
Interdisciplinary, cross-company new product development in the future automotive industry – the case ARENA2036

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Abstract: The German automotive industry succeeds by technological leadership. Several circumstances like politics of global warming or increased global competition force the whole industry to break new ground for new kinds of collaborative research and development. ARENA2036 represents such a new cooperation form that hosts diverse scientific and industrial partners in one campus in order to research innovative production and light-weight construction topics. The diversity of the partners in ARENA2036 challenges the new product development process (NPDP). In this case study the individual processes of the partners are analysed and a NPDP system is developed. The analysis bases on interviews covering all partners. The NPDP system supports the needs of the interdisciplinary and cross-company partners. It is characterized by a layered structure in order to preserve flexibility for research topics combined with institutionalized parts to manage interfaces. The final NPDP system is evaluated by the partners.

Keywords: New product development; interdisciplinary; cross-company; research campus; collaboration; cooperation.

1 Introduction and Motivation

The automotive industry faces three major challenges – shortage of fossil fuels, politics of global warming, rising competition. In order to remain competitive companies have to develop more efficient and alternative fuel vehicles. Functional integration combined with new technologies and materials are the keys to stable success in this industry. The development of complex products like automobiles claim skills of various disciplines e.g. engineering, IT or chemistry. Furthermore, these skills are spread all over the supply chain and also beyond the boundaries of the automotive industry. Research establishments and governmental institutions gain importance. Hence, cooperation and collaborative innovation is absolutely essential.

Different organizations usually have their unique new product development (NPD) processes. Therefore, it is necessary to evaluate how NPD can be supported regarding processes in order to overcome the challenges arising like different company cultures, disciplines or an increasing number of interfaces. Such interdisciplinary and cross-company research and development projects need new processual models so as to coordinate the collaborators.

As case example we regard the start project “intelligent light weight construction with integration of functions” (LeiFu) of the research campus “Active Research Environment for the Next Generation of Automobiles” (ARENA2036) in this paper. ARENA2036 is a new cooperation form, where diverse partners from the industry, research institutes and universities elaborate collaboratively future topics in the field of production and light weight construction under “one single roof”.

The aim of this case study is the analysis of the needs of each partner involved in LeiFu concerning the NPD process. Especially the challenges arising from the interdisciplinary and cross-company character of the project are taken into account. At the moment of data collection the partners have been agreed on work packages necessary to achieve the objective of LeiFu.

2 Background

Research Campus ARENA2036

ARENA2036 is a new cooperation that started July 2013 after it won the competition for “public-private partnerships for innovation” of the German Federal Ministry of Education and Research. The cooperation focusses on the future automobile especially on function-integrated lightweight construction and sustainable, flexible and adaptable production. All activities within ARENA2036 will be systematically consolidated in one research factory where the results can be tested and implications for further projects can be achieved.

The manner of collaborative R&D in ARENA2036 is unprecedented. Divers partners from research establishments, universities and the industry, including small and medium

sized companies do research on innovative future topics concerning manufacturing and lightweight construction under “one single roof”. At the moment the ARENA2036 building is built, where all partners can do research together. The building is about to be finished in 2016. The design of the cooperation model of ARENA2036 matches largely the characteristics of a research campus. The coordination of the collaborators e.g. organizational or financial issues, public relations etc. is supported by a management team which works full-time for ARENA2036.

ARENA2036 started with seven partners therefrom three industrial and four scientific institutions. Today it grew up to 15 partners. Hence the research campus doubled within the first one and a half years and is continuing to grow constantly. All the new partners have an industrial background. Together they invest 23 million Euros in addition to the funds of the German Federal Ministry of Education and Research within the first five years. In total about 60 million Euros are invested in the first period, including the construction of the ARENA2036 building.

Even though the partners can work together in one building the communication is inhibited. They are used to their company or institute communication systems that are not interoperable or have restricted connection gateways. Furthermore, there are experts from divers disciplines working together who have different requirements to a web-based collaboration system, e.g. the partners that simulate the behaviour of materials will need more capacity to exchange data than an engineer who develops new material.

The research in ARENA2036 focusses on fibre-reinforced plastics. This research is divided into three separate projects which are linked to each other:

1. LeiFu: intelligent light weight construction with integration of functions
2. DigitPro: Digital prototyping of new materials and processes
3. ForschFab: Research production – the production of the future

These three projects are supported by one further project, KHoch3, that research the cooperation ARENA2036, the ways of knowledge transfer and the creative work. KHoch3 improves and monitors the research campus within itself and across the existing nine research campuses in Germany.

Early phases of the new product development process

New product development process (NPD) consists in most models found in literature of the idea, product planning, concept development, product development, prototype testing, and production means development phase in most models found in literature (Ehrenmann (2013); Gebhardt (2000); Westkämper (2006)).

This work focusses on the early phases of the NPD. In theory the early phases are determined by the idea, product planning, and concept development phase (Becker, Graf, Grzesiak (2007); Birkhofer et al. (2007)). Concerning the case example ARENA2036 the product development phase will also be considered.

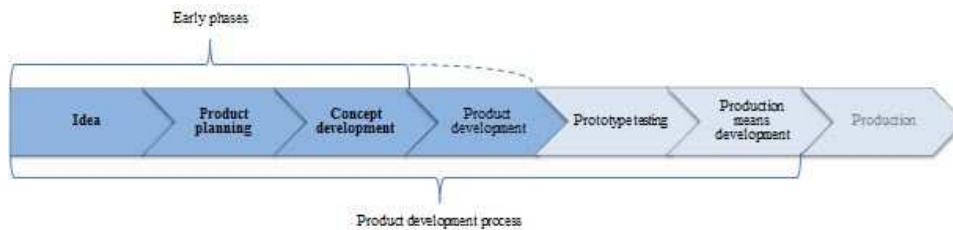


Figure 1 Early phases of the new product development process

Within the **idea phase** new approaches are developed (Meyer (2003); John (2010)). It consists of idea generation and idea evaluation (Ehrenmann (2013)). In the next phase, the **product planning phase**, the scope is defined as well as the product functionalities, the constructive basic principles, and manufacturing methods (Gebhardt (2000)). The result is a functional specification document and the product design (Ehrenmann (2013); Westkämper (2006)). The definition of the product concept based on the selected ideas in phase one is part of the **concept development phase**. The specification of the concept is based on the characteristics and functionalities demanded by the final customers. The evaluation of the concept can be supported by sample testing and bench marking (Meyer (2003)). The result is a product requirement document (Gebhardt (2000)). The subsequent product development influences construction, design and production of the final product (Feldhusen and Grothe (2013)). As a consequence of the tasks in this phase it also leads to interdisciplinary work groups (Ehrenmann (2013), Gebhardt (2000)).

The product development process also contains methods in order to secure quality and thoroughness of each phase. The **quality gate method** controls if the beforehand defined quality criteria are fulfilled at the end of a phase. Only then the next phase can be started (Eversheim, Luczak, Pfeifer (2005); Hab and Wagner (2013); Hammers and Schmitt (2009)). A quality gate basically is a measurement that filters results according to their requirements (Giebel et al. (2009)). Moreover **mile stones** can serve as a decision point even within a phase in order to demonstrate the project progress.

In the industry several company departments and even other companies are involved in new product development (Eversheim, Schuh, Assmus (2005); Hermann (2010)). Therefore, the next chapter explains the particularities of interdisciplinary and cross-company cooperation.

Interdisciplinary and cross-company collaboration

The participants of cross-company cooperation come from different departments and companies. Therefore, they are influenced by divergent company culture, performance targets, communication structure and working procedures (Hilf and Tilebein (2013)). The present age demands multi-level solutions that can only be delivered by interdisciplinary and cross-company collaboration (Raasch et al. (2013)). Hence the challenges of this kind of collaborations need further explanation.

Company culture influences actions, thinking, and feeling of the people and consequently their manner of collaborative work. A successful cooperation needs to create a culture that enforces collaboration. An open company culture positively affects

the behavior of the worker because he is also open for cooperation and collaboration (Lühring (2006)).

One of the most challenging aspects is the **communication** in an interdisciplinary, cross-company cooperation. Seemingly common terms can be interpreted in a different manner or not understood by the collaborators. This fact leads to communication problems and misunderstandings among the collaborators (Defila and di Giulio (1996); Blaschke and Lukatis (1976)).

Further challenges of **interdisciplinarity** are the implementation of diverse know-how, different aims, special knowledge of the team members, and the connection of diverse academic practices and applied science (Jooß et al. (2014)). Following several possibilities which help to overcome these challenges are presented. Formal as well as informal structures help to enforce effective and efficient collaborative team work in R&D projects (Hab und Wagner (2013)). Fixed, formal processes and procedures support actions according to the predefined plan. This helps to predict and control the behavior of each project partner (Rosenstiel and Nerdinger (2011); von der Oelsnitz (2009)). On the other hand predefined processes and rules lead to routine what might decrease performance and motivation and consequently creativity of the workers (von der Oelsnitz (2009); Weber (2006)). Thus as many rules as necessary and as much freedom as possible is especially important for innovative organizations (von der Oelsnitz 2009)).

Successful collaborations need to support trust and joint motivation and the right configuration of informal processes (Krüger (2012); Porschen (2008)). That is why interdisciplinary and cross-company projects require adequate **incentive schemes** and **team development methods** which will be explained more detailed (Weber 2006)). Fostering individual incentives is a crucial factor for the consequent achievement of the aims of the companies (von Rosenstiel und Nerdinger (2011); Weber (2006)). Incentives like autonomy and self-determination, the challenge of the task, or the recognition of their work have a higher value for researchers and developers than monetary incentives (Weber (2006)).

The performance of a team is determined up to 50 % by interpersonal factors. The ability of productive team work and a strong communication base are core elements of successful collaboration (Hab und Wagner (2013)). Both factors are developed during the team building process which thus is an essential prerequisite for an optimal collaboration (Defila, di Giulio, Scheuermann (2006)).

3 Methodology

Empirical approach

The focus of this study is to gain new insights of the NPD in research campus by a close analysis of the start project LeiFu of the research campus ARENA2036 rather than to confirm existing knowledge. Therefore guideline interviews and workshops are used to collect data. The aim is to receive an overview from all perspectives of each partner involved in LeiFu.

The interviews are analyzed by the qualitative content analysis. The interview text is systematically categorized according to the research questions. The analysis criteria are detailed in the following chapter.

Description of the analysis criteria

The interview results can be categorized to the criteria developed during the interview analysis. The following table gives an overview of the criteria and shows if the criteria refer to the actual status of the involved parties in LeiFu or their desired status. It also shows if it refers to the NPD or collaboration issues.

Table 1 Overview of the analysis criteria

Criteria	Status	Topic
Communication channel	actual	collaboration
Time and actuator of the communication	actual	collaboration
Access to information	actual	collaboration
Requirements for successful information transfer	desired	collaboration
Fixed work plan	desired	NPD-process
Sequence of NPD phases	actual	NPD-process
Type of result measurement in the NPD	actual	NPD-process
Characteristics of the desired NPD	desired	NPD-process
Organization of product development in LeiFu	desired	NPD-process

The first criterion, **communication channel**, demonstrates the manner of communication in Leifu. The second criterion, **time and actuator of the communication** define if there are defined actuators for the communication in the project. The criterion, **access to information**, measures if all parties in LeiFu have access to the information needed for their tasks. **Requirements for successful information transfer** describes the needed factors from the collaborators point of view for a rewarding information exchange. **Fixed work plan** shows the extent of the determination of the processes desired by the LeiFu partners. The way each organization in LeiFu passes the NPD phases is recorded in the criterion **sequence of NPD phases**. The evaluation of the results is described by the criterion **type of result measurement** in the NPD. Last but not least the **characteristics of the desired NPD** are admitted and the last criterion **organization of product development** in LeiFu determines how the individual NPD process can be integrated in LeiFu.

4 Results

Insights of the interviews

Communication channel

86 % of the interviewees prefer a combination of formal and informal information exchange. Formal communication in most cases are regular meetings or other predefined communication scenarios. Informal communication, however, is spontaneous and as needed without any predefined frame like place or communication medium. Interviewees mentioned meetings, phone calls, personal talks and email communication as the most frequent informal communication channels.

Time and actuator of the communication

Likewise 86 % of the interviewees prefer a combination of regular and irregular communication. Regular communication means that the appointment is defined in time and place and is repeated regularly. Irregular communication, however, is actuated by the need of a collaborator for information. According to the interviewees, existing regular appointments and spontaneous communication e.g. in the hallway, at lunch time or in coffee break are sufficient to as indicators for communication.

Access to information

According to the partners' opinion 67 % state that they have access to work relevant data within a decent time period. Information access, however, is granted in an unstructured way, usually by email or phone.¹ Moreover, there are several decisions that are communicated late to some collaborators and some information was only delivered after several reminders.

Requirements for successful information transfer

60 % of the interviewees appreciate formal as well as informal communication. Fixed communication structures support being informed about everything above the own tasks and the presentation of results. Informal communication is mostly used for personally needed information for the tasks and networking.

Fixed work plan

Half of the interviewed partners prefer a fixed work plan with some flexible aspects. They often mentioned that predefined deadlines, mutual work standards, and mutual definitions assist building a common knowledge base and also help to avoid redundancy.

Sequence of NPD phases

At the moment 40 % of the partners pass the phases partly parallel. It means that some phases overlap or run even at the same time. Another 40 % move back into earlier phases if necessary e.g. in order to correct planning mistakes.

¹ At the time the study was executed a common IT-platform did not yet exist.

Type of result measurement in the NPD

The most important instruments according to the interviewees are mile stones (36 %), meetings (21 %), and quality gates (14 %) They see mile stones as the predefined deadline of an event or result. Quality gates refer to the quality and thoroughness of the results. Meeting according to their view are fixed repeated appointments with all participants of the project.

Characteristics of the desired NPD

The collaborators would like to have a NPD process that is flexible but with certain restrictions (50 %). They desire sufficient freedom for their work and on the other hand standards and clear objectives.

Organization of product development in LeiFu

75 % of the interviewees stated that they want a NPD process at the level of the entire project LeiFu that contains standards and clear objectives. They prefer mile stones for the objectives on this level. The collaborators do not want to be integrated into this top level NPD process regarding to their procedures and working manners. This should be defined in a more individual process and on a lower level. The lower level processes shall be integrated into the top level NPD process.

Requirements for the new product development process for LeiFu

Based on the results of the interviews and the theoretical background the requirements for the new product development process for LeiFu will be determined in this chapter. The focus lies on the early phases of the NPD process.

The new NPD process has to allow **flexibility** in order to support autonomous creative thinking and working of the collaborators. This also includes **moving back** into an earlier phase if the objective of the phase cannot be reached without correction. Moreover, it should be possible to have **overlapping** phases or even phases that run at the same time in order to mitigate interfaces of connected or even dependent phases.

The structuring of the project has to facilitate the subdivision of the tasks, give an orientation within the whole project, and control the results. The creation of mile stones supports the project structure. The implementation of quality gates support performance measurement and secure the quality of the product development. Therefore, this two methods help to lower the risk of the project and implement and adapt the customers' demands.

The existing NPD processes of the participants in LeiFu differentiate from each other. This is why a NPD process on the overall level of Leifu is necessary. In this top level NPD process the individual NPD process have to be integrated. As a result the flexibility and the individual way of work can be preserved. At the same time the common objectives, standards, and guidelines will be followed.

Four out of six actual NPD processes of the partners are consistent in the naming of the first two phases (idea and planning phase). This is also consistent with the first two phases mentioned in theory. These phases will be adapted for the new NPD process for LeiFu in order to prevent misunderstandings or confusion.

In addition to the above mentioned, detailed work plans and time schedules within the subtasks have to be documented and controlled in order to reach the mile stones.

Configuration of the new product development model for LeiFu

The interdisciplinary and cross-company character of ARENA2036 and its start projects like LeiFu go beyond the requirements of a general in-house or bilateral NPD. The inclusion of researchers as well as SMEs does not allow a straight sequential and inflexible configuration of the NPD process.

The new NPD process for LeiFu contains out of **six phases**. This six-phase NPD process builds the top level NPD process which applies to all LeiFu participants. The first phase, planning phase, overflows to the second phase, the idea phase, followed by the concept development. Concept development is divided by three phases. Two of them run at the same time namely concept development for the car floor module and concept development for the new technologies. The third phase of the concept development phase is the conceptualization of the demonstrator. After concept development is completed the final phase of the early phases of the NPD starts. The product development phase is also the last phase of LeiFu in ARENA2036. Therefore, the successful completion of this phase is also the closure of LeiFu. The following figure demonstrates the top level NPD process for LeiFu.

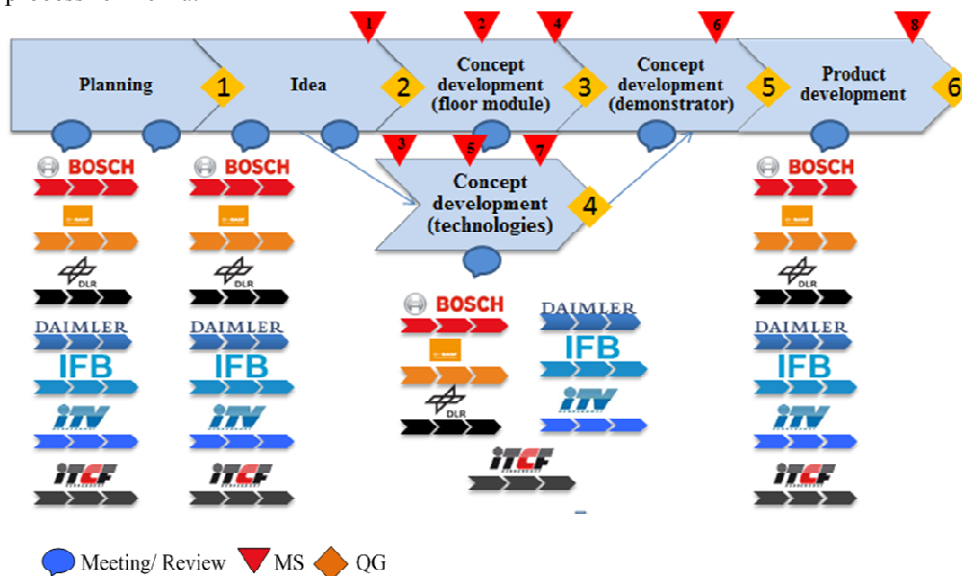


Figure 2 Top level NPD process with individual NPD processes of the partners

The **planning phase** includes the definition of the requirements for the car floor module and the collection and analysis of the technical state of the art. It consists out of two work packages that will cover these two contents. A third work package does start within the planning phase and serves as an overflow to the second phase. The idea phase does start with this third work package while the planning phase is still running. Hence first idea creation does take place parallel to the planning phase.

The results of the third work package are extended and in a fourth work package they are evaluated and selected for further elaboration. The results of the **idea phase** flow into the next phase where the most eligible idea will be further developed.

The **concept development** is divided into three phases according to the content. In the phase concept development (car-floor module) the rough and detailed structuring of the floor module is developed and documented. Parallel the phase concept development (technologies) runs. In this phase the technological state of the art collected and analysed in the planning phase are specified, evaluated and tested. For the testing adequate demonstrators of the applied technology are built. After the completion of the floor module concept and the technology evaluation the concept development for the demonstrator starts. Now the results of the first two concept development phases are consolidated and finalized to the concept of the complete car-floor module.

The division of the concept development is reasoned by an improvement of transparency for the collaborators. Clearly defined and closed work packages can be defined during concept development. As the work packages run parallel for a significant time and flow together in the last stage of the concept development the relations of the tasks becomes more transparent for the collaborators and also for the project leaders. Better controllability accompanies the improved transparency.

The concept of the complete car-floor module is the initial point of the **product development phase**. In this final phase of LeiFu the floor-module demonstrator is constructed and is used for several tests that assure an adequate product for the customers. In this phase there will be close cooperation with the start project DigitPro (simulation) and rising exchange of information with the start project ForschFab (flexible manufacturing).

The new NPD process is accomplished by meetings, mile stones and quality gates. Meetings are meetings of the work package leaders, round tables of the PhD candidates and researchers, or workshops that take place on a regular and defined base. The higher amount of meetings at the beginning of the NPD ensures sufficient communication in order to syntonizer the actions of the participants in LeiFu. During the parallel phases of the concept development the tasks and procedures differentiate the most from each other and seek for an individual approach of the partners. Therefore, in these phases there are fewer meetings.

Concepts for the collaboration and new product development

The first concept is a glossary for assuring a shared definition of the terms used in the project. Thereby, a shared understanding of all partners for important terms of LeiFU can be reached and misunderstandings are minimised.

The second concept is a standardized form for meeting minutes, e.g. for work package leader meetings which are held every two weeks. The benefit is a project-wide standard which always has the same structure and can easily be understood by all partners.

The third concept addresses the so-called quality gate assessments. Their aim is to structure working time before the completion of a mile stone and assuring the specified quality gates are met. The quality gate assessments contain out of the general workflow and a four-level escalation model. Level one starts six weeks before the end of a phase

and includes the invitation of all members involved in the work package by the work package leader. Four weeks before the end of a phase, the quality gate assessment meetings take place again (level two). A standardised document is completed. It includes the actual status and the desired status and action for reaching the target. In addition clear dates for the fulfilment of the tasks and responsibilities are assigned. The actual state is visualised by traffic lights. The third level starts two weeks before the end of each phase with a meeting of the task members. Target fulfilment as defined in level two, is controlled and the current status is updated. The fourth level includes the comparison and evaluation of results including the aims regarding their quality. This meeting is joined by all work package leaders who are responsible for reaching the quality gate or depend on its results for their own work package.

The associated **escalation model** is adapted to the workflow of the quality gate assessments and shall solve the problems arising in them. The involvement of responsible participants with the right of decision will fill the undefined spots. An example: There was no action taken to prevent the failure of a sub-task which will delay the whole work package. This possible failure and thereof possible delay of the work package will be detected during step two of the quality gate assessment by the completion of the form. Now this issue escalates to the task leader who is enabled to take action in order to prevent the delay. Is the problem still not solved in the third step of the quality gate assessment, the work package leader will take action. If at the end of the quality gate assessment the status is still not on “green” the project leader will be informed for further instructions. The procedure of the quality gate assessments also helps that the participants are less likely to go back to a previous phase.

The fourth concept is a responsibility matrix. This matrix shows who is can be asked for each work package and topic to the collaborators. The documentation of the responsibility matrix clarifies the responsibilities and facilitates the inner-project communication.

The fifth concept is a common IT-platform. This platform is set for the whole research campus ARENA2036. Everyone active in ARENA2036 has access. Within this platform a secure area is established for LeiFu. In this account documents, the responsibility matrix, meeting minutes, the glossary etc. can be exchanged. Moreover there is a visual table where all participants that are involved in LeiFu can check on the actual status of the project and on the activities in the work packages. The following figure shows the concept of the platform.

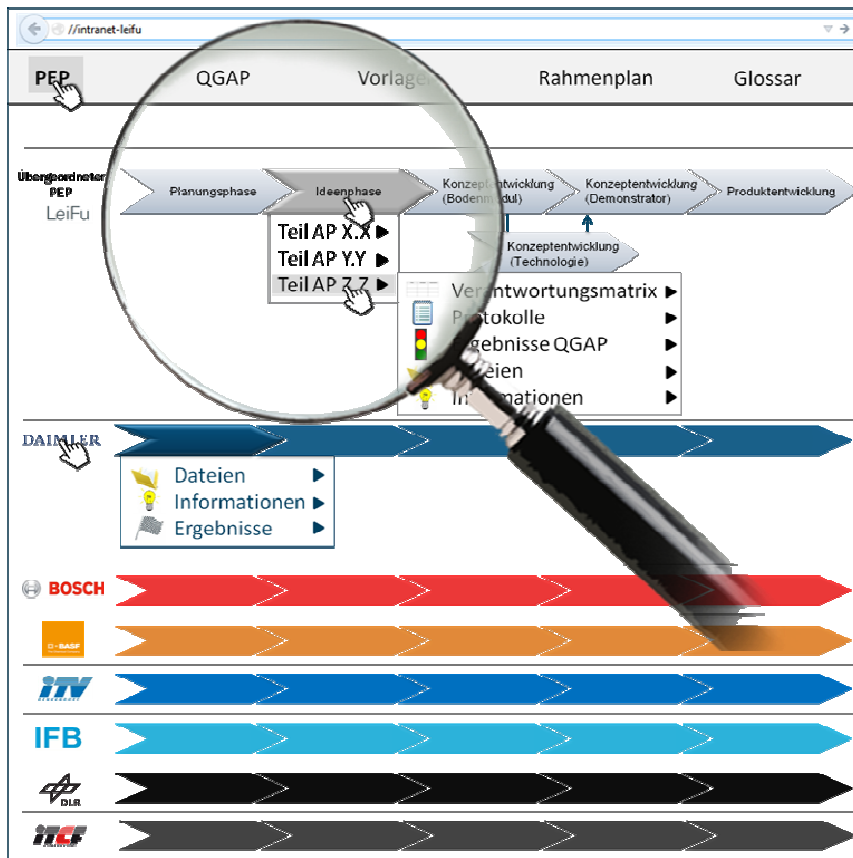


Figure 3 Status information for LeiFu on the IT platform

Analysis and critical evaluation of the final NPD process

As final step the elaborated results have been presented to the project partners and in the course of this validated. The validation process outcomes for the developed NPD model for LeiFu shall be briefly summarized and critically assessed below.

The authors conditionally share the view of the respondents that in the new NPD model mile stones are increasingly used. The concept limits itself to two additional mile stones - the end of the concept development phase and the overall project ending. The implementation of quality gates is essential to assure the measurement of results and the achievement of the mile stones. The authors acknowledge the expected additional effort for the project partners which is caused by the implementation of quality gates and mile stones. However, it would be necessary to ensure the final objectives achievement of the project phases through other measures. These measures would also tie up time and resources. This compensates the additional effort of the suggested measures.

Regarding the time period of the quality gate assessments the opinions of the project partners varied. This shows that it is not possible to define a clear stipulation for the

chronology of the project. The duration of the various work packages show a large deviation. Based on that, it is recommended to adapt the time period for the quality gate assessments individually. Furthermore there are critical responses which indicate as consequence of the quality gate assessments the number of meetings increase significantly. But completing the quality gate assessment document could be done already during the regular meeting without any significant additional effort.

Another point of the validation addresses the escalation model which is seen critical by some project partners. Nevertheless the authors recommend the implementation of an escalation model. It assigns clear role profiles and responsibilities. In case of non-achievement of mile stones or quality gates a quick decision for further steps to ensure the future target achievement can be made.

The importance of quantifiable objectives is estimated to be high. This opinion is shared by the authors. Quantifiable objectives interconnect the project partners and are the basis for consensus about clear objectives. Furthermore, misinterpretation and consequently misunderstandings can be prevented.

For the authors it is quite understandable that the project partners cannot identify with descriptions which contain the word 'product' such as for the product development phase. Especially the glossary can prevent such difficulties.

The flexibility and research freedom desired are key incentives for the work of the project partners. Consequently these issues should be considered for the NPD process development. Further reconciliations with the project partners to include the individual desires of the project partners should become routine. The project partners consider team development as important factor. It is recommended to appoint a particular person to coordinate the team development.

Finally, references should be made to the fact that the missing structures in LeiFu should be implemented in the course of the project to ensure the realization of the NPD and a successful cooperation.

5 Conclusion

The final NPD model concept meets widely the demands of the participants of LeiFu. The multi-layer structure respects the needs of the entire LeiFu as well as the needs of each individual partner. Moreover, the additional concepts for fostering collaborative work round off the model.

The NPD model for LeiFu does not have to be seen as a fixed setting. It has to be applied and adjusted to the practical circumstances in the project. Especially the individual NPD processes of the partners have to be adjusted and implemented in the overall NPD model.

As further steps the model has to be implemented in LeiFu and extended across the whole research campus ARENA2036.

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