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Agile–Stage-Gate for Manufacturers

Changing the Way New Products Are Developed

Integrating Agile project management methods into a Stage-Gate system offers both opportunities and challenges

Robert G. Cooper and Anita F. Sommers

Early adopter manufacturing companies are finding significant benefits by combining Agile and Stage-Gate® for new-product development , but also new challenges. Solutions are being found. Based on 6 case study firms.

Summary: Agile development methods borrowed from the software industry are now being used by a handful of manufacturing firms for the development of physical products. This article presents six case studies from major firms experimenting with Agile–Stage- Gate hybrids. These results show that early outcomes are positive, with firms reporting significant improvements in time to market and development productivity, also faster responses to changing market conditions and customer needs and higher project team morale. However, they also identified many challenges in implementing Agile–Stage-Gate hybrids. Based on case firms' experiences, recommendations for implementing a hybrid product development system are provided.

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FEATURE ARTICLE

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OVERVIEW: Agile development methods borrowed from the software industry are now being used by a handful of manufacturing firms for the development of physical products. Agile methods, which include time-boxed sprints, daily stand-up meetings, and early demos and retrospectives, are typically embedded within some or all of the stages of an existing Stage-Gate system. This article presents six case studies from major firms experimenting with Agile–Stage-Gate hybrids. These results show that early outcomes of these efforts are quite positive; some firms report significant improvements in both time to market and development productivity, as well as faster responses to changing market conditions and customer needs and higher project team morale. However, they also identified many challenges in implementing Agile–Stage-Gate hybrids, including addressing management skepticism, finding the needed resources to field dedicated teams, and dealing with fluid product definitions and development plans. Based on case firms' experiences, we provide recommendations for implementing a hybrid product development system.

KEYWORDS: New product development, Agile–Stage-Gate hybrid, Agile, Stage-Gate

The pace of change in many markets and technologies has reached a critical point—product cycles have accelerated to the point where traditional new-product development methods no longer work. Today's gating processes are too linear and rigid, inhibiting proactive response to change during the development process. As a result, a handful of leading manufacturers in North America and in Europe, among them Honeywell, LEGO Group, Tetra Pak, GE, Chamberlain, and Danfoss, have begun to experiment with integrating elements of Agile development processes into their existing gating systems. The result is a hybrid model—Agile–Stage-Gate—that promises to yield the best of both systems. This new model has the advantage of providing the company's existing stage-and-gate system, which provides focus, structure, and control, with the benefits of an Agile approach and mindset, namely speed, agility, and productivity.

The benefits of Agile development methods in the software world—flexibility, productivity, speed—have been widely studied and documented (see, for example, Begel and Nagappan 2007). Software development firms were the first to combine Agile with Stage-Gate, beginning in the early 2000s (Boehm and Turner 2004; Karlstrom and Runeson 2005). Those successes attracted the attention of physical product manufacturers seeking ways to accelerate their product development processes; Sommer and colleagues (2015) describe the new model and some early, mostly positive experiments with it.

These early adopters now have sufficient experience to offer some insights, not only on the results that might be achieved but also—and perhaps most importantly—on the challenges that must be addressed in integrating Agile into a Stage-Gate system. A case study looking at the experience of six major firms provides perspective on how the Agile-Stage-Gate model works, what challenges and opportunities it presents, and how others might proceed in adopting (or adapting) the model.

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Evolving from Stage-Gate to Agile–Stage-Gate

Stage-Gate describes a system in which the product development process—from idea generation to market launch—is broken into discrete stages, each with defined tasks and prescribed deliverables (Cooper 1988, 2017). Gates that precede each stage mark Go/Kill or investment decision points. The method has been widely adopted by manufacturing firms to drive new-product projects to market.

Traditional gating systems, however, are no longer suitable for many of today's businesses—from food to construction equipment (Cooper 2014; Ettlie and Elsenbach 2007; Karlstrom and Runeson 2005; Lenfle and Loch 2010; Leon, Farris, and Letens 2013). In traditional Stage-Gate systems, when a project is approved to begin heavy development work, the proposed product is clearly defined and a plan of action with associated costs is approved. But in many projects, important elements of that product definition and action plan change as development work proceeds: customers' needs evolve, market requirements change, and plans must change with them. The traditional gating model does not allow for this change—the product definition and development plan are locked in—creating change management issues downstream. Gating systems are simply too linear and too rigid to adapt effectively to the unstable and rapidly changing markets and customer needs that drive today's new products.

To address the need for a more fluid, adaptable system, some leading-edge manufacturing companies are looking to Agile, a development process that emerged from the software industry, where it has delivered positive results since the 1990s (Rigby, Sutherland, and Takeuchi 2016). The Agile Manifesto, the impetus for Agile product development practices, calls for a development process that values collaboration, response to change, and a working product (Beck et al. 2001). Agile development addresses these values by supporting adaptive planning and evolutionary delivery through a time-boxed, iterative approach that emphasizes rapid delivery of incremental components of a product and frequent communication among team members and with stakeholders (see "Agile Basics," right). The result is a system that is adaptive and flexible and thrives on change; its core element is a continually evolving product definition that emerges through short-term, dynamic planning.

These attributes are the basis of Agile's appeal to product manufacturers; another impetus is the growing role software is playing in physical products. For instance, for a manufacturer of construction vehicles, product development has traditionally meant new engines, new transmissions, and new articulation systems—largely electrical and mechanical engineering work. But today's new vehicles incorporate a whole range of software—tools to maximize productivity, minimize waiting times at job sites, and monitor maintenance and repair needs.

Along with the promise it offers, Agile also brings challenges for manufacturers. It is not strategic enough and may be too short-term focused for many manufacturers.

Agile Basics

Agile, specifically the Scrum version, is a set of software development methodologies that breaks the development process into a series of short, iterative, incremental sprints, each typically one to four weeks long (Beck at al. 2001; Schwaber 2004; Scrum Guides 2017). The main components of the process are:

- *Sprint planning meeting*—At the beginning of each sprint, the development team meets to agree on what it can accomplish in the sprint and creates a task plan.
- *Daily stand-up meetings*—During the sprint, the team meets every morning to ensure that work is on course to accomplish the sprint goals, review what has been accomplished in the last 24 hours and what should be done in the next 24, and resolve problems; these meetings are also sometimes called *scrums*.
- *Demo*—At the end of each sprint, product increments or new features developed in the sprint are demonstrated and validated with stakeholders, including both management and customers.
- *Retrospective meeting*—At the end of each sprint, the team meets to review how team members worked together and how the team can improve.

The team then plans and begins the next sprint based on customer and management feedback on what needs improving and what needs to be developed next. Product requirements and technical solutions, and even the project plan, thus evolve over the development cycle.

There is no traditional project leader or project manager in Agile. Rather, the process relies on a set of defined roles:

- *The scrum master*, a servant-leader for the team, ensures that the team adheres to Agile theory, practices, and rules.
- *The product owner*, a member of management, represents the product's stakeholders and the voice of the customer and is accountable for ensuring that the team delivers value to the business.
- *The development team*, a dedicated project team that does the development work; the development team is usually physically collocated.

The development team's work is visible to all, tracked and monitored via a set of visual scheduling and tracking tools that are displayed in the team room:

- The *Project Backlog* displays a list of features to be completed in the current sprint.
- The *Kanban Board* (also sometimes called the *Scrum Board*) organizes sprint tasks in three categories—to do, doing (underway), and done.
- The *Burndown Chart* is a two-dimensional graph that shows progress versus the plan; the sprint time period is on the x-axis and the sprint task times are on the y-axis.

The sprints that give Agile its adaptability and productivity are excellent for mapping what the development team should do each week, but that ultra-short-term focus can make it difficult to keep the long-term goal in sight. As a senior R&D executive in a major optical equipment firm, participating in a workshop on Agile and Stage-Gate, remarked about a troubled Agile-based project, "They're in their 39th sprint, and I'm not sure they really know where they're heading or where the goal line is." Nor does Agile deal with the issue of whether the company should be doing the project in the first place; Agile projects are rarely stopped. By contrast, Stage-Gate brings a strategic orientation to product development. The gates allow space for management to consider the bigger questions around a project as it moves forward: Are we doing the project right, and are we doing the right project?

A hybrid model that integrates elements of both Agile and Stage-Gate can help companies capitalize on the strengths of both. Such a model has been described in some detail (Cooper 2014, 2016; Cooper and Sommer 2016a, 2016b; Sommer et al. 2015). Briefly, an Agile–Stage-Gate hybrid embeds the Agile way of working within Stage-Gate stages (Figure 1), replacing traditional project management tools and approaches, such as Gantt charts, milestones, and critical path planning, with Agile tools and processes. Thus, each stage is composed of a series of time-boxed sprints, each lasting about two to four weeks (Figure 1, right). As in pure Agile, each sprint is planned in real time, on the fly, yielding a process that is highly responsive and adaptive. At the end of each sprint, the project team produces a tangible result of some kind—a prototype or other physical model that can be demonstrated to stakeholders, including customers, for validation and to identify needed design changes. Many firms also conduct tactical planning every one to three months across all development teams and with management. Here, teams meet to create a joint tactical plan, prioritize activities, and allocate limited resources for the next period (Figure 1, left).

A hybrid model that integrates elements of both Agile and Stage-Gate can help companies capitalize on the strengths of both.

This rapid, iterative, and incremental release of concepts, designs, and prototypes provides fast customer feedback, which is integrated into the next sprint to move the product closer to what customers want and need. Customers, in turn, refine their definitions of their needs through their participation in the process. The voice of the customer thus becomes a dynamic driver throughout the project. The post-sprint retrospective allows the team to determine whether the assigned tasks have been completed—whether the sprint is actually "done"—and provides an opportunity to consider how the team can work better in following sprints. As in Agile for software projects, the project team is ideally dedicated to the one project and collocated in one team room and has daily stand-up meetings (also called *scrum meetings*) to facilitate communication and productivity.

Gates and stages remain an important part of this hybrid model. Gates provide vital go/kill decision points—culling out weak projects, providing focus in the development pipeline, and enabling senior management to review projects at key transition points. Stages provide a high-level overview of the project's main phases and a guide to required or recommended activities and expected deliverables for each stage. The deliverables specified for

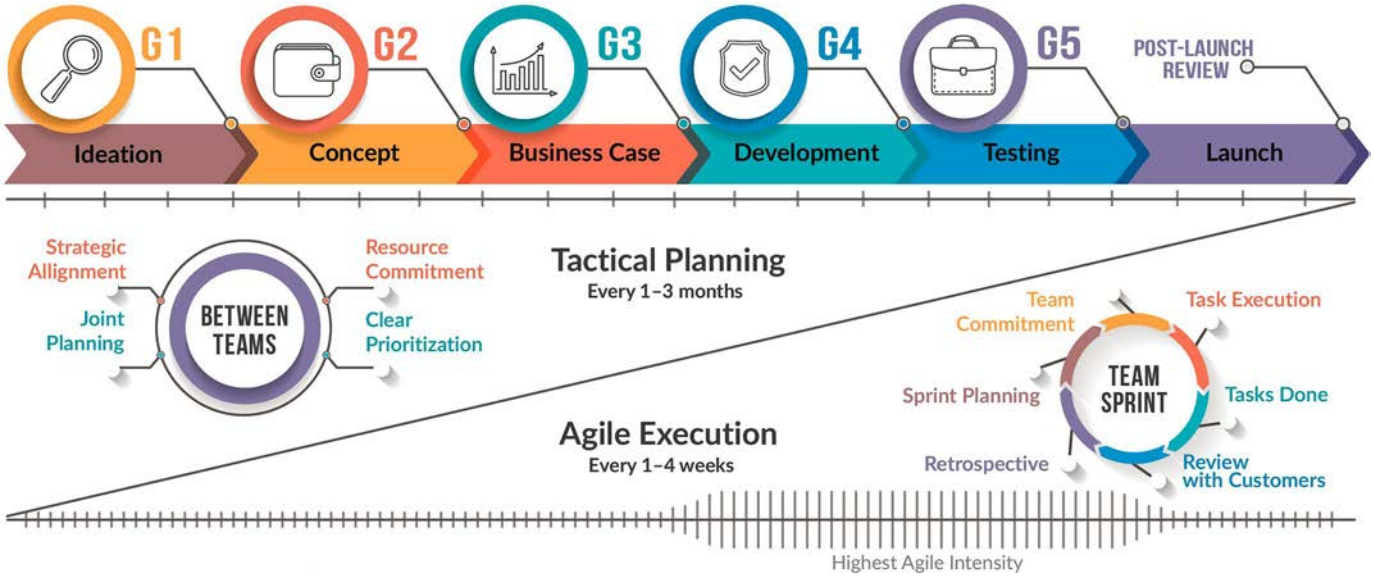

FIGURE 1. A typical Agile–Stage-Gate hybrid model, with Agile sprints built into stages

each gate, however, are leaner, less granular, and more flexible than in the classic gating model, and they are more tangible—product designs or prototypes rather than reports or slide presentations.

A number of leading manufacturers have begun to experiment with Agile–Stage-Gate hybrid models, some as early as 2013. Often, those experiments began with software developers using Agile to develop the software component of a larger project; as groups responsible for the physical components of these projects observed Agile at work, they decided to try the Agile model themselves. LEGO Education, for example, is a long-time user of traditional Stage-Gate processes. Its hardware developers were introduced to Agile in 2015, when the Digital Solutions (software) group was invited onto the struggling *Story Teller* project, a product aimed at teachers of young children. The software team brought with it its Agile processes; the *Story Teller* project immediately experienced a rapid acceleration, and a highly successful product was launched within 12 months—after four years of struggle using the classic Stage-Gate system. LEGO Education quickly absorbed that lesson and by 2016, several other major projects were using an Agile–Stage-Gate hybrid model. Impressed with results in that business unit, LEGO is now rolling out the hybrid process to most technology departments in the company.

The results from these early adopters have been quite positive (Cooper 2016; Cooper and Sommer 2016a, 2016b), but most firms are still in a piloting phase; only a few have had the new system in place for more than three years. Still, these early results are intriguing. The most comprehensive study, of five major European manufacturing firms that implemented Agile–Stage-Gate, identified major benefits in a range of areas (Sommer et al. 2015). The hybrid model, the study found,

- increased design flexibility;
- improved productivity, communication, and coordination among project team members;
- drove better focus on projects, resulting in better prioritization of time and effort; and
- raised team morale.

That study also revealed some negatives, including difficulties in acquiring team members and keeping project teams connected to the rest of the organization, mismatches between the requirements of Agile and the company's reward systems, and still too much bureaucracy.

These early findings were based on very short experiences with hybrid models. Now, some firms have been working with these processes for three years or more, gaining additional insight into both opportunities and challenges.

Case Studies: Early Adopters

To find out what early adopters are learning about Agile–Stage-Gate models and their strengths and challenges, we examined the experience of six major firms that were early adopters of Agile–Stage-Gate—Chamberlain, Danfoss, GE, Honeywell, LEGO Group, and Tetra Pak (see "The Study," right).

The Study

To gather more information about what firms are learning about Agile–Stage-Gate hybrid models, we undertook detailed case studies in six firms that had been working with Agile–Stage-Gate hybrid product development models for two to three years or longer. These analyses were undertaken in early adopter firms, which were identified at our workshops and from personal networking.

The interviews, which lasted about an hour, were based on an interview guide developed by the authors; the questions asked the interviewee to describe the firm's Agile–Stage-Gate process, explain why the firm opted to try this development approach, and detail the results achieved. It then delved into major issues and challenges faced in implementation and the solutions the company found. Typically, we interviewed two or three people in each firm; the senior person in charge of the Agile–Stage-Gate implementation was interviewed, as well as either Agile–Stage-Gate task force members or project team members. Interviews were conducted separately.

Interviews were recorded and transcribed; transcriptions were used to generate a final case outline, which was reviewed and approved by the firm. We returned to some firms at several points in time, to gather updates or where it was agreed that a follow-up interview, after information on implementation and results had solidified, would be advisable.

All six firms are predominantly manufacturers, although software is playing an increasingly important role in the products they manufacture (particularly at Honeywell, Chamberlain, and LEGO). They operate in a variety of industries, including process controls, packaging equipment, remote control equipment, and even toys. None is in a traditional process industry, such as chemicals, polymers, materials, or pharmaceuticals. Half the firms were based in North America and half in Europe.

Before adopting an Agile–Stage-Gate hybrid, all six firms had been using a fairly traditional Stage-Gate system, successfully and for many years; they adopted hybrid models for a range of reasons, from a need to resolve internal conflicts to a call for faster, more efficient product development (see "Case Firms," p. 21). When they moved to the hybrid model, these firms kept their classic stage-and-gate processes and applied Agile within some or all of the stages. The hybrid system is deployed on a minority of development projects in these firms, generally the larger, higher risk, and more ambiguous or uncertain projects. Most firms estimated using the hybrid system on about 20 percent of projects. While many common Agile–Stage-Gate practices, challenges, and solutions emerged, there remain variations; this is a new model and a new way of working, and a dominant model has not yet emerged.

Interviewees found it very difficult to quantify the improvements resulting from the adoption of the hybrid model; only one of the six firms had installed objective

Case Firms: Variations on the Agile–Stage-Gate Journey

Chamberlain

Chamberlain, a US-based manufacturer of remote-controlled household devices (for example, garage door openers), moved to its hybrid model, Agile within Stage-Gate, in 2013, in order to resolve the conflict between hardware developers, who used a stage-and-gate process, and software developers, who relied on Agile (Cooper 2016). Agile is employed in the development and testing stages of the Stage-Gate system. Each stage is divided into a series of sprints, each lasting exactly three weeks. Sprints follow typical Agile procedures.

After four years using the system, David Schuda, Business Transformation Leader, estimates "a 20–30 percent cycle time reduction because there is much less 'redo' in projects now" as well as improvements in productivity.

Danfoss

Danfoss, a producer of valves and fluid-handling equipment, began piloting an Agile–Stage-Gate hybrid model for physical products in mid-2015. While the company's Stage-Gate system remains in place and unchanged at the leadership level, an adapted version of Agile-Scrum is used at the project-team level throughout the entire development process. Both design developments and customer validations are executed in two-week sprints. Project teams are dedicated and collocated and use Agile tools and procedures.

Bo Bay Jørgensen, Senior Director, Product Development Program, told interviewers that the hybrid model has "restarted our learning journey . . . now we are finally doing what the Stage-Gate prescribes. We ask for early insights from our customers, we adapt to learnings up front, and we kill or significantly change the scope of projects when necessary . . . much earlier than before." The system has delivered a 30 percent reduction in time to market, measured from the preliminary business case to launch.

GE

GE's Agile–Stage-Gate model, called "FastWorks," has been used for the company's most important strategic product development programs for the past three years (Power 2014). The approach merges GE's Stage-Gate system with approaches drawn from Ries's (2011) Lean Startup, which mixes Agile and Lean principles. The development program is governed by Stage-Gate, with teams within the program using Agile methodology within stages. The FastWorks model has three main stages: Seed, Launch, and Grow. The Seed and Launch stages use Agile, focusing on producing a minimum viable product and collaborating closely with customers.

The new process has reduced the time before an aero-engine is tested in flight from three to one and a half years.

Honeywell

Honeywell is a process controls firm whose development programs include both software and hardware; thus, the company's Agile–Stage-Gate approach is designed for both. The product development system includes three layers: the leadership layer, focused on business decisions, uses a Stage-Gate model; the lower two levels, which deal with executing business decisions, use different versions of Agile, one with two- to four-week sprints and one with longer iterations of eight to twelve weeks. Teams are free to choose what system they use and which specific Agile practices they employ. Some hardware teams operate at the eight-week iteration level, while teams that are heavily integrated with software teams often do short sprints in cadence with their software counterparts.

Global Technical Director Willem van der Werf notes that it is premature to claim major improvements, but "touching the customer regularly is having a positive impact by changing the culture internally and yielding success in the marketplace with several pilot projects."

LEGO Group

LEGO's IT departments have experimented with Agile for over a decade, but it was not adapted to the development of manufactured products until 2015. Agile is built into the firm's Stage-Gate system. Within stages, teams engage in sprints of one to four weeks; sprints follow typical Agile processes—including sprint planning meetings and daily stand-up meetings—and use typical Agile tools.

Although formal metrics have not been installed, management believes the hybrid model has been beneficial. One interviewee told us, "Projects actually finish on time and exceed expected market success."

Tetrapak

Tetrapak began using an Agile–Stage-Gate hybrid in one division four years ago; the system is now being piloted across the company. The company retained its traditional Stage-Gate model, replacing the project manager, a core team, and an extended team with a product owner, scrum master, and semi-dedicated project team.

Tetra Pak is implementing Agile using a "learn and adapt" approach, which is central to the new mindset. "Theorizing forever will not get you anywhere," says Pontus Andersson, lead on Agile–Stage-Gate implementation. "We need to fail fast, and learn and adapt our approach along the way." For example, the company initially started with four-week sprints but realized after a few cycles that this was too short to produce tangible products. Through feedback sessions (retrospect meetings), the teams decided to try eight-week sprints instead—and it worked!

Just as plans are constantly evolving in Agile, so, too, are product definitions.

performance measures for the Agile–Stage-Gate model. In spite of the lack of hard metrics, however, interviewees in all six firms indicated that they believed they had achieved significant benefits with the hybrid model. They estimated approximately a 30 percent reduction in time to market and a 30 percent improvement in productivity. These improvements are consistent with results from other firms in earlier studies (Cooper 2016). Other frequently cited benefits include faster response to changing market conditions and customer needs and higher project team morale.

Addressing Challenges in Practice

Integrating the Agile approach into an existing Stage-Gate system is not easy. The case study firms identified a number of issues and challenges they encountered when implementing Agile within Stage-Gate for physical products. Apparent inconsistencies exist between the two systems, such as fluid versus fixed product definitions and short-term versus long-term planning cycles. The case firms also described a number of other challenges, including management skepticism, a lack of resources to support dedicated teams, and the difficulty of producing a concrete demonstration product in a two-week sprint. These firms suggested a range of potential solutions; we also discussed these issues in several workshops and panel discussions (see "Additional Inputs," right).

Resolving Inconsistencies

While Agile and Stage-Gate can work well together, each balancing the other's strengths and weaknesses, they can also clash. Companies who hope to access the best of both systems must find ways to resolve those clashes to create a harmonious process. The potential conflicts become evident in the struggle to balance short-term fluidity with long-term planning, and Stage-Gate's need for a concrete product definition with Agile's constantly evolving product definitions.

One of the core principles of the Agile Manifesto is "maximizing the amount of work not done" (Beck et al. 2001). One outcome of this principle is an absence of long-term plans—long-term plans don't exist, for the simple reason that they'll not be valid for long, and so the work of making them will be wasted. But manufacturers trying to implement an Agile–Stage-Gate hybrid face a dilemma: if the project plan is short term and evolving, how can development times and costs—data needed to support a business case and secure project approval—be estimated?

This dilemma can be resolved initially by creating a schedule of tasks for each stage based on best estimates at the time. The schedule is similar to a traditional project plan or Gantt chart, but it is very tentative and much higher level, providing just enough detail to allow an equally tentative estimate of costs. At the same time, management must learn to live with some ambiguity—and be prepared to approve projects when plans, costs, and times are only estimates that are likely to change. But, as one interviewee pointed out, "There's nothing really new here. We're always approving projects where costs and times change!" The difference here is that the likelihood of change is acknowledged—and embraced—up front.

Just as plans are constantly evolving in Agile, so, too, are product definitions. In the Agile world, the product is defined as it emerges through repeated iterations based on customer feedback. Managers must remember, as Peter Andersen, Senior Director of R&D at Danfoss noted, "Agile–Stage-Gate allows for early and frequent customer validations of physical and virtual product designs. The main change is that design specifications are no longer fixed up front, but are continuously adapted through the design iterations: no longer is there a pre-Development design freeze." The product backlog—a list of features to be implemented in the product—is not locked in early in the project; it varies based on customer feedback and the results of sprints, evolving over time as the project progresses and more data becomes available, from experiments and from customer feedback. Thus, as in planning and budgeting,

Additional Inputs

The case study firms provided the core data set for the article, but case studies by their nature represent a very limited sample size. In order to broaden the base of information from which we derived insights, we sought additional inputs from a larger sample of firms via two channels: a set of workshops and panel participation.

Workshops. First, we gathered insights from participants at 14 open workshops held in the United States (five workshops, hosted by ISBM at Penn State University and the Management Roundtable) and in Europe (four in Germany, three in Denmark, and two in Sweden). Attendees were both from other early-adopter companies and from companies interested in adopting the new model. Workshop sessions focused on problems with firms' current or classic Stage-Gate processes and key issues and challenges in implementing Agile–Stage-Gate.

Panel. Both authors participated, along with some case companies, Danfoss and LEGO Group, and other Danish firms, on the advisory panel for an initiative sponsored by the Danish government to introduce Agile–Stage-Gate to mid-sized firms in that country. That experience provided additional insights into what worked and what did not for these companies.

Some of these additional inputs were confirmatory, reiterating what the case data had already revealed. Other inputs provided new insights, especially regarding possible solutions to challenges and issues identified by case companies.

manufacturers must learn to accommodate more ambiguity than they might be comfortable with in product definition, moving forward based on a high-level, although again somewhat tentative, product definition.

Addressing Management Skepticism

As Helen Hosang, a marketing director at Honeywell, told interviewers, "Implementation involves a major cultural transformation," so leadership buy-in is critical. To be successful, Hosang said, companies must "ensure that [the] transformation is leadership sponsored and has cross-functional buy-in and support." That may be a simple task, but it is not an easy one. Several interviewees, and attendees at our workshops as well, noted skepticism from the management team as a hindrance to the adoption of Agile–Stage-Gate hybrid models. Management resistance often arises from common misconceptions: many don't understand that implementing Agile does not mean abandoning Stage-Gate.

Case companies mostly sought to overcome this resistance by designing their hybrid systems *around* managers—the leadership team saw only results, not the process. At Chamberlain, for instance, where senior leaders were initially skeptical of the new Agile-Scrum system, the product development function simply implemented the changes at the project level. The senior management team was not required to learn Agile because the traditional gates remained intact. Similarly, Danfoss chose not to change its Stage-Gate system, except to add risk assessment and customer insights at an early gate. Here again, most of the changes occurred at the project-team level, and project leaders implemented the Agile approach. Senior leaders saw only the project's results at the gate points.

Designing the system in this way puts the focus for leaders on results, not process, by measuring performance. Solid, measurable results can go a long way in convincing a skeptical leadership team. Many of our case companies are missing an opportunity in this regard—only one of the six case-study firms had implemented formal metrics to gauge performance improvements, and that firm did so as a matter of course, not with the aim of managing leadership skepticism.

Finding Resources

The main challenge for many manufacturers is finding the resources needed to support an Agile approach—especially the dedicated project teams required by a full implementation of the system. Short sprints, daily stand-up meetings, and quick deliverables are much more difficult—perhaps even impossible—when team members are spread across several other projects or not in regular contact with each other.

Case companies have largely found it untenable to have people assigned to only one project at a time, but they have experimented with various compromises. At Tetra Pak, Pontus Andersson, Project Manager and lead on Agile–Stage-Gate implementation, told interviewers, "First we tried teams with people dedicated 50 percent of their time, which did not work at all. Then we moved to 70 percent dedication, which was better but not optimal. Now, the rule is a maximum of one other project per person, taking no more than 30 percent of their time. This works, but we might even have to move to 100 percent." Among both case companies and workshop attendees, we've found that most manufacturers do make compromises like Tetra Pak's, not fully dedicating personnel but limiting maximum loads. In workshop discussions, an attendee from a major California bio-tech firm described how his company handles the dedicated team challenge by creating a single team that works on a cohort of concurrent Agile–Stage-Gate projects—all similar projects and requiring similar skills. This allows team members to stay in constant contact and keeps them from being diverted to other tasks; daily stand-ups may deal with more than that one project. Another solution is to be selective about which projects use the hybrid model.

Defining Sprint Deliverables

In software, a development team can usually produce something that works—executable software code—by the end of each sprint. The notion of a "done sprint" does not apply so neatly to manufactured products. The development of a new engine, medical device, or machine cannot be so easily incrementalized. Even when it's possible to create a concrete prototype at a particular stage, it takes time—sometimes longer than a typical sprint—to physically build it.

Our case companies have addressed this problem by redefining "done" for physical product development. The result of a done sprint in this context is not necessarily a working product; it is merely some tangible result of the work completed in that sprint. For example, in earlier stages at the front end, the definition of "done" may be a business case, or the results of preliminary experiments or a voice-of-customer study. Beginning in the development stage, however, a "done sprint" usually yields something physical that the customer can respond to and management can see: design drawings, a computer animation, a virtual product, a crude model—in short, a product version somewhere between a concept and a ready-to-trial prototype, sometimes called a *protocept* or a *pretotype*.

At Honeywell, according to Willem van der Werf, "For hardware developments, the definition of 'done' for a sprint may be a 'demo-able' simulation, or something that is testable or 'integrate-able' as opposed to having a shippable software feature." At Chamberlain, the "something tangible" delivered by a sprint could be design drawings or an early prototype, while at GE, the deliverables for a sprint could be outcomes of virtual experiments conducted through simulation modeling. The range of possible deliverables is being extended by new technology: Newer techniques such as computer simulation and 3D printing mean that traditionally long-lead items (for instance, securing cast components or making electronic circuit boards) are disappearing from the Development phase (Cooper 2016).

One of the key questions is where to integrate Agile—both where in the product development process and for which projects.

Getting quick customer feedback at the end of the sprint can also be a challenge. For software, getting feedback involves sending the new feature to customers, usually electronically, and soliciting feedback by the same channel. But hardware products can't be e-mailed or downloaded. And some customers don't want to move so fast or cannot undertake tests so quickly. Case companies have addressed this challenge in a number of ways. At LEGO and Danfoss, entire sprints are devoted to seeking customer validation. GE asks strategic customers to commit to take part in the development process before the project is initiated. The advantage for the customer in investing their time and efforts is that the final product is fitted to exactly their needs and instantly implementable into their systems.

Deciding Where to Implement Agile

One of the key questions in implementing an Agile–Stage-Gate hybrid is where to integrate Agile—both where in the product development process and for which projects.

Fitting Agile into the Stage-Gate Structure

Agile practices may not work equally well for all stages of product development. The ambiguity that can drive innovation and productivity in early design may not be tolerable in later stages, when precision is needed and planning is more constrained.

Most of our case companies implemented Agile first in the technical stages, development and testing. Often the technical people heard about Agile first, frequently from their own IT people, and decided to try it for the technical work. The focus on producing a working or demonstrable protocept as the sprint outcome suits the technical phases of a new-product project, which are focused on addressing technical and design issues. And technical people are more likely to be dedicated to a single project, making implementation easier from a resourcing standpoint in these phases.

Some companies, including Danfoss and LEGO, have also found that the hybrid can work well in even earlier phases, such as ideation and concept feasibility (Figure 2). These firms find that Agile's iterative nature fits well with

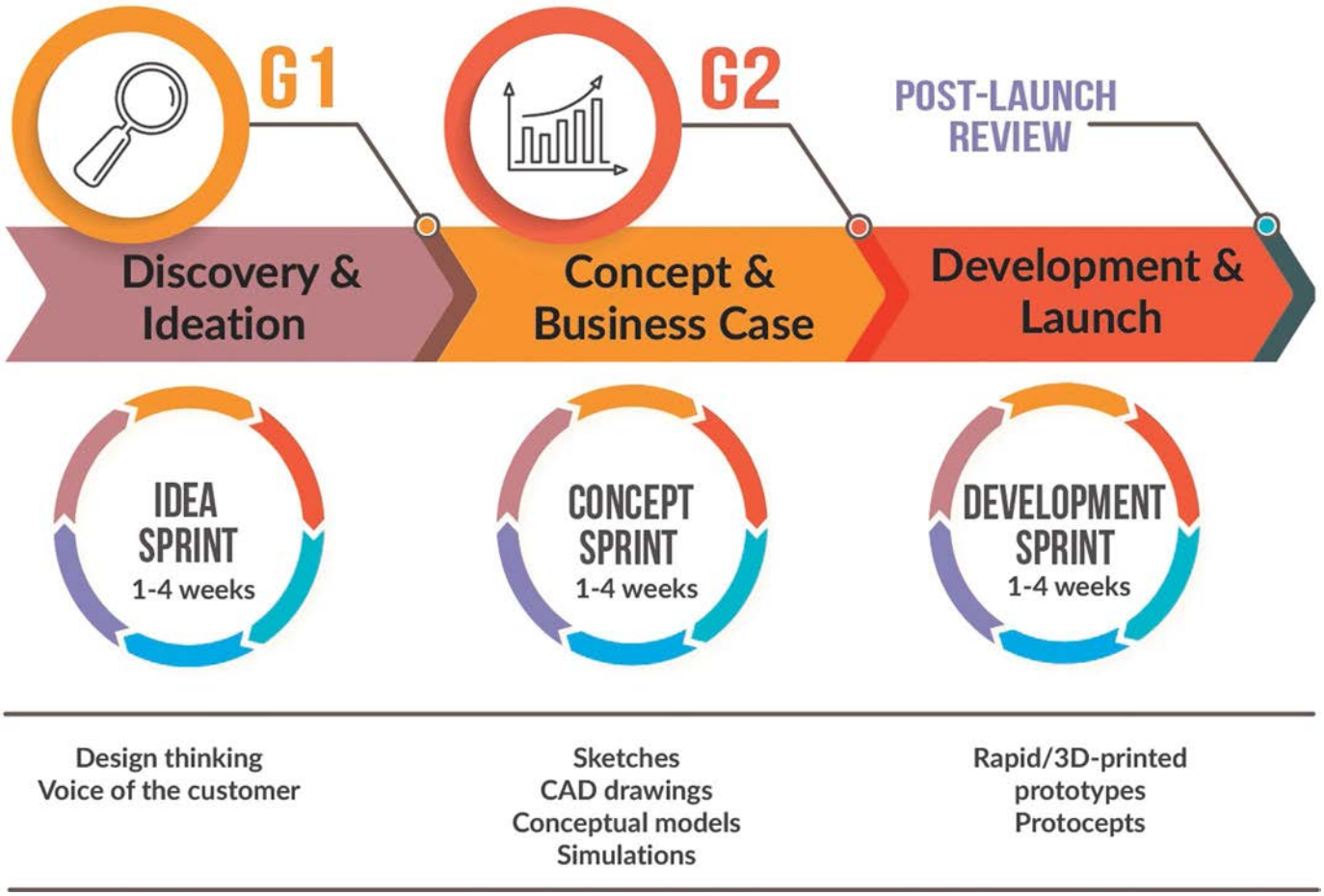

FIGURE 2. Agile–Stage-Gate at the fuzzy front end (adapted from Kielgast, Vedsmand, and Cooper 2016)

the design thinking methods (Brown 2008; Kielgast, Vedsmand, and Cooper 2016) they use to build out concepts in the front end, before the full-blown product development process takes hold. Other functional areas, such as marketers or manufacturing engineers, may find it more difficult to adapt to the Agile way of working, but, as at LEGO, given solid training, an effective change management effort, and proper resource allocation, Agile–Stage-Gate can work across the entire project development process.

Matching Projects to Processes

Although in theory the Agile–Stage-Gate hybrid is suitable for all development projects, in practice the greatest advantages may be reaped in more ambiguous and uncertain initiatives. Where markets and customer needs are known and stable, the linear structure of Stage-Gate is not a disadvantage and it may be more efficient. Further, Agile requires significant resources—not least, a fully dedicated or nearly fully dedicated team—that simple incremental projects may not warrant. Reserving Agile for projects that truly need it can help make sure resources are available for those projects.

Our case companies addressed this decision in different ways. Chamberlain employs its hybrid approach only for major revenue-generating projects—about 20 percent of the projects in its development pipeline. At Danfoss, Agile–Stage-Gate is applied to all innovation projects (more transformational projects) across all divisions and disciplines, from heating to cooling solutions to development of power drives. And at LEGO, Agile–Stage-Gate so far is reserved for development of LEGO Education products and higher-tech products such as Mindstorms.

Implementing Agile–Stage-Gate

The potential gains are tempting, but the process of implementing a hybrid model can be daunting. The challenges can be managed, however, with management buy-in and a clear, implementation process that allows the company to build on previous learning.

Generally, the process begins with a small task force made up of people from the different functional areas involved in product innovation—technical, operations, marketing, and sales—and from different business units and geographies. The task force may employ an outside expert or facilitator as well. While the task force is getting up to speed on the Agile method, it also dissects the firm's existing stage-and-gate process to produce a current state assessment. The first task is often to streamline the current system, using Lean Six Sigma methods (Fiore 2005) to make requirements less onerous. For example, before Danfoss implemented Agile–Stage-Gate, it first employed more traditional techniques to make its existing innovation process leaner, cutting cycle time in half even before the move to the hybrid model.

Once the Stage-Gate system is streamlined, the task force then maps the new hybrid model, determining where Agile will work, for which stages and which projects. The task force must also determine how to address the challenges that arise. In the spirit of Agile, however, the team should avoid intricate over-planning. Instead, leaders at Danfoss recommend beginning with a pilot project, ensuring that it receives senior management attention and sufficient resources, and watching to see what happens.

Our case companies offered one piece of resounding advice: "Just try it!"

Most important, the task force must recognize that Agile–Stage-Gate is still new: everyone is still learning how to do it and there is not one right way to proceed. It's important to remember that this is a new way of working for both executives and project teams. An interviewee at Tetra Pak cautioned that project team members will have an "adjustment time"—a period of frustration as they navigate what can be a steep learning curve. Honeywell addressed this learning curve by sponsoring extensive training for pilot teams and bringing in external coaches to provide additional support; training and coaching are now ongoing practices for the company. Other case companies recommended adapting the model to suit the organization and providing for open dialogue throughout implementation to deal quickly with issues and challenges as they arise.

Whatever approach is taken, however a company decides to move forward, our case companies offered one piece of resounding advice: "Just try it!"

Conclusion

Agile has revolutionized product development in the software industry. Agile–Stage-Gate is now poised to transform how new products are developed in the manufacturing world. By combining Agile with the classic Stage-Gate system, the new hybrid model promises to yield broad impact across many industries. There are challenges in reconciling the two approaches and in overcoming organizational limitations, but most early-adopter firms have found solutions. The greatest challenges are management skepticism and finding the dedicated resources to make this new model work. But businesses that embrace Agile–Stage-Gate and commit the necessary resources stand to reap benefits in increased R&D productivity, faster time to market, and stronger new offerings.

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