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IMPROVING PROJECT MANUFACTURING COORDINATION

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Abstract
The objective of this research is to develop firms' project manufacturing coordination. The development will be made by centralizing the manufacturing information flows in one system. To be able to centralize information, a deep user need assessment is required. After user needs have been identified, the existing system will be developed to match these needs. The theoretical background is achieved through exploring the literature of project manufacturing, development project success factors and different frameworks and tools for development project execution. The focus of this research is rather in customer need assessment than in system's technical expertise. To ensure the deep understanding of customer needs this study is executed by action research method. As a result of this research the information system for project manufacturing coordination was developed to respond revealed needs of the stakeholders. The new system improves the quality of the manufacturing information, eliminates waste in manufacturing coordination processes and offers a better visibility to the project manufacturing. Hence it provides a solid base for the further development of project manufacturing.

Keywords
manufacturing coordination, production management, customer need assessment.

Introduction

This paper describes the execution of a development project for the improvement of a firm's project manufacturing coordination. The target firm's offering consists of single instruments as well as wider combinations of these instruments, projects. The different nature of project execution and instrument manufacturing sets challenges for the internal manufacturing coordination system.

The challenge in the firm's project manufacturing is that the Enterprise Resource Planning (ERP) system does not offer visibility on project manufacturing as a whole. ERP does not contain all the information needed for project manufacturing, either. For example, information about the stakeholders involved in manufacturing is inadequate. These challenges induce extra work to project coordination and require the use of a parallel system. Also the possibility to follow up project manufacturing is discontinuous. This causes both poor visibility and poor predictability in the process.

The objective of the study is to increase the performance and visibility of project manufacturing by centralizing the manufacturing information in one system. A centralized system would decrease non-value added coordination work and raise awareness about the performance level of project manufacturing. Better performance in the manufacturing phase would also decrease lead times, which would have a positive effect on the inventory level. To achieve these goals, the three objectives of the study are to:

1. find out the stakeholders' and the organization's needs for the system,
2. centralize project manufacturing information flows in the common system,
3. create visibility in the project manufacturing process.

This research is based on applying appropriate theory and collaboration of the researcher and users to solve the firm's practical problem. The development project is supported by applying the literature of project manufacturing as a way of doing business and the literature of single development project execution. The purpose of the project manufacturing theory is to offer understanding of the operational environment of the research, and the theory of project execution guides and supports the realization of the development project. The literature review comprises two parts. The first part contains a summary of project manufacturing and its special characteristics. The second part of the review explores development project execution and its key success factors. The second part also shortly reviews the frameworks and tools used in development projects.

The empirical study was carried out by the qualitative action research method. Action research is broadly defined as an approach in which the researcher and a client collaborate in the diagnosis of a problem and in the development of a solution based on the diagnosis. Action research applies and contributes to both academic theory and practical action [1]. Action research was considered an appropriate method because the objective was to solve a real-life problem by combining theoretical knowledge and empirical observations. The method was also supported by the fact that the researcher co-operated closely with the stakeholders of the portfolio company. The empirical knowledge was gained through interviewing 28 different employees in 52 interviews.

The empirical study focuses on providing understanding of how the development project has been executed in practise. Section 3 describing the empirical study is divided to a three parts, where the first part deepens the understanding of the operational environment, the second part focuses on the real development process, and the third part sums up the advantages gained through the developed system.

Literature review

Project manufacturing

In project manufacturing a company operates on the basis of the make-to-order or build-to-order principle and produces projects instead of products [2]. The operations of a firm need to be strategically aligned to the market requirements. An important input for a firm's strategic design is a customer order decoupling point (CODP), which means the point in the material flow where the product is tied to a specific customer order [3].

Different manufacturing situations, such as make-to-stock, assemble-to-order, make-to-order and engineer-to-order are all outcomes of different positions of the CODP. The different situations of the CODP are related to a firm's ability to customize or stock its products. The CODP divides the material flow from forecast-driven to customer order-driven flow [3].

Project manufacturing is unpredictable due to the uniqueness of projects. This gives the authority of project design and manufacturing to an individual customer. Changing customer needs bring about changes in production schedules and design. The company has to deal with multiple projects which share a constrained pool of resources [4]. Altogether, complicated, unpredictable and changing activities are the reason why the project manufacturing business is characterized by dynamic complexity [5].

Project manufacturing is usually done in several departments of a firm. Without good integration of information in the whole project manufacturing funnel there is a risk for "islands of information". This means that information does not flow from one department to another [6]. The firm's flexibility is a key to success in project manufacturing. Flexibility is the organization's ability to meet an increasing variety of customer's expectations without excessive costs, time, or performance losses [7]. In addition, it is recommended that to improve effectiveness of construction supply chains, organisations should focus on product customisation, waste reduction and IT applications to reduce time lag in various processes [8].

For empirical research, it is important to identify the special characteristics of project manufacturing. The most important characteristics are:

- The customer has strong authority over the manufacturing [2];
- Control of the schedule and resources is challenging [4];
- Integration of manufacturing phases is important [6];
- Project manufacturing requires flexibility from the manufacturing firm [7].

Information system development project

In the big picture, development projects are carried out to execute strategically important improvements which are too demanding or inappropriate for the line organization to accomplish [9].

Understanding the critical success factors of a development project has evolved a lot from the 1970s. The focus has changed from tight internal cost control to a more customer-centric view [10]. An information system project aims to deliver a satisfactory system for users [11].

An information system development (ISD) project can be seen as a problem solving process in which developers apply their knowledge to solve problems raised by a customer. Mutual understanding is a key to accomplishing the task [12]. If the ISD project is co-produced by the developer and the customer, it has a much better chance of not falling short of the actual need and also stay in the planned budged and schedule [13].

Unlike engineering projects, the ISD project can meet the technical requirements but still be rejected by the users [14]. The usability and the acceptance of users may go beyond technical quality in ISD projects [15]. Andersen and Jansen [16] state the following: "Our analysis shows that by thinking of simple and small-scale solutions, including taking the user's needs and premises as a point of departure rather than focusing on advanced technology, the implementation process was made possible".

For the execution of an empirical development project it is important to identify the key success factors in development projects presented in the literature. The most important findings are listed below:

- Deep understanding of customer needs [15];
- Users' acceptance for the project is acquired [16];
- User and developer success to integrate knowledge [12].

There are numerous public project frameworks for ISD-project execution. Some of the models concentrate on ISD-projects and some are just general project models [17]. The purpose of these frameworks is to divide the project into smaller pieces, which makes decision making and follow-up easier [9].

Well-known project framework providers are for example IPMA (International Project Management Association), PRINCE2 (Projects IN Controlled Environment) and PMI (Project Management Institute). Although there are a great variety of different project models, the problem can be combining these models in one specific project. Traditional models focus on overall resource management, whereas ISD-models concentrate on technical execution [18].

A common structure was identified in almost every project model, although it was divided in several ways. In every model there were phases for project planning and specification, design and execution, testing and implementation. A short description of the identified project phases and some tools for their execution is given below.

In the specification phase the main objective is to identify the customer needs and the operating environment [17]. Before the project execution can be started, the customer needs have to be surveyed and analyzed deeply [19]. A common knowledge base between the customer and developer increases the chances of the development project to meet its goals [13].

The purpose of the design and programming phases is to bridge the gap between the system requirements and the available technology. An important method for completing this challenge is an architectural design where the system and its requirements are divided to smaller components. This makes it possible to design a solution for one component at a time instead of the whole system. The system can then be constructed by completing the coding of the components [17].

In information system implementation, the main focus is on informing the users about the change. Through this the stakeholders are kept satisfied, and also their needs and thoughts will be heard during the implementation [20]. Understanding the overall situation and progress of the project increases the stakeholders' commitment to the project and its goals. The given information has to be clear and accurate, and the right channels have to be used [9].

Different tools were used in the present study to support the execution of the project phases. The tools were selected with two criteria: they had to be easy to apply and they had to form a whole together. The tools are listed in Table 1.

Table 1
Tools supporting the development project.

Phase	Tool	Purpose	Ref.
Specification	Value stream mapping	Overall process understanding	[21–23]
	Trace matrix for business chains	Detailed process information	[19]
	Benchmarking	Existing solutions	[24, 25]
Design and programming	Architecture design	Dividing the system into components	[17]
	QFD	Dependencies between needs and features	[26, 27]
Implementation	Evolution prototype	Testing the technical solution	[17]

Project manufacturing coordination and its development

Overall situation

To be able to understand project manufacturing coordination and its development, one has to be aware of overall project delivery process. The project manufacturing process takes place between project sales and project installation. Project manufacturing begins when sales has closed the deal with a customer and hands the project over to manufacturing.

Project manufacturing includes three main phases. The first phase is the final technical design and planning of the manufacturing. The actual manufacturing starts in the second phase. Project-related components are manufactured or purchased according to the production plan. In the third phase the whole system is assembled, configured and tested. The third phase ends after the project has been disassembled, packed and is ready for shipping.

The installation phase includes shipping to the customer site, site acceptance and hand-over to the customer. After installation start life-cycle services. The whole delivery process and the scope of the development project in the study are presented in Fig. 1.

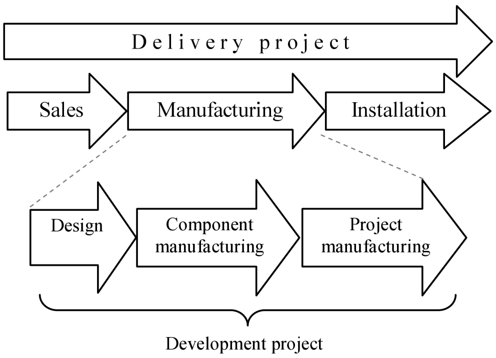


Fig. 1. Development project as a part of the whole delivery project.

Development process

The development project started by mapping the information flows in the project manufacturing process by using the Value Stream Mapping (VSM) technique. The mapping was made in co-operation with the stakeholders by presenting the current state map in the interviews and correcting the map according to stakeholders' instructions.

When the current state map was finished, the design of the next steps began. The basic idea was that there would be two steps and therefore two different versions of the system. The first version would include the basic features and test the functionality and logic behind the system. The second version would include more advanced features like production phase follow-up and a project performance dashboard. The second version would be developed based on the design of the first version as an evolutionary prototype. Figure 2 shows the simplified current state map.

The idea is to see the change and development in value stream map information flows, not to perceive a full process-level picture. Going to the process level would be too detailed and it would not serve the purpose of this paper, which is to offer understanding of the overall development project.

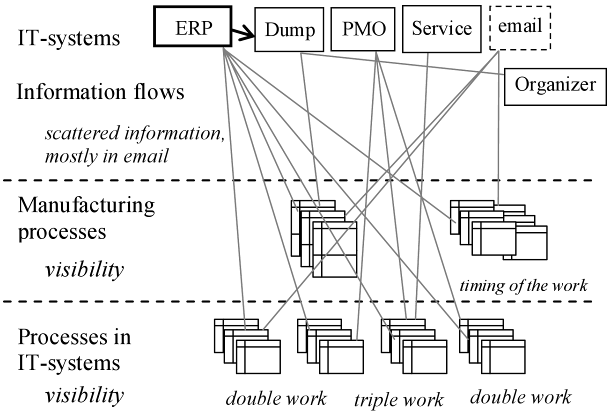


Fig. 2. Current state map.

Benchmarking was considered to be useful for the development project to avoid consuming time in solving problems which were already solved. Seeking for a company having the same kind of project manufacturing was started in the early state of the project, and an appropriate benchmarking partner was found soon. Through the benchmarking visit, valuable information about the principle of project manufacturing coordination and performance measurement was achieved.

The base for the project manufacturing coordination system development was the user needs found in 52 interviews. To get a full and complete picture about the process, the interviewees were selected from different levels of the organization. The interviewees included employees from production to middle management and function managers. Because several stakeholders were involved in the project manufacturing, some of the needs caused conflicts of interest. After the interviews, a list of found needs was constructed. The user needs were divided by the stakeholder groups. The discovered needs are presented in Table 2.

After the needs were found and listed, a Quality Function Deployment matrix (QFD) was constructed to avoid missing the relations between user needs and product features. One challenge was getting the real needs discovered in the interviews. In many cases the interviewee proposed a new feature which would solve his problem but did not indicate clearly what the original need was. This placed challenges for finding the optimal solution. Through the QFD method it was ensured that the needs and system features were optimal combinations for the whole. The system features weighted by the QFD method are presented in Table 3.

Table 2
Discovered user needs divided by the stakeholder groups.

Source	Requirement
Common	– The system has to include both ERP and user-feed information – It has to be synchronized with ERP – It has to include a project manufacturing schedule – The human resources of the project have to be included in the system – All possible data updates are added only to the ERP system
Project manager	– The system has to include a view about the overall manufacturing situation – It should include as little information as possible – Highlighting the change is important – The project has to be in the system long enough
Project coordinator	– There should be more time in shipping the projects – The production phase of the project should be seen in the system – The system should include a clear and detailed manufacturing schedule – It should show the amount of lines in a project
System expert	– The system should show whether a system expert is needed or not – It should warn about unusual components – It should offer achieved information about delivered projects
Service	– No more parallel Excel systems
Packing	– The system should prevent rushes by giving a schedule – It should include shipping term information
Factory	– Projects should be scheduled to decrease the lead times – The system should tell if the manufacturing is delayed – Information about delivered projects should be achieved for later analysis

Table 3
System features weighted by the QFD.

System features	Weight (%)
Human resources	8
Project information	11.5
The automation	17
Color codes	9
Scheduling	10
Manual information	13
Production follow-up	11
Project design phase	6.5
Stakeholder specific information	7
Information groupping	7

Scheduling

One of the biggest single needs was an improved project manufacturing schedule. Before the development project, the only dates defined for project manufacturing were the date when to begin the integration and the date when the system should leave the factory. However, between these two dates existed several different production phases, and in the need assessment it was found that a manufacturing schedule should be made for each phase separately.

For many projects, the restrictions of the firm's ERP system caused stretching of the manufacturing lead time. If a project was delayed for an external reason (e.g. customer), the firm's ERP system allowed changing the date when the project manufacturing should be ready but not the date when it should be started. This prolonged the project manufacturing because the manufacturing was started unnecessarily early. It was the factory's biggest interest that the new project manufacturing coordination system would tackle this problem.

To solve the challenges, a new way of project manufacturing scheduling was designed. The principle of the new scheduling is presented in Fig. 3. The new schedule bases itself on the date when the shipment should leave the factory. From that date it counts all the other dates backwards based on the information given by the project manager. This ensures that in case the project is delayed, the project manufacturing start date is still in the right place.

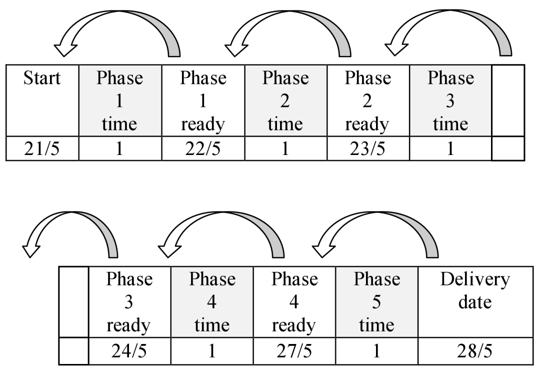


Fig. 3. The principle of manufacturing scheduling.

Measurement

To be able to monitor the development of the project manufacturing process, the performance measurement system was integrated in the manufacturing coordination tool. The principle behind the measurement was that it should offer rough lead time averages from all the three phases of project manufacturing so that the overall trend of lead times could be seen.

Because the focus of the research was the project manufacturing phase, it was measured more accurately than the two other phases. When the project manufacturing phase was divided into smaller phases for better scheduling, it became possible to follow also the progress of single project manufacturing in a more detailed manner. The number of projects and their stock values in different project manufacturing phases were added to the measurement system. This information will help to identify the bottlenecks in the process.

Because the manufacturing coordination tool was only partly automated, the third issue to follow up was user activity. User activity was measured by comparing the number of manual cells with and without information. User activity is a key parameter because it indicates the reliability of all other data in the system. The project manufacturing process measurement idea is presented in Fig. 4.

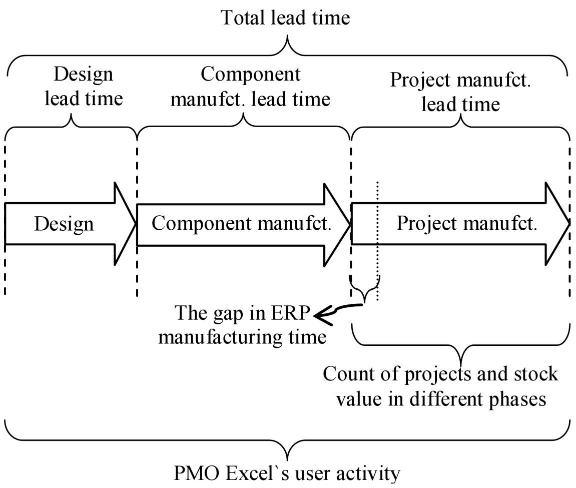


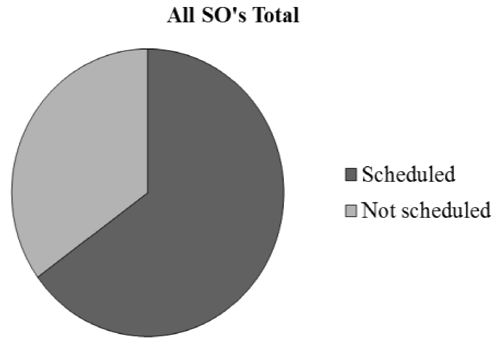
Fig. 4. The principle of project manufacturing performance measurement.

One week cycle time was considered to be reasonable in saving the measurement system result. Because the measurement system offered also real time data about the stock values and number of projects in different phases of project manufacturing, also the instant refresh option was integrated in the system. The draft of the developed performance measurement dashboard is presented in Appendix 1.

Implementation

The literature highlighted the importance of decent implementation in order to succeed in an information system project. During the empirical work it was also revealed that the implementation and informing of the stakeholders would be a challenging but a vital task.

To succeed in informing the stakeholders, several meetings were organized before the launching of the new coordination tool. Every stakeholder group was first informed separately, and a common introduction session was organized before the actual launch. After the new tool had been taken in use, the stakeholders were informed weekly about the activity of using the tool. The weekly information about user activity is presented in Fig. 5. The abbreviation SO refers to Sales Order, which is the same as a project from the internal point of view.



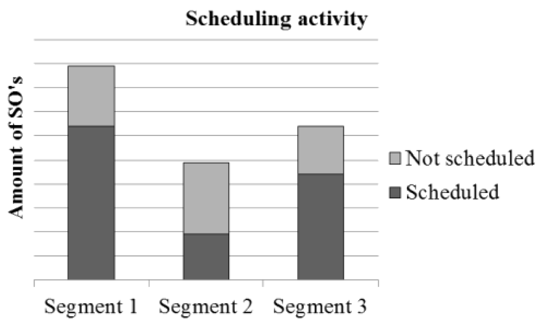


Fig. 5. Weekly information about user activity after tool implementation.

Results

The development project in the study managed to achieve its objectives, and the advantages gained from the new project manufacturing coordination system can be divided into short-term operational improvements and longer-term possibilities. The most important issues achieved through the new system are:

- Stakeholders' needs are identified accurately, made possible by the development of a common system;
- The new system integrates ERP and user information;
- The new system offers both schedule and production phase follow-up for the project;
- Through the performance measurement system and the history data archiving, a solid base for further development of project manufacturing was achieved.

The new system offers several improvements to the operational functions of project manufacturing coordination. The most important improvement is that with the new system, all the stakeholders use a common system for coordinating the project. This saves a lot of time and effort because the stakeholders know where to find the most recent information about the project instead of sending several emails or searching through several different systems.

Another big change is project manufacturing scheduling and follow-up. These features increase the awareness of the overall manufacturing situation which helps the team leaders to allocate the resources for future workload better, and also helps the project managers working abroad to get a picture about the progress of their project manufacturing.

The biggest strategic advantage provided by the new system is the ability to measure the operational performance level and to see the development. This makes it possible to judge whether the further development activities have reached their targets or not. Before the system was implemented, a barrier for project manufacturing development was the lack of manufacturing information. This caused the situation where it was very hard or even impossible to verify the impact of different development activities.

Conclusions

The first challenge after the study had been started was the term project. There is a very wide range of theory and articles written about project-related issues, but projects can be very different, and finding the valid literature for the research was not a simple task. The type of project manufacturing in the current research is quite different from for example the construction of a power plant. However, when searching for the term project manufacturing information which is a mix of both will be found.

An interesting finding when searching for information about ISD project execution was that the current understanding about the focus in ISD project execution is very customer-centric, whereas a couple of decades ago the focus was strongly in internal cost, time and quality control. The critical success factors are very close to the success factors identified in new product development.

The empirical project revealed that the issues highlighted in the theory were really essential. One very important issue stressed by both the theory and the project in the study was informing the stakeholders. This is an issue that should be taken very seriously, especially in big organizations which are continually under some changes. Without well-planned and executed informing about actions it is almost impossible to commit the stakeholders to the project.

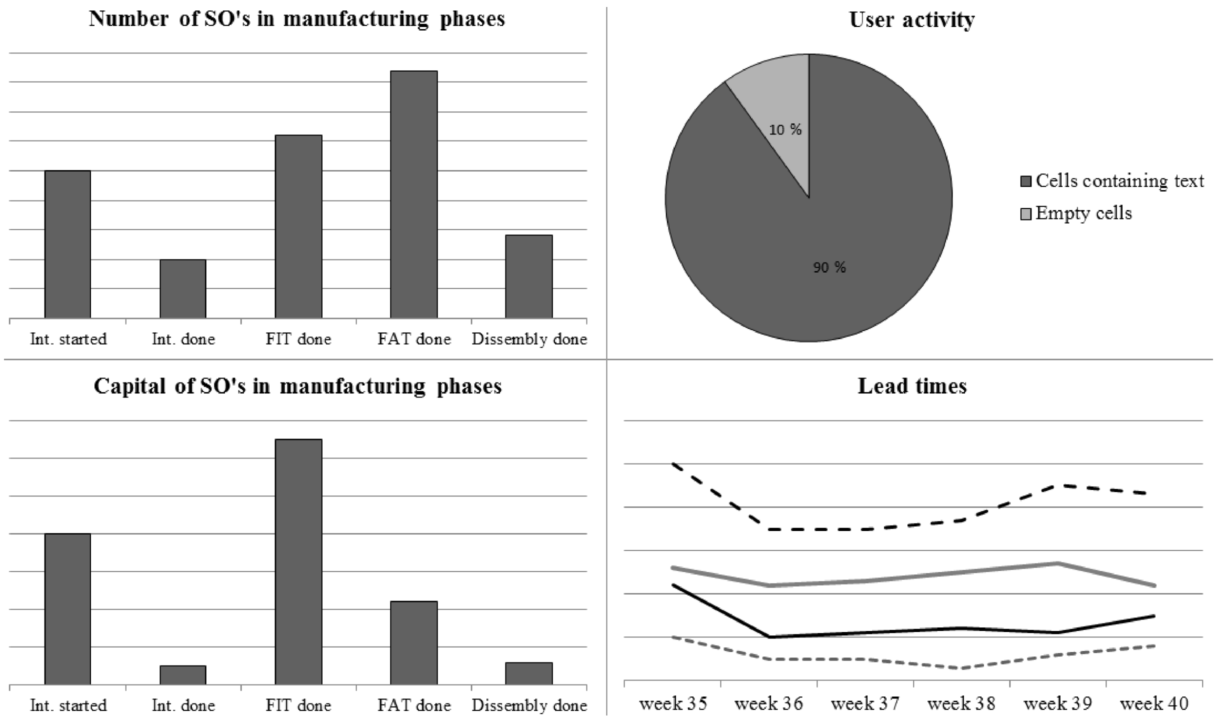
Another interesting issue raised by the literature and proved by the development project was organizational barriers and their integration in project manufacturing. Different parts of the company's organization have different internally placed targets. Although the targets should aim at common good, they easily cause some conflict of interests. An example of this could be that a part of the organization wants to optimize the production and minimize the stock value when another part rather allows some stock if it helps to deliver the goods on time. Organizational interfaces should be identified and considered carefully.

To see the impact of the new project manufacturing coordination system it would be interesting to have performance measurement data gathered from the time period of one year from the implementation. One challenge in verifying the results of the development project was that the time for monitoring the data after implementation was only a couple of months. The needed time would be the minimum of one year because the target company's offering varies depending on the time of the year, and therefore the closest time to get comparable data is one year.

Several articles concerning project manufacturing suggested different kinds of simulation tools for identifying problems in the project manufacturing process. Also the number of articles dealing with manufacturing simulation is increasing. The simulation model cannot replace the coordination system, but when the coordination system is more for everyday operational management, the simulation model could be very useful in finding the current state problems and planning further development activities. For this reason, the modelling of project manufacturing could be a reasonable topic for further research.

Appendix 1

Project manufacturing performance dashboard.



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