SOFTWARE INTENSIVE SYSTEMS | WHITE PAPER

Process management 4.0 for engineering success

LET'S GO

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Executive summary

Developing products for an increasingly complex world challenges or even exceeds engineering capabilities. Many factors impact complexity, such as connectivity, security, safety, product variants, development velocity, reliability and quality.

Many argue that the major driver to better manage this complexity is the engineering paradigm of Industry 4.0.

- To succeed in this new age, engineers must look for solutions to adapt engineering to a more dynamic world. This white paper introduces a solution to address the engineering challenges of the modern-day industrial revolution.

The industry 4.0 paradigm

Industry 4.0 facilitates the vision and execution of a smart factory (see Figure 1). Within the modular structured smart factories of Industry 4.0, cyberphysical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions. Over the Internet of Things (IoT), cyberphysical systems communicate and cooperate with each other and with humans in real time, and via the Internet of Services, both internal and cross-organizational services are offered and utilized by participants of the value chain.

Characteristics of Industry 4.0 include:

- Serves more complex (production) processes
- Flexible and responsive
- Decentralized and adjustable

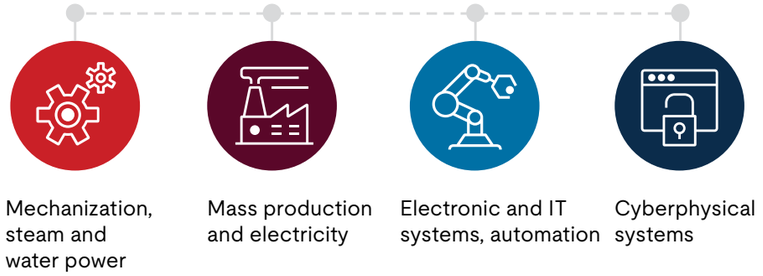


Figure 1: The evolution to industry 4.0

What should be changed to prepare for this paradigm will vary significantly by company or product. Managed change is much more critical. To guide this organization, the new paradigm calls for flexibility and agility and has little tolerance for waste.

Engineering change

Engineers typically embrace the opportunity to learn and adapt. However, as engineers and teams alone face diminishing returns, organizations must learn to change, to be responsive, faster and more agile. Agile principles such as those originally outlined in the Agile Manifesto have long been popular. In recent years, frameworks such as Disciplined Agile and Scaled Agile have emerged to help expand the benefits of agility beyond a single team. Such frameworks can be valuable tools to create the cohesive structures for organizational change. However, the basis for change must be the business needs or goals. The organization then needs the ability to set direction and steer and deploy resources effectively and efficiently.

Product development can only succeed in the Industry 4.0 paradigm by building a learning organization. In many organizations, this means addressing fundamental factors required to empower the organization to change and learn. Building a learning organization requires engineering management foresight to reset inefficient practices and deploy resources more systematically.

Indicators of organizations with a low ability to learn include excessive rework and low engineering efficiency, leading to overruns and recalls as engineers may be stuck firefighting. This may also result in low employee satisfaction and retention, leading to knowledge drain.

The notion of learning organizations is not new; the concept was coined through the work and research of Peter Senge in 1990:

> "A learning organization is the business term given to a company that facilitates the learning of its members and continuously transforms itself. Learning organizations develop as a result of the pressures facing modern organizations and enables them to remain competitive in the business environment."
>
> **— Peter Senge**

According to Senge, the typical benefits of a learning organization may include:

- Maintaining levels of innovation and remaining competitive
- Being better placed to respond to external pressures
- Having the knowledge to better link resources to customer needs
- Improving quality of outputs at all levels
- Improving corporate image by becoming more people-oriented
- Increasing the pace of change within the organization

Extending this concept into engineering will help us to better manage the challenges of Industry 4.0.

Effective process management

Good process management is the foundation of establishing a learning organization in a complex engineering environment. Without process management, organizations may be chaotic, dependent on a few contributors, and not prepared properly for each project. This scenario introduces waste, redundancy and risk.

Performing process audits and assessments around the globe in over 700 engineering organizations, UL Solutions Software Intensive Systems (SIS) has witnessed many examples of best and less effective practices. Organizations that invest in process management to support their business have a higher chance of success.

Industry 4.0 processes are individualized due to factors that impact use, such as compliance, safety or risk levels, product lines, departments, or customers. Many tools for business process management insufficiently capture, manage and communicate these engineering processes due to differing requirements; business processes are often repeatable and require less context and depth of understanding. Due to this fact, organizations often resort to using applications like Microsoft PowerPoint, Word, Excel and Visio. These tools have significant limitations for process capture; creating clear, consistent and understandable processes is a challenge. Dependencies that exist within and between documents are difficult to manage. In addition, thousands of work hours are invested to draw and communicate processes.

The process consumer is then challenged with processes that are disconnected, incomplete and inconsistent. Significant time and effort is required to sort through numerous documents and understand what needs to be performed in the context of the business unit, program, project, product line or customer. As a result, UL Solutions SIS has often seen processes that are theoretical, vary in granularity, are outdated and do not allow tailoring. These factors increase the chances that processes are not accepted, followed or improved.

However, there is a way out. The digitization of quality management systems by placing processes into a database is required to succeed in Industry 4.0. Our web-based process management software, Stages, provides

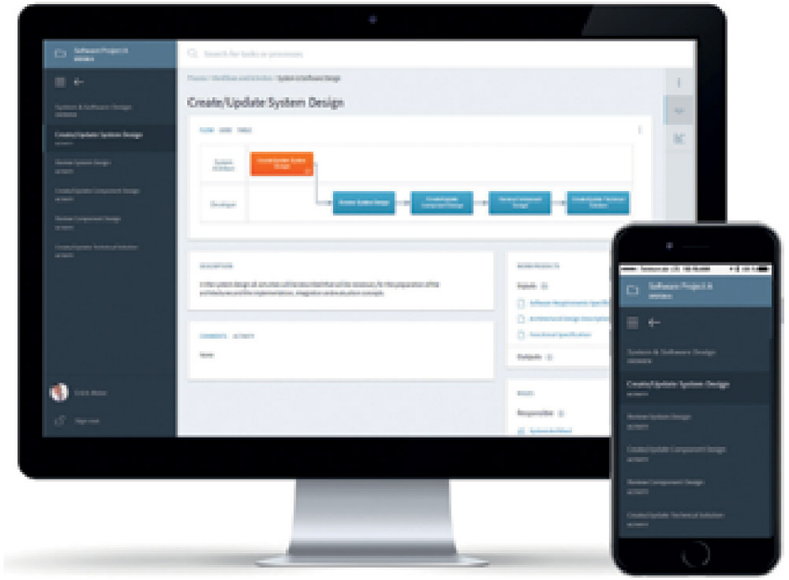


Figure 2. The Stages process management software by UL Solutions

engineering organizations with a platform to manage flexible and decentralized complex processes. In a modular and extendable way, Stages provides the right context for the end user, generating different perspectives to support and enhance understanding. Capturing the process landscape in a database ensures interfaces are managed and processes are consistent. Only in this way can processes be usable, focusing on process content and learning instead of management and capture.

Effective process management helps the learning organization:

- Assist with organizational development according to changing business objectives.
- Meet business objectives in a managed and repeatable way.
- Manage repeatable experience by definition of processes.
- Establish measurable process improvement following the changing business objectives.

The methodology

All too often, process investments and improvement projects in large engineering organizations are made without a clear methodology, resulting in compounded waste and failure. SIS has many examples of documentation of processes that do not support understanding and exclude tools and instructions to use them.

These experiences led us to develop a methodology to support engineering organizational change and learning. Rather than following a hit-and-miss approach, our goal has been to capture the lessons of effective process management and help engineering organizations to compete in the Industry 4.0 age.

Process Management 4.0 is the methodology that allows organizations to specify and manage processes for building and using the Internet of Things (IoT) for development and production purposes. It supports on-the-fly created value chain approaches and business models.

Typical statements often heard that indicate ineffective process management and a weak learning organization:

Project manager: “Without a running product, we can‘t care about the processes.”

Engineering manager: “We do not need processes — we have tools.”

Process responsible: “We have to harmonize processes before we can release them.”

EPG lead: "We just care about the processes — we do not deal with the project work.”

Benefits of Process Management 4.0

- Serves more complex processes (in development and production)
- Is flexible and responsive (in design and execution)
- Is decentralized and adjustable (in definition and responsibility)

1) Define goals

Change should be guided by the business goals. When goals are identified and traced to projects and activities, they can steer the organization. In this way, we can help ensure the efficient and effective use of resources. Traceability of objectives and goals to actions helps to focus the organization and can resolve difficult discussions and reduce waste. We recommend the Goal-Question Metric approach, such as those from Basili and Rombach, as effective tools.

Many organizations define their process improvement goals from what they are forced to do by their customers, OEMs or the regulators. This leads to goals such as "We have to meet Automotive SPICE® Level 3 until the end of the year" that almost never have any sustained value for the organization because all the efforts are targeted toward reaching the level and all process efforts are abandoned after the appraisal. The real business goals are determined by asking "Why?" until you find the real goal.

In most organizations we worked with that were targeting a certain level, asking the "Why?" question led us to goals such as "We would like to win at least 10 new customers because we want to grow by 25% in revenue." This can then be broken down into subgoals to make the organization more efficient, e.g., including the use of automation, to be able to scale up their business, and to define and document lean processes to allow the organization to grow 20% in engineering personnel. This looked to bring value to the organization, the improvements were sustained and institutionalized, and meeting the required Automotive SPICE® level was a mere side effect.

2) Analyze process capability

Understanding capability might be established through assessment or audit based on capability frameworks such as SPiCE® or CMMI®. We may also pull together contextual information, such as the tools in use, history and structure of the organization. With a transparent and realistic assessment of the current state of engineering, we can start to build a road map. This way, we help ensure problems are handled in proper order.

Examples for such capability determinations are either a semi formal gap analysis against a subset of SPICE®, such as SWE.1 Software Requirements Analysis, MAN.3 Project Management, and SUP.8: Configuration Management), or a lightweight SCAMPI C appraisal against the CMMI-DEV level 2 process areas. Both methods only take a few hours of effort if they are conducted by experienced assessors or appraisers.

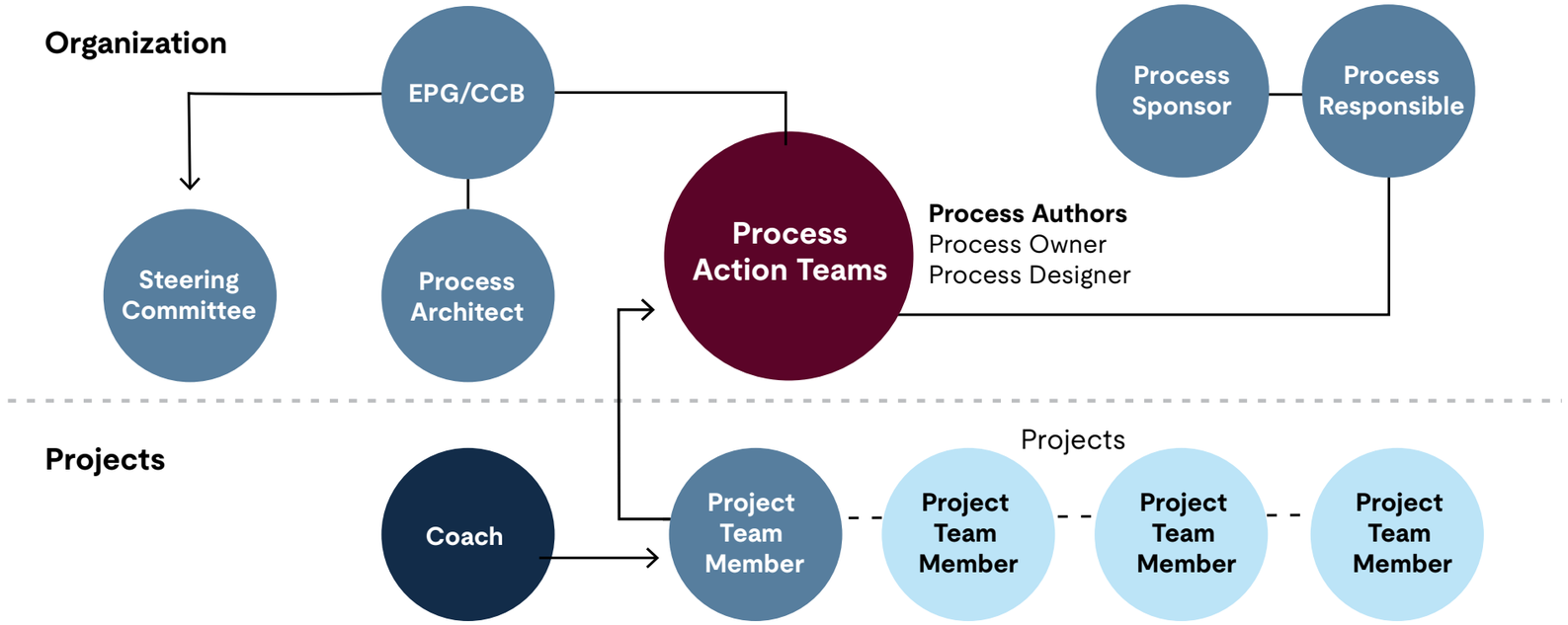
3) Define business process management organization

Now that we have a clear understanding of our business, we can identify the process architectures that will be required in our organization to support the business. Understanding the different types of architectures is critical. We can reduce the risk of future rework by defining clear architectures at this point.

Figure

3

Example BPM (Business Process Management) organization



Ensuring the right stakeholders are involved is a critical factor, as change will only happen when engineers see value and own and accept the process. This requires that the process management organization is set up correctly with a mixture of support roles and practitioners. Many organizations do not build clear roles and responsibilities in the process management organization. Examples of a BPM structure is outlined in Figure 3.

Things to consider in building effective process governance include:

- Process architecture
- Process management team
- Process management program
- Process management tool set
- Modeling guideline

4) Model processes

Process definition must be managed to ensure consistency, and we need clear process governance. This includes defining terminology, guidelines and the landscape based on the outlined architecture. Guidelines will help to address variations in granularity and approaches used in the definition.

An example of a guideline taken from the Process Management 4.0 methodology:

"ER 3.4 Granularity of Roles Define as few roles as possible. Splitting or merging of roles shall be done considering the skill sets."

The methodology provides an extensive library of best practices guidelines. These approaches will have a large impact on the outcomes and will shape the landscape for learning. For example: Should work products or activities be captured first, or should reviews be explicitly defined? The process modeling will be an iterative process repeated per process area. It should be noted that processes must not be 100% complete, and shorter release cycles are recommended where feedback is integrated quickly. This type of approach versus a big bang approach will help to overcome resistance to change, and forge a culture of learning.

From our experience, a good approach focuses on modeling the value chain processes first and leaving management and supporting processes on the side for the first few iterations. The value chain can best be determined by looking at the organization's product life cycle, or following the technical system engineering processes from chapter 6.4 of ISO 15288 ("Systems And Software Engineering — System Life Cycle Processes").

5) Establish a learning organization

To learn, organizations need built-in measurements that are traced back to business goals. Principles should be established, such as no process should exist without feedback, no process without the evacuation of measurements and allow changes and improvement all the time.

One of the most successful organizations applying our methodology processed and incorporated over 1,000 feedback items from its engineers within a single year. This way, the process participants felt empowered to influence the way they work, which resulted in a very high process acceptance and institutionalization.

Establishing a learning organization is a process but also a cultural change. Processes capture the knowledge and experience of an organization. Therefore, processes will always change, because our knowledge and experience grows every day.

Usually you start to do intuitive engineering of new products to be creative. Whenever you have been successful in engineering, you try to repeat that approach for future development. To repeat your success, you write down what you have done. This written down experience is called a process.

Summary and conclusion

Organizations need the ability to respond to change in a dynamic engineering environment. Change is a process and a culture of learning that steers the organization. This process enables people to function together, develop and grow. Building a learning organization is about creating the structures to enable people to change together.

The foundation of transformation is effective process management coupled with a systematic approach to change focused on business goals. In this way, engineering organizations can learn to adapt to the needs of Industry 4.0 to be flexible, responsive, decentralized and adjustable.

> “People don’t resist change. They resist being changed.”
>
> **Peter Senge**

Take a training and learn more about the methodology described in this white paper:

Process Management 4.0–Best Practices

Courses are available at our training center
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