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SOCRADES

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Executive Summary

Deliverable D1.2 is intended to lay down the fundamentals for the design of the SOCRADES architecture, its components and characteristics while investigating potential use cases for networked embedded components and the explanation of requirements visible at the current stage of the project.

Whereas use cases are described in D1.2 and its associated "Annex to D1.2" very extensively, requirements became improved and extended after expert work done within the dedicated working packages.

The results of work on requirements, as done within different WPs, became clustered, prioritized and finally presented within this Annex 2 to D1.2. This overall approach is illustrated below.

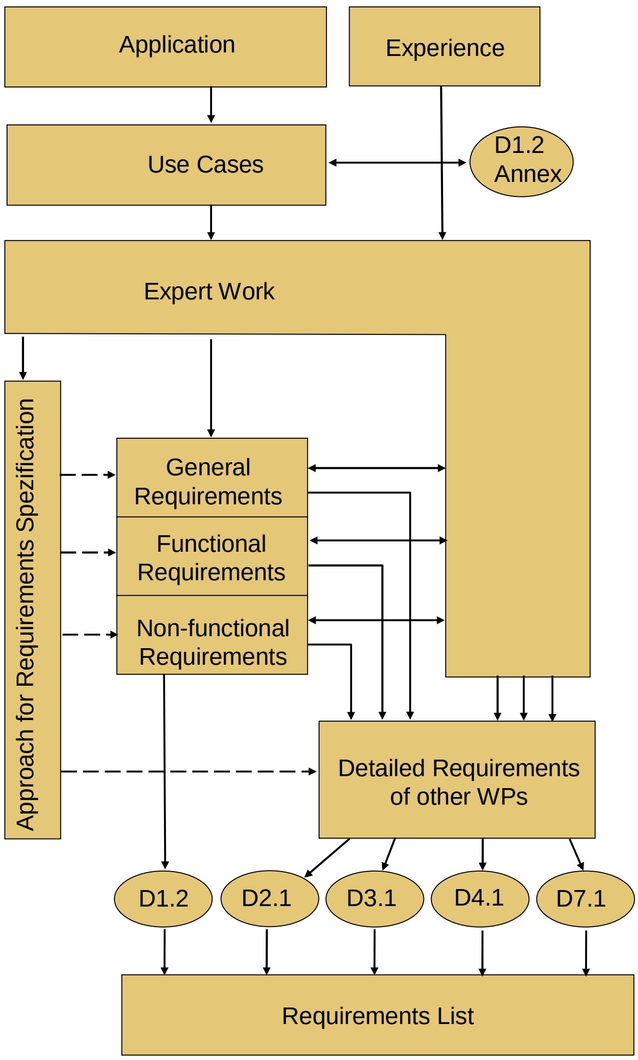

Figure 1: Overall requirements specification strategy

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1. Requirements List

Following the requirements list, as derived from different requirements related documents, is presented. To ease the presentation of the requirements, this list does not repeat all the elements of the requirements specification template. It rather concentrates on the major elements. The list is structured as follows:

Nature of the requirement

This column divides the list into elementary parts:

- General requirements
- Requirements on Platform Characteristics
- Requirements on Management of Components
- Requirements on Wireless Components
- Requirements on Engineering

Priority

Following the request from the last review meeting requirements became prioritizes. The following priorities are differentiated

- STRONG
- MEDIUM
- LESS

Req-Id

This element is a unique identifier for the requirement. The Id is the same as used within the several requirements documents.

Requirement

This is a concise description of the requirement that will be used as a title.

Description

This is a detailed description of the purpose and the objective of the requirement. This requirements element provides the specification of the essential subject, matter of the system. Specifying a requirement clarifies the system's subject matter and in doing so, may trigger requirements that have not yet been thought of.

Target WP's

This element provides the information about WP's targeted by this requirement.

	Priority	Req-Id	Requirement	Description	Target WP's
General Requirements	STRONG	R(D1.2)2.3.8.04 UR1.4 UR3.5	SOCRADES system MUST be a vendor neutral system/open system	Open, vendor neutral systems are advantageous particularly to the end-user and machine builders and could have significant impact through all machine lifecycle phases. They have the potential to significantly reduce costs, training requirements and interfacing problems. An open system architecture supports to interface machines, sensors and control components faster and more easily.	WP2 WP3 WP4 WP5 WP6 WP7
	STRONG	UR1.13 UR3.12 D6.1-2.10	Inherent support for compliance with standards	Engineering tools need to inherently support and enforce the compliance of automation system implementation with relevant standards, e.g., for safety, interoperability, quality. Data exchange should be based on definitions by standards bodies (e.g. W3C and OASIS). [D6.1, p.26]	WP2 WP7 WP6
	STRONG	UR1.8 R(D1.2)2.3.8.06	Ensuring design simplicity where possible	Particularly from an end-user perspective, current automation system design methods are often complex and too general purpose. Design simplicity is therefore and important goal.	WP5 WP7 WP8
	STRONG	R(D1.2)2.3.1.01	The system MUST allow high level functionalities (e.g. control) to be distributed (i.e. embedded, deployed) into devices	We must be able to provide the capability to distribute high level functionalities (control functionality being one of them) into automation devices … (cont'ed on the following req.) This has an impact both on footprint requirements (as small devices are targeted) and performance requirements for the message exchanges, as control flow that was centralised must now be distributed.	WP2 WP4 WP5
	MEDIUM	R(D1.2)2.2.03	Engineering process SHOULD be suitable to non-high-skilled users	Today engineering of an automation system is a several steps approach (hardware configuration, communication engineering, application engineering). This situation should be improved after an introductory phase of the SOCRADES system architecture. The use of tools SHOULD be adapted or adaptable to the abilities of people who do the appropriate engineering task today. As the introduction and improvement of each new technology needs several time this requirement targets a time frame of some years after termination of the project.	WP7
	STRONG	R(D1.2)2.3.6.3	The concept/architecture MUST be applicable on devices with Small Resources	Only a small amount of computing power and memory are available on typical sensors.	WP3
	STRONG	R(D1.2)2.2.05	Interoperability MUST be supported between heterogeneous devices deployed in various platforms and	Today's applications demonstrate that the geographic and environmental conditions and dimensions are of enormous diversity. Applications can be small manufacturing cells of a few square	WP2 WP7

			networking technologies	meters, chemical plants of square kilometres or even gas or electricity distribution applications ranging over several 10 or 100 kilometres. This requires applications spanning different physical network types. From the application point of view this fact is irrelevant as long as QoS are appropriate. In case this diversity is not considered during the design phase of the system architecture, extremely high effort is needed during later phases for adaptation of components. This shall be avoided by appropriate design of the SOCRADES system architecture. The SOCRADES architecture MUST consecutively support heterogeneous network environments.	
	MEDIUM	R(D1.2)2.3.5.01	Devices and IT applications SHOULD be able to interact together without intermediaries and no protocols translation.	A SOCRADES enabled device must allow “direct” communication from the physical sensor/actuator level throughout the machine control level up to higher levels of the business process management system (ERP/MES/SCADA). From a logical view, applications from the IT and devices “from the field” are at the same level, an ERP application can communicate directly with the devices using and sharing the same universal interoperable communication infrastructure. Alternatively legacy on non-SOCRADES enabled devices may become integrated through gateways.	WP2 WP5 WP6
	STRONG	R(D1.2)2.2.01	The SOCRADES architecture MUST support heterogeneous (wired, wireless) network environments.	Today it is not foreseeable what the real application of an individual SOCRADES component will be. Today's applications demonstrate that the geographic and environmental conditions are of enormous diversity. Many of those applications can be realised through combination of wired and wireless sub-systems. In case this diversity is not considered during the design phase of the system architecture, extremely high effort is needed during later phases for adaptation of components. This shall be avoided by appropriate design of the SOCRADES system architecture. The SOCRADES architecture MUST consecutively support heterogeneous (wired, wireless) network environments.	WP2 WP3 WP7
	MEDIUM	R(D1.2)2.2.04	Functional behaviour SHOULD be independent on whether cabling or wireless technologies are used for networking of embedded devices.	Replacement of a wired network segment by a wireless network should not influence the overall functional behaviour. The project SHOULD consider degradation regarding QoS and provide basic roles for engineering. Quality of Services is even more essential for application design and finally control applications.	WP2 WP3 WP4
	MEDIUM	UR2.10	High level IT integration	The virtual engineering environment should as well be integrated into the higher level IT infrastructure like ERP and MES. For example, MES can be used to control the material flow based on customer	WP5 WP6 WP8

				orders and short time based factory diagnostics and can also be implemented as a web service. A production system has to be optimised based on the virtual model before building the real hardware. If this process detects a necessary change, this is quite more cheap than changing the hardware later.	
	STRONG	UR1.14	Remote assistance from experts to rectify machine problems	Engineering systems should inherently offer support for the rectification of machine problems from remote locations, e.g., from the machine builder and control vendor sites. Consideration of safety and security are of key importance.	WP6 WP7 WP8
	STRONG	UR3.9 R(D1.2)2.3.8.07 UR1.12	Effective and seamless IT systems integration	Control systems, sensor networks or databases have to be designed to enable a seamless integration with the IT system planned for the new installation. Engineering efforts are also necessary to guarantee a proper integration with the existing IT infrastructure of the enterprise (CAD system, supply chains, production planning, etc.) and legacy systems. The provision of a consistent approach to the integration of control systems with IT systems is a key retirement for cost effective enterprise wide systems, impacting across the supply chain.	WP4 WP5 WP6 WP7 WP8
	STRONG	R(D1.2)2.3.6.15	It MUST be possible to bridge information between wireless and wired network domains	The system will consist of a mix of wired and wireless network domains and it must be possible to transparently interconnect these domains. Wired domains include legacy systems.	WP3 WP4
	STRONG	R(D1.2)2.2.07	The basic concepts of migrating from data centric access to field level devices to service oriented approach within field level SHOULD be described.	Introduction of a new technology is easier within a new installation than in a retrofit project. But new installations may be the exception depending on the industrial branch. Most projects are retrofit installation. Retrofit means substitution of a part of an existing installation. To target this large part of the installation market the SOCRADES architecture must consider integration of existing system components. This requires the support of service interfaces attached to standard field devices as well as service gateway/proxy for access to classical field devices through different communication interfaces.	WP2 WP4 WP5 WP6
	STRONG	R(D1.2)2.3.1.03	The service-centric infrastructure MUST enable devices to expose their functionalities as Web services.	Enabling services on devices provides the functional abstraction view, and high level service accesses. Web services play a critical role in plug-and-play mechanisms, as they can be described using machine-readable metadata.	WP2 WP5 WP6 WP7
	MEDIUM	D6.1-2.1	WEB-Service support	Machines and devices should provide their functionality via Web-Services. [D6.1, p. 24]	WP2 WP6
	MEDIUM	R(D1.2)2.2.02	Engineering of SOCRADES components SHOULD support	Functionality of a component firstly depends on the hardware the component is representing. This is the natural case for sensors and	WP2 WP5

			composition of application task related services.	actuators. Or, more generally, devices with process interface. General purpose controllers like a PLC or a modular I/O device are more flexible. Secondly functionality depends on operating systems capabilities and build-in software representing the devices physical functions and those functions depending on e.g. measurement principles. Taking those limitations under consideration, it is possible to scale and modify services provided by a component (representing a device or machine) through service intelligence built by aggregating the incremental intelligence offered by small smart devices.	WP7
Requirements on Platform Characteristics	MEDIUM	R(D1.2)2.3.1.04	The system SHOULD provide the ability to dynamically assemble services to provide higher level functional capabilities.	"Assembly" is one of the main SOA properties. The assembly (or composition) of services could become a service, which can be accessed and reused.	WP2 WP5 WP6 WP7
	MEDIUM	R(D1.2)2.3.1.05	The service-centric infrastructure MUST allow service assembly to be embedded into devices.	Service composition should not be limited to high-end systems, but should also be supported in devices.	WP2 WP3 WP5
	MEDIUM	R(D1.2)2.3.2.04	The service-centric infrastructure MUST enable the automatic binding to a service during runtime.	A device requiring a predefined known service during runtime, has the capability to search for several service providers and then automatically and dynamically bind to the desired one.	WP2 WP5
	MEDIUM	R(D1.2)2.3.3.01	The service-centric infrastructure MUST support the deployment (and un-deployment) of services (and assembly of services) on devices.	Functionalities (services) could be control functionalities, diagnostics functionalities…and they can be deploy dynamically (at any time, when it is required) on devices. The deployment must not impact the device firmware. The deployment should be done without stopping the device's operation. And of course without device reboot. It makes sense to be able to un-deploy a service once stopped (or inactive).	WP2 WP5 WP7
	MEDIUM	R(D1.2)2.3.3.02	The service-centric infrastructure MUST support the reconfiguration of the service binding during runtime.	The service-centric infrastructure MUST support the reconfiguration of the service binding during runtime.	WP2 WP5
	MEDIUM	UR1.1 UR3.1	Ability to configure and reconfigure machines built from smart modules (e.g. add/remove devices)	In order to maximize manufacturing agility at minimum time and cost, it is vitally important to be able to reconfigure production machinery easily and quickly. This is a key requirement for machine engineering perspective. It is also important that smart modules should be easily integrated with higher level enterprise systems. During the lifecycle of those modules, they will be created and supported by all the supply chain partners. Manufacturing and automation engineering should favor the integration of modular machinery components and control system architectures based on standardized interfaces.	WP5 WP7 WP8

	STRONG	R(D1.2)2.2.08	SOCRADES components MUST provide capabilities for identifying and characterising themselves to each other and to higher level systems.	One major problem of operational service within a plant or even approaches of auto-configuration is the capability of online identification features of the installed equipment. This is not necessarily state of the art today. Identification is needed within different life cycle phases for each equipment and must be a feature for SOCRADES components.	WP2 WP5 WP6 WP7
	MEDIUM	R(D1.2)2.3.2.01	The system MUST support automatic discovery of newly plugged-in and previously unknown device.	This requirement means that before interacting with new devices, an application must at least be made aware of their presence.	WP2 WP5 WP7
	MEDIUM	R(D1.2)2.3.2.02	The system MUST support the dynamic interaction with a newly plugged-in and previously unknown device.	A machine (composite of devices) that is not known in advance, must be automatically and dynamically discovered, and the application must take automatically into account their capabilities as much as possible, and if possible without even stopping the rest of the application. In the context, “automatically” means without human intervention; “dynamic” means that the device is able to find a new device when required rather than in advance with a static pre-configured link.	WP2 WP5 WP7
	STRONG	R(D1.2)2.3.4.01	The service-centric infrastructure MUST enable the notification of newly deployed and un-deployed services.	Peer devices have to be informed of any deployed and/or un-deployed services.	WP2 WP5 WP7
	STRONG	R(D1.2)2.3.4.02	The service-centric infrastructure MUST provide the notification of service and/or device downtime or failure.	This means that a presence protocol is required.	WP2 WP5
	STRONG	UR2.2	Discovery	If a new device is added it searches automatically for any existing devices. In addition, devices send advertisements.	WP2 WP5 WP6 WP8
	STRONG	R(D1.2)2.3.6.12	The system SHOULD be Self-Describing	Self-describing systems have the ability to forward their specification autonomously to others. They posses knowledge about their feasibilities, name, location etc.	WP3
	MEDIUM	R(D1.2)2.3.2.03	The system SHOULD support semantic description capabilities, based on shared ontologies, allowing a service consumer to dynamically adapt to a service	The promises of semantic Web Services are that consumers and providers can be made interoperable even when their communications interfaces differ, as long as they have the same semantic meaning. It could provide much greater flexibility in domains where standardisation is difficult.	WP2 WP5

			provider providing the requested functionality through an unexpected service interface.		
	MEDIUM	R(D1.2)2.3.5.02 R(D1.2)2.3.5.03	Devices and IT applications SHOULD implement the same Web services messaging, description, and security protocols (compatible and interoperable at least).	i.e. messaging protocols are SOAP and WS-Addressing, description protocols are WSDL, and WS-Policy, security protocols are WS-Security*. Since the same protocol is used to communicate from the device level to the application level, and everybody communicates at the same level, it is now extremely easy for an ERP by example to access a counter of finished products on a production chain, or for a SCADA system to access a diagnostic service, and on the user demand, to read a more precise parameter in a sensor.	WP2 WP5 WP6
	STRONG	R(D1.2)2.3.4.03	The service-centric infrastructure MUST support the management of deployed (hosted) services on device.	Manage a service means: - Get its status (Operational state, Faulty state…) - Start, Stop - Set/Get properties	WP2 WP5 WP7
	STRONG	R(D1.2)2.3.4.04	The service-centric infrastructure MUST support the management of devices.	Manage a device means: - Get its status (Operational state, Faulty state…) - Start, Stop	WP2 WP5 WP7
	MEDIUM	R(D1.2)2.3.6.1	The System SHOULD be Low Priced	To enable an economic application, especially sensor nodes have to be relatively low priced.	WP 3
	MEDIUM	R(D1.2)2.4.1.01	A minimal version of the service-centric infrastructure SHOULD be supported by physical devices with limited hardware resources, typically a 32 bits microprocessor, with 512Kbytes of Flash memory and 96Kbytes of RAM memory.	Including the OS, the TCP/IP stack, the container and components, a simple device can run on top of a limited-resources hardware. The typical hardware resources of the device are a 32 bits microprocessor, with 512Kbytes of Flash memory and 96Kbytes of RAM memory. The minimal version of the service-centric infrastructure MUST support at least built-in capabilities such as service & device declaration, discovery, service invocation, eventing and deployment. Obviously, the service-centric infrastructure can run on a more powerful device (such as PLC) if capabilities are expected (security, or hot swapping capabilities for the field devices).	WP5
	LESS	R(D1.2)2.3.6.13	The system SHOULD fulfil all/several functions of Self-Monitoring	Self-Monitoring characteristics serve the purpose of failure detection and are a basic feature of self-healing systems.	WP3
	LESS	R(D1.2)2.3.6.14	The system SHOULD fulfil all/several functions of Self-Management	The four characteristics *self-configuration*, *-healing*, *-optimisation* and *-protection* are summarised by the term *self-management.*	WP3
	STRONG	R(D1.2)2.3.7.01	The service-centric infrastructure MUST provide a diagnostics Web	This diagnostic service must be a standardised Web Service; At least, all devices should share the same diagnostic interface (e.g.	WP2 WP5

			service for automation devices.	standardising the device status and an event sent when a fault occurs). This web service provides a consolidated relevant view, i.e. a field device level view, a machine level view, an application level view… This Diagnostic web service properties are: • Extensible (Optional interfaces could be added as required) • Autonomous and independent of other web services	WP6
	MEDIUM	R(D1.2)2.3.1.02	The system MUST allow peer to peer communication between devices.	The system must have the capability of peer to peer asynchronous devices communication (non-hierarchical, flat application). Such devices could recognise themselves automatically and have peer to peer exchanges to build simple applications. These new capabilities will allow system integrators and/or machine vendors to choose which architecture best suit its requirements and constraints.	WP2 WP3 WP4 WP5
	STRONG	R(D1.2)2.3.1.06	The service-centric infrastructure MUST support a publish-subscribe interaction mechanism.	Notification mechanisms allow a component (event producer) to dynamically interact with previously unknown components (event subscribers and consumers), hence providing increased flexibility.	WP2 WP5
	MEDIUM	R(D1.2.3.1.07	The service-centric infrastructure SHOULD support a procedure-driven interaction mechanism.	A central service should be able to invoke sequentially a set of remote services.	WP2 WP5
	LESS	R(D1.2)2.4.2.01	The service-centric infrastructure SHOULD support high performances messaging.	Most industrial systems require strict real time constrains. In order to accomplish it, there is a need to improve the communications between devices. Using high performances messaging (e.g. Binary XML) will reduce both the size of messages and the time required to parse them.	WP2 WP5
	STRONG	R(D1.2)2.3.7.02	The service-centric infrastructure MUST provide a way for troubleshooting/debugging distributed application.		WP2 WP5 WP7

Requirements on Management of	STRONG	D6.1-2.3	Service lifecycle management	The Mean Time To Repair (MTTR) should be reduced. Therefore assets should provide services like start and stop applications, configure and parameterize running services.[D6.1, p.25]	WP2 WP6
	STRONG	D6.1-2.4	Business process modelling	It should be possible to integrate Web Service based asset services into business workflows by using business process modelling tools.[D6.1, p.25]	WP2 WP6
	STRONG	D6.1-2.5	Occasionally connected assets (mobile assets)	Assets, which are occasionally connected to networks, should update their information at a time they have a network connection. This	WP2 WP6

				approach requires that these devices have to provide data caches and synchronization mechanisms as well as automatic network detection and connection establishment facilities.[D6.1, p.25]	
	STRONG	D6.1-2.6	Occasionally disconnected assets (stationary assets)	Occasionally disconnected assets have to provide long term data persistency. Additionally there is the need for partial replication of backend data and business logic.[D6.1, p.25]	WP2 WP6
	MEDIUM	D6.1-2.9	Risk Management	Assets should provide services and messages, which indicate how long it may achieve the remaining tasks without or with limited maintenance. [D6.1, p.26]	WP2 WP6
	MEDIUM	UR1.2 R(D1.2)2.4.4.01 UR3.3 D6.1-2.7	Provision for integrated production and business process monitoring	From an enterprise perspective, monitoring production rate is a key requirement to ensure that it is ramping up satisfactorily. Individual machine monitoring is also important to ensure that system reliability targets are being met. The provision of such capabilities in a seamless manner is important preferably using a common implementation approach/technology for control and IT related systems. Assets should provide state monitoring services and meaningful error messages. [D6.1, p.26]	WP5 WP6 WP7 WP8
	STRONG	UR3.2	Provision for process monitoring	During ramp up and operation monitoring is necessary to assure the reliability of each individual machine. From the process perspective monitoring is essential to guarantee high quality products. In case of failure monitoring enables easier trouble shooting and error handling.	WP5 WP6 WP7 WP8
	STRONG	UR3.13	Error management	To identify failure situations and handle system malfunction error handling should be assisted by the engineering tools e.g. by failure monitoring and solving strategies, log functions, error messaging.	WP5 WP6 WP7 WP8
	STRONG	D6.1-2.8	Alerting	Additionally to the general messaging mechanisms assets should provide the possibility to prioritize selected messages, e.g. for notification of a message as an alarm event.[D6.1, p.26]	WP2 WP6
	STRONG	D6.1-2.11	Maintenance control	Assets should provide Web Service interfaces for invocation of tests, measurements, replacements, adjustments and repairs. [D6.1, p.26]	WP2 WP6
	MEDIUM	D6.1-2.12	Predictive maintenance	Devices and control systems should provide prediction units and event generation systems to support predictive maintenance. It should be possible to place supplemental predictive units into the business process control system, which work on state and event data provided by the assets. [D6.1, p.27]	WP2 WP6
	MEDIUM	D6.1-2.13	Access to device status	There should be a rich interface for accessing the device status and options to configure it or even allow code to be downloaded to the	WP2 WP6

				asset and executed there. [D6.1, p.27]	
	MEDIUM	D6.1-2.2	Support an Event Driven Architecture (EDA)	Business applications need to be informed about product, asset and network states. Shop floor systems should notify state changes via messages to the business applications. Message filters should be used to select the important information. Event Driven Architecture (EDA) is seen as a complementary part of the Service Oriented Architecture (SOA).[D6.1, p.24]	WP2 WP6
Requirements on Wireless Components	MEDIUM	R(D1.2)2.2.06	Basic concepts and roles MUST be developed within the SOCRADES project for control over wireless links.	The SOCRADES solution shall be suitable to a wide range of applications and industries ranging from discrete manufacturing to process industry. A majority of the applications in process industry are control of continuous systems described by dynamic models. Those applications are implemented by means of classical automatic control today. The successful introduction of new approaches, SoA and wireless technologies, depend on several reasons: reduction of engineering and infrastructure costs, new useful functionalities and convenient handling to name a few. The over all driving force is, however, the constant need for increased productivity in this industry. This is manifested by constant modifications and upgrades of the automation equipment. One of the major concerns for the SOCRADES introduction in process control is to provide robust wireless control which meets the same level of control performance as of today's wired systems.	WP3 WP4
	MEDIUM	R(D1.2)2.3.6.4	The system SHOULD be able to work with a maximum degree of Autonomy	The coordination of sensor nodes happens without intervention from the outside. Objective is to fulfil the respective task and to stay functional over a maximum amount of time.	WP3
	MEDIUM	R(D1.2)2.3.6.6	The system SHOULD fulfil the necessary functions for Location Awareness	That is, devices will know where they are, know what objects and places are nearby, and be able to communicate with other devices and servers over new, standardised protocols, such that *location* becomes a new data type in our applications - a prerequisite for attribute based addressing.	WP3
	LESS	R(D1.2)2.3.6.7	The system SHOULD fulfil all/several functions of Self X	In order to support flexible and re-configurable networks for flexible and re-configurable manufacturing systems, wireless devices should provide the capacity to self-manage a certain number of attributes.	WP3
	MEDIUM	R(D1.2)2.3.6.8	The system SHOULD fulfil all/several functions of Self-Organisation/ -Configuration	Self-organising networks are able to form a network from single nodes without external support. In this context the involved participants by means of an interactive negotiation process define their respective roles and establish suitable connections and routing paths.	WP3

	MEDIUM	R(D1.2)2.3.6.9	The system SHOULD fulfil all/several functions of Self-Stabilisation/-Healing	A network is said to be self-healing when it is able to detect errors in single nodes or within the communication and when it is able to heal these errors by its own means (within reasonable limits).	WP3
	MEDIUM	R(D1.2)2.3.6.10	The system SHOULD fulfil all/several functions of Self-Optimisation	Self-optimisation means the possibility of the system and of its single components to continuously search for possibilities to increase its own efficiency and performance.	WP3
	STRONG	R(D1.2)2.4.2.02	For real-time control, the system MUST support a wireless real-time network domain where the quality of control is guaranteed.	To support process control the system must provide a network domain where the quality of control can be guaranteed even under poor SNIR and high probability of communication outage.	WP4
	MEDIUM	R(D1.2)2.3.6.2	To fulfil the requirements of process automation the system MUST be Multi Functional, for the requirements of factory automation it CAN be.	Sensor nodes measure data, process these and transmit them to other nodes; each node simultaneously has to act as router for multi-hop connections.	WP3
	LESS	R(D1.2)2.3.6.5	The system SHOULD be able to fulfil Attribute Based Addressing functions	"Where is the temperature higher than 20°C?", NOT: „Which temperature do we have at node xyz?"	WP3
	STRONG	R(D1.2)2.3.6.11	The system SHOULD fulfil all/several functions of Self-Protection	The ability to detect (and even avoid) unauthorised access to system functions and information is called "self-protection". Corresponding systems are enabled to protect themselves against disturbances or attacks and, thus, to keep the installation running.	WP3
	MEDIUM	R(D4.3)2.0	A commissioning tool must be able to measure wireless parameters.	The commissioning tool should be able to measure communication parameters such as signal strength, number of retransmissions etc. This tool is for internal use and is not a product available for the customer.	WP3
	MEDIUM	R(D4.1)2.0 R(D4.2)2.0	The system must comply with ISM band regulations	To be able to deploy the system world wide it is important that the system comply with the ISM band regulations.	WP3
	MEDIUM	R(D4.1)3.0 R(D4.2)3.0	The system must handle a node density of 10 nodes per 10 m2	A typical process section has a rather scares deployment of instruments and actuators.	WP3
	MEDIUM	R(D4.1)4.0 R(D4.2)4.0	The system must control processes that cover an area up to 500…1000 m2.	Process installations can be very large covering large areas.	WP3
	MEDIUM	R(D4.1)5.0 R(D4.2)5.0	The system must handle inter node distances up to 100m.	Process installations can be very large covering large areas.	WP3
	MEDIUM	R(D4.1)6.0 R(D4.2)6.0	The system must sustain an outage probability that is up to 10%	In simple terms, outage probability can be defined as the probability that the desired signal-to-interference-plus-noise ratio (SINR) falls below an appropriate threshold that is determined based on system	WP3

				design requirements. [1]	
	MEDIUM	R(D4.2)1.0	The system SHOULD control processes that today are sampled at 10 ms	A majority of the processes in a process industry belongs to a class of fairly fast processes. They are today controlled by PI(D) loops implemented in DCS controllers (typically a ABB AC800M control) with millisecond sampling time.	WP3
	STRONG	R(D3.1)4.2.2-1	Protocols MUST be able to handle different device distances (1m up to 50m) between devices in wireless networks	In typical process automation environments the number of nodes is between five and ten in a 30x30 meter room. Note that the nodes are probably not evenly spread out in this area but rather grouped in small clusters. The node density per square meter is not very high (probably 2-3 at most) since increased node density also leads to more interference. From this it is clear that the distance between the nodes can be quite different, ranging from 1 meter to 30-50 meters.	WP3
	STRONG	R(D3.1)4.2.2-2	Timing constraints for wireless process automation	In cases where polling-based communication is used, update times are typically 50 ms or more. Alarms are however typically event driven. The communication load per node and second varies but payloads of 50-100 bytes are not uncommon. Packets are usually about twice that size due to protocol overhead.	WP3
	MEDIUM	R(D3.1)4.1.5	Low latency in wireless factory automation	Wireless factory automation: In order to fulfil the required latency, the network topology has to be designed to support this design goal. Therefore, wireless networks for the factory automation domain will most likely have a star topology with the sensors and actuators at the outside and some kind of gateway in the centre of the star. This is to ensure predictable response times throughout the system architecture.	WP3
	STRONG	R(D3.1)4.1.6	Determinism in wireless factory automation	Wireless factory automation: A wireless network for factory automation purposes has to guarantee deterministic behaviour, which means that upper bounds can be given for the responsiveness within the system. This does not necessarily mean low response times. The exact numbers depend on the target domain. Only the deterministic behaviour makes wireless systems applicable for automation purposes.	WP3
	STRONG	R(D3.1)4.1.7	Dependability in wireless factory automation	Wireless factory automation: The use of a shared communication medium brings many issues concerning availability and reliability into play. A reliable data transmission comparable to a wired connection cannot be guaranteed out of the box when using a wireless system. In order to meet the requirements of the factory automation domain, at least an equal level of dependability concerning the wireless data transmission is crucial for the use of a wireless infrastructure. System	WP3

				downtimes because of unreliable wireless communication are unacceptable for customers in the factory automation business.	
	MEDIUM	R(D3.1)4.1.9	New HMI approaches SHOULD allow for more flexible usage in wireless infrastructures	Wireless infrastructures bring many new possibilities into play especially concerning user interactions with the wireless system components and the system as a whole. In order to empower a user to handle a wireless infrastructure, intelligent concepts for the HMI must be integrated into the system and its components.	WP3 WP7
	STRONG	R(D3.1)4.2.1	wireless sensor networks MUST be able to operate in harsh environments	Generally, industrial environments are harsh on equipment. Many process industries, like the pulp and paper business and mining business, are also normally very dirty with oil, grease and other types of contaminators covering the plant – food and drug processing industries being the obvious exceptions. Hence mechanical robustness and protection in terms of EX classification and such are important in order for any equipment to sustain the environmental conditions.	WP3
	MEDIUM	R(D3.1)4.2.3-2	Security SHOULD be ensured in order to allow for transmission of timing-critical information on wireless networks	Security is becoming more important in process automation. It is however difficult to protect wireless communication and it is therefore likely that safety-critical information is not transmitted using WSNs.	WP2 WP3
	MEDIUM	R(D3.1)4.2.3-3	Batteries for wireless devices SHOULD last for 5 years, or longer	Battery is the most commonly used power source in WSNs with a supply voltage of about 3 Volts. The supply voltage can be higher for actuators. It is not unlikely that the supply levels will decrease in the future to enable lower power consumption. The minimum life time of the batteries is impossible to predict since it depends very much on the application. As a rule of thumb the batteries should last for at least five years in most WSNs.	WP3
Requirements on Engineering	MEDIUM	R(D4.3)1.0	Installation of the system must be done without changing the apparatus in the plant.	Controller interfaces must be similar to today's controller. Nodes should be easy to install in the apparatus.	WP7
	STRONG	R(D4.3)3.0	The process engineer must be able to set control parameters.	A process engineer should not be required to have detailed knowledge about wireless parameters. These should be "hidden" in the system.	WP3
	MEDIUM	R(D4.3)4.0	The process engineer must be able to tune the system.	A process engineer should be able to tune the performance of the control system. This should be similar to how tuning is done in a standard wired controller.	WP7
	MEDIUM	R(D4.3)5.0	The process engineer must be able to visually verify operation of the system.	This should be similar to how operation is verified in a standard wired controller.	WP7

	MEDIUM	R(D4.3)6.0	The process engineer must be able to verify the performance of the control system.	A process engineer should be able to visually see the performance of the control system. This should be similar to how it is done in a standard wired controller.	WP7
	MEDIUM	R(D4.1)1.0	The system must control processes that today are sampled at 0.5s	A majority of the processes in a process industry belongs to a class of fairly slow processes. They are today controlled by PI(D) loops implemented in DCS controllers (typically a ABB AC800M control) with a 0.5 – 1s sampling time.	WP3 WP4 WP7
	STRONG	UR3.14 UR1.15	Lifecycle support from engineering tools	Engineering tools need to assist throughout the entire lifecycle of the installation in terms of set-up & configuration, programming, calibration, operation, failure management, or maintenance.	WP6 WP8
	MEDIUM	UR2.7	Integration	The engineering phase, where the controls are defined, has to be integrated into the *PLM (Product Lifecycle Management)* concept of the company. Specifically, a data model is needed, that describes the main aspects of the production system. These main aspects include the product, process and resource model and relations between these entities. In addition, a PPR model is necessary to define possible different equipment configurations and therefore represents the lifecycle of the production system. If the production process change, e.g., the required production capacity is growing, the SOA must be flexible enough to react automatically. This flexibility is not only required for the final production system, it is also the answer to the quick changes that are typical for factory planning projects.	WP5 WP6 WP7 WP8
	MEDIUM	R(D1.2)2.3.8.01	The SOCRADES approach MUST support the ability to configure and reconfigure machines built from smart modules.	In order to maximize manufacturing agility at minimum time and cost, it is vitally important to be able to reconfigure production machinery easily and quickly. It is also important that smart modules should be easily integrated with higher level enterprise systems. During the lifecycle of those modules, they will be created and supported by all the supply chain partners.	WP7 WP3 WP4
	STRONG	R(D1.2)2.3.8.03 UR1.3	Reuse of machine components MUST be maximized	There is the requirement to compress the time for machine build related activities wherever possible through concurrency and the reuse of previous designs and also physical components. An effective virtual engineering environment is required to support such reuse activities effectively.	WP5 WP6 WP7 WP8
	MEDIUM	R(D1.2)2.3.8.05	SOCRADES approach SHOULD provide ability for virtual engineering	In order to reduce costs and minimize time to market a virtual engineering environment is required capable of support all aspects of the machine lifecycle. This virtual environment must be capable or accurately predicting machine behaviour.	WP7
	MEDIUM	R(D1.2)2.4.3.01	Engineering SHOULD provide high	Process description needs to be done in a manner that the process	WP2

			level process description	engineers can directly relate to. A high-level graphical description method is likely to be applicable.	WP6 WP7
	MEDIUM	UR1.6 UR3.6	High level process description	Process description needs to be done in a manner that the process engineers can directly relate to. A high-level graphical description method is likely to be applicable.	WP5 WP7 WP8
	MEDIUM	R(D1.2)2.4.3.02	High level engineering tools SHOULD support plant layout support	It is desirable for engineering tools to be capable of supporting the definition of the end-user site layout to allow specification and optimization of the system.	WP7
	MEDIUM	UR1.5	High level machine configuration capability	In order to be able to reconfigure production machinery easily, quickly and predictably the provision of a high level, process engineering oriented configuration capability is important where machine related resources can be defined and configured.	WP5 WP7 WP8
	MEDIUM	UR1.7 UR3.10	Virtual engineering as much as possible	In order to reduce time and costs during system ramp-up phase or set-up of the system a virtual engineering environment is required that is capable in assisting in all aspects of the system lifecycle. This has to include programming, monitoring & diagnosis, process engineering, error handling, predicting machine behaviour etc.	WP6 WP8
	MEDIUM	UR2.11	3D presentation	As part of the PLM concept of a company, the virtual model needs a 3D representation. This is required for two reasons. First, the definition of the products and resources are made using 3D based software. Consequently, not working in 3D would be a cut in the information flow. Secondly, a 3D model is much more intuitive to show possible problems. In complex production scenarios, this is of valuable help.	WP7
	MEDIUM	UR1.11	Plant layout support	It is desirable for engineering tools to be capable of supporting the definition of the end-user site layout to allow specification and optimization of the system.	WP5 WP7 WP8
	MEDIUM	UR2.12	Efficient model creation	The time needed to develop the web service in the virtual engineering environment has to be as short as possible. A lot of systems lack especially here, because importing of 3D data is required for every changes and a lot of work needs to be redone as the systems are not integrated into an overall PLM concept. For the virtual engineering environment, a tool is required, that allows making most of the work automatically and that is integrated into the PLM concept of the company.	WP7
	MEDIUM	R(D3.1)4.1.8	Engineering tools SHOULD allow strategy for expressing semantics of (virtual) connections	In a wired infrastructure, where the sensors and actuators are connected to input/output components of the system, certain parts of the engineering process are done implicitly. This is especially true for	WP7

				all aspects that deal with the semantics of the system elements. Therefore additional requirements arise that must be fulfilled by the engineering system that deals with wireless. It has to provide the user a strategy for solving the semantics related issues in wireless infrastructures with the constraint of not complicating the engineering process and thus increasing engineering costs. Potential savings due to not having to bring out the wires must not be ruined by far more complex engineering processes.	
	STRONG	UR2.1	Addressing (of virtual devices in engineering)	A unique address for a device is needed for communication purposes.	WP2 WP5 WP6 WP8
	STRONG	UR2.3	Description (of virtual devices in engineering)	A controlling device that has detected a controlled device needs a description “meta data” of the latter like a definition of command messages and service responds.	WP2 WP5 WP6 WP8
	STRONG	UR2.4	Control (of virtual devices in engineering)	The controlling device can activate a web service and a specific action. The controlled device may send a response message.	WP2 WP5 WP6 WP8
	STRONG	UR2.5	Eventing (of virtual devices in engineering)	Asynchronous eventing should be supported for example implemented by a "publish subscribe" mechanism.	WP2 WP5 WP6 WP8
	LESS	UR2.6	Presentation (of virtual devices in engineering)	Some devices may expose a presentation interface, for example to display (X)HTML pages.	WP2 WP5 WP6 WP8