Improved Product Development Performance through Agile/Stage-Gate Hybrids

The Next-Generation Stage-Gate Process?

Combining a Stage-Gate process with elements of Agile development offers a more flexible alternative to conventional Stage-Gate NPD systems.

Anita Friis Sommer, Christian Hedegaard, Iskra Dukovska-Popovska, and Kenn Steger-Jensen

OVERVIEW: Product development at manufacturing companies is increasingly complex. Linear product development processes, including the traditional Stage-Gate process, cannot support the iterative cycles and external collaboration that characterize today's product development efforts. Hybrid processes combining elements of Agile and Stage-Gate models offer a more flexible alternative to conventional systems. A comparative case study of seven technology-intensive companies shows how combining Stage-Gate models, at the strategic level, with the Agile method Scrum, implemented at the execution level, can offer performance improvements and other advantages over even improved Stage-Gate processes. The key contribution of this study is a generic Agile/Stage-Gate hybrid process based on best practices as identified in the case companies.

KEYWORDS: New product development, Agile, Scrum, Stage-Gate

As globalization increases competition, product life cycles are decreasing in almost all technology-intensive industries (Jou et al. 2010). Companies have to deliver new products, and more customer value, faster than ever to stay competitive. This forces innovators to think about more flexible ways of managing product development without sacrificing efficiency (Tatikonda and Rosenthal 2000); companies are exploring a range of different solutions to find the best new product development process for their unique requirements (Hong et al. 2010). One of the avenues being explored is the adaptation of Agile methods from software development in the context of existing Stage-Gate processes (Cooper 2014). Case studies on integrated product development (Ovesen 2012) and software engineering project management (Karlstrom and Runeson 2005) show similar trends.

However, there has been little research on how the integration of Agile and Stage-Gate processes may affect performance. Motivated by these trends, we conducted a multiple- case study to explore how integrating Agile models with Stage-Gate processes can help improve NPD performance for manufacturers.

Agile Methods for Product Development

Process models and methods become increasingly important to product development management as process complexity grows (Browning and Ramasesh 2007). Most companies

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today rely on some version of the Stage-Gate process (Ettlie and Elsenbach 2007), which is linear in nature and relies on extensive documentation across a fixed set of activities (Cooper 1979). These models consist of a series of product development stages, typically starting with idea generation followed by development and implementation phases, and ending in a final product launch or evaluation stage.

The advantages of Stage-Gate include increased development speed, better quality, greater discipline, and better overall performance compared to informal development processes (Cooper, Edgett, and Kleinschmidt 2002). The aim for many of the tools associated with the Stage-Gate process is to decrease iterations by predicting the process from the start (Zhang 2012). Many adaptations of Stage-Gate are focused on improving performance at the "fuzzy front end" (Koen et al. 2002), and thus reducing iterations through the development process.

However, in an increasingly complex product development context, some change iterations—even at the later stages of development—are unavoidable, and may even be crucial for a successful outcome; thus, the aim should be not to eliminate iterations but rather to induce them at the most productive points of the development process (Leon, Farris, and Letens 2013). This mindset—that iterations are to be managed rather than eliminated—is an embedded part of the Agile product development approach (Schwaber 2009; Tseng and Abdalla 2006). Agile methods are lightweight, with faster, nimbler processes than those invoked by more-traditional development methods (Abrahamsson et al. 2003).

Today, no less than nine different Agile methods have been described, including Scrum, Crystal, Extreme Programming, Adaptive Software Development, Agile Modeling, Dynamic Systems Development Method, Feature Driven Development, Internet Speed Development, and Pragmatic Programming. Each method offers different advantages and each comes with its own set of tools and approaches and its own development culture. However, most of these methods do not directly consider all aspects of project management; rather, they supply tools to support discrete elements of the product development process. Only the Scrum framework is explicitly intended for managing projects across the development process (Abrahamsson et al. 2003).

The Scrum Framework

Although it was originally developed for the software industry, Scrum has begun to attract serious interest from the industrial product development community. The Scrum method was first widely adopted by IT departments; the results of those projects attracted the attention of other departments, including R&D, where it is beginning to be seen as an alternative method for managing new product development.

The Scrum model, as described in the definitive text on the subject, *The Scrum Guide* (Schwaber and Sutherland 2013), includes three repetitive stages: product backlog development, main sprint, and daily sprints (Figure 1). The Scrum model is iterative; the three stages are repeated throughout the product development process as the solution develops, with each iteration leading to increased customer value. The *product backlog*, which functions as an alternative to a business case or demand specification, contains a list of features that may or may not be included in the final product. Initially, the product backlog is developed in collaboration with both external and internal stakeholders. The development process is then broken down into a number of *sprints*, high-productivity work cycles that may vary in length from two to four weeks. Each sprint works from a *sprint backlog*, which describes the set of priority features (or product increments) to be developed in the current sprint, selected because they are high priority and they can be completed within the defined period of the sprint. While a sprint is under way, the sprint backlog may not be changed.

The development activities required to produce the new features or incremental improvements described in the sprint backlog are broken down into a number of sub-activities, each requiring no more than two days to complete. The sub-activities are described on sticky notes on a *Scrum board*, which is maintained in a dedicated project room. Once every 24 hours, the team has a 15-minute stand-up meeting, called the *daily sprint*. At the daily sprint, each team member briefly states what he or she has done since the last meeting, what he or she will do by the next meeting, and what problems he or she is having. Following the daily sprint, team members work on addressing the problems identified in the meeting and may change the scheduled sub-activities to accommodate them.

Progress is monitored during a sprint using a *burndown chart*, a two-dimensional

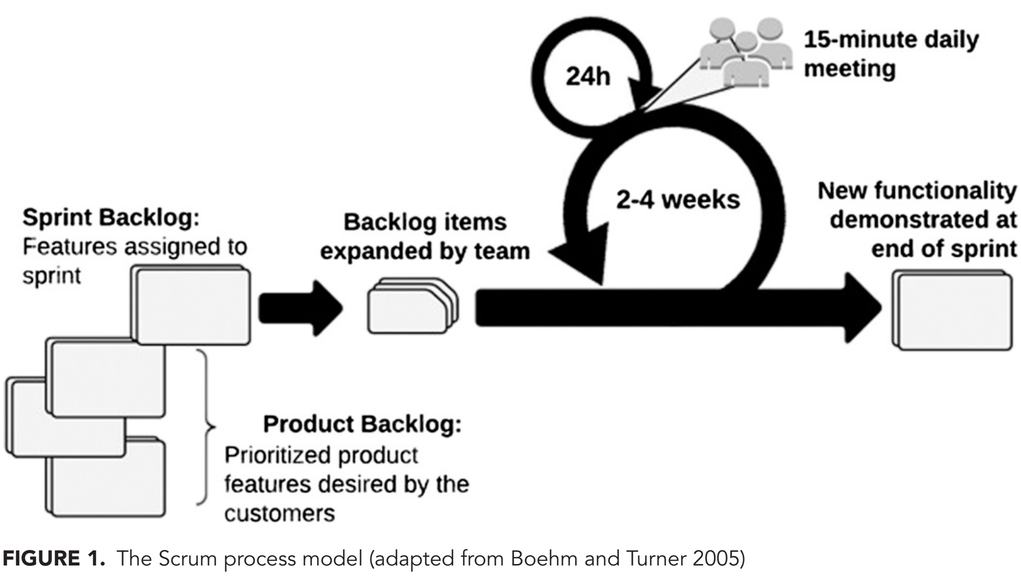

FIGURE 1. The Scrum process model (adapted from Boehm and Turner 2005)

graph with the sprint time period on the x-axis and remaining sprint task times on the y-axis. Ideally, as the sprint progresses, the remaining task time is a linear function of the remaining sprint time. If task completion is lagging, it will immediately show on the burn-down chart, as the line starts to curve at a smaller gradient compared to the linear baseline. The burn-down chart maintains an ongoing focus on executing tasks according to plan and provides a visual overview of progress.

A sprint is defined by a time period; the sprint ends as scheduled regardless of whether all of the features on the sprint backlog have been completed. When a sprint is over, the results are evaluated against the product backlog. At this point the product backlog may be modified in agreement with the customer and other key stakeholders based on changes in customer requirements or on new knowledge emerging, for instance, from test results. Features named in the sprint backlog but not finalized during the sprint are placed at the top of the product backlog. When the new product backlog is final, a new sprint backlog is developed and a new sprint cycle is initiated. The iterations continue until the requirements listed in the product backlog are fulfilled or customer expectations are met.

Begel and Nagappan (2007) studied the implementation of Agile development in software companies and identified three primary benefits over Stage-Gate software development: improved communication and coordination, quicker releases, and flexibility to allow quicker responses to changed customer requirements or technical context. However, Scrum does present some challenges for manufacturers, among them a lack of scalability, a proliferation of meetings, and a lack of management buy-in due to the differences from the Stage-Gate systems most managers are currently comfortable with.

Scrum and Stage-Gate

Recent work shows that implementing Scrum does not necessarily mean abandoning Stage-Gate; rather, Scrum can be added to Stage-Gate (Cooper 2014), creating an Agile/Stage-Gate hybrid that incorporates features of both systems. Although companies are adopting Agile/Stage-Gate hybrids for new product development (Cooper 2014), little work has been done to explore the consequences of this choice, including its impact on performance measures, especially compared with the more conventional approach of improving the Stage-Gate process.

Cooper (2014) has argued that Agile/Stage-Gate hybrid approaches should outperform existing Stage-Gate processes. However, empirical performance studies of hybrid models are still scarce; we identified only two (Begel and Nagappan 2007; Karlstrom and Runeson 2005). To fill this gap, we sought to illuminate the performance outcomes of Agile/Stage-Gate hybrids compared with improving Stage-Gate processes. More importantly, we set out to develop a generic model for hybrid new product development processes that incorporates the best practices identified in our study.

Implementing Scrum does not necessarily mean abandoning Stage-Gate; rather, Scrum can be added to Stage-Gate, creating a hybrid that incorporates features of both.

The Study

To explore these questions, we focused on product development processes at manufacturers of products with a high degree of complexity. Seven manufacturing companies in a variety of industries participated in our in-depth case studies. Participants were identified by contacting academic researchers, consultants, and company managers to locate companies in their professional networks that either were about to improve or had recently improved their product development processes through implementation of Scrum or through improvements to their Stage-Gate systems. The seven participating companies identified through this process are producers of wind turbines, valves and sensors, insulin, plastic toys, music amplifiers, windows, and cross-country power cables.

Four of the seven companies were followed through time as they implemented improvements to their NPD systems. Two of them, WindT and Valves, sought to improve NPD performance by upgrading their existing Stage-Gate processes, while the other two, Windo and Power, implemented Scrum and developed Agile/Stage-Gate hybrids. These longitudinal studies, which followed the implementation of improvements as they unfolded, provided direct insight into the changes implemented and their results. Three other companies that had developed and implemented Agile/Stage-Gate hybrid processes using Scrum—Pharma, Toys, and Electro—were also included to provide a deeper understanding of hybrid NPD processes and their implementation. These companies were studied retrospectively. Although the nature of the improvements varied, all of the case companies initiated improvements in their new product development processes in response to significant challenges including, among others, exceeded project budgets, overarching lack of process control, and chaotic resource allocation.

We used a range of methods to collect data, including interview studies, observation studies, and review of internal documents and emails. Interviews were conducted with direct process stakeholders, including project managers, team members, line managers, process improvement managers, and customers. Observation studies were conducted at process improvement team meetings, project team meetings, steering committee meetings, and internal workshops. The internal documents included process models, descriptions and examples of tools and methods in use both before and after the improvements, and other relevant documents. Finally, emails were used to track process flow between activities. The interviews and observations were recorded and transcribed when possible; when recording was not possible, extensive notes were taken during meetings and afterward developed into detailed summaries.

Transcribed interviews and summaries were analyzed using a conceptually ordered display in which statements were clustered according to subjects of interest (Arbnor and Bjerke 2008). These displays were compared to the process models and other data in a joint, iterative research process that moved between theory building and data analysis (Eisenhardt 1989). This resulted in an overview of the participating companies' NPD process models, methods, and performance outcomes, which formed the basis of a comparative analysis. The longitudinal case studies were based on more data and as such carried a higher internal validity than the cross-sectional, post-implementation case studies. A final cross-case analysis led to a generic Agile/Stage-Gate hybrid framework based on the best practices identified in our analysis.

Finally, a questionnaire was developed to assess the relative importance of the perceived advantages and disadvantages of hybrid systems, identified from interview data, in the five companies implementing this solution. The questionnaire was administered to project managers from the five participating companies at an external workshop arranged by the authors. At this workshop, findings and conclusions were also discussed and the applicability of the generic solution framework was evaluated through group dialogue.

Findings

The seven companies included in the case study implemented a range of process modifications to address deficiencies and failure points in their new product development processes (Table 1). These modifications, supported by a selection of new tools, were intended to increase visibility, reduce process complexity, and improve performance with regard to budget and schedule targets.

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Improving Stage-Gate

Two companies, WindT and Valves, retained their Stage-Gate models, but modified them to address weaknesses, adding additional stages and gates and implementing supporting tools. WindT initially employed a basic Stage-Gate model, using the same process across business units. In interviews before the implementation of the process changes, employees revealed that they struggled with the lack of models or methods for managing NPD. One project manager stated, "We have a generic project model, but it is not operational in detail. So from this level and down it is up to the individual project manager how to do it." The solution to this problem was the addition of a new five-step Stage-Gate process within Phase 4 of the existing process and the implementation of an online tool kit. The tool kit offered a more detailed Stage-Gate model applicable to all projects, templates for all mandatory deliverables in a project, a project portfolio management tool for the top management group, an implementation plan and education program for all employees, and control and follow-up tools for project portfolios.

Valves enhanced its Stage-Gate model with an additional set of methods for customer-initiated product development. The motivation was a management report showing low market success for customer-initiated product development

TABLE 1. Case study process modifications and tools instituted

Process Type	Company	Process Modifications	Tools Instituted
Stage-Gate	WindT	Added 5 steps in stage 4 (product design) of existing 7-stage model	Toolbox including manuals, best practice, and ideas for improvement
	Valves	Added an iteration step in first phase of existing 5-phase model	Product specification sheet, idea selection scoreboard
Hybrids	Pharma	Added Scrum in step 4 (product design) of 6-step Stage-Gate model	Scrum boards, burn-down chart, daily Scrum, product backlog, value-chain model
	Toys	Added Scrum as alternative to step 3 in 5-step Stage-Gate model	Scrum boards, burn-down chart, daily Scrum, product backlog, work packages
	Electro	Added Scrum for project execution and retained Stage-Gate for strategic project management	Scrum boards, burn-down chart, daily Scrum, product backlog
	Windo	Added Scrum for project execution and retained Stage-Gate model for strategic project management	Scrum boards, burn-down chart, weekly Scrum, product backlog, value-chain model
	Power	Added Scrum in steps 3 and 4 (requirements and analysis) of 5-step Stage-Gate model	Scrum boards, burn-down chart, daily Scrum, product backlog, work packages

caused by a significant lack of knowledge sharing, along with a new company strategy that called for increased customer orientation. Prior to the implementation of the improvements, sales managers described the company's customer-initiated NPD process as leading into "a black hole" in headquarters, where product requests would be left unanswered for months only to emerge as final products. To resolve this problem, the implemented solution included a more flexible front-end process with less required documentation and a more informal process iteration between headquarters and sales, which increased the level of informal communication. Furthermore, methods for idea selection and portfolio management were implemented to focus increased attention on strategy, and a structured document flow and document storage system were designed to provide increased visibility across the process.

These changes yielded little in the way of measurable performance improvements. WindT saw no decrease in budget overruns, and lack of visibility and control within and across projects remained a problem. Most active development projects are still exceeding both schedules and resource estimations. Interviews indicate that the challenges of WindT are caused by a dysfunctional culture rather than simply a lack of appropriate models and methods. Interviewees pointed to the company's "fear of failure" culture and its "culture of secrecy." The improvement initiative did not target cultural changes, since this is not an explicit part of the Stage-Gate methodology. Agile methodologies, by contrast, bring with them the Agile value set, which, among other things, promotes knowledge sharing and acceptance of change as an embedded part of the process.

Valves saw moderately better results. Its "hit rate"—the percentage of developed products ordered by any customers—improved from 48 percent to 61 percent. This means that in 39 percent of cases in which the company developed and released a product based on customer request, the product never sold. Although this is a significant improvement, it is still far short of the company's goal of 90–95 percent. Furthermore, employees reported experiencing only minor improvements under the new system, and several interviewees told us they did not experience any changes that positively affected their performance. For instance, a project manager told us, "Nothing has really changed in the past year . . . We have a better view on our requests and process globally, but that is just statistics. It doesn't really help us with anything." A senior sales manager said, of the front-end process, "Everything considered, I have not gotten what I hoped for. There is still too much bureaucracy . . . now I even have two more coordination meetings every week. We needed to reduce complexity, which has not happened."

Project efficiency was enhanced through continuous resource reallocation, enhanced process visibility, and enhanced communication and knowledge sharing.

Developing Hybrid Systems

Five companies implemented Scrum methods alongside their existing Stage-Gate systems, creating hybrid Agile/Stage-Gate processes.

In Pharma, NPD had experienced significant project overruns and issues with resource allocation. The company chose to implement Scrum to support project execution, since some project managers had heard positive reports from their peers. After implementation, the company maintained Stage-Gate for steering committee meetings and portfolio coordination but used Scrum within most projects. The management team also implemented a value chain coordination process that includes a daily meeting, held at a centrally placed whiteboard picturing the company value chain. This meeting is attended by department and project managers, who share progress and, when necessary, work together to reallocate resources.

Performance improvements were documented through an internal evaluation report. The report showed significantly improved project efficiency across development projects. Our qualitative post-implementation study supported those findings and showed that efficiency was enhanced through three practices: continuous resource reallocation, enhanced process visibility through the use of visual tools, and enhanced communication and knowledge sharing within and across projects.

Toys struggled with a growing mismatch between Stage-Gate requirements and project activities. As a result, employees frequently abandoned the Stage-Gate tools, creating a chaotic situation characterized by redundant activities and a lack of process visibility. Based on the experience of the company's IT department in using Scrum, the management team decided to roll out Scrum as an addition to Stage-Gate, while maintaining the steering committee/board role and some of the existing Stage-Gate tools. Today, Scrum is fully integrated into the company's NPD standards as an addition to the traditional Stage-Gate process. Projects running with Scrum have dedicated project rooms with Scrum boards and use Scrum methods.

Toys did not produce internal performance measurements of its hybrid process, but our interview study revealed that the hybrid process has reduced process iterations and thus resource consumption remarkably, and it is now supported throughout the organization. The management team believes the success of the hybrid process arises from improved process visibility, better-defined goals, and the development of high-performance Agile teams with a high degree of employee ownership and team independence.

Electro was drawn to Scrum in a time of financial crisis. In the wake of a management shake-up, the new CEO committed to implementing Scrum from the top down. As with the other companies in our sample, Electro used Scrum for project execution while maintaining Stage-Gate processes for communication and overview within steering committees. The most significant change was the introduction of Agile values, which are now physically visible as the "Agile value tree" depicted on walls throughout the company. The hybrid process has allowed Electro to maintain a constant product introduction rate and improve market success even with a workforce reduced by 25 percent. Our data show that the hybrid process also decreased customer complaints, reduced late-stage change orders, and increased team morale and employee motivation. The company now has a solid sales and growth rate, which the management team believes has been produced by "going Agile."

In Windo, the major performance issue was time delays caused by frequent rework due to lack of knowledge sharing within projects. One of Windo's house consultants recommended a pilot implementation of Scrum in three project teams, which ultimately went full scale. Here again, Scrum was added to the company Stage-Gate standard; Stage-Gate methods were used within steering committees and Scrum was used by the project teams. Company reports show that the hybrid process reduced rework by at least 20 percent, and data from interviews also show increased customer collaboration in early stages of product development, more cross-organizational collaboration, and better resource coordination.

The final company, Power, had experienced a high level of activity iterations, delays, and redundant work, which they found was related to a mismatch between their Stage-Gate process and the complexity of the process activities. The company IT department had implemented Scrum, and the dynamics within the IT teams intrigued project managers in R&D. A pilot study ultimately lead to the implementation of Scrum at two stages within the existing Stage-Gate process. The outcome of the implementation included fewer iterations as a result of increased cross-organizational coordination, improved process visibility, and increased employee motivation.

All five companies retained Stage-Gate models for strategic management, using Scrum to structure execution within the development teams. Project teams report to a steering committee that uses a Stage-Gate model to monitor project progress, budget changes, and expenses. As a Pharma project manager described it, "We now run most of our development projects with Scrum . . . but our management board still measures our progress with the old Stage-Gate model." In other words, Stage-Gate and Scrum are applied at different planning levels.

In operation management, planning and control are divided into three levels: strategic, tactical, and execution (Stevenson 2005). Strategic planning and decision making takes place at the strategic level, weekly resource planning occurs at the tactical level, and day-to-day decisions are made at the execution level. The division between strategy and execution is present in all five companies, and four of the five have a distinct tactical level as well, focused on resource planning and knowledge sharing across project teams. The intermediate tactical level is valuable because it facilitates the integration between Stage-Gate and Scrum in the hybrid systems. Electro was the only company implementing a hybrid process that did not have a distinct tactical planning level. Instead, that company integrated the Stage-Gate approach directly with Scrum activities, including the entire Scrum team at steering committee meetings and frequently involving committee members at Scrum meetings.

All five companies retained Stage-Gate models for strategic management, using Scrum to structure execution within the development teams.

The implementation of that tactical layer varied, however. Pharma applied a value-chain model, presented in a visual representation that illustrated value flow across departments. The team used this representation to facilitate tactical project evaluation at portfolio meetings. The value-chain board is maintained at a central location. Each day, representatives from each department meet at the board to present their status and changes in resource needs. At this meeting, the R&D department representative presents the resource demands (most often changes in needs) within R&D projects. Windo also uses a value-chain model (a large physical board depicting the company's internal value chain, capturing the value-creation process across company departments to support collaboration) to involve all relevant departments in project evaluation, increasing business process integration across departments. Employees at Windo and Pharma find the value-chain model quite useful, as it helps them coordinate projects and operations on a daily basis. As the R&D manager at Pharma told us, "By noon, I know exactly what is going on in the entire organization . . . I cannot imagine how the company has survived so many years without it. Now I have complete visibility from the bottom up."

In contrast, Toys and Power incorporated work packages from PRINCE2, a project management standard developed by the British Government (Figure 2).[1] Work packages are template-based documents stating the deliverables from each employee and team; these are developed at the beginning of each stage in the PRINCE2 Stage-Gate process. However, when deliverables change during a stage, which is not uncommon in complex development projects, there is no procedure for adapting work packages. Work packages are static documents assigned at the initiation of each stage, unlike the value-chain models used by other companies, which offer a dynamic method to respond to changing resource needs. The implementation of work packages as a tool to integrate Agile and Stage-Gate at the tactical level

[1] PRINCE2 (Projects In Controlled Environments version 2), developed by the British Government, includes among other tools a template and method for applying work packages, which are detailed descriptions of project deliverables created before the activity is initiated (Office of Government Commerce 2002).

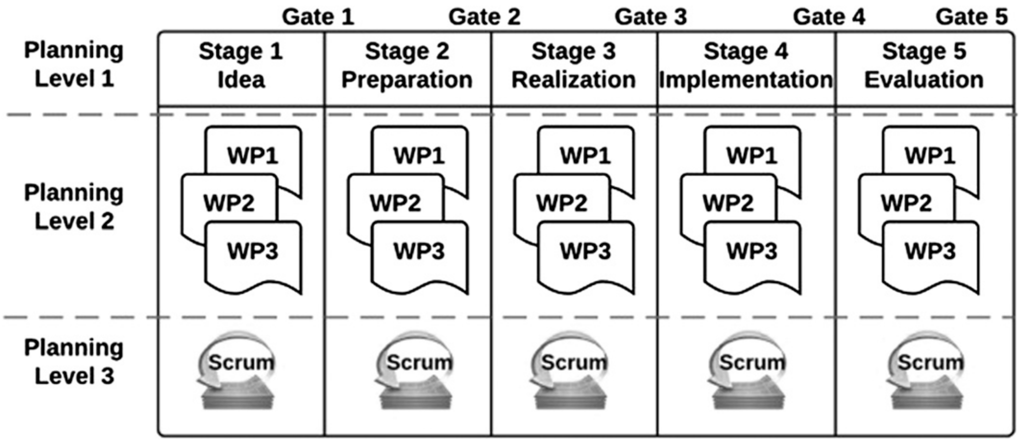

FIGURE 2. Planning levels in Agile/Stage-Gate hybrids with work packages

brought distinct challenges to both companies. As a Power employee told us, "We have to jointly agree (with the steering committee) on these work packages, but we never follow them in practice once we get started, and I find that we put too much work into something we do not really use."

Comparing Performance Results: Stage-Gate Only vs. Hybrid Systems

Comparing the case studies reveals a significant difference in performance results between companies seeking to improve NPD performance by improving existing Stage-Gate processes and those implementing Agile/Stage-Gate hybrids. While Stage-Gate improvements yielded little or no measurable change for our two case companies, those implementing Agile/Stage-Gate hybrids experienced major improvements, in some cases supported by significant performance measures (Table 2).

The companies were inspired to change by various performance challenges. Our data show that in all cases, management perception and internal analyses linked financial loss to process performance challenges. At the same time, project managers in all of the case companies advocated for change, actively making their needs known to management. Hence, the change initiatives were all initiated from the bottom up, indicating that resistance to change was relatively low in all of our case companies.

Measuring quantitative improvements was problematic, as only three companies (Valves, Electro, and Windo) used quantitative performance measurements. Pharma engaged

TABLE 2. Case study performance challenges, measurements, and improvements

Process Type	Company	Performance Challenges	Quantitative Performance Measurements	Qualitative Performance Improvements
Stage-Gate	WindT	Uncontrolled iterations, budgets overruns, delayed projects due to resource constraints	No performance measurements within or across projects	No improvements identified
	Valves	Hit rate (% of finalized products actually sold) at only 48%	Hit rate increased from 48% to 61% in two years, still short of target hit rate of 90%	Perceived project performance remains largely unchanged
Hybrid	Pharma	Budget overruns, project scope creep due to lack of visibility, insufficient resource allocation	Qualitative measurements through informal evaluation showed perceptions of significantly improved project efficiency	Improved resource allocation, improved communication, increased knowledge sharing, more process visibility
	Toys	Mismatch between Stage-Gate and project activities creating redundant activities and lack of process visibility	Performance measurements not available	Improved visibility, better-defined goals, improved team independence and employee ownership
	Electro	Company crisis due to low market performance of new products	Reduced workforce by 25% while maintaining product introduction rate	Increased market success, decreased customer complaints, eliminated change orders in late stages, and increased team morale and motivation
	Windo	Inefficient development process, frequent delays due to inadequate knowledge sharing	Rework reduced by at least 20%	Increased customer collaboration, improved cross-organizational collaboration and coordination
	Power	Mismatch between Stage-Gate activities and process activities generating unnecessary iterations and redundant work	Performance measurements not available	Increased cross-organizational coordination, increased visibility, increased employee motivation

TABLE 3. Advantages and disadvantages of hybrid processes

Priority	Score*	Advantages	Score*	Disadvantages
1	10/0/0	More flexibility in design process	7/1/2	Delays due to resource distribution
2	9/1/0	Improved communication and coordination	5/4/1	Lack of fit between reward system and method
3	9/1/0	Increased team productivity	5/2/3	Lack of Agile culture in the organization
4	8/2/0	Improved prioritizing of tasks	4/4/2	Insufficient knowledge management across functions
5	8/2/0	Better fit between work process and methods	4/4/2	Project documentation too bureaucratic
6	8/2/0	Improved morale and motivation	3/4/2	Difficulty of ending or handing over projects

* Scores are listed as high/middle/low.

in an internal qualitative study of NPD process performance, but the other three case companies employed no performance measurements at all, making it impossible to track changes in performance. At these companies, engaged people drove the change process without the support of solid proof that it was working.

However, we could track, via interview data and observations, perceptions of improvement. Analysis of interview transcripts provided an overview of the perceived advantages of the improved processes. In our analysis, improvements highlighted by a majority of interviewees in a given company were compared with observations and data gleaned from company documents to create a list of qualitative performance improvements, captured in Table 2. This list of improvements may not be exhaustive, but it represents the most recognized improvements in each company.

However, perception of improvement was not universal. There were notable differences in perceptions between companies sticking to Stage-Gate and those implementing hybrid models. At WindT and Valves, companies that focused on implementing changes to their Stage-Gate processes, most interviewees did not recognize a positive impact on performance. Only a few stakeholders at the heart of the initiative perceived minor improvements, such as slightly more cross-organizational collaboration and improved documentation templates. By contrast, interviewees at all five companies that implemented Agile/Stage-Gate hybrids reported significant positive effects from the changes to the NPD system. A cross-case analysis suggests that these performance improvements may be correlated to increased knowledge sharing and communication, improved resource coordination, increased visibility, and team empowerment. However, quantitative studies with a large pool of respondents are needed to confirm the existence of such a correlation.

Despite our findings of positive performance effects, hybrid processes are not without their own challenges. In a follow-on questionnaire, participating project managers were asked to indicate the major advantages and disadvantages of hybrid systems (Table 3). While the top advantages fit with our findings with regard to performance improvement findings—including increased flexibility, improved communication, and a better fit between process and tools, the disadvantages point up the potential challenges in implementing such systems: respondents reported that projects were (still) delayed by hiccups in resource distribution, that there was a lack of fit between the reward system and the methods, and that there is a lack of an Agile culture to support the implementation in their organizations.

Finally, we find that the significant change is not only in the tools and methods that are used, but perhaps more importantly in the change in organizational values. As stated by a Scrum master in Electro, "If the Scrum Guide is read like the devil reads the Bible, it can become the most rigid method of all. Scrum has to be based on the Agile values, and the team must be empowered to make their own decisions." In other words, the first step toward an Agile approach to NPD is an awareness of the Agile value set, as expressed in the Agile manifesto (Fowler and Highsmith 2001), which states that product developers/designers should value:

- Individuals and interactions over processes and tools,
- Functional products over comprehensive documentation,
- Customer collaboration over contract negotiation, and
- Responding to change over following a plan.

These points capture a shift in values based on a different understanding of what is important to manage. An expression of Agile values can be seen in the tool set evolved to manage complex product development projects. As complexity increases, static tools (like Gantt charts and project plans, documentation, and task specifications) become a burden to maintain. Worse, if these tools are not updated as the process changes, incorrect and outdated information will remain in the process, undermining trust in the tool. In Agile, static tools are replaced with dynamic tools (such as the burn-down chart, the Scrum board, and the product backlog), and the process itself ensures continuous updating of the information in the tools, which in return increases trust in them. Since they are built to evolve over the course of a project, these tools do not aim for comprehensiveness. This means that management must let go of an element of control

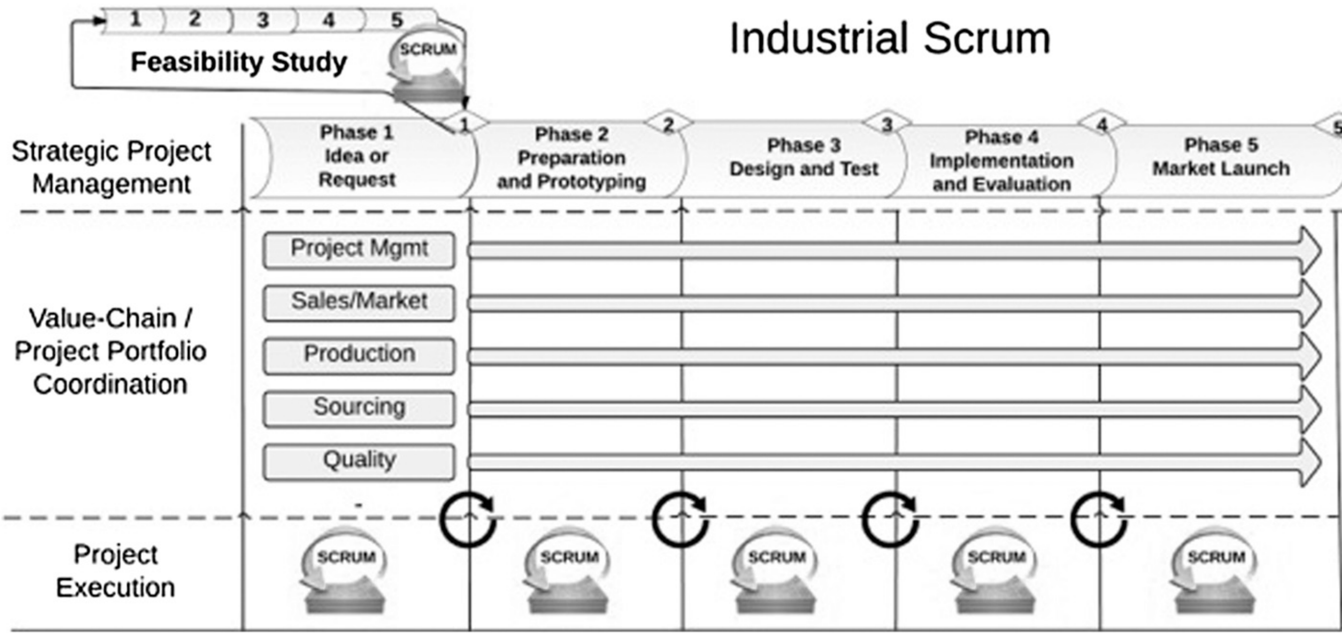

FIGURE 3. Industrial Scrum framework for new product development

and accept the fact that changes will have to be dealt with throughout the development process.

This also implies a softening of the typically hard deadlines associated with the gates in the Stage-Gate process. Furthermore, managers must be prepared to accept some degree of requirements change throughout the development process. On the other hand, the Agile component functions within the stages of the Stage-Gate process, and thus Agile tools and activities must be adapted to a higher degree of management control and documentation. Hence, the combination of Agile and Stage-Gate approaches generates a healthy tension between fixed planning and iterative problem solving, between process control and productive disorder.

The Product Development Solution Framework

Based on these findings, we propose an Industrial Scrum framework that captures the elements found to create consistent business value across the hybrid cases (Figure 3). The Industrial Scrum model is divided into three hierarchical planning levels:

- *Strategic project management* is the planning level for the product portfolio management and steering committee. At this level, the linear Stage-Gate model with company-specific phases and gates is maintained.
- *Value-chain/project portfolio coordination* is the tactical planning level between product development teams and the operational organization. This level is managed using a visual method, in which stakeholders from across the organization periodically meet at a physical board to coordinate resources.
- *Project execution* is the planning level of the development team, which is managed using Scrum methods and supported by a project manager.

Industrial Scrum includes a feasibility study in which the product goes through a mini version of all the product development stages just after initial idea development. The feasibility study is conducted by a Scrum team made up of representatives from the main stakeholder departments. The team refines the product portfolio, develops the initial product backlog, and creates a pre-prototype followed by

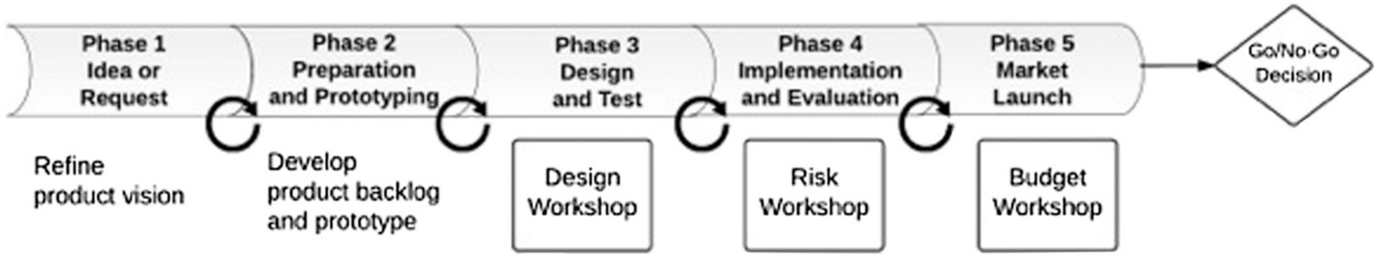

FIGURE 4. Detailed process model for Industrial Scrum feasibility study

three workshops, focused on design, risk, and budget, and attended by representatives of all stakeholder departments (Figure 4). The feasibility study leads to a final go/no-go decision; in the event of a go decision, the product enters Phase 2, preparation and prototyping. The activities within each of the phases are conducted in a number of Scrum sprints, which are only crudely defined beforehand and which are then adapted to the evolving process. At each gate, the progress through the sprints is evaluated by the project steering committee to determine whether the project is ready to move on or not.

The roles and responsibilities in Industrial Scrum reflect the method's combination of traditional product development processes and Scrum. As in traditional NPD processes, a steering committee or board is responsible for strategic decisions, including budget decisions, changes in scope, and changes in resource allocation. The project manager is the locus of communication between the various stakeholders. It is the responsibility of the project manager to communicate with all participants, request required resources from project stakeholders, and provide necessary inputs to the Scrum team. The project manager shares ownership of the project with the business manager, who functions as the voice of the customer, providing detailed knowledge of customer needs and direct communication with customers involved in the project. The project team is responsible for execution decisions that fit within the strategic decisions made by the steering committee. Finally, a project portfolio management group is responsible for the strategic distribution of resources across the project portfolio, while the value-chain group coordinates resources and information sharing between projects on a daily or weekly basis.

Conclusion

Our study shows that industrial companies can gain substantial performance benefits from implementing Agile/Stage-Gate hybrid processes for new product development. We propose our Industrial Scrum framework as a hybrid model that is based on the common practices we identified in our case companies, all of whom have internal evidence of significant positive performance effects.

However, the mechanisms driving these positive effects remain largely unknown. Our interviewees identified the most potent sources of improvement as the inculcation of Agile values via the use of Agile tools, the effect of visualization techniques on communication and knowledge sharing, and the bolster of employee motivation and productivity. However, more work is needed to determine how these factors each and in combination produce the performance effects we observed. We also need to understand more fully how corporate governance impacts the implementation of hybrid NPD models and how companies can nurture processes that integrate seemingly contradictory paradigms to accommodate complex NPD projects.

Agile/Stage-Gate hybrids offer industrial companies a promising alternative to traditional Stage-Gate systems. If we can understand the mechanisms behind their success, we can offer direction and guidance for implementation efforts, leading to better performance outcomes.

The combination of Agile and Stage-Gate approaches generates a healthy tension between fixed planning and iterative problem solving.

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