Strengthening Leadership in Digital Technologies and in Digital Industrial Platforms

Digitization in the **Process Industries** through the **SPIRE PPP**

Most reports indicate that the process industry is about to see a number of radical changes. This is a challenging scenario where resource efficiency, productivity and sustainability are necessary goals for the technology development. All the phases of the value chain need to be questioned.

Within this change, digitalisation is a general condition and facilitator for changing organisations, business models and product /service supplies while at the same time increasing and supporting people's needs and abilities.

CONSEQUENCES OF DIGITALIZATION THAT PROCESS INDUSTRY MUST RELATE TO

1. *PRODUCTIVITY DEVELOPMENT* - ability to translate technical progress into effect in processes, organisations and value systems. The stage for productivity improvement will be moved to the value system perspective. The potential of integrating the mobile production system into the raw materials industry and the complete logistics chains represents the main goal of this revolution.

2. *RESOURCE EFFICIENCY* - while labour productivity has almost doubled in the world the improvement in efficiency in terms of resource consumption is less than 10 %. In view of the technological advances in the same period, resource efficiency could be tripled over the next few decades.

3. *DATA MODELS TO DIFFERENTIATE THE OFFER* - flexible and easy customization and differentiation of products and services are instead becoming more important i.e. formulas, process models, optimisation algorithms and customer value services determine the competitiveness of the offer.

4. OPTIMISATION THROUGH THE USE OF BIG DATA EXTENSIVELY APPLIED IN ALL STAGES OF THE MANUFACTURNG CHAIN - provide the objective base for value extraction, data is capital for reliable and precise models at the base of predictive manufacturing to be further processed by means of analytics focused on the key issues of the industrial competitiveness. Objectively tuned up first principle models and statistical/mathematical techniques improve the extensive application of optimization methods at each stage of product/process chain up to the commercial and business management for making predictions and increasing knowledge. Data is allowed to flow freely from the time that the production processes are given a design and dimensions, to the installation and start-up phases and finally to operation and maintenance. The Physical Factory is strictly linked to

its Digital Twin linking the same data flow for simulation and gamification and, not least, in attracting new talents to the Process Industry.

5. *TRANSFORMATION OF BUSINESS MODELS* - Digitalisation entails more data that has been refined into information and ultimately knowledge allowing the development of business models supporting sustainability strategies like the transition to the Circular Economy.

6. *PRODUCT/SERVICE DEVELOPMENT* - The change from property to use and from offering products to offering value through services better focusing customer needs and expected values based on the data streams. Digitalisation, in fact, provides flexible access and possibilities for alternative revenue streams through the aforementioned service-oriented business models seizing on usage rather than hardware facilitating the access to SMEs in high added-value supply chain.

THREE MAJOR TRENDS important for process industrial digitalization:

1. *CLOUD SERVICES* as a platform for value-creating services that create information flows and transparency while effectively distributing large-scale computing power in customised portions.

2. *INDUSTRIAL APPLICATION OF INDUSTRIAL TECHNOLOGIES* that makes it possible to communicate with every possible manmade object that can be foreseen

3. *BIG DATA ANALYTICS* is a key to higher value creation

Some EXAMPLES on development areas including technology, business models, value chains and people:

- Integration of the engineering process
- Industrial digital ecosystem platform
- Efficient data processing to information
- Integration and standards for information exchange
- IoT
- Industrial Infrastructure as a Service
- Smart digital twins of plants and products enabling material tracking for all kinds of products
- Gamification and scenario simulation techniques
- Machine and deep learning techniques
- Operator and Manager empowering HMI based on Cognitive Engineering applied to Decision Support tools
- Integration of explicit and tacit knowledge into planning and control solutions
- Remotisation of operations in harsh and hazardous environments
- Advanced forth and back planning systems for faster reaction due to product deficiencies and enabling of smaller lot sizes

- Improvement of data quality (reliability and completeness) and data security (unwanted external access and/or manipulation)
- Streaming techniques enabling in process decision support and condition monitoring and predictive maintenance

There are several on-going projects running as SPIRE and non-SPIRE projects (funded also in the member states) DEMONSTRATING the potential of the above for process industry funded and coordinated on European level (not exhaustive):

- Advanced process control and new type of sensors in process industry (Chemical, Metal etc.)
- Databases and management systems enabling industrial symbiosis within steel, chemical and cement industry
- 5G pilot remote control of vehicles and business models with mining industry
- Online computation and visualization of resource efficiency indicators in chemical and steel industry
- Gamification with P&P industry
- Competence on demand with energy industry and energy market balance through the cooperation between demand and offer in the energy network and markets, including social entities and communities
- Eco system platform with supplier industry
- Product optimization within chemical, biopharmaceutical and metal industry
- Next generation smart industrial systems with automation and infrastructure suppliers
- Standardized exchange of KPIs with chemical industries
- New flexible workforce for the challenging ecosystem

<u>R&I PRIORITIES FOR DIGITIZATION OF THE PROCESS INDUSTRIES:</u>

1. Cognitive equipment and plants retrieving information from sensors for continuous and batch-processes. This is linked with simulation capabilities including combined multi-scale and multi-physics first principle models and data analytics in high performance computing environment to enable cyber-physical systems for the online plant control and management. In this context, attention is focused on recognition of unusual situations, proposal of optimized recovery measures, condition monitoring and processing of environmental targets, energy consumptions, emissions (industrial symbiosis), including retrofit of ‘brownfield’ assets. Simulation capabilities along the whole life-cycle of a plant specifically in early design phases of processes and plants, and especially supporting a flexible, modular, miniaturized and de-localizable plant concept.

2. Core software platform(s) for digital engineering and plant operation (digital twin/cognitive plants) in an integrated way along the whole life cycle of a plant, covering product and process development, plant engineering, procurement, plant construction, commissioning, later operation, as well as plant flexibility, extensions and reuse for next generation and new products. Such digitized approach must be developed taking care about the completeness and consistency of information about the current status of development that continuously allows studying different design alternatives in parallel, and alerts users if the assumptions they used in a certain design step became invalid.

3. Enabling industrial symbiosis within the process industry which is placed at the roots of many manufacturing value chains. Integration of digitization technologies spurring industrial symbiosis requiring cross-company and interoperable management platforms to exchange information in-between industrial sectors.

4. Drive the growth of new flexible skills and workforce educated to fast learning and use digital technology as the central source for process optimization, control, smart data applications and plant maintenance. In the environment of Machine-to-Machine and Human-to-Machine (M2M, H2M), humans-in-the-loop concept is always central for operation control and management in the operation of plants belonging to process industries. Cognitive Sciences play a capital role in order to extensively and optimally capitalise their knowledge and experience and to provide support combining situation awareness and knowledge with advanced control algorithms and optimization. Such an approach empowers people actions through the extended adoption of wearable systems, augmented reality technologies and virtual reality based training, improving dramatically safety and effectiveness in operations in the same time.

5. Capabilities to significantly lower the effort and cost of building digital twins of existing plants (considering brown field vs. green field projects) though the interoperability of models and tools, the standardization of taxonomies and the extended adoption of semantics techniques.

6. (Cloud) Data platforms and standards to foster industrial symbiosis, match demand and offer of resources (waste, energy, water etc.) between plants, industrial sites with different industries and Social Communities to enable the circular economy. Industrial data market places must be compliant with the needs of enabling the development of software tools and apps for fast and efficient access to information and markets themselves.

7. Standardization of software interfaces is of utmost importance to enable human-in-the-loop concept providing specialized solutions with total interoperability between the physical and digital twins, of cause the use of existing software packages is encouraged.

Questions addressed by the European Commission (DGCNECT/DGRTD) DEI-GROUP:

1. **What is the current landscape of activities in Europe (national initiatives, EU funded activities, other)?**

Digitization and process control is part of the 2030 Roadmap of the SPIRE cPPP. The current portfolio of running SPIRE projects related to ICT has an EC funding volume of about 85 Million Euro. Important project examples include the F3 Factory (flexible, fast, future) project's results demonstrating the advantages of operating modular continuous plant processes that are more economical and sustainable than current operations and only possible by digital process control and online analytics. Built on the F3 Factory concept, the SPIRE project CONSENS is advancing the continuous production of high-value products that meet high quality demands in flexible intensified continuous plants by introducing novel online sensing equipment and closed-loop control of the key product parameters.

Other SPIRE projects targeting large scale resource efficiency gains through multi-stakeholder industrial symbiosis within large multi-sectorial industrial parks and clusters, including resource and energy intensive process industries. As example, the SPIRE projects SYMBIOPTIMA technological advancements are built around cross-company and interoperable management platforms for integrated optimization of energy and resources of symbiotic industrial clusters. The aim of the project is to develop software and hardware tools that could help improve the overall performance from process industries plants till industrial cluster levels through optimization of the consumption (and, if possible, re-use) of its main resources: water, thermal energy, electricity, raw materials, waste, etc. Another example, the SPIRE EPOS project is targeting enhanced energy and resource efficiency in process industries operations via onsite and cross-sectorial symbiosis involving 5 key relevant sectors: steel, cement, chemicals, minerals and engineering. EPOS main objective is to provide a wide range of technological and organisational options for making business and operations more efficient, more cost-effective, more competitive and more sustainable across process sectors.

Both SusChem (Chemical Industry) and ESTEP (Steel Industry) ETPs are actively promoting the digitization aspect, e.g. a new roadmap in the field of "Integrated Intelligent Manufacturing (I2M)" has been created by ESTEP addressing many aspects of digitalisation in the European Steel Industry. It would be very important to join or form an accompanying effort in all process industry, or SPIRE, to identify the synergies and understand the differences from manufacturing and from internet technologies for consumer markets.

EFFRA has started a CSA, called 'Connected Factories', the project will analyse and review the significant platforms both arising from research projects and what becomes already available commercially. It would be very important to join or form an accompanying effort in process industry – SPIRE – to identify the synergies and understand the differences, from manufacturing and from internet technologies for consumer markets.

Former ARTEMIS (current ECSEL) deals with ICT related topics, both in its SRA and also in completed and running projects. Many elements originate from the ProcessIT.EU roadmap.

2. **Where do we want to go?**

o What kinds of next-generation platforms are needed (if any)?

The core sections that are most time- or safety-critical may not change very quickly from today's process automation, SCADA, PLC, safety automation, alarm systems legacy but many other areas in factories will change in the same way we are starting to see discrete manufacturing change as described in some examples:

1) Process and factory design, automation design. This is carried out extensively with the aid of software intensive tools, the projects are multi-technology, multi-provider, distributed, etc., and the necessary interoperability's must be implemented by using effective platforms, as well, in the same way design time activities shift to Industrie4.0 like platforms.

2) Remote condition monitoring & maintenance, operations support - there is a trend that in an operative plant condition monitoring, support, etc., are outsourced to and offered by machine or equipment vendors, third party service companies. As in manufacturing industry, IoT platforms are becoming enablers for such distributed and growing businesses.

3) ERP, MES, CRM or other higher level factory management software. They are shifting to Industrie4.0 like platforms, both in manufacturing and also in process industries. It is also essential to implement connectivity from higher level systems to lower, more critical parts of process control and management.

4) Industrial symbiosis on industrial site and cluster levels requires cross-company and interoperable management platforms for the integrated optimization of energy and resources of such symbiotic industrial clusters.

o What kinds of large-scale federating initiatives are needed (if any)?

In the same way as in discrete manufacturing, large pilot projects (IA) are needed in the process industries. As with former ICT, automation, and design tools, interoperabilities, standards, tools support are essential in real industrial usage.

o What concrete gaps/problems could be addressed through platform development and large-scale initiatives at EU level?

Process control and management becomes ever more complex and comprehensive. Present day process automation, etc., must be extended, respectively, and this will most probably happen according to Industrie4.0 or other IoT principles.

The aspect of self-organisation is a very important topic for all process industries, which have to handle a long process chain with all its planning and scheduling tasks. Digital process and product twins, powerful information exchange along the process chain and solutions for distributed and multi-criteria optimisation based on software agent or swarm technologies would solve this challenging task.

Platforms like RAMI 4.0 have the value that they help us to understand and communicate what we do in different projects – but it is probably too much expectation and focus on having a new and common architecture model for all industries.

There is a lack of progress where commercial actors today build proprietary and closed platforms in these areas, leading to a slower adaptation. Further, the rapid adaptation of new technology such as IoT leads to increased complexity and new types of complex failure modes, which needs to be followed by a focussed effort on quality assurance in these areas. Further, the gap between the E.U. and the U.S. (the current leading nation in digitalization) must be closed. Ambitious, large-scale initiatives in the area, with focus on cutting edge R&D, have the potential to narrow this gap.

3. **How do we bridge the gap between what we have and what we want to achieve?**

o What concrete platform building initiatives and large-scale pilots can be expected/supported/promoted?

Besides manufacturing, platforms are emerging in distributed energy or smart cities. Engineering information tends to remain in silos, i.e., silos determined by larger industrial ICT technology vendors, country or continent specific standards (official or vendor related). To achieve pan-European interoperability, that ensures SME's etc. enter the market, significant technology advances are necessary.

Platforms for cloud-based analytics and machine learning, with support for pay-per-transaction and subscription business models will become necessary.

o How to combine large-scale demonstrators across the EU and across Member States, taking into account already on-going national developments?

This challenge is the same in every domain.

4. **Who are the main stakeholders to be involved?**

o How can PPPs contribute to building platforms?

In order to reach the objectives of Europe 2020 and the COP21 agreement it will be necessary to implement industrial symbiosis within the process industries - which is placed at the roots of many manufacturing value chains - due to the implications for circular economy. Improved integration of digitization technologies requiring data platforms and standards for exchange of relevant

information in-between industrial sectors will be necessary. Initiatives could be built on existing SPIRE projects in the field of industrial symbiosis, as described above, to leverage its full potential across Europe and all process industries.

The launch of projects targeting (software) platforms for integrated digital engineering and operation are required that supports decision making and documentation in an integrated way along the whole life-cycle of a plant covering process development, basic and detailed plant engineering, procurement, construction, commissioning, plant operation, as well as extensions, modifications and reuse of plants for new products. The solution could be based on a "digital twin" of the plant that reflects the current status of development, that is refined and modified over time, and that enables adequate simulations throughout all stages. Standardization of software (existing and new) interfaces is of utmost importance to enable tool and application developers to provide specialized solutions that can easily interoperate with the digital twin. Best available elements of tools and software for sustainability assessment need to be interfaced with such "digital twins".

Sector specific pilot projects/demonstration projects in the process industries at higher TRL are very interesting for attracting industry interest and probably facilitating interest to participate in projects also on lower TRL-levels. CSAs are a good instrument to get overview on active initiatives/projects and to propose future directions.

o What are the complementarities/synergies/needs for coordination between EU (PPPs) and MS levels? How to avoid overlaps and strengthen synergies?

In general, PPPs tend to operate – unfortunately – in isolation. Few stakeholders participate in many of them, and therefore see their overlaps, relationships, and differences. Funding programmes in the PPPs and other initiatives with a 'digital agenda' need to be complementing each other.