For the manufacturer undertaking new-product development, Digital Transformation means smart new products with embedded software. Digital products in turn require software and hardware development teams to work together – a hybrid project – which ultimately leads to combining software development methods with the more traditional gating process that manufacturers use.

The result is a new more agile gating approach to product development. Some leading manufacturers have already adopted Agile-Stage-Gate and have achieved very positive results. Digital platforms may also be required to support the embedded software. Many manufacturers are already familiar with the technology development process, but this typically is for physical science and invention, not software. The new digital platforms thus require manufacturers to significantly modify their familiar technology development methods; a sample model is presented. Digital Transformation also offers new tools for product developers – from testing via simulations, to AI to invent or design the product, to using neuro-sensors to gauge consumer response to products – that greatly accelerate or enhance the new-product process.
The New Digital World for Manufacturers

Digital Transformation promises huge benefits in the field of new-product development, but also major challenges, especially for manufacturers of physical products. For a traditional manufacturer, Digital Transformation impacts the field of new product development in a number of significant ways: It dramatically changes the firm’s new-product landscape – its products, methods, organization, processes, and even mindset – specifically:

- Developing smart products with embedded software, which in turn requires a new development methodology, different from traditional gating processes that manufactures have relied on for decades.
- Employing new digitally-based tools that provide insights to user needs, predict lab test outcomes, and even invent new materials, all designed to make the development process more efficient and effective.
- And developing digital technology platforms, as opposed to traditional product or technology platforms.

More than 70% of US-based companies plan to introduce a new digital technology platform, digitize their products (that is, physical, software, and hybrid), or digitize their innovation management processes. The Institute for Digital Transformation defines Digital Transformation as: “The integration of digital technologies into a business resulting in the reshaping of an organization that reorients it around the customer experience, business value and constant change.”

Smart or Digital Products

Digital Transformation means the manufacturer must develop smart new products, specifically new products that feature digital technologies built in; that is, software in combination with hardware that provides new functionality for the customer. Historically, the hardware part of combined hardware/software product had been the differentiator in the market; now the situation is reversed: The software component increasingly becomes the factor that leads to differentiation and competitive advantage.

What percentage of manufacturers’ R&D expenditures is now going to software development (as opposed to mechanical, electrical, and materials engineering and design) is unknown. A 2019 German investigation sheds some light, however. This study of 124 manufacturing firms reveals that the hardware component still dominates product development: More than 50% of the product composition (the share of the product) is hardware for almost two-thirds of manufacturing firms. But a further analysis shows that embedded software is now 28.9% of the composition of these manufacturers’ new products, on average, a significant percentage.

A More Agile Development Process

A major impact of digital new products becomes the need to change the way the manufacturer develops its new products – the development process. Traditionally, manufacturers have relied on rather linear and rigid gating processes, such as classic Stage-Gate, with each stage or phase of the project being quite well defined and laid out in a sequential fashion from Ideation through to Development and then into Launch – see box “Stage-Gate”.

Article on innovationmanagement.se on March 2020
**Stage-Gate**

Stage-Gate describes a system in which the product development process – from idea generation all the way to market launch and beyond – is broken into discrete stages. Typically there are about five or six stages, from Ideation through to Launch, each stage with defined tasks to be done and prescribed deliverables. Gates that precede each stage mark Go/Kill or investment decision points, and are where the project team secures the needed resources to move forward. The method has been widely adopted by manufacturing firms to drive new-product projects to market.

But such processes don’t work well for software development, where the project’s circumstances, information, timeline, plans, and even the product definition are much more fluid. The software world thus relies on a set of methods and a mindset called Agile Development. Potential for conflict obviously exists between these two quite different development approaches when the development project entails both hardware and software development.

**Actual Versus Expected Results**

(Study of 228 Manufacturing Firms – Mostly Engineering)

<table>
<thead>
<tr>
<th></th>
<th>Actual Value</th>
<th>Expected Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shorter product development (time to market)</td>
<td>2.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Improved adherence to schedule</td>
<td>2.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Improved team morale/motivation</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Reduced project risk (tech feasibility; project failure)</td>
<td>2.4</td>
<td>2.7</td>
</tr>
<tr>
<td>Increased productivity of development project</td>
<td>2.6</td>
<td>2.9</td>
</tr>
<tr>
<td>Increased flexibility to react to changes</td>
<td>3.1</td>
<td>3.1</td>
</tr>
</tbody>
</table>


*Figure 1: Performance improvements in manufacturing firms using Agile Development methods.*

What development process is right for these combined software/hardware development projects? An increasing number of manufacturers have paved the way by already adopting elements of Agile Development methods, borrowed from the software world.4 These firms have embedded Agile methods – see box “Agile Basics” – into the stages of their traditional Stage-Gate or gating system, thus creating what a Danish researcher called the “Agile-Stage-Gate hybrid model.”5 The motivations for doing so were to accelerate their existing Stage-Gate process for physical products. And the results have been positive, according to two large-scale studies done in the EU – see Figure 1: faster to market, higher development productivity and better team morale.6,7
Another benefit is “… the growing role software is playing in physical products”. Indeed, a recent study of six global firms using Agile methods within Stage-Gate showed that all six firms – from LEGO to Honeywell – had adopted the new model largely to accommodate combined software-hardware projects. Further, the Institute for Digital Transformation notes that “the operational control of product development does not need to undergo massive change as a company transitions from industrial age to digital age. Almost all industrial age companies are now developing new products using cross-functional teams and managing those teams with a Stage-Gate control process. This general approach is still used in the digital age, but the time spent in each stage can be significantly reduced.”

**Agile Basics**
The Scrum version of Agile (the most popular) breaks the development process into a series of short, iterative, incremental time-boxed sprints, each typically about two weeks long. Sprints consist of:

- **Sprint planning meeting**: At the beginning of each sprint, the team meets to agree on what it can accomplish in the sprint and creates a task plan.
- **Daily stand-up or scrum meetings**: During the sprint, the team meets every morning to ensure that work is on course.
- **Demo**: At the end of each sprint, software increments or new features, potentially releasable, are demonstrated to stakeholders (both management and customers).
- **Retrospective meeting**: Finally, the team meets to review how they can improve the way they work.

The team then plans the next sprint based on customer and management feedback. Product requirements and technical solutions, and even the project plan, thus evolve over the development cycle. The development team’s work is visible to all, and monitored via a set of visual tools displayed in the team room.

There is no traditional project leader or project manager in Agile-Scrum. Rather, the new roles are:

- **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, typically a senior marketing person, represents the product’s stakeholders, and provides direction to the team (e.g., at the sprint planning meeting).
- **The development team**, a dedicated team that works 100% on this one project, usually technical people, and physically collocated.

The Agile-Stage-Gate model is ideal because it can handle both types of developments – software and hardware – needed in a smart product. The model in Figure 2 has been previously described; briefly, manufacturers typically keep their Stage-Gate model, suitably modified, and embed Agile methods within the stages of that model, much as LEGO. Honeywell, Danfoss, and Tetra Pak did. The rationale is that Agile is a project management method, whereas Stage-Gate is not. Stage-Gate is more strategic in nature, providing guidance about how to do the project and what tasks are required, and whether or not do the project at all (Go/Kill). In this new hybrid model in Figure 2, Agile project management simply replaces the old project management tools, such as Gantt charts and critical path plans, within the stages of Stage-Gate. So Agile is not a substitute for Stage-Gate, but rather complements it. A large-sample study confirms this in practice: The study reveals that 100% of top performing manufacturers using Agile do employ sprints between the gates of their traditional process, and 59% of firms use individual Agile methods within their traditional gating process, in other words, they adopt a hybrid model.
Manufacturers do make some changes to software-Agile as they adopt and adapt this new model:

- Typically, manufacturers don’t use Agile-Stage-Gate for the majority of their projects as software developers do, but for about 20% of projects, and usually only for the more ambiguous, riskier, and less-defined projects.
- They apply Agile-Stage-Gate to all or most stages of the process – Ideation through to Launch – and not just the Development or technical phase as in software-Agile.
- Manufacturers elect longer sprints, often 4-6 weeks or longer, and much longer than software-Agile’s 1-4-week sprints, in order to allow the team time to develop and demo something physical.
- They employ less frequent scrums – not daily, but typically 2-3 times per week, but still with the entire team present.
- The project team is usually not 100% dedicated as in software-Agile: Given inevitable waiting times, a team working 100% on one project is not feasible. But the team is nonetheless quite focused with 60% to 75% of their time on the one project, and much more focused than for manufacturers’ traditional projects. And co-location – all in one room – is usually not possible, given the cross-functional nature of the team (from different departments or locations).
- And many manufacturers keep the role of the Project Leader or Project Manager, partly because their projects tend to be more complex with people from many more departments (software-Agile dispenses with this Project Manager role), and also because this avoids having two different team structures for Agile versus traditionally-managed projects.
With digital or smart products and more agile development processes comes a new more agile mindset. Figure 3 shows a sample proposed mindset, borrowed from the Agile-software world, but suitably modified for the manufacturer.\(^\text{16}\)

**Digital Tools to Accelerate the Process**

A second major impact of Digital Transformation in NPD is the use of digital technologies to *aid and accelerate the development process*. Today, algorithms and bots are investigating user forums, blogs, crowd funding platforms, and social media postings to learn about wishes, pains, and even investment interests of potential customers. An example is the analysis of social media to propose tailor-made new clothing items for the consumer seeking a new dress for a special event.\(^\text{17}\) Further, voice-of-customer research is beginning to adopt neuroscience methods to acquire deeper insights from direct user interaction. Using EEG, biosensors, and eye tracking enables the measurement of attention, engagement, memory, activation, impact, and implicit association which delivers more insights than just a consumer interview or focus group. For example, a producer of orange juice tested which product-attribute versus price combination delivered the maximum consumer valence (positive mental well-being) by using neuro-sensors, specifically EEG (electroencephalography), a medical technique to measure brain activity.\(^\text{18}\)

Newer technologies have made prototype development easier, faster and less expensive. Rapid prototyping based on 3D printing was the precursor of these new prototyping tools; a rapid prototype could be used not only to test technical facets of the product’s design, but also to seek customer feedback and validation for the proposed new product. Rapid prototyping, now much cheaper and more ubiquitous, partially solves the number one reason for new product failure, namely the lack of understanding of
customers’ needs. As Steve Jobs, never a proponent of traditional market research, famously said “People do not know what they want until, you show it to them.” Rapid prototyping makes this possible. And today, 3D printing has gone beyond just prototypes; finished products are now being 3D printed. For example, more than a third of the components in GE’s advanced turboprop engine are made by 3D printing.

Other digital testing technologies are being used in a similar way. Simulations not only test new products technically, but also allow customer-testing of a product that does not yet exist. For example, Volvo Construction evaluates new truck designs before a working prototype is built by using a real-time simulator, not unlike a flight simulator. And Alphabets’ (Google’s) self-driving car, Waymo, had logged 10 billion miles as of mid-2019, all done by simulation.

More recently, Virtual and Augmented Realities are being used to test early versions of products, long before the real product is developed. VR and AR can be used to simulate the user’s environment so that test-customers can try the product, not just in a lab, but in its intended setting. For example, in the development of FedEx’s new drop-box, an early prototype was first developed from cardboard. With potential users fitted with VR googles, developers were able to allow users to see and use the prototype in a variety of environments, for example at their own home, and also to test different drop-box finishes and colors.

AI is also beginning to be used to predict the outcomes of technical product tests, thus accelerating the choice of the right technical solution well in advance. In this context, AI is a tool that uses real-world data and analysis to predict outcomes, faster and cheaper than traditional lab-testing methods. The pharmaceutical industry is beginning to recognize the power of AI as companies achieve some success: “The step-wise serial process of R&D will change to be hyper-iterative and integrated, so that real-world information coming back from development will, in real time, change the research being conducted.” Companies such as Amgen, Pfizer, Novartis, Sanofi, GlaxoSmithKline, and Merck have all announced partnerships with AI startups to discover new drug candidates for a range of diseases. Now, even the design or “invention” of the new product can be accelerated by the use of digital technologies such using machine learning to invent new materials for solar panels or batteries.

Developing Digital Technology Platforms for Manufacturers

A third impact of Digital Transformation is the challenge of developing platforms, but not traditional physical product platforms. For physical products, a platform was defined as a “the design and components that are shared by a set of products in a product family”. An example was an engine-transmission assembly in an automobile which can be used in a number of auto models. Instead, the new platforms needed are technology platforms – defined as a major software, such as an operating system, an operating environment, or a database, under which various smaller application programs can be designed to run in short, an environment for running applications, processes and systems. Technology platforms can be viewed as toolsets for developing and operating tailored and customized services and processes, as well as a new information and sales channel to customers; some sample technology platforms include database, analytics, IoT, and AI platforms. These technology platforms enable users to exchange information, purchase products or services, and promote the product. For example, the manufacturer of packaging equipment develops a software platform (AI, analytics, and IoT) for monitoring and analyzing equipment performance; from this platform, the firm then develops specific applications for each piece of its equipment it develops, as Tetra Pak is doing.

The development of these software-based platforms for use with physical products also requires a new process, or at least the integration of several existing methods. A number of leading firms already utilize a technology platform development process based on Stage-Gate, where the end-result is a new science
or a new technological capability, that can then be used in the firm’s physical-product developments. For example, 3M employs a five-stage new-product gating process, called NPI, for developing new products, which is fed by a three-stage technology development process, called NTI. This technology development process, often called Stage-Gate-TD, has been well documented for physical-product contexts.

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**The Three-Stage Technology-Platform Development Model**

![Diagram of the Three-Stage Technology-Platform Development Model](image)

**The Five-Stage, Five-Gate Agile-Stage-Gate® New-Product System**

![Diagram of the Five-Stage, Five-Gate Agile-Stage-Gate® New-Product System](image)

*Figure 4: The Technology-Platform Process – Agile-Stage-Gate-TD – for developing digital platforms.*

Where the technology is a software-based platform, Stage-Gate-TD is modified as follows – Figure 4:

1. Agile methods are built into this TD process, much as was outlined earlier in the article for Agile-Stage-Gate. That is, within the stages of Stage-Gate-TD are sprints, iterations, scrums and demos.
2. Often the full impact – all the potential applications of the platform – are not known at the beginning of development. The development of platforms for smart-phones is a case in point: The original platform-developers could not have envisioned the many apps that eventually were built from their platform, nor even entirely new services, such as text messaging.
3. One implication of item 2 is that the “project definition” is often unclear or incomplete at the start of the project, and evolves over the development process or in subsequent releases as potential applications become clearer. The Agile-Stage-Gate approach accommodates such ambiguous projects which lack clear definition.
4. Another impact of item 2 is that developing a business case for such a platform development is difficult because not all the applications, hence many revenues streams, are known at the time the critical Go/Kill decisions are made. Thus new techniques for making such platform investment decisions under extreme conditions of uncertainty are enquired, such as Agile portfolio methods.
5. Finally new releases and updates to the digital platform, once developed, are required on an on-going basis as improvements are sought and new potential applications are uncovered. Thus the developer also requires a fast-track version of Stage-Gate-TD, not unlike Stage-Gate XPress – a two-stage, two-
gate version now used for physical-product extensions and improvements, but with adjustment, for fast-release projects.

New Products, New Challenges, New Solutions in a Digital World

Digital Transformation provides dramatic opportunities for product developers in the manufacturing sector, not only to differentiate their new products, but also to improve the way these products are conceived, developed, and launched. The payoffs are significant, but so are the challenges to getting this transformation right. Solutions include adopting a new, more agile development process to handle software/hardware projects; implementing new digital methods for market research and product testing, and even product invention; and employing a systematic but iterative approach to digital platform development.

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