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A Study on the socio-technical aspects of digitization technologies for future integrated engineering work systems

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Abstract

There is a wide demand for digitization technologies among production industries initiated by new developments in industrial internet, IoT (Internet of Things) and IoS (Internet of Services). However, companies have a difficult choice due to high variety, wide spectrum and not clearly known potentials of these technologies. Additionally, new uprising discussions on ergonomic effects of digitization and the role of humans in interaction with technology are aspects that gain increased importance. Therefore, they should be regarded in early phases of decision-making processes to ensure a sustainable digital transformation. Furthermore, individual characteristics and requirements of transforming companies, e.g. existing technologies, work systems and organizational demands, are crucial for selection, configuration, launch and usage of new technologies. To consider all these issues before installing new technologies and processes, an innovative 'Technology Map' was developed. It serves as an assessment instrument that supports companies finding the optimal solutions for their individual requirements based on a socio-technical approach.

This article aims to provide a scientific framework for developing digitized integrated work systems specially in engineering using the socio-technical approach. For this purpose, the effects of digitization on engineering work are addressed. Model Based Engineering approaches supported with Systems Engineering fundaments are considered as capable solutions for developing multidisciplinary digitized products and improving engineering work processes. In this paper, Model Based Systems Engineering (MBSE) as an emerging product development technology is investigated and assessed according to identified criteria in the Technology Map.

Keywords: engineering, digitization, technology map, work system, product development, MBSE, socio-technical system, cybertronic systems, design of cyber-physical systems, product lifecycle, technology assessment, transformation process, digital design

1 Introduction and motivation

Digitization has become the innovation motor in a broad range of industries (Porter & Heppelmann, 2015). Numerous new IT-based solutions are changing eruptively the conventional way of technical, economic and social procedures (Bley, Leyh, & Schaffer, 2016). Two significant effects of digitization are increased efficiency of processes through rapid information transfer and processing within cybertronic systems (explained in detail later in this paper), as well as digital working tools and equipment entering engineering and production processes (Anderl, Eigner, Sendler, & Stark, 2012).

The vast majority of companies are not in the position to develop their own IT system optimization actions and therefore look for qualified technologies on the market, which suit best for their individual needs (Issa, Lucke, & Bauernhansl, 2017). With regard to the large number of available technologies, selecting the best solution seems to be hardly possible without an appropriate assessment tool. Currently there is a lack of supporting methods and tools for evaluating digitization measures, which results in a demand for studies on direct and indirect effects of Industry 4.0 solutions (Wagner, Herrmann, & Thiede, 2017).

Within this paper, a so-called 'Technology Map' is presented. The Technology Map is a technology assessment instrument, which aims to help companies identifying possible digitization technologies for their individual Use Cases. Additionally, the Technology Map provides a description and evaluation for the chosen digitization solution to enable companies selecting the most appropriate one for their special needs. Digitization technologies are here referred to technologies which capture, process, transfer and integrate analog information e.g. data, documents and procedures, into digital (virtual) values. Adding the social aspects to the digitization technologies, they form digitization solutions.

This is part of the research project 'InAsPro' (Integrated work systems in digitized producing companies). Key objective of the project is the interdisciplinary development of a generic transformation concept for the selection and implementation of digitization solutions within different product lifecycle phases (conceptual design, development, production/assembly, aftersales) in producing companies of different sizes. To validate the concept, applications aiming integrated digitization of 'work systems' (described in detail in section 2.2) are piloted. In this context, the technical, humane and organizational optimized implementation of digitization solutions is addressed.

The focus of this paper is on the socio-technical potentials of engineering technologies, which play a distinctive role in designing 'cybertronic systems' (described in detail in section 2). Model based Systems Engineering has a major usage in early product lifecycle phases, specially system architecture (conceptual design) and development and is evaluated here as an engineering technology with regard to its socio-technical impact.

In this context, the major questions are: How does digitization affect engineering work? How can companies find the best digitization solutions, which solve their socio-technical challenges (e.g. technological impacts on employees and organization) and enhance the integration of engineering work systems? What are the benefits and challenges of MBSE as an example of modern digitization solutions for engineers?

Section 2 will present an overview of the most important topics for digitization decisions such as requirements of developing IoT based products, socio-technical approach towards engineering system development, digitization effects on engineering work systems and existing approaches for assessing technologies. In section 3 the concept of the Technology Map as well as the identified criteria for evaluating digitization solutions will be presented. Section 4 introduces MBSE briefly before it will be assessed according to the criteria of the Technology Map. The last section will conclude the results and provide an outlook.

2 State of the art and background

Technical products are already increasingly multidisciplinary systems (e.g. mechatronic products) developed by multiple engineering disciplines (mechanics, electric/electronics, software and services). Interdisciplinary between different domains of engineering and collaboration between the different stages of the product lifecycle, are the basis of the modern product development process. Smart improvements of products and their service systems will dominate most industrial sectors in the near future and lead to the 4th Industrial (R)evolution (Abramovici, Göbel, & Neges, 2015). This means networked, communicating systems in form of complex product systems and related services. Increased connection and mutual interaction significantly enhances the functional range of modern mechatronic systems. As these systems communicate with each other, they are referred to as cybertronic or Cyber-Physical Systems (also CTS / CPS) (Broy, 2013). To handle the complexity of such innovative, interdisciplinary and interconnected products, their production systems and connected services, a rethinking of current engineering design methodologies, digitization solutions, processes and their enterprise organization is needed (Cadet et al., 2017; Eigner, 2018).

2.1 Socio-technical approach towards engineering system development

The term 'socio-technical systems' was described by Emery and Trist as systems which involve a complex interaction between humans, machines and the environment of the work system (Emery, Thorsrud, & Trist, 1969). Nowadays, this interaction is true for most enterprise systems. The socio-technical approach implies, while developing a system such as a digitized work system, all of the subcomponents, such as people (e.g. employees), machines (technical tools) and context (e.g. work system or organization), should be considered, analyzed and designed simultaneously (Schleidt, 2009).

The overriding presumtion of socio-technical thinking is that systems design should be a process that takes into account both social and technical factors which influence the functionality and usage of systems. The main reason for adopting socio-technical approaches to systems design is, that failing to do so, can increase the risk that systems will miss their expected contribution to the goals of the organisation. This means, systems often meet their technical requirements but are considered as failed because they do not deliver the expected support for real work within the organisation. The source of the problem is, that techno-centric approaches to systems design do not properly consider the complex relationships between the organisation, the people enacting business processes and the system that supports these processes (Baxter & Sommerville, 2011). The People (Men), Technology and Organization approach, 'MTO' (Strohm & Ulich, 1998) emphasizes also the interdependence of humans, technology and organization. The central element in this analysis is the work processing, in which system elements must function together. This approach is therefore suitable for the analysis of socio-technical systems (Schleidt & Eigner, 2013). According to Cherns, engineers already perceive that they are involved in organization design and that although their work contains much of technical knowledge and less of social knowledge, they are designing socio-technical systems. Therefore, it seems necessary to integrate the concepts of socio-technical systems and the MTO approach into systems development (Cherns, 2008).

Another approach focusing on employees' working conditions is the human factors engineering approach. This multidisciplinary approach is centred on the employee working within a work system. In order to judge the conditions, five elements are monitored: people, work, organization, environment and equipment (Leva, Naghdali, & Alunni, 2015). These elements are interlinked within the system and therefore need to be judged together in designing work systems.

A more detailed approach for making a socio-technical system assessment is the 'Process Methods, Tools and Environment' (PMTE) analysis. Thereby the collection of related processes, methods and tools is defining the technology analysis methodology and functioning as a general instruction set. This Methodology can be thought of as the application of PMTs to a class of problems that all have something in common (Martin, 1997). Associated with the above definitions for processes, methods and tools is working environment (E), which is provided by the organization. PMTE analysis can be considered as a refinement of the MTO approach. It specifies the intersection of Technology to People and Organization setting. In Fig. 1. the relationship between PMTE elements is visualized and linked to counterparts in the MTO approach.

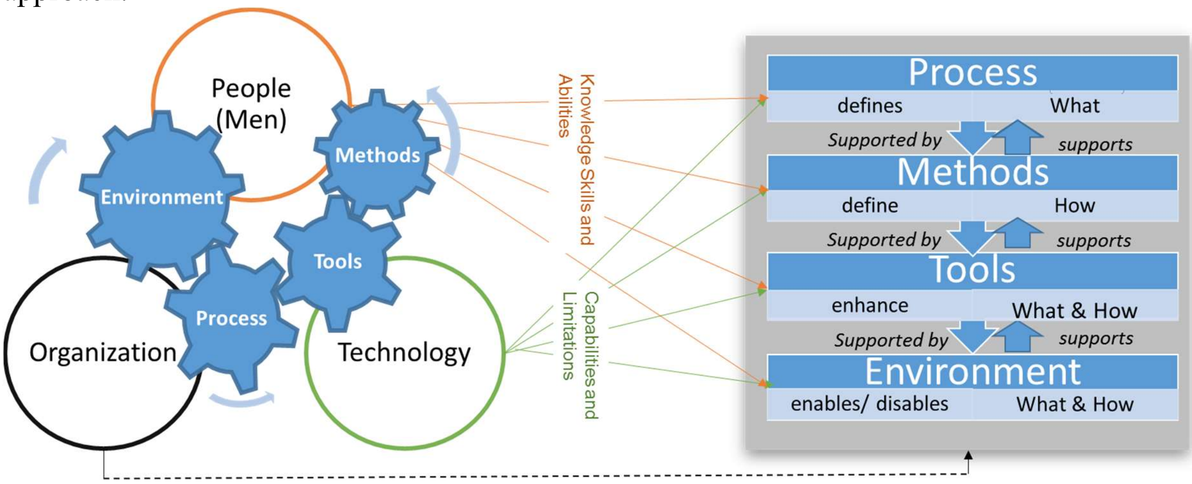

Figure 1. Relation between MTO approach and PMTE elements based on Estefan

When socio-technical elements are to be varied or modified, choosing the right mixture of them is essential. Technological requirements as well as technological effects, capabilities and limitations should be addressed, to carry out a holistic approach towards work system evaluation. In terms of people involved, knowledge, skills and abilities of the them should be considered.

To sum it up, technology should not be used just for the sake of technology. Technology can either help or hinder engineering efforts. Thus, digitization needs to be judged socio-technically; in the light of all aspects of the work system e.g. technological advantages, changes within the organizational settings and impact on employees (Zink, 2014).

Integrating the socio-technical approach into system development as a core activity of engineers leads to work systems that are more efficient and acceptable and deliver higher values to stakeholders.

2.2 Digitization effects on engineering work systems

Digitization is going to have a big impact on work, on the work design and the content of work. At the least in the medium term it will change the working world dramatically. How this change will look like depends very much on how processes and technologies will be designed and used (Zink, 2015).

On the one hand, digitization and automation are increasing productivity, on the other hand, they are also changing work systems. A work system is a socio-technical system that involves the interaction of one or more workers with the work equipment to perform the function of the system, within the work environment and under task's conditions. Thus the work system can be used to describe a *work place* transforming incoming materials and information into

outgoing work results and to identify changing conditions (Deutsches Institut für Normung, 2004).
Considering engineering work, increased digitization worldwide, rapid growth in the range of functions and consequently increased complexity of product systems necessitate more effective engineering work organization and engineering business management (Sendler, 2018). Therefore, engineering work foundations should adopt themselves to new conditions and requirements (Anderl et al., 2012). Other new conditions are stronger differentiation of the value creation process among producers and providers, e.g. increased outsourcing tendency for specialized work, as well as the connection of development, production and after sales inside and outside company boundaries'. Engineering work systems will also be varied due to automation of simple activities, interdisciplinary collaboration demand, possibilities of remote work or training and increasing mobility. These changes result in new revenue models such as temporary cooperations in interdisciplinary teams over company boundaries (open innovation), engineering service marketplaces and sharing approaches as well as operator models for engineering tools (Abramovici et al., 2015).
Engineers are driving and using the changes to improve their capabilities. Their activities consist of creative processes and, therefore, even artificial intelligence (rule-based automata) is able to support, but not conduct them autarchic. This is especially true for engineering beyond incremental innovation (Künzel, Schulz, & Gabriel, 2016).
The spectrum of engineering tasks raises by conception and implementation of cybertronic products and connected services, the utilization of new technologies from different fields of application, the definition and realization of special development tasks, big data and analytics driven development but also by the development of new business models (Gausemeier et al., 2017). Thus, engineers remain the leading player of the creative development processes in future (Künzel et al., 2016).
Empowering engineering through qualified tools, appropriate methods and well-designed organizational processes enhances the effectivity of work system, increases innovation rate and finally improves company's competiveness in time of big changes.
To find out how companies can find the best digitization technologies and solutions, which solve their socio- technical challenges and enhance the integrative design of work systems, existing assessment tools were analyzed in the following section.

2.3 Existing approaches for assessing technologies

The technology monitoring is part of the technology management and observes detected existing technologies over time (Schuh & Klappert, 2011). The goal is to pursuit technologies for a set topic on an unlimited time scale. As a result, technology trends can be identified by means of the systematic observation (Schuh & Klappert, 2011). Using e.g. portfolio techniques (Dussauge, Hart, & Ramanantsoa, 1996), technology radars or technology curves (Warschat, 2015), technologies can be recognized, assessed and observed.
Technology radars or maps are used to support companies in identifying premature relevant technology trends focusing on assessing suitable technologies. A technology radar is a visualization tool, which assesses a large number of technologies and it is used as a base for detecting e.g. digitization technologies. Furthermore, the technology radar represents a competitive advantage by identifying opportunities emerging from technological developments at an early stage and provides an overview about technological capabilities needed to face these challenges (Rohrbeck, 2010).
A comparison of existing approaches reveals that none of the technology radars considers more than one technology field at the same time. The regarded technology fields only focus on one

area, e.g. nanotechnology (Warschat, 2015) or IT (ThoughtWorks, 2017).Furthermore, the description of the technologies within the technology radars is kept short (Gausemeier et al., 2017), varies depending on the technology (Blumröder, Gerling, Pretzel, Sievers, & Heidkamp, 2015) as well as neglects requirements for the implementation within companies. Because a consistent comparison is the base for optimized technology selection, a structured description including main requirements for implementation is required.
The available technology radars and maps give an overview about existing technologies within different technology fields and areas, but are not capable to assess the technology's socio-technical impact on work systems. There is a lack of suggestions and selection aid for implementing digitization technologies and solutions, which solves company specific challenges. For implementing digitization technologies and solutions, it is necessary to consider more than one product lifecycle phase as interdependencies might influence their selection and implementation.
Representing technologies within a radar screen supports the overview about existing technology options. As the presented Technology Map considers more aspects and criteria than the existing approaches, the creation of a simple radar screen was proved not to be sufficient for the considered project requirements. Therefore, a comprehensive filter process for receiving the suitable digitization technologies has been developed.
The Technology Map presented in next section tries to fill the existing gap of assessment tools and aims to help companies selecting suitable technologies for their individual work systems by including socio-technical aspects into the decision making process. The resulting Technology Map also fasciliates a particiative design of human technology interfaces and competence development for the implementation of the digitization technologies.

3 Technology Map conception

The Technology Map is a tool, which aims to help companies to identify possible digitization solutions for their individual Use Cases. Additionally, it provides a description and evaluation for the chosen digital solutions to enable companies to select the most appropriate one for their needs. In a more creative way, the Technology Map can be a source of inspiration for further possibilities of development within the company. By presenting new and innovative technologies, the user can get ideas on how to increase the competitiveness of the company even further.

3.1 Technology Map preparation

The Technology Map was developed on the base of theoretical information from a market and literature research combined with practical insights gained through interviews with industrial partners and results from preliminary work. Focusing on studies about Industry 4.0 and related technologies (Kilger, Bley, & Vogel, 2016; Sendler, 2018; Urbanski & Weber, 2012), guidelines (BITKOM, 2016) and research projects (Gausemeier et al., 2017; Schebek et al., 2017) eight major technology trends with direct effects on production industries have been identified:

1. Human Machine and Machine to Machine Interface as well as Communication;
2. Analytics and Artificial intelligence;
3. Virtual Product Development;
4. Data Integration, Provision and Connectivity;
5. Predictive Maintenance and Sensor networks;
6. Additive Manufacturing;
7. Cloud Computing and Big Data;

8. Track and Trace.

By projecting these trends to given goals and context of the project and consolidating the sources (Gartner, 2016) (Bundesministerium für Arbeit und Soziales, 2017) some possible *Application scenarios* were configured as following:

- Offering additional services for customer;
- Assistance systems for employees supporting their work task;
- Management, provision and integration of information to empower task automation, communication within the company and enabling value-chain collaboration;
- Distribution and analyzing information, which can be used by cybertronic systems;
- Integrated product development and simulation.

The relevance of the application scenarios has been verified by the four companies within the project. In a next step the structure of the technology map has been developed. An analysis of strategic potentials and expectations of industrial partners was conducted to understand the demand of the target audience. Results suggested a demand for a Use Case based Technology Map, which contains holistic solutions (due to whole work system requirements). The analysis revealed that beside general information about the technology objectives, advantages and disadvantages for employees and companies should be considered. Companies are interested in achieving their technological goals and, at the same time, improving their work systems and organizational efficiency. This verifies that a socio-technical assessment of digitization technologies is crucial and should be conducted prior to their implementation.

Based on the theoretical framework introduced in previous sections and practical insights, relevant information was gathered and reflected gradually on different drafts of the Technology Map. One of the main challenges in designing the Technology Map was to introduce assessment criteria which are as general, that they could be applied to different solutions from the wide spectrum of development, production and after sales activities and as specific, that no relevant information gets lost. Another difficulty was deciding on a solution or problem based approach. To combine the advantages of both approaches an *Application scenario* incipient procedure was applied to clarify aims and potentials of technologies.

For selecting the TM assessment criteria, the MTO approach was chosen in order to encompass relevant socio-technical subcomponents of work system. In this case employees are regarded as People and company is regarded as Organisation. The identified criteria are *Goals for employee*, *Advantages and Disadvantages* of technologies on *Companies' Level* as well as *Best Case* and *Worst Case on* E*mployees' Level*.

To describe the intersection of a digitization solution to needed people's knowledge, as well as environmental preconditions for installing the solution, PMTE approach (described in section 2.1) were selected as methodological description of solutions. For this purpose, related factors were tailored to solution scopes. Resulting identified criteria hereby are *Method, Process Support*, *Hardware* and *Software* (for Tool) and *Infrastructure* (for Environment).

3.2 Technology Map structure

When using the Technology Map some information need to be provided to the system in order to initiate a step-by-step selection procedure. The established four-step filter system guides the user from his given situation to possible digitization solutions.The Technology Map consisting of the filter process and the structure of resulting digitization solutions is presented in Fig. 2.

The user starts with selecting his *Application scenario* in the first step. In a next step, he is asked to specify the *Phase of product Lifecycle*, where the digitization solution needs to be installed. Lifecycle phases are conception, development, production, assembly, aftersales and supporting functions.

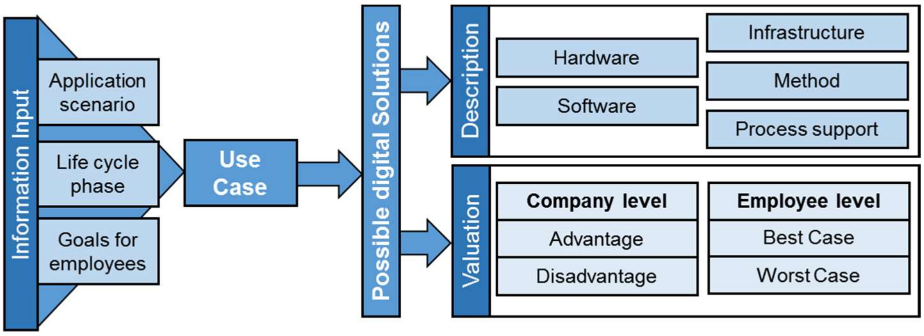

Figure 2. *Technology Map* structure and filter process

Within a third step, the *Goals for the employees* as part of the work system are selected. For the described Use Case, a list of all relevant digitization solutions will show up. Because the scale of the project is limited, the selection of the solutions is based on the relevance of technology trends identified by literature research. The digitization solution always contains a structured description about *Hardware* and *Software* components, which need to be installed to use the solution. Furthermore, information about *infrastructur*e, corresponding *Methods* and supporting *Processes* is provided. Finally, the valuation criteria containing *Advantages* and *Disadvantages* (difficulties) of the digitization solution on a company level, as well as *Best* and *Worst Case* scenarios for the usage of the implemented digitization solution from employees' perspective are provided.
Nevertheless, the Technology Map cannot make a final decision, which technology should be implemented for a specific problem. It presents different options of digitization solutions, as well as advantages and disadvantages to support the decision-making process.

4 Evaluation of MBSE with regards to Technology Map criteria

In the following, MBSE as a new modelling technology in industrial product development is briefly introduced in order to be assessed exemplarily with the Technology Map afterwards. It is not intended to describe all technical details, but to give a short overview of MBSE fundaments.

4.1 Model Based Systems Engineering

Design approaches, which integrate different disciplines, can be assigned to the Systems Engineering domain. Systems Engineering (SE) addresses the issue of complexity and multidisciplinarity within engineering design processes, using an integrative and interdisciplinary view of a product over its entire lifecycle (Martin, 1997).
According to the International Council on Systems Engineering (INCOSE), MBSE is the formalized application of modeling to support requirements recording, design, analysis, verification and validation of complex systems beginning in the conceptual design phase and continuing throughout development and later lifecycle phases. MBSE can be considered as a set of interconnected models, which are composed according to SE Methodology. These Models (e.g. requirements, structure and behavior models) are an abstraction of reality. The Object-Oriented Systems Engineering Method Working Group (OOSEM) as a part of INCOSE and ISO-15288 provide guidelines for decomposing the system into its logical components (Friedenthal, Moore, & Steiner, 2008; ISO/IEC/IEEE15288:2015).
One of the general-purpose modeling languages for Systems Engineering applications including MBSE is called SysML (Systems Modelling Language), wich originates from UML

(Unified Modelling Language). SysML is a graphical language and defines modeling elements with a notation, a formal syntax and semantics (Fig. 3). SysML model is not merely a mental abstraction, but a collection of complex data structures that can be edited, MBSE is considered as best practice approach for development of complex products as cybertronic systems and was also validated in previous projects (Ashton & Klavans, 1997; Eigner, Koch, & Muggeo, 2017; Ralf Schuler et al., 2015).

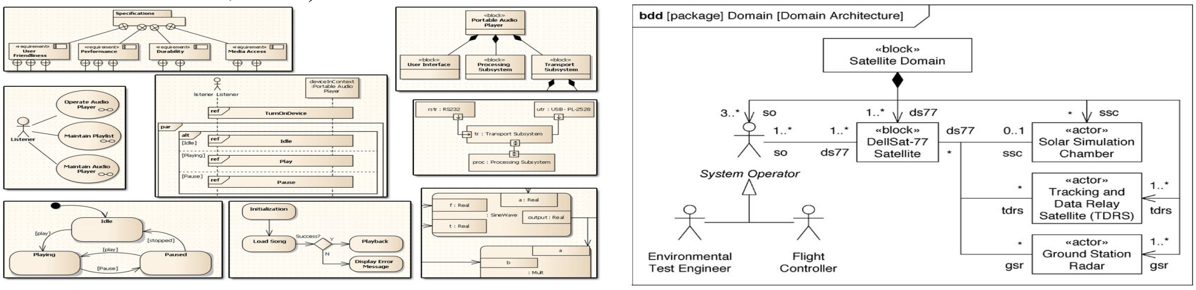

Figure 3. SysML Notation (Delligatti, 2014)

Estefan characterizes MBSE methodologies as a collection of related PMTEs (processes, methods, tools and environment) to support the discipline of SE in a model driven context (Estefan, 2007). In Fig. 4. the TM suggested realization criteria of MBSE as a *digitization Solution,* are visualized. These and more evaluations according to TM criteria are described in the next section for a TM assessment example.

4.2 Evaluating MBSE as a possible digitization solution

MBSE conducted with digital tools was identified as a *digitization Solution*. It can be applied in product development process and further *product lifecycle phases*. Implementing MBSE requiers MBSE *Softwares* and languages as enabling Modeling tools and computer equipped engineering work place as *Hardware*. It should be supported with SE *Methods* (Fig. 4) and model based Design *Processes*, enriched with System Engineering *Processes* (Eigner, Koch et al., 2017).

MBSE tool can be integrated as an authoring system in a Product Lifecycle Management (PLM) *Infrastructural* Environment, which serves as data provision and distribution backbone. This Integration builds the needed Industrial Internet IT architecture; a model-based architecture framework (Eigner, Dickopf, & Apostolov, 2017). MBSE-PLM integration enhances also tools interoperability and traceability of MBSE artefacts for system environment (i.e. other systems) (Eigner, Koch et al., 2017).

MBSE is assigned to 'Integrated product development and simulation' as a basis for Engineering 4.0 and smart engineering, as well as 'Distribution and analyzing Information, which can be used by cybertronic systems' *Application scenarios* (Eigner, 2018).

Within the Technology Map, remaining dimensions of Fig. 2. are supplemented by:

- Possible *Use Cases*: Developing mechatronic and cybertronic products and systems, digital design, smart products and service design, as well as deployment of Model based Engineering and Systems Engineering;
- Allocation to *Product Lifecycle Phase*: MBSE should be deployed in conception phases, especially system analysis and architecture design and further through product development activities, but it can also cover the whole product lifecycle;
- *Goals for employee*: Competence acquisition (knowledge, skills and abilities), avoiding errors and improving design performance, engineering assistance through automation of design work and digitized documentation.

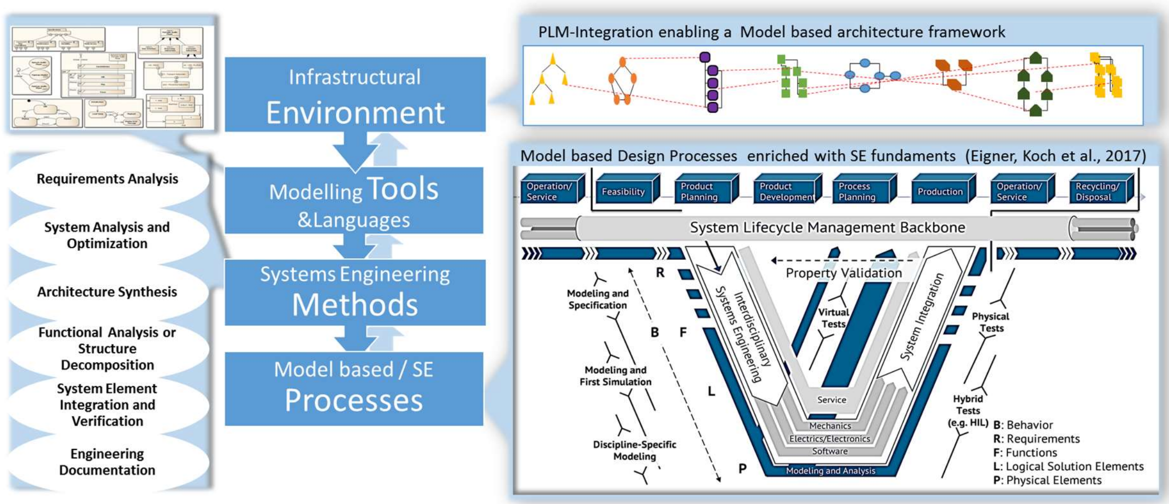

Figure 4. Example for MBSE suggested realization criteria based on PMTE approach

Work system enhancement potentials of MBSE were assigned to company (organization) level and employee's level.

Advantages for the company: MBSE enhances the ability to capture, analyze, share and manage the information associated with the complete specification of a product. It leads to improved product quality by providing an unambiguous and precise model of the system, which can be evaluated for consistency, correctness and completeness. Early identification of requirements, integration of system design ideas, allocation of requirements to hardware and software, embedding of specifications and consistent documentation are further organizational advantages. MBSE contents can be integrated and assigned to the PLM system (Eigner, 2018). It acts also as the interconnection point of different modelling tools of different disciplines. Hence, it facilitates requirement management, integration of design and functional modelling, alignment and justification of simulation and system functions, logical units, physical parts and behavior, verification and process planning. Furthermore, it facilitates interdisciplinarity, traceability of requirements, system transparency, agility and cost management (Le Sergent, Dormoy, & Le Guennee, 2016 Toulouse).

Difficulties (*Company's Disadvantages*) may occur since effective MBSE requires a disciplined and well-trained project team and a mature process approach (i.e. a model based SE driven approach). Modeling a complex product or a system along the full design process with functional, logical and physical architecture requires mastering a modeling language, a suitable method and a powerful IT tool. Installing all requirements and training employees is time-consuming and cost-intensive and necessitates the willingness of people involved. (Estefan, 2007; Friedenthal et al., 2008)

In the *Best Case* scenario the software supports the employee in his development tasks, so that the work can be accomplished more efficiently. The increased efficiency gives the engineer more time for further activities that enrich his task. Specific socio-technical benefits through this technology are:

- Improved communications among the development stakeholders (e.g. the customer, program management, systems engineers, hardware and software developers, testers and specialty engineering disciplines) even across spoken language barriers;
- Increased ability to manage system complexity by enabling a system model to be viewed from multiple perspectives and to analyze the impact of changes;
- Enhanced knowledge recording and reuse of the information by capturing information in more standardized ways and leveraging built in abstraction mechanisms inherent in

model driven approaches. This in turn can result in reduced cycle time and lower maintenance costs to modify the design;
- Improved ability to teach and learn SE fundamentals by providing a clear and unambiguous representation of the concepts (Ralf Schuler et al., 2015).

In the *Worst Case* scenario, the engineer is not adequately trained to use the methods and tools or failed to attain qualification requirements, resulting in additional work load that contributes to the employee's job dissatisfaction. Another potential risk is high technical dependency. Special risks arise, because modeling all information and their relation is difficult and time consuming. Model based process activities that support the engineering process should be accomplished through development of increasing detailed models. Like any oder computer language SysML (usual MBSE modelling Language) can be used in many different ways, including many wrong ways.

5 Conclusion and outlook

Digitization needs to be judged in the light of all aspects of the work system: Technological advantages, changes within the organizational setting and impact on employees. Hence adopting a socio-technical approach to engineering work system development leads to systems, which deliver added value to all stakeholders. A detailed approach for making a socio-technical system assessment is the 'Process Methods, Tools and Environment' (PMTE) analysis. Empowering engineering through qualified tools, appropriate methods and well-designed organizational processes enhance the effectivity and integration of work systems and improve company's competiveness in time of changes.

The Technology Map is designed as a tool, which aims to help company's protagonists in identifying possible digitization solutions for their individual Use Cases. It provides description and evaluation criteria for assessing digitization solutions based on a socio-technical approach. As an example Model based Systems Engineering, as an enabling digitization Technology was assigned to criteria defined by the Technology Map. Implemented correctly, MBSE can provide a solution for engineering process optimization and complexity management. It can improve engineering work processes by facilitating interdisciplinarity, data integration and traceability. In future stages of the project 'InAsPro', more digitization solutions will be included in Technology Map, covering all product lifecycle phases. Furthermore, digitization level of companies will be assessed and evaluated according to the efficiency of already implemented solutions. For this purpose, maturity studies for assessing company's readiness to install digitization measures will be conducted former to the development of a holistic digital transformation concept.

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Zusammen. Zukunft. Gestalten.

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