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TOWARDS A MORE EVENT-DRIVEN NPD PROCESS: FIRST EXPERIENCES WITH ATTEMPTS OF IMPLEMENTATION IN THE FRONT-END PHASE

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ABSTRACT
The search for effective and reliable innovation processes has concerned companies for decades. Stage-Gate (SG) is one of the most common models employed to structure new product development (NPD) efforts. Despite its popularity along with other efforts made to enhance NPD performance, overall innovation failure rates are still reported high. From the perspective of a NPD team SG is not a process at all, it is essentially a series of checkpoints introduced to ensure compliance between resource allocation and perceived business potential. Therefore, NPD teams need a more dynamic environment, focusing on problem-solving and risk mitigation at a more knowledge-based level. The present paper seeks to establish an event-driven NPD process within existing business processes, and determine its applicability in a real-world case study in a company that develops advanced products. An incremental implementation strategy was chosen, introducing the concept in the front-end of a single project, rather than across the entire company. The first experiences show that team performance is improved across three dimensions: outcome (effectiveness); process (efficiency); execution environment.

Keywords: new product development, stage gate, integration events, execution environment, team performance

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1 INTRODUCTION

Nowadays, the growth and prosperity of companies are more than ever before tied to their capability in identifying opportunities (needs), developing concepts and successfully bringing valid products to customers. The market is in constant change, sped up by globalization and new technologies, causing tougher competition than ever (Olsen and Welo, 2011). To sustain in today's ultra-competitive marketplace, therefore, it is widely accepted that innovation is any company's countermeasure against this wicked challenge. Innovation is explained as (Carlson and Wilmot, 2006): "*the successful creation and delivery of a new or improved product or service in the marketplace ... Innovation is the process that turns an idea into value for the customer and results in sustainable profit for the enterprise*." Hence, innovative products are needed and wanted because they provide new value to customers.

However, the high risk and failure rates for technological innovation are also well known; the more newness associated with New Product Introduction (NPI) activities, the higher the risk and the greater likelihood that the product will fail to meet expectations (Flyvberg et al. 2002). One of the major outcomes of the quest for effective NPI processes over the past several decades is the Stage-Gate® model for New Product Development (NPD), (Cooper, 1995a, 1995b, 1998), which was first introduced by R. Cooper based on empirical findings of numerous studies. By 2009, about 70% of US companies are using the Stage-Gate process model or a similar system for their NPI process (Cooper, 2008). Despite its popularity, however, overall innovation failure rates are still reported varying anywhere between 70 to 98 %—a level that would be totally unacceptable for any other known 'process'. Over the years, there have been numerous critiques addressing multiple issues with the Stage-Gate model. It is therefore reasonable to assume that ensuring the success of NPI cannot be obtained solely by a strategy of introducing business decision checkpoints for making high-level choices, ensuring that resources allocated on a specific project represent a good investment for the company. Hence, the Stage-Gate process is essentially a governance tool for prioritization of resources between optional projects (portfolio management).

To its very basics, the purpose of NPD is to make a recipe of useful information that collectively reduces the risk of producing and delivering a new product (Reinertsen, 2009). Since knowledge is the work product in NPD, the usefulness (or value) of any effort undertaken is strongly related to the quality of information provided. Therefore, the process of generating, communicating, generalizing and (re)using knowledge is a core component of innovation (Kennedy, 2003; Ward, 2007). Since NPD project progress is proportional to the rate at which risks are mitigated at both project and company (multiple-project environment) levels, value creation can be assigned to both the product process (from idea through distribution) and the knowledge generation process. In any enterprise, therefore, there are two parallel value streams to which value creation should be assigned: the product(ion) value stream—according to traditional financial thinking—and the information value stream (Shook, 2008). Knowledge creation and becoming a learning organization is the only source of permanent competitive advantage of a company. Seen from any company's perspective, therefore, there may also exist a value stream across different projects, which is the dynamic knowledge standard of the company (Kennedy, 2003) representing a strategic asset of the company. Every NPD project is kicked off with a given knowledge ballast as basis, and activities are thus considered creating value if they result in new learning that is truly used to extend the body of knowledge within the company—even though the knowledge is not instantly useful to a particular project. This presumes, however, that there are 'mechanisms' to capture, transform, generalize and (re)use the knowledge outside the project environment. Organizational learning is therefore directly related to the rate at which new knowledge is converted into becoming an asset of the company for solving future problems.

One important mechanism to make useful knowledge accessible and reusable is by pulling information from each project and into the knowledge standard by introducing a concept denoted *integration events* into the NPD business process, as reported by Toyota (Morgan and Liker, 2006). In all, an integration event is a scheduled dynamic occasion where cross-functional NPD teams collectively solve problems and align solutions to successively mitigate risks on an as-needed basis as project-based learning takes place. Hence, an integration event is a point where the product's value stream and the company's knowledge value stream merge together to address particular issues or problems and use the outcome as input to later events and organizational learning, resembling in many ways a 'Kaizen blitz' in manufacturing. Another primary purpose of integration events is to mitigate project risks by leveraging existing knowledge and best-practices through active involvement of functional managers as technology (knowledge) owners. While Stage-Gate gates essentially are high-level business decision points, integration events are engineering-driven project meetings where knowledge is pulled together in order to solve problems associated with the product design and production processes (Radeka, 2012) and associated interrelationships. In this connection, it may be noticed that Stage Gate processes have evolved from its origin in 1986; e.g. Cooper (2008) has lately provided a next-generation Stage-Gate process that includes elements in the direction of a more knowledge-driven approach. Notwithstanding, the Stage-Gate is, and will always remain, a business governance process, whereas the search towards a more event–driven NPD process is motivated from the desire to establish an execution environment for efficient and effective *guidance* of design and engineering project teams.

The objective of this paper is to identify important promoting and constraining factors associated with the application of an event-driven NPD process concept in a real-life industrial setting. The research questions are posted as follows:

- RQ1: How can integration events, if any, be seamlessly integrated within the existing business process without disturbing the environment around in the implementation phase?
- RQ2: What are the 'low hanging fruits' when it comes to the practices and efforts needed to direct the team focus away from task completion lists to quality of information and knowledge?
- RQ3: Does it work—and what are the experiences made by the team members after the first trials of changing one single stage (front end) in the NPD process?

Since changing existing business processes within an enterprise is associated with considerable risk, complexity and resistance, the study is limited to first attempts to implement key aspects of the concept into the front-end phase of a pilot project. The case company is a large international actor that develops, manufactures and supplies advanced product for the military and civilian markets. The selected team was responsible for engineering and development of a rocket engine for a missile. The paper first gives a description of reasons behind the need for a more event-driven guidance process within the business framework of a traditional stage-gate process, including theory and a brief description of a generic model forming the basis for this investigation. The next part presents the case study, including company description, challenges (current state), the design of the case study along with result and experiences from the new way of executing the early phases in NPD. Finally, conclusions are given.

2 THE CONCEPT OF INTEGRATION EVENTS IN NPD

2.1 The stage-gate model in brief

There exists a number of so-called phase-gate models in the literature; for example, Departmental stage gate model, Saren (1984), Cross-functional models, Network models (Nonaka and Takeuchi, 1995); Activity and decision stage models (Cooper, 1998), or just Stage-Gate, which is by far the most common one. The Stage-Gate model was originally developed as a management tool for NPD processes with the company being the stakeholder and executer. It was conceived to reduce the cost, time, and uncertainty, while increasing the probability of success. The basic idea of the Stage-Gate process is the tollgates to function as filters, making the portfolio going through a funnel that shows a decreasing number of projects with time. To its very basics, The Stage-Gate approach assumes interdependency between the projects included in the entire portfolio, so that one project can be canceled without affecting any of the others. In addition, it assumes that the overall resource capacity is a fixed (internal) quantity, independently of the number of tasks or projects that an individual has to handle at a given time. A generic NPD Stage-Gate process is shown in Figure 1 (Cooper, 1998), including six phases with different time lines and gates, all with different requirement to the detail level of information delivered by the project team.

Stage 1: Discovery is the stage in which an idea is brought to others for evaluation. During the discovery phase, the company begins to narrow down the number of ideas and decide which ones to take further. At Gate 1, ideas are screened and some are given a funding commitment for the next phase based on certain evaluation criteria. The purpose is to get a very limited budget and resource commitment to further explore the characteristics associated with a new technology or product idea. Here it is important to provide a flexible system that stimulates idea generation and creativity in the organization, and to make sure that there is a system to provide feedback.

Stage 2: Scoping is the phase in which the selected product idea is more thoroughly evaluated. Many of weakness and strengths of the idea are identified. The overall objective of Gate 2 is to build the business case by selecting the most promising projects for the following technical assessment based on deliverables from the Scoping phase, including project ownership, scope, goals and documentation required to answer evaluation criteria, which are at a more detailed level than at the first gate.

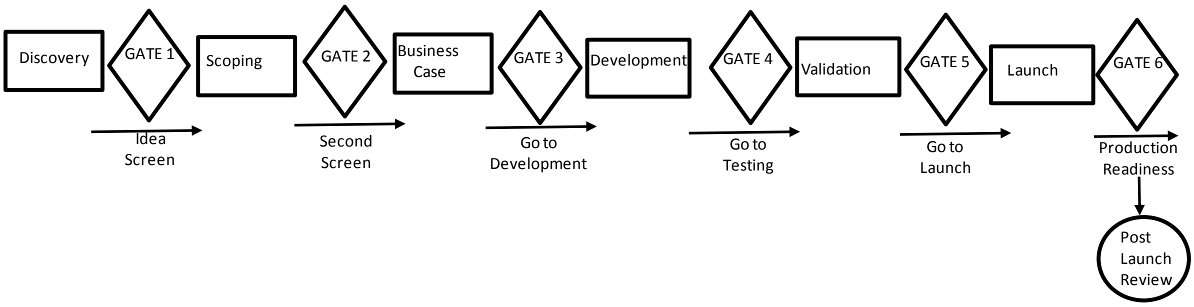

Figure 1. Structure of a generic stage-gate process

Stage 3: Build business case typically includes providing detailed information related to fit to business strategy and strategic importance; strategic leverage; business potential; probability of technical success; probability of commercial success; and financial review. In other words, this is the stage at which the final concept is proven with respect to technology, market, commercial, financial and operational aspects. Hence, the data provided at Gate 3 must be sufficient detailed to build the overall business case of the project. Since this task represents a major commitment to resources and further spending, top management is typically involved in the gate review.

Stage 4: Development is the stage in which knowledge is generated to support decisions related to product readiness (technical and commercial) and further application path. Hence the overall objective of Gate 4 is to conclude on the 'R' in the R&D process, representing a handover to the operational part of the business. This stage involves the execution of the business plan. The product is evaluated with regard to all the (production) processes and other requirements. The Gate 4 review team typically includes top management and project owner, representing the part of the operation that is going to bring the product further to market.

Stage 5: Testing and Validation is divided into different categories of examination related to product performance and market. The former typically includes the path from simple prototype tests at subsystem level (verification) to field testing of product systems produced with production-intent tooling (validation). Validation may also include trials with selected customers (e.g. lead users), providing vital feedback on product's field performance. Testing may also include commercial aspects associated with how the product is received in the market place.

Stage 6: Product Launch is the stage where the organization puts the marketing strategy into place. This includes production schedules and capabilities, quality control plans, distribution channels, prices, training of personnel throughout the supply chain, etc.

2.2 Towards a more event-driven process in NPD

The Stage-Gate model presented above has gained acceptance through its capabilities as a management tool for almost three decades. When seen through the eyes of a NPD team, however, Stage-Gate is not a 'process' as such. Rather than providing engineering guidance, Stage-Gate is a governance process—whose philosophy has roots from investment thinking in finance—which uses a number of gates to determine compliance with (pre-determined) checklists based on certain business criteria, see for example Mascitelli (2007). As a countermeasure to this shortcoming, therefore, many companies employ their own business process or quality system (TS/ISO/QS), project management tools or other methods/tools to provide more design and engineering guidance at team level.

In NPD, value is generated by creating products that differentiate from other currently available offerings relative to the efforts needed to bring the product to market. Thus, the nature of NPD has both process type attributes—i.e., recurring activities where consistency is important to value—and series-of-projects type attributes—i.e., non-recurring activities where variability is important to value. Although the portion of process type attributes relative to project type attributes varies with business model and product category, NPD teams generally need a flexible guidance scheme to allow for knowledge-based problem solving which is unique to each project.

The term *event-driven* has its origin from computer programming, representing a paradigm in which the flow of the program is determined by events—e.g., sensor outputs, user actions or messages from other programs or threads. Hence, the program no longer specifies the sequencing of operations directly but is organized instead as a set of *services* which are ready to be triggered in response to *events*; e.g. a sensor detecting a temperature change. At any time, the next event determines which service gets solicited. Once that service has carried out its function, the program gets back to waiting for events. In business process modeling, for example, event-driven process chain is a type of flow chart used for resources planning and business process improvement (Hommes, 2004). When translated into the world of NPD, an *event-driven scheme* means that the Stage-Gate system ('program') does not by itself defines the order of operations nor determines which external conditions to evaluate. Instead the specific project and the actual challenges to be solved ('external world interaction') determine the focus and sequencing among a set of options in response to, say, the knowledge gaps identified at various integration events. Hence, the project dynamics—rather than a rigid, one-size-fits-all system—is in charge of the tasks and sequencing.

One of the most basic recurring challenges in NPD is to ensure that transformation of knowledge shifts from one function to another function. This occurs in association with transitions between functional areas as well as minor handoffs between individual team members. Therefore, any effort that encourages cross-functional collaboration is important for improving value creation in NPD. One example that has successfully promoted cross collaborative problem-solving is the so-called *kaizen* event, which is one of the most commonly used improvement tools in lean manufacturing (Morgan and Liker, 2007). Bringing together and empowering a cross-functional team for focused problem-solving events, following a standardized agenda and tools, have proven to be very successful. The idea is that some elements from this principal kaizen concept can be applied to NPD by integrating a series of standard work events into the existing Stage-Gate model. Hence, combining standard work with product design-specific problem solving and knowledge assessments at different stages in the NPD process may stimulate collaborative work to takes place in a structured manner.

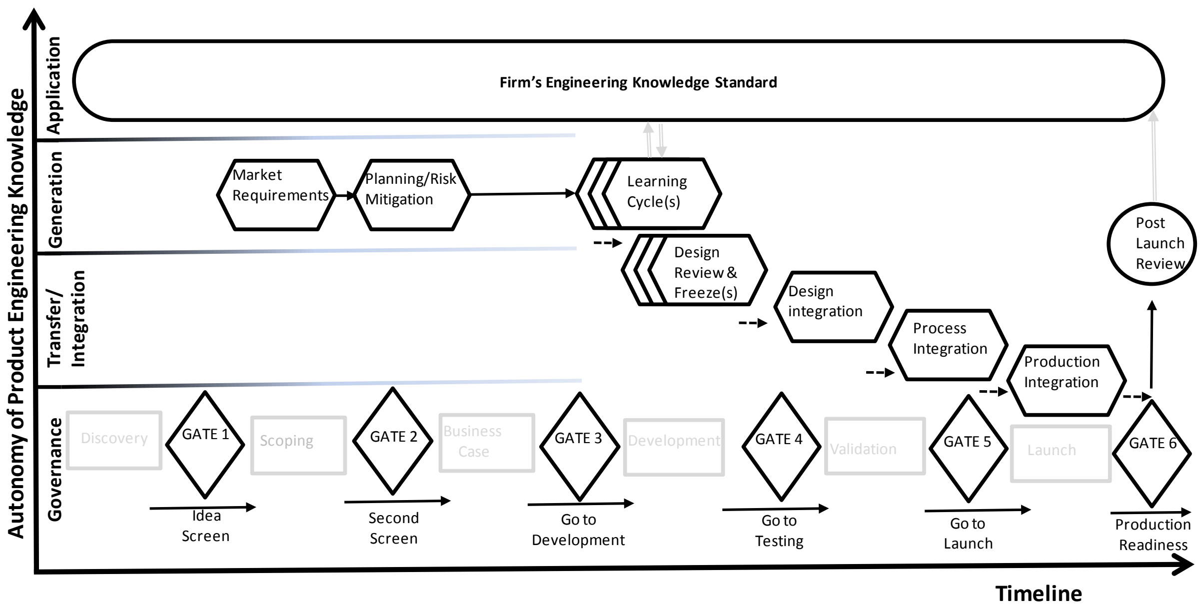

Figure 2. Structure of a generic event-driven NPD process integrated within the framework of a traditional business process (Stage-Gate and Knowledge Standard).

A principal event-driven NPD process is illustrated in Figure 2 with the gates in a traditional Stage Gate process high-lightened at the very bottom of the figure and with the events shown in a parallel stream above. To emphasize a key feature associated with the present approach, the process charts are drawn within a principal graph where the vertical axis reflects the *autonomy of product engineering knowledge* as a basis for decision-making; hence, as learning cycles are completed and main design elements frozen, the nature of the events will to an increased degree be driven by the business objectives and governance. The horizontal axis represents the timeline. At the very top of the figure, the company's engineering standards are illustrated as a source for continuous application in R&D. Here formalized learning cycles is a methodology used to capture and document new knowledge for application within the project as well as for updating the knowledge standard. In a multi-project environment, therefore, continuous exchange of knowledge between the individual project and the engineering standard is a key mechanism for increasing the value of knowledge, making it become an important asset of the company. In addition, making knowledge available through capture, generalization and standardization, is a documented strategy to save time, reduce risk and cost, and prevent design re-loops in the next round. The present example shows a scheme that includes seven types of events (Mascitelli, 2007), including Market requirements, Project planning and Risk mitigation, Learning cycles, Design reviews, Design integration, Process integration and Product integration. Here it should be noted that each of these events is integrated as a part of the regular development process, including the Stage-Gate process. Their structure (input, agenda and output) is determined form standard work while the actual content is driven by the identified needs for generating new knowledge that collectively reduce the identified risks in the project. Hence, the scheme has much in common with kaizen events in lean production, where co-workers collectively solve problems and improve existing processes. One difference, however, is that in case of an event-driven NPD process, the major amount of work (knowledge creation and problem solving) takes place between the events—not during the event itself. The events serve to collaboratively assess deliverables, apply standard tools and methods, make valid choices, assign actions and establish a path forward, focusing on continuously solving product engineering problems at team level.

3 DESIGNING THE CASE STUDY

3.1 About the case company environment

The case company is a high-tech company located in Norway with core competence within development and production of ammunition, rocket motors, and shoulder-launched munition systems. Advanced use of high strength metals and polymer composites, and combinations of these, makes the company a preferred supplier to leading defense system integrators around the world. The case company has more than 2,000 employees in different production sites in six countries, and its ownership is equally shared between the Norwegian and Finnish government.

Product performance, quality, and reliability are main drivers in the defense and aerospace industry, providing strict guidelines for how product development projects are conducted. Moreover, it is not unusual that it takes 10-12 year from concept to a qualified and customer-approved product is ready for delivery. This time horizon calls for focus and awareness of choosing the right concept along with follow-up of cost, time, and risk by stringent management routines throughout the different (sequential) project stages. Due to the strong dependencies and interrelationships gradually evolving over time under these requirements and conditions, avoiding design iterations and re-loops are keys to ensure a successful outcome. The company has in response to this important challenge introduced a series of dependent improvement initiatives. Back in the early 1990's, the company initiated an internal program named Total Quality, which was soon replaced by Agile—an improvement program that all suppliers to a major American defense actor had to comply to. Agile is a methodology commonly used in the software industry, and is elsewhere used in situations and environments for activities where scope and content are somewhat dynamic; thus, Agile is a highly relational approach to project work and product development processes.

Today SixSigma is the preferred, and main, tool to systematically improve products, processes and work routines. In total 11 people hold a black belt rank and more than 40 hold a green belt. Fact-based decisions (supported by data) are central in SixSigma. Moreover, SixSigma is a suitable approach for identifying and assessing knowledge gaps, and define actions to close critical gaps. Establishing practices to document project decisions and the rationale behind them through explicit knowledge is of crucial importance when projects last for many years. The number of actors escalates during the course of the project, and the team that ultimately launches the product may not at all be the same as the one who initiated it. Recalling the introduction of separate value streams above, another reason why documentation practices grow in importance as time passes is the strategic value of continually transferring knowledge to other projects. Thus failing to provide, or delaying the generation of, correct information and valid knowledge may incur severe costs to a project-driven company.

3.2 The current situation

The traditional way of executing product development projects within the case company is similar to practices within most other manufacturing firms. One of the key characteristics associated with these practices is that the product design is locked in at an early stage; that is, *point-based design* approach. From this point of no return, the team put all their efforts into modifying the base design to meet requirements with the suboptimal starting point. The actual reasons for such an approach may be plentiful; however, informal conversations with a select number of project team members revealed a few interpretations:

1. “we like to start with the known—which gives a perception of rapid progress”
2. “we dig into details too early”
3. “we do not involve and dedicate enough resources up-front”
4. “we do like to come up with our own inventions—without checking the status at the neighbor team or what has been previously done”.

These insights are supported by many studies from different perspectives, see e.g. Reinertsen (2009) reporting on factors associated with unsuccessful outcomes from the product development processes. All these examples may be summarized into the need for an alternative path, one that enable the creation of more knowledge through experimentation and testing multiple alternatives early on; hence, delaying the design selection as far as possible to the point where as much knowledge and information as possible are available—within the constraints of the critical path of the project. The approach is commonly referred to as *set-based concurrent engineering* or just, ‘test first-and-then design’ as opposed to the traditional point-based approach, i.e. ‘design first-and-then test’, Kennedy (2007).

Overall, it is not easy to change the culture of a project organization into a ‘test first-and-then design’ type of mindset. The most feasible way of testing out new design principles in a mature organization is defining a pilot project. In the present case, one tempting opportunity came along when the company was offered to compete for an attractive business contract; and even more importantly, following the conventional design process in the early phase from request-for-quote to submission of offer, would in this case not be realistic due to the extremely tight time constraints associated with the project. The principles behind the alternative path where inspired by results derived from being part of LPD research projects for over five years.

3.3 The pilot project in-brief

The missile products division has developed and produced advanced Rocket Motors, primarily for the NATO (North Atlantic Treaty Organization) market since the early 1960’s. The main niches within tactical propulsion technologies are rocket motors for short-range air-to-air missiles and boosters for medium to large size naval missiles. In 2010, an international customer asked the case company to qualify an alternative rocket engine, providing an uninterrupted supply, for a new product. The reasoning behind the need for a second supplier source stems from identified problems with this original supplier of rocket motors.

The present product supports an all-weather and all-environment medium range missile system in response to NATO and other allied operational requirements. To become certified as a supplier on such a short notice, however, required a new concept stage approach. As compared to normal timelines for this type of projects, in this case they had less than one third of the time usually required to come up with a fire-ready prototype.

3.4 Methodology

An assessment sheet was made to continuously track the progress of implementing the concept of integration events within the NPD process scheme. The assessment was structured into three main components (categories), which collectively reflect the success of introducing the concept of integration events: Overall result (O); Process (P); Execution Environment (E). Each of the components were divided into four characteristics (sub-categories), representing the believed most important elements within each one. For example, the component Process (P) was divided into Focus (P1), Communication (P2), Leadership (P3) and Collaboration (P4). Each characteristic was divided further into a set of easily identifiable statements; e.g., for P4, “In this integration event, standard processes, methods and tools for collaborative decision-making, problem-solving, and conflict reduction were used. In general, decisions were taken by the team as a whole on basis of facts and documentation—and not by the higher-level manager(s)".

The assessment structure was used as basis for semi-structured interviews with senior project people to determine how the concept was received and experienced in the team. The main results from these interviews, made after the completion of the concept phase of the project, are summarized in Table 1 in the result section below.

4 RESULTS

4.1 Implementation

The concept of integration events was only introduced in the concept stage of the project; that is, before the project heads into a more customer-driven phase. Still, there were clear requirements to time schedule, first prototype ready for ignition, and customer-defined milestone. Below is a summary of actions taken to achieve a better new product development process, product quality, timing and cost performances within the new concept of integrations events in the NPD front-end phase. Hence, securing more frequent and better communication with focus on knowledge creation and quality of (engineering) delivery, rather than compliance with check sheets and business targets focused in Gate reviews within the Stage-Gate process.

4.1.1 Replacing 2D drawing with 3D models

By focusing on rough 3D models (skeletons) as base line instead of heading into detailed 2D drawings with measures, characteristics and dimensional tolerances, the team created a new and common language, which shaped a better foundation for communication and decision making in the project. This approach was also mirrored in the PLM system (Product Lifecycle Management) where all participants in the project could view models and alternatives, say, as a part of the preparation for the next meeting. Earlier project teams spent long hours on conducting design/construction reviews, where a lot of people were gathered to complete task-based check lists and review every minor detail on particular drawings. The improved visualization possibility with the 3D model approach led the discussion towards interfaces instead of points. Thus, by establishing a common, more visual, platform for communication the team achieved better involvement and engagement, providing true cross-functional collaboration and commitment. In addition, bringing people together at an early stage to work with a common project language secured better coordination and more parallel activities.

4.1.2 War room

A project war room (also referred to as *Obeya* room in the lean production literature) was established and fully dedicated to the project team. The purpose of the war room was to have an infrastructure in place for planning and prioritization of resources to perform project activities and to visualize status, responsibilities, progress and further actions. This project environment formed the location for frequent and short stand-up meetings where the team members typically reported on progress, where they were in the process and how they planned to close defined knowledge gaps. Risk and knowledge gaps were listed, followed-up by green (OK), yellow (needs more attention), and red (in need for a SixSigma project to define root cause) tags on a board. This methodology was inspired by the approach for defining knowledge gaps suggested by Mascitelli, (2007). In summary the method is based on the assumption that project progress can be related to the rate at which, say, the top-ten risk issues mitigate over time. The idea is that the at-any-time most critical risk issues are collectively assessed and ranked within the team. It should be noticed that risks may increase within certain shorter periods as new knowledge is generated, but seen in a longer perspective the collective risk score of the top-ranked risk issues must decline, vanishing at the time of project launch.

4.1.3 Strategies to close knowledge gaps

By identifying knowledge gaps at an early stage, the case company was able to distinguish between research (internal customer) and development (external customer), avoiding highly uncertain activities on the critical path of the project. To mitigate risks defined with red tags (see above), the company more than before initiated SixSigma projects to solve problems at the root cause on the basis of more fact-based decisions. In a SixSigma project, the defined phases Define, Measure, Analyze, Improve and Control completes the DMAIC data-driven improvement problem solving cycle. The main objective to undertake such a SixSigma project is for optimizing and stabilizing business and designs processes. Traditionally, SixSigma projects where defined to solve problems in manufacturing, but during the course of this project they found the approach also adequate for testing and verification in the concept stage of a NPD project. Other design tools such as Ishikawa (also denoted fishbone diagrams) and Design Of Experiments (DOE), together with better integration of computer-aided engineering tools, explicit (dynamic) and implicit (static) Finite Element Analysis, with physical component tests to build a broader organizational knowledge base, were used to accelerate concept processes and decision making.

4.1.4 Chief engineer (project manager)

Based on past experiences, it is a widely recognized that the degree of success of a NPD project is heavily dependent on having a dedicated and experienced project manager onboard. In the present project, therefore, the appointed project manager had extensive experience within management and SixSigma as a methodology for continuous improvement (black belt). The approach is similar to the one used by Toyota, who uses an experienced, entrepreneurial chief engineer to lead the development of new vehicles.

It is noteworthy that the project was given top priority by top management, and labeled ‘high-impact’ due to its value potential with one of the key players in the industry being the customer. Allocating sufficient resources at any time was therefore not an issue. Thus, the basic organization structure was determined by strong support from the top management and an experienced chief engineer with strong technical background, authority and close relations to both the top management and the customer.

4.2 Assessment summary

According to the project classification system used by the case company, this project was ranged medium in terms of complexity and technology newness. The company had some years ago developed a forerunner with some similarities. Still, they did not categorize the product as a carryover. What they experienced was that the customer, more than ever before, followed up project progress and quality requirements—which could be explained by the failure of the original supplier and the following reduced time span to complete the concept design.

Table 1. Summary of key findings from the semi-structured interviews.

Dimension	**Traditional concept approach**	**New concept approach**
O1. Overall Result	Often costly loopbacks and need for extra resources close to milestones, but performance, quality and time are never altered	Concept phase reduced from 10 to 3 months with the same performance, quality, cost and resources
O2. Output Assignment	Unstable processes in verification and ramp up stages	More robust product transfer from development to manufacturing
O3. Commitment	Dedicated and engaged team	Dedicated and engaged team
O4. Collaboration	All day meetings with many participants and unclear expectations	Short stand-up meetings involving the needed resources
P5. Focus	Milestone oriented – identifying risks late in the process	Risk mitigation and knowledge gaps – identifying risks early
P6. Communication	Through formal project meetings	By focusing on interfaces a common language was established at an earlier stage – frequent and informal
P7. Leadership	Dedicated project manager, but not acceptance of heavy front loading	Experienced project manager with SixSigma black belt – and dedicated resources from the beginning
P8. Group Processes	Dedicated resources with a plan for project up-scaling	Frontloading of resources who worked together on defined product interfaces
E9. Structure	SixSigma approach, but more sporadic use of this methodology	SixSigma methodology with clear rules for identifying risks and knowledge gaps
E10. Support	Detailed 2D drawings – focusing on details	Rough 3D model – focusing on interfaces
E11. Infrastructure	Available meeting rooms	Dedicated war room with information boards for meeting and visualization
E12. Enabling tools	Inconsistent use of improvement tools and PLM system	Structured through SixSigma projects

Table 1 summarizes key results, based on the anticipated correlation between process, results, and execution environment, obtained from implementing a methodology that leveraged bridging knowledge gap by systematic problem-solving in the early stage of the pilot project.

5 CONCLUSIONS

Based on the investigation made herein, the following conclusions can be drawn:

- The need for an event-driven NPD guidance process for prioritization of project efforts based on knowledge gaps, rather than business investments and check sheets, has been identified and elaborated;
- A description is given of how the concept of integration events can be integrated within the framework of existing business processes, using an incremental implementation approach introduced in one single phase of a pilot project;
- The 'low hanging fruits' for capturing value from the concept includes tangible measures such as war rooms, boards for visual planning and management, stand-up meetings, closing knowledge gaps through learning cycles, chief engineer and 3D modeling;
- An assessment tool providing a summary of the experiences gained throughout the concept phase in a real-life pilot project has been developed and completed.

For the case company this pilot project has derived such positive results that the core principles are implemented into other concept studies. Further research will report on this broader implementations strategy.

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