INTEGRATION OF SUPPLIERS INTO THE PRODUCT DEVELOPMENT PROCESS USING THE EXAMPLE OF THE COMMERCIAL VEHICLE INDUSTRY

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ABSTRACT
During the last years the duties and responsibilities of engineering units in the vehicle industry changed drastically. Time pressure, cost pressure and the complexity of products are constantly increasing. Furthermore, companies are working to a greater extent on an international basis. These reasons lead OEMs and suppliers to increase their cooperation and to undertake extensive efforts to optimize the processes in their supply chain. The research project aims at developing a workflow model which helps improving and accelerating the cooperation between clients and contractors in the product planning phase.

Keywords: *integration of suppliers, commercial vehicle industry, product development process, requirements management*

1 INTRODUCTION
The automotive industry is constantly undergoing profound changes. Currently, this industry is again in a process of reorientation, defined as third revolution. There are a lot of reasons for this development, as shown in Figure 1. They vary from the reduction of product life cycles, accompanied with a reduction in development time and costs, to the growing complexity and increasing quality requirements of customers. Moreover, the increasing globalization and the rise of the international cooperation causes a rising dynamic behavior in the economic and political surroundings.[1] This development is also noticeable in the commercial vehicle industry, which is characterized by technically high-quality and sophisticated products.

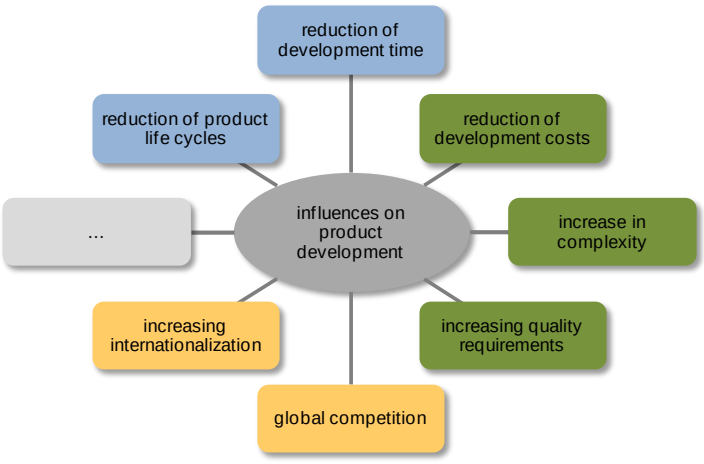

Figure 1. Reasons for the third revolution

All these factors lead to changes in the involved enterprises, for example to a stronger concentration on core competences as well as to a reduction of the added value depth because of intensified co-operations between OEMs and suppliers. To increase the competence of the involved enterprises and to provide opportunities to open new synergies, a reorganisation of the product development processes as well as the cross-company processes is necessary. This is understandable, because the success of a product is decisively determined by the definition of the product features in the early phases of the product life cycles.

Studies show that in the year 2015 about 90% of all manufacturing activities are carried out by suppliers. Also in the product development of the automotive industry a rethinking process has taken place. Especially in the automotive industry a stronger integration during the pre-development and the volume development can be noticed, see Figure 2.[2]

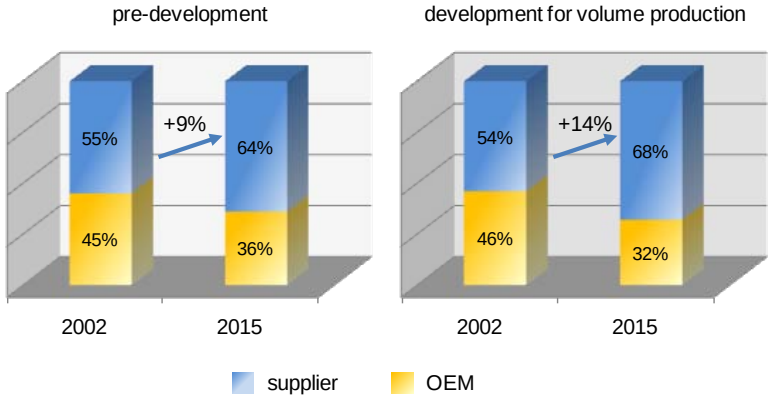

Figure 2. Integration of suppliers into the product development / based on [3]

Hence, a comprehensive design of a cross-company product development process can become a decisive success factor for the involved enterprises. In this case, especially the field of product development offers a high potential for cost reductions and failure prevention, see Figure 3.

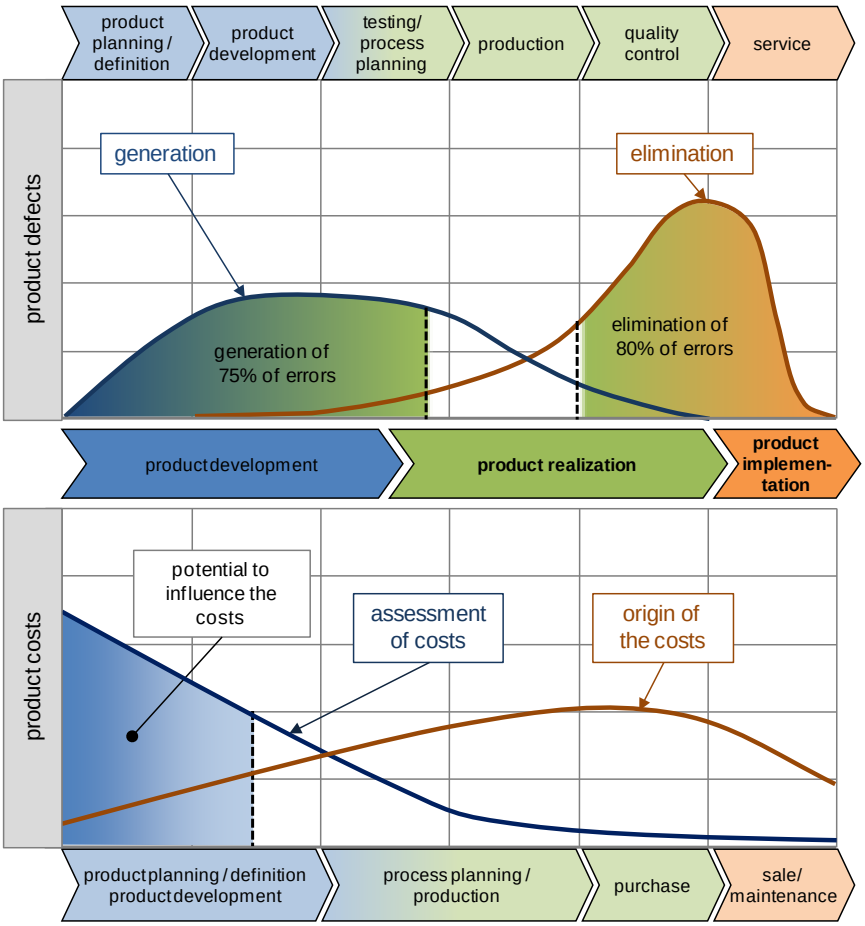

Figure 3. Product costs and product defects / based on [4] and [5]

Of course, the reinforced supplier integration goes along with changes in the supplier structure and models, see Figure 4. Until the 1980s a direct procurement between OEM and the single part suppliers was a usual procedure. In this case the development was mostly done by the OEMs. The suppliers acted only as contract manufacturers.

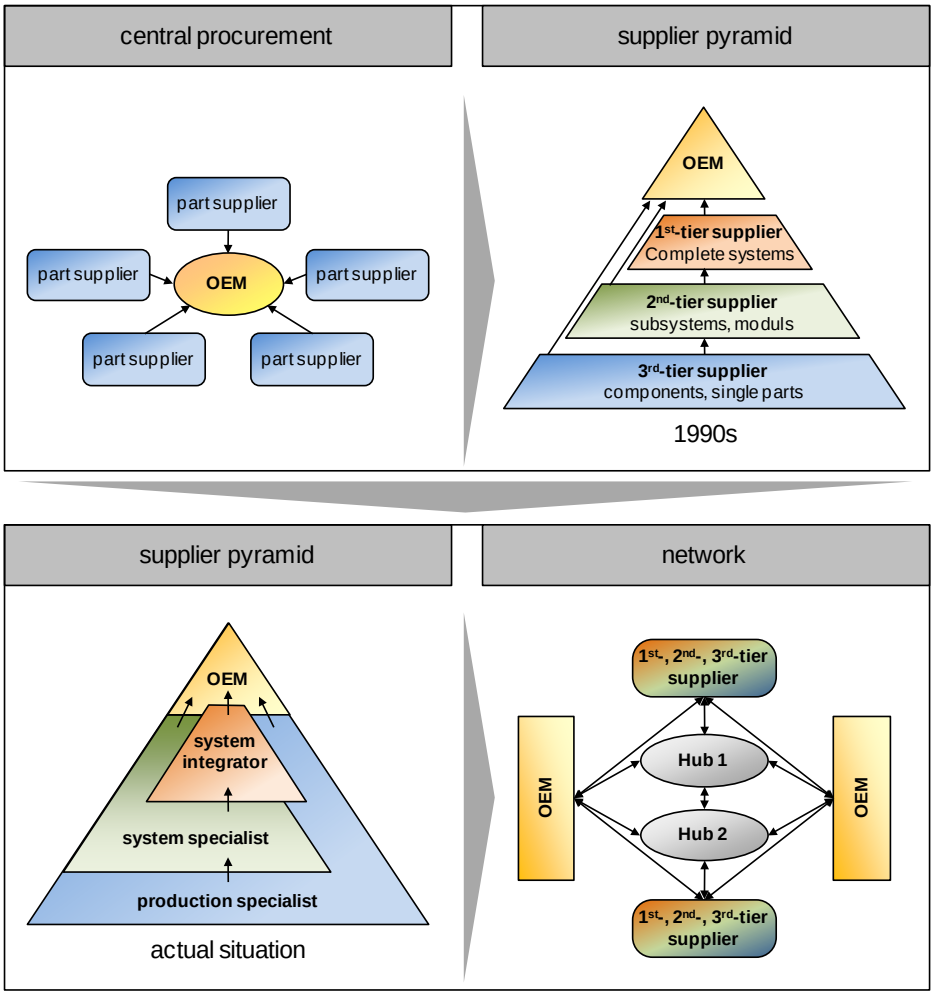

Figure 4. Changes in supply structure / based on [6]

In the 1990s the focus of the companies was in the reorganisation of company-internal processes processes.[7] This specialization created new suppliers forms, which changed the relations between OEMs and suppliers in the automotive sector with lasting impact. The increasing product complexity as well as the partial shift of the complete responsibility to the suppliers requires more intensive relations and better processes of coordination between the involved companies.[8] Due to the reduction of the direct suppliers, the structure changed according to the first supplier pyramid, shown in Figure 3. Nevertheless, the suppliers pyramid should be considered critically. Primarily, it is criticised that the suppliers are in mutual, cross-linked delivery relations, so that a correct characterization and classification to a certain supplier type seems to be problematic.

The first displayed supplier's pyramid was only temporary structure in the 1990s.[8] A change of the pyramidal structure is on the one hand caused by a progressive concentration process and, on the other hand, caused by a reduction of the direct suppliers because of lean production concepts and new organisational concepts.[1] In this context, DUDENHÖFFER (2002) depicted that the pyramid will get a wide "specialist's head", because of a new supplier form, the system integrators, who are well trained in special fields of technology.[9] In the future the supplier pyramid will be changed in a network structure with co-operating and cross-linked linked supplier companies, co-ordinated by global system integrators. Then, nearly the whole vehicle will be produced by a few mega suppliers. It’s assumed that in the long term, worldwide only from 30 to 50 system integrators will exist. Their added value in the development will rise steadily and the OEM will concentrate themselves only on specific technical competences or design and service.[1] At the same time the system integrators have to build up other or new competences to control their fields of activity.[10]

These factors lead to a reduction of the suppliers in the market. By approx. 30.000 suppliers at the end of 1980s, less than 10% will survive as independent enterprises in the year 2015, see Figure 5.

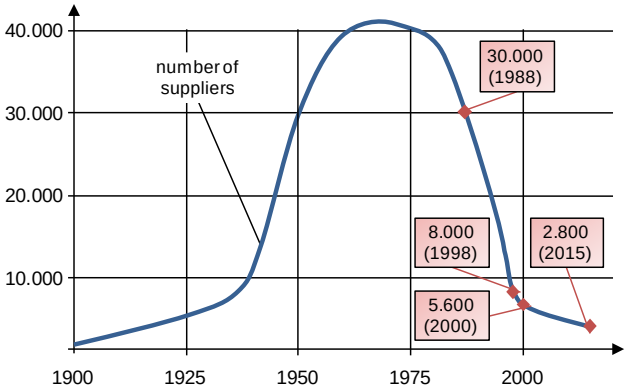

Figure 5. Number of suppliers in the market / based on [3]

The different supplier types in today's supplier structure differ clearly in their integration and innovation potential and in the importance for the product development, shown in Figure 6.

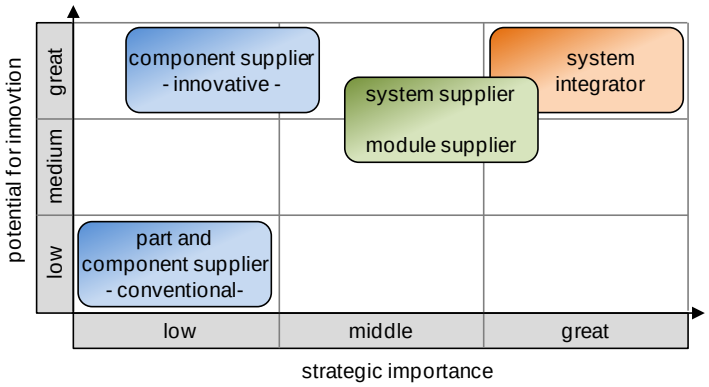

Figure 6. Innovation and integration possibilities of different suppliers

In the following the different types of suppliers will be explained more detailed.

Part supplier and component supplier

The conventional part suppliers produce only standardised products.[1] A co-operation with such suppliers in the product development is not necessary, because of the limited innovation potential of their products.[11] Because of these facts, the co-operation and connection between these suppliers and their clients are less intensive than those with other types of suppliers, in spite of high order frequency.[12]

In contrast, some component suppliers are mentioned in the literature as innovation centers. They offer high and part-specific innovative capabilities as well as relatively high order volumes, because they work with both OEM and system integrators.[3] In comparison to the part suppliers, the products of the component suppliers are more complicated and specialized and offer a higher value-adding.[1] The components are often customer-specific solutions with non-standardized interfaces.[13]

Module and system suppliers

In addition to their production-specific skills, module suppliers are characterized by special abilities in the field of logistics, because they integrate modules, components and parts of their subcontractors to functional units.[14] These modules represent, according to the OEM's, complete solutions, which can be directly integrated in the production. [13] The know-how of these suppliers is usually limited to the development of their own components.

The system suppliers also obtain complete modules, components or parts of their subcontractors. In contrast to modules, which have to be a spatial unit or mounting unit, a system only describe a functional unit.[1] This supplier type is characterized by extensive R&D know-how, which refers to the whole system. Due to its independent development and its high potential for innovation linked with the latest knowledge in production and logistics, a system supplier plays an important role for the OEM.[11] Furthermore the system supplier takes the whole responsibility for the complex system and parts which were produced by sub-suppliers as well.[13]

System integrator

In the literature the system integrator is often described as 0.5-tier, because of its position in the supply network. This type of supplier acts as a link between OEMs and their sub-suppliers and co-ordinates the functional aims.[1] The responsibilities for fields which belong in the past to the competences of the OEM, are now characteristic tasks of the suppliers. In addition to extensive development know-how and high potential for innovation, a system integrator needs the competence to evaluate and control sub-modules concerning his product and to integrate them.[11]

Based on the supplier specific characteristics concerning innovation, integration and development possibilities there are different suitable times for the integration during the product development process, see Figure 7.

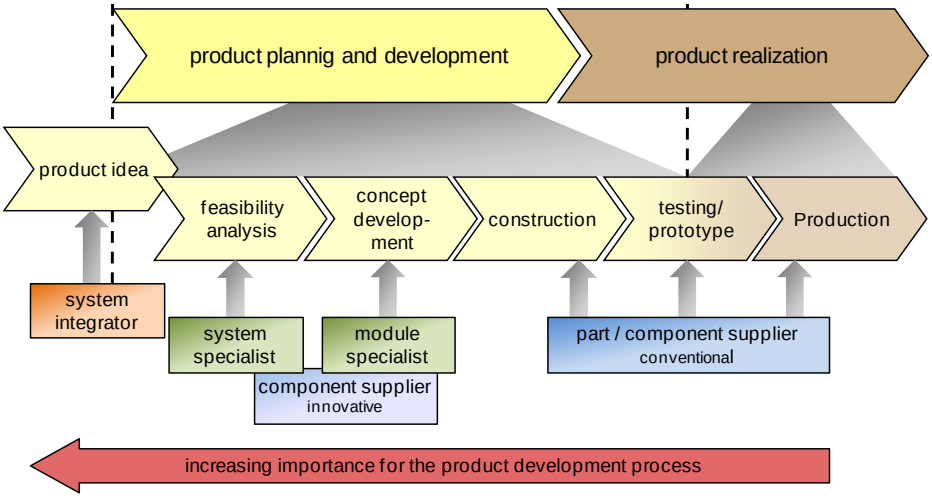

Figure 7. Times of integration

Except for part and component suppliers without own development work, the figure shows that suppliers should be integrated during the concept development at the latest or even better during the definition of the requirements.

The early supplier integration and the special knowledge of the supplier can help the clients to better understand the specific requirements of the customers and to transfer them into technical requirements, which can be used in the development departments.[15] The importance of these factors becomes obvious, considering that more than 30% of the reasons for project failures are associated with the requirements definition, see Figure 8.

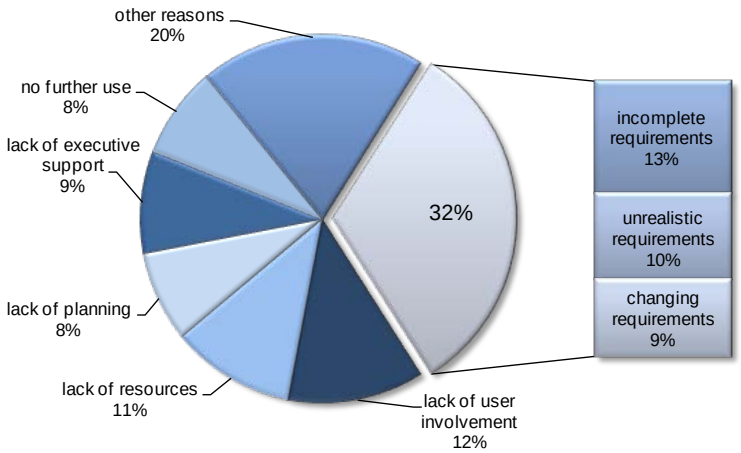

Figure 8. Reasons for project failures / based on [16]

Especially the management of the requirements and the changing requirements lead to difficulties during complex development projects. Concerning the steadily increasing number of requirements, the intensified co-operation and the demand for reduced development times, it is absolutely necessary to develop a regulated process for the requirement management regarding the different company-specific

development methods. The correct arrangement of these processes can be an important factor for the success of the companies and their products. But, in these cases a rethinking in the commercial vehicle industry regarding the requirements definition and its management is needed. Especially during communication-intense co-operations it is particularly important that both OEM and suppliers can work with the current versions of the documents and are able to exchange information easily. To implement these new concepts without the use of advanced software solutions in the field of requirements management seems hardly possible.[17] While the OEMs and large suppliers of the automotive industry use such systems for a long time, the use in the commercial vehicle branch, especially for manufacturer of special vehicles and smaller suppliers, is further doubtful. To identify the reasons, a survey was conducted.

2 RESULTS OF THE SURVEY AND CONCLUSIONS

In the literature there are many sources that deal with the integration of suppliers in the automotive industry. Comparable information concerning the integration in the commercial vehicle industry (trucks as well as buses, construction and agricultural machinery, harvesting machinery, cranes etc.) is barely available. Hence, in order to analyze the present situation in today's commercial vehicle sector a survey was developed and dispatched to numerous enterprises of that field. For comparative reasons, enterprises, which are active in multiple industries (e.g. truck and car manufacturers) or in similar branches were also interviewed, see Figure 9. The survey addresses specific questions concerning the current situation regarding requirements specifications and requirements management along with general questions about the product development process. In addition, it should be investigated which problems exist actually in the co-operation between clients and suppliers and which chances would arise by a stronger integration.

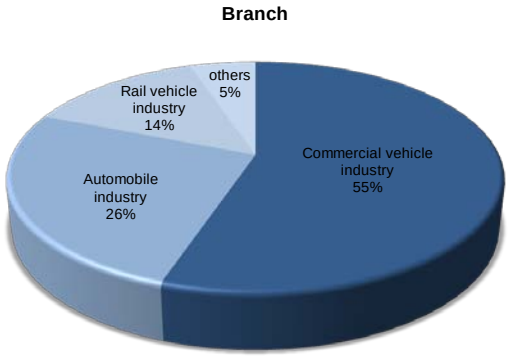

Figure 9. Overview of the surveyed branches

Because the main focus of this investigation is on the actual situation of suppliers in the commercial vehicle industry, only the statements of the interviewees from this branch are considered in the following graphics.

The next figure illustrates, that nearly half of the questionnaires were answered by 1st-tier suppliers and nearly 30% by OEM. About one third of the interviewees work in different domains (mechanics and electronics) of the developing departments and about 20% of the interviewees belong to the purchasing department, which is mostly responsible for supplier integration.

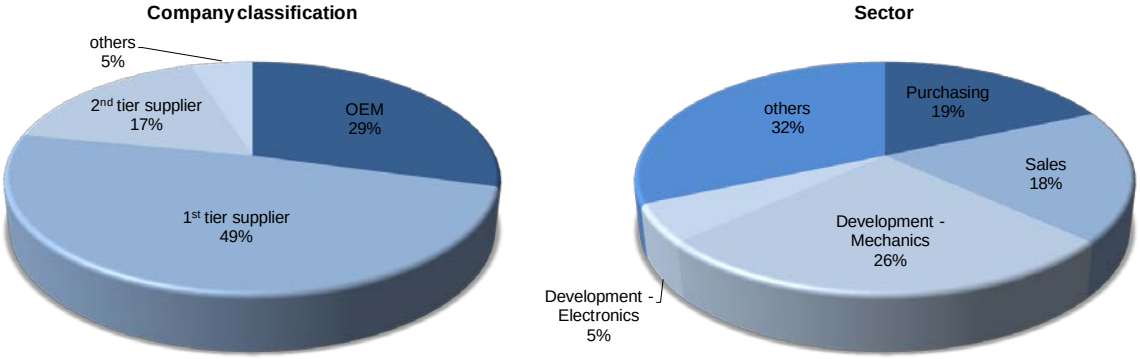

Figure 10. Information about the status and the involved departments

In the future, as already described in Chapter 1, greater supplier integration in all fields of the product development process has to be expected. Unfortunately, the benefits of a stronger integration have not yet been recognized by all interviewees. Just half of the respondents attach high or even great importance to supplier integration, although only 13% acts with contract manufacturers without development work. More than 55% of the suppliers work in the field of component development or even system/module development. Especially these suppliers should be involved in the product development process at an early stage (see Figure 7), because the development of new products requires exact, entire and realistic information concerning product functions. For this reason a stronger supplier integration during the requirements definition would be advisable. According to the surveyed companies, a continuous integration and common definition of requirements only take place in 6% of all development processes up to now. In almost 70% of all cases, supplier integration during the requirements definition only takes place if required by the OEM.

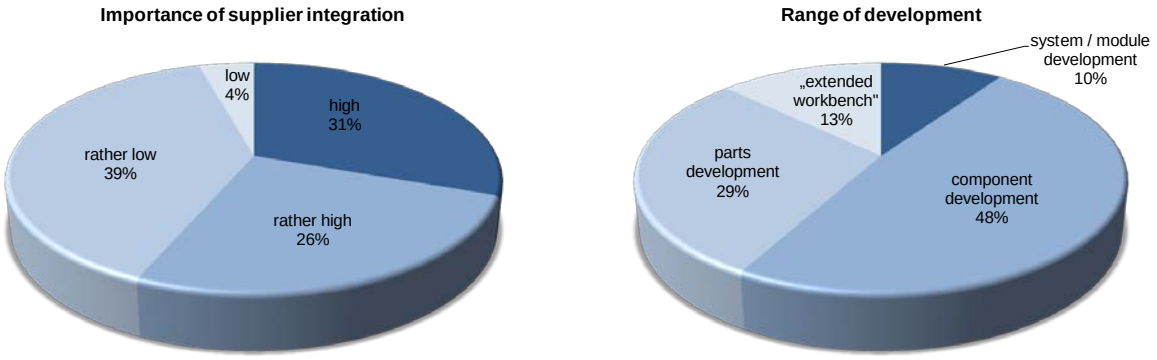

Figure 11. Supplier integration and range of development

Unfortunately, the missing integration has negative effects on the number of changes in requirements during the development process. The interviewees stated that in nearly 60% of all developments up to 25% of the requirements have to be changed subsequently. In about 20% of all cases even more changes of requirements are needed. On this occasion, the extent of the changes should also be taken into consideration. According to the opinion of the respondents, more than 50% of the changed requirements have great or even massive effects on the product under development. These subsequent changes in requirements could be significantly reduced in future through intensified and coordinated co-operations between suppliers and OEMs. Therefore, however applicable process descriptions and supplier programs will be necessary. But only 20% of the surveyed companies use special supplier programs to coordinate the co-operation, see Figure 12. The co-operation between most enterprises takes place either by personal order or by self-determination of the suppliers. Because of the lack of suitable process descriptions, there are difficulties in the co-operation over and over again. On this account, only 20% of the interviewees are completely satisfied with the co-operations.

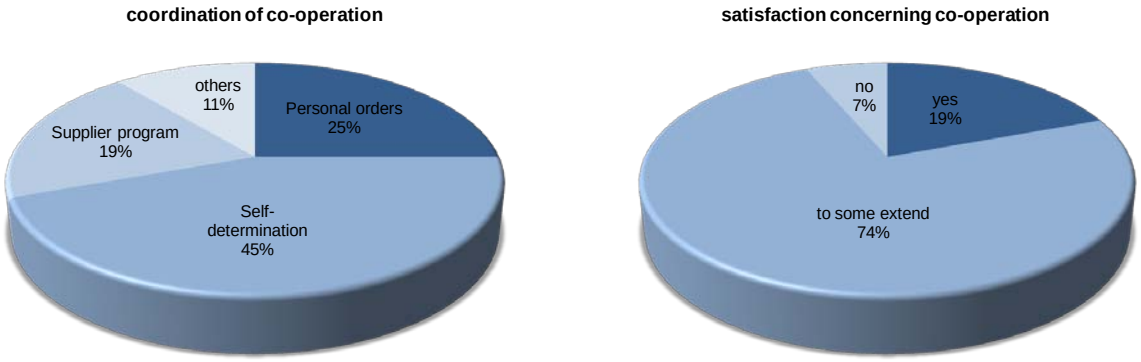

Figure 12. Co-operation forms

Even the handover of the requirements documents happens in most cases in a relatively traditional way. Almost half of these documents are delivered by email and nearly 20% even by mail. Modern requirements management systems, which ensure the topicality of all documents at all times, have

played a minor role for the delivery until now. The reason for this is that 80% of the surveyed suppliers don't use such systems so far.
The stated reasons for this are amongst others:

- High acquisition and training costs
- Resentments of the employees
- Extensive maintenance of the requirements
- Expected exchange difficulties

The lack of suitable systems leads, especially with regard to requirement changes, to difficulties, because no automatism is available and the information transfer is dependent on the respective employees.

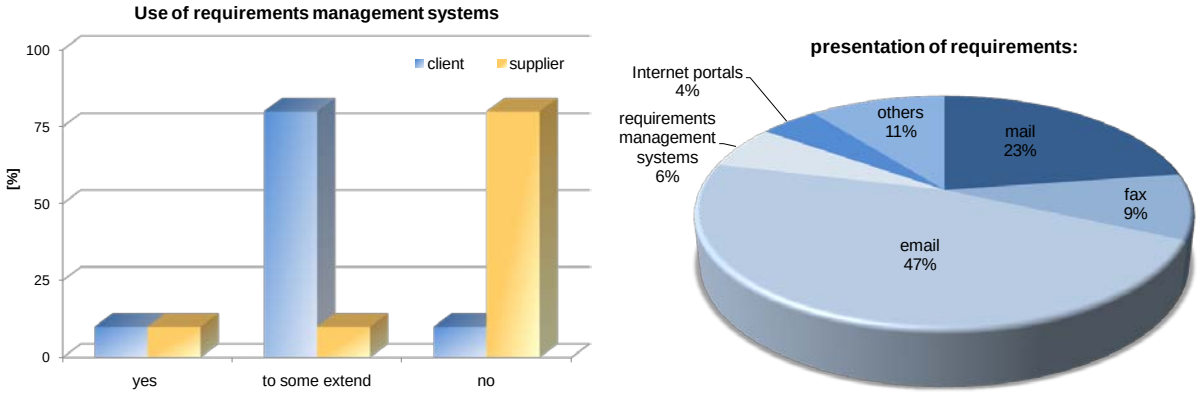

Figure 13. Handover of requirements documents

The presented results show only an extract from the complete survey and should be used together with the other results to elaborate possible means to improve the product development process of the commercial vehicle industry. One way to improve the supplier relations is the simplification and modernization of the data exchange and the improvement of the communication ways as well as the requirements identification. These improvements could be achieved by a cross-company use of advanced software solutions, which provide access to current project data at any time. By using requirements management systems, some main reasons for project failures, see Figure 8, could be eliminated. Figure 14 shows an overview of the main advantages of requirements management systems in the context of the product development.

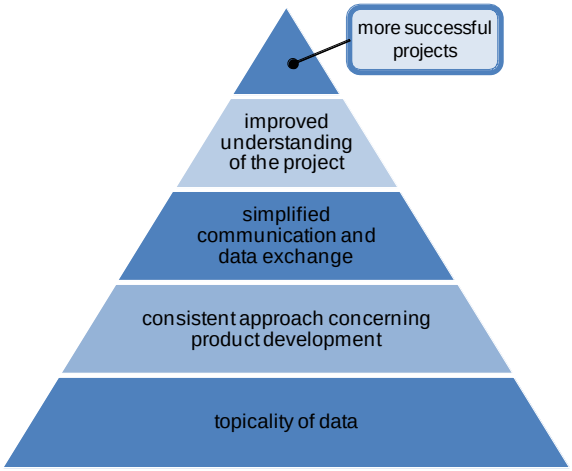

Figure 14. Advantages of requirements management systems

To dispel the doubts of many suppliers concerning requirements management systems, different tools have been investigated and evaluated for their suitability in the commercial vehicle industry, shown in Table 1. To obtain a comprehensive overview, additional systems, as e.g. Rational DOORS are tested at the moment.

Table 1. Investigated requirements management systems

System	Company name
Rational® RequisitePro®	IBM
CaliberRM™	Borland
TopTeam™ Analyst	TechnoSolutions
Polarion® Requirements™	Polarion Software
consentor®	consentor GmbH

The aim of this evaluation is to give a recommendation for qualified and appropriate systems for different company sizes and structures. For this purpose, an evaluation sheet, which is divided into six important fields, see Table 2, was developed. The content of this evaluation sheet is based on the results of a research project, regarding requirements management in the commercial vehicle industry, which was carried out by the Chair of Design in Mechanical Engineering and on the "iX-Studie Anforderungsmanagement" [18]. By means of this evaluation form, the different tools can be analyzed in detail and compared with one another because of using equal criteria.

Table 2. Contents of the evaluation sheet

category	topics (in extracts)	number of criteria	weighting coefficient
Costs and services	license / training costs, support / maintenance, updates / training possibilities	8	5%
Data processing / architecture	operating systems, data formats, database systems, information architecture	23	10%
User management / teamwork	accessibility, user administration, access authorisation distributed working	11	10%
Development of requirements	requirements identification, specification, documentation and traceability	18	35%
Interdependences	creation and traceability of interdependences, graphic illustration	21	20%
Change management	changing possibilities, baselines, automatic updating of requirements, automatic communication	9	20%

The evaluation of the tools is based on the efficiency analysis. All criteria were marked according to their importance with the classifications: absolute must (F1; importance = 100%), necessity (F2; importance = 75%) or wish (importance = 50% or 25%). In this evaluation, a F1-requisite has to be fulfilled completely, because it's absolutely needed for the requirements management. If these requirements are not met, the system is considered as inappropriate. The fulfillment of each criterion is measured by a scale ranging from 0 to 5 points.

The following figures show the results of the so far investigated requirement management systems arranged in the 6 basic categories and the overall results. The system TopTeam™ Analyst showed within the scope of this study the best performance, closely followed by the systems Caliber RM™ and Rational® RequisitePro®. The results of the "smaller" systems Polarion® Requirements™ and consentor® are significantly lower.

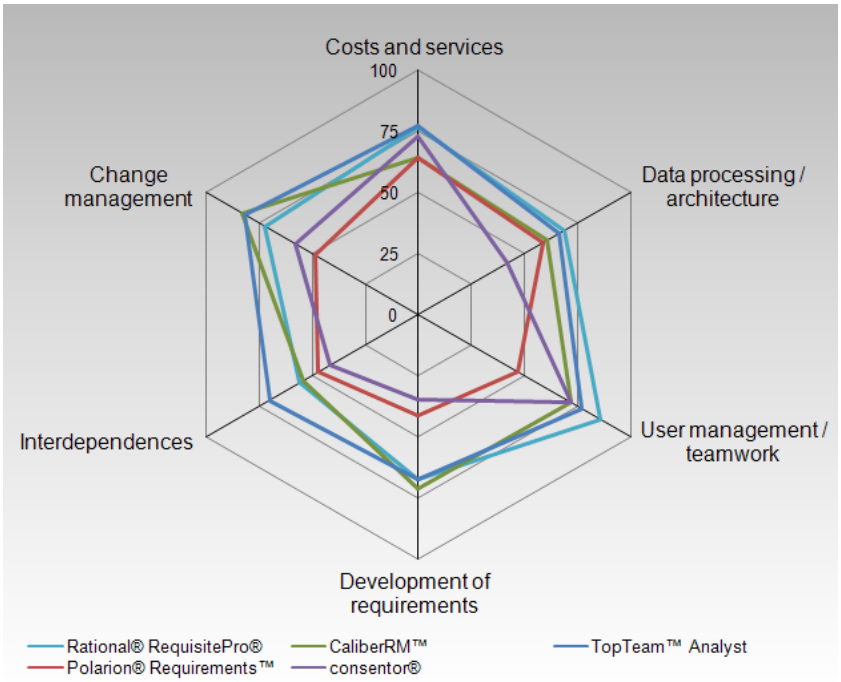

Figure 15. Results by categories

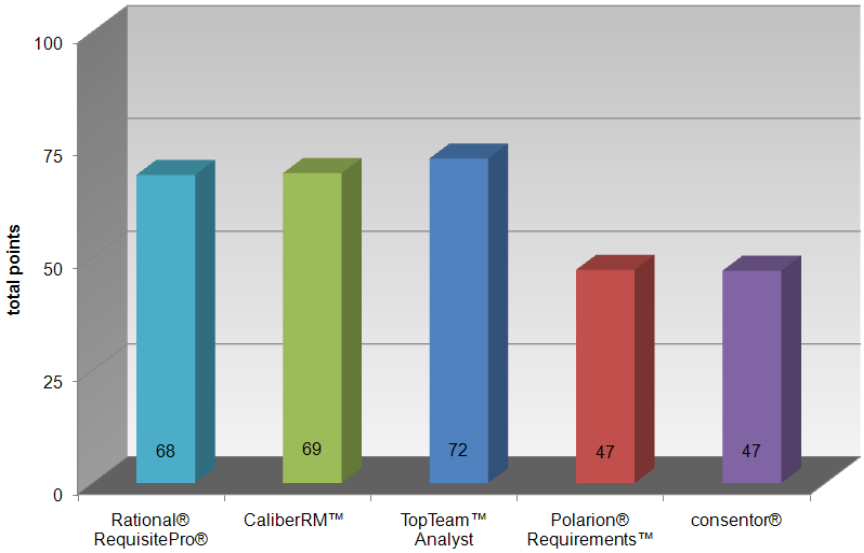

Figure 16. Overall results

In summary, for small and medium-sized enterprises, the system TopTeam™ Analyst by TechnoSolutions could be recommended. Besides the highest score, the comparatively low license costs argue for this management systems. This system achieved good results in all evaluations categories and is absolutely sufficient for the main disciplines in the requirements management.
Especially for large, global acting companies, the possibilities of accompanying software should be considered. In particular, Caliber RM™ by Borland and Rational® RequisitePro® by IBM offer a large number of additional software systems.

4 FURTHER STEPS

Furthermore a corresponding workflow model will be developed. This workflow model, which will also be presented on the conference, describes the optimal co-operation process between client and supplier and should control the compliance with certain formalities like the processing sequences and releases. By such a process it is possible to define obliging rules (e.g. for the requirements specification and management) for all project partners, even before the project starts officially.

A cross-company, unified and determined approach in the context of requirements development can improve the comprehension of the involved employees and will have positive effects on the problems concerning unrealistic, incomplete or incorrect requirements.

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