INTERNATIONAL DESIGN CONFERENCE - DESIGN 2016
Dubrovnik - Croatia, May 16 - 19, 2016.

SUCCESS FACTORS FOR THE INDUSTRIALIZATION OF PRODUCTION TECHNOLOGIES IN THE PREDEVELOPMENT STAGE - AN ANALYSIS IN THE AUTOMOTIVE INDUSTRY

M. J. Hilt, D. Wagner, M. Ordung and A. Kampker

Keywords: success factors, predevelopment, production technology, e-mobility, agile

1. Introduction

A cost-efficient production of powertrain components for electric cars requires a significant reduction of both development costs and production costs in the future. With the new product design of electric cars (especially batteries and electric machine) the entire value-added chain is altered, making a mastering of new production technologies necessary. Whereas the production of combustion engines requires mainly casting and chipping technologies, the winding and impregnation for the production of electric machines constitute particular challenges [Kampker et al. 2013]. Technologies used in series production systems today cannot ensure cost-efficient manufacturing of electric cars in the future. Effective ways to make e-mobility competitive can mainly be found in an optimization of production technologies [Kampker et al. 2013].
Due to the wide range of new product technologies new process innovations occur constantly, thus new concepts concurrently become state of the art and outdated. As a result time to market is becoming more and more significant and product development periods are curtailing. A crucial factor to success for the electric car industry and other disruptive fields lies in a permanent generation of technology innovations and a rapid transfer to series production at low cost. Therefore automotive companies pay attention to an effective and efficient predevelopment of production technologies affecting both future product design and suitable manufacturing systems.

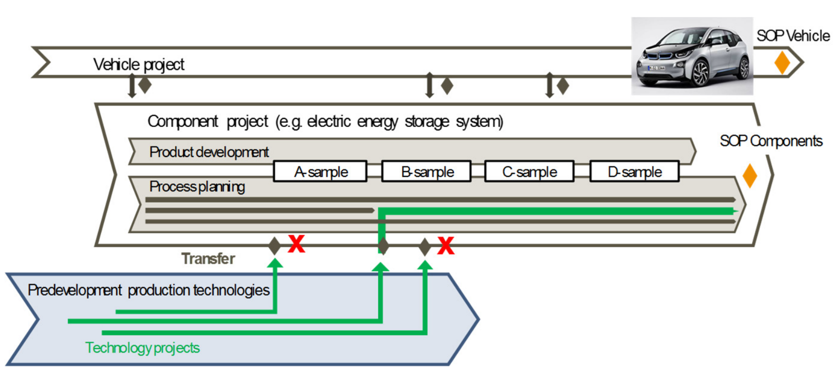

Figure 1. Project landscape for the implementation of production technologies

In the automotive industry organizations with separated pre- and series development departments are common. The separated pre- and series development is leading to higher transfer rates than the integrated predevelopment which is carried out by the same developers working in series development projects [Schröder 2012]. The main aim of the predevelopment department is the generation of new concepts including a proof of feasibility, meaning a risk reduction in series development projects. New technologies have to be taken into account by both product development and process planning in series development projects to be implemented in production systems. The responsibility for the innovations is handed over to the production planning department once the technology is incorporated ("transfer") by series development projects. This transfer is a requirement for new concepts to be tested in the official sample phases (called a-d samples) and to prove stability. Figure one shows the multi-project landscape between technology projects, powertrain projects and car projects including specific milestones at which decisions are made. In the company in which the studies took place, the predevelopment department is responsible for the development of new technologies as well as assurance of the predictability of new products as well as a production-orientated product design in the early stage.

Companies are often facing difficulties transferring alternative production technologies into new production system projects. Innovations are combined with risks of higher costs at later stages during development in the case problems occur. High risks cannot be taken by developers under increasing competitive pressure and shortening development periods resulting in a refusal of promising new technologies due to risk-concerns. Arguments presented against innovations often showed to be not fully precise, thus not sufficient for predevelopers to derive measures from. From our experience many technologies fail with several rather vague arguments being presented. In order to analyse reasons for predeveloped production technologies are being rejected by the company internal collaboration partners and to identify success factors in the early stage a survey at a German car manufacturer producing both conventional and electric vehicles was conducted.

2. Theoretical background

The success of projects depends on many different aspects including technical factors, psychological aspects and suitable project management methods. We analysed literature focusing on barriers to innovation in industry and success factors for projects as well as methods to overcome these barriers.

Research on success factors of innovations has been carried out for decades, leading to a wide range of theories and models. The aim of research in this field is to explain differences in the success of enterprises and to derive action recommendations that can support project success. Past research projects have created a broad variety of models for different areas concerning arguments for and against innovations, key success factors and decision criteria.

A large study conducted by Hauschildt analysed arguments against innovations in 151 companies and summarized them to four major groups: technological arguments (e.g. "the innovation is not going to work"), market arguments (e.g. "there is no demand"), financial arguments (e.g. "too expensive") and juridical arguments (e.g. "not patentable") [Hauschildt 1999]. According to the author technical and financial reasons are the major arguments against innovations. Diffuse arguments appear only in 10 % of the cases. Hauschildt´s study also analysed the width of arguments finding out that in 62 % of the projects two or more reasons against the innovation were given. Hauschildt characterises technology refusal by two layers of perspective that have to be analysed separately. On the surface rational arguments appear which are most commonly technical, financial, legal and ecological. Underneath there are the real reasons for opposition of the individual that can be described by factors classified in "not-knowing" and "not-willing". Schreyögg adds the category "not-able" to explain the reasons for resistance, depicting the resistance pyramid by Galpin [Galpin 1996], [Schreyögg 2003]. Schreyögg points out, that resistance by individuals has to be discussed on three different levels to be understood, namely cognitive, emotional and rational factors.

Lechler is presenting a widely spread inventory of 44 empirical studies from different authors with 5,760 projects being analysed identifying central success factors for projects in general. From this study a model describing the influence of factors on project success was derived. Lechler summarizes all success factors in eight major categories from which six support success and two can lead to project failure. Supporting factors are information and communication, participation, planning and control, project leader, project team and top management. Aspects leading to failure can be summarizes as conflicts and changing objectives. According to Lechler the two negative categories have a much stronger influence on project success then the positive ones [Lechler 1997]. Specifically changing objectives are common when developing in a disruptive environment as technology is changing quickly. Cooke-Davies analysed success factors from a different perspective concluding ten factors for project success such as different aspects of risk management a short project duration and a scope change control process (among others) [Cooke-Davies 2002].

Balachandra and Friar conducted an extensive review of literature to investigate whether a general agreement exists about factors leading to success or failure focusing on product development and research projects. The review shows that the list of criteria is extensive and by comparing factors across different studies. It demonstrates that different authors have found the degree of significance varying significantly [Balachandra and Friar 1997]. The results illustrate that it is difficult to derive generic statements about success factors which are correct for different kinds of projects and precise enough to be operationalized at the same time. A an example Pinto and Slevin present a model of 10 factors influencing success of R&D projects derived from a large study. Factors include management support, project planning, communication within the team and with the client and personnel aspects [Pinto and Slevin 1988].

Schröder specifically focuses on success factors in the predevelopment stage in products development concluding five important success factors:

- Strategic alignment
- Workable process models
- Minimum of project management
- Linkage to organization with a good trade-off between proximity and distance
- Leadership of employees

The author does not describe in detail, what the right extent of these factors is, making it hard to derive specific measures for practical use.

Another broad overview of opposition in projects, symptoms that show on the surface and measures to handle and overcome barriers is given by [Hansel and Lomnitz 2003] and [Steppeler 2010].

A study of the University of Kassel in Germany regarding the current status and trends in project management published in 2009 confirms necessity for research of success factors in industry. Research should orientate on multidimensional aspects and coherences between different factors. [Spang and Özcan 2009]

The identified studies do not specifically investigate in the transfer of technologies from predevelopment to series development. There is no investigation in technical requirements to predevelopment (e.g. test validation thoroughness, test conditions etc.) either. No study supplies information about whether there is a difference between requirements to predevelopment activities when developing in a disruptive technology field (such as electric powertrains) compared to established technologies (such as combustion engines). With the study presented in this paper the authors look at project success in industry from a different perspective in order to find out which rational factors influence project success in predevelopment projects. The questions the study has to answer are "What are the reasons for which promising predeveloped technologies fail in industry? What are the main challenges in transfer from pre- to series development? What do series developers expect from predevelopers to ensure implementation of new technologies into production systems?"

3. Interview study

3.1 Methodology

In order to investigate barriers in technology transfer and success factors for predevelopment projects concerning new production technology, we conducted a survey at a large car manufacturer. We divided the analysis into three steps: First we identified all projects concerning battery production from the past which developers tried to transfer. Interviews and two workshops with experts who worked in these projects (all project leaders as well as other members of staff) were used to collect data on an empirical qualitative base. We focused on the technologies affecting product design, as we observed those were the critical ones in terms of transfer difficulties. The following questions were asked for each project:

- To which powertrain project did you attempt to transfer the new technology and was this the first transfer attempt?
- At which milestone in the series development project did the transfer fail?
- For how long had you been working on this technology before?
- What was the reason the technology could not have been transferred?
- What was the decision based on (e.g. idea, drawings, material test, prototypes etc.)?
- Was the project carried on after the failed transfer attempt?
  From today's perspective: Would it have been possible to fulfil the transfer criteria?

Secondly in the same way similar projects that were successfully transferred to the same series development projects were analysed in order to find similarities and differences.

In the third step of the survey we summarized all the different reasons and success criteria mentioned by the experts into 14 categories and carried out an online survey in order to quantify their importance for technology transfer. In the online survey experts from both electric powertrain and combustion engine development participated. These experts were working in product development (in all stages), predevelopment of production technologies, process planning and others (production, purchase, quality management & innovation management).

3.2 Results from the project analysis

First of all we identified all projects involving developing of production technology with influence on product design from the past. The projects started between 2008 and 2014. We divided them into three categories:

- compulsory projects (those were necessary to ensure product function of the new energy storage system and therefore all were transferred)
- successfully transferred projects for alternative technologies
- projects for alternative technologies with unsuccessful transfer attempts

The project's contents were heterogeneous, reaching from a parameter variation of an existing joining process that required product testing to different variations of the cell bracing process including a replacement of several product parts and production steps. One project focussed on the automation of a manual assembly process of the battery module. Another one compared different materials for the heat removal from the battery module.

Figure 2 shows the quantity of projects spread over a total of nine powertrain projects in which the technologies could have been transferred. There has been a noticeable quantity of unsuccessful transfer attempts in the past years, whereas in the development of the first electric cars for small-scale production transfer problems did not occur. The total number of alternatives developed increased over time whereas the number of compulsory technology developments went down.

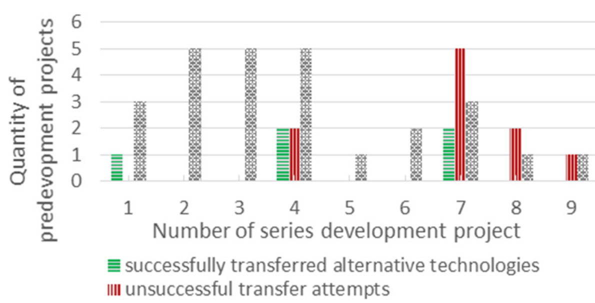

Figure 2. Distribution of technology projects analysed in this study

The likely reason for an increase in problems with technology transfer is that both products (in this case batteries) and production systems in e-mobility have recently improved significantly. The first steps into e-mobility were accompanied by technical challenges making new technologies unavoidable. In the past years optimization activities gained relevance, focussing on cost reduction, increasing flexibility for

both volume and product versions as well as improved quality. According to the experts the increase in failing transfer attempts can also be explained by growing risk-aversion, based on experiences with technical challenges in the early production systems.
In the first step the projects were analysed by temporal factors following an examination of failure reasons. In total we identified ten projects that could not have been transferred and five alternative technologies that were transferred successfully. In eight cases the failed transfer was the first attempt, twice developers had unsuccessfully tried to implement the new technology in another production systems before. Investigating the moment the decision was made it becomes clear that the early phase is the most important. Most projects failed before the A-sample (first official sample of the entire product) or before the b-sample, as a-samples do not always exist (see Figure 3). Thus in most cases there was no opportunity for official validation in hardware. The most important milestone for transfer is known as the "target agreement": Here product design and associated production technologies are fixed (usually taking place during b-sample phase) meaning later changes require complex administration and involve high costs, making a transfer unlikely. The highest chance for success is given when transferring before the first sample (the four successful projects shown in Figure 3 did not have an a-sample). Only two failing technologies were already included in the concept of the new production system before they failed.

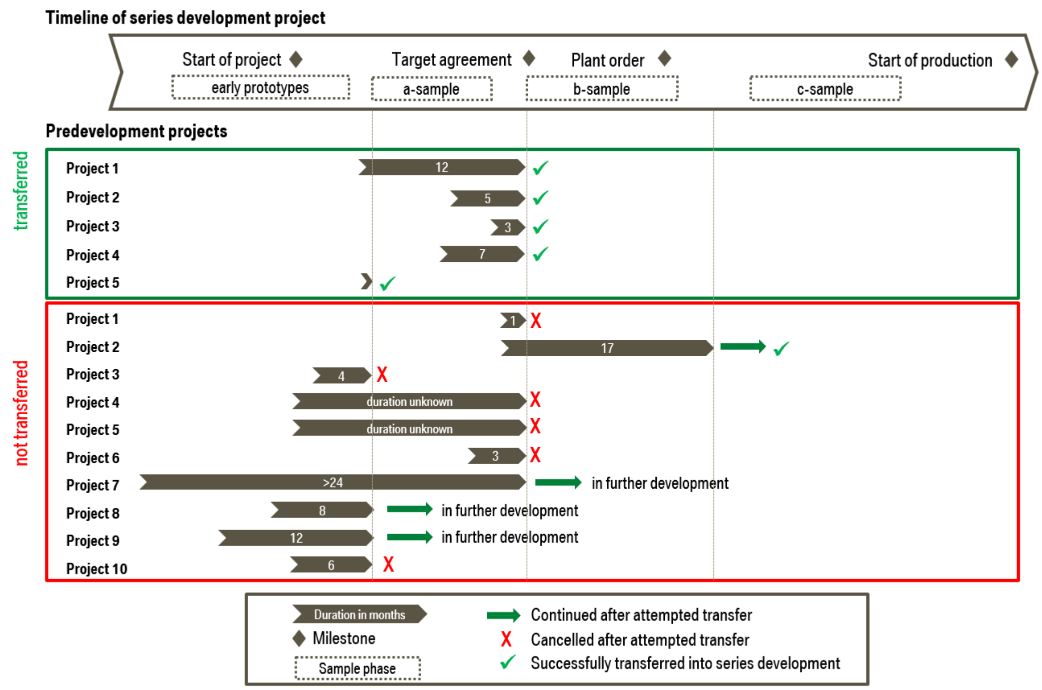

Figure 3. Temporal classification of predevelopment projects

Before the decision against a new technology was made, experts had worked on the projects for two to >24 months in total with different intensity (not always full time). Successful projects had been active for 1-15 months, so no dependencies between project duration and project success could be identified. The top part of Figure 3 shows successful projects, the lower part unsuccessful attempts illustrating the moment of decision in the product development process and the duration of work before the transfer attempt. In conclusion we can state that technologies fail mainly before the first sample. Therefore they do not get the opportunity for official validation, meaning earlier isolated validation is necessary. Once technologies are considered by series development projects the chance for successful market implementation is high. We can also conclude that longer predevelopment time is not a success factor in general.
The presented research focused on identifying reasons for failure of predevelopment projects and success criteria in industry. In all cases analysed the attempt failed by a rejection of other departments

such as the product development department, the process planning, the production or a combination of two of them. The reasons were rather heterogeneous reaching from technical problems in the a-sample (e.g. insufficient tolerances) over financial arguments (e.g. no will to invest) to insufficient technological readiness and a shortcoming of hardware tests.
We found out that especially for technologies that were not tested in hardware during predevelopment time, risk-concerns were the major reasons. Risk-concerns could not always be specified precisely though. In a project concerning an alternative technology for heat removal at the bottom of the battery module the absence of near-series conditions at the prototype machine was named as the main reason for rejection, though the technology was tested on an existing system at a system manufacturer. Conditions for "near-series" could not have been specified by the process planning department rejecting the technology.
Six projects failed by reasons that can be classified as "technological readiness" and six failed by financial reasons. One project concerning a new quality testing method failed by a negative business case doing worst-case calculation with the statement of the experts that additional tests would have proven a positive business case. We counted this case as technological readiness. Financial reasons occurred in most cases in which the transfer attempt came late during the series development project due to altering costs. In five out of six projects in which technological readiness was the main argument, not enough hardware existed at the time of the decision. This was specifically pointed out as the reason for failure. As an example, a project for a simplified sealing system of the battery pack including manual assembly failed by rejection of the process planning team due to a lack of assembly tests for the sealing on the actual hardware. Criteria for a transfer had not been discussed and the lack of hardware test was not transparent to the process planning department early enough to intervene. In another case a new battery module assembly was tested on a prototyping machine made for this specific tests. Risks concerns of product developers concerning the durability of a joint under climatical influences lead to rejection. These concerns were mentioned too late for predevelopers to be able to carry out the necessary series of tests. The other six projects did not use hardware at all before the transfer attempt.

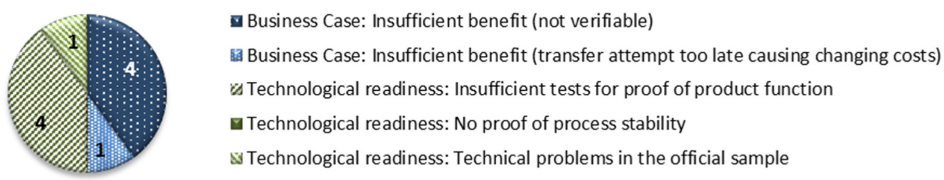

Figure 4. Classification of arguments against new technologies

We summarized the identified reasons for rejection into five categories as seen in Figure 4. In just one project several reasons were given, in the remaining nine one major reasons was stated. In two cases we identified diffuse arguments, as engineers from predevelopment could not quite understand the concerns and were not able to fully explain the reason for rejection. This can be interpreted as general risk-concerns or other individual reasons (such as personal objectives), classified as cognitive, emotional and rational factors according to [Schreyögg 2003].
The decision base for a rejection of the new technology included tests in hardware in six cases. This was leading predevelopers to classify them as ready for transfer. One decision was based on a concept with cost evaluation and three concepts were simply in the idea stage.
Looking at the transferred projects, the only striking difference we observed was the presence of hardware including tests for all projects at the time of transfer.
We asked the question "From today's perspective: Would it have been possible to fulfil the transfer criteria?". In five out of six cases in which insufficient technological readiness was responsible for failure experts were able to name specific measures that would have made a transfer possible. The main points were additional tests under laboratory conditions as well as additional time for development. The stated reasons for not being able to transfer can be summarized to three aspects:

- open requirements and late definition of requirements to the technology (future product specifications as well as production system assumptions)
- changing requirements due to product concept changes and complex coherencies

- insufficient time for development and overload in developers capacity making prioritization difficult

All in all we discovered: Tests in hardware are very important for risk reduction and a necessary conviction of partners. Comparable transparent assessments of benefits and risks for people taking over responsibility as well as transparency about project progress are key factors of success of predeveloped production technologies. The major challenge is that transfer criteria are not fully known when working with new technologies for both product and process due to a lack of experience. Without methodological support for handling the identified challenges potential of technology refinement disappears.

3.3 Results from the online-survey on success factors

In order to confirm and quantify the conclusions from the project analysis, we conducted an online-survey in which criteria for success were evaluated by a broad range of experts. We asked the question "How important do you assess the following criteria for a transfer of a new production technology into a powertrain project in the early stage?" followed by 14 major categories we derived from the project study. The criteria were validated on a six point end-named scale reaching from 1= "not important" to 6 = "very important". In addition we asked for further important criteria using a free-text field.

Department	absolute	relative	
Predevelopment production technologies	49	31,0 %	
Process planning	47	29,7 %	
Product development	45	28,5 %	
Others (production, purchase, controlling)	17	10,8 %	
Product	**absolute**	**relative**	
Conventional powertrain	58	36,7 %	
Electric powertrain	100	63,3 %	
Sum	158		

Figure 5. Group of participants in the online-survey

The participant group consisted of 158 experts (fully completed) from both electric powertrain and combustion engine development. We asked experts working in product development (all stages), predevelopment of production technologies, process planning and others (including production, purchase, quality management & innovation management). Figure 5 shows the distribution.

As the most important factor we identified an intensive exchange of information between predevelopment, product development and planning, whereas product development turned out to be the most important partner (average ranking 5.49). As the major reason we assume quickly changing requirements and complex coherencies making an intensive concurrent engineering necessary in the early stage. As the second important criteria we identified transparency about risks (4.98) and benefit potentials (4.96). The third most important criteria is a proof of function in hardware (4.86). Other important criteria are the ones concerning customer orientated predevelopment processes with predefinition of transfer criteria (4.64), agreements for transfer (4.83) and a transparent transfer process (4.68). Close integration of the purchase department was ranked as least important with an average of around 3.68.

Comparing the results for the electric powertrain and the conventional one it shows that differences are negligible for many criteria. One striking difference is regarding intensive information exchange within predevelopment and production planning as well as production. These were ranked higher for the conventional technologies, though one might expect information exchange to be more relevant when developing disruptive technologies. One way to explain the results is that, concerning established products, predevelopment is considered less important. It is possible to plan production systems without input from predevelopment projects by using established technologies. The need for intensive information exchange can be explained as a need for the promotion of innovations in order to support transfer. In disruptive environments the strong need for communication is based on volatile requirements and specifications as well as the need for new production technologies in order to enable product function. The same arguments support the fact that the last three criteria concerning the definition of transfer criteria and a transfer process is ranked slightly higher by experts for combustion engines: In this field challenges in transferring new technologies are also present but based on problems concerning acceptance of new technologies in general (as production systems work without them) rather than a lack in technological readiness and risk-concerns related to product function. Figure 6 illustrates the results distinguishing between experts from electric powertrain and expert from combustion engines.

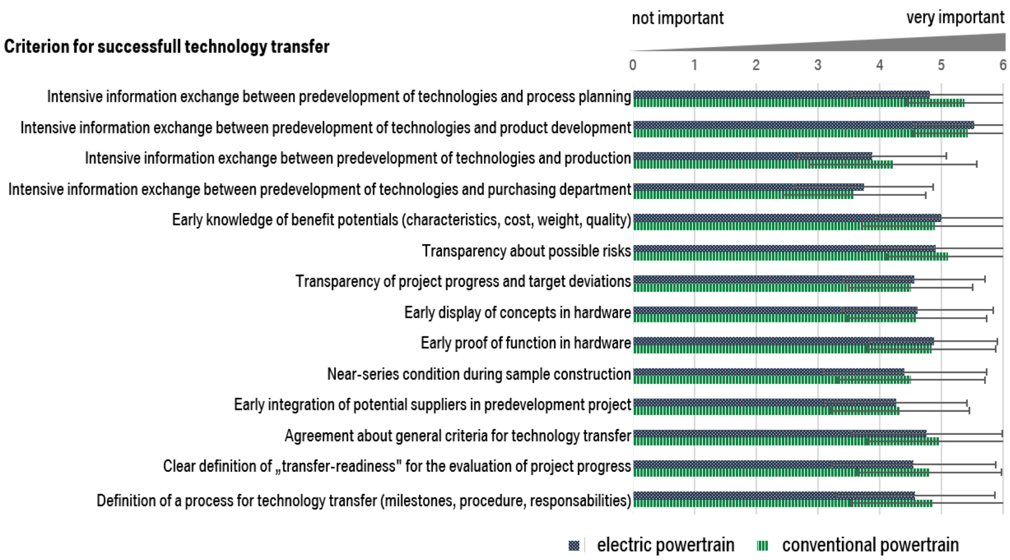

Figure 6. Evaluation of success criteria for technology transfer

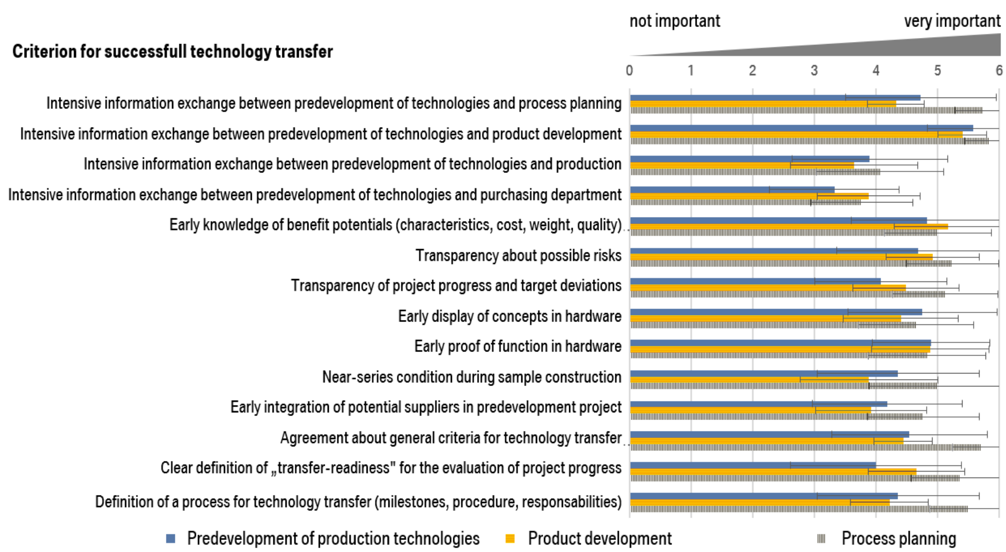

Figure 7. Success criteria for technology transfer from different perspectives

Concerning the electric powertrain we have analysed the criteria in detail distinguishing between technology predevelopment, product development and process planning. Results show that intensive communication is considered more important by process planners than by predevelopers. The same trend can be seen concerning transparency, which is desired much more by "customers" of predevelopment than by predevelopers themselves. The three process-aspects (the least criteria in Figure 7) also seem to be more important to internal customers than to predevelopers. Additional criteria named in the free-text field were an early clarification of requirements as well as a clear definition of necessary tolerances and required stability of new processes.

4. Conclusion

Using a project study we identified reasons for which new production technologies for electric energy storage systems were not being implemented at a car manufacturer. We derived factors for successful transfer of predevelopment projects concerning production technologies into series development projects. Via an online-survey with experts from different departments we rated the identified success factors according to their importance to different groups. The most important aspects are intensive concurrent engineering in the early phase, transparency about project risks and benefits, early realization of hardware and a detailed process design for technology transfers taking transfer criteria into account.

The results demonstrate that the importance of success factors for predevelopment projects differ when asking experts from different cooperating departments. Many aspects which have to be ensured by predevelopers are considered most important by process planners who take over responsibility for the new technologies. There is demand for a detailed model describing "transfer-readiness" for predevelopment projects individually, as a lack of knowledge about relevant factors was a reason for failure in several cases. We could not identify significant differences between the rating of success factors to experts working in a disruptive field compared to those developing improvements of conventional technology. From our experience we assume the reasons behind the importance of several factors to be different but did not proof the assumption in this study.

An isolated consideration of the factors identified is nearly impossible, as for instance information exchange is a precondition for transparency as well as early prototypes. Moreover, prototypes support transparency and both contribute to an evaluation of project progress. The most important challenges in technology transfer we identified in the field of disruptive technologies are undefined and constantly changing requirements and determining factors to the production technologies during the development process. This makes an increase in technological readiness in the early stage difficult as interdependencies are complex. Managing these challenges is very important though as development periods are too short to wait until conditions are set before starting the development process.

Our results confirm approaches from other authors in a way that a broad variety of factors need to be taken into account in order to support project success and that interdependencies are strong. We did not put our research on a broad data basis as for instance Lechler or Balachandra and Friar did [Lechler 1997], [Balachandra and Friar 1997], but went into detail focussing on a single car manufacturer in the field of e-mobility. We were able to identify success factors in the specific field for predevelopment of production technologies adding a new specific perspective to the existing literature.

The major decisions we discovered against new technologies can be rated as rational factors according to [Schreyögg 2003]. We could only identify a few hints to emotional and cognitive factors affecting transfer as vague arguments (such as "the technology is too risky and not ready for transfer") could often be reduced to a lack of transparency thus communication over departments. We observed that technological arguments are often diffuse when analysed in depth, as there is no precise definition of criteria that predevelopment activities have to fulfil. According to [Hauschildt 1999] we focussed on the "surface layer" of resistance, not explaining psychological reasons behind decision.

We identified very few cases in which several arguments against one innovation occurred. This might make methodological support less complex in the area which was observed in this study compared to a more generic approach that would be necessary to overcome challenges in projects [Hauschildt 1999] analysed. From the results requirements for methodological support in technology transfer were derived, giving an outlook on further research needs.

5. Outlook

As the authors of this paper focused on production technologies in the automotive industry exclusively, further research should be done. Further studies can evaluate if the identified challenges and success factors are valid for predevelopment activities in general by including a broad variety of companies and technical fields.

Having identified critical success factors, further research will concentrate on methodological support for predevelopment departments in industry intensifying concurrent engineering in the early stage, supporting early hardware test under open conditions, supplement transparency for predevelopment projects and increase efficiency in project managements concerning transfer readiness as the main goal when prioritizing tasks. For the latter a detailed survey of project readiness factors with a chronological classification over the predevelopment process of production technologies is necessary. A model

describing "transfer-readiness" of new production technologies would help prioritize tasks during predevelopment.
One promising approach the authors will analyse in detail are agile methods deriving from software industry, as challenges in software development are similar to the ones identified in this paper. Gloger names the main advantages of agile methods to be intense customer orientation, shortening market introduction and increased transparency regarding project progress based on his experience in applying agile methods to product development projects [Gloger 2013]. Supported by studies analysing agile methods in not IT- departments an adaption of agile methods for predevelopment projects for production technologies help overcome the challenges. According to a survey by Komus these methods have showed increased efficiency in many areas including hardware development [Komus 2014]. Link shows that agile methods in general help handle complexity in innovation processes [Link 2014]. These methods are rapidly expanding into different areas [Komus 2014]. Schneider successfully implemented an agile model for production planning of combustion engines and Gonzales concluded agile methods also to be applicable for predevelopment on a theoretical basis [Schneider 2014], [Gonzales 2014]. An implementation for the predevelopment of production technologies should therefore be analysed.

References

Balachandra, R., Friar, K., "Factors for Success in R&D Projects and New Product Innovation: A Contextual Framework", IEEE Transactions on Engineering Management, Vol.44, 1997, pp. 276-287.

Cooke-Davies, T., "The 'real' success factors on projects", International Journal of Project Management, Vol.20, 2002, pp. 185–190.

Galpin, T., "The human side of change: a practical guide to organization redesign", Jossey-Bass Publishers San Francisco, 1996.

Gloger, B., "Scrum. Produkte zuverlässig und schnell entwickeln", Carl Hanser Verlag München, 2013.

Gonzalez, W., "Applying Agile Project Management to Predevelopment Stages of Innovation", Int. Journal of Innovation and Technology Management, Vol.11, No.4, 2014, pp. 1-22.

Hansel, J., Lomnitz, G., "Projektleiter-Praxis - Optimale Kommunikation und Kooperation in der Projektarbeit", Springer-Verlag Berlin, Heidelberg, 2003.

Hauschildt, J., "Widerstand gegen Innovationen – destruktiv oder konstruktiv?", ZfB-Ergänzungsheft, Vol.2, ZFB Zeitschrift für Betriebswirtschaft, Gabler-Verlag, Wiesbaden, 1999, pp. 1-22.

Kampker, A., Vallée, D., Schnettler, A., "Elektromobilität. Grundlagen einer Zukunftstechnologie", Springer Vieweg Verlag Berlin, 2013.

Komus, A., "Status Quo Agile. Second study on success and forms of usage of agile methods", BPM-Labor Hochschule Koblenz, Germany, 2014.

Lechler, T., "Erfolgsfaktoren des Projektmanagements", Lan-Verlag Frankfurt am Main, Berlin, 1997.

Link, P., "Agile Methoden im Produkt-Lifecycle-Prozess – Mit agilen Methoden die Komplexität im Innovationsprozess handhaben", In: Schoeneberg, K. (Ed.), Komplexizitätsmanagement in Unternehmen, Springer, Gabler Verlag Wiesbaden, 2014.

Pinto, J. K., Slevin, D. P., "Critical success factors across the project life cycle", Project Management Journal, Vol.19, No.3, 1988, pp. 67–75.

Schneider, S., "Agile Prozessplanung im Produktentstehungsprozess am Beispiel der Motorenproduktion", Technischen Universität Dortmund, 2014.

Schreyögg, G., "Organisation – Grundlagen moderner Organisationsgestaltung", 4. Auflage, Gabler Verlag, Wiesbaden, 2003.

Schröder, A., "Vorentwicklung - Innovationen aufspüren. Ideen managen. Plattformen realisieren", In: Der F&E Manager, Vol.1, 2012.

Spang, K., Özcan, S., "GPM-Studie 2008/2009 zum Stand und Trends des Projektmanagements", Universität Kassel, 2009.

Steppeler, H., "Management von Widerstand in Innovationsprozessen", In: Marktorientierte Problemlösungen im Innovationsmarketing, Gabler Verlag Wiesbaden, 2010, pp. 29-55.

Martin Johannes Hilt, PhD-Student
BMW Group, Manufacturing Technologies and Prototype Shop
Taunusstraße 41, 80807 München, Germany
Email: martin.hilt@bmw.de