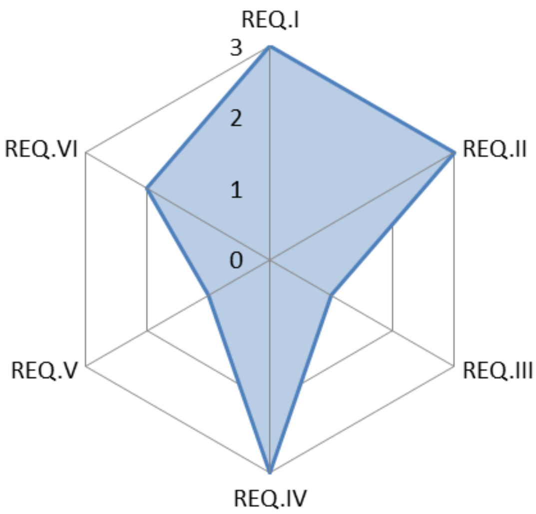
2.3 Current obstacles of the ramp-up

Referring to the [DoW, Part B, Page 2; Fleischer 2004] "82% of manufactures do not achieve their cost, time and quality goals during the ramp-up phase". The causes for delays are manifold. [Romberg, Haas 2005, Page 19 et seqq.] lists major sources as follows:

- Low level of transparency regarding actual project data or insufficient quality and quantity of data
- No indications for upcoming disruptions and insufficient emergency schedule in case of troubles during the ramp-up
- No effective and sustainable project management
- Insufficient knowledge management
- Low level of business processes and workflows documentation
- Missing synchronization of business processes and workflows within the company and/or external partners
- Focusing optimization on single detailed aspects instead on "the big picture"
- Unsynchronized documents (e.g. customer vs. supplier specifications)
- Undefined tasks, competences, and responsibilities
- Low level of efficiency during the progress of ramp-up
- Insufficient communication of priorities
- Increasing complexity of technological and organizational aspects

2.4 Existing approaches in ramp-up management

For each individual aspect of cause of delay the industrial, consulting and academic institutions developed solution to solve one or several of possible obstacles in the process of ramp-up.



REQ I: Documentation of holistic and robust reference structures

REQ II: Mastering of complexity requirements

REQ III: Quality of interfaces between development and production

REQ IV: Integration of logistic- and supplier management

REQ V: Availability of methodical support

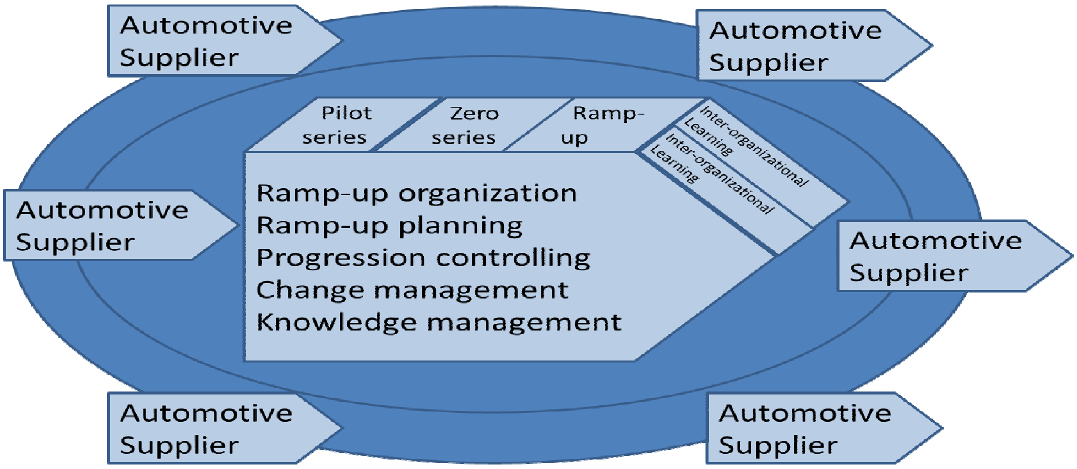
REQ VI. Approach to system integration

1: Low level of achievement
2: Medium level of achievement
3. High level of achievement

Graph 3 – Profile of competences [Bruns 2001 Page 46 from Jabs 2002]

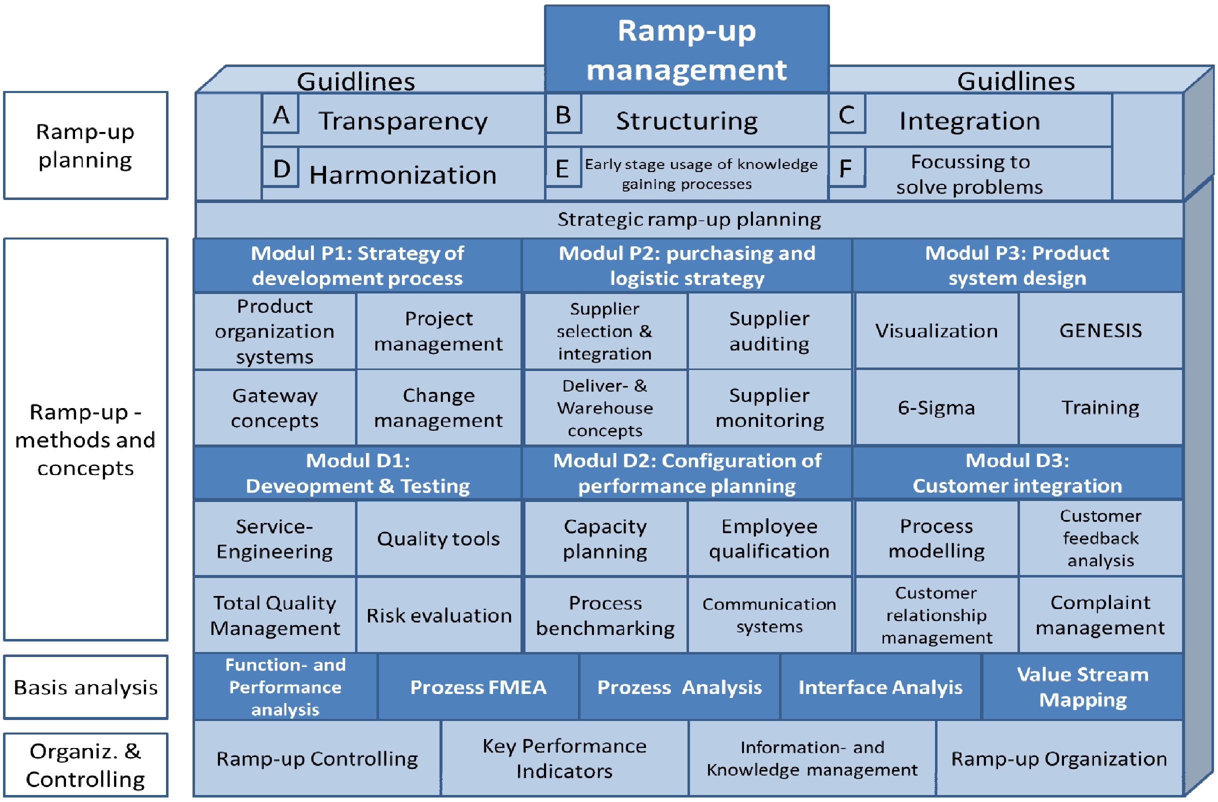
Giving an example [Jabs 2007] describes a method making competence profiles and current status considering quality management of the ramp-up organization more transparent.

Additionally to this several approaches aim to cover several of the challenges listed in the chapter 2.3. A well accepted procedure, especially in the field of automotive industry, is the so called "St. Gallen Ramp-up model". On a high level it depicts planning phases and its dependencies within a ramp-up considering various aspects of the ramp-up of production lines.



Graph 4 – St. Gallen Ramp-up model [Bruns Page 49 from Fitzek 2006]

A more integrated approach which considers also aspects related to risk management, controlling and other relevant instruments is provided by [Bruns 2001 Page 75 from Wildemann 2007].



Graph 5 – Integrated Ramp-up management

2.5 Conclusion

The ramp-up as an integrated part of the Product Development Process comprises as well product designing and prototyping as well as the ramp-up of the production line. In this context three main Key-Performance-Indicator (Quality, Time, Costs) groups have an impact to requirements, acceptance test, and evaluation of level of achievement after finishing the ramp-up phase.

Due to the complexity of planning objects and its dependency within the Product Development Process and existing obstacles in organization and technology in most ramp-up projects KPI-goals are missed.

Applying known approaches to handle complexity help to achieve project goals, but still does not exploit all existing potentials in the field.

The I-Ramp³ approach aims to integrate these existing approaches and create a basis for daily life in industrial applications and additionally develops innovative solutions by using intelligent configurable machines in the process of ramp-up to further make the ramp-up more efficient and more reliable.

3. Scenarios

3.1 Definition of scenarios

In this chapter the scenarios which are related to the I-Ramp³ project are being described and defined. In this context, a scenario, in general, is the circumstance which makes a ramp-up necessary. Specific characteristics of each individual scenario, in context to the use case, have to be considered. The following sub-chapters describe three scenarios which lead to ramp-ups. According to the experience of all industrial partners, these three scenarios reflect the main causes for ramp-ups in practice.

3.2 Initial Ramp-up

An Initial Ramp-up is being executed after finishing the Prototype phase (see chapter 2.1).

Additionally to this, the perspective from planning of production equipment and facilities provides a different point of view. This aspect becomes relevant, as facilities and production equipment, by nature, are necessary to start with the ramp-up procedure.

In certain cases, a new production line is built-up in a new building ("Green-field engineering"). In that case, from the perspective of production equipment and facilities, an Initial ramp-up may start to be executed (Ramp-up release) after finishing construction of the factory facility, the installation of medias, the move-in of production equipment, the hook-up of equipment to medias, and the (mainly) successfully past acceptance test of equipment. Depending on the type of process, also automation equipment like conveyor belts need to be installed and have to become workable to execute its intended function.

In cases the building already exists, the literature refers to this case as "Brown-field engineering". Thus, the construction of the building becomes obsolete and, depending on requested rebuilding and engineering, the process above starts with the renovation or retrofitting of facilities and/or utilities.

Summing-up within the I-Ramp³ project, if one of the above described occasions will take place (NEW PRODUCT or NEW PRODUCTION EQUIPMENT) one refer to it as Initial Ramp-up.

In this case, both pre-requirements are necessary to pass the milestone "Ramp-up release":

- Prototype phase needs to be finished → What is being produced?
- Equipment capable to execute its intended function → All needed resources are available. (The scope of needed resources depends on individual use case)

(Please refer to chapter Definition of terms for the terms NEW PRODUCT and NEW PRODUCTION EQUIPMENT)

3.3 Ramp-up after scheduled maintenance

In context to the usage of this term within the I-Ramp³ project, a scheduled maintenance is defined as a planned process, not necessarily a time consuming interruption, executed on the production equipment or its controlling systems (software). At the start of the scheduled maintenance the production equipment has been working in nominal full production mode.

Giving examples, a scheduled maintenance includes:

- Preventive maintenance
  A maintenance schedule might be triggered by time (time intervals) or by predefined events respectively conditions occurring
- Part exchange
  "Part" is defined as a component of a machine. It includes tools, spare parts, and wear parts.
- Product exchange
  In case a certain process is needed to execute the exchange of product or variant.

Like for Initial Ramp-up, the scope of requirement to start with ramp-up procedure depends on the use case.

3.4 Ramp-up after unscheduled maintenance

Within the I-Ramp³ project, an unscheduled maintenance is considered as a business process which is executed due to unexpected failure of one or more components within the production equipment (e.g. breakage of an axis within the production equipment).

It also may include activities which become necessary, due to unexpected malfunctions at different production equipment, automation equipment, or parts of facility or utility with an impact to other equipment, (e.g. the conveyor belt supplying the production equipment has a breakdown).

Also activities to bring the equipment back to nominal full production mode, caused by missing work pieces, consumables, auxiliaries, utilities or other materials are considered, indirectly, as unscheduled maintenance (e.g. lack of lubricants at bearings).

Like for Initial Ramp-up and scheduled maintenance, the scope of requirement to start with ramp-up procedure depends on the use case.

4. Use cases

4.1 Definition of an use cases

A use case is defined as a physical application unit which is subject of the ramp-up process. It is an integrated part of the production system.

Its scope may range from a component of a module (e.g. clamping jig), a module itself (e.g. axis), an equipment (e.g. drilling machine), a production system (machine centre) to an entire facility (e.g. production line).

According to the DoW devices applied are specified as heterogeneous ("fast and optimized ramp-up and operation of production lines with heterogeneous devices") [DoW, A1 Project summary, Abstract].

(Among the partners, currently discussions are on-going, how to consider production software, like Manufacturing Execution Software (MES), as use case within the I-Ramp³ project. The decision on this topic is pending.)

4.2 Iterative development progress of ramp-up procedure

Project partners, in particular industrial partners, are facing the situation that the procedure of the ramp-up is being executed in a significantly different way.

In order to enable a common base for joint technologies and use cases, the standard ramp-up procedure described in chapter 4.3 "Generic ramp-up procedure" is being development and established (STEP 1). Executing this approach, it is expected that industrial partners will improve significantly their Key-Performance-Indicator (see chapter 2.2) in short-term notice after implementation.

Additionally to quick wins, the generic ramp-up procedure establishes a sound basis for future high sophisticated technologies applying the I-Ramp³ approach (STEP 2).

Chapter 4.4 "Integration of single applications into demo production line" shows a proposal for a rough timeline for the implementation of the generic ramp-up procedure and the following release applying higher sophisticated NETDEVs.

4.3 Generic ramp-up procedure

Aim of the generic ramp-up procedure is to establish a standardized method and nomenclature before, during, and after the ramp-up. It also includes the integration of data related to objects considered by the ramp-up. The following list shows the generic procedure:

1. Pre-conditions to start with ramp-up procedure
2. Description Process of Ramp-up
3. Acceptance and Qualification procedure
4. Documentation

The development and completion of the generic ramp-up procedure is subject of the project and is being executed in cooperation with all project partners.

Additionally to this, in order to increase the integration of planning phases (product & equipment/facility) the potentials of an extended scope including planning phases will be evaluated during the project.

4.4 Integration of single applications into demo production line

This chapter describes the integration of use cases provided by industrial partners.

After intensive discussion with industrial partners, as well as with other partners, all participants involved has agreed upon a procedure which enables first achievements earlier than requested in DoW allow partners to develop tailored solutions and demonstrators based on I-Ramp³ technology, without being dependent on other project partner facilitate the future integration into the demonstrator.

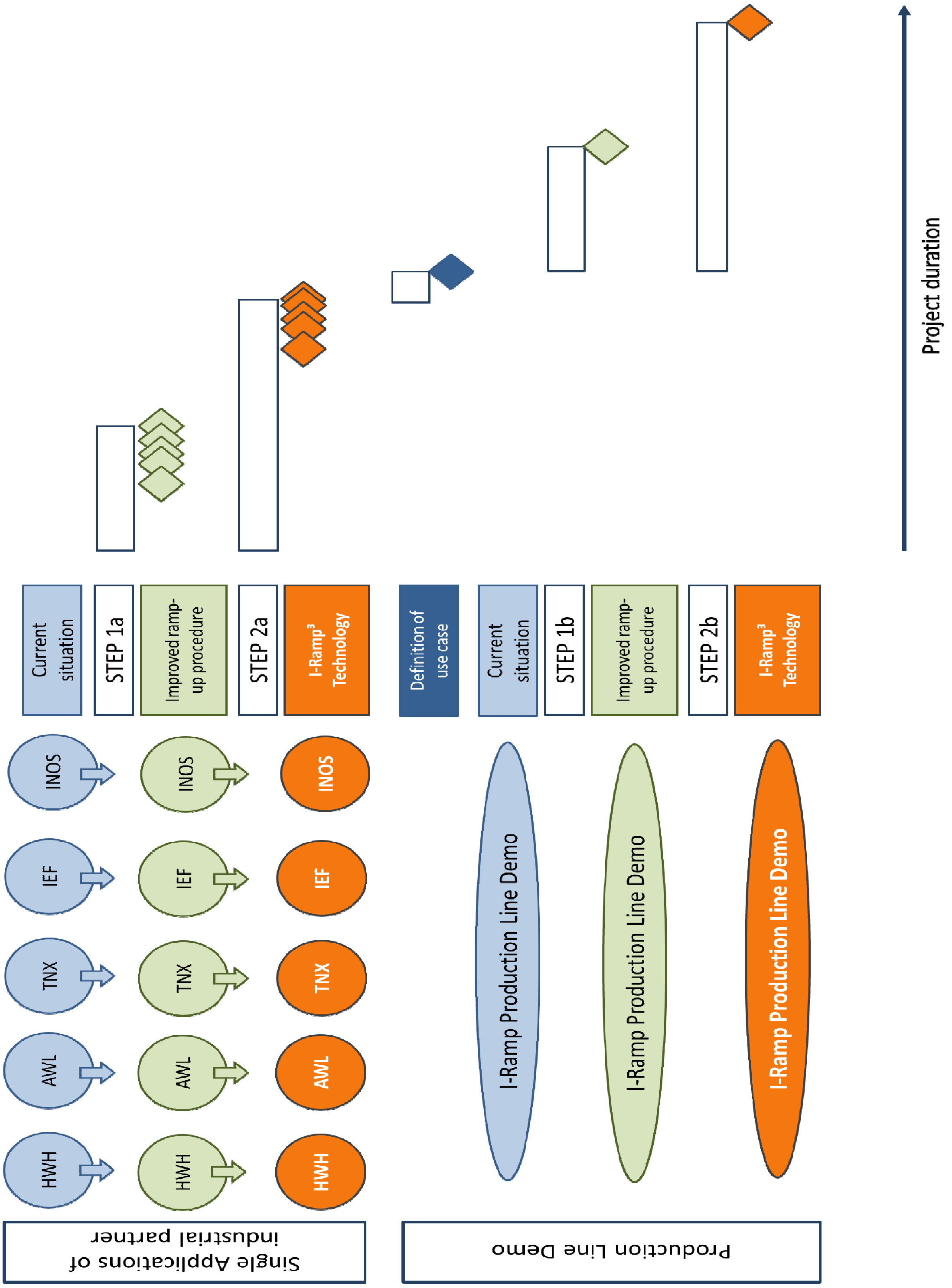
Instead of developing one demo production line which integrates components from every industrial partner from the beginning, every industrial partner will strive for development its own application first. After the single applications of industrial partner are equipped with I-Ramp³ technology, the components will be then integrated into one or more demonstrators incorporating partner technologies.

Proceeding in this way will

- increase the intrinsic motivation of all involved partner
- enable earlier start and availability of development results

- reduction of complexity
- identify of exploitable results at an early stage of the project
- prove technology for integration into demo line(s)

The sketch of the time schedule (Graph 6) illustrates this proceeding in combination with the Iterative development progress of ramp-up procedure explained in chapter 4.2.



Graph 6 – Iterative development of single applications and demo production line

4.5 Use Cases provided by partners

Structure of use case information provided by industrial partner

Main use case: Obligatory use case

Description of physical unit

- *Name of the use case*
- *Description of value added process the process step is integrated in*
- *Components of the unit considered*
- *Short description how the unit is integrated into higher levels of the production system.*
- *Interfaces to other units (hardware, software)*
- *Possible integration into a production line with other industrial partners within the I-Ramp³ consortium.*

Value adding

- *What is the product?*
- *Short description of value added by unit*

General description of ramp-up scenario applied (according to chapter 3 Scenarios)

- *Type of scenario*
- *Pre-conditions to start with ramp-up procedure*
- *Description of ramp-up execution (e.g. workflow, information, resources)*
- *Acceptance test and qualification*
- *Documentation*

Current issues and expected potentials

- *Existing issues (Cost, Time, Quality, Risk, etc.)*
- *(if applicable) possible solutions*
- *Potentials*

Optional: Additional use cases

[Same structure as for Main use case] & additionally

- *What are the synergies need to be achieved with main use case?*

4.5.1 HARMS & WENDE GMBH & CO KG

Use case: **Possibilities for data storage in I-Ramp³ technology**

Scenario: **Component Exchange / Schedule Maintenance**

In order to reduce the ramp-up time when exchanging a component in a network composed of NETDEVs, access to data (operating parameters, network addressing, etc.) which described the behaviour of the exchanged component can be useful. If the replaced component is identical to the original one and if it will be loaded with the same parameters, it can be assumed to get the same functionality as before. Little or no adjustments will be required.

Going one step further and replacement of a component by a similar one that provides more or lesser capabilities, it may be beneficial to have access to former data as well.

In the following there is a surely incomplete list of possibilities to store such data and some notes.

1. Local storage on a movable device like USB-Stick or SD-Card
   Data can be stored during normal operation. After exchange the storage device can be inserted into the new and up to now uninitialized NETDEV.

2. Special NETDEV as a central storage server (or additional to the normal NETDEV functions)
   NETDEVs are supposed to perform a task. Such a task can be 'Store and Retrieve Data'. Other NETDEVs may send a message into the network like 'I have data which I would like to backup, the data volume is 1 MByte, who can do that for me?' A storage-NETDEV may answer 'I can do that, my free capacity is 1 TByte'. After some more negotiation details the data finally may be transferred to the server with additional information about the origin and validity of the data.

3. Special NETDEVs as nodes of a distributed storage system (or additional to the normal NETDEV functions)
   There are state of the art methods to distribute and retrieve data over a whole network. In this case the NETDEVs should have functions to support such distributed storage. Also the language for inter-NETDEV communication must have suitable force of expression.

4. Each vendor of NETDEVs is responsible for his data storage, but supported by the system
   Support by the inter-NETDEV communication language can be to provide the possibility for vendor specific extensions.

5. Each vendor of NETDEVs is responsible for his data storage without any support by the NETDEV network
   In this case, the NETDEV needs additional logic or physical communication channels to vendor specific storage systems. The local storage method as mentioned under 1. can also be seen as such a storage system.

4.5.2 AWL-TECHNIEK BV

For AWL-Technieks the use case "Production equipment for spot welding and clinching steel structures for automotive industry" is considered as the main reference scenario. However, the technology approach developed within the I-Ramp³ project shall also be applied in future use cases specified in this document as "Arc Welding cell" and "Laser Welding".

Use case: **Production equipment for spot welding and clinching steel structures for automotive industry**

Scenario: **Initial ramp-up**

A typical concept for this kind of production equipment consists of:

- Part feeding on belt
- Loading position with vision guided handling robot and gripper
- Turning table with 2 off clamping tools for the product to be welded
- Spot welding robot with MF-servo welding gun en welding controller
- Handling robot with gripper
- Clinch position with servo press with clinching tool
- Unloading position

The challenge for AWL is for this kind of production equipment to have the most effective way of commissioning all the different components during assembling and start up in our shop.

Analysis of this commissioning shows that a lot of time is lost with configuring all the different components.

Most of the profit can be found however in diagnostics. Nowadays a lot of time is lost in finding the reasons for failures. It would be of great benefit if components would have excellent diagnostic features. If this diagnostic information can be available through a NetDev, and therewith available for the overall control, maintenance etc., a lot of time in finding failures can be saved.

Overview of the issues involved during this commissioning process are:

- All components have to be configured with a lot of parameters to make them do their job
- All of the components must communicate to overall control about availability and diagnostics
- Some of the components must have information typical related to the product to be welded:
  - Robots need dedicated robot programs, maybe for different product types
  - Welding gun/welding controller need welding programs, based on product parameters
  - Clinch tool will need clinch programs related to the product
  - Clamping tool can have different clamping programs related to product types

AWL sees this case as a good opportunity to specify and develop NetDev's for the different components used in this concept.

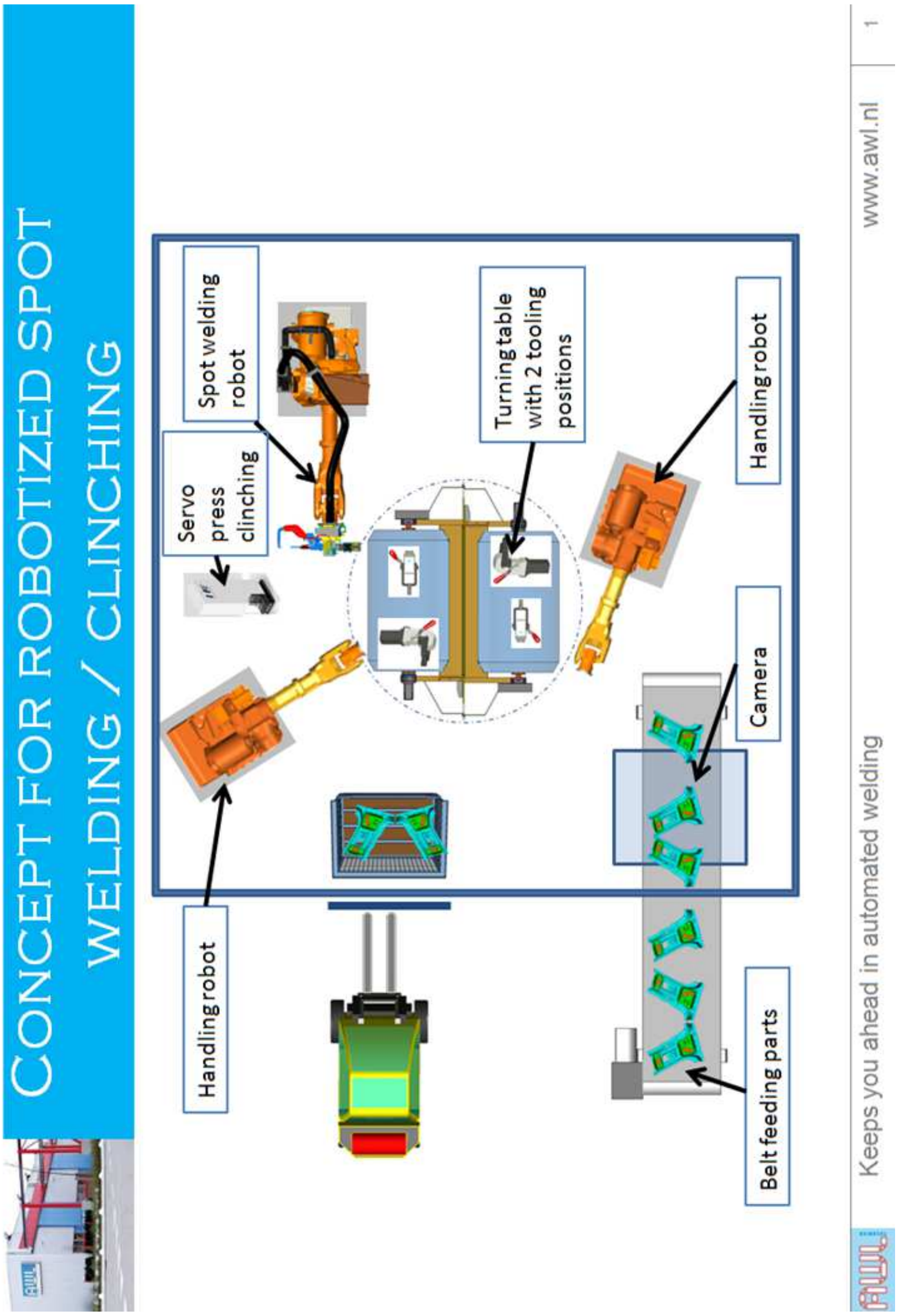
For this case following components of the partners involved in the project could be used:

- For the welding controller: Genius from H&W
- For the clinching: servo press from IEF-Werner
- For the vision part: INOS

For the other components we recommend the following (to be discussed)

- Welding gun: Düring Servo gun
- Robot : ABB

This case offers also the opportunity to be used (partly) as a demonstrator.



Graph 7 – AWL - Concept for robotized spot welding / clinching

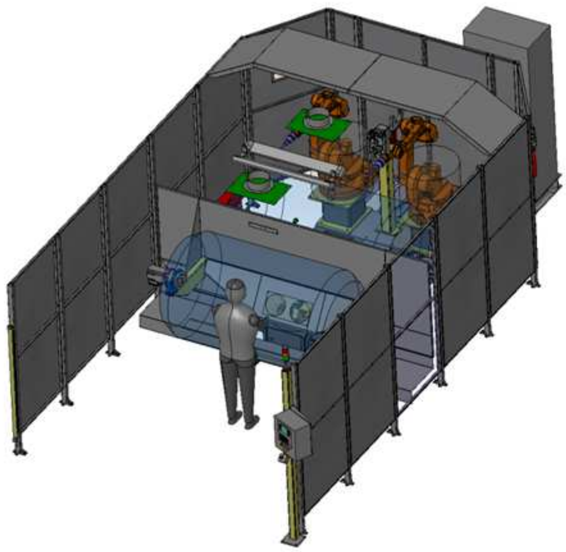
Additional Use case: AWL standard basic arc welding cell

Another use case that could be considered is a so called AWL standard basic arc welding cell.

Although the components used in this equipment are rather common, the time needed for configuring and programming these components should be decreased.

In this case the components working together are:

- 2 off robots
- 1 turning table with 2 clamping tools
- 2 off welding equipment
- Welding monitoring system



Graph 8 – AWL standard basic arc welding cell

As stated in the use case for spot welding also in this case we are targeting for saving time on configuring, programming and diagnosing this components.

Development of NetDev's for these components should target on:

- Configuring parameters
- Programming different products
- Excellent diagnostics

Additional Use case: Laser Welding

This scenario is based on a typical AWL application: Laser welding technology is applied to weld car parts, for example car seats.

Graph 9 – AWL - Laser welding device

In such an application welding parts are assembled on a welding jig either manual or with a robot. The assembled parts are inspected by a vision system and subsequently rolled into a welding cell. In the cell the welding process is executed by welding robots. The robots control where and how the welding laser power is delivered by the more laser sources.

During the welding process the reflected light is monitored and compared with a stored reference in order to assess the quality of the weld.

Depending on the success of the welding process the welded car part is routed to subsequent process steps.

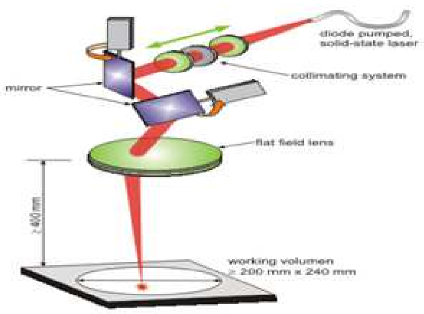
Graph 10 – AWL - Device for welding car parts

The geometry of the welded car parts is periodically manually measured as is the strength of the welds and macro sections are made.

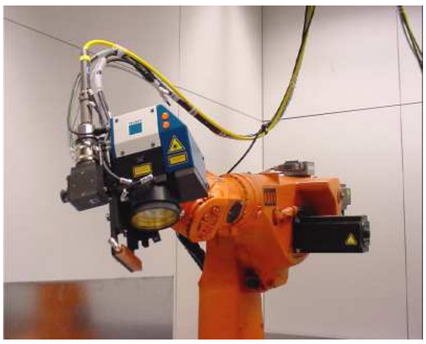
Components

The scenario consists of a number of components:

- Optical assembly
    - High power lasers
    - Optical mirror and lens module (for focus length setting)
    - Beam switches, to allow for one laser to be shared with 2 robots
    - Fibres
- Laser Power units
- Cooling units
- Airflow units (laser light has to travel through clean air)
- Robots
- Jig / Jig system
- HMI
- Welding Monitoring system
- Visual inspection system (camera)
- Safety system



Graph 11 – AWL - Optical assemblies



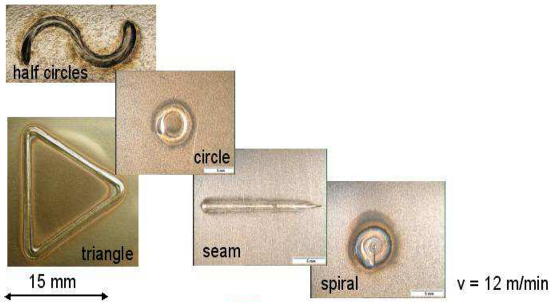
Graph 12 – AWL - Robot applying optical assemblies

Process Parameters

Laser weld process parameters :

- Power (including ramp up profile)
- Spot with (controlled by the focus and distance from the work piece)
- Welding Speed
- Weld geometry (triangle, ½ circles, etc.)
- Weld position
- Weld direction

These parameters vary per weld. One car part can have up to 50 welds in one process step.



Graph 13 – AWL - Weld geometries

Ramp-up

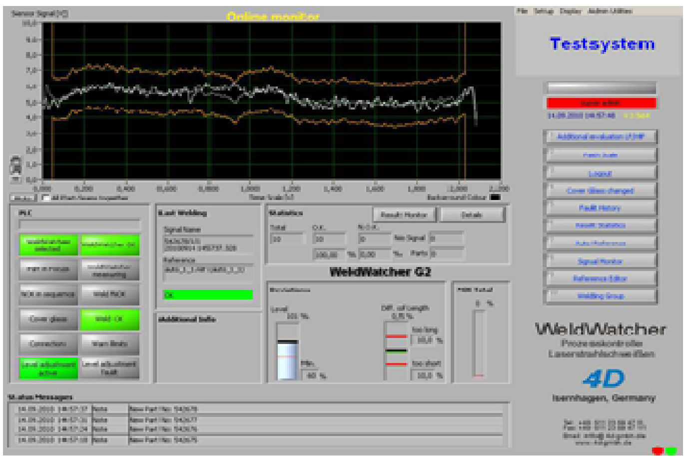
In the RAMP-UP phase all the above mentioned components are parameterized, configured and integrated. Each component has its own logical interface, most of them are physically interconnected by standard industrial interfaces (Device net, Profibus, etc.). Some components have a very sophisticated HMI but completely proprietary.

The process parameters values are produced by calculations, best practice rules, experience and by experiments. Normally the overall process is optimized for speed. Typically one process step takes about 20 sec. It is verified whether all the components are ok before the welding process commences. (No software process feedback mechanisms are normally implemented nor are the results of the manual inspection correlated with the actual measured parameters.) The stability of the process is proven in practice by making test runs.

In Process quality monitoring

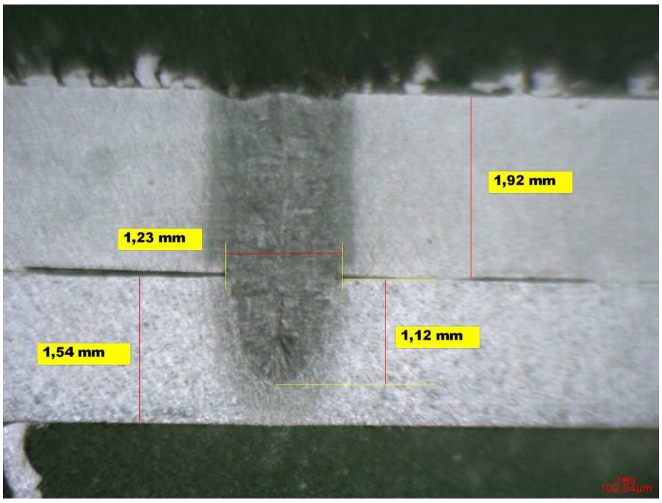
<u>Assembly</u>
A camera system checks the presence of the assemblies. The camera compares the actual assembly with a stored reference picture. When OK the assembly is handled by a robot with a gripper and placed on the welding jig. The jig senses if all the parts are there and is rolled in the welding cell. The position of the Jig is validated, welding does not commence if invalid If the welding cell is properly closed (security) the welding process commences.

<u>Welding process</u>
During the welding process is the reflected laser light measured and for each weld compared with a stored reference value which are proven to be right. The measured curve has to fit the reference curve within a certain bandwidth. The width of the bandwidth is configurable per weld.



Graph 14 – AWL - Screen shot of a Welding process control system

When the measured curve is outside the bandwidth the part is declared NOT OK. Periodically the welds are fractured and macro's are made. When the macros are NOT OK the machine is halted and the welds are re-parameterized. Periodically the welds are force tested. When NOT OK macros are made.



Graph 15 – AWL - Weld macros

Robot

The robots execute the welding process. Key is of course synchronization and avoidance of collisions. The servo's of the robots are used to assess if they are above the correct position.

Geometry

Samples of welded car parts are taken periodically and measured.

Fault management

The correct functioning of all the support equipment (laser health, cooling, power, air pressure, security systems) need to be all monitored. These are mostly very basic non standardized mechanisms. Some components only have a very basic fault reporting functions

Optimization

The process is optimized by experts before the system is put in service. As mentioned no feedback mechanisms between the measured quality values once the process runs are in place.

Maintenance

Periodical maintenance is prescribed and documented.

AWL interests

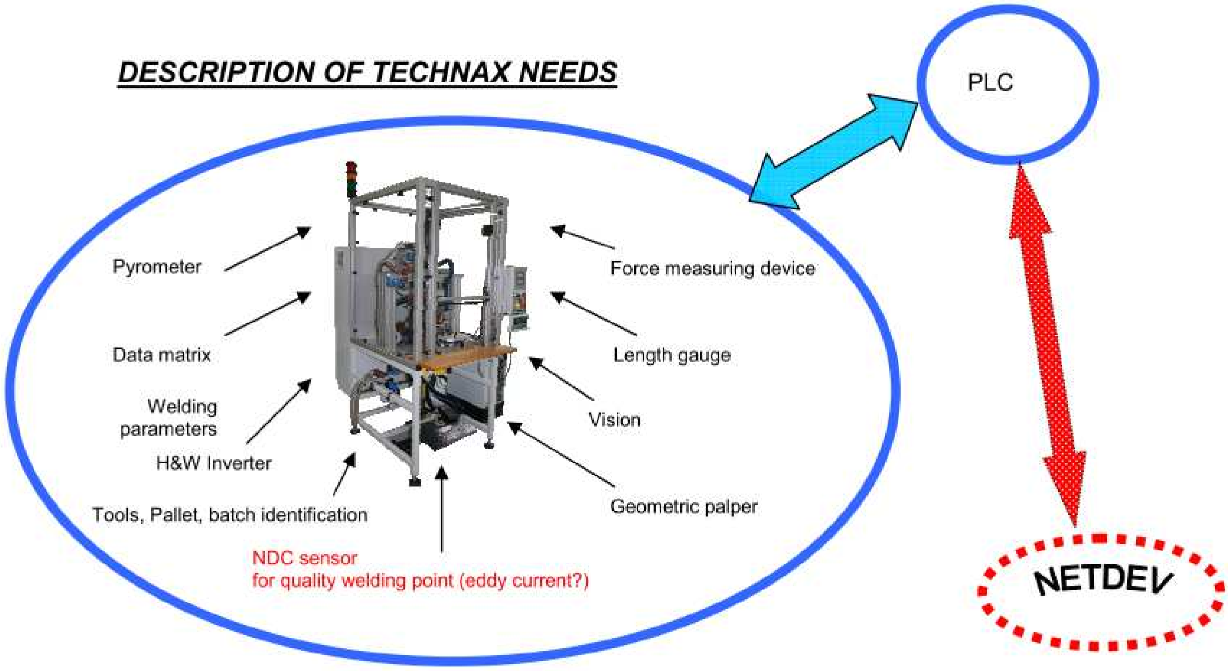
AWL first interest is for IRAMP to provide for a technology which allows for a fast configuration and integration of the mentioned components. These are industrial grade (A class) components.

Easy and intuitive operation of the system. Advanced local and remote fault diagnostic capabilities are essential during the ramp-up and operation of the systems. We see web based systems as the way forward here, our remote services are currently web based.

Automated Process optimization is currently gaining interest so AWL wants to explore the possibilities in this area.

4.5.3 TECHNAX INDUSTRIES

DESCRIPTION OF TECHNAX NEEDS



Graph 16 – TNX - Description of Technax' needs

1. A NON-DESTRUCTIVE SENSOR SYSTEM AS NEW MMS (Metrology Measurement System)?
   In order to evaluate the quality of the welds, welders are used to destruct parts. This working-out job is time consuming and can quickly have a cost impact.
   At the beginning of the ramp-up phase, the only solution to know if a welded sub-assembly is ok or not is indeed to make destructive tests (for mechanical requirements). But every time parameters are changed, the welding needs to be re-qualified (time consuming).
   When all the machine parameters are set, the production of parts in real conditions can start (requirement of flow). Some products are then randomly picked up and destroyed for tests. In case of complex products, for instance with SMI, the costs can be high and other human resources are needed to make tests (costs impact).

To reduce the number of destructed parts, Technax industry puts control on its process to be able to qualify its stability and therefore to provide always the same welding quality. As long as one part (weld) meets the requirements, the machine ecks that the
following ones stay within the same range. In this case, they are supposed to be good too.

To decrease the time consumed for the tests and therefore to decrease the ramp-up stage, one research lead is the use of a MMS, i.e. a non-destructive sensor system. This means that besides the process control, there would be also a product control. The advantage would be of course the reduction of costs for each non-destroyed product but above all the reduction time for the ramp up phase. Moreover, it would give additional information for product traceability.
In Task 5.3, it is proposed to develop a sensor for metrology applications based on I-RAMP³ technology.
One subject proposed by Technax industry is an application which could measure the quality of a welding point with non-destructive control. Till now, Technax industry does not use non-destructive control. The sensor may lean on the eddy current technology.

The first stake is then to look in the state of the art technology, whether a sensor could afford or not the requirements.

2. INTERESTS OF HAVING A NETDEV FOR DIAGNOSTIC / OPTIMIZATION

The second stake would be to use these results (good welding / bad welding) to improve the capacity of the machine in a minimum of time. To do so, we think of a NETDEV which could be able to gather and to proceed all sort of data coming from the process in order to make a diagnostic analysis or at least a help for the person in charge of the machine running.
The table underneath shows the type of sensors and their relative data often used in manufacturing industry.

TYPE OF SENSOR	DATA
VIBRATION, DEFORMATION, PRESSURE	Strain gauges (resistor bridge)
INDUCTIVE (presence)	Voltage digital input (ex: 24VDC)
FORCE	Voltage analog input (ex: 0..+10V)
PRESSURE	Current analog input (ex: 0..20mA)
DISPLACEMENT	Incremental encoder
CURRENT (H&W)	Voltage analog input
Welding time (H&W)	-
Temperature	Thermocouples/mV analog input
Resistance	Resistance analog input (ohms or by temperature conversion RTD, PT100)
PRESSURE	Potentiometer measurement
ENERGY CONSUMPTION	Power measurement
Non destructive control: Eddy current?	?

Table 1 – TNX - Types of sensors

The diagnostic capability of a network is a crucial factor for availability and commissioning times – and therefore overall costs. Only faults that are quickly and accurately detected and located unambiguously can be quickly rectified. Therefore we propose to use Ethernet or etherCAT communication.

This NETDEV would be useful for two main applications. The first application is for debugging a machine at the beginning of its lifecycle but also during production (for instance after a modification). This NETDEV must be able to connect itself to a machine (standard or with NETDEV's included) and to analyse all parameters. But it should be independent from the machine and mobile because most of the time the NETDEV is connected only for ramp-up phase and reconfiguration phase. Let's take an example: many Technax machines are supplied with a rotary table holding several tools. During the ramp-up phase, there might be some wrong parts coming out from the first machine runs. It can take a long time till the technician finds out the causes. In our scenario, the causes of the problems were due to one specific tool which was not so fine adjusted and gave different results than the others.

Thanks to the NETDEV which would include in its network besides many controls also a tool, pallet or batch identification, we would have found the causes quicker and saved a lot of time. Moreover, if the machine is designed from the beginning with the option "NETDEV", a remote-controlled communication avoiding expensive and time consuming travels could be implemented.

The second application could be to permanently install this NETDEV into the machine. It would yet be useful for the early steps of the ramp-up phase but it would also help the maintenance people during production phase and increase traceability for quality plan. Indeed with this NETDEV, maintenance staff could see eventual parameters drift and react quickly to avoid a reduction in quality or a breakdown.

3. STAKES FOR SOFTWARE

The software needed is a melting pot of SCADA, MES, EMI, SPC, DATABASE SQL for one machine. The software should be able to:

- import into a database all the process and welding data coming from different sensors and device (H&W inverter)
- Manipulate and proceed all data for :
  - Supervising and optimizing the quality process via a friendly GUI (data search, curves, data exportation, etc.) in the mobile version.
  - Traceability: potential temporal drift -> give a help for predictive maintenance in the permanent version.
  - OPTION: Smart Analysis / help decision tool -> suggests the modification to be done.

The program should be composed of different parts with for example a tool bar with the classical tab (file, edition, tool, etc.) and different windows according to the task done.

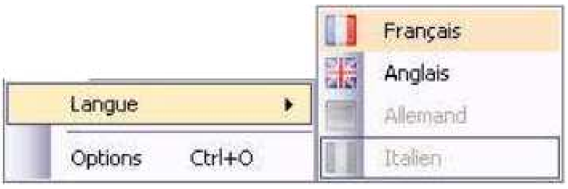
For instance, in the toolbar:

Graph 17 – TNX - File → Export results

It enables the results saving of the data search. The recording is done by default under CSV format.

Graph 18 – TNX - Tools -> Information - List of all failures codes

Through this selection, the displayed language of the programme can be changed (minimum English).



Graph 19 – TNX - Tools -> Language

Enables to display the “Options” page of the program:

Graph 20 – TNX - Tools -> Options

Graph 21 – TNX -? -> About..

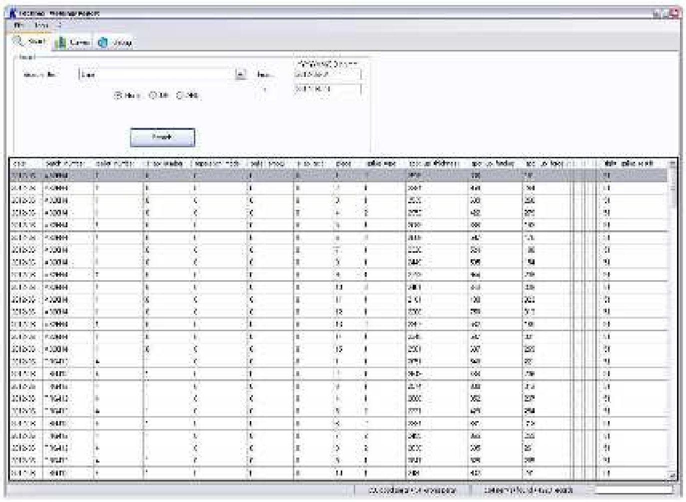
Graph 22 – TNX -? -> License information

Graph 23 – TNX - Analysis -> Research function

A screen which enables the search of the values saved in the database. Several search filters should be available (date, pallet number...). Possibility to combine filters.

This screen enables to display in a convivial interface the results of the filtered data. Choice of information which is displayed on the screen: pallet number, welding parameters, current state of the pallet...

Maybe it would also be interesting to have the parameters directly in words values like in the PLC (without interpretation).



Graph 24 – TNX - Analysis -> Gathering data

- Analysis -> Options

For example:

- Modification of the ratio between the good parts and the bad parts. This ratio is used to scale the quantity of good parts for the display of curves.
- To select the display of some columns in the results screen.
- .....

- Analysis -> Curves function

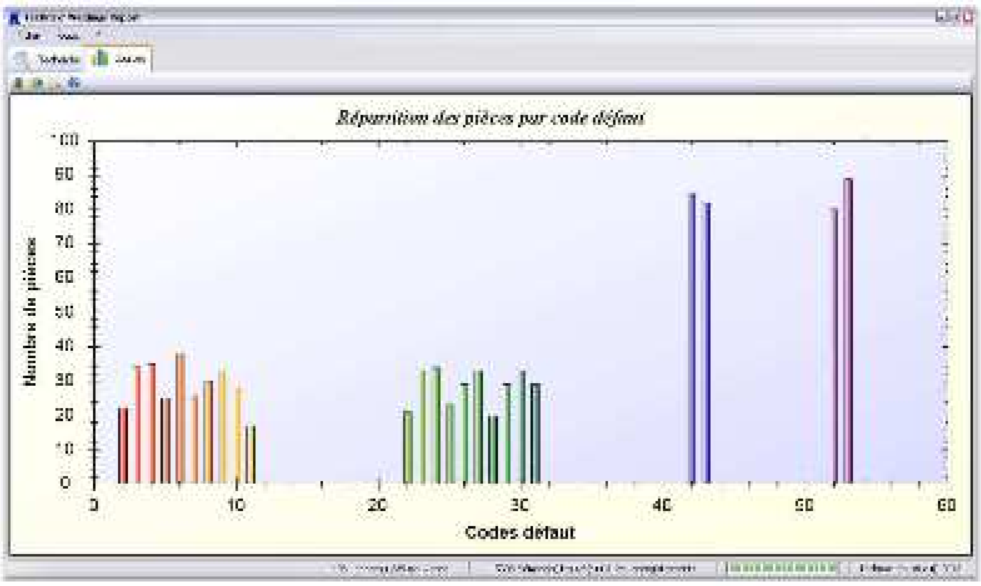
Through this page, a graphical representation of the found results should be seen.

Several curves types are available:

For example:

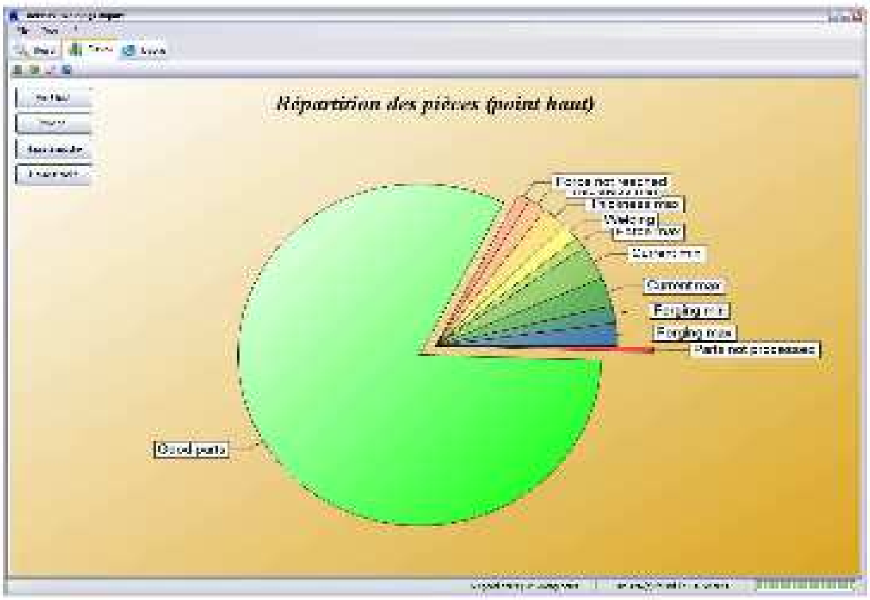
- Analysis -> Curves function-> Bar graph

It shows the repartition of the bad parts by failure code.



Graph 25 – TNX - Analysis -> Curves function-> Bar graph

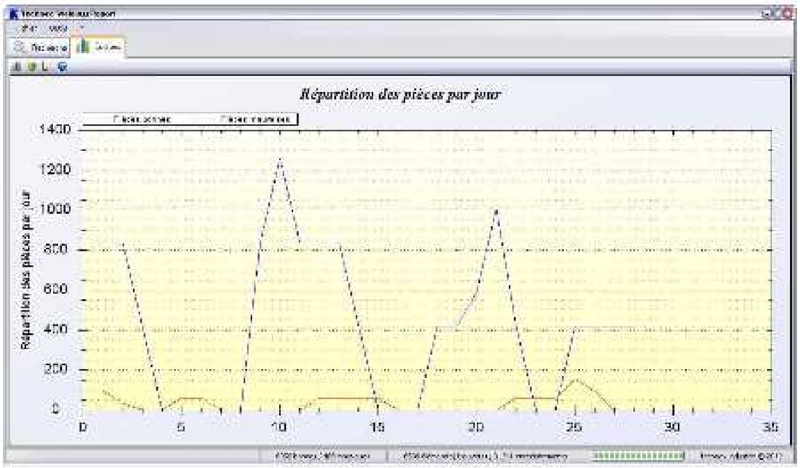
It shows the repartition of all the parts: good ones, bad ones and non-performed ones.



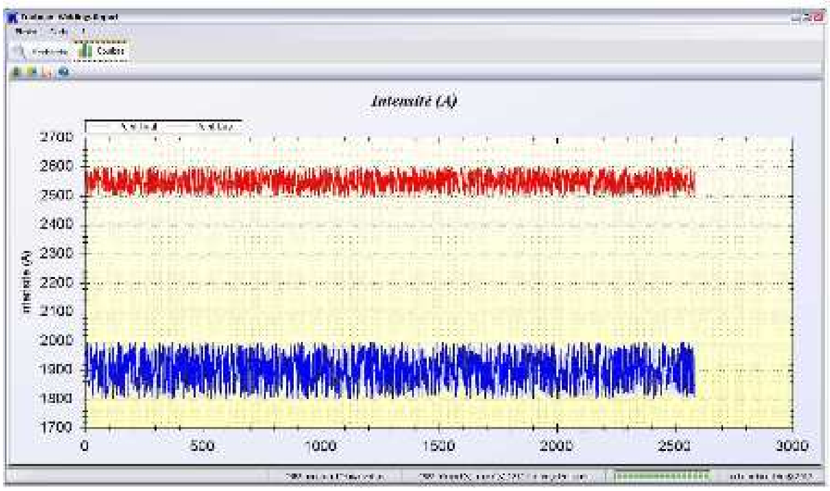
Graph 26 – TNX - Curves function-> Circle diagram

They show the results according to the search filters.

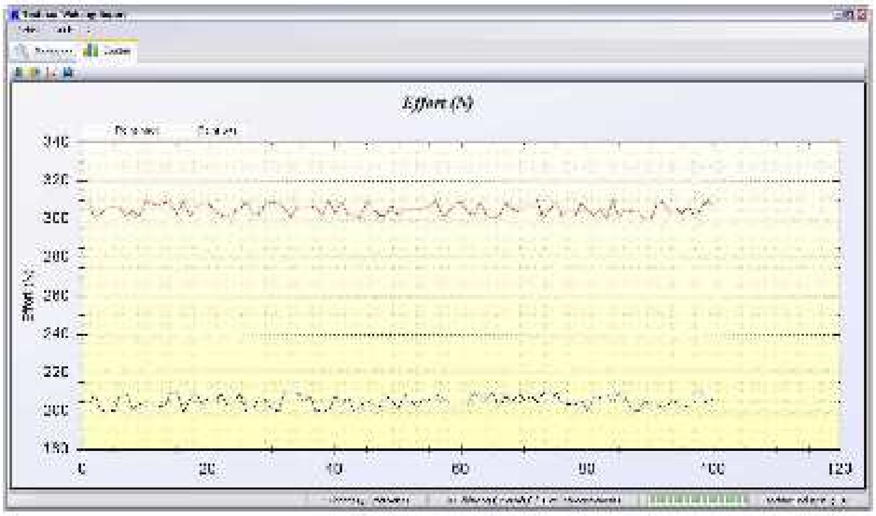
A few examples of curves:



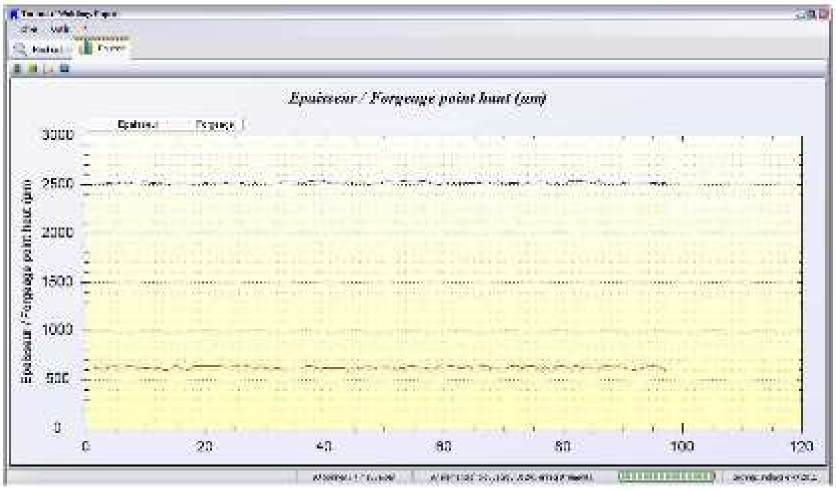
Graph 27 – TNX - Analysis -> Curves function-> Curves (I)



Graph 28 – TNX - Analysis -> Curves function-> Curves (II)



Graph 29 – TNX - Analysis -> Curves function-> Curves (III)



Graph 30 – TNX - Analysis -> Curves function-> Curves (IV)

- Analysis -> SMART ANALYSYS

- An intelligent diagnostic tool capable of seeing a drift or abnormal results inside one parameter type.
  - Automatic alarm function in case of drift.
  - Use of results from the NDC to propose best welding parameters.

4. I-RAMP³ TECHNAX DEMONSTRATOR

   For the demonstrator in the I-Ramp³ project, Technax industry thinks to develop a numerical welding head equipped with force, displacement, current devices and a non-destructive control system (according to the outcomes of this new MMS developments). The permanent or remote version of the NETDEV will be integrated according to what is decided within the Consortium. Technax can also test the NETDEV on different specific machines (in remote version) during ramp up phases to demonstrate in real case the benefits and in particular the significant saving in time. It will simulate also the integration of new elements (reconfiguration) as every machine made by TECHNAX is new (specific).

4.5.4 IEF Werner GmbH

Use case: **servo press aiPRESS**

Scenario: **Initial setup of a new application**

The scenario description is based on full equipped servo press application. The IEF Werner servo press is called aiPRESS. aiPRESS servo presses are used to produce accurate and reproducible joining connections. The flexible design allows the integration into a production line as well as the installation as stand-alone unit. These characteristics fit perfectly into the requirements of the scenario “Initial Ramp-up”.

Description of the servo press aiPRESS

Graph 31 – IEF - aiPRESS

The aiPRESS servo press series is classified into different areas of strength and it is designed for precision operations, and can handle the force areas 200N, 500N and 1000N in one device. It consists of following components:

C – Frame; high-precision ball screw; sleeve guide; servo drive; housing; guarding with safety switch; 12” multi-touch user panel; and a switch cabinet. The servo press offers optimal possibilities in customizing the joining process to the application. Process factors such as feed force, speed, positioning time and accuracy can be adapted using a large number of optional components and a sophisticated configuration system - especially for the drive chain.

In order to reduce the ramp-up time when starting the initial setup of a new application in a network composed of NETDEVs, access to data (operating parameters) which described the behaviour of the components is needed.

At the beginning of the project the operating parameters of the components, the process and the product must be determined manually. These parameters will be saved on a local storage or a central storage server.

Different kind of parameters must be determined:

1. Process parameters

   Process parameters are all parameters that describe the press process. The PLC of the servo press needs these variables to fulfil the operation, in our case to join 2 pieces. The variables are:

- Stroke
- Speed
- Acceleration and deceleration
- Jerk
- Position
- Force

   Within the process the movement of the stamp can be adjusted until it reaches a position or a predefined force.

2. Product parameters

   The product related parameters cannot be described. It depends on the application. If one product has several types the product parameters can be used for the product family. One essential role has the stamp. There is the need metrics to define similarity. To determine a product automatically barcodes or sensors can be used.

3. Quality parameters

   The quality is measured directly during the operation. IEF qualifies the ready processed work piece in good and bad quality. We can have force quality or position quality parameters.

These parameter types are combined in the control of the servo press. When some applications are done the process, product, and quality parameters are saved on a storage. Knowledge about the previous applications can be used, if the applications are similar. The previous parameter settings are used for a starting point and must be fine-tuned manually or can be used for automatic fine-tuning. The data base will be increased and several application scenarios will be indicated. If the database is big enough to reach most applications, the machine have the ability to automate the ramp up phase which will reduce the ramp up time substantially.

Initial Setup on a defined product

For further discussions and to demonstrate the initial setup a simple product should be defined.

IEF has the possibility to use a customer product which is called micro gearbox. The application should show the initial setup of the servo press for the joining of the 2 parts. The shaft must be joined to the disc. The disc is clamped in a work piece holding fixture, and the shaft is held by using vacuum.

4.5.5 INOS HELLAS

A) INTRODUCTION

In this document INOS presents two industrial scenarios to guide the implementation of the I-RAMP3 project that are in turn decomposed into three and two use cases respectively. These scenarios while realistic and product oriented present a basis for defining some of the requirements for the project and in particular focus on elucidating points that in the view of INOS Tasks 3.1 and 5.3 must address

The first scenario and its use cases focus on possible improvements to the architecture of the «INOS Station» which is a generic INOS software framework product that is adapted to the needs of each customer installation. The use cases are selected to demonstrate:

a) Technology for Hierarchical configuration of complex systems
b) Cooperating NetDev's in the sense of semi-autonomous agents and
c) «Logical NetDev's» that exist for modeling, design and software structuring purposes but for performance or cost reasons are implemented as traditional hardware elements attached to communications networks.

The second scenario and its use cases focus on improving the process and assorted software support for the initial installation and ramp up as well as the in-production change of product work piece (set up) and contains two use cases, one for a new potential INOS product and one for an existing INOS product.

B) SCENARIO: IMPROVED INOS STATION ARCHITECTURE

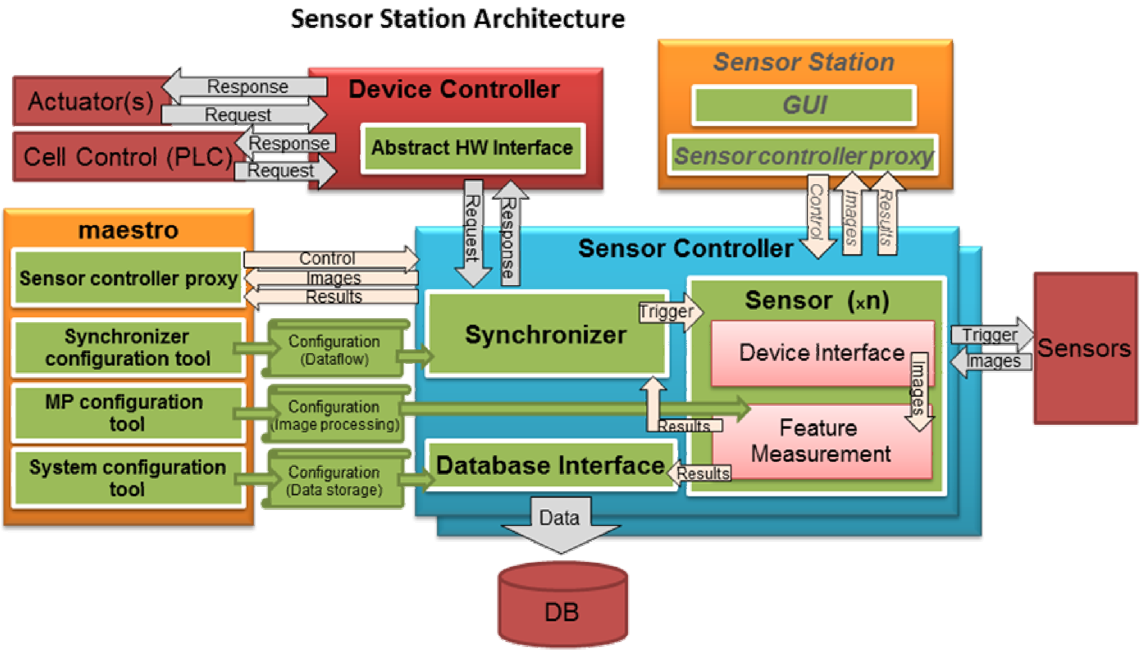
B1) USE CASE: INOS STATION AS A NETDEV

Objective

Reengineer the INOS Station as a NETDEV leveraging the technologies developed in WP 3, 4, 5. Obtain a quantifiable reduction in initial configuration and ramp up effort.

Description

The «INOS Station» is a generic INOS software framework product that is adapted to the needs of each customer installation. An architectural overview is shown in the image below.



Graph 32 – INOS - Sensor Station Architecture

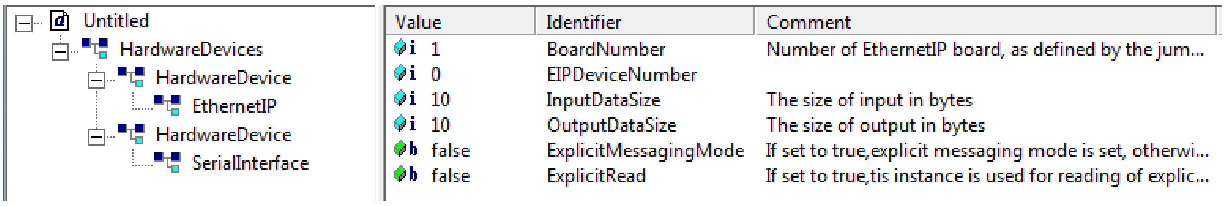
In this use case the NetDev concept and DIL are used to ease initial installation of an INOS Station derived customer station. I-RAMP³ will be delivering in the specification of the semantics of the DIL a technology for Hierarchical configuration of complex systems. INOS currently has such a technology that is based on hierarchical lists of attributes stored as ascii (.alf) files. The file encoding is a proprietary INOS standard and is editable using a proprietary INOS configuration editor (the «maestro» product). The DIL should support all the features of this standard and expand on it. An equivalent GUI based editor should support the creation of DIL descriptions. Furthermore INOS has a dataflow based representation for the sequencing of the image acquisition and measurement operations (synchronizer) and another representation for storing information in a database and as entries in lo files, which should also be describable using the DIL

Process Parameters

- Syntax and Semantics of Hierarchical Attribute Lists
- Syntax and Semantics of Configuration Files for sequencing operations, defining information storage and logging.
- Product Parameters
- Hierarchical Attribute Lists for Measurements
- Configuration Files for Operation Sequencing, Data Storage, Logging, Customer equipment (PLC, Robot Controller)

An example of a PLC connection would be:

Graph 33 – INOS - Example of PLC Connection



Quality Parameters

- Availability
- Debugging effort and calendar duration

Initial Setup Process Example

- Initial Station Customization
- Initial Station Configuration
- In Factory Station Configuration
- In Factory Debugging

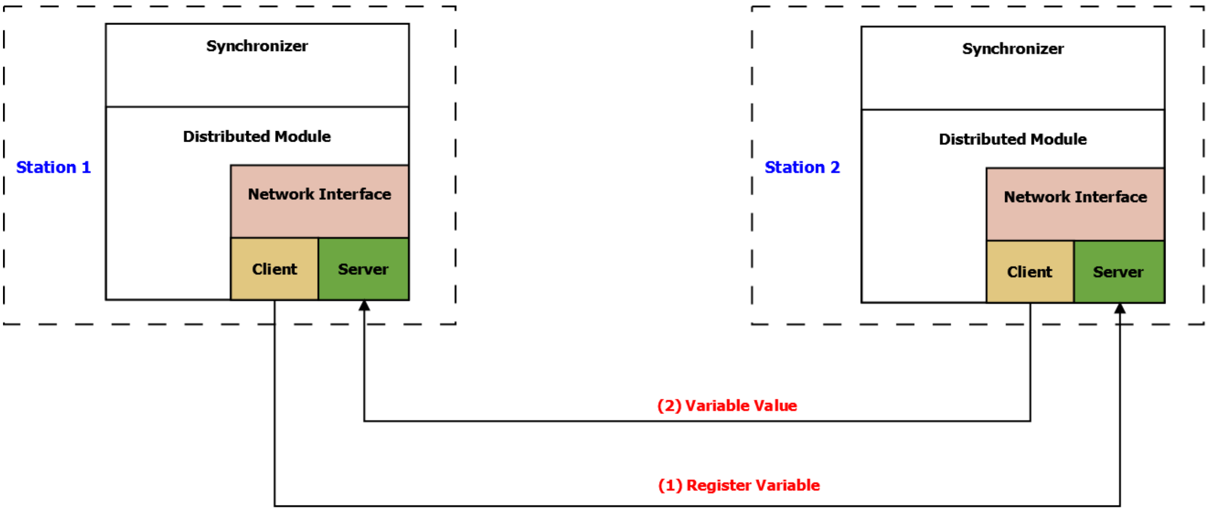
B2) USE CASE: DISTRIBUTED INOS STATION

Objective

Use the cooperating NETDEVs concept to construct a distributed INOS Station based on the capabilities of the DIL (WP3) and SAAM/SAAL (WP5). Obtain a quantifiable reduction of effort, rework effort and duration of a distributed station configuration.

Description

Currently, when INOS needs to install multiple «INOS Stations» that coordinate in some sense (as required by customer applications), we use ad-hoc synchronization and data exchange methods that are extrinsic to our architecture. INOS has a concept for a «distributed synchronizer» that integrates multiple Stations into an integral Station, as shown in the figure below, and a proprietary implementation design.



Graph 34 – INOS - Distributed INOS Station

We propose to use DIL to setup this configuration and then use SAAM and SAAL to either directly exchange in-process information or if performance and customer considerations preclude it to setup an ad-hoc communications mechanism.

Process Parameters

- Allocation of Functionality to Distributed Stations
- Communication Settings
- Distributed Timing

Product Parameters

Operation sequencing (synchronization) described under the assumption of an integral «Station»

Quality Parameters

- Configuration Effort and Duration
- Availability
- Debugging effort and calendar duration

Initial Setup Process Example

- Configure component sensors at the sensor hardware and measurement point level.
- Configure «integral» Station at the synchronization (sequential control) level
- Automatically configure Distributed Station
- Debug and Tune Distributed Station

B3) USE CASE: CONFIGURABLE IMAGE SENSORS AS NETDEVS

Objective

Use the concept of Logical NETDEVs to support hierarchical integration of third party image sensors that do not have a native NETDEV interface. Use IDL to configure, initialize and manage and SAAM/SAAL to set up the logical sensor devices within the INOS Station which is in turn a composite NETDEV. Obtain a clean software architecture that eases understandability and potentially reduces development effort, even though it may be difficult to quantify.

Description

Starting from a GiGEthernet connection imaging sensor, design a software mechanism for instantiating a «Logical NETDEV» that is visible to the DIL based interfacing APIs a just another NETDEV.

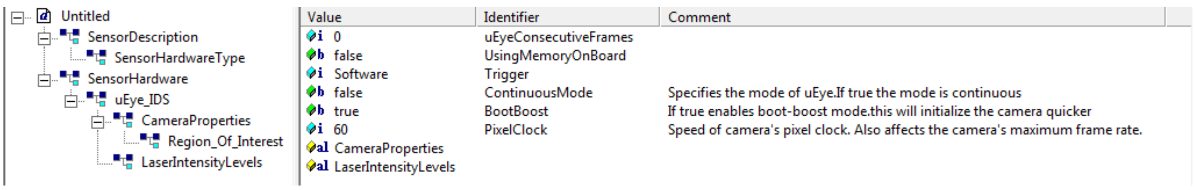
Process Parameters

Attribute list format or DIL representation describing an imaging sensor.

Product Parameters

Attribute list or DIL description of imaging sensor.

As an example, a camera sensor would have the following representation:



Graph 35 – INOS - Configurable image sensor as NETDEV

Quality Parameters

- Configuration Effort and Duration
- Availability
- Debugging effort and calendar duration

Initial Setup Process Example

Setup of a number of Imaging Sensors (cameras, laser scanners) within an INOS station

C) SCENARIO: IMPROVED INOS STATION SETUP

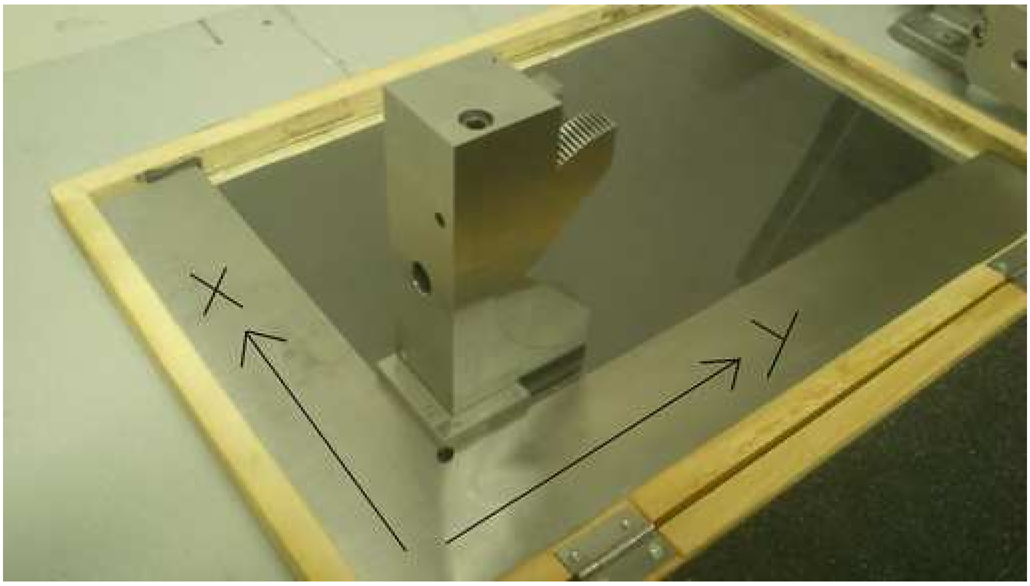
C1) METROLOGY

Objective

Identify and localize an object in space by measuring points. Addresses WP1, T3.1 and T5.3. The use case drives requirements for DIL features and capabilities and for the robot portable measurement head.

Description

An example of the type of object should be identified and localized is shown in the photograph below.



Graph 36 – INOS - Improved INOS station setup

The object has very specific corners that must be detected and measured in an absolute sense, using optical means. In the photograph a simplified work piece is shown; in a real setting this part may be attached to a larger part and in a difficult to access location accessible via robot manipulator.

Process Parameters

- Image processing method parameters: 10 element vector, including numbers (laser intensity, exposure time) and method selection (example: Line profiler method :3 options)
- Camera Sensor Calibration Parameters, 5 intrinsic (e.g. focal length), 6 extrinsic (camera location with respect to illuminating laser and measurement point)
- Sensor Registration Parameters (6)
- Illumination and Exposure Parameters (Application Specific)
- Timing parameters (Application Specific)
- Dimensional and Location Measurements (Work piece and customer application specific)

The DIL must be able to describe and specify the process parameters to be set.

Product Parameters

- Customer Equipment Communication Protocol Parameters (Application specific)
- Work piece Reference Dimensions – CAD data (Work piece specific)
- Mounting Environment Reference Dimensions –CAD data (Application and/or work piece specific)
- Product (work piece) type identifier and serial number

The DIL must be able to define the communication protocol, the reference dimensions and the structure of the type identifier.

Quality Parameters

- Measurement uncertainty
- Measurement repeatability
- Measurement drift
- Correlation with CMM measurement (vector)

The DIL must be able to define and communicate the measurement quality parameters

Initial Setup Process Example and Operations Process

- Mechanical and electrical installation
- Communications setup
- Sensor calibration parameters setup (from sensor manufacturing file)
- Sensor registration
- Measurement of reference objects
- Correlation estimate calibration
- Setup of work piece type specific measurement
- Experimental, iterative convergence of measurement repeatability, accuracy and correlation with CMM measurement to INOS and customer defined standards
- Normal Operation
- Tracking of measurement drift
- Change of work piece

C2) GAP & FLUSH INSTALLATION

Objective

Measure gap and flushness between assembled parts (doors, fenders, hoods, roofs etc.) on automobiles. Addresses WP1 and T3.1. The use case is based on the requirements of an existing INOS product that requires significant effort to configure, both initially and upon car model change.

Description

A robot manipulator moves a system based on laser triangulation sensors around a vehicle body and measures the gap and flush at manufacturer specified points (measurement points) based on a manufacturer specified definition of how these parameters are measured.

Graph 37 – INOS - Gap & Flush Installation

Process Parameters

- Image processing method parameters including numbers (laser intensity, exposure time) and method selection
- Camera Sensor Calibration Parameters, 5 intrinsic (e.g. focal length), 6 extrinsic (camera location with respect to illuminating laser and measurement point)
- Illumination and Exposure Parameters (Application Specific)
- Timing parameters (Application Specific)

The DIL must be able to describe and specify the process parameters to be set.

Product Parameters

- Customer Equipment Communication Protocol Parameters (Application specific)
- Measurement Points (Vehicle model specific)
- Gap Reference Dimensions – CAD data (Vehicle model specific and optional)
- Product (vehicle) type identifier and serial number

The DIL must be able to define these parameters.

Quality Parameters

- Availability
- False positives and false negatives rates

Initial Setup Process Example

- Mechanical and electrical installation
- Communications setup
- Sensor calibration parameters setup (from sensor manufacturing file)
- Setup of vehicle type specific measurement points either experimentally or using CAD data
- Measurement of reference vehicle
- Debugging of communication issues
- Reduction of measurement error

D) CONCLUSION

A range of possible scenarios and use cases that are I-RAMP3 appropriate and address specific INOS technology, product, process and customer requirements are presented. These are intended as a guide for extracting and specifying the requirements that will guide the work in WPs 3, 4, 5 and secondarily to be considered candidate requirements for the demonstrators with the caveat that they should somehow fit with the demonstrators that address the requirements of the other I-RAMP3 industrial partners.

5. Methods of requirement engineering

5.1 Description of standard requirement engineering process

The standard requirement engineering process covers all phases of a project and aims to ensure successful planning and realization of a project independent its goal and target.

According [Ebert 2008] requirement engineering starts with stakeholder's vision and determines with the successful acceptance of deliverables.

In detail [Ebert 2008 Page 55] lists as follows:

- Vision
- Use case / scenarios
- Evaluation
- Requirement specification
- Project plan
- Test procedure
- Technical specification
- Planning of release
- Product catalogue
- Contract
- Acceptance

In this reference approach it is assumed that all relevant information is available before closing contract. By that it reflects an ideal proceeding as it does not consider any loops after contract.

Additionally to requirements respective Meta data (such as requisitioner, responsibilities (according RACI scheme), or date of elicitation) are recorded and tracked over the requirements engineering process.

5.2 Requirement engineering process

Referring to the standard process, the requirement engineering process in this document differ in some details in order to adjust to existing frame conditions and additionally become more flexible. The process includes following steps:

1. Vision (form "DoW")
2. Scenarios
3. Use cases
4. Requirement specification
   a. Requirement elicitation
      i. Normative requirements (from "DoW")
      ii. Initial survey with all partners
      iii. Workshops with industrial partners
      iv. Technical advisory group
   b. Requirement Consolidation and classification
   c. Documentation
5. Maintenance of requirements throughout whole project
6. Definition of test protocol based on Key-Performance-Indicators
7. Acceptance procedure

In this procedure the requistioner is documented in survey or meeting protocols of the partners.
All tasks (and its responsibilities) are incorporated into work packages and tasks with clear defined responsibilities.
Due to the fact that all requirements have been gathered in a short period of time the exact date of elicitation is less relevant. However, changes of requirements will be tracked over the duration of the project.

5.3 Definition of priority terms

All requirements gathered by means of initial survey with all partners are classified according to the strength of its requirement:

MUST	=	Obligatory requirement
SHOULD	=	Important requirements, however not obligatory
COULD	=	Optional requirements
MUST NOT	=	Requirements which should not be achieved
UNCONSIDERED	=	Not considered requirements

In this context, normative requirements as listed in chapter 6.2 are considered as MUST requirements.

5.4 SMART

In order to ensure a high quality level of information all requirements defined have to be aligned with the so called “SMART” rules:

S → Specific

M → Measurable

A → Attainable

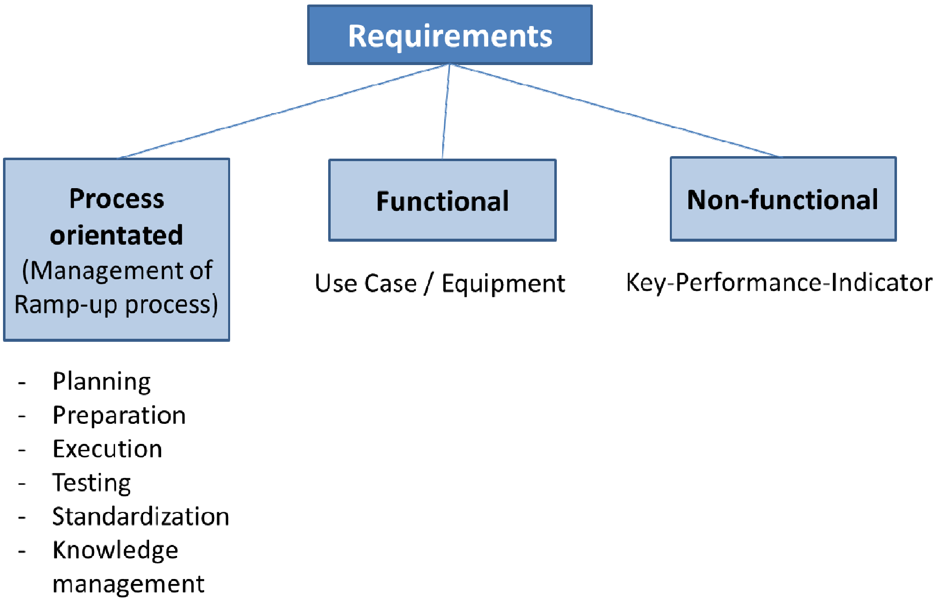
R → Relevant

T → Time-bound

Proceeding “SMART” ensures, that targets and requirements are becoming more reliable but also more realistic.

5.5 Classification of requirements

In order to structure requirements in a practicable way gathered requirements are being listed according to an adapted standard structure [Ebert 2008 Page 27] mostly applied for technical products.



Graph 38 – Classification of requirements

5.6 Definition of business data classes and dependencies

Depending on the hardware device, software architecture, and organizational aspects relevant attributes describing each individual business object are being captured and business data related to these attributes will be gathered.

In a second step a structured approach is being developed aiming to gather the complete range of relevant attributes for the scenario and use case.

Proceeding in this way, the data structure of each relevant business data class is captured. Furthermore, this process facilitates administration of future data changes, enhancement for number of attributes and business objects.

Additionally, a clear data structure is a pre-condition to enhance business object data with interdependencies. This enables future changes and appropriate conclusions during all phases of the Product Development Process.

By that, hardware, software, and organizational business processes are becoming more flexible on future adjustments and enhancements of existing requirements and variations in terms of business environment.

6. Project requirements

6.1 Vision

The vision of I-RAMP³ 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-RAMP³ 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.

By that, I-Ramp³ enables European industry towards smart and innovating manufacturing systems in conventional production and improves its competitiveness and global market perspectives.

6.2 Normative requirements

The following requirements are derived from the document "Grant agreement for collaborative project, Annex I – Description of Work" and form the framework for requirements of the innovative solution applying "Intelligent Reconfigurable Machines for Smart Plug&produce Production".

- Business goals: Optimized ramp-up and operation of production lines
  - Significant reduction of time and efforts during setup and re-configuration
  - Production costs will be reduced by increasing efficiency of manufacturing
- Technical requirements:
  - Optimized ramp-up of heterogeneous devices by applying standardized interfaces, standardized communication protocols, self-descriptive capabilities
  - Easy adaptability of NETDEVs for maintenance and re-use purposes by innovative Plug-in-concept
  - New approaches for smart introduction of intelligent sensors and actuators by using standardized interfaces and advanced communication skills
- Increased flexibility and fault-tolerance during production

- Increased level of modularity, maintainability, and reusability
- NETDEVs are able to optimize themselves to varying setup of production and production conditions by negotiating with each other
- Knowledge-based modules for Manufacturing Execution Systems
- Allows for increasing flexibility and fault-tolerance during production
- Increased level of modularity, maintainability, and reusability
- NETDEVs are able to optimize themselves to varying setup of production and production conditions by negotiating with each other

6.3 Requirement elicitation

This chapter provides gathered and summarized requirements from involved partners, as well as from the technical advisory group. (Responses from partners on initial survey, the tables can be found in the Annexes.)

In the process of requirement elicitation, the scenarios have been defined as "Initial Ram-up", "Set-up", and "Reconfiguration". During development work it revealed that the definition scenarios need to be corrected in order to cover unscheduled maintenance. Due to that, the scenarios considered as "Set-up" may include requirements which are also applicable for scenario "Ramp-up after scheduled maintenance", but also for "Ramp-up after unscheduled maintenance". Due to that, the gathered requirements for "Set-up" will be assigned to scenario "Ramp-up after unscheduled maintenance". (Scenarios Initial Ramp-up remains identical and scenario "Ramp-up after scheduled maintenance" remains covered by "Reconfiguration".)

Additionally to this, a verbal correspondence with the consortia partner Critical Manufacturing (CMF) provides two important requirements regarding the I-Ramp³ project.

As the Manufacturing Execution System is an integrated and also significant part during the ramp-up, CMF states that the MES should be treated as a Use case, also. Additionally to this, CMF suggests to apply an approach based on agile software development within the I-Ramp³ project.

Comment from author: based on this suggestion, partly this approach has already been applied in this document. Chapter 4.4 "Integration of single applications into demo production line" goes back on this proposal.

6.3.1 HARMS & WENDE GMBH & CO KG

Scenario 1 - Initial Ramp-up

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S1-HWH-MGT-1	KPI's of the components must be known	(Must)	Initial survey
REQ-S1-HWH-MGT-2	The success of the (manual) optimization must be visualized for the maintainer	(Must)	Initial survey
REQ-S1-HWH-MGT-3	NETDEVs could automatically provide information on device operation, capabilities, procedures etc. in a standardized way (hand book, movies, drawings,…)	(Must)	Initial survey
REQ-S1-HWH-MGT-4	A standardized business process for ramp-up must be available	(Must)	Workshop
REQ-S1-HWH-MGT-5	The ramp-up process covers technical aspects, as well as organizational and data management aspects, as well as measurement, data back-up, verification, etc.	(Must)	Workshop
REQ-S1-HWH-MGT-6	A responsibility matrix is provided tin order to assign tasks (RACI-Matrix)	(Must)	Workshop
REQ-S1-HWH-MGT-7	The standardized business process for the ramp-up, standardizations and communication protocols enable integration of all industrial partners	(Must)	Workshop
REQ-S1-HWH-MGT-8	State-of-the-art knowledge (such as "SMED") for fast ramping up shall be considered.	(Should)	Workshop
REQ-S1-HWH-MGT-9	The capabilities and limitation of the components should already be available during the design phase	(Should)	Initial survey
REQ-S1-HWH-MGT-10	The general NETDEV operation should be as simple as possible	(Should)	Initial survey
REQ-S1-HWH-MGT-11	Feedback on the users activities and used features of the NETDEV.	(Could)	Initial survey
REQ-S1-HWH-MGT-12	NETDEVs could automatically provide information on device operation, capabilities, mainentance procedures etc. in a standardized way (pdf, movies, drawings,…)	(Could)	Initial survey
	Solution (Use Case) related		
REQ-S1-HWH-UC-1	The interfaces of the various components must fit	(Must)	Initial survey
REQ-S1-HWH-UC-2	The capabilities of the NETDEV's must be assessible for other NETDEV's	(Must)	Initial survey
REQ-S1-HWH-UC-3	NETDEV's must fulfill their tasks in an optimized manner	(Must)	Initial survey
REQ-S1-HWH-UC-4	Components are required which are easy to integrate	(Must)	Initial survey
REQ-S1-HWH-UC-5	Components must be pre-configured in order to obtain a fast production start-up	(Must)	Initial survey
REQ-S1-HWH-UC-6	The setup of a NETDEV must be accessible from "outside" in order to realize maintenance, etc.	(Must)	Initial survey
REQ-S1-HWH-UC-7	Heterogenous devices must be integrated => a common communication scheme and integration mechanism must be available	(Must)	Initial survey
REQ-S1-HWH-UC-8	Manual optimization must also be supported by the NETDEVs.	(Must)	Initial survey
REQ-S1-HWH-UC-9	Backup processes shall be available. It is conceivable to realize these as manual processes.	(Must)	Workshop
REQ-S1-HWH-UC-10	Information of process parameters (process recipe) need to be available for ramp-up after exchange of tools.	(Must)	Workshop
REQ-S1-HWH-UC-11	Ability to react flexible to even major changes e.g. in terms of kVA.	(Must)	Workshop
REQ-S1-HWH-UC-12	In general, new solution including NETDEV needs to fulfill requirements of today's solutions in term of reliability and flexibility	(Must)	Workshop
REQ-S1-HWH-UC-13	Flexibility reasons the planning objects shall be gathered and its dependencies will be identified	(Should)	Workshop
REQ-S1-HWH-UC-14	Manual work orders shall be supported by manual work order instruction, displayed e.g. on a pad.	(Should)	Workshop
REQ-S1-HWH-UC-15	The quality of the products must be at 100% from the very beginning of production	(Should)	Initial survey
REQ-S1-HWH-UC-16	Optimization is done automatically	(Should)	Initial survey
REQ-S1-HWH-UC-17	Interfaces of senors, sensor grids and actors should be standardized	(Should)	Initial survey
REQ-S1-HWH-UC-18	NETDEV configuration and setup should be stored permanetly and must be safe e.g. in case of sudden power loss	(Should)	Initial survey
REQ-S1-HWH-UC-19	An online integration of the components capabilities could speed-up the design process	(Could)	Initial survey
	Key-Performance-Indicator		
REQ-S1-HWH-KPI-1	The costs for the initial ramp-up must be kept within the given range	(Must)	Initial survey
REQ-S1-HWH-KPI-2	The initial ramp-up time must be as short as possible	(Must)	Initial survey
REQ-S1-HWH-KPI-3	The effort for the initial ramp-up (e.g. parametrization, communication protocol, etc.) must be as low as possible	(Must)	Initial survey
REQ-S1-HWH-KPI-4	Components must be pre-configured in order to obtain a fast production start-up	(Must)	Initial survey
REQ-S1-HWH-KPI-5	At the end of the initial ramp-up the quality of the product must be in the specified range (Changed priority)	(Must)	Initial survey
REQ-S1-HWH-KPI-6	The efforts for the ramp-up of a NETDEV should be very low	(Should)	Initial survey

Scenario 2 - Ramp-up after scheduled maintanance

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S2-HWH-MGT-1	Information on the "new" product must be available for the operator (product type, quality requirements, other specifications, …)	(Must)	Initial survey
REQ-S2-HWH-MGT-2	Capabilities and limitation must be known	(Could)	Initial survey
REQ-S2-HWH-MGT-3	Feedback on the users activities and used features of the NETDEV.	(Could)	Initial survey
	Solution (Use Case) related		
REQ-S2-HWH-UC-1	Components must be as flexible as possible in order to adapt them for new products/variants	(Must)	Initial survey
REQ-S2-HWH-UC-2	The wohle production line must be reconfigurable --> Integration of new components and removal of components must be possible	(Must)	Initial survey
REQ-S2-HWH-UC-3	Components must be able to adapte themselves to new variants; limitations of components must be expressed by components	(Must)	Initial survey
REQ-S2-HWH-UC-4	Easy integration and revoval of components	(Must)	Initial survey
REQ-S2-HWH-UC-5	Exchangability of the components even if they come from different vendors must be guaranteed	(Must)	Initial survey
REQ-S2-HWH-UC-6	The configuration (network configuration, data, parameters, etc.) of a NETDEV must be transferable to other NETDEVS e.g. in case of a NETDEV breakdown or malfunction	(Must)	Initial survey
REQ-S2-HWH-UC-7	The descsription of the task must be flexible in that sense that either a generic task description can be provided or a explicit "program number" can be selected.	(Must)	Initial survey
REQ-S2-HWH-UC-8	NETDEVs must provide a mechanism for the "prediction" of the process quality in advance of the production of a new product	(Must)	Initial survey
REQ-S2-HWH-UC-9	NETDEVs must find their optimal process setup in an automatic way without (much) manual operation	(Must)	Initial survey
REQ-S2-HWH-UC-10	The component (NETDEV) should be able to work with different devices/tools	(Should)	Initial survey
REQ-S2-HWH-UC-11	Components should be extensible in order to fit the requirements for the production of the new products	(Should)	Initial survey
REQ-S2-HWH-UC-12	Hardware and firmware exchange should be possible in an easy way	(Should)	Initial survey
REQ-S2-HWH-UC-13	Used components could be integrated	(Could)	Initial survey
REQ-S2-HWH-UC-14	"Hot plug" capabilities of the NETDEVs would be great	(Could)	Initial survey
REQ-S2-HWH-UC-15	An exchange of the real-time systems of a NETDEV during NETDEV operation could be very useful	(Could)	Initial survey
	Key-Performance-Indicator		
REQ-S2-HWH-KPI-1	The costs for the components must not be too high	(Must)	Initial survey
REQ-S2-HWH-KPI-2	A process quality value must be available from the component	(Must)	Initial survey
REQ-S2-HWH-KPI-3	The quality of the process related to the respective component must be stable	(Should)	Initial survey
	Undefined / To be clarified		
REQ-S2-HWH-Undifined-1	Global optimization capability	(Must)	Initial survey
REQ-S2-HWH-Undifined-2	Flexible task interpretation capabilies	(Must)	Initial survey

Scenario 3 - Ramp-up after unscheduled maintenance

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S3-HWH-MGT-1	Easy exchange of optimization goal must be possible	(Must)	Initial survey
REQ-S3-HWH-MGT-2	Feedback on the users activities and used features of the NETDEV.	(Could)	Initial survey
REQ-S3-HWH-MGT-3	The NETDEVs could provide assistance for pro-active and preventive maintenance	(Could)	Initial survey
REQ-S3-HWH-MGT-4	Service and maintenance information could be generated automatically by the NETDEVs and could be transferred to a mobile device to the maintainer	(Could)	Initial survey
REQ-S3-HWH-MGT-5	The NETDEVs could provide assistance for device condition monitoring	(Could)	Initial survey
REQ-S3-HWH-MGT-6	Exceptional information such as error messages, warnings, etc. could be generated automatically by the NETDEVs and could be transferred to a mobile device to the operator	(Could)	Initial survey
REQ-S3-HWH-MGT-7	General device information could be accessible from remote by the operator	(Could)	Initial survey
	Use Case related		
REQ-S3-HWH-UC-1	Components must have the ability of task switching	(Must)	Initial survey
REQ-S3-HWH-UC-2	It should be possible to produce even small lot sizes. Task switching "costs" should be low	(Should)	Initial survey
	Key-Performance-Indicator		
REQ-S3-HWH-KPI-1	Switching between the different products assembled on a production line must be possible without huge efforts	(Must)	Initial survey
REQ-S3-HWH-KPI-2	The quality of the product must be at 100% after the switch	(Must)	Initial survey
REQ-S3-HWH-KPI-3	Switching between the different products assembled on a production line must be possible without huge efforts	(Must)	Initial survey
REQ-S3-HWH-KPI-4	The quality of the product must be at 100% after the switch	(Must)	Initial survey
REQ-S3-HWH-KPI-5	Switching to a "new" product must be easy without (much) manual re-configuration	(Must)	Initial survey
REQ-S3-HWH-KPI-6	The time required for obtaining optimal process behaviour must be very low	(Must)	Initial survey
REQ-S3-HWH-KPI-7	The task switching times should be as short as possible	(Should)	Initial survey
REQ-S3-HWH-KPI-8	Component should be flexible enough to enable the production of different variants	(Should)	Initial survey
	Undefined / To be clarified		
REQ-S3-HWH-Undifined-1	No reconfiguration of the components/devices/machines should be required	(Must)	Initial survey
REQ-S3-HWH-Undifined-2	Flexible task interpretation capabilies	(Must)	Initial survey

6.3.2 AWL TECHNIEK BV

Scenario 1 - Initial Ramp-up

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S1-AWL-MGT-1	Specify in standard terms	(Must)	Initial survey
REQ-S1-AWL-MGT-2	Stable standards and open	(Must)	Initial survey
	Solution (Use Case) related		
REQ-S1-AWL-UC-1	IRAMP for all welding kit	(Must)	Initial survey
REQ-S1-AWL-UC-2	Ability to chose between different options	(Must)	Initial survey
REQ-S1-AWL-UC-3	Have off line intergration environment (tool)	(Must)	Initial survey
REQ-S1-AWL-UC-4	Trouble shoot functions	(Must)	Initial survey
REQ-S1-AWL-UC-5	initutive GUI	(Must)	Initial survey
REQ-S1-AWL-UC-6	Development of self-diagnostic functionalities	(Must)	Workshop
REQ-S1-AWL-UC-7	Future solution must be applicable in the field.	(Must)	Workshop
REQ-S1-AWL-UC-8	Realization of self-diagnostic system should be realized by means of standardization, based on existing controlling systems and communication platforms (e.g. web-based)	(Must)	Workshop
REQ-S1-AWL-UC-9	I-Ramp technology must be applicable to all optional use cases also	(Must)	Verbal
REQ-S1-AWL-UC-10	Vision: Placing orders to suppliers according "I-Ramp³"-compliant specification	(Should)	Workshop
REQ-S1-AWL-UC-11	I-Ramp³should be subject of current development process	(Should)	Workshop
REQ-S1-AWL-UC-12	The ability to adjust customer's requirements (regarding product, process, throughput, etc.) after placing the order (dependency diagram)	(Should)	Workshop
REQ-S1-AWL-UC-13	Brand independent	(Should)	Initial survey
REQ-S1-AWL-UC-14	Help function	(Should)	Initial survey
	Key-Performance-Indicator		
REQ-S1-AWL-KPI-1	Reaching stability of process during ramp-up in shorter time and with higher reliability	(Must)	Workshop

Scenario 2 - Ramp-up after scheduled maintanance

No.	Requirement	Priority	Source
	Solution (Use Case) related		
REQ-S2-AWL-UC-1	Plugins	(Must)	Initial survey
REQ-S2-AWL-UC-2	Existing interfaces (general)	(Must)	Initial survey
REQ-S2-AWL-UC-3	Solution for backward compatibilty	(Must)	Initial survey
REQ-S2-AWL-UC-4	Ease of use	(Must)	Initial survey

Scenario 3 - Ramp-up after unscheduled maintenance

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S3-AWL-MGT-1	Limits definitions	(Must)	Initial survey
REQ-S3-AWL-MGT-2	Stable standards	(Must)	Initial survey
REQ-S3-AWL-MGT-3	Verifications tests (general)	(Must)	Initial survey
REQ-S3-AWL-MGT-4	Config check mechanisms	(Must)	Initial survey
	Key-Performance-Indicator		
REQ-S3-AWL-KPI-1	Increase Speed	(Must)	Initial survey
	Undefined / To be clarified		
REQ-S3-AWL-Undifined-1	Specification ease	(Must)	Initial survey

6.3.3 TECHNAX INDUSTRIE SAS

Scenario 1 - Initial Ramp-up

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S1-TNX-MGT-1	Know the management requirements in terms of ramp-up speed to take the right decisions fulfilling the management goals.	(Must)	Initial survey
REQ-S1-TNX-MGT-2	Reckon with present-day environment (communication, space, suppliers, storage room…)	(Must)	Initial survey
REQ-S1-TNX-MGT-3	Provides in time the equipment which fulfill the expectations of the equipment builder in terms of technology (required functions considering price/quality ratio)	(Must)	Initial survey
REQ-S1-TNX-MGT-4	Provide standardisation Netdev's -> all characteristics is known from the very begining -> speed up parametrization and communication	(Must)	Initial survey
REQ-S1-TNX-MGT-5	Know the fab planner expectations and provides a machine which complies with his requirements (i.e. producing the machine in time, with the required quality and with the appropriate flows)	(Must)	Initial survey
REQ-S1-TNX-MGT-6	Stay in closed cooperation with the fab planner along the machine building time	(Must)	Initial survey
REQ-S1-TNX-MGT-7	Be present during the first machine start.	(Must)	Initial survey
REQ-S1-TNX-MGT-8	Deep inside knowledge of machine	(Must)	Initial survey
REQ-S1-TNX-MGT-9	Know how to replace spare parts and sensors	(Must)	Initial survey
REQ-S1-TNX-MGT-10	Be trained to the use and running of the most critical components	(Must)	Initial survey
REQ-S1-TNX-MGT-11	Have been trained to the running of the machine and be aware of that he/she can do and not do (for his/her own safety)	(Must)	Initial survey
REQ-S1-TNX-MGT-12	Required features for future application: flexible welding system	(Must)	Workshop
REQ-S1-TNX-MGT-13	Have an overview of the future production in order to make choices which do not irreversably affect the possible evolutions of the machine - be able to suggest alternatives in case of important delivery delays of some suppliers.	(Should)	Initial survey
REQ-S1-TNX-MGT-14	Be able to suggest alternatives in case of important delivery delays of some suppliers.	(Should)	Initial survey
REQ-S1-TNX-MGT-15	Inform the machine builder in case of important dysfunction of the machine	(Should)	Initial survey
REQ-S1-TNX-MGT-16	Feedback on Netdev's which are already running	(Should)	Initial survey
REQ-S1-TNX-MGT-17	Inform the fab planner if he thinks the latter is wrong regarding the machine specifications.	(Should)	Initial survey
REQ-S1-TNX-MGT-18	Be reactive and able to modify components in case things don't run so good as expected.	(Should)	Initial survey
REQ-S1-TNX-MGT-19	Inform the operator about the maintenance procedure	(Should)	Initial survey
REQ-S1-TNX-MGT-20	Have a spare parts list of the most critical machine components to be able to react quickly in case of breakdown (to have it in stock)	(Should)	Initial survey
REQ-S1-TNX-MGT-21	Operator should be involved before the delivering date	(Should)	Initial survey
REQ-S1-TNX-MGT-22	Know all the types which are concerned by the new equipment and the requirements in terms of production increasing speed.	(Should)	Initial survey
REQ-S1-TNX-MGT-23	The I-Ramp project should result in a real saleable product for Technax	(Should)	Workshop
REQ-S1-TNX-MGT-24	It should be able to realize it with partners Technax is working with already today	(Should)	Workshop
REQ-S1-TNX-MGT-25	Assist and listen to the operator remarks during the first days in order to improve the machine productivity (reduction of stop times)	(Could)	Initial survey
REQ-S1-TNX-MGT-26	Assist and listen to the operator remarks during the first days in order to improve the machine productivity (reduction of stop times)	(Could)	Initial survey
REQ-S1-TNX-MGT-27	Assist the machine builder during the first runs to react in case he did not give the right indications.	(Could)	Initial survey
REQ-S1-TNX-MGT-28	Think of the best design in order to facilitate plug and play equipment for eventual new futur requirements	(Could)	Initial survey
REQ-S1-TNX-MGT-29	Propose a degraded mean of production (eg. without definitive frame and all automated motion) before official delivered date in order to start the training phase and produce prototypes	(Could)	Initial survey
REQ-S1-TNX-MGT-30	Possible potentials are also seen by using operator guidance based on work order instructions provided by a pad or handheld	(Could)	Workshop
REQ-S1-TNX-MGT-31	Give tips to improve the machine running by noting most occuring failures	(Could)	Initial survey

	Solution (Use Case) related		
REQ-S1-TNX-UC-1	Propose the best compromise between what equipment builder asks and which component fits the best considering environment builder (connections and communications with the other components)	(Should)	Initial survey
REQ-S1-TNX-UC-2	Think of the most critical points in order to be able to provide another solutions (other trademark, other technology,) to respect delivery times -> connections and communications have to be compatible	(Should)	Initial survey
REQ-S1-TNX-UC-3	Propose design amelioration of the machine in order to improve quality and productivity	(Could)	Initial survey
REQ-S1-TNX-UC-4	Be able to proceed to parts changing if obvious conception mistakes appear within the first days.	(Could)	Initial survey
	Undefined / To be clarified		
REQ-S1-TNX-Undifined-1	Respect the product flow as soon as possible	(Must)	Initial survey
REQ-S1-TNX-Undifined-2	Be able to suggest the best materials matching the specifications of the machine builder.	(Should)	Initial survey

Scenario 2 - Ramp-up after scheduled maintanance

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S2-TNX-MGT-1	Have made prior trials to speed up the ramp-up time of the machine for the new batch.	(Must)	Initial survey
REQ-S2-TNX-MGT-2	Know the changing procedure when producing a new batch.	(Must)	Initial survey
REQ-S2-TNX-MGT-3	Inform his responsible if the type changing is too long due to the machine conception.	(Must)	Initial survey
REQ-S2-TNX-MGT-4	Have tested the components outside the machine,	(Must)	Initial survey
REQ-S2-TNX-MGT-5	Be aware of the new machine fittings in order to avoid damaging or wrong manipulation.	(Must)	Initial survey
REQ-S2-TNX-MGT-6	Give to the operator the new parameters to able a smooth start of the production.	(Should)	Initial survey
REQ-S2-TNX-MGT-7	Assist the operator and be able to debug the machine if needed.	(Should)	Initial survey
REQ-S2-TNX-MGT-8	Know the characteristics of the new parts to be made in order to inform the equiment builder about its matching with the components	(Should)	Initial survey
REQ-S2-TNX-MGT-9	Be able to suggest solutions providing quick changes by implementing so called NETDEV	(Should)	Initial survey
REQ-S2-TNX-MGT-10	Be informed by the fab planner about the new changes to check that everything will run smoothly	(Should)	Initial survey
REQ-S2-TNX-MGT-11	Inform the operator of the consequences of the installation of new components, like new procedures and warnings.	(Should)	Initial survey
REQ-S2-TNX-MGT-12	Assist the operator and be able to debug the machine if needed	(Should)	Initial survey
REQ-S2-TNX-MGT-13	Inform Operators responsible about good starting or not of the new production piece	(Should)	Initial survey
REQ-S2-TNX-MGT-14	Assist the fab planner by giving him advices in new components adjusting.	(Could)	Initial survey
REQ-S2-TNX-MGT-15	As main machine user, he could give tips to speed up the ramp-up phase of the new piece.	(Could)	Initial survey
REQ-S2-TNX-MGT-16	Assist the fab planner during machine restart.	(Could)	Initial survey
	Solution (Use Case) related		
REQ-S2-TNX-UC-1	Propose a Netdev which can trained from the Feedback of former Netdev and which can optimized itself	(Must)	Initial survey
REQ-S2-TNX-UC-2	Fits with the other components	(Must)	Initial survey
REQ-S2-TNX-UC-3	Propose a Netdev which can trained from the Feedback of former Netdev and which can optimized itself	(Must)	Initial survey
REQ-S2-TNX-UC-4	Fits with the other components	(Must)	Initial survey
REQ-S2-TNX-UC-5	Check the compatibilty of the new components with the whole machine's running to avoid damage.	(Must)	Initial survey
REQ-S2-TNX-UC-6	Keep a look on the first production hours to be sure that that the process runs without problem.	(Should)	Initial survey
REQ-S2-TNX-UC-7	Give to the operator the new parameters to able a smooth start of the production.	(Should)	Initial survey

6.3.4 IEF WERNER GMBH

Scenario 1 - Initial Ramp-up

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S1-IEF-MGT-1	Machine knowledge transfer to the line	(Must)	Initial survey
REQ-S1-IEF-MGT-2	Easy to handle ramp up phase	(Must)	Initial survey
REQ-S1-IEF-MGT-3	Fast learning curve	(Should)	Initial survey
REQ-S1-IEF-MGT-4	Using standard software for data presentation	(Could)	Initial survey
REQ-S1-IEF-MGT-5	For manual tasks the project might consider manual workplace instructions	(Could)	Workshop
REQ-S1-IEF-MGT-6	Additionally operator guiding by means of an Pad or similar equipments combined with internal sensors	(Could)	Workshop
REQ-S1-IEF-MGT-7	Demo shall consider Module, System, Line	(Could)	Workshop
	Solution (Use Case) related		
REQ-S1-IEF-UC-1	Supply of basic information of the component for the ramp up to the control Integration of standard interfaces	(Must)	Initial survey
REQ-S1-IEF-UC-2	Control with menues which guides the operator easier for ramp up.	(Must)	Initial survey
REQ-S1-IEF-UC-3	Component could communicate with Beckhoff or Siemens system with standard bus EtherCAT. or Siemens Profinet	(Should)	Initial survey
	Key-Performance-Indicator		
REQ-S1-IEF-KPI-1	Ramp-up should not only become faster but also more reliable and predictable	(Must)	Workshop

Scenario 2 - Ramp-up after scheduled maintanance

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S2-IEF-MGT-1	Performance tool / Cycle time simulation for new product	(Must)	Initial survey
REQ-S2-IEF-MGT-2	Supply of static and dynamic information of the component for the setup to the control	(Must)	Initial survey
REQ-S2-IEF-MGT-3	Reusing requirements with a learning software	(Must)	Initial survey
REQ-S2-IEF-MGT-4	Fast requirement analysis	(Must)	Initial survey
REQ-S2-IEF-MGT-5	Self descriptive set up task	(Must)	Initial survey
REQ-S2-IEF-MGT-6	Process knowledge transfer to the control	(Should)	Initial survey
	Solution (Use Case) related		
REQ-S2-IEF-UC-1	Supply of basic information of the component for the ramp up to the control Integration of standard interfaces	(Must)	Initial survey
REQ-S2-IEF-UC-2	Auto tune technology	(Must)	Initial survey
REQ-S2-IEF-UC-3	Short set-up time	(Must)	Initial survey
REQ-S2-IEF-UC-4	Database memory to save old configuration	(Should)	Initial survey

6.3.5 INOS HELLAS

Scenario 1 - Initial Ramp-up

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S1-INOS-MGT-1	Component performance must be predictable and consistent	(Must)	Initial survey
REQ-S1-INOS-MGT-2	KPI's of the components must be known	(Must)	Initial survey
REQ-S1-INOS-MGT-3	The general approach should focus on quick wins within the project followed by more sophisticated solution together with project partners from universities	(Must)	Workshop
REQ-S1-INOS-MGT-4	Ramp up duration and effort should be predictable	(Must)	Initial survey
REQ-S1-INOS-MGT-5	Faster ramp-up by enabling field engineers to quickly gain experience during the ramp-up process. By that the ramp-up learning curve shall be increased from the very beginning.	(Must)	Workshop
REQ-S1-INOS-MGT-6	The NETDEV should base on a solid proofed business process, which is well documented and supported by IT	(Must)	Workshop
REQ-S1-INOS-MGT-7	Standardized documentation and checklist should be applied	(Must)	Workshop
REQ-S1-INOS-MGT-8	The capabilities and limitation of the components should already be available during the design phase	(Should)	Initial survey
	Solution (Use Case) related		
REQ-S1-INOS-UC-1	Components are required which are easy to integrate	(Must)	Initial survey
REQ-S1-INOS-UC-2	Ramp up curve should not be late steep but progressive and ideally early steep	(Must)	Initial survey
REQ-S1-INOS-UC-3	Components must be pre-configurable	(Must)	Initial survey
REQ-S1-INOS-UC-4	Heterogenous devices must be integrated => a common communication scheme and integration mechanism must be available	(Must)	Initial survey
REQ-S1-INOS-UC-5	Support large information sets (images) from information rich machine sensors (i.e. cameras, scanning lasers)	(Must)	Initial survey
REQ-S1-INOS-UC-6	Support fast information (sampling) rates from intelligent machine sensors	(Must)	Initial survey
REQ-S1-INOS-UC-7	NETDEV configuration and setup must be stored permanetly and must be safe e.g. in case of sudden power loss. Must be available remotely (changed priority)	(Must)	Initial survey
REQ-S1-INOS-UC-8	Increase availability of possible range of configurations	(Must)	Workshop
REQ-S1-INOS-UC-9	Possible application ralized on a pad: Work order management system	(Should)	Workshop
REQ-S1-INOS-UC-10	Possible application ralized on a pad: knowledge management system	(Should)	Workshop
REQ-S1-INOS-UC-11	Possible application ralized on a pad: Decision support system	(Should)	Workshop
REQ-S1-INOS-UC-12	An abstraction layer for protocols and interfaces between INOS software and robot controller is suggested in order to increase standardization	(Should)	Workshop
REQ-S1-INOS-UC-13	Future solution should be based on available technologies but also be backwards compatible.	(Should)	Workshop
	Key-Performance-Indicator		
REQ-S1-INOS-KPI-1	Ramp-up time must be as short as possible	(Should)	Initial survey
REQ-S1-INOS-KPI-2	A more reliable ramp-up and increased predictability of ramp-up progress	(Should)	Workshop

Scenario 2 - Ramp-up after scheduled maintanance

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S2-INOS-MGT-1	Reconfiguration effort and duration should be predictable and effort low	(Must)	Initial survey
	Solution (Use Case) related		
REQ-S2-INOS-UC-1	Components must be as flexible as possible in order to adapt them for new products/variants	(Must)	Initial survey
REQ-S2-INOS-UC-2	Switching between products should be a software operation	(Must)	Initial survey
REQ-S2-INOS-UC-3	Easy integration and revoval of components	(Must)	Initial survey
REQ-S2-INOS-UC-4	Exchangability of the components even if they come from different vendors must be guaranteed	(Must)	Initial survey
REQ-S2-INOS-UC-5	Remote setup	(Must)	Initial survey
REQ-S2-INOS-UC-6	Components should be extensible in order to fit the requirements for the production of the new products	(Should)	Initial survey
REQ-S2-INOS-UC-7	It should be possible to produce one sized lots of build to order products.	(Should)	Initial survey
REQ-S2-INOS-UC-8	Used components could be integrated; Capabilities and limitation must be known	(Could)	Initial survey
	Key-Performance-Indicator		
REQ-S2-INOS-KPI-1	The costs for the components must not be too high	(Must)	Initial survey
REQ-S2-INOS-KPI-2	Task switching "costs" should be very low	(Should)	Initial survey

Scenario 3 - Ramp-up after unscheduled maintenance

No.	Requirement	Priority	Source
	Solution (Use Case) related		
REQ-S3-INOS-UC-1	Switching between the different products assembled on a production line must be possible without huge efforts	(Must)	Initial survey
REQ-S3-INOS-UC-2	Component should be flexible enough to enable the production of different variants	(Must)	Initial survey
REQ-S3-INOS-UC-3	No reconfiguration of the components/devices/machines should be required	(Should)	Initial survey
	Key-Performance-Indicator		
REQ-S3-INOS-KPI-1	The quality of the product must be at 100% after the switch	(Must)	Initial survey
REQ-S3-INOS-KPI-2	Set-up duration should be low and effort minimal	(Must)	Initial survey
REQ-S3-INOS-KPI-3	The task switching times should be as short as possible	(Should)	Initial survey

6.3.6 CRITICAL MANUFACTURING

Scenario 1 - Initial Ramp-up

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S1-CMF-MGT-1	Delivery plan, sequence of tools or lines to be delivered	(Should)	Initial survey
REQ-S1-CMF-MGT-2	Applying agile software development approach in order to achieve faster results	(Should)	Verbal
	Solution (Use Case) related		
REQ-S1-CMF-UC-1	The system needs to provide the characteristics of the new components required to run the new lines	(Must)	Initial survey
REQ-S1-CMF-UC-2	Detailed specs for every new tool and sensor to be produced and delivered	(Must)	Initial survey
REQ-S1-CMF-UC-3	MES should be treated as an Object within the ramp-up, also	(Should)	Verbal

Scenario 2 - Ramp-up after scheduled maintanance

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S2-CMF-MGT-1	Be able to simulate different configurations and have it integrated with planning and scheduling tools	(Must)	Initial survey
REQ-S2-CMF-MGT-2	To provide spec changes for the existing components and requirements for new components and tools	(Must)	Initial survey
REQ-S2-CMF-MGT-3	Maintenance plan changes	(Must)	Initial survey

Scenario 3 - Ramp-up after unscheduled maintenance

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S3-CMF-MGT-1	Know the overall master data changes required to setup a new line (new tools, new products that can be produced, its flows, etc)	(Must)	Initial survey
REQ-S3-CMF-MGT-2	To provide locations, delivery times, stockage requirements, certifications	(Must)	Initial survey
REQ-S3-CMF-MGT-3	Maintenance schedule, part list, workflow for maintenance activities (part replacements, orders, inventories, etc)	(Must)	Initial survey

6.3.7 GAMAX

Scenario 1 - Initial Ramp-up

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S1-GMX-MGT-1	Know the place in the line	(Must)	Initial survey
REQ-S1-GMX-MGT-2	Have a good catalogue how and where to put the component and how to configure it	(Must)	Initial survey
REQ-S1-GMX-MGT-3	Know what the component is able to do (catalogue) and the place in the line	(Must)	Initial survey
REQ-S1-GMX-MGT-4	Have a catalogue how to build a line	(Should)	Initial survey
REQ-S1-GMX-MGT-5	Have a good catalogue how to initially configure with optimal parameters	(Should)	Initial survey
REQ-S1-GMX-MGT-6	Know the order and the place in the line, so can see the results in an optimal way	(Should)	Initial survey
REQ-S1-GMX-MGT-7	Create reports for next fab planning	(Should)	Initial survey
REQ-S1-GMX-MGT-8	Have a Q&A (wiki) with most of the information collected	(Should)	Initial survey
REQ-S1-GMX-MGT-9	Know the order in the line - so could optimize connection between components	(Could)	Initial survey
REQ-S1-GMX-MGT-10	Have a report-collection place where other similar ramp-up reports can be seen (wiki)	(Could)	Initial survey
	Solution (Use Case) related		
REQ-S1-GMX-UC-1	Have some results for optimal solutions	(Could)	Initial survey

Scenario 2 - Ramp-up after scheduled maintanance

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S2-GMX-MGT-1	Know the results of the previous set-ups, so can optimize new plannings	(Must)	Initial survey
REQ-S2-GMX-MGT-2	The old parameters how to be changed to work like requested	(Must)	Initial survey
REQ-S2-GMX-MGT-3	See the results that everything is working with best performance	(Must)	Initial survey
REQ-S2-GMX-MGT-4	Be able to continue work without any problem	(Must)	Initial survey
REQ-S2-GMX-MGT-5	Know how much productivity loss will be when reconfiguration is made	(Should)	Initial survey
REQ-S2-GMX-MGT-6	The old parameters how to be changed in an optimal way for better efficiency	(Should)	Initial survey
REQ-S2-GMX-MGT-7	Report optimal set-up parameters to fab planners	(Should)	Initial survey
REQ-S2-GMX-MGT-8	Be able to continue work without any interruption	(Should)	Initial survey
	Use Case related		
REQ-S2-GMX-UC-1	Be able to reconfigure fast locally near the machine	(Must)	Initial survey
REQ-S2-GMX-UC-2	Have a solution to change parameters remotely	(Could)	Initial survey

Scenario 3 - Ramp-up after unscheduled maintenance

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S3-GMX-MGT-1	Know the results of the previous set-ups, so can optimize new plannings	(Must)	Initial survey
REQ-S3-GMX-MGT-2	Know about old components to be easily replaced with the new ones	(Must)	Initial survey
REQ-S3-GMX-MGT-3	Have a document of initial ramp-up so can easily set-up with new paramters	(Must)	Initial survey
REQ-S3-GMX-MGT-4	See the results that everything is working with best performance	(Must)	Initial survey
REQ-S3-GMX-MGT-5	Be able to see and find changes in the user interface easily	(Must)	Initial survey
REQ-S3-GMX-MGT-6	Know the productivity loss when equipment builders set up the line	(Should)	Initial survey
REQ-S3-GMX-MGT-7	Know how to change optimally old components to be replaced with the new ones	(Should)	Initial survey
REQ-S3-GMX-MGT-8	Know about similar component set-up results and reports	(Should)	Initial survey
REQ-S3-GMX-MGT-9	Report optimal set-up parameters to fab planners	(Should)	Initial survey
REQ-S3-GMX-MGT-10	Understand changes really fast	(Should)	Initial survey
	Use Case related		
REQ-S3-GMX-UC-1	Have a solution to configure remotely (via web or phone)	(Could)	Initial survey

6.3.8 UNIVERSIDADE DO PORTO

Scenario 1 - Initial Ramp-up

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S1-FEUP-MGT-1	Get information on the requirements of the process/product	(Must)	Initial survey
REQ-S1-FEUP-MGT-2	Have an indication on the KPIs	(Must)	Initial survey
REQ-S1-FEUP-MGT-3	Be able to test alternative configurations	(Should)	Initial survey
REQ-S1-FEUP-MGT-4	Measure impact on KPIs	(Should)	Initial survey
	Solution (Use Case) related		
REQ-S1-FEUP-UC-1	Have automatic tools to help him	(Could)	Initial survey

Scenario 2 - Ramp-up after scheduled maintanance

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S2-FEUP-MGT-1	Get information on the capabilities of the equipment	(Must)	Initial survey
REQ-S2-FEUP-MGT-2	Get information on the requirements of the process/product	(Must)	Initial survey
REQ-S2-FEUP-MGT-3	Have an indication on the KPIs	(Must)	Initial survey
	Solution (Use Case) related		
REQ-S2-FEUP-UC-1	Have automatic tools to help him	(Must)	Initial survey

Scenario 3 - Ramp-up after unscheduled maintenance

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S3-FEUP-MGT-1	Get information on initial tests	(Must)	Initial survey
REQ-S3-FEUP-MGT-2	Be able to use test results for future planning	(Should)	Initial survey
REQ-S3-FEUP-MGT-3	Information on KPIs	(Should)	Initial survey

6.3.9 Hochschule Karlsruhe Technik und Wirtschaft

Scenario 1 - Initial Ramp-up

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S1-IAF-MGT-1	Acquire boundary conditions	(Must)	Initial survey
REQ-S1-IAF-MGT-2	Acquire capabilities/efforts of potential components	(Must)	Initial survey
REQ-S1-IAF-MGT-3	Arrange cells, lines	(Must)	Initial survey
REQ-S1-IAF-MGT-4	Simulate and assess production arrangement (fab)	(Must)	Initial survey
REQ-S1-IAF-MGT-5	Optimize fab arrangement	(Must)	Initial survey
REQ-S1-IAF-MGT-6	Create fab communication infrastructure	(Must)	Initial survey
REQ-S1-IAF-MGT-7	Verify fab cooperation and optimization	(Must)	Initial survey
REQ-S1-IAF-MGT-8	Offer component capabilities/efforts	(Must)	Initial survey
REQ-S1-IAF-MGT-9	Simulate component communication	(Must)	Initial survey
REQ-S1-IAF-MGT-10	Simulate component optimization/operation	(Must)	Initial survey
REQ-S1-IAF-MGT-11	Supply component life cycle data	(Must)	Initial survey
REQ-S1-IAF-MGT-12	Acquire capabilities/efforts of potential components	(Must)	Initial survey
REQ-S1-IAF-MGT-13	Acquire fab optimization goals wrt. Cell/line	(Must)	Initial survey
REQ-S1-IAF-MGT-14	Simulate, assess and optimize cells, lines	(Must)	Initial survey
REQ-S1-IAF-MGT-15	Create & modify staff training documents	(Should)	Initial survey
REQ-S1-IAF-MGT-16	Set up refurbishment plan	(Should)	Initial survey
REQ-S1-IAF-MGT-17	Set up life cycle management	(Should)	Initial survey
	Solution (Use Case) related		
REQ-S1-IAF-UC-1	Connect to the environment	(Must)	Initial survey
REQ-S1-IAF-UC-2	Set-up component models (process, wear, opt.)	(Must)	Initial survey

Scenario 2 - Ramp-up after scheduled maintanance

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S2-IAF-MGT-1	Acquire product requirements	(Must)	Initial survey
REQ-S2-IAF-MGT-2	Acquire boundary conditions	(Must)	Initial survey
REQ-S2-IAF-MGT-3	Acquire capabilities/efforts of potential components	(Must)	Initial survey
REQ-S2-IAF-MGT-4	Arrange cells, lines	(Must)	Initial survey
REQ-S2-IAF-MGT-5	Simulate and assess production arrangement	(Must)	Initial survey
REQ-S2-IAF-MGT-6	Optimize arrangement	(Must)	Initial survey
REQ-S2-IAF-MGT-7	Create communication infrastructure	(Must)	Initial survey
REQ-S2-IAF-MGT-8	Verify cooperation and optimization	(Must)	Initial survey
REQ-S2-IAF-MGT-9	Offer component capabilities/efforts	(Must)	Initial survey
REQ-S2-IAF-MGT-10	Simulate component communication	(Must)	Initial survey
REQ-S2-IAF-MGT-11	Simulate component optimization/operation	(Must)	Initial survey
REQ-S2-IAF-MGT-12	Supply component life cycle data	(Must)	Initial survey
REQ-S2-IAF-MGT-13	Acquire capabilities/efforts of potential components	(Must)	Initial survey
REQ-S2-IAF-MGT-14	Acquire optimization goals wrt. Cell/line	(Must)	Initial survey
REQ-S2-IAF-MGT-15	Simulate, assess and optimize cells, lines	(Must)	Initial survey
REQ-S2-IAF-MGT-16	Create staff training documents	(Must)	Initial survey
REQ-S2-IAF-MGT-17	Set up refurbishment plan	(Must)	Initial survey
REQ-S2-IAF-MGT-18	Set up life cycle management	(Must)	Initial survey
REQ-S2-IAF-MGT-19	Create & Modify training docs	(Should)	Initial survey
REQ-S2-IAF-MGT-20	Modify refurb. Plan	(Should)	Initial survey
REQ-S2-IAF-MGT-21	Modify life cycle management	(Should)	Initial survey

6.3.10 FRAUNHOFER IPA

Scenario 1 - Initial Ramp-up

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S1-IPA-MGT-1	Clear specification of solution in terms of hardware, software, interfaces, etc.	(Must)	Initial survey
REQ-S1-IPA-MGT-2	Environmental conditions, building, clean room, electricity are ready to use	(Must)	Initial survey
REQ-S1-IPA-MGT-3	Re-qualification process clear	(Must)	Initial survey
REQ-S1-IPA-MGT-4	It contains a documentated process work flow	(Must)	Initial survey
REQ-S1-IPA-MGT-5	Manual workorder instructions for set-up are available and clearly defined	(Must)	Initial survey
REQ-S1-IPA-MGT-6	Clear and explicit documentation of process flow for installation	(Should)	Initial survey
REQ-S1-IPA-MGT-7	It contains a documented process work flow	(Should)	Initial survey
REQ-S1-IPA-MGT-8	Regular reporting & Ad-hoc reporting during initial ramp-up phase	(Should)	Initial survey
REQ-S1-IPA-MGT-9	Interdependecies are clear	(Should)	Initial survey
REQ-S1-IPA-MGT-10	Is-built documents and layouts are available	(Should)	Initial survey
REQ-S1-IPA-MGT-11	Manual workorder instructions for supporting are clearly defined	(Should)	Initial survey
REQ-S1-IPA-MGT-12	Transparent system in order to learn how to use the system	(Should)	Initial survey
REQ-S1-IPA-MGT-13	Interfaces allow quick ramp-up (e.G. standardisation)	(Could)	Initial survey
	Solution (Use Case) related		
REQ-S1-IPA-UC-1	Simple and quick implementation of the new solution into current processes	(Should)	Initial survey
REQ-S1-IPA-UC-2	Plug-and-play implementation of new solution into current processes	(Could)	Initial survey
REQ-S1-IPA-UC-3	Prevention of misusage and detection of mistakes (Poka-yoke)	(Could)	Initial survey
REQ-S1-IPA-UC-4	User-friendly GUI	(Could)	Initial survey

Scenario 2 - Ramp-up after scheduled maintanance

No.	Requirement	Priority	Source
	Management of Ramp-up process		
REQ-S2-IPA-MGT-1	Clear and documented process flow for reconfiguration of the equipment / line	(Must)	Initial survey
REQ-S2-IPA-MGT-2	Requirements for new tools are available at right time	(Must)	Initial survey
REQ-S2-IPA-MGT-3	Re-qualification process clear	(Must)	Initial survey
REQ-S2-IPA-MGT-4	Reconfiguration process flow is clearly documented	(Must)	Initial survey
REQ-S2-IPA-MGT-5	Regular reporting & Ad-hoc reporting from reconfiguration	(Should)	Initial survey
REQ-S2-IPA-MGT-6	Controll of usage of utilities, such as electricity or gas	(Should)	Initial survey
REQ-S2-IPA-MGT-7	It contains a documentated process work flow	(Should)	Initial survey
REQ-S2-IPA-MGT-8	Self-reconfiguration of the system	(Should)	Initial survey
REQ-S2-IPA-MGT-9	Good forecasting of tools	(Could)	Initial survey
	Solution (Use Case) related		
REQ-S2-IPA-UC-1	Simple and quick implementation of the new solution into current processes	(Should)	Initial survey
REQ-S2-IPA-UC-2	Solution is flexible for all variants of products	(Should)	Initial survey
REQ-S2-IPA-UC-3	Self reconfiguration of the system	(Should)	Initial survey
REQ-S2-IPA-UC-4	Single-piece reconfiguration after each part with no production delay	(Could)	Initial survey
REQ-S2-IPA-UC-5	Self description of system	(Could)	Initial survey
REQ-S2-IPA-UC-6	Prevention of misusage and detection of mistakes (Poka-yoke)	(Could)	Initial survey
REQ-S2-IPA-UC-7	No special tool-kit required	(Could)	Initial survey
REQ-S2-IPA-UC-8	Remote-Access	(Could)	Initial survey
REQ-S2-IPA-UC-9	User-friendly GUI	(Could)	Initial survey
	Management of Ramp-up proces		
REQ-S2-IPA-MGT-1	Availiability of spare parts	(Must)	Initial survey
REQ-S2-IPA-MGT-2	Is-build-plan and documentation	(Must)	Initial survey
REQ-S2-IPA-MGT-3	Re-qualification process clear	(Must)	Initial survey
REQ-S2-IPA-MGT-4	It contains a documented process work flow	(Should)	Initial survey
REQ-S2-IPA-MGT-5	Regular reporting & Ad-hoc reporting from ramp-up	(Should)	Initial survey
REQ-S2-IPA-MGT-6	Good forecasting of ware and spare parts	(Could)	Initial survey
	Solution (Use Case) related		
REQ-S2-IPA-UC-1	Accessibility to all parts	(Must)	Initial survey
REQ-S2-IPA-UC-2	Existing redundancies	(Should)	Initial survey
REQ-S2-IPA-UC-3	Modular construction system	(Should)	Initial survey
REQ-S2-IPA-UC-4	Quick and easy exchange of parts	(Should)	Initial survey
REQ-S2-IPA-UC-5	Short response time in case of breakdown	(Should)	Initial survey
REQ-S2-IPA-UC-6	Prevention of misusage and detection of mistakes (Poka-yoke)	(Could)	Initial survey
REQ-S2-IPA-UC-7	Remote-Access	(Could)	Initial survey
REQ-S2-IPA-UC-8	No special tool-kit required	(Could)	Initial survey
REQ-S2-IPA-UC-9	User-friendly GUI	(Could)	Initial survey
	Key-Performance-Indicator		
REQ-S2-IPA-KPI-1	Reliable in terms of less number of disruptions and short time to repair	(Must)	Initial survey

6.3.11 External advisory group

Peter Zahn, Manz AG – Reutlingen (Germany)

Before start of project

Ensure that the milestones as follows are finished / achieved:

1. Building "Ready for Move-In"
2. Facilities built-up and utilities available
3. Definition of ramp-up plan considering dead-lines, move-in sequence considering local conditions and roads, gate-ways, requirements regarding cleanliness, sequence of delivery of units
4. Personal is available and scheduling plan is finished for persons in charge, local team, support team (e.g. supplier). Considering a backup plan in order to have additional personal resources at once disposal.
5. Define responsibilities and clarify communication (contact persons, regular meetings, ad-hoc meetings, reports, etc.) and escalation procedure. Definition of critical equipment.
6. Organize tools and auxiliary materials (e.g. crane, fork-lifter, tools, etc.)
7. Clarify of EHS (**E**nvironment, **H**ealth, **S**afety) aspects (evacuation plan, safety areas, emergency exits, etc.)

Start of project

1. Jour-fixe with all participant
2. Daily reports on ramp-up progress
3. Continuous update of project plan and aligning of priorities
4. Weekly project-review-meeting with team and steering committee

After project finalization

1. Gather lessons learned for the whole period of time of the project
2. Final report considering Plan- and real – KPI's

Dr. Kevin Reddig, Robert Bosch GmbH – Stuttgart (Germany)

Planning phase:

Helpful to prepare (This is not actually part of the ramp-up, but it helps a lot and should be mentioned.) Apart from good specifications you should care about:

- Flawless documentation of design changes during planning and assembly of the equipment

- Exact definition of acceptance test procedures and the required circumstance. In many cases the processes around the to-be-tested equipment are not ready or finished; therefore a test procedure should be agreed on, if in a defined time-frame the original test objects (products) are not available

Move-in and hook-up phase

When it comes to move-in and hook-up of equipment you should also care about some minor details

- Who, when and how long will be on-site from the supplier

- Carefully track and monitor all supplier employees

- Make short daily meetings with all participants

- The supplier should document all deviations from the installation plans (e.g. electrical wiring). You will have to operate the equipment in the long run, not the supplier.

- Make sure you know, which other parts of the factory will be affected

Trial-run and acceptance

- Define realistic trial run scenarios and the required environment

- Make detailed check-lists of all aspects to be tested and checked, based on the specification and other documents (e.g. technical guidelines, standards, etc.)

- Very important: Do not let the supplier leave the site until not every single item on your open-point-list is closed. Once the supplier employees are busy on other sites, it will be very unnerving to get them back on your site

Ramping-up the equipment

- Once you dismissed the supplier after having finished the final acceptance some things might be important: You will nevertheless find some faulty in your equipment. Document them, agree on deadlines to have them fixed by the supplier and also agree on some kind of compensation if the supplier will not meet the deadlines. He will certainly miss many of those.

- Constant tasks for the next months or even years are:

    - Minimizing process windows for all equipment and processes

    - Constant improvement of the equipment. Build up your internal experts and do not rely on the supplier too much

    - Document the improvements you have made and all aspects the equipment is missing. You will need it latest for the specification of the next generation

    - Monitor spare parts usage and maintenance requirements. The supplier is usually only able to give you some hints. He seldom operates his equipment, he just build and sells it.

    - If possible test other (better or cheaper) materials you need for the product. Sooner or later someone will demand it from you anyway.

Matthias Zapp, Henkel KGaA – Düsseldorf (Germany)

Initial ramp-up (Scenario 1)

Must:

- Operator: The fast resolution of performance issues during ramp-up has to be ensured by resolving issues automatically or suggesting potential root causes for errors.

Scenario (2 & 3)

Must:

- Maintenance engineer: Maintenance procedures (documentation) for new components / machines have to be available on the spot.

- Maintenance engineer: The system has to suggest optimal maintenance cycles and procedures based on current product characteristics and derived machine data.
- Maintenance engineer: The system should offer maintenance engineers the possibility to log errors, root causes and spent effort (time & materials)
- Operator: The operator has to be supported in determining the configuration / process parameters for new products or product variants.
- Operator: The operator has to be able to overwrite all calculated system settings.

Should:

- Maintenance engineer: Every system's suggestion (e.g. maintenance cycle) should be comprehensible by the maintenance engineer
- Maintenance engineer: The system should offer the possibilities for integration with standard maintenance solutions (e.g. SAP Plant Maintenance)
- Operator: The operator has to be supported in conducting the required steps for system set-up / configuration by a workflow function

Could:

- Maintenance engineer: The system could offer mobile access for maintenance engineers, giving controlled access to service providers

Michael U. Mohr, formally Heliatek – Dresden (Germany)

Most important KPI's:

- Ramp-up time
- Production yield

6.4 Industrial requirement consolidation

Summarizing industrial requirements as listed above four topics are mainly highlighted:

- Applicability of future solution developed within the I-Ramp³ project
- Clear business process for ramp-up procedure
- Focussing on time of ramp-up, duration as well as reliability is important
- Availability
    - Achieve first results by improvement of ramp-up procedure
    - High sophisticated solution in order to achieve full gain of potentials
    - Solution must be available for all partners even none of other partners is participating

6.5 Sustained requirement engineering

This document, in current version, describes gathered and consolidated requirements from partners. After release of this document by partners and project coordinator the requirements will be submitted to the European Commission.

In the following this document will be maintained in order to ensure KPI-focussed sustainability throughout the whole project. In case of modification of Use Cases applied an updating of requirements need to be evaluated. Modifications of requirements are executed along with change management application, including documentation, communication and evaluation and also execution of sub-sequent impact.

By that, requirements will be documented according to formal standards. As described in [Pohl 2011 Page 46] a possible approach could be the IREB-Standard.

After this, a test protocol based on Key-Performance-Indicator will be defined. The practical experience shows, that additionally to the criteria itself, this test protocol will also verify if all requirements comply with SMART approach, described in chapter 5.4.

Glossary

EHS	**E**nvironment **H**ealth **S**afety
FAT	**F**inal-**A**cceptance-**T**est
IREB	**I**nternational **R**equirements **E**ngineering **B**oard
KPI	**K**ey-**P**erformance-**I**ndicator
MES	**M**anufacturing **E**xecution **S**ystem
RACI	**R**esponsibility – **A**ccountable – **C**onsultant - **I**nformed
SMART	**S**pecific - **M**easurable - **A**ttainable - **R**elevant – **T**imely
SOP	**S**tart-**o**f-**p**roduction
Time-to-market	Time period starting with product development until SOP
Time-to-customer	Time period from SOP until FAT of the production line

Definition of terms

AUTOMATION EQUIPMENT	Equipment which executes handling and transport and by that, does not provide an added value to the work piece
NEW PRODUCTION EQUIPMENT	PRODUCTION EQUIPMENT which has been new installed or significantly retrofitted and which has not been operating since than
PRODUCTION EQUIPMENT	Physical construction which provide an added value to the work piece, excluding AUTOMATION EQUIPMENT
NEW PRODUCT	New product or variant of a product which passed the prototype phase and has not been p

Annexes

Annex 1: WP1 – REQ – Initial survey – AWL

I-Ramp - Requirements from Project Partners
(by Ramp-up Phase & Roles)

Fraunhofer IPA

Roles		Ramp-up Phase: Initial Ramp-up	Ramp-up Phase: Set-up	Ramp-up Phase: Reconfiguration
Fab planner (AWL customer)	Must	enable new insigts (also for next roles) specify in standard terms tool set (incl mgt) (how do we measure?)	specification ease speed limits definitions	plugins
	Should	HL simulation		
	Could			
Component supplier (AWL supplier)	Must	Main stream technologies Stable standards and open	Stable standards	
	Should			
	Could			
Line / cell / equipment builder (AWL)	Must	IRAMP for all welding kit be able to chose between different options Have off line intergration environment (tool)	verifications tests (general)	existing interfaces (general) solution for backward compatibilty ease of use
	Should	brand independent		
	Could			
Maintenance engineer (Customer Technican)	Must	Trouble shoot functions		
	Should	In		
	Could			
Operator	Must	initutive GUI Quality indications	config check mechanisms	
	Should	help function		
	Could			

Annex 2: WP1 – REQ – Initial survey – CMF

Fraunhofer IPA

I-Ramp - Requirements from Project Partners
(by Ramp-up Phase & Roles)

Roles		Ramp-up Phase: Initial Ramp-up	Ramp-up Phase: Set-up	Ramp-up Phase: Reconfiguration
Fab planner	Must	Be able to edit the new line/factory workflow, line setup	Know the overall master data changes required to setup a new line (new tools, new products that can be produced, its flows, etc)	Be able to simulate differnt configurations and have it integrated with planning and scheduling tools
	Should			
	Could			
Component supplier	Must	The system needs to provide the characteristics of the new components required to run the new lines	To provide locations, delivery times, stockage requirements, certifications	To provide spec changes for the existing components and requirements for new components
	Should			
	Could			
Line / cell / equipment builder	Must	detailed specs for every new tool and sensor to be produced and delivered		To provide spec changes for the existing tools and requirements for new tools
	Should	delivery plan, sequence of tools or lines to be delivered		
	Could			
Maintenance engineer	Must	complete maitenance plan provided by the equipement builder	Maintenance schedule, part list, workflow for maintenance activities (part replacements, orders, inventories, etc)	Maintenance plan changes
	Should			
	Could			
Operator	Must			
	Should			
	Could			

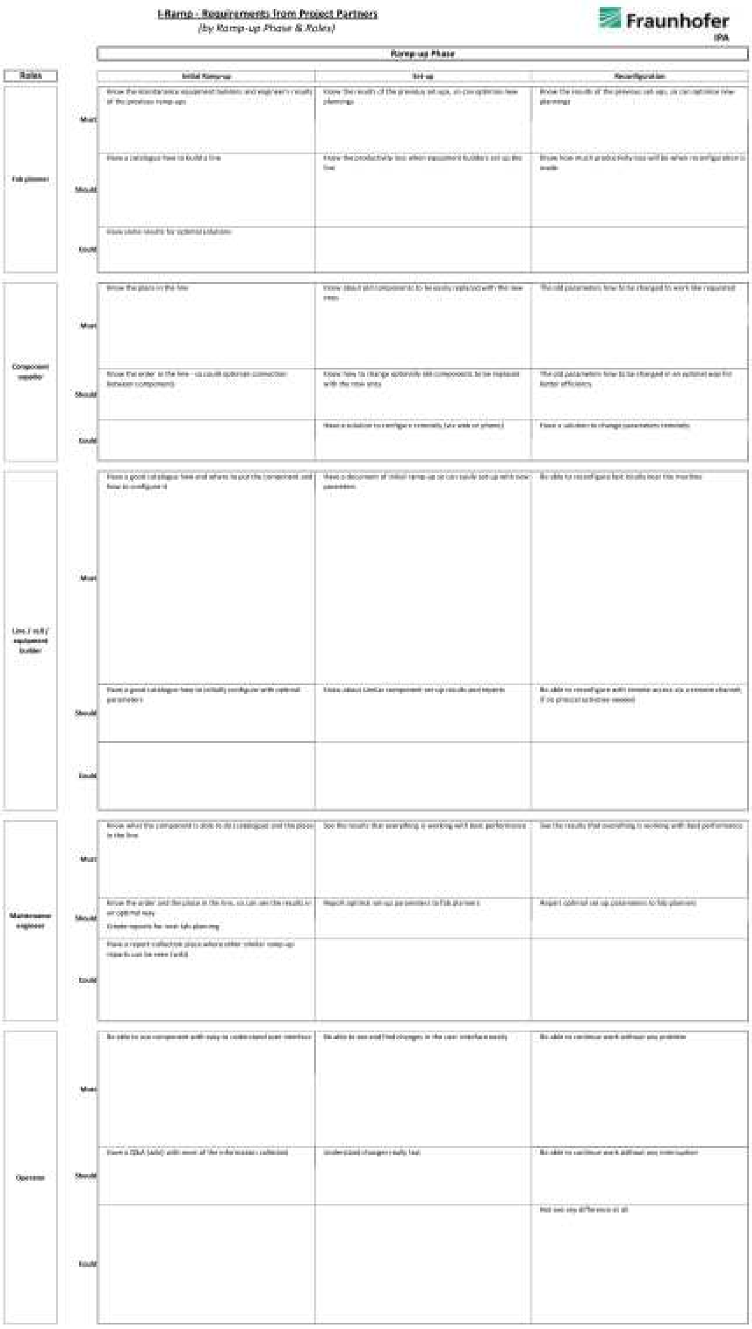
Annex 3: WP1 – REQ – Initial survey – FEUP

Fraunhofer IPA

I-Ramp - Requirements from Project Partners
(by Ramp-up Phase & Roles)

Roles		Ramp-up Phase: Initial Ramp-up	Ramp-up Phase: Set-up	Ramp-up Phase: Reconfiguration
Fab planner	Must	Get information on the capabilities of the equipment Get information on the requirements of the process/product Have an indication on the KPIs	Get information on initial tests	Get information on the capabilities of the equipment Get information on the requirements of the process/product Have an indication on the KPIs
Fab planner	Should	Be able to test alternative configurations Measure impact on KPIs	Be able to use test results for future planning information on KPIs	
Fab planner	Could	Have automatic tools to help him		Have automatic tools to help him
Component supplier	Must			
Component supplier	Should			
Component supplier	Could			
Line / cell / equipment builder	Must			
Line / cell / equipment builder	Should			
Line / cell / equipment builder	Could			
Maintenance engineer	Must			
Maintenance engineer	Should			
Maintenance engineer	Could			
Operator	Must			
Operator	Should			
Operator	Could			

Annex 4: WP1 – REQ – Initial survey – GMX

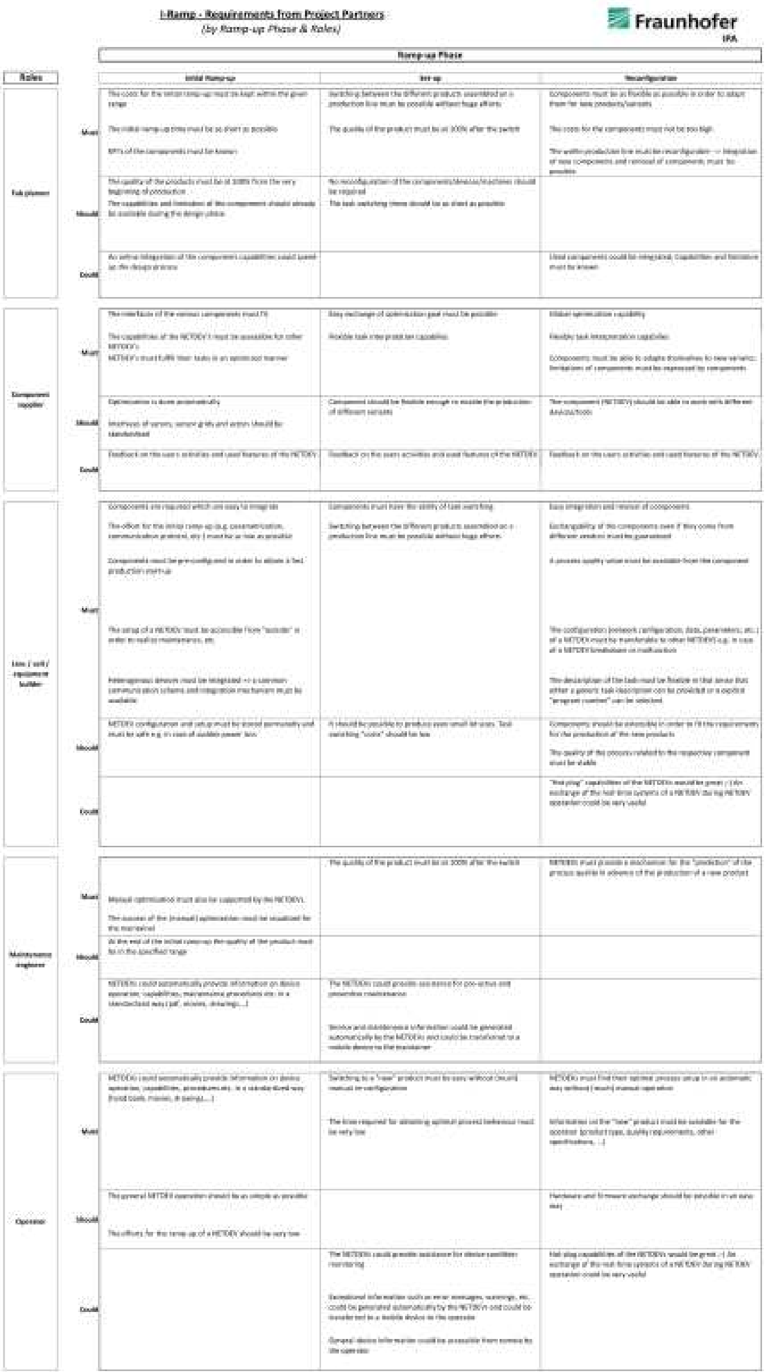


I-Ramp - Requirements from Project Partners
(by Ramp-up Phase & Roles)

Fraunhofer IPA

Roles		Ramp-up Phase: Initial Ramp-up	Set-up	Reconfiguration
Fab planner	Must	[illegible]	[illegible]	[illegible]
	Should	[illegible]	[illegible]	[illegible]
	Could	[illegible]		
Component supplier	Must	[illegible]	[illegible]	[illegible]
	Should	[illegible]	[illegible]	[illegible]
	Could		[illegible]	[illegible]
Line / cell / equipment builder	Must	[illegible]	[illegible]	[illegible]
	Should	[illegible]	[illegible]	[illegible]
	Could			
Maintenance engineer	Must	[illegible]	[illegible]	[illegible]
	Should	[illegible]	[illegible]	[illegible]
	Could	[illegible]		
Operator	Must	[illegible]	[illegible]	[illegible]
	Should	[illegible]	[illegible]	[illegible]
	Could			[illegible]

Annex 5: WP1 – REQ – Initial survey – HWH



Annex 6: WP1 – REQ – Initial survey – INOS

I-Ramp - Requirements from Project Partners
(by Ramp-up Phase & Roles)

Fraunhofer IPA

Roles		Ramp-up Phase		
		Initial Ramp-up	Set-up	Reconfiguration
Fab planner	Must	Ramp-up cost and schedule must be predictable Component performance must be predictable and consistent. KPI's of the components must be known	Switching between the different products assembled on a production line must be possible without huge efforts The quality of the product must be at 100% after the switch	Components must be as flexible as possible in order to adapt them for new products/variants The costs for the components must not be too high
	Should	The capabilities and limitation of the components should already be available during the design phase Ramp-up time must be as short as possible	No reconfiguration of the components/devices/machines should be required The task switching times should be as short as possible	
	Could			Used components could be reengineered. Capabilities and limitation must be known
Component supplier	Must	Components must be able to interoperate Ramp up duration and effort should be predictable	Switching between products should be a software operation Set-up duration should be low and effort minimal Component should be flexible enough to enable the production of different variants	Reconfiguration effort and duration should be predictable and effort low
	Should			
	Could			
Line / cell / equipment builder	Must	Components are required which are easy to integrate Ramp up curve should not be too steep but progressive and ideally early steep Components must be pre-configurable Heterogeneous devices could be integrated → a common communication scheme and integration mechanism must be available Support large information sets (images) from information rich machine sensors (i.e. cameras, scanning lasers) Support fast information (sampling) rates from intelligent machine sensors	Remote setup	Easy integration and removal of components Exchangeability of the components even if they come from different vendors must be guaranteed
	Should	NETDEV configuration and setup must be stored permanently and must be safe e.g. in case of sudden power loss. Must be settable remotely	It should be possible to produce one sized lots of build to order products. Task switching "costs" should be very low	Components should be extensible in order to fit the requirements for the production of the new products
	Could			
Maintenance engineer	Must			
	Should			
	Could			
Operator	Must			
	Should			
	Could			

Annex 7: WP1 – REQ – Initial survey – IPA

Fraunhofer IPA

I-Ramp - Requirements from Project Partners

(by Ramp-up Phase & Roles)

Roles		Ramp-up Phase: Initial Ramp-up	Ramp-up Phase: Set-up	Ramp-up Phase: Reconfiguration
ALL	Must	Solution is conform with all legal aspects, e.g. regarding EHS, employment law		
	Should	Responsibilites and escalation steps are clear defined (RACI)		
Fab planner	Must	Solution can be integrated into the standard process flow It achieves advantages in terms of invest, running costs, time, quality, or risks	Reliable in terms of less number of disruptions and short time to repair Availiability of spare parts	Clear and documented process flow for reconfiguration of the equipment / line
	Should	It contains a documented process work flow Simple and quick implementation of the new solution into current processes Regular reporting & Ad-hoc reporting during initial ramp-up phase Interdependecies are clear	It contains a documented process work flow Regular reporting & Ad-hoc reporting from ramp-up	It contains a documented process work flow Simple and quick implementation of the new solution into current processes Regular reporting & Ad-hoc reporting from reconfiguration Solution is flexible for all variants of products
	Could	Plug-and-play implementation of new solution into current processes	Existing redundancies	Single-piece reconfiguration after each part with no production delay
Component supplier	Must	Clear specification of solution in terms of hardware, software, interfaces, etc. Sufficient time for development	Accessibility to all parts	Requirements for new tools are available at right time
	Should	Clear and explicit documentation of process flow for installation	Modular construction system	Controll of usage of utilities, such as electricity or gas
	Could	Interfaces allow quick ramp-up (e.G. standardisation)	Good forecasting of ware and spare parts	Good forecasting of tools
Line / cell / equipment builder	Must	Environmental conditions, building, clean room, electricity are ready to use	Spare parts available	Self reconfiguration of the system
	Should	Is-built documents and layouts are available Additional equipment and tools available	Additional equipment and tools available	Additional equipment and tools available
	Could	Prevention of misusage and detection of mistakes (Poka-yoke)	Prevention of misusage and detection of mistakes (Poka-yoke)	Selfe description of system Prevention of misusage and detection of mistakes (Poka-yoke)
Maintenance engineer	Must	Re-qualification process clear	Accessibility to all parts Is-build-plan and documentation Re-qualification process clear All spare parts required are available	Re-qualification process clear
	Should	It contains a documentated process work flow	It contains a documented process work flow Quick and easy exchange of parts Short response time in case of breakdown	It contains a documentated process work flow
	Could	Participation in inititial ramp-up in order to understand system in a better way	Remote-Access No special tool-kit required	No special tool-kit required
Operator	Must	Manual workorder instructions for supporting are clearly defined	Manual workorder instructions for set-up are available and clearly defined	Reconfiguration process flow is clearly documented
	Should	Transparent system in order to learn how to use the system	Knowledge about the system for low service levels	Self-reconfiguration of the system
	Could	Participating in intitial ramp-up in order to understand system better User-friendly GUI	Prevention of misusage and detection of mistakes (Poka-yoke) User-friendly GUI	User-friendly GUI

Annex 8: WP1 – REQ – Initial survey – TNX

I-Ramp - Requirements from Project Partners
(by Ramp-up Phase & Roles)

Fraunhofer IPA

Roles		Initial Ramp-up	Set-up	Reconfiguration	KEYWORD
		Ramp-up Phase			
Fab planner	Must	- anticipate unforeseen delays of equipment (schedule of all deliveries). - know the management requirements in terms of ramp-up speed to take the right decisions fulfilling the management goals. - reckon with present-day environment (communication, space, suppliers, storage room...)	- have made prior trials to speed up the ramp-up time of the machine for the new batch.	- have tested the components outside the machine, have made simulations to ensure the changes will be immedialtely effective	
	Should	- have an overview of the future production in order to make choices which do not irreversably affect the possible evolutions of the machine - be able to suggest alternatives in case of important delivery delays of some suppliers. - inform the machine builder in case of important dysfunction of the machine	- give to the operator the new parameters to able a smooth start of the production. - keep a look on the first production hours to be sure that that the process runs without problem.	- assist the operator and be able to debug the machine if needed.	TIME
	Could	- propose design amelioration of the machine in order to improve quality and productivity - assist and listen to the operator remarks during the first days in order to improve the machine productivity (reduction of stop times) - be able to proceed to parts changing if obvious conception mistakes appear within the first days.			

Component supplier	Must	- Provides in time the equipment which fulfill the expectations of the equipment builder in terms of technology (required functions considering price/quality ratio) - Provides the equipment in time (fullfill requirement in term of delevery times) - Provide standardisation Netdev's -> all characteristics is known from the very begining -> speed up parametrization and communication	- Propose a Netdev which can trained from the Feedback of former Netdev and which can optimized itself - Fits with the other components		QUALITY TIME
	Should	- Propose the best compromise between what equipment builder asks and which component fits the best considering environment builder (connections and communications with the other components) - Feedback on Netdev's which are already running - be able to suggest the best materials matching the specifications of the machine builder.		know the characteristics of the new parts to be made in order to inform the equiment builder about its matching with the components	
	Could	- assist the machine builder during the first runs to react in case he did not give the right indications.	- assist the fab planner by giving him advices in new components adjusting.		
Line / cell / equipment builder	Must	- know the fab planner expectations and provides a machine which complies with his requirements (i.e. producing the machine in time, with the required quality and with the appropriate flows) - stay in closed cooperation with the fab planner along the machine building time - be present during the first machine start.			QUALITY TIME
	Should	- think of the most critical points in order to be able to provide another solutions (other trademark, other technology,) to respect delivery times -> connections and communications have to be compatible - inform the fab planner if he thinks the latter is wrong regarding the machine specifications. - be reactive and able to modify components in case things don't run so good as expected.		- be able to suggest solutions providing quick changes by implementing so called NETDEV - be informed by the fab planner about the new changes to check that everything will run smoothly	
	Could	- think of the best design in order to facilitate plug and play equipment for eventual new futur requirements - propose a degraded mean of production (eg. without definitive frame and all automated motion) before official delivered date in order to start the training phase and produce prototypes		- assist the fab planner during machine restart.	

Maintenance engineer	Must	- Learn the general machine's running. - know how to replace spare parts and sensors - know the project of the fab planner and machine builder in order to assess the good accessibility of the different components - be trained to the use and running of the most critical components		- check the compatibilty of the new components with the whole machine's running to avoid damage.	COST QUALITY TIME
	Should	- inform the operator about the maintenance procedure - have a spare parts list of the most critical machine components to be able to react quickly in case of breakdown (to have it in stock)		- inform the operator of the consequences of the installation of new components, like new procedures and warnings. - assist the operator and be able to debug the machine if needed	
	Could				
Operator	Must	- Respect the product flow as soon as possible - have been trained to the running of the machine and be aware of that he/she can do and not do (for his/her own safety)	Know the changing procedure when producing a new batch.	be aware of the new machine fittings in order to avoid damaging or wrong manipulation.	
	Should	- Be involved before the delivering date - know all the types which are concerned by the new equipment and the requirements in terms of production increasing speed.	inform his responsible if the type changing is too long due to the machine conception.	inform his responsible about good starting or not of the new production piece	
	Could	give tips to improve the machine running by noting most occuring failures		as main machine user, he could give tips to speed up the ramp-up phase of the new piece.	

Annex 9: WP1 – REQ – Initial survey – IAF

I-Ramp - Requirements from Project Partners
(by Ramp-up Phase & Roles)

Fraunhof

Roles		Ramp-up Phase: Initial Ramp-up	Ramp-up Phase: Set-up	Ramp-up Phase: Reconfiguration
Fab planner	Must	Acquire product requirements Acquire boundary conditions Acquire capabilities/efforts of potential components Arrange cells, lines Simulate and assess production arrangement (fab) Optimize fab arrangement Create fab communication infrastructure Verify fab cooperation and optimization	Recall production arrangement Recall product requirements Get knowledge about new/changed cell/line capabilities Re-optimize fab arrangement Re-organize fab arrangement Verify modified fab cooperation and optimization	Acquire product requirements Acquire product requirements Acquire capabilities/efforts ofexisting components Acquire capabilities/efforts of potential componer Otherwise as in Initial Ramp-up
	Should	Create fab staff training documents Set up fab refurbishment plan Set up fab life cycle management	Modify training docs Modify refurb. Plan Modify life cycle management	As in Set-up
	Could			
Component supplier	Must	Offer component capabilities/efforts Simulate component communication Simulate component optimization/operation Supply component life cycle data Install component Plug&Play the component Connect to the environment Set-up component models (process, wear, opt.)	Offer new/changed capabilities Otherwise as in Initial Ramp-up	Offer component capabilities Otherwise as in Initial Ramp-up
	Should			Modify/add capabilities Restore capabilities
	Could			
Line / cell / equipment builder	Must	Acquire capabilities/efforts of potential components Acquire fab optimization goals wrt. Cell/line Arrange cells, lines Simulate, assess and optimize cells, lines Install components Create cell/line communication infrastructure Verify cell/line cooperation and optimization	Recall cell/line arrangement Get knowledge about new/changed component capab. Otherwise as in initial Ramp-up but with mod. Cell/line	Acquire capabilities/efforts ofexisting components Acquire capabilities/efforts of potential componer Acquire fab optimization goals wrt. Cell/line Otherwise as in Initial Ramp-up
	Should	Create cell/line staff training documents Set up cell/line refurbishment plan Set up cell/line life cycle management	As in initial Ramp-up	As in initial Ramp-up
	Could			
Maintenance engineer	Must	Create cell/line staff training documents Set up cell/line refurbishment plan Set up cell/line life cycle management	As in initial Ramp-up but with mod. Fab	As in initial Ramp-up but with mod. Fab
	Should			
	Could			
Operator	Must	Training	Training	Training
	Should			
	Could			

Annex 10: WP1 – REQ – Initial survey – IEF

Fraunhofer IPA

I-Ramp - Requirements from Project Partners

(by Ramp-up Phase & Roles)

Roles		Ramp-up Phase: Initial Ramp-up	Ramp-up Phase: Set-up	Ramp-up Phase: Reconfiguration
Fab planner	Must	Diagnose tool for error causes Simulation software must be available	Performance tool / Cycle time simulation for new product	Simulation tool for calculating performance of existing components Automatic proposal of new components.
	Should			
	Could			
Component supplier	Must	Supply of basic information of the component for the ramp up to the control Integration of standard interfaces	Supply of static and dynamic information of the component for the setup to the control	Supply of static and dynamic information of the component for the setup to the control
	Should	Component could communicate with Beckhoff or Siemens system with standard bus EtherCAT. or Siemens Profinet	Database memory to save old configuration	Database memory to save different configurations
	Could	Using standard software for data presentation		
Line / cell / equipment builder	Must	Control with menues which guides the operator easier for	Reusing requirements with a learning software	
	Should		Auto tune technology	Auto tune technology
	Could			
Maintenance engineer	Must	Machine knowledge transfer to the line	Fast requirement analysis	
	Should			
	Could			
Operator	Must	Easy to handle ramp up phase	Self descriptive set up task Short set-up time	Self descriptive set up task Short set-up time
	Should	Fast learning curve	Process knowledge transfer to the control	
	Could			

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