This is the published version of a paper published in *Procedia Manufacturing*.

Citation for the original published paper (version of record):

https://doi.org/10.1016/j.promfg.2018.06.127

Access to the published version may require subscription.

N.B. When citing this work, cite the original published paper.

Permanent link to this version:
http://urn.kb.se/resolve?urn=urn:nbn:se:hj:diva-41284
Integration of Suppliers’ Workflows in the OEMs’ New Product Development Process

Paraskeva Wlazlak, Kristina Säfsten, Per Hilletofth, Glenn Johansson

* Corresponding author, e-mail: paraskewa.wlazlak@ju.se
a: School of Engineering, Jönköping University, P.O. Box 1026, SE-551 11, Jönköping, Sweden
b: School of Innovation, Design and Engineering, Mälardalen University, P.O. Box 325, 631 01 Eskilstuna, Sweden

Abstract

This research explores integration of the suppliers’ workflows in the OEM’s new product development (NPD) process, to support the production ramp-up. Based on multiple-case study approach, incorporating both the OEM and the supplier perspective, this research explains critical aspects for the integration of suppliers’ workflows in the OEM’s NPD process, and when these aspects need to be addressed. The results show that face-to-face meeting on a project level, standardized work model, readiness of the component specifications, role of Supplier Quality Assurance (SQA) engineer, quality assurance document provided to the suppliers, etc. are critical aspects.

Keywords: integration, processes, supplier, workflow, OEM.

1. Introduction

The prior research concludes that the production ramp-up cannot be regarded in isolation from the previous stages of the new product development (NPD) process [1]. As it is explained the efficient transfer of a product from the NPD’s development stage to the industrialisation stage preconditions successful production ramp-up. However, studies on production ramp-up are often carried out in a single company [2]. Hence, cross-functional integration and intra-organizational issues are primarily discussed [3, 4, 5]. A thorough literature review conducted by Sürbier et al. [6, p.19] indicates that “very few articles consider the suppliers or the whole supply chain when treating the ramp-up issues”. This is interesting since companies have nowadays moved from vertical integration to delegation of various activities to many international suppliers. Consequently, this trend implies that it is no longer the transfer within one company, but rather between the customer and its suppliers working in the NPD process. Furthermore, companies nowadays work in environment with high market uncertainty and changing requirements, which in turn have
consequences for the processes, organization and integration of the suppliers responsible for the customers’ product and production system development, as well as product industrialisation. Therefore, it would be beneficial to extend the production ramp-up studies by incorporating the aspects of supplier integration in the OEM’s NPD process.

The OEM’s NPD process defines not only division of tasks and responsibilities internally, but also determines when and how various suppliers should be integrated in the development effort [7]. The suppliers typically execute OEM orders as workflows. In this study, the supplier workflow is an umbrella concept that covers both the quotation and the industrialisation processes necessary for the supplier to complete its work. For more details see section 4.

This paper undertakes a process perspective to explore integration of the suppliers’ workflows in the OEM’s NPD process, to support the production ramp-up. It encompasses the supplier and the customer views to answer the following two questions: (1) what aspects are critical for the integration of the suppliers’ workflows in the OEM’s NPD process? (2) when the aspects need to be addressed.

2. Literature exposition

2.1. Preconditions for successful production ramp-up

Disturbances during the production ramp-up are often caused by, among others, the product (e.g., insufficient product specifications, late and many product changes), or the suppliers (e.g., timely and quality components delivered by the suppliers) [6, 8]. Supplier problems are mostly related to the inability of the suppliers to update tools, manage relations with sub-suppliers, or change fast production processes when late and many component engineering changes take place. For example, Terwiesch, Bohn and Chea [4] indicate that 20 out of 55 production line disturbances during ramp-up were related to problems originating from the suppliers. Therefore, it is important to find the sources of various disturbances, prior to the actual production ramp-up, i.e., to ensure the fit between the product and production system [9, 3]. In other words, the actual fit of product and production system affects the success of production ramp-up [10], i.e., fast increase of production volumes in accordance to predefine targets of quality and cost [11].

Achievement of fit between product and production system is associated with the companies’ capabilities to manage the integration between the product development and production processes, often executed in parallel during the NPD [4]. The prior research provides important insights about the production ramp-up but omit to discuss the supplier integration issues [12]. This is important since the prerequisites for integration has changed in the last decades, where companies have moved from vertical integration to delegation of various activities to suppliers and collaboration in supply networks [13]. Hence, the question is not how to ramp-up production at the OEM, but rather how to integrate product and production system development processes, executed by various partners to secure the production ramp-up at both the suppliers and the OEM.

2.2. Process view of product development

The NPD is often described as a stage-gate process [14]. Smulder et al. [15] consider the NPD as a single process initiated by an idea and ending with a specific product ready to be delivered at the market. However, it is no longer the case where companies carry out product development, industrialisation and production processes in-house, but rather these processes are executed by various partners along a supply network. Studies dealing with supplier integration, typically present the overall NPD process with various stages and supplier-related activities, such as selecting suppliers, and co-ordination of basic design activities [16]. In some stage-gate NPD processes, the supplier-related activities are mentioned under the manufacturing’ responsibility (e.g., identification of suppliers for key components) [14].

Other studies do not emphasize on the supplier-related activities in the NPD process, but rather focus on the timing of supplier integration [17]. Le Dain et al. [18] present a simplified view of two types of suppliers’ collaboration through the various stages of the OEM’ NPD process; collaborative design and collaborative development. The collaborative development is the focus of this study and covers suppliers that are responsible for industrialisation and production of a component. The major role of these suppliers does not come into a play until the industrialisation stage of the OEM’ NPD process, though, it is recommended that the suppliers are consulted during the design stage to provide manufacturing inputs [19]. Caden and Downes [20] develop an early supplier integration model that takes
care of various deliverables and tasks to be measured and confirmed at each NPD gate. This gateway model aims at
guiding the timing of supplier integration. Fliess and Becker’ [21] is one of the few researchers that seek possible
ways of controlling the supplier integration process in the OEM’ NPD process. Based on a blueprinting method, i.e.
two-dimensional picture, their study represents various deliverables and tasks completed by the OEM and by the
suppliers involved in a co-development process.

Other studies discuss various processes that are necessary to effectively manage the supplier integration in the NPD
process. For example, van Echtelt et al. [22] stress the need for coherence between management of supplier integration
on both process and strategic levels. Further, the prior research stresses the inter-organizational relations and focuses
on internal management and organization of customer-supplier collaborations [23]. Von Corswant and Tunälv [24]
state, for example, that the suppliers’ internal organization of product development and production and their
cooperation with other manufacturers have implications for the management of the suppliers in the OEM’s NPD
processes. Furthermore, Twigg [19] develop a taxonomy of integration mechanisms between the customer and the
supplier with respect to three stages of the NPD process, namely pre-project, design and manufacturing stages.

3. Methodology

The results presented in this paper are part of the research project Efficient Industrialisation Supporting Successful
Production Ramp-up in Supply Chains (INUDS). Based on an exploratory multiple-case study approach, the results
in this study elaborate and add new insights into existing literature on the production ramp-up. Theoretical sampling
was appropriate to enrich the existing literature [25]. The sampling procedure included two steps; first, to minimize
variance a large Swedish OEM was selected, referred to Company Outdoor, i.e., the OEM or the customer. Second,
the Company Outdoor selected two representative suppliers that manufacture according to the customer’s
specifications, henceforth referred as to Company Metal and Company Polymer. Furthermore, the analysis of
integration included not on the Company Outdoor but also other key customers to the suppliers.

Data was collected by means of open-ended face-to-face interviews during 2013-2017. In total, 27 group and
individual interviews were conducted with key respondents at the suppliers. 9 interviews were carried out at the
Company Outdoor. Three workshops served the purpose for verification of the findings. A survey was conducted
during the Supplier Day (see section 5). Answers to the survey were collected from 14 external suppliers to the
Company Outdoor, involved in one NPD project. The suppliers were both located in Sweden and internationally. Data
analysis followed the three flows of steps advised by Miles and Huberman [26], namely, data reduction, display, and
conclusion. Within-case analysis was carried out [27].

4. Description of the OEM’s NPD process and the suppliers’ workflows

The following section shows the Company Outdoor’ NPD process and the suppliers’ workflows, and includes
stages, and activities (inputs/output) of the processes which are considered critical for the success of the process
integration. The suppliers’ workflows are controlled by a quality assurance document provided by the customer at the
beginning of the collaboration. This document contains requirements for APQP (Advanced Product Quality Planning)
and PPAP (production part approval process). These requirements are based on standards from the automotive industry
and the Company Outdoor’s requirements.

The NPD process at the Company Outdoor progresses in stages. The NPD process consisted of 4 stages, namely
specification, development, industrialisation and production stages. The industrialisation stage consists of pre-series
runs and pilot series. The purpose with the pre-series runs (industrialisation stage 1) is to ensure the conformity
between technical specifications and the components produced in equipment intended for series production. When all
the components are technically and PPAP approved, the customer makes an assessment if the complete product can
be released for manufacturing pilot, during the pilot series (industrialisation stage 2). This is followed by start of
production (SOP), where the production rate is gradually increased.

The suppliers’ workflows cover both the quotation and industrialisation processes. During the quotation process,
the suppliers prepare simple tool and fixture layouts, preliminary production methods, measurement methods, and
procurement of materials. The first stage from the industrialisation process refers to tool/equipment design. This stage
begins when the suppliers receive a purchase order. During this stage, detailed design of the tools and production
equipment (e.g. fixtures) is conducted. The second stage refers to tool production/equipment assembly. The production
of newly designed tools is followed by the assembly of the tools together with production equipment at the suppliers’ production sites. The third stage refers to tool/equipment verification. Design samples are the first step of approval of new components by the R&D at the customer, and typically takes several rounds to improve component design. When a component has been successfully tested at the suppliers’ location and verified, the component receives a status technical release. After that the customer sends a PPAP call-off, which trigger examination of the capability of the production process for commencing series production. PPAP-samples, i.e. samples from serial-like production, are examined, and improvement rounds carried out. The suppliers’ workflows end with PPAP-samples approval and production sign-off procedure.

5. Case analysis and findings

The following section contains insights that the interviewees provided while reflecting on the various aspects critical for the integration of the suppliers’ workflows in the OEM’ NPD process. The aspects are summarized in Table 1, where it is also stated the origin of the various aspects and when these aspects need to be addressed.

Table 1 Aspects

<table>
<thead>
<tr>
<th>N</th>
<th>Aspect</th>
<th>Stated by:</th>
<th>When</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Face-to-face meeting on a project level</td>
<td>Outdoor</td>
<td>Beginning of the OEM’s industrialisation stage 1</td>
</tr>
<tr>
<td>2</td>
<td>Standardized work model</td>
<td>Outdoor</td>
<td>Non-stage specific (suppliers’ workflows)</td>
</tr>
<tr>
<td>3</td>
<td>Quality assurance document provided to the suppliers</td>
<td>Outdoor</td>
<td>At the beginning of the collaboration with the suppliers</td>
</tr>
<tr>
<td>4</td>
<td>Internal integration at the OEM and the role of SQA</td>
<td>Outdoor</td>
<td>Non-stage specific (OEM’s NPD process)</td>
</tr>
<tr>
<td>5</td>
<td>Readiness of the component specifications</td>
<td>Outdoor</td>
<td>Before first release to the suppliers</td>
</tr>
<tr>
<td>6</td>
<td>Timing of supplier integration and selection</td>
<td>Outdoor</td>
<td>Before the full technical specifications are completed and released with the project order</td>
</tr>
</tbody>
</table>

*SD: Suppliers’ survey during the Supplier Day

Aspect 1: Face-to-face meeting on a project level. A respondent from the Company Outdoor explained that the Supplier Day “is important since it gets the people [the suppliers] involved and committed to keep up with and understand the project scope and dependencies between components and organizations. The Supplier Day was a unique event, initiated for the first time by the project team in one of the projects at the Company Outdoor. This face-to-face meeting on a project level between the OEM and its suppliers was outside the NPD process, and was carried out at the beginning of the industrialisation stage 1, after the supplier selection. One of the suppliers mentioned: “we appreciated the given chance to talk with different people involved in the project [...] it was good that we met people from R&D as well as management level. This gave the suppliers a chance to see the application of their components, which in turn facilitated discussions between the R&D and the suppliers about the component design.

Another valuable aspect with the Supplier Day was that “for the first time, the overall time plan and the schedule was presented [...] we had the opportunity to know the contact persons from the customer’s side [...] as well as what is expected from us [the suppliers]”. Furthermore, one of the suppliers expressed a wish for more formal communication from the customer side. As it was clarified: “formal documents would facilitate better internal communication [at the supplier]”. In this case, this assisted the communication between the application engineer located in Germany and the manufacturing site in Japan. It was emphasized that “Japanese doubt information that is not formal and hence not working according to it”.

Aspect 2: Standardized work model. The suppliers Polymer and Metal stated that they work according to various customers’ requirements and need to adapt their own work models according to the individual customer. Work models describe how to organize and manage the workflows, and contain critical tasks and responsible persons. There should be no doubt as to the information that needs to be provided to and received from the customer (e.g., technical specifications). As the Company Metal explained: “now the road to the SOP is like a roller coaster, where the work takes on different directions all the time”. The problem is not that the supplier does not have control over its internal
workflow, “but that it depends on the customer that continuously comes with new directions during the development process”. Company Metal reported that one of their key customers (other than the Company Outdoor) had a very structured model for working with suppliers. Hence, the key customer contributed to the Company Metal’s high quality and structure of the internal workflow. This in turn was beneficial not only for this particular key customer, but also for Company Outdoor and other customers of Company Metal.

Both suppliers mentioned that adaptation of the work model based on the customers’ wishes is important competitive factor. However, these adaptations should be made based on the suppliers’ standardized work model. As Company Metal continued: “this work model should not include strict rules but instead has to be rebounded when there is a need for that, if something unexpected happens […] we should find one work model that covers most of the parts of the customers’ work models”. The company Polymer stated that: “a standardized work model would help to coordinate the work internally at the supplier”. This would also facilitate the education of the staff in project management. The education, for example, could start with the suppliers own standardized work model, and after that different adaptations of this model regarding key customers could be discussed. Furthermore, a standardized work model also makes it possible to learn lessons between different projects and implement the lessons in the standardized work model.

**Aspect 3: Quality assurance document provided to the suppliers.** The suppliers mentioned the lack of transparency concerning the Company Outdoor management of its NPD process. For example, the suppliers lacked understanding of the duration of various stages of the NPD process. That is why, representatives from the Company Outdoor suggested that the quality assurance document provided to the suppliers at the beginning of the collaboration should be updated with information concerning the NPD process. According to the customer to provide transparency in its NPD process, the quality assurance document should incorporate a simplified version of the NPD process. It is important to visualize the integration between the suppliers’ workflows according to APQP/PPAP in the Company Outdoor NPD process. As one representative explained: “the NPD process must be linked to the APQP process and they must be harmonized […] it is important to insert relevant parts of [Company Outdoor NPD process] into the quality assurance document”. It was stated that “before the suppliers send a quotation they need to understand all the [Company Outdoor] quality requirements”.

**Aspect 4: Internal integration at the OEM and the role of Supplier Quality Assurance (SQA).** To provide better communication and transparency between the Company Outdoor NPD process and suppliers’ workflows, it is important to define the responsibilities and all roles (e.g., purchasing, SQA, R&D) in each stage of the NPD process, and define who will communicate what and when with the supplier. There are different functions at the Company Outdoor that contact the supplier in relation to one project. As the Company Metal explained, “this creates misunderstandings”. Therefore, it is important that R&D-SQA-purchasing have discipline in internal information exchange. It was recommended that R&D should have internal discussion with the SQA before initiating certain component changes. For example, the R&D can contact the SQA and receive information concerning the stage in which the supplier is according to the workflow. This would facilitate the decision if the supplier should proceed according to the workflow or stop and wait until the R&D has introduced design changes. SQA has an important role to exchange information with the suppliers, for example receive information from the supplier on the time plan and provide information to the supplier when changes occur in the Company Outdoor time plans.

**Aspect 5 Readiness of the component specifications.** A respondent from the Company Outdoor stated that often changes in the component design originate from the insufficient work with the product specifications. Based on customers’ needs the product specifications are established and then the R&D (Company Outdoor) proceed to design and engineer the product. In other words, CAD drawings and specifications are released to the suppliers without thorough consideration of how and if the product specifications can be fulfilled. That is why, the suppliers mentioned that many and late component engineering changes are common practice. On many occasions, the PPAP call-off preceded the components’ technical release. When a component fails during the verification it cannot be technically approved. In practice, as one of the respondents from Company Outdoor explained they often fail with the technical approval so early in the process, and hence it is difficult to follow the steps prescribed according to PPAP. There are many improvements rounds and it takes longer to verify a component, and in order to have a material for manufacturing pilots they need to send timely PPAP call-off to the supplier (even if the component is not technically approved). It was further mentioned by the customer that they lacked procedure to handle late engineering changes. It was suggested that the customer should select suppliers that are prepared to handle changes fast and have good communication channels. Furthermore, physical proximity to the supplier was mentioned as an important factor for rapid management of engineering changes.
Aspect 6 Timing of supplier integration and selection. Early supplier integration was mention by 7 of the suppliers at the Supplier Day. All of the suppliers were provided with technical specifications, and the question of early integration was associated with the possibility of the suppliers to influence the component design before the full technical specifications are released with the project order. It appears that often the suppliers’ input was not searched for at the beginning of the collaboration as the suppliers were provided with fixed drawings and specifications. For example, the Company Metal argued: “we need to focus more on early discussions in the project about the manufacturability issues”. Another supplier stated: “if we are involved earlier it will be possible for us to give more feedback on the design”. Likewise, the Company Metal argued that “early integration would lead to possibility for [the Company Outdoor] to get feedback on the geometry, material […] or simple adjustments that greatly affect the component price and quality”.

Company Polymer stated that the Company Outdoor has the tendency to play-off several suppliers against one another during the development stage and select a supplier rather late. This is in order for the customer to receive the best prices for the production tools and lead-time. Therefore, some of the suppliers emphasized not only early supplier integration but also selection. It was suggested by the represent from the customer that to avoid the engineering changes the component should be developed together with the supplier rather than sending fixed drawings and specifications to the suppliers.

6. Discussion and conclusions

The above data shows six aspects critical for the integration of the suppliers’ workflows in the OEM’s NPD process, that support the production ramp-up. This study undertakes a holistic approach that focuses on both the customer’ NPD process and suppliers’ workflows and considers the interaction between them (input/outputs) rather than studying them separately.

It is worth to mention that all the critical aspects were intended to lower the levels of uncertainty and equivocality by information processing and information transfer from one party to another. Uncertainty occurs where there is a “difference between the amount of information required to perform a particular task and the amount of information already possessed by an individual” [28, p.5]. Reduction of the uncertainty requires acquisition of additional information that will facilitate making decisions and evaluating the probability of future outcomes. In turn, equivocality levels increase when various partners interpret the information differently [29]. Managing equivocality requires exchange of subjective information, which help defining the problems and resolving disagreements [30].

By conducting content analysis, the outlined aspects were classified into three dimensions suggested by Nobelius [31]. The author defines three dimensions to study the link between applied research and product development. The first dimension refers to strategic and operational synchronization and reflects the right time of technology transfer based on technology readiness and alignment of the technologies and the product portfolio. Mismatches in timing are the main obstacles of the technology transfer. The second dimension refers to technology scope and answers the question “what to transfer” (e.g., concepts, prototypes, lesson-learned books). The third dimension refers to transfer management, i.e., how to carry out the technology transfer. This dimension involves methods and procedures for managing the transfer of new technology (e.g., procedures, human factors, organizational bridges) [31, 19]. These dimensions were further used to analyze the transfer of a product from product development to production [32].

The aspect 6 (i.e. timing of supplier integration and selection) could be assigned to the first dimension, namely transfer synchronization. This study shows that missing the right time of transfer of component drawing and specifications is an obstacle to integration of suppliers’ workflows in the customer NPD process. The data shows high levels of uncertainty due to the serial mode of interaction, where the suppliers are involved after the R&D (Company Outdoor) has completed the component drawing and specifications. In most cases the designs were “thrown over the wall” to the supplier [19], and there were less possibilities to ensure the component/production system fit [9]. Therefore, it is not surprising that the suppliers express a need for early integration with possibility to influence the component design and specifications, and hence avoid late and many engineering changes that disturb the suppliers’ workflows. As prior research shows late engineering changes lead to suppliers’ incapability to timely deliver in the right quality during the production ramp-up [8]. Early release of information from the OEM is also related to the issues of early supplier selection. The customer tends to decide rather late which supplier will get the purchase order. This seems not be unique for the suppliers interviewed in this study but rather a common issue [20]. Thus, from the first day of the industrialisation process the suppliers are under extreme time pressure.

The aspect 5 (i.e. readiness of the component specifications) could be assigned to the second dimension, namely
transfer scope. It appeared that lack of sufficient specifications disturbed the steps required according to the Company Outdoor’ APQP and PPAP. It is apparent that the lack of clear requirements of how the design should look like and no requirements on how durable the component should be led to late engineering changes. It seems that the R&D engineers had no structured way to set and investigate the specifications, but rather their work was based on trial-and-error, where many tests had to be carried out before the “good enough” design was frozen. The consequences are associated with lengthier and costlier suppliers’ workflows. Moreover, late design changes imply constant changes in the prerequisites for design of tool at the supplier, which in turn can results in not optimal tools [8, 4]. Therefore, more sufficient work with the product specification, before first release to the suppliers, would reduce many of the uncertainties and equivocality [14].

The aspect 1, 2, 3, 4 (i.e. face-to-face meeting on a project level, standardized work model, quality assurance document provided to the suppliers, and internal integration at the OEM and the role of SQA) could be assigned to the transfer management dimension. On the one side, the Supplier Day provided opportunity for the suppliers to get to know the customer’ NPD process, time plan and requirements on how to conduct their work, i.e. increase the customer’ NPD process transparency. This reduced some levels of equivocality [30] hence, facilitated the suppliers’ preparation for the SOP and volume production. Furthermore, this event could be an opportunity to clarify the steps that the suppliers need to follow with respect to PPAP. On the other side, the Supplier Day assisted in suppliers’ understanding of the product complexity and increased the commitment and trust. In turn, some ideas for component design improvements arose. Hence, the Supplier Day can be considered as an integration mechanism that enhances the mutual adjustment between the customer and the supplier [19]. As the prior research states, face-to-face meetings reduce equivocality as they enable discussions and exchange of opinions [29]. Moreover, it was also an opportunity for the OEM to get to know the suppliers’ requirements as well. As it was recommended by one of the suppliers, working across cultures requires formal ways of communication.

The suppliers’ work models are associated with how the suppliers organize and manage their workflows. Various requirements from the customers increase the levels of equivocality and uncertainty at the suppliers. Standardized work models would reduce the uncertainty internally at the supplier and ease the transfer of lessons between the different managers and projects. Hence, the managers at the suppliers would have an appropriate support to predict future outcomes and scenarios [19]. It is worth to mention, that customers with high requirements can contribute to the internal quality of work at the supplier and supplier workflows, and hence increase their competitiveness.

By updating the supplier quality assurance document with visual figure representing the integration of the suppliers’ workflows according to APQP/PPAP in the OEM’ NPD process, the level of equivocality at the suppliers could be reduced. Hence, the visualization of the meeting points between the OEM’s NPD process and suppliers’ workflows could help reduce the levels of equivocality [29]. This would increase the suppliers’ understanding of how suppliers’ workflows fit the overall NPD process. The idea behind it is to make the communication between the processes visible and to ensure that the suppliers understand their responsibilities. Furthermore, an aspect related to the transparency of the NPD is associated with clear definition of who is contacting when the suppliers during the different stages of the NPD process. It appears that the role of the SQA engineer is important for management of the engineering change. The SQA engineer could help the R&D engineers make the trade-off between finishing task now or continuing with component design improvements. SQA engineer has an important role to update functions to the suppliers, and to provide up-to-date information to the suppliers’ workflows according to APQP/PPAP in the OEM’ NPD process, the level of equivocality at the suppliers could be reduced. Hence, the visualization of the meeting points between the OEM’s NPD process and suppliers’ workflows could help reduce the levels of equivocality [29]. This would increase the suppliers’ understanding of how suppliers’ workflows fit the overall NPD process. The idea behind it is to make the communication between the processes visible and to ensure that the suppliers understand their responsibilities. Furthermore, an aspect related to the transparency of the NPD is associated with clear definition of who is contacting when the suppliers during the different stages of the NPD process. It appears that the role of the SQA engineer is important for management of the engineering change. The SQA engineer could help the R&D engineers make the trade-off between finishing task now or continuing with component design improvements. SQA engineer has an important role to update functions to the suppliers, and to provide up-to-date information to the suppliers. Hence, SQA role is important for the integration, and particularly synchronization of the suppliers’ workflows and the customers’ NPD process.

To conclude, this research extends prior research on production ramp-up by emphasizing on the important role of the suppliers and provide insights into some inter-organizational issues. Moreover, the results strengthen the conception of the component transfer as a process and indicate six aspects of importance for managing the integration of the suppliers’ workflows in to the OEM’s NPD process. Moreover, this research provides insights into when the aspects need to be addressed. Based on insights from Nobelius [31] the aspects were grouped according to three dimensions that are important for the integration of the OEM process and the suppliers’ workflows, i.e. transfer synchronization, transfer scope and transfer management.

The results have also a managerial value. The findings implied aspects of improvement regarding, among others, the transparency of the OEM’ NPD process, the role of the SQA to support the R&D engineers in making trade-off between finishing a component sooner or continuing with design improvements. If the supplier’s workflow and the customer’s NPD process are not well integrated, various problems might arise, for example, inappropriate and low levels of supplier integration or lengthier suppliers’ lead times and increased cost.
The results in this study were generated through a multiple case study and a survey. The perspectives of both the customer and the suppliers were considered. One limitation could be that even though the suppliers manufacture according to specifications (involved in the survey) they might have different characteristics, which can influence the findings in this study, especially regarding the timing of involvement and selection. This research could be further developed in several directions. First, a quantitative analysis can be carried out based on the aspects suggested in this study. Second, it would be beneficial to investigate integration of suppliers responsible not only for the industrialisation, but also suppliers involved in the product design. Third, the paper can explore the supplier readiness aspects to a greater extent in a future work.

Acknowledgements

The financial support for this research was received from the funding agency, the Knowledge Foundation, and is gratefully acknowledged. We also thank the participants from the involved companies for their time and willingness to share their experiences.

References