

INNOVATIVE PROCEDURES FOR PROJECTS IN CUSTOMER-SPECIFIC MACHINERY ENGINEERING

Wagner, U.; Riedel, R. & Müller, E.

Abstract: *Currently there is a great need for process and organisational innovation in the project execution in customer-specific machinery and plant engineering. Deficits result from inefficient project execution processes, insufficient information flow or inappropriate computer systems. In result, the productivity of enterprises is diminished. The main reason for the unused potential in this domain is the lack of standards for the project execution. In the following paper we present solutions to overcome this lack of standards.*

Key words: innovation, standardisation, project execution, reference model, procedure model

1. INITIAL SITUATION

The implications of the lack of standards for the project execution are a non-transparent diversity of information, inconsistent data and the loss of information. This leads to unnecessary additional work and respective additional expenditure of time for the project execution. Not only information is lost in projects due to insufficient documentation, but also knowledge is not appropriately exploited in other projects. Therefore, the transfer of knowledge to succeeding projects is limited. This derogates the further improvement of processes as well as of machines and plants. Another result of the lack of standardization is poor coordination between the producers and users of machinery and equipment. Costly errors and modifications during the project execution result from this. [1], [2], [3], [4]

Figure 1 shows typical problems and potential causes resulting from the described lack of standardization in project execution.

Typical problems	Possible causes
Losses due to improper calculation of costs	Neglect of price-related factors in proposal preparation
Time expenditure on project execution is too high	Duplication and multiple inputs
Insufficient cooperation and Information break-ups	Inconsistent data base
Delays within start-up	Insufficient acceptance tests
Repeated errors	Insufficient use of know-how/empirical knowledge

Fig. 1. Problems in project execution and possible causes

Within the context of standardization the described initial situation is about to be improved by innovative approaches.

2. STANDARDIZATION VS. INNOVATION

A research project at the department of Factory Planning and Factory Management of Chemnitz University of Technology (Germany), was addressing this initial

situation. The project was realized together with a special-purpose machinery manufacturer and a software company. Beyond this the results of this project have been further developed in the scope of a doctorate research. In the end we could achieve an innovation in project execution by standardization of processes and information flows. In order to illustrate how standardization could lead to innovation, these two terms need to be defined in a first instance. The term standard is defined as the best solution for tasks of the same kind [5]. **Standardization** is defined as harmonization of measures, types, processes and further issues concerning standards [6]. Hereby, unified best practices are developed, implemented and evaluated for recurring tasks [7]. Furthermore, processes and respectively methods are defined or recommended in the context of standardization. In the scope of this article standardization refers to the execution of processes (cf. [8]).

Innovation means an invention and its sustainable economic use [9]. An innovation can result from the development of a new product and/or process that has firstly been implemented in the respective company [10]. In this article innovation means organizational changes in the respective company, in order to renew processes and to eliminate problems (cf. [11]).

At first sight, it could be assumed that **standardization and innovation** contradict each other. Taking a closer look though, standards can provide a basis for innovation. It turns out that standardized processes clarify and simplify the project execution for complex customer-specific products. In result, the actual task of the planning and realization of innovative machines and plants can be focused on.

3. CHALLENGES

The challenge of using standardized approaches in order to improve the initial situation in this case refers to the special

field of application, which is the customer-specific machinery and plant engineering.

Projects in this area are characterized by the requirements of the customer, which lead to specifications for the planning and manufacturing of machinery and plants. These machinery and plants are either custom-built or manufactured in very small quantities. They offer a high technological novelty grade.

Special-purpose machinery and plants can be planned for a vast amount of purposes. There are for example special-purpose machine tools, assembly and handling plants. Special-purpose machinery is designed for the manufacturing of only one product or a limited family of parts. This limited field of application, however, is counterbalanced by high productivity. [12], [13]

In spite of novelty grade and diversity of these machinery and plants, standardized and innovative approaches could be developed for their project execution. Thus, the elimination of problems referring to the above-mentioned problems is possible.

4. REFERENCE MODEL FOR PROJECT EXECUTION

For the standardization of project execution a reference model has been developed. This model illustrates connections through simplification. The resulting schematization allows a reasonable degree of standardization, in spite of the highly complex processes in customer-specific machinery and plant engineering.

4.1 Overview

Figure 2 gives an overview about the constituent parts of the reference model.

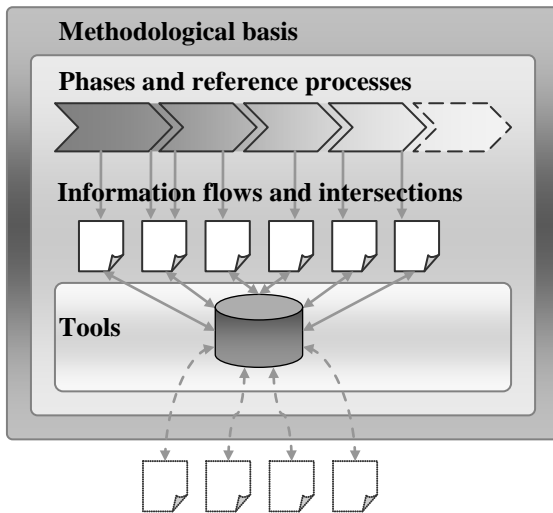


Fig. 2. Constituents of the reference model

A first main focus of the developed reference model is set on an existing methodological basis, which includes for example Simultaneous and Requirements Engineering.

Phases and respective reference processes of project execution represent further parts of the reference model. Referring to this, typical project phases have been defined for the customer-specific machinery and plant engineering. The next step consisted of specifying these phases by reference processes.

Information flows and intersections be-

tween documents represent further parts of the reference model. For this purpose documents were subdivided into information modules. These modules were then visualized and described in detail.

Computer-based tools represent another constituent part of the model. They have been designed in order to support processes of project execution and related documentation as well as information flows.

Besides that, there are documents that have not been standardized and consequently subdivided into modules (e.g. design documents). However, they have been integrated in process and information flow evaluation, but in a simplified manner.

4.2 Reference processes

The development of reference processes was realized on the basis of technical literature (cf. [14], [15], [16], [17]). Besides, existing reference models could be used to collect information about characteristics, potential information bases and modelling options. Furthermore, project execution processes were evaluated in operational practice and included in the development of the reference processes.

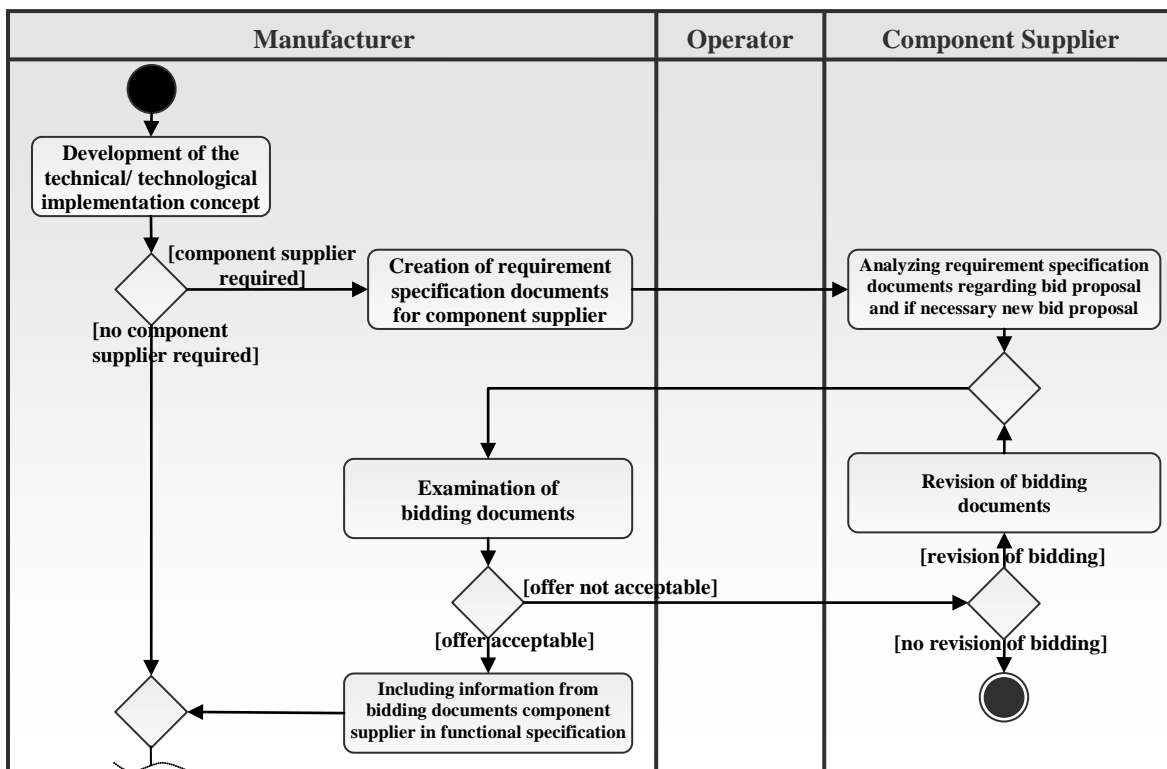


Fig. 3. Bidding and contract conclusion phase - bid proposal (part of the process stage)

As a result the following reference processes have been developed for project execution.

- Bidding and contract conclusion phase
- Development, construction and process planning
- Manufacturing, assembly and start-up in-house (at the manufacturer's factory)
- Delivery and start-up on-site (at the operator's factory)
- Service and warranty (maintenance)

The reference processes were graphically represented and described in detail through activity diagrams of UML (Unified Modeling Language). An example for this graphical representation is shown in figure 3. It contains an excerpt from a reference process.

4.3 Information modules and flows

In order to provide a basic understanding these two terms will be defined in a first instance.

An **information module** represents the grouping of information. The purpose is a reutilization of coherent information, in order to depict intersections between documents.

Information flow means the transfer of information or respectively information modules between organizational units and documents, both within the company and externally. The transfer includes computer-based as well as manual transmission and conversion.

Relevant documents have already been named within the scope of process stages of the developed reference processes. In a next step these documents had to be identified in detail, which was followed by the specification of their content. Consequently, the structuring of documents was carried out by means of information modules. Additionally, intersections and connections between documents were described with the help of information flows. Therefore specific types of information flows, as for example transmission, selection and conversion, had to be defined.

Figure 4 illustrates this approach. However, in this case it is strongly simplified and only shows four exemplary documents.

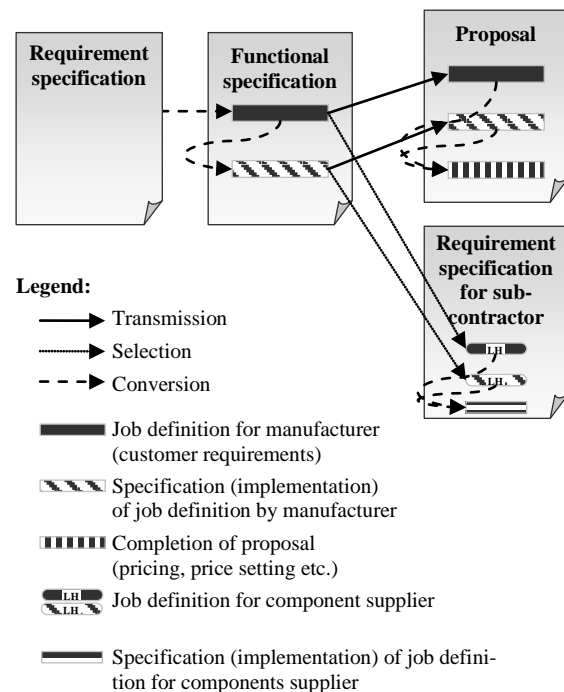


Fig. 4. Information modules and flows

As shown in figure 4 a legend was prepared for the graphical representation of connections between documents and related modules.

4.4 Extended process view

The next step was to specify the reference processes through the reflection of documents and information flows. This is how the extended process view was developed. Process steps were extended in detail by documents, information modules and appropriate information flows.

In this context activity diagrams of the modelling language UML were modified. The modification concentrated especially on the modelling element activity, which was subdivided into three sections by means of dotted lines. The upper section contains the actual activity that already exists in the unmodified version. The two lower sections represent an extension. They contain input or respectively output of the activities, i.e. documents, test results

or other information. In the scope of UML modelling rectangles are modelled to the activities in which input and output parameters are described. This representation is also modified by integrating the developed information modules in place of the rectangles. Documents, their structure and modifications within different process steps as well as their interaction with test results can now be described in detail. The above mentioned modification is schematically shown in figure 5.

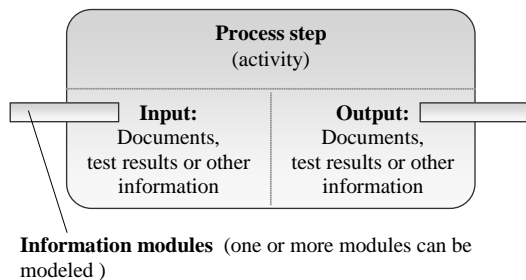


Fig. 5. Extension of process steps

Besides, further information modules had to be introduced for reflections of documents and information flows. These are for example modules for test results or documents that appear optionally.

4.5 Tools

In order to establish reference processes and related information flows with minimal effort in (operational) practice computer-based tools are needed. They have also been derived from the reference model and are for example:

- Questionnaires
- Document configurator
- Extended document configurator (for checklists)
- Change log and evaluation tool

Tasks, the area of application as well as essential requirements have been defined for those tools. On this basis tools were assigned to those reference processes they can be applied in. Besides, interaction between tools was explained. And as tools are planned to be adaptable to different basic conditions and business activities of

companies, there was still the need to describe requirements for configuration.

5. PRACTICAL IMPLEMENTATION

For the introduction and implementation of the reference model in different companies a guideline has been worked out, which describes a systematic approach. The following figure 6 shows an excerpt from this recommendation.

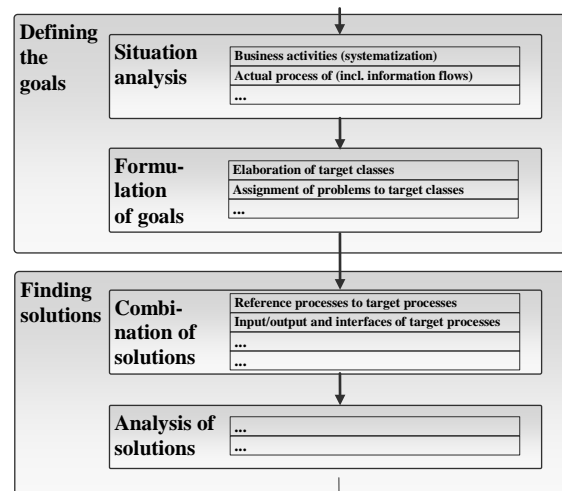


Fig. 6. Guideline (excerpt)

The explanation of recommended steps is, in addition to this, exemplified by a pilot application at a special-purpose machinery manufacturer. Thus, a part of the practical implementation is described. A further part of the practical implementation is a computer-based prototype, which has been developed on the basis of the explanations concerning the drafted tools. In result, a prototype for a computer system has become available, which supports the standardization of the project execution.

6. SUMMARY

One of the results that has been described in the article, is a reference model for the standardization of project execution in the aforementioned domain. The model contains standardized processes and respective information flows. Computer-based tools were drafted for their support. Another result of the project is a guideline describ-

ing a systematic procedure for the introduction and implementation of the reference model in the enterprise. The results were evaluated through a pilot application at a special-purpose machinery manufacturer. For this purpose, the drafted tools were implemented by a software company.

7. ACKNOWLEDGEMENT

The authors are grateful for the financial support to this project.

This project is funded by the European Regional Development Fund (ERDF) and the Free State of Saxony.



8. REFERENCES

1. Müller, E.; Riedel, R.; Gansauge, L.: Prozessmanagement im Werkzeug- und Formenbau. VDI-Z integrierte Produktion, 2006, **III** (Special Werkzeug-/ Formenbau), 20-23.
2. Gizanis, D.: Kooperative Auftragsabwicklung – Architektur, Praxisbeispiele und Nutzenpotenziale. Universität St. Gallen, St. Gallen, 2006.
3. Schuh, G.; Schweicher, B.: SCM mit Kosten- und Nutzensparenz. Werkstatt-technik online, 2008, **4**, 297-304.
4. Kuttkat, B.: Standardisierung und Automation machen Werkzeugbauer fit. <http://www.maschinenmarkt.vogel.de/themenkan-aele/produktion/umformtechnik/werkzeuge/articles/107572/>, 26.08.2009.
5. Hünemann, C.: Brockhaus Enzyklopädie online. <http://www.brockhaus-enzyklopaedie.de/>, 14.08.2007.
6. Schilling, W.; Windmüller, B.; Meißner, E.: Technische Normung – Technischer Fortschritt. Verlag Tribüne, Berlin, 1961.
7. Schäfer, C.: Großwörterbuch – Neue deutsche Rechtschreibung. Buch und Zeit Verlagsgesellschaft, Köln, 1999.
8. Brandner, A.: Assess - Wissensbilanzen für KMUs.

<http://assess.daa.at/default.asp?id=22>, 09.08.2007.

9. Voigt, K.-I.: Industrielles Management – Industriebetriebslehre aus prozessorientierter Sicht. Springer Verlag, Berlin/ Heidelberg, 2008.
10. Granig, P.: Innovationsbewertung. Deutscher Universitäts-Verlag, Klagenfurt, 2007.
11. Hauschildt, J.: Innovationsmanagement. Verlag Franz Vahlen München, München, 1993.
12. Böttcher, C.; Dähnhardt, J. W.: Werkzeugmaschinen II - Gebaute Maschinen. <http://cgi.tu-harburg.de>, 14.10.2007.
13. Deutsches Institut für Normung (DIN) (Hrsg.): DIN EN 14070 - Sicherheit von Werkzeugmaschinen: Transfer- und Einzweck- oder Sondermaschinen. Beuth Verlag, Berlin, 2003.
14. Verein Deutscher Ingenieure (VDI) (Hrsg.): VDI 2221 – Methodik zum Entwickeln und Konstruieren technischer Systeme und Produkte. VDI Verlag, Düsseldorf, 1993.
15. Verein Deutscher Ingenieure (VDI) (Hrsg.): VDI 4505 – Auftragsabwicklung – Methodische Abwicklung von Aufträgen im Investitionsgütergeschäft. VDI Verlag, Düsseldorf, 1997.
16. Helmus, F. P.: Anlagenplanung – Von der Anfrage bis zur Abnahme. Wiley-VCH Verlag, Weinheim, 2003.
17. Bullinger, H. J.; Scheer A. W.: Service Engineering – Entwicklung und Gestaltung innovativer Dienstleistungen. Springer Verlag, Berlin/ Heidelberg/ New York, 2006.

9. CORRESPONDING ADDRESS

Ulf Wagner
Chemnitz University of Technology, Department of Factory Planning and Factory Management
Erfenschlager Straße 73
09107 Chemnitz, Germany
Phone: +49 371 531 36 021
Fax: +49 371 531 836 021
E-mail: ulf.wagner@mb.tu-chemnitz.de