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Success Factors of Plant Engineering Projects

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Abstract

Projects in plant manufacturing business are characterized by low margins and high risks. The knowledge and support of success factors, i.e. influencing factors that explain the success of a project, provide a suitable lever for plant manufacturing companies to improve their competitiveness. However, plant manufacturing business has not been a major field of success factor research yet. This contribution aims to close this research gap. In an extensive literature review existing success factors of other research fields are collected. 490 factors were examined on their applicability for engineering projects in expert interviews and an online survey. After consolidation, 41 success factors could be identified. If plant manufacturers consider these factors in project design and planning, project and business success can be influenced in a positive way. Since success factor research has been subject of criticism recently, this contribution includes a critical discussion of success factor research, too.

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Keywords: Critical success factors; CSF; plant manufacturing; plant engineering; project business

1. Introduction

1.1. Project failure

In the last years several failed and troubled projects made front page headlines: The new airport of Berlin, Boeing´s 787 dreamliner or the British Airways Terminal 5 transition are just some examples in the press [1,2,3].

The volatility of the market environment, the complexity of organization and solution, complex controlling and management tasks and many other factors are reasons that lead to failures in planning, engineering and

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implementation and thus endanger the complete project [4]. The described challenges also apply for projects in the plant manufacturing industry

1.2. Plant manufacturing business

In this business companies provide engineering, construction and service of industrial - especially large-scaled - plants for e.g. petroleum refining, chemical processing, iron and steel processing or power generation [4,5]. Engineering is a key discipline in this business - defined as all technical-oriented services, processes, and working appliances to realize a customer specific solution from definition, concept, implementation to commissioning of an industrial plant [5].

Orders in this business are processed by means of projects and contract volumes range up to several hundreds of millions of Dollars [5]. A key characteristic of industrial plants is the integration of components and systems delivered by suppliers and contractors. The solution is developed specific to the customer´s requirements in a customer project. However, the system is technically understood in principle and is not "first-of-its-kind". Finally, the engineering of a system requires integration of different disciplines like civil, mechanical or electrical engineering [5].

Beside the complexity of the solution development process, plant manufacturers compete in a dynamic environment. They are challenged by competition and customers to reduce costs and development time while meeting increasing expectations on innovation and quality [4].

2. Motivation

The completion of engineering projects within the budget, schedule and quality restrictions is essential for sustainable business success. This is even more important for plant manufacturers since project business is characterized by a small profit margins and high risks compared to product business (Fig. 1) [5,6].

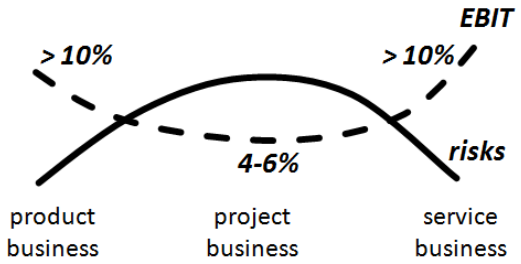

Fig. 1. Profit margins in different types of businesses [5].

Project business makes it difficult to generate more profit than expected. However it is easy to produce a crisis. And a single crisis project may eliminate the profit of several projects due to high penalties fees (Fig. 2).

For projects with high capital investments, e.g. power plants several hundred-thousands of Dollars of penalty costs per day are not unusual [7]. At the new airport of Berlin for example, problems with fire protection prevented the start of operation in June 2012. The exact operation date is still unclear, it is only clear that these problems cost 20 million of Euros every month [8]. Especially medium-sized firms soon could reach their financial limit in such cases.

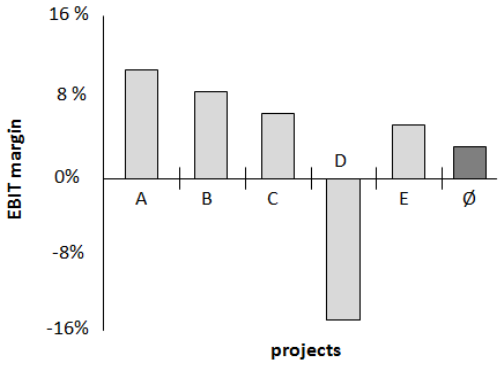

Fig. 2. Influence of failed projects on EBIT margins [5].

In order to avoid such risks, research identified a number of influencing factors that can explain the success of a company or a project [9]. Despite the multi-dimensionality and multi-causality of these factors, it is possible to break them down to a manageable number of so called critical success factors (CSF). If these factors are considered and adequately supported in project design and planning, project success can be influenced in a positive way [9,10]. In differentiation to success criteria, success factors contribute to the success of a project, while success criteria define how success is judged [11].

3. Research methodology

The research approach for this contribution consisted of three major steps. First, an extensive literature review was conducted to collect existing success factors. Since only few publications on success factors for the plant manufacturing domain were available, success factors of other related research fields were considered, too. At the end of this step, totally 490 success factors were identified (Table 1).

In a second step a consolidation of the collected success factors was conducted. Missing factors were added, duplicates were merged and factors with no reference to plant manufacturing were omitted in consultation with three experts who had several years of experience in project management in the plant manufacturing business. After this consolidation process, a manageable number of 41 success factors remained.

The third step aimed for the evaluation of the remaining factors in an online survey to back up the results of the expert interviews. For this survey 19 persons in the field of plant manufacturing business were asked to answer a web-based questionnaire. Suitable interview partners were manually selected by their profiles on the platform XING (http://www.xing.com), a global social network of business contacts. Totally, 114 potential interview partners were approached via electronic mail. 19 experts completed the questionnaire, which is a response rate of 17 %.

The survey aims to confirm the relevance of the CSFs identified in step 1 and 2. A prioritization of the CSFs was not our goal for two reasons:

First, in order to achieve a representative survey, a larger number of participants would have been necessary. Second, the importance of CSF is highly dependent on the respective business, company, environment and other factors. In this contribution, we want to give an overview of CSFs which are relevant in general for plant manufacturing projects. It is the individual decision of the respective plant manufacturer on which factors emphasis should be laid on.

4. Definitions

4.1. Engineering project

A project is defined as „*any task which has a definable beginning and a definable end and requires the expenditure of one or more resources in each of the separate but interrelated and interdependent activities which must be completed to achieve the objectives for which the task was instituted*" [12]. In the context of plant manufacturing business we understand a project as the task to develop a complex technical solution – the industrial plant. Such projects typically require a significant share of engineering activities, i.e. the solution is developed specific to the customer´s requirements in a customer project, and are therefore called engineering projects.

4.2. Project success

In this contribution success is defined as the achievement of the determined success criteria. Besides the 'official' criteria (budget, schedule, quality), which are determined by the management and owners of a project, every stakeholder of a project can have his own 'hidden' objectives, which are usually not explicitly defined [13,14].

Success criteria are specific for each project and company. However, they usually include aspects of cost, schedule and quality in varying weighting.

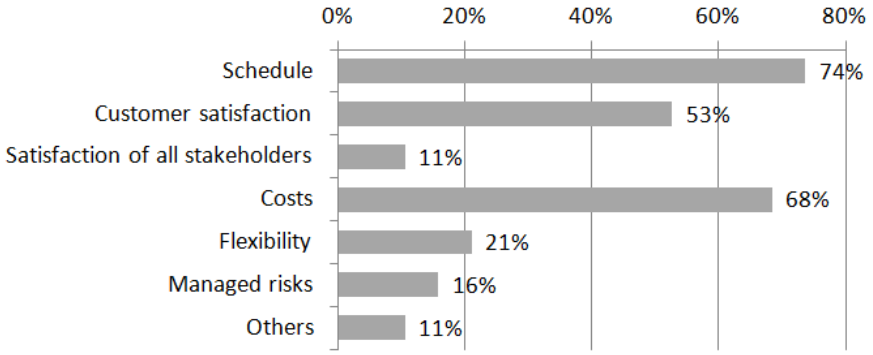

Fig. 3. Applied project success criteria [survey data].

In the conducted survey, costs and schedule were the driving success criteria for projects. Quality was regarded in terms of customer and stakeholder satisfaction or risks (Fig. 3).

5. Literature review

The literature search was carried out in three databases for academic publications GoogleScholar, Ebscohost and Proquest (search term: 'success factor' OR CSF AND 'plant manufacturing' OR 'plant engineering' OR 'plant business'; search period: 1980 – 2013; all fields and subjects). I turned out that there is not much research in the field of success factors of engineering projects. Only few publications were dedicated to success factors in plant manufacturing business and engineering. Therefore, we had to extend our search. First, publications in the field of plant manufacturing and engineering projects, which had no explicit reference to CSF research, were examined for implicitly mentioned success factors. Second, success factors of other domains (but with a certain reference to the manufacturing business) were considered too [14,15]. After the literature research, 490 success factors could be identified (Table 1).

Table 1. Identified success factors in literature.

Topic / field	Identified success factors
Plant manufacturing	3
Engineering	31
Engineering Projects	14
Engineering, Procurement and Construction Projects	4
Success factors of product development	32
Success factors of IT projects	38
Success factors of technical services	45
Project business	82
Innovative industrial services	30
Construction	134
Project management	35
Process automization	29
Reengineering	8
Strategic technology management	5
Σ	490

The majority of the topics referred to business management topics such as project management, service business or innovation research. These fields of research have a long history in success factor research. In addition, a large number of success factors are related to construction.

6. Consolidation

For practical use, the large number of 490 CSFs had to be reduced. Duplicates i.e. similar or identical factors in different categories were eliminated or merged and renamed respectively. Many factors (especially in the field of 'construction') also had a rather specific technical context and were not suitable for engineering projects. After this step the number of potential success factors could be reduced from 490 to 57. The fact that the factors could be summarized in such a drastic way indicates that there seems to be a common base of CSFs over different domains.

In a second step of the consolidation process these 57 potential success factors were evaluated by experts if they are applicable for plant engineering projects. Three experts, who had at least 10 years professional experience, were asked in semi-structured interviews, if – in their opinion - factors are applicable for plant manufacturing or if any factors need to be added. At the end of the qualitative data collection and consolidation process, 41 potential success factors were left for the web-based evaluation.

7. Data sample structure

To confirm the selection of success factors, we choose to conduct standardized online survey according to the OECD guideline for collecting and interpreting technological innovation data [16]. The interviewees could choose their level of acceptance for each success factor using a five-digit Likert scale according to Bortz und Döring [17] (5- strongly agree, 4 – agree, 3 – neither agree nor disagree, 2 – disagree, 1 – strongly disagree). Besides the assessment of potential success factors, the survey included other questions, so that the survey can be divided in five sections:

1. personal data
2. evaluation of success factors for engineering projects
3. question regarding the role of engineering
4. general questions for projects
5. success factor research.

Most domains of plant engineering were represented by the interviewees. The majority of the participants were working on manufacturing plants or plants for chemical processing (Fig. 4).

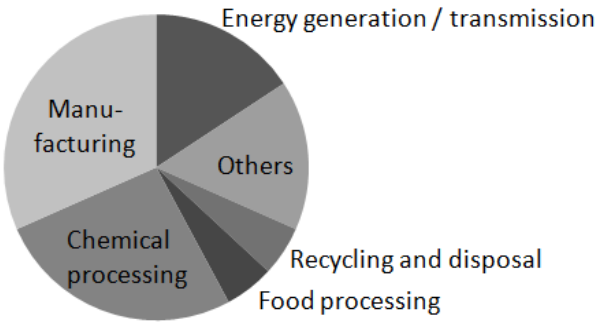

Fig. 4. Plant engineering domains of participants [survey data].

The majority of the experts (79 %) hold a management position. 21 % had an executing function. The experts further had long-year experience in the project business (68 % had more than 5 years experience, 35 % more than 10 years).

8. Evaluation results

In order to get a structured overview of the various success factors, we choose the balanced scorecard as a framework for several reasons: Balanced scorecard (BSC) is an established model for classification and is suitable for the use in various domains [18,19]. BSC is defined as "*a performance measurement and management approach that recognizes that financial measures by themselves are not sufficient and that an enterprise needs a more holistic, balanced set of measures which reflects the different drivers that contribute to superior performance and the achievement of the enterprise's strategic goals*" [18].

The four dimensions of BSC help to classify the success factors into different categories. The following tables show the consolidated factors, their average rating (avg.) and standard deviation (dev.).

Table 2. Financial perspective.

No.	Financial perspective	Avg.	Dev.
1	Holistic cost calculations	4,11	0,66

From a financial perspective there is only one success factor. Since costs are a controlling tool, their role as a success factor is small. Nevertheless, a holistic assessment of costs seems to be important in general, but especially critical for plant manufacturing business to make sustainable decisions [13].

Table 3. Customer perspective.

No	Customer perspective	Avg.	Dev.
2	Continuous improvement process for products	4,47	0,61
3	Consequent claim- and contract management	4,05	0,62
4	Active management of customer integration	4,05	0,52

Customer focused success factors are perceived as important as expected, due to role of the customer in a made-to-order project business.

Table 4. Process perspective.

No	(Internal) business processes	Avg.	Dev
5	Identification and integration of project stakeholders	4,63	0,50
6	Ensure motivation of project employees	4,58	0,51
7	Senior-management support	4,47	0,70
8	Proactive risk management	4,42	0,69
9	Determine realistic project goals	4,42	0,51
10	Precise definition of tasks, competences and responsibilities	4,26	0,65
11	Optimization of business processes	4,21	0,42
12	Early identification and management of conflicting interests	4,21	0,63
13	Stakeholder-specific information and communication policy	4,05	0,62
14	Continuity of processes in the value chain	4,00	0,75
15	Compliance with business processes	3,95	0,62
16	Consolidated IT landscape	3,89	0,57
17	Definition of reference processes	3,79	0,85
18	Integration of trades in the value-add process	3,79	0,79
19	Project breakdown into manageable activities (‘chunk size bites’)	3,79	0,85
20	Global engineering networks/activities	3,16	0,76
21	Outsourcing of activities and processes	2,89	0,74
22	Definition of a corporate governance	2,84	0,90

In the category referring to internal business processes only “definition of corporate governance” and “outsourcing of activities and processes” were not seen as success factors (avg < 3). Interdisciplinary topics like the identification and consideration of project stakeholders as well as a motivated project team were rated as important though.

Table 5. Learning and growth perspective.

No	Learning and growth	Avg.	Dev.
23	Re-use knowledge and experience from previous projects (lessons learned)	4,74	0,45
24	Qualified project manager	4,58	0,69
25	Composition of project team	4,47	0,61
26	Domain-specific know-how	4,42	0,77
27	Competence in technology and technology management	4,32	0,58
28	Qualification and training measures for employees	4,32	0,58
29	Standardization	4,21	0,63
30	Tool support of processes	4,16	0,69
31	Integrated quality management	4,16	0,69
32	Reliable cost assessment and resource allocation	4,16	0,83
33	Development of a project management culture	4,11	0,74
34	Modularization	3,89	0,57
35	Re-use of engineering activities	3,89	0,74
36	Consideration of project environment (technology, politics, society, economy, etc.)	3,89	0,66
37	Re-use of engineering activities	3,79	0,71
38	Specification of corporate and business strategy	3,79	0,63
39	Definition of a continuous improvement process	3,58	0,77
40	Profit sharing for employees	3,53	0,70
41	Hard-to-imitate products	3,42	0,90

In the last category the re-use of knowledge and an experienced project manager were seen as main success factors.

The participants were also encouraged to add further success factors to all categories. Of all free answers it turned out that only a small number of factors could not be assigned to already existing factors (see list below). This indicates that the evaluated 41 factors are a quite exhausting selection of success factors for engineering projects.

- Up-to-date project management tools and techniques (e.g. SCRUM)
- Defined validation and verification procedures
- Sufficient budget

- Clearly defined requirements and contracts
- Continuous controlling by stakeholder

9. Discussion

The results of the survey indicate that the majority of evaluated success factors are considered relevant by both the experts and the survey participants. Only two of 41 potential success factors were rejected (factor 21, 22). The results further show that holistic considerations are important for the success of engineering projects. Plant manufacturers should not limit themselves to certain stakeholders in their decisions but should take all opinions into account.

Most factors which are seen critical for projects in general do also apply for engineering projects. But there is a stronger technical focus in engineering projects. Especially re-use and knowledge related factors (factors 23, 24, 26 – 29) seem to play an important role.

10. Critical view on success factor research

Despite its popularity, success factor research is discussed controversially. Especially the low practical use of success factors is a central point of critics [20]. Our survey could confirm this statement: 69 % of the participants complain that there is too less practical relevance of CSF studies. However, the majority agrees that research on CSFs in general is reasonable (73 %), and further 58 % state that it is important for project success to know CSFs. Despite this acceptance, only 21 % have deliberately considered studies on success factors in project planning. However, the interviewees are aware that the knowledge of success factors does not automatically lead to project success (79 % agree).

11. Limitations

Geographically and language-wise the survey was limited to German speaking experts executing industrial services globally. Basic limitations of this quantitative research approach are the lack of control over the participants and whether they answer truthfully as well as the need for simple questions due to the lack of a common terminology [15].

This survey included only a small number of interviewees and experts. However, both could positively contribute to the quality of the results due to their high level of experience.

As mentioned, the practical relevance of CSFs is a common point of critics. In this survey we only focused on the relevance of success factors of other research fields for plant engineering projects. The practical implementation of these CSFs was deliberately excluded and will be subject of further research.

12. Conclusion

The completion of engineering projects within the budget, schedule and quality restrictions is essential for sustainable business success. This is even more important because project business is characterized by smaller profit margins and higher risks than product business. CSFs can provide a suitable lever for plant manufacturers to increase profitability in this environment.

This contribution collected success factors from literature and identified those which are of specific relevance for plant manufacturing business based on a survey. Most CSFs which apply for projects in general proved to be applicable for engineering projects. However, success in engineering projects requires more attention on technical expertise and re-use of knowledge and activities.

Further research may examine if firms which consider these success factors have a better performance and competitive advantage to those who do not. It is also recommended to develop measures, which promote the support of CSFs in a company.

References

[1] Financial Times (2013), 'More wrangling delays Berlin´s new airport, 16.08.2013, http://www.ft.com/intl/cms/s/0/c565071c-e7b9-11e1-95e1-00144feab49a.html#axzz2Jeym3mbW, retrieved on 01.02.2013.

[2] BBC (2010), 'Boeing Dreamliner 'a failure', says Qatar Airways Boss,' 25 November 2010, http://www.bbc.co.uk/news/business-11842597, retrieved on 01.02.2013.

[3] BBC (2008), 'What went wrong at Heathrow's T5?,' 31.05.2008, http://news.bbc.co.uk/2/hi/uk_news/7322453.stm, retrieved on 01.02.2013.

[4] Large Industrial Plant Manufacturer's Group VDMA (2010), 'Large industrial plant manufacturing – Industry concerned about the future,' Status Report 2009/2010, Frankfurt: VDMA.

[5] U. Löwen (2012), 'Engineering of industrial plants,' Lecture, Chair of Manufacturing Automation and Production Systems, University Erlangen-Nuremberg.

[6] Little, Arthur D. (2003), 'Ergebnissicherung im Anlagenbau. Zusammenfassung Studienergebnisse,'(Result in plant protection. Summary of study results), in: http://www.adlittle.de/studien.html?view=230, retrieved on 26.06.2013.

[7] Flauger, Juergen (2009), 'Bau von RWE-Kraftwerk verzögert sich wegen Alstom,' in Handelblatt 17.12.2009,(Construction of RWE power plant delayed by Alstom, 'in Handelsblatt 17.12.2009), http://www.handelsblatt.com/unternehmen/industrie/energieversorger-bau-von-rwe-kraftwerk-verzoegert-sich-wegen-alstom/3329170.html, retrieved on 01.02.2013.

[8] Funk, Petra (2013), 'Ruhender Flughafen Berlin kostet 20 Millionen Euro monatlich,'(Dormant Berlin airport costs 20 million euros a month) in http://www.ingenieur.de/Branchen/Verkehr-Logistik-Transport/Ruhender-Flughafen-Berlin-kostet-20-Millionen-Euro-monatlich, retrieved on 25.06.2013.

[9] Krcmar, H., Leimeister, J.M. & Sidiras, P. (2004), 'Success factors of virtual communities from the perspective of members and operators: an empirical study.' 37th Hawaii International Conference on System Sciences (HICSS), Hawaii, USA.

[10] Leidecker, J. K.; Bruno, A. V. (1984), 'Identifying and Using Critical Success Factors. In: Long Range Planning,' vol. 17, iss. 1, pp. 23-32.

[11] Crawford, L. (2000), 'Profiling the Competent Project Manager.' Project Management Research at the Turn of the Millenium, Paris, France, 21 - 24 June, Project Management Institute, Sylva, NC: 3-15.

[12] Martino, R.L. (1964), 'Project Management and Control,' vol 1, Finding the Critical Path, New York.

[13] Gepp, M. et al (2013), 'Assessment of engineering performance in industrial plant business,' Proceedings of IEEE International Symposium on Industrial Electronics, Taipei.

[14] Pinto, J.K., Covin, J.G. (1989), 'Critical factors in project implementation: a comparison of construction and R&D projects,' in : Technovation, vol.9, iss. 1, pp 49-62.

[15] Shenhar, a.J., Dvir, D. (1996), 'Toward a typological theory of project management, in: research policy,' vol. 25, iss. 4, pp 607-632.

[16] OECD/Eurosat (2005), 'The Oslo Manual – Guidelines for Collecting and Interpreting Innovation Data,' vol. 3, Paris.

[17] Bortz, J.; Döring, N. (2006), 'Forschungsmethoden und Evaluation: Für Human- und Sozialwissenschaftler.'(Research Methods and Evaluation: For human and social scientists), Springer Medizin Verlag, Berlin.

[18] Gartner Inc. IT glossary (2012), 'Balanced Scorecard,' http://www.gartner.com/it-glossary/balanced-scorecard/ retrieved on 01.02.2013.

[19] Siebert, D. (2011), 'Die Balanced Scorecard: Entwicklungstendenzen im deutschsprachigen Raum.' Diplomica Verlag (Development trends in German-speaking countries. 'Diplomica Publisher).

[20] Nicolai, Alexander; Kieser, Alfred (2002), 'Trotz eklatanter Erfolglosigkeit: Die Erfolgsfaktorenforschung weiter auf Erfolgskurs.' Die Betriebswirtschaft (DBW),(Despite blatant failure. Success factors research continues to be successful 'The Business (DBW), vol. 62, pp. 579–596.