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How to Effectively Manage & Improve System Engineering Processes

1 Introduction

Building large complex systems like airplanes, plants, trains or automobiles with world class quality does not work without mastering the appropriate development processes. Corporations producing systems with poor quality run into the risk of losing reputation, customers and revenue and even endanger the whole enterprise. But creating the appropriate processes and implementing them in a sustained way is not an easy task. Too often these processes are documented in Powerpoint, Visio, Word or even on huge piles of paper and there is a large gap between process theory and project practice. This paper describes an approach that enables process managers and process users to bridge this gap by defining processes and using them directly in engineering projects.

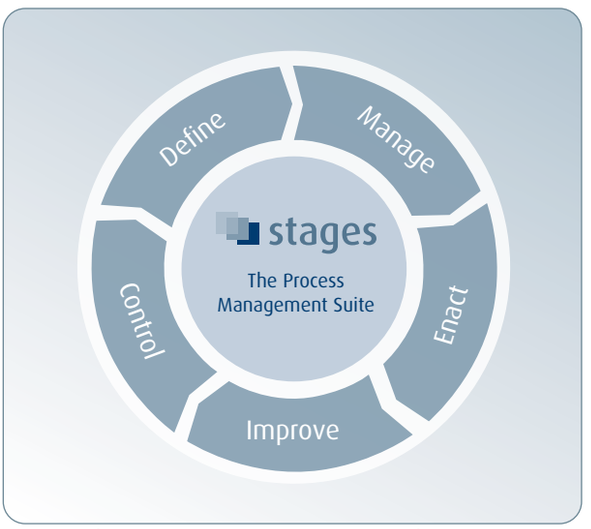

Figure 1: The Stages Process Improvement Cycle

2 Systems engineering processes

What is so special about system engineering, that process adoption is such a problem? Processes in system engineering projects differ from normal business processes in the following criteria:

Complexity: In system engineering projects, different disciplines like hardware, software, electronics or mechatronics need to cooperate to produce a high quality product. This requires lots of parallel work, coordination and collaboration resulting in lots of process interfaces. Often these projects are run in matrix organizations what makes coordination, responsibilities or resource planning even more complex.

Creativity: Developing complex systems requires both expertise and creativity. Engineers should know the best practices and right methods to implement their tasks, but there is no given detailled workflow that can be followed to develop an innovative automobile. Therefore, system engineering processes are hardly exactly repeatable, system engineers need to have specific degrees of freedom to perform their work.

Diversity: Whereas business processes are usually implemented end-to-end in ERP systems like SAP/R3, system engineers have to use lots of different tools for requirements engineering, project management or document management. All these tools perform or support parts of the process, but usually they lack a seamless integration or even common configuration. As a result, system engineering projects are hard to estimate and to plan and hard to control. So they tend to be over budget, behind schedule and at the end produce less quality than required.

3 The „Stages“ Idea

The key idea behind the “Stages” process management system is to bring process theory and project practices together. Stages is optimized for complex but creativity-driven processes and integrates with a large number of tools typically used in system engineering environments. It focuses on the end user of processes and provides him with easy access to process descriptions, allowing him to understand both transparent end-to-end processes and role-centric process details. Over a web-based interface, the user has direct and easy access to all project documents, document templates, best practices or know-how pools instead of lots of process theory and complex workflow graphics. Furthermore, the process definitions in Stages can be used to drive and configure other engineering tools like PLM suites and project management or

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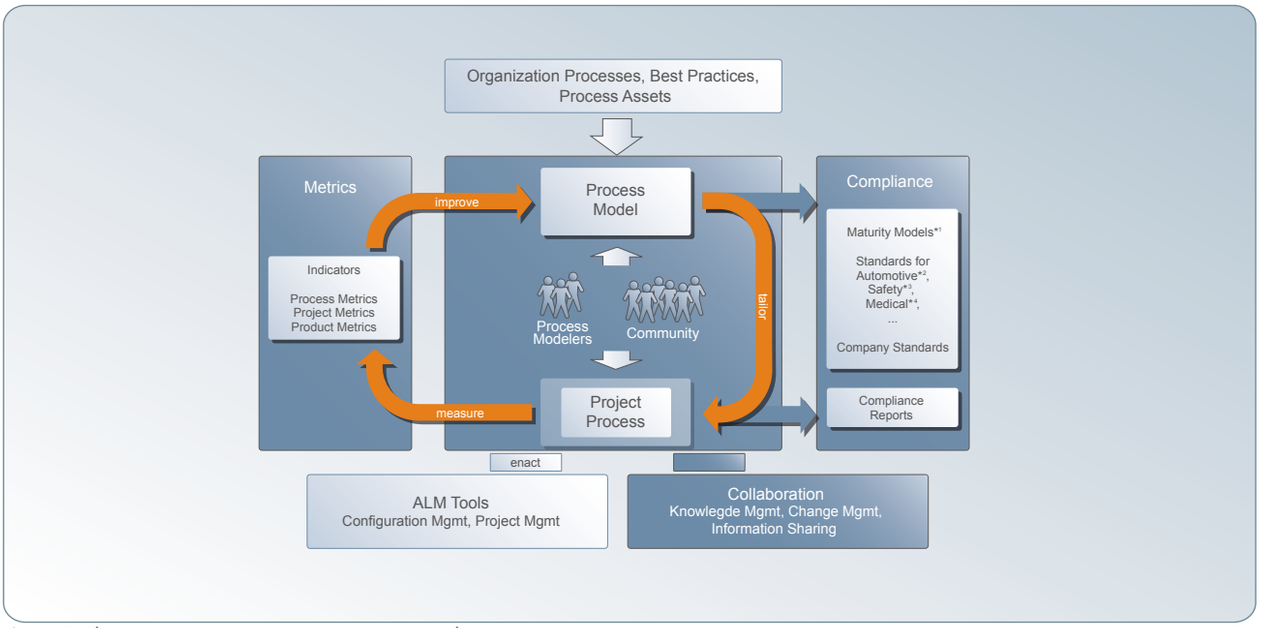

Figure 2: The Stages Process Management Approach

configuration management systems. The underlying framework for Stages is a process development cycle shown in Figure 1. It is inspired the proven SixSigma DMAIC cycle and consists of five basic steps:

Define: All necessary process assets are defined in a fast and easy, but nevertheless structured way. Process assets can be coarse-grained end-to-end processes like product development process overviews, detailed process descriptions like requirements engineering information flows or additional process guidance like work procedures or document templates.

Manage: Process descriptions need to be checked for consistency, reviewed or version- and change-controlled. Additionally, processes can be checked for compliance with frameworks like CMMI, ISO 15504 or ISO 9001. This allows assuring the fulfillment of required process standards that are important for the organization's type of business.

Enact: To help projects in adopting and implementing the defined processes, process descriptions can be instantiated and tailored to the specific requirements of a project. Projects can range from system engineering programs to product development projects or software projects and subprojects. The project's tool landscape is then configured to match the specific project processes and integrated into the Stages GUI. End users can create and access project documents in a process-oriented way without having to know any technical details.

Control: process performance needs to be measured and controlled. Therefore, key performance indicators defined in the process description can be automatically collected from various information sources. All data sources can be aggregated to product, project, program or any organizational level metrics.

Improve: to implement continuous process improvement, feedback can be collected either directly from the end users or by performing analysis of the process performance metrics. Process improvements can be implemented in new versions of the process descriptions. Projects can then be promoted to new process versions in a controlled way.

Within this cycle Stages allows organizations to implement their specific process management strategy. The optimal strategy largely depends on the organization's type of business and internal culture. They can either start by top-down modeling their full process landscape top or by defining the as-is processes on the project level and then doing a stepwise standardization. A mix between these two approaches is also possible.

4 Solution Details

Processes are an integral part of an organization's business. And just as very different business models exist, very different ways of describing and implementing processes are required. This is especially true for engineering-driven companies where the system engineering or R&D processes are usually considered to be the most important processes. The culture of an organization must be reflected in their way of describing processes.

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Flexible Process Metamodels

Processes in Stages can be described in a very flexible way. Processes may have arbitrary levels of depth and detail. The underlying process metamodel, e.g. the relationships between phases, activities, roles, documents, methods and tools, can also be arbitrarily configured. Stages is even capable of managing processes with different metamodels at the same time. This can be used to describe complex development processes with a metamodel containing more information and organizational management processes that can be sufficiently described with simpler structures. This means, that Stages is capable of running multiple process notations in parallel. Additionally, a process metamodel may contain multiple views of a process description. For example, the process modeler can use a very detailed view of the process metamodel to define processes and assure consistency amongst the processes. In turn, an experienced end user can use a metamodel view that only contains the information that he requires for his daily work (e.g. documents and templates). Standard process views like process turtles, RASIC or SIPOC can be integrated. With its flexible and scriptable process visualization, Stages automatically generates process diagrams like swim lanes or process flows that support the user in understanding the process. Although they might not be optimally suited for an organization, standard metamodels like SPEM or SEMDM are also supported and can be used in conjunction with custom metamodels. The process definition itself is done in a Wiki-like style. This is easy to learn, requires almost no training and is easily remembered for users that do not model processes every day. A specific client can be used to perform advanced modeling tasks like bulk updates or process refactoring. Stages is able to import already existing process descriptions from process modeling solutions like MS Visio, ARIS or the Eclipse Process Framework (EPF). This protects investments and avoids rework.

Compliance Management

To support organizations in using reference models like CMMI or SPICE for process improvement, Stages is able to flexibly map process descriptions against the requirements of different reference models. A large number of already preconfigured standards are already directly available. For specific industries (e.g., Automotive, Medical, Defense) even specific preconfigured content packages have been built, that contain all relevant standards (e.g. ISO TS 16949, Automotive SPICE and ISO 26262 for the Automotive industry). The mapping of processes against standards has to be created only at process definition time and can then be used for gap analysis of the process library as well as the tailored and implemented project processes. By using the mappings from the reference model to the process models and from the process models to the project's processes and work products, Stages is able to generate input for evidence maps like CMMI PIIDs. See [WP1] for more detailed information on this topic.

Process Enactment

Enacting the process is the most important step, because it puts the process theory into practice. With Stages, process managers can develop tailoring rules and guidelines for their processes. The project managers can select a process from the process library, instantiate and tailor it to the specific requirements of the project. For example, if a project does not produce a safety critical product, all safety-related process elements (e.g. FMEA method application, product verification for safety requirements, safety manager role) are automatically tailored away. Furthermore, the roles in the process are assigned to real persons in the project. This enables Stages to show user-centric and role-specific information like process views or document lists. As the project's process is connected to the project's tool environment, users can directly and easily access project documents through Stages without having to know where they are stored and how they are controlled. A project manager can quickly get an overview of the status of all relevant project documents. Integrations to the following configuration and version management tools are available: ClearCase, Synergy, MKS Source Integrity, PVCS Version Manager, Dimensions, CVS, Subversion. Other tools can be integrated on client request. Other tools can also receive the project's process as an input. For example, the tailored process activity list can be transformed into tasks and resources and serve as a basis for a WBS transferred to a project management or PLM tool. For that purpose, Stages already contains interfaces to standard tools like MS Project, Actano RPLAN or PTC Windchill. In recent years, integrated software development platforms have become increasingly process-aware and can be used for implementing or automating parts of the development processes, for example requirements engineering or product testing. With Stages being able to generate process configurations for systems like IBM Rational Team Concert/Jazz, Microsoft Visual Studio Team System or MKS Integrity, process managers can assure the defined processes are readily implemented in practice.

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Process Control
KPIs are a valuable instrument to assure that a process is correctly performed. For this purpose, Stages contains a powerful and flexible metrics engine. Metrics or KPIs can directly be defined in the process descriptions, data can automatically be collected from various information sources. As Stages controls the project's specific process, it can generate combined metrics showing correlations between different tool data sources. For example, the correlation between requirements stability and defect rates can be monitored, analyzed and controlled. All data sources can be aggregated to form project, program or any organizational level metrics. Dashboards can be defined that contain the KPIs that need to be monitored on a regular basis. Metric reports can be exported to PDF, Powerpoint or Word, so that project reporting activities can be automated. This saves project managers lots of valuable time by eliminating manual work having also the effect of reducing error rates.

Process Change & Configuration Management
To maintain a stable process infrastructure, all changes to process descriptions can be controlled. Processes can be baselined, reviewed and released as valid. Project managers can choose to adopt new process versions in a controlled way. This allows all employees to work according to the latest valid processes. In turn, this enables organizations to easily fulfill the requirements of standards like ISO 9001ff.

Technical Details
The Stages portal solution is built upon a flexible and scalable J2EE standard web platform. It uses an SQL database backend to store all process data. For consistency reasons, all data, e.g. the status of the project documents, is stored only once and cached for performance purposes. Users only need a web browser to work with Stages. For advanced process modeling tasks, an Eclipse Rich Client with a roundtrip interface to MS Visio can be used. To allow Stages to seamlessly integrate into existing IT landscapes, the architecture contains multiple integration possibilities for external tools and data stores. This allows organizations to protect their investments for example into project management, document management or configuration management tools.

5 Advanced Concepts

With organizations reaching higher process maturitylevels, they can apply advanced process management methods for becoming even more efficient.

Distributed Process Management
Especially large organizations will need to implement multiple levels of process management. Top level process groups will define the overall process architecture, the most important engineering processes and their key interfaces on an abstract level. This architecture will then be detailed by other process groups to adapt these processes to the local business requirements, products and tools.
To facilitate this top-down approach, Stages supports the definition of core processes. These core processes can be refined and localized by decentralized process groups. Core process managers are able to determine, which parts of the process can be detailed or overridden (e.g. document templates, tools usage) and which parts may not be modified by local authorities (e.g. controlling procedures). The dissemination of new core process versions while retaining local modifications is also supported. This concept can also be used to have multiple groups defining different process areas (e.g. design, implementation, testing) and to later integrate these process definitions into a global engineering process architecture.

Multi-model Compliance
For organizations that are required to comply with more than one standard, so called multi-models are an efficient way of proving compliance. By linking standards to other related standards (e.g. CMMI to ISO 9001 or SPICE), overlapping parts of the standards can be identified and every distinct standard requirement will only need to be implemented once. For example, organizations are able to build a single CMMI model that consists of links to all three current CMMI constellations (DEV, SVC, ACQ) containing only those aspects that are relevant for the organization. Another example is an Automotive multi-model fulfilling Automotive SPICE and the ISO 26262 safety standard in parallel. Multi-models for the development of medical devices or defense electronics are also available. Stages fully supports the creation and usage of multi-models. In multi-model environments, Stages is able to even indirectly perform process gap analysis or generate evidence data. For example, using a mapping from CMMI to ISO 9001, evidence data for ISO 9001 can be generated for processes mapped to CMMI. This saves organizations valuable resources.

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High Maturity and Six Sigma Support

Stages is able to support and automate advanced measurement techniques like derived metrics or end-to-end process metrics. With its ability to connect the metrics engine to external data sources, Stages can for example use the results of process performance model evaluations and compare the current data values against predictions. This allows detecting significant process deviations before they cause bigger impact on the business. Additionally, the Stages metrics data can be imported into analysis tools like Minitab or Crystal Ball. The analysis results can be used for systematic process improvement or directly fed into Stages dashboards. With these mechanisms, Stages supports the practices of CMMI Maturity Levels 4 and 5 and enables organizations to use Six Sigma in a cost efficient way.

6 Business Benefits

When implementing a suitable process management solution, it is crucial to focus on specific benefits that leverage the business of the organization. Employing well-run processes that are standardized on the appropriate level allows organizations to gain efficiency in a number of areas. This starts with users being able to clearly understand their specific responsibilities in the processes where they are involved in. Furthermore, process participants save time by quickly being able to find their respective documents, templates and other related information. With more personnel following defined processes, planning stability improves. In turn, costs and time estimations for system engineering projects become more precise. Process performance control is largely automated, which reduces manual and error-prone work and facilitates stakeholders to receive exact just-in-time reports. Most important, by following higher quality processes, organizations will improve quality of project deliverables. As another positive effect, organizations are able to save efforts during preparation and performance of audits and appraisals. Because both the process descriptions and the project work products are managed and can be traced to standard requirements, generating evidence data for proving process performance can be largely automated. Some organizations have reported more than 60% savings in preparation for audits or appraisals. All in all, employing a powerful process management solution allows all stakeholders to concentrate on real and effective process improvement instead of tedious and time consuming process administration.

7 Summary

Well-defined and implemented processes result in better organizational performance, better planning and higher product quality. All of this results in what all organizations should have as their ultimate goal: higher customer satisfaction. This paper introduced a powerful, flexible and easy-to-use solution enabling users to define, implement and continuously improve processes in system engineering organizations.

To learn more about the Stages solution, request your personal webinar, register for a product trial under http://stages.methodpark.com or contact us directly via info@methodpark.com.

Literature

[WP1] “Effectively Managing Process Compliance“ Whitepaper, http://www.methodpark.com/en/resources/resources/

Abbreviations

DMAIC: Define, Measure, Analyze, Improve, Control
KPI: Key Performance Indicator
RASIC: Responsible, Approve, Support, Inform, Consult
SPEM: Software Process Engineering Metamodel
SEMDM: Software Engineering Metamodel for Development Methodologies
SIPOC: Supplier, Input, Process, Output, Customer
WBS: Work Breakdown Structure

About Method Park

Method Park’s engineers and consultants are experts in the field of software development for automotive and medical systems, especially where high demands on quality and safety are made. We are your experienced partner for engineering services, coaching, training and consulting in software development processes and process maturity models. Method Park, which was founded in 2001 in Erlangen, Germany, currently has more then 100 employees. Method Park has subsidiaries in Erlangen and Munich in Germany, as well as Detroit and San José in the USA. For further information please contact:

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