Hybrid Agile-Planned product development processes

Preparing the manufacturing sector for industry 4.0

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INDUSTRIENS FOND FREMMER DANSK KONKURRENCEEVNE
The Danish Industry Foundation

The Global Product Development project

Globalisation is a phenomenon that all Danish firms, irrespective of their size, face. In 2012, the Danish Industry Foundation funded a guide based on empirical evidence to support Danish industry in the globalisation of their value chains. This showed that many decisions were made on an ad hoc basis and that greater support was needed. Based on this project, it was recognized that industry need better understand how to measure the effectiveness of projects when parts of the product development process is globalized, as well as support in their decisions to globalize.

The Danish Industry Foundation has funded this project on Global Product Development to create methods and tools to support Danish industry in Global Product Development led by Prof Saeema Ahmed-Kristensen and a team of researchers at the Technical University of Denmark together with around 40 Danish firms. The project has developed tools and frameworks that can help other Danish companies in: measuring performance of globalized product development through a framework to set up Key Performance Indicators (KPI); support the decision making process, and; move to hybrid agile/planned product development models. The guide book focuses upon the Hybrid agile and planned product development process, and is the second of two guide books produced based on the knowledge gained.

Mads Lebech
CEO, The Danish Industry Foundation.

The Global Product Development Project

Many Danish companies have globalised part of their development process; from detailed design, testing to production. This has created many new possibilities but also new challenges. Through our close collaboration with more than forty Danish companies, we identified a critical need for tools to support industry in Global Product Development, this includes the need for new Key Performance Indicators that identify and address issues that are specific to Global Product Development, such as culture or communication and support the decision making process.

The project focused on research and based on this research the development of pragmatic tools to support global product development in Danish industry by investigating three key research areas. The Final part form this guide:

Performance Measurement
The dynamic consequences of sourcing or offshoring parts of the product development methods are made measurable by providing approaches to develop robust metrics for assessing the companies' performance as the project progresses. A framework has been proposed based on a number of interviews, observations and testing and refining the framework with case study companies.

Decision Making
The decision making theme examined a number of cases to unfold the issues supporting manufacturing firms in making decisions to outsource or offshore part of the global product development decisions and translate these to a guide to sup-port this process.

Joint innovation models hybrid agile processes
Understanding how to bring agile methodologies into planned models to move towards. 10 cases, with Danish and European industry have been investigated to understand best practice and develop models of hybrid agile approaches. These models support Danish Industry in preparing for Industry 4.0.

Throughout the project, engagement with industry has been a priority, and in addition to a number of publications with the research contribution, a number of initiatives were undertaken to engage industry to maximize impact of this project. This includes eight workshops held with industry in addition to over deep case studies including over 40 interviews held in Denmark, China and Malaysia to bring an insight into the challenges of global product development. The workshops were not only a place for the results to be disseminated but also best practices shared and even the new companies formed from the network, leading to new entrepreneurial efforts. The project is supported with 6,000,000 DKK from the Danish Industry Foundation (Industriens Fond), without this the project would not be possible. To the companies that so kindly gave their precious time for cases studies, Radiometer, Danfoss, and those who attended the workshops, presented and supported thank you, especially Roy Nielsen and Christian Ernst who have attended almost all the workshops and followed the project over the years. Also, thanks to all members of the Global Product Development research and administrative team past and present for their dedication.

Prof Saeema Ahmed-Kristensen
Head of Design Products, School of Design, Royal College of Art and Technical University of Denmark for this project.

Participating Companies

This guidebook is the result of the "Practical Tools for Global Product Development Project", which was funded by The Danish Industry Foundation and carried out at the Management Engineering Department at the Technical University of Denmark. The authors would like to sincerely thank the companies that participated in the project for their contributions towards making this guidebook a reality.

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Motivation for the guidebook

The recent drives for Industry 4.0 and a move towards greater automation of physical systems has been pushing manufacturing companies to experiment and adopt a greater level of agility in their product development processes.

Stage-gated models have long been the main framework used in product development in manufacturing companies once they reach certain size, in order to make the innovation process more manageable, to facilitate coordination of information and tasks. Software-based companies, on the other hand, have relied on more flexible product development models such as the Agile processes, e.g. Scrum, eXtreme Programming (XP), and Feature-Driven Development (FDD). Such models allow more responsiveness and are well adapted to production processes based on codes. The flexibility of code production allows their development cycles to be relatively fast (order of hours, days) and requirements can be changed along the development process.

Given the current trend of integration of software and hardware in many manufacturing sectors that traditionally relied on Stage Gate processes, the analysis of the process by which firms combine both processes is still very incipient. A combined use of the models, for instance, could provide software developers with a rich set of methods and strategies, each with their own benefits (Boehm, 2002).

Building on these findings, a four-year research project was conducted that aimed to gain a deeper understanding of the impact that global product development has on Danish companies, and to develop practical tools to support the implementation of Agile frameworks within manufacturing companies.

The results from the project, which involved collaboration with over 60 multinational Danish manufacturing companies, have been compiled in this practical guidebook for industry.

Aim of the guidebook

How can we support management to overcome the challenges and help adopt the right combination of Agile and Stage Gate elements in their product development processes?

The aim of this guidebook is to provide management with a series of insights from well known companies that support to overcome the many obstacles and maximize potential opportunities when combining elements from Agile and Stage gate in their product development processes, especially in cases there both software and hardware elements are present and interact in the product development. The guidebook develops understanding towards the key drivers and challenges the interviewed companies face, and the current practice. With the explorative work presented in the guidebook, we aim to inspire management with a range of strategies they can adapt and experiment with in the context of their own organization.

Fundamental for the development of this guidebook is the inclusion of the knowledge and experience from over 10 Danish and European manufacturing companies during the research project “Practical Tools for Global Product Development”. While the companies are not named in the guidebook, the case examples provided throughout are based on experiences observed in the companies that participated in the research project.

Who should use this guidebook?
This guidebook is aimed at practitioners, project and program managers and decision makers involved with the management and implementation of new product development projects, especially those that integrate hardware and software elements.

Planned product development (Stage Gate) models

Planned product development models have long been part of product development in the manufacturing industry. These models can be characterized as a “conceptual and an operational model for moving a new product from idea to launch” (Cooper, 1990, p.1). It does so by prescribing a number of stages or phases in the product development process each guarded by a gate where certain pre-determined results need to be delivered before moving to the next stage. Stage gate models are typically introduced in companies once they grow over a certain size, in order to make the innovation process more manageable, to facilitate coordination of information and tasks. Such processes have been part of the engineering design field for many decades, with the recognition of the need for methods to become more predictive and evaluative (Gregory, 1966). Over time, stage gate models evolved in various generations of models (Ulrich and Eppinger, 2015). Innovation models evolved from being simple, linear technology push to more and more integrated models that balanced technology push and market pull, interaction between stages and stakeholders (Tidd and Bessant, 2009).

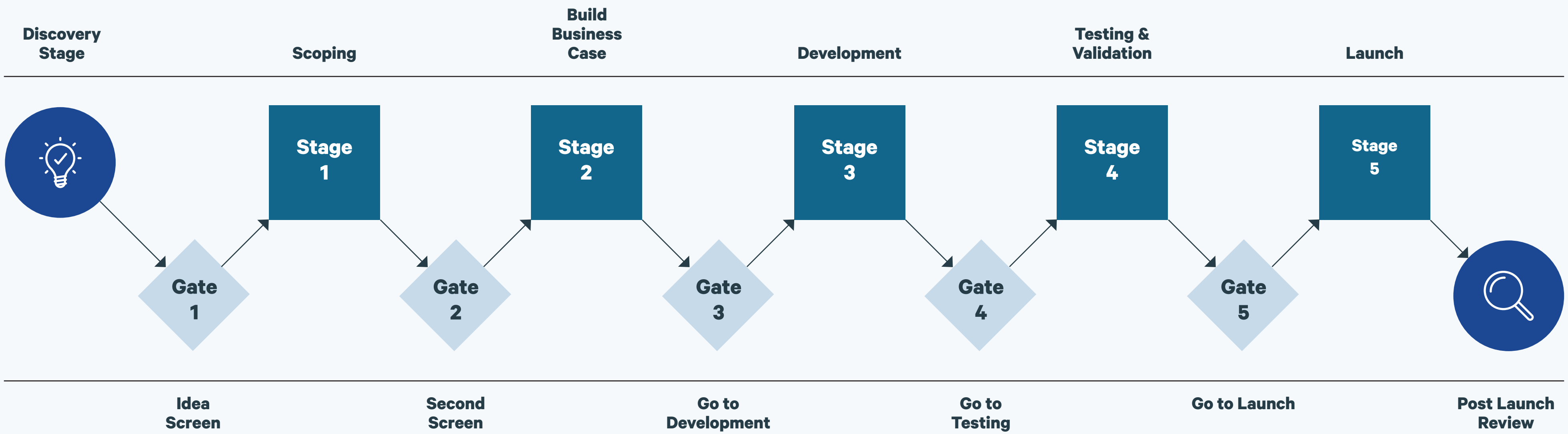


Figure 1 – Generic Planned product development model

Agile Development

Agile product development models emerged in the 1980's out of the need for organizations to become faster and more flexible in their innovation efforts (Takeuchi and Nonaka, 1986). Agile models were developed as a response to the sequential stage-gated models and have a more holistic nature in which multi-disciplinary teams work in parallel along the product development process. In the words of Takeuchi and Nonaka, teams work "as in rugby, the ball gets passed within a team as it moves as a unit up the field" (1986, p. 1). These authors characterized agile product development in terms of six qualities:

- First, an agile process has built-in instability.
- Second, agile development requires self-organizing teams.
- Third, development phases overlap.
- Fourth, agile processes induce "multi-learning". Due to the tight interactions between team members, learning happens along individual, group and corporate level as well as across functions.
- Fifth, management exercises "subtle control". Management leaves teams largely on their own, yet builds in sufficient checks to avoid chaos, emphasizing self-control, control through peer pressure and control by passion.
- Lastly, team members also transfer their learning to others outside of the group across the organization.

More recently, the agile manifesto (Beck, et al., 2001) was published within the software development community, outlining 4 agile values, and 12 agile principles. The 4 agile values describe very briefly what is seen as valuable work, versus the practices that are valued less:

1. Individuals and interactions over processes and tools
2. Working software over comprehensive documentation
3. Customer collaboration over contract negotiation
4. Responding to change over following a plan

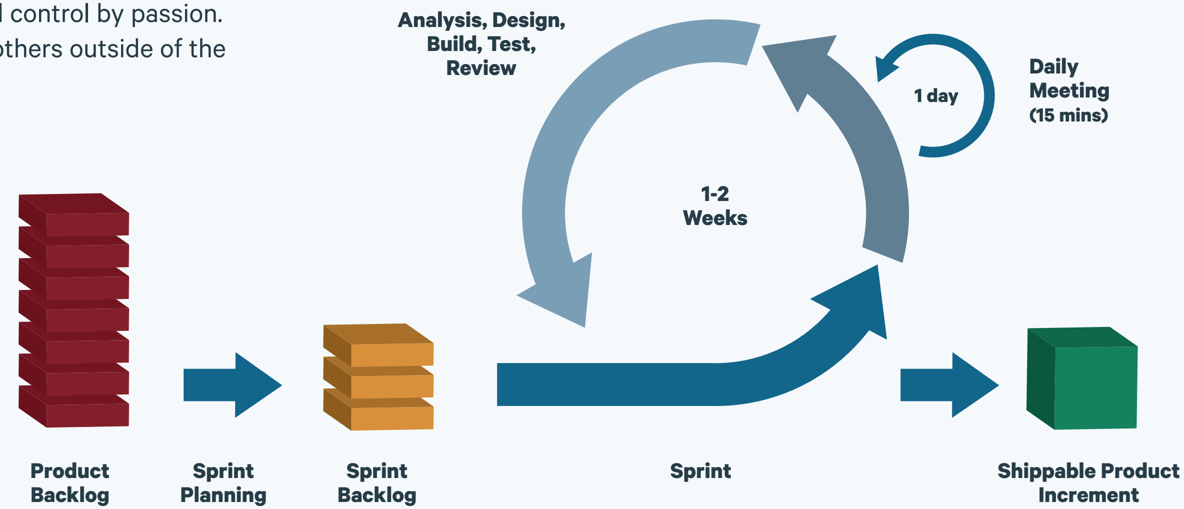


Figure 2 – Agile development model, with the sprint as the core structure.

Global Product Development

Stage gate models are predominantly employed in manufacturing industries, usually characterized by capital investments that are committed at an early stage. Thus, product development processes have long been organized as stage-gate systems in which requirements and specifications are formulated early and fixed in subsequent stages.

Agile models, on the other hand, have long been dominant in the software industry, where the definition of specification and the production of code are both driven by human capital, often at the same time. Thus development cycles can be relatively fast (order of hours, days) and requirements can be changed along the development process.

Recently, manufacturing firms are beginning to combine agile processes with more formalized planned processes such as stage gate models. Very few studies address the combining of planned models with agile models. A possible explanation for this is the relative newness of the approach in manufacturing companies.

The home grounds (set of optimal conditions) for agile and plan-driven processes are characterized along four dimensions: application, management, technical and personnel (See table on the right)

Project characteristic	Agile home ground	Plan-driven home ground
Application		
Primary goals	Rapid value, responding to change	Predictability, stability, high assurance
Size	Smaller teams and projects	Larger teams and projects
Environment	Turbulent, high change, project focused	Stable, low change, project and organization focused
Management		
Customer relations	Dedicated onsite customers, focused on prioritized increments	As-needed customer interaction, focused on contract provisions
Planning and control	Internalized plans, qualitative control	Documented plans, quantitative control
Communications	Tacit interpersonal knowledge	Explicit documented knowledge
Technical		
Requirements	Prioritized informal stories and test cases, undergoing unforeseeable change	Formalized project, capability, interface, quality, foreseeable evolution requirements
Development	Simple design, short increments, refactoring assumed inexpensive	Extensive design. longer increments, refactoring assumed expensive
Test	Executable test cases define requirements, testing	Documented test plans and procedures
Personal		
Customers	Dedicated, collocated performers who are collaborative, representative, authorized, committed, and knowledgeable	Performers who are collaborative, representative, authorized, committed, and knowledgeable., not always collocated
Developers	At least 30% full-time highly mature method users. No novice or uncommitted method users	50% highly mature experts early in process, 10% throughout process. 30% novice method users is workable. No uncommitted method
Culture	Comfort and empowerment via many degrees of freedom (thriving on chaos)	Comfort and empowerment via framework of policies and proce-dures (thriving on order)

Source: Ahmed-Kristensen, S.; Daalhuizen, J. (2015)

About the cases

The insights in this guide were taken from a series of interviews that were conducted in order to investigate how stage gate and agile models are combined in the manufacturing industry. The interviews were conducted with project managers or vice presidents of research and development who were involved in the design and implementation of the product development process. The interviews were conducted in eight companies, all acting on an international level. Some information about the case companies is summarized on the table.

The guide presents information about a series of topics extracted from the interviews. The first topic presents the main challenges of combining both frameworks. After, insights on the strategies that the cases use in order to combine planned and agile elements are discussed. The third topic approaches how companies deal with specifications and change of requirements. Thereafter, aspects of team organization and communication are analyzed. Lastly, insights on the benefits of combining Agile and Planned processes are presented.

Case	Industry	Number of employees
A	German leading premium manufacturer of automobiles and motorcycles	> 120.000 worldwide
B	Dutch multinational manufacturer of consumer and healthcare products	> 100.000 worldwide
C	Danish manufacturer of hearing measurement devices	> 500
D	Danish manufacturer of hearing aids and diagnostic audiological instrumentation	> 4000 worldwide (1000 in Denmark)
E	Danish manufacturer of audio solutions	> 5000
F	Danish manufacturer of audio solutions	> 500
G	Danish manufacturer of large industrial valves	> 24.000 worldwide (5400 in Denmark)
H	Danish manufacturer of medical devices	> 2700 worldwide

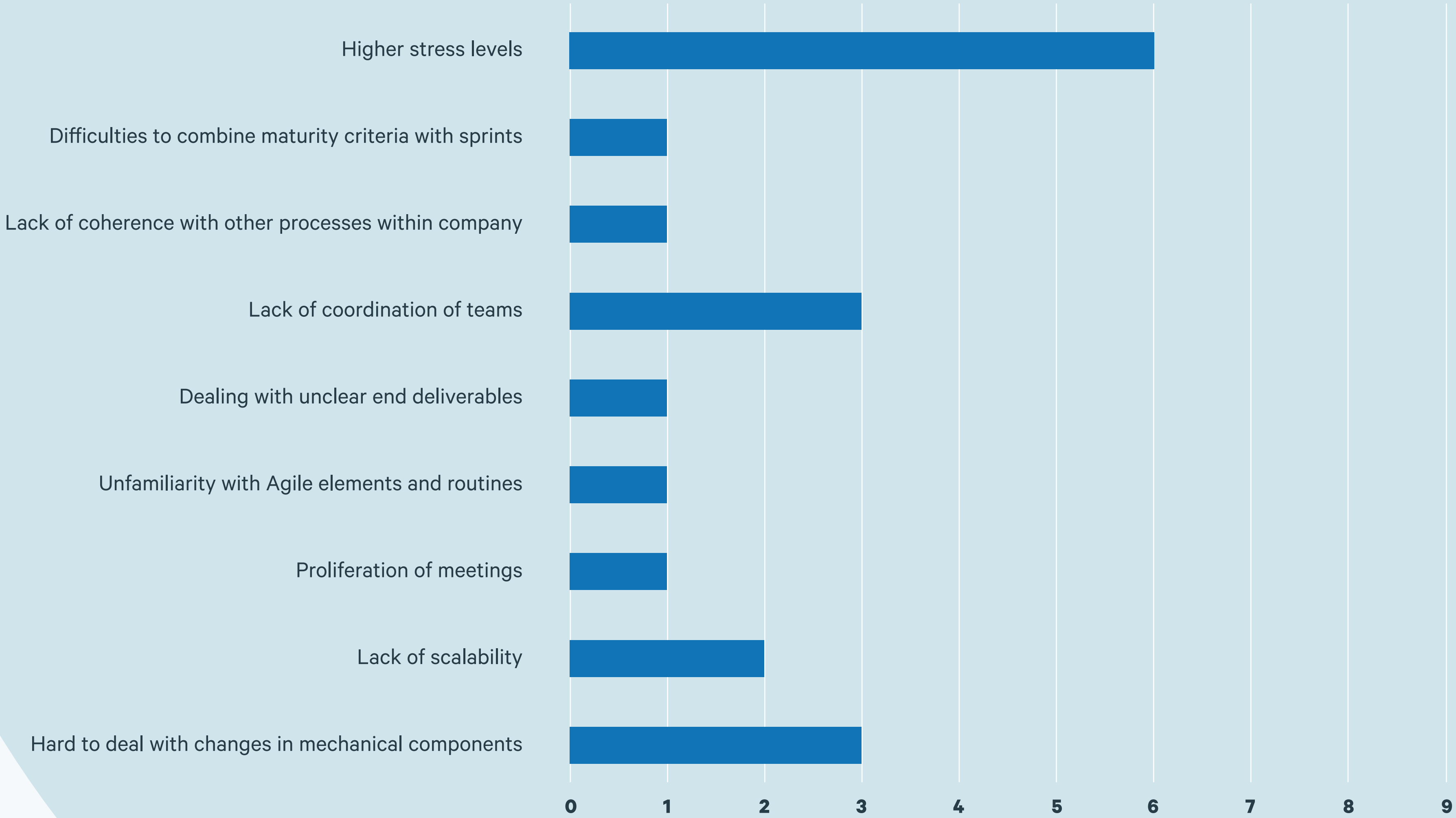
Key challenges when combining Agile and Stage Gate

Despite the potential benefits of combining Agile and Stage gate elements, it does not come without its challenges, and understanding these challenges is an important step for developing precautionary measures and optimize the benefits of such integration. The challenges are summarized in Figure 3.

High levels of stress: The main challenge that firms reported when adopting Agile is that it increases the levels of stress of the team members. Most cases mentioned that members working Agile experience higher and more constant levels of stress, whereas in pure Stage Gate the stress levels are normally lower and only peak immediately before the gates. The interviews also indicated that stress levels are higher when working with multiple projects in parallel. To cope with this problem, some companies adopt informal rules, e.g. that team members should work on one project at least 50% of their time, strengthening the connections among the colleagues and allowing teams to focus. Members working in Agile and Stage Gate projects at the same time might also experience more stress, since agile projects usually require more dedication and depend on the co-location and simultaneous presence of team members . Case B explains that, in this case, the firm could coordinate the members so that they work as a scrum team in specific days of the week only. Additionally, highly specialized individuals with unique skills are often required to work in several projects at the same time and thus experience higher levels of stress. Finally, some interviewees also cited that unfamiliarity with the routines and tools used in Agile might contribute to increase the stress levels of the team members, especially those attached to a Stage Gate mindset. However, not all cases agreed that working Agile increases stress. In fact, two cases (C and G) mention that the Agile framework might actually reduce stress levels due to better communication and higher levels of independence that the team members experience.

“Before the gate stress level increases much higher than in the agile. As with the agile you do more work far before the gate. As you set your intermediate results you put the stress on yourself and then you have a higher maturity degree before the actual gate comes up.” (Case A)

Figure 3 – Challenges associated with Agile



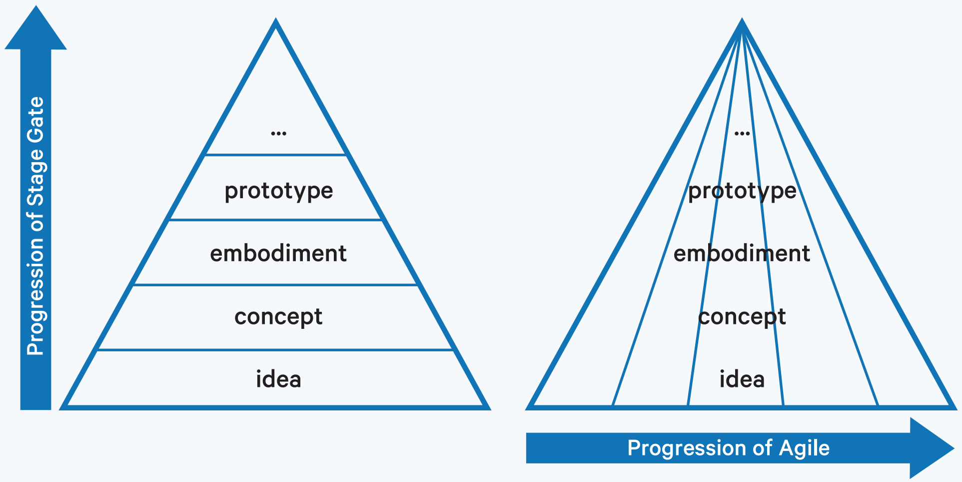
Key challenges when combining Agile and Stage Gate

Incompabilities between Agile and hardware development: many physical aspects of hardware are not compatible with short sprints and may obstruct the coordination of stakeholders and teams. Software, by definition, does not contain any physical components and thus it is much easier and faster to test the product and perform any changes, since it only requires modifications in the code, making Agile elements such as short sprints well fitted for software development.

Hardware, on the other hand, involves a series of steps once the design is defined in order to reach the actual physical form of the product designed. These steps might require an amount of time, resources and coordination that is incompatible with Agile elements. In relation to the sprints, for example, the biggest challenge is how to deal with the time necessary to order and receive mechanical components, especially if they need to be shipped overseas. This kind of operation may take six or eight weeks to be completed, making it challenging to adopt sprints that last a few weeks, for example.

Furthermore, hardware products are usually put together through many sub-components, each with its own supply chain composed of external partners. Relying on several external stakeholders make it difficult to coordinate sprints on a short time frame without incurring in delays. Changes in requirements might also take a much longer time since they would have to be passed on to the respective suppliers, possibly requiring a reconfiguration in their production processes and a new shipment order that might take several weeks to be completed, or even the inclusion or exclusion of suppliers, which would require a new coordination effort.

> *What sense does it makes to have 3 week sprints with something that takes, you know, 6 weeks to crunch out [a tool] in a factory in China.*
> *(Case E)*



How are the processes combined?

The cases showed a range of strategies for combining Planned and Agile elements in their product development processes. Overall, most companies use stage-gated processes as governance model and subsequently use diferent combinations of agile and their stage-gated process according to different criteria.

A Hybrid Agile-Planned approach. Case companies often used elements of agile methods, but not a 'pure' agile approach. For example, they used time-boxing and sprints, but kept the conventional project management role and formal gates.

Stages and gates are used to handle the broader elements of the project such as high level requirements and maturity criteria for a whole project, while agile elements were often used to drive development and to support teams to learn what works and what doesn't. It also helps to gain a better overview of failures and progress of the teams.

Stage-gated governance is used to deal with product documentation issues. In order to meet regulations specific to their areas- for example in the medical context, where companies need to comply to regulatory requirements - firms adopt a stage-gated process as their main governance framework since the level of formality and control is much higher for this approach than for Agile. According to the interviews, using agile elements to manage development activities and a stage-gated model for documentation is an optimal strategy since it reduces the amount of documentation relative to the project while keeping the documentation necessary for the product regulations.

Table 2. Strategies for combining Agile and Stage Gate

Projects with higher levels of technology complexity, novelty, uncertainty, and intersections with other departments include more Agile elements.
The software content is the defining criteria to use Agile, but even in purely software projects, Stage Gate is used to cope with documentation and regulation issues. Moreover, fixed time scales and ending dates for the projects are usually adopted.
Agile and Stage Gate are combined for software content, but the hardware part remains purely Stage Gate.

“

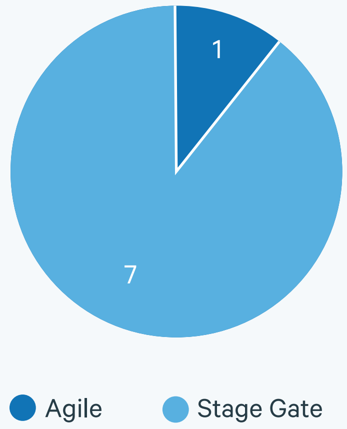
If you have higher levels of uncertainty and change required, and if overall I would say, the complexity of the program is higher, (…) that is where you would typically refer back to more agile or more scrum based teams. (Case B)

How are the processes combined?

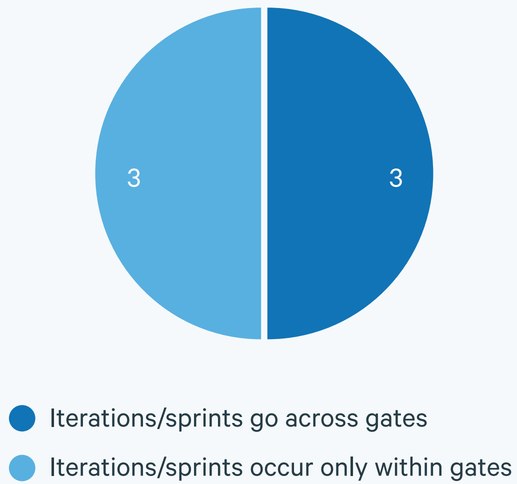
Some cases allow the sprints to go across gate and others do not. The cases that do not allow sprints to go across gates cite that usually this is not an issue because the sprints are short compared with the time frame between the gates, so that they can manage to finish a sprint before a gate. The time span between gates is often several months, while the sprints usually take two to three weeks. When agile elements are well coordinated within the stages and gates, gates attain a specific purpose; to ensure that the project meets the criteria necessary to move forward at key moments in the project. The cases that allowed sprints to go across gates cite that they do so because the gates and agile elements are not coordinated, stopping sprints mid-way would drain momentum in teams and lead to delays. Therefore, the decision to stop the sprints at the gates is related with the level of coordination between the Agile and planned elements of the development process.

> *They [Stage gate and Agile] actually match pretty well. Because the stage gate model is very much able to handle the overall things. Making sure that we have specifications in the rights points of time. The agile is very good at implementing and following up on it and figuring out if we are actually able to meet specs. So they do supplement each other quite well.*
> *(Case G)*

Governance model



Iterations and Gates



Integration of Agile Principles in Planned Approaches

From the cases, a number of different strategies emerge to set project agendas and plan projects. For example, companies employ different strategies for when to use agile methods in distinct parts of the product development process. While all case companies use agile principles and tools in the development stage, there were substantial differences between cases across the other stages. The use of Agile within Planned Development Process for the cases analyzed can be observed on Figure 5. The areas in green represent the phases where Agile is utilized. Difference were observed in how early in the development process agile concepts were integrated, with two of the cases (A, B) utilized agile thinking in the planning stage. Most cases started using agile in the definition stage and into the verification stage.

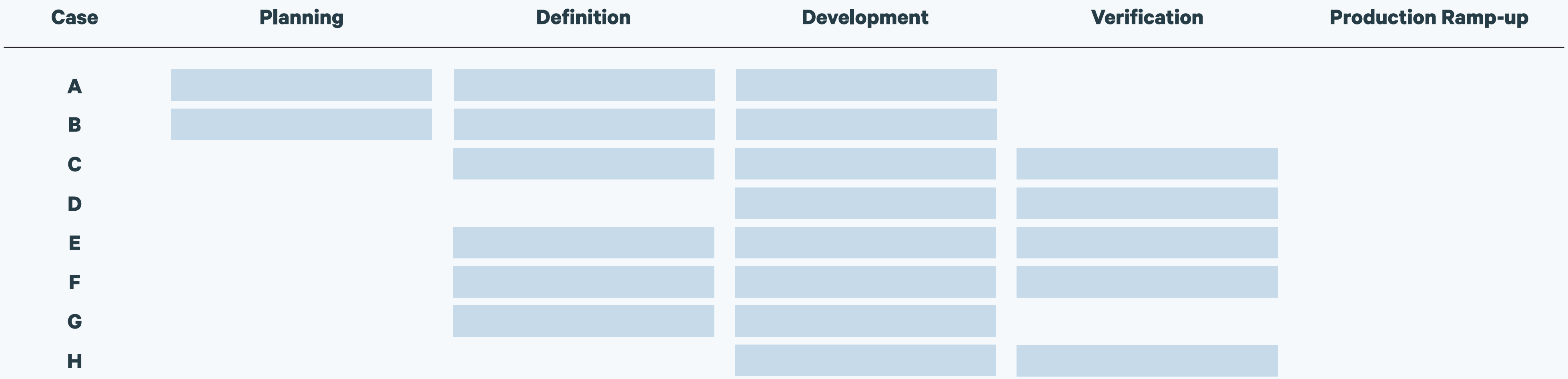


Figure 5 – Integration of Agile within Planned product development process

Dealing with specifications and change of requirements

One of the key differences between stage gated models and agile processes, is how the models help teams deal with changes during the development process. Change is welcome in agile processes, whereas planned models prescribe definition of requirements to happen early in the process, with the specifications being fixed for subsequent stages.

Incorporating agile elements helps improve a firm's ability to adapting to and handling changes in specifications along the project. An agile way of working helps discover and adapt to change earlier in the project because of the frequency of the iterations (sprints) compared to how often gates occur in planned approaches as well as the emphasis on delivering and reviewing presentable increments for each sprint in review meetings with relevant stakeholders. Research has shown that even systematic development of large engineering systems according to planned approaches can include a large amount of late changes in requirements, which can be costly (Vianello & Ahmed-Kristensen, 2012). These results point to the need to discover the need for changes early in the process. This quality of an agile way of working is a key reason for integrating agile principles in the manufacturing context.

The nature of the capital investments in a given project in the manufacturing context might be one of the defining issues when deciding to use a stage-gated or agile approach, so that if capital investments are increasing progressively along the process, the firm might want to avoid changes and increasingly fix requirements. In such cases, companies tended to rely on a stage-gated approach. When the capital investments were constant along the entire development, one might deal with changes continuously through an agile approach.

A common strategy along the cases is to **discuss potential changes through a committee that usually include customer representatives and project managers**, whose role is to decide if the changes in requirements are feasible or if they should put the project on hold. Such decision is often taken based on the capital investments required and the validity of the requirements overall. It should be noted that such strategies conflict to some extent with the agile principle of autonomous teams, and risk that a team looses momentum and perhaps even motivation in a project.

	Changes in specifications later in the process
Strategies	Discuss the probability of change of each requirement and specification with the customer. If the specifications or requirements are not valid any longer, they might decide to put the project on hold and wait until requirements become more clear Adopts retrospective meetings after each sprint to discuss improvements for the next sprint. The project manager handles changes and might take the recommendation to a governing bodyand they would decide together it the changes are allowed Deal with changes as a change requests.

	Design freeze
Strategies	Uses only for target agreement Have a design freeze for components only, usually during development phase After the verification phase requirements are locked Around half a year before the product is launched (final hardware). From this point it is just fine tuning the hardware and software.

Dealing with specifications and change of requirements

Across all the cases, an advantage of the combined agile process was stated as faster identification of the need to change a requirement in comparison to the case of using a stage gated model alone. Late changes in product development are not desired where hardware is involved, for example because of the high cost of redesigning manufacturing tools. The use of agile processes means that issues are likely to be identified earlier is a significant improvement.

The number of changes is more or less the same with both a hybrid-agile planned approach and pure stage gated approach. With the latter they all come at the same time (on the gate) whereas in Agile they are better distributed over the project with makes it easier to handle.

Mostly, the companies cite that there is a design freeze at some point in the development process but that is room for changes if necessary. Some cases also cite that they only use design freeze for some components of the product. For example, one case company choose to work in a hybrid approach to develop features that could be embodied in software first, and then only switched to a stage-gated approach once the features were left that needed to be embodied in hardware.

We often have projects that are kept on hold, wait for the customer to decide which product alternative to implement, ... the important thing is to have the intense information exchange, to get the information of radical changes very quickly to be able to react to it. And this is what agile helps with. In the past when we did not use agile it happened that we had projects and carried them on for a couple of weeks because we just didn't know that there were radical changes. But now using the agile, actually within one sprint, you always have to, you always get the information, what happened with the specifications from other departments. (Case A)

Team organization and structure

A key element of agile ways of working is the way teams are structured as self-organizing. This means that Agile teams are typically highly autonomous and can determine how they operate to a large extent.

The optimal size of the teams when working in an agile way are typically small, specifically around 5 to 12 members. For smaller teams it is easier to align, communicate and be interconnected. More practically, as agile teams typically communicate much more about what they work on, how this is going and what they are challenged by while they work, and this would be challenging in bigger teams. That poses a problem for bigger projects that might require more people. Some of the cases mentioned that bigger projects might be composed of multiple agile teams, in which at least the software part is isolated from other disciplines (e.g. hardware, mechanical engineering) in a specific team (See Table).

Teams often work in more than one project at the same time. Working in more than one project is however not desired because it limits the amount of time and effort that can be spent for each project. The cases mention that often the members that work in several projects are those with special skills that cannot be found in other team members.

Working with global product development is a challenge. The companies that work with teams located in different countries mentioned that it is a challenge to keep the members aligned when dealing with factors such as different time zones and multiple cultures, which ends up creating obstacles to the functioning of the project. Even though some cases mention that they are connected all the time through video conference tools, they try to bring the team together for the most important meetings, preferably in "neutral ground".

> *I cannot understand the list of requirements system architects write, he doesn't understand my requirements, but we both understand what we'd like to achieve from end-user point of view. You can distill the requirements and tasks for himself out of those end-user stories.*
> *(Case B)*

Team organization and structure

Communication level between the team members becomes more intense in agile context. By increasing the number of meetings and stimulating people from multiple disciplines to be constantly in contact with each other, the level of communication between the team members becomes more intense. This increase in contact between the members can be considered as a main benefit of combining agile elements and stage-gated processes in relation to the team organization. Therefore agile ways of working typically improve the shared understanding among the team members, even (or especially) in multidisciplinary projects. According to the cases, the teams work more independently to solve issues and the members have a better view of the overall goals of the project in the agile environment, independently of the disciplines involved. Even if the lists of requirements of different teams cannot be mutually understood, the focus on end user stories offers a broader view of the high level requirements and goals.

Using agile elements improves the alignment within the project. This alignment comes directly from team to team instead of having the project manager making the connections and solving issues, which reduces the bottlenecks. The agile framework forces the members to discuss their points of view together, and by doing that, it helps the members to level their opinions and expectations about the tasks, definitions of done, what has to be fulfilled at the next gate and so on. Some cases cite the importance of retrospective meetings to identify problems and implement improvements much quicker than for stage-gated ways of working.

“Agile is more bottom up approach, team members are more involved and more aligned, with “less politics”. Agile teams are better at controlling the important factors in a product, because they are better at screening themselves.” (Case E)

Team organization and structure

	CASE A	CASE B	CASE C	CASE D
Team size	Very small teams with only 20 or 30 tasks in total.	Maximum 10-12 people per team. If the project is big, they split the user cases in multiple scrum teams	Two teams, 5-6 on each team. Each team consists of one discipline: software and “the rest” (firmware, hardware, and mechanical engineering)	Agile works well with 5-7 people, all from software. The people working with Agile and Stage gate only integrate on a project manager level
Multiple projects	Teams usually work in 3-5 projects, and the amount of commitment depends on their prioritization. No fixed time span allocated to each project.	Teams work in multiple projects but that is not desired.	Team members typically work in several projects combined in one scrum team, but typically the software team works in only one project at time.	Majority of teams work full time in a single project, except for specialists
Global product development	No distributed teams. Teams are located all in the same building and move together for every meeting (e.g. sprint planning, retrospective meeting)	First company to have agile processes working 24 hours a day, 3 teams across the globe.	3 teams, with the first meeting bringing people together.	Typically 3 software sites. Scrum teams are distributed across the countries. The members are not collocated for any of the sprints.

CASE E	CASE F	CASE G	CASE H
5-8 people each team	8-12 people each team	Small teams	8-10 people each team
Typically not. If so, they have a resource system to allocate the members.	Try to avoid teams working at multiple projects. On main project the member has to be at least 50% of the time in one project.	That depends on the tasks, because some of the sprints does not necessarily require full time dedication.	Full time in a project
International team works with an external company that is part of the project	Team members can be placed in different locations, although they try to avoid it. They use skype and video equipment to keep people connected all the time, but time differences are a challenge	Experience difficulties in making cross continent teams work due to time difference and culture	

Benefits of combining Agile and Planned approaches

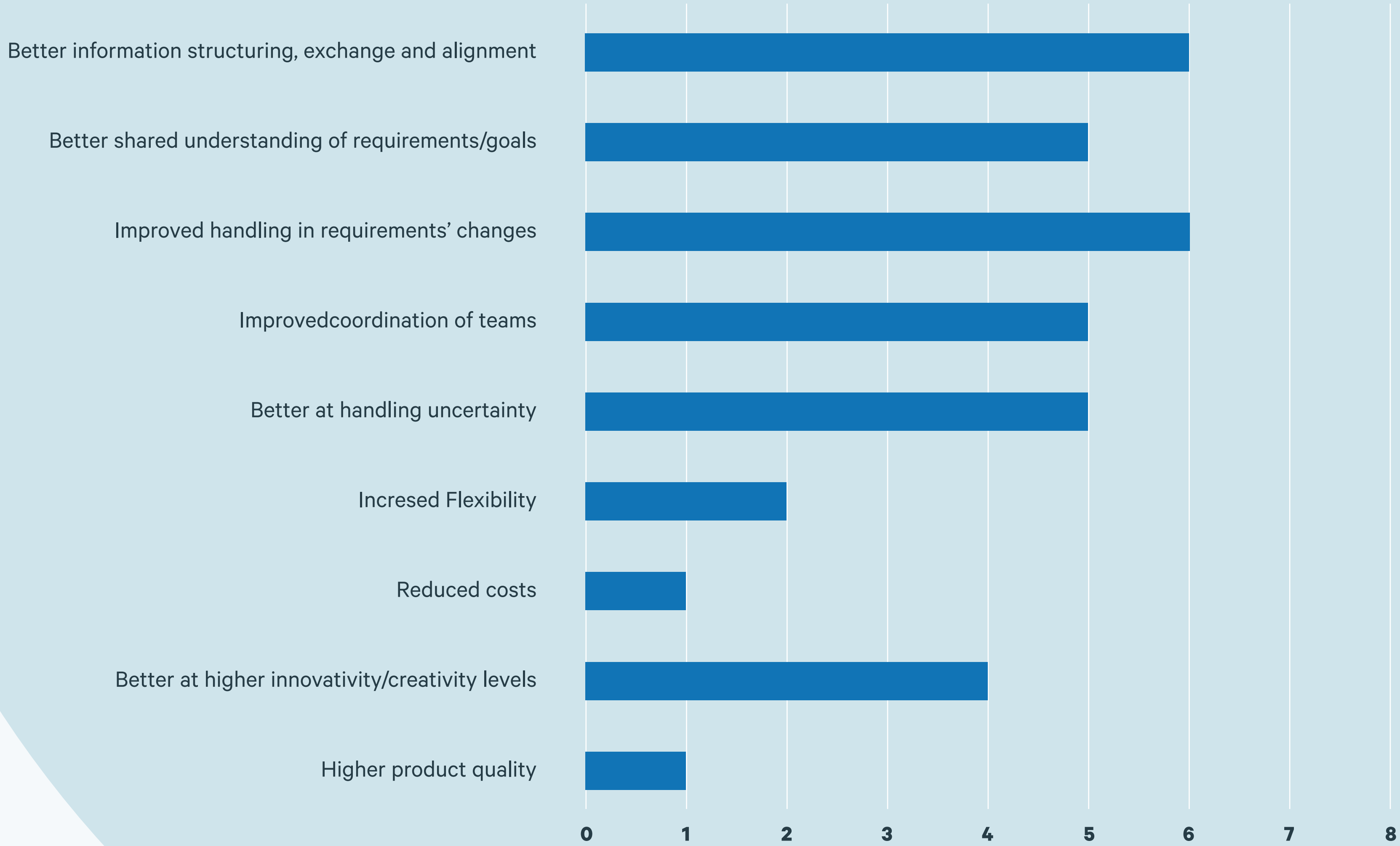
Despite the number of challenges that companies face when combining both approaches, the cases also mention several advantages related with the introduction of agile elements within planned product development models. The benefits are summarized on Figure 6.

Most benefits are related with the observation that an agile way of working increases the information flow between the members, improving the understanding, coordination and information structure. By incorporating agile elements in their planned production processes, the cases relate an increase in the shared understanding of requirements and goals among the members and provides a better structure for information exchange and alignment, for example, regular meetings where everyone is supposed to be at the same time to present their point of view and results. It is also argued that agile helps handling uncertainty by breaking down the requirements into tasks and sprints, helping the team members to have a better overview of the progress of the project and what they can work on at any given point in time.

Some cases report that agility seems to help increasing the innovativeness of projects by opening space for testing and creativity, as long as the mistakes can be detected in time through the meetings. However, not all participants agreed, as some cases reported that the sprints push engineers to make decisions in a very short time, which might interfere with the creative process that often requires time to reflect, incubate and experiment.

"But when you do look at innovativeness in the Agile process then you have more room for being creative, you give a better place for the creativity, as you can also made very fast models (prototypes), so you can easily come to somewhere where you can say, okay that doesn't fly, I need to tweak this and this and this"
(Case D)

Figure 6 – Benefits associated with the introduction of Agile



Team organization and structure

Who defines and prioritizes tasks, is a central question within the agile framework. Whereas in the stage-gated practices, the definition and prioritizing of tasks is typically the responsibility of a single person, e.g. in the form of a project manager, with the mandate for decisions often being distributed over multiple stakeholders (e.g. steering committee, line managers, etc.). Within an agile framework, the team is typically jointly responsible for the definition of tasks, with the product owner being the one that is responsible for prioritization and with the mandate to make decisions in this respect (i.e. a single point of decision making mandate).

	CASE A	**CASE B**	**CASE C**	**CASE D**
Defining tasks: who and how?	Project team	Product owner	Product owner and project manager	The project manager structures the tasks with the input from the team
Task Prioritization: who and how?	It is a team decision but with the input from the customer representative	Scrum master and product owner	Scrum master	Project manager, based on the most important features and the resources available.

CASE E	CASE F	CASE G	CASE H
Project team	Some of the tasks are defined by the project manager and some (technology related) are defined by the team	Project team	Project team with supervision of project manager
Product owner	Project manager and line manager	Project team	Project team

Conclusion

The combined use of Agile and Stage gate present several challenges but also important benefits for manufacturing companies willing to extract the advantages of Agile while keeping the structure provided by traditional planned development models.

The main challenges include higher levels of stress when working with multiple projects in parallel, difficulties in coordinating the teams, as well as difficulties in integrating the Agile elements within hardware development. Companies use a diverse range of strategies in order to overcome these challenges. First of all, most companies use Stage gate as the main governance model and introduce some Agile elements in specific phases of the development process. Therefore, Stage gate is used to handle the broader elements such as high level requirements and maturity criteria for a whole project, while the Agile elements were often used to drive development, support teams and find failures rapidly.

All cases agree that the optimal size of the teams is relatively small, from 5 to 12 members for each team. That reflects the lack of scalability in Agile. Companies also present many strategies when dealing with changes in specifications and task management, which reflects the fact that there is no optimal solution for all companies and managers have to realize which strategies make sense in their companies, given it’s characteristics and operational structure.

Finally, the cases also mention several benefits of combining both models. The incorporation of Agile increases the information flow between the members and therefore improves the shared understanding about the requirements, project goals and potential gaps and failures. With information improvement and increased control over the project, it is said that the incorporation of Agile might also increase the levels of innovativity in the project by opening space for testing and creativity.

Useful Literature

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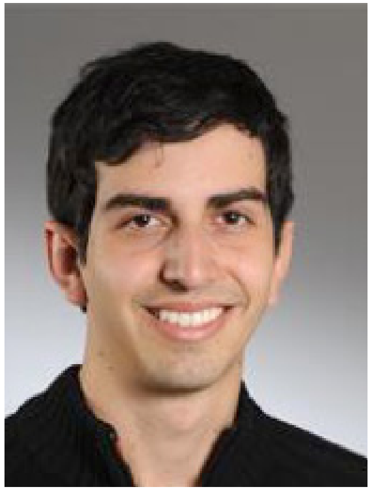

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