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Risk profiles for the pre-series logistics in automotive ramp-up processes

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Abstract

The increasing complexity and shortening process duration of ramp-up projects in the automotive industry causes research and industry since years to optimise the ramp-up phase and develop supporting methodologies. Risk management seems to be a promising approach to identify and analyse critical processes. This paper presents a risk survey approach, based on the knowledge of existing methodologies for the ramp-up management. The applicability of these methods and tools depends on the project-specific risks within the sub-processes of the ramp-up phase. Hence, suitable indicators are necessary to monitor the risk drivers and sources and thus to identify the risks. Nevertheless, the adoption of suitable indicators from these sets for an individual pre-series project requires the derivation of a specific risk profile. Based on a framework of pre-series logistics sub-processes a survey approach will be presented, allowing to deduce risk profiles for ramp-up projects. Following, the results of an exemplary survey, which has been conducted at a German premium automotive manufacturer and the resulting logistical risk profile are presented. The paper concludes with a summary and an outlook on further research.

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Keywords: risk management, project management, ramp-up, pre-series, logistics

1. Introduction

Automotive developments are highly complex projects [1] which are driven by the continuous derivatisation and shortening life cycle strategies of the manufacturing industry [2][3]. Complex projects are characterised as chronological, localised and objective work tasks using resources like consumables and labour [4]. Additional costs appear if unexpected developments throughout the project duration occur. Increasing technical complexity of automobiles and the constantly decreasing time-to-market additionally cause new challenges for engineering. The available development time gets shorter and process quality has to be optimised due to the strategic targets [5]. Concluding the latitude for special tasks in critical situations also gets shorter [6].

Thus, important as well as critical is the ramp-up phase of a new or updated automobile, i.e. the last step before start of production (SOP). Approximately 80% of all failures become apparent here whereupon 75% of all failures already originated from the earlier development and planning phase [7]. Nevertheless, the lead time to SOP is usually restricted, and thus, a high number of unscheduled ad-hoc resources are regularly installed to achieve the once set qualitative targets within the given time limits [3]. The increasing amount of disruptions in the ramp-up process causes industry and research since years to develop new methods and tools to support the ramp-up management. Most of the existing approaches focus either on measuring the product maturity degree or the process maturity degree. Caused by increasing technological challenges the importance of risk management becomes more and more apparent. Its advantages to raise the process transparency and early indicate critical situations proves the usability [8]. The application and combination of existing ramp-up methodologies can be applied to prevent disruptions in the ramp-up phase [1]. Furthermore, research confirms the applicability of risk based management methodologies in the ramp-up phase [2].

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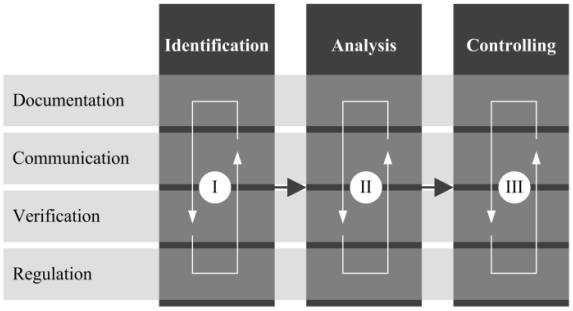

Fig. 1. Generic risk process

In **Fig. 1** the basic processes of a generic risk management process are represented. The first requirement is an identification of risks, wherefore a risk profile of focussed processes is necessary. Consecutively risk analysing methodologies should be applied for supporting the holistic risk controlling [9]. Nevertheless, the applicability of suitable risk management approaches for the problems of the pre-series depends on a respective risk profile which has yet neither been explored nor is available. This paper presents an empirical survey approach to fill this gap in the pre-series logistics research for the automotive industry. Therefore, a classification of the pre-series logistics is given upon where its basic sub-processes are discussed. A detailed survey approach is derived to gain a risk profile for the logistical ramp-up phase.

This paper is structured as follows: In chapter two a process analysis of the logistics processes in ramp-up management is conducted. The related state of the art is presented in chapter three, followed by the description of the developed survey approach, which allows deducing risk profiles for ramp-up projects. The results of an exemplary survey conducted at a German premium automotive manufacturer will be presented in chapter five. The paper concludes with a summary and an outlook on further research.

2. Logistics and ramp-up management

Activities in the product life cycle are structured into three phases:

- The series development (composed of the product and the series process development),
- the ramp-up and
- the series production.

Despite the increasing interest on ramp-up management in the last years, no standardised definition of ramp-up or ramp-up management has been formulated [5]. Most authors define the ramp-up phase as the "period between the end of product development and full capacity production" [10] considering fluent phase transfers. The project targets of this period are to bring a production system up to operation [11] while ensuring process and product quality. The job of the ramp-up management is to coordinate, control and monitor all involved functions within the ramp-up sub-phases [3]. A complete illustration of the relevant processes is visualised in **Fig. 2** (see also [12] and [13]).

During the ramp-up phase – in contrast to the product-development – no prototypes are being build. Nevertheless, to assure the series production readiness automobiles are built under conditions comparable to series production. Usually, two main sub-phases (pre-series phase I and pre-series phase II) followed by a final phase (zero series phase) are introduced which differ in the quality targets both for the product and the production process. Pre-series phase I focusses at least on mould assembled components for mass production. The targets are to prepare the production system and to prove product readiness for the later series production. In contrast, pre-series phase II focusses on optimisation of product and production quality to reach a customer acceptable level. Finally, within the zero series phase all responsibilities are transferred to the series facilities.

Logistics activities in development and ramp-up are divided in practice into two main functions. Logistics planning prepares the logistics processes, i.e. material flow and warehousing, for series production. These activities are strongly driven by information of the development facilities. The logis-

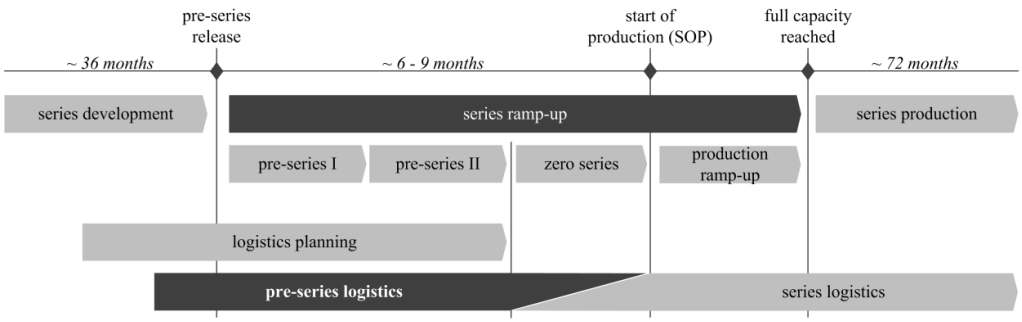

Fig. 2. The product development process

tics planning is not involved in the production of pre-series automobiles or prototypes. The other logistical point of view is the equivalent for the series logistics for the production of prototypes and the pre-series automobiles. ROMBERG AND HAAS [3] define the pre-series logistics as an already series process close department with the tasks

- to ensure the technical quality of components from external suppliers,
- to coordinate the material flow for supply of pre-series production and
- to coordinate the information flow in the pre-series phase itself.

These three main tasks are related to each other and substantial part of all logistics processes in pre-series. **Fig. 3** explicates these tasks and their sub-tasks coordinated by logistics, which are strongly influenced by the still developing product maturity degree. Especially disposition, JiS coordination, program planning, warehouse management and production controlling [14] are challenged by continuously changing components (so called qualitative enhancements), a yet not standardised supply chain structure and the permanently changing bill of material. Respectively, additional measures are necessary to ensure the product quality.

Here, the readiness process is to coordinate these continuously changing components. From the moment components are ready to be manufactured by mass production moulds, pre-series logistics is responsible to supply pre-series automotive production with components of newest technical standards. In result, high communication expenditures between the supplier, the departments for technical development, the procurement and the quality management is necessary. If components have been not only updated but completely changed, change management has likewise to coordinate these departments to prove deadlines. Finally, release management represents the last board before component volumes are approved for series production, i.e. components have to fulfil the defined customer acceptable quality from here on.

The highly complex information structure and fast changing quality gates affect a structured process controlling and causes short term disruptions. Here, risk management approaches can provide suitable methods and tools. The following chapter presents the relevant state of the art in risk management.

3. State of the art in risk management methodologies for the ramp-up phase

In literature, the references discussing risk management for the automotive ramp-up phase are limited. Financially driven performance measurement systems in form of controlling tools dominate literature [15]. Within highly complex ramp-up projects, costs can often not be defined exactly for each process. Thus, the applicability of financial approaches is limited, i.e. non-financial solutions have been focussed in the past.

NAGEL presents a methodology for risk identification within the automotive ramp-up phase based upon the critical path method to identify time-critical processes. Additionally,

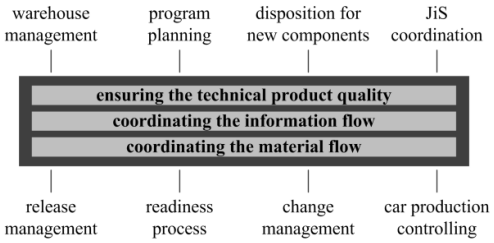

Fig. 3. Pre-series logistical sub-processes

measurement gates are defined to determine the project maturity degree using phase dependent figures. Here, the maturity degree is not influencing the risk controlling but supports the management with an overview of the project status [1].

NAU ET AL. present a risk assessment method for hybrid manufacturing technologies based on the Quality Function Method (QFD) and based on simulation. Here, risks, which have been identified and analysed in a first step, are aggregated by simulation in order to compare them with the risks of alternative processes to offer potentials for optimisation [14]. A third process orientated controlling approach is given by RISSE. Based upon historical information he defines a planning approach to structure different ramp-up processes with the option to optimise them during the ramp-up [16].

In addition to these process controlling sets different approaches have been defined to measure process quality during the ramp-up. GENTNER provides key performance indicators for development projects which measure efficiency by evaluating specific process in- and outputs. Here, the process efficiency equals its quality, providing information about the efficient use of resources [17]. CZAJA has focussed on pre-series supply chain indicators as a base for a risk management. His empirical survey analyses process quality between the manufacturer and supplier [18]. SCHMAHLS proposes a performance measurement system to identify and reduce technical and process-related disruptions from a production oriented point of view near to the assembly line. His measurement approach is based on an optimisation methodology by learning from failures [19].

Because of the high technical complexity of automobiles, product orientated controlling approaches are seldom applied. The gateway concept defines the common qualitative development targets for the product components and the whole automobile in each phase [20]. The high complex information structure and the huge amount of process partner in the development process decreases significantly transparency over dependencies and affects data availability for more detailed maturity degrees. WEINZIERL defines detailed key performance indicators for components (e.g. technical quality, process quality of the supplier) and weights them for each ramp-up phase. He offers a concept for aggregation to derive the overall product maturity degree [21]. HEGNER solves the information problem by concentrating on basic maturity degree key performance indicators for each phase in an automotive ramp-up process. Random trend analysis is applied to forecast the development situation, i.e. of achieving the key performance indicators, thus resulting in the ramp-up curve [2].

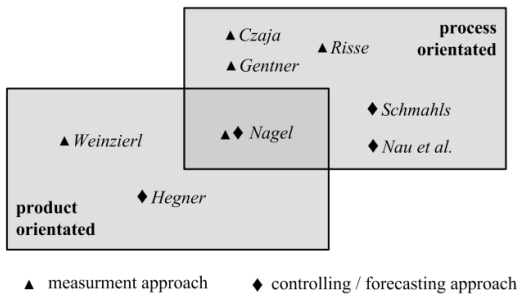

Fig. 4. State of the art

Concluding, the discussion of available methods (see also **Fig. 4**) already revealed the challenges for developing a risk management for pre-series logistics: For any individual pre-series project, the adoption of suitable indicators from available approaches is necessary. The applicability of a certain method or tool strongly depends on the project specific risks within the sub-processes. Therefore, it is for any project necessary to gain more information on its orientation (process or product) and level of detail of data. The next chapter presents a survey approach to derive such a project-specific risk profile.

4. Survey approach

The international ISO standard 31000 for "Risk management – Principles and guidelines" [22] enumerates four organisational risk attributes:

- sources of risks,
- areas of impact,
- events (including changes in circumstances) and
- causes and potential consequences.

The range of sources is not limited to the self-controlled sources. ISO recommends both the analysis of qualitative consequences and effects as well as the preparation of quantitative reports. ISO suggests repeating and assessable processes to identify recent disruptions and analyse their frequencies and impacts. Without emphasizing a specific technique, the involvement of experts is suggested, which confirms a survey approach as a first step for the generic risk process [22]. In the late phases of a ramp-up process – when series processes get installed more and more – this approach is applicable as exemplarily shown by SCHMAHLS [19] or TERWIESCH/BOHN [23].

Nevertheless, this approach proposed by ISO for the identification of risks is restricted in its applicability when it comes to earlier phases in the pre-series logistics processes in the ramp-up phase. These earlier phases in the ramp-up process are mostly influenced by a high degree of process uncertainty. Project management methodologies, e.g. the critical path methodology, are often used to fill this gap by generating indicators to assess the process maturity degree [1]. Nevertheless, the specific function of the pre-series logistics as a 'connector' between process and product complicates the identification of risks. The high technical complexity of the product and therefore the large number of responsible parties for vehicle components increase the number of sources for uncertainties once more, severed by the still ongoing technical changes [24].

In consequence, pre-series logistics processes risks cannot be identified as fully connected to explicit disruptions. For a holistic risk management a flexible characterisation of criteria or indicators is needed, which allows to assess process uncertainties as a basis of a risk index. Only these indicators are able to support the further steps of risk management for the pre-series logistics without implying a necessity for repeating survey processes. Then, this approach can close the gap to identify and rate the risk of the pre-series logistics.

In consequence, this paper presents a survey approach which targets to identify the relevant criteria necessary for developing a risk management for the pre-series logistics which allows to identify "risky" processes. Based on the named four risk attributes three questions have been derived which form the survey framework.

- Which of the presented phases of pre-series logistics is affected mostly by disruptions in the sense of probability of occurrence and severity of consequences?
- What characteristics do these disruptions have?
- What events caused the disruptions, i.e. which processes are responsible?

The decision whether to implement a holistic risk controlling or to apply a more specific methodology strongly depends on the severity of potential risk consequences. The following analysis and classification of frequency, consequences and trends of disruptions over the last years form the basic knowledge for a tailored risk management. The risk effects are structured to the effort and necessary time for mitigation as well as according to whether these risks have impact on subsequent processes or even the overall project target. Furthermore, the respective risk sources need to be analysed in order to identify critical information flows and to distinguish between internal and external process disruptions. This is especially important to identify internal process-related weaknesses.

In the following chapter exemplary results of the survey which has been constructed according to these guidelines are presented.

5. Exemplary survey results

The survey itself was conducted at the pre-series logistics of a German premium automobile manufacturer. 25 experts of the pre-series logistics were consulted. Most of these experts had already supported more than five ramp-up projects, in most cases in different functions and departments.

5.1. Risk areas of impact

In a first step the experts classified disruptions according to their chronological occurrence (see **Fig. 5**). It can be seen, that most disruptions have arisen within the pre-series I and been caused by the preceding development phase. Hence, critical information, for example in form of key performance indicators to measure the risk probability, is input from the development phase. Though, the expert assessment of severity of consequences ranged from pre-series I to zero series, the most critical processes were assigned to pre-series I. It is plausible that early disruptions induce severe consequences in the zero phase (short duration to series production). Considering the disruption probability, risk management has less sense than a measurement method in the pre-series phase II. Furthermore the survey results confirm a tailored risk management approach based on an individual risk characterisation: the experts confirmed higher risk probabilities and more intensive consequences compared to past ramp-up projects. Also the development trend for the future seems unimproved. High efficient IT systems are still seen as one of the most important measures to compensate the increasing complexity, shorter process durations and internationalisation. However almost all experts predicted a stagnation of IT system capabilities in support of the ramp-up process. Thus, the importance of performance measurement and risk management – especially with focus on process quality – was stressed.

5.2. Characterisation of disruptions

With a main focus on the pre-series I the potential disruptions have been detailed in the next step. As **Fig. 6** represents, disruptions usually are resolved rather fast. Disregarding the fast solved disruptions with mean effort (these are mainly caused by wrong or old information or material flow failures), more than half of the experts have classified the remaining disruptions in pre-series I as only solvable with (very) high effort. Even worse, more than 20% could not be solved without inducing negative effects on the overall ramp-up project, time-wise or quality-wise. The main reasons behind these disruptions are false forecasts, rapid changes of once committed dates, not-sufficient quality of components and rapid changes in production demands for pre-series automobiles.

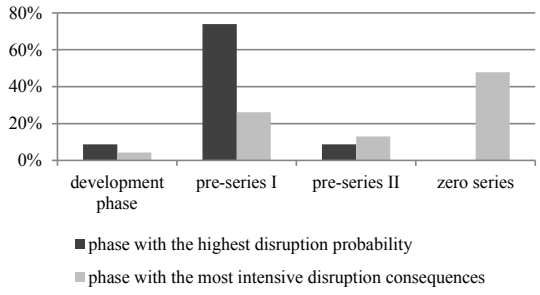

Fig. 5. Chronological classification of disruptions

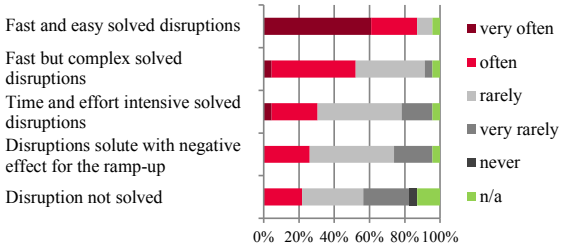

Fig. 6. Characterisation of disruptions in the pre-series I

Interestingly enough, though literature usually emphasizes disruptions in the supply chain between the manufacturer and the supplier, rarely experts named problems in this area.

5.3. Responsibility for disruptions

Triggered by the results from risk characterisation, responsibilities for disruptions were discussed next. In summary, according to the survey a specific department is rarely responsible for causing a disruption. It was stated, that the low quality of the interface between departments causes failures. Especially, the interface between technical and process-related departments, which are intensely involved into the development process, caused the most disruptions. This may be attributed to the strongly differing functional focus. The risk for disruptions increases at all those interfaces, where information about dates and quality forecast has a high uncertainty: Imminent technical quality problems, the adherence to planned technical updates and disruptions in the sourcing process are critical due to the impact and uncertainty of upcoming developments. As already identified in chapter 5.2, all experts have confirmed the low criticality of supply-chain processes for the pre-series. A reason may be that these processes are very communication intensive, but include no severe uncertainties. Furthermore, the disruptions occurring in the supply chain originated mostly from internal processes of the manufacturer (see **Fig. 7**).

These exemplary survey results strengthen the need of a sophisticated risk management in the logistical pre-series phase. The high proportion of internal risks within the project and a concentration on the pre-series phase I illustrate the general problem in information flow between the process and product-related organisations.

6. Conclusions and future work

In this article a survey approach has been presented which identifies and formalises risks within the sub-processes of the pre-series logistics of an automotive manufacturer. Most of the pre-series sub-processes are equivalents to series processes. The main difference is a higher effort on the communication and information flow to ensure a new material flow for supplying the pre-series production; especially under consideration of permanently changing components in the product related bill of materials.

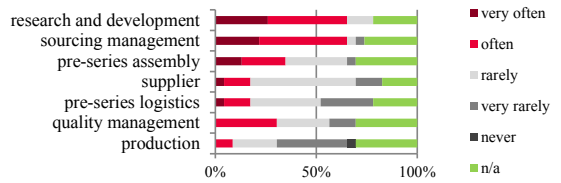

Fig. 7. Risk sources

The results of an exemplary survey at a premium automotive manufacturer demonstrates, that risk management approaches are useful in pre-series I, whereas in later phases a performance measurement approach should be preferred. Furthermore, most disruptions are caused by interfaces between the process and product-related departments. A holistic risk management needs to target exactly this problem. Nevertheless, considering the high uncertainty in this early phase the effort in acquiring all relevant qualitative information and quantitative data (key performance indicators) is often not justifiable. As a solution, the knowledge of experts as well as information from historical ramp-up projects can be applied more easily to identify risks. Nevertheless, the uncertainty of information and data as one of the main drivers for risks need to be integrated. Further research shall focus on this identification and analysis of risks in the logistical ramp-up phase as starting point for an holistic risk management.

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