

Digital Engineering

The new growth engine
for discrete manufacturers



Executive Summary

Digital technologies are reshaping the manufacturing landscape. Product-based business models are being disrupted by service-based business models, new skills are needed in a world of smart products, and innovation success depends on the effectiveness of a company's open ecosystem.

This research examines how manufacturers are balancing two different but complementary priorities: using digital to get legacy products to market quicker while investing in new smart products to capitalize on the servitization opportunity (deriving revenues from services). The key findings are:

- We estimate that the size of the smart, connected products prize globally will be \$519 billion to \$685 billion by 2020. Manufacturers estimate that close to 50% of their products will be smart and connected by 2020, a 32 percentage point increase from 2014. In fact, 18% say that they plan to stop manufacturing products altogether and move to a pure service-based business model.
- To capitalize on new service-driven opportunities, manufacturers will need to improve their digital capabilities. Companies will need to add non-physical skills – such as data, IT and software competencies to their traditional physical skills base: non-physical capabilities are expected to grow up to about 50 % by 2020. Outside hires will not fill the digital talent gap completely, which means that organizations will need to invest in digital training, tools and new collaborative ways of working for their existing employees.

An extended digital ecosystem will also be critical to design and provide new end-to-end services. Our research shows that 54% of organizations have instituted programs to foster collaboration with start-ups, third parties and suppliers. However, less than a third have leveraged such programs to co-develop products and services.

- In parallel, manufacturers need to reboot current approaches to legacy product innovation and development using a consistent source of information running across the product lifecycle – from engineering to manufacturing to services. Around 60 % of manufacturers are struggling to ensure “digital continuity” throughout the whole lifecycle. Similarly, despite being responsible for 58% of global research and development spend in 2017, less than one-in-five (19%) of discrete manufacturers featured in the Forbes' list of the most innovative companies 2018, highlighting the ‘anchor’ effect of legacy products and the need to rethink current approaches to product and services innovation and engineering.
- Manufacturers have responded enthusiastically to new technologies and are already rebalancing their IT investments accordingly. Around 50% of manufacturers aim to spend more than 100 million euros in Product Lifecycle Management (PLM) platforms and digital solutions in the next three years, while the proportion of IT budget earmarked for maintaining legacy systems has dropped significantly, declining from 76% in 2014 to 55% in 2017.
- While digital investment has increased significantly since 2014, few manufacturers have been able to scale their efforts. Manufacturers are struggling to tap data from products and customers to drive innovation. Only a quarter of manufacturers are using data to deliver actionable insights for product innovation. In terms of new product development, only two in five of manufacturers indicated they are using AI technologies to analyse customer data.
- Overall, few companies are making significant progress in transforming their approach to innovation and engineering. Only 21% of manufacturers are at an advanced stage, with close to a third still only running pilots. The use of model-based system engineering, data continuity, and virtual simulation within the industry is low; only 16% of organizations are fully implementing Digital Twins* while 45% are not beyond the pilot stage.
- We have identified a group of companies that have successfully transformed engineering and product innovation. They display a number of characteristics that represent best practices: they have a concrete digital vision and roadmap, make better use of the partner ecosystem, invest more in digital technologies, recruit talent in digital skill-sets, and create a culture of experimentation and agility.

* Digital Twin is the digital representation of the “current state” of a manufactured product or system at any given point in time.

Introduction

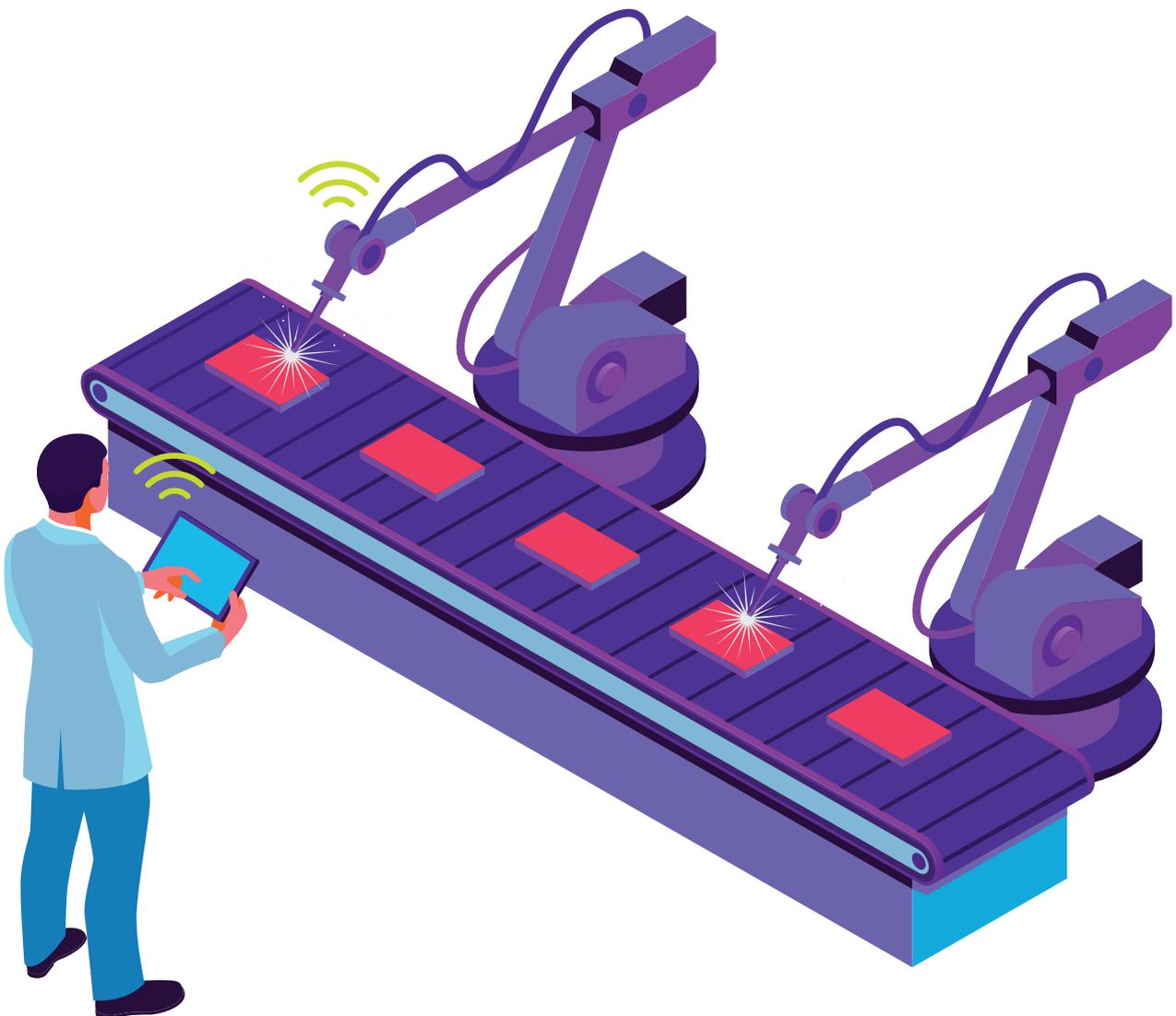
Does pioneering manufacturer Local Motors provide a glimpse into the future of manufacturing engineering? The firm, only founded in 2007, has co-designed multiple vehicles using the largest community of car designers and engineers in the world. Rally-Fighter – its first vehicle – was designed by 2,900 community members from 100 countries.

This example illustrates how digital technologies are reshaping the manufacturing landscape.

Even as discrete manufacturers are grappling with how to accelerate speed to market and develop mass customization capabilities, newer challenges emerge in the areas of product innovation and development. As products become more complex and increasingly comprise software, new engineering capabilities are required. Product-based business models are changing as services become a major source of value. Product innovation has evolved from being closed-loop to an open ecosystem, requiring firms to explore different ways of collaboration, both internally and externally.

In this environment, traditional approaches to product innovation and engineering – how manufacturers move from discovery and innovation to product release – need to change and meet the realities of a digitized environment. To understand how leading manufacturers are approaching this transformation, we surveyed over 1,000 senior executives of large, discrete manufacturing organizations around the world. Drawing on the views of executives from across discrete manufacturing segments – including industrial manufacturing, aerospace and defense, medical devices, and high-tech – the report examines four areas:

- 1. Why transforming product innovation and engineering is critical**
- 2. How manufacturers are transforming this critical capability**
- 3. What can be learnt from successful organizations**
- 4. How to overcome key challenges on the road to transformation.**

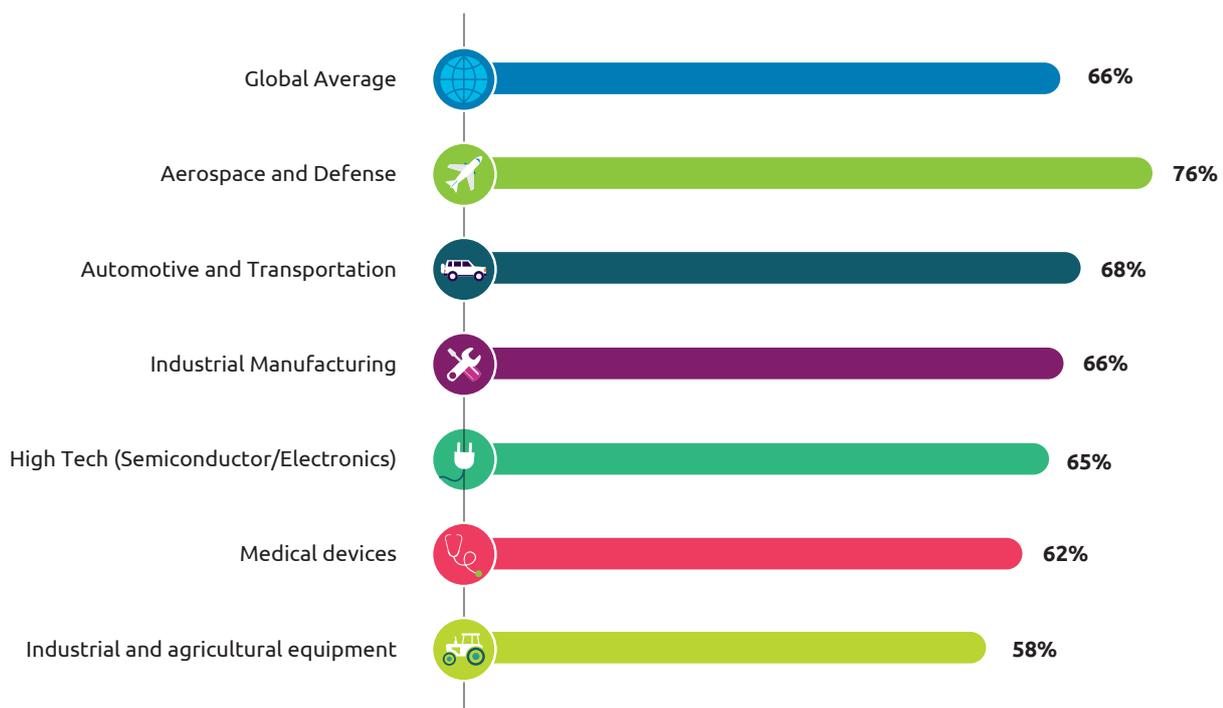


Transforming product innovation and engineering – why it matters

In our research, a majority of manufacturers acknowledge that sustaining and growing their core business while finding new sources of revenue growth is a constant challenge (See Figure 1). These organizations are attempting to balance two very different but complementary priorities:

- Accelerating time-to-market of legacy products by ensuring there is data-sharing and continuity across the product lifecycle and through continuous product innovation and development.
- Investing in smart, connected products to move away from transactional product sales to services and product-as-a-service models.

Figure 1: Share of manufacturers agreeing that they face twin challenge of continuous product development and developing new services



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

In most sectors, organizations will still need to juggle both priorities. Despite initiatives to grow their connected products portfolio, their traditional products continue to be the main revenue driver. However, the opportunity to create new sources of value from connected devices makes the shift to a service centric model an imperative.

Delivering against these twin priorities requires significant change. Organizations will need to focus on two areas::

1. Reboot approaches to product innovation and development recognizing that:
 - Current legacy approaches are not ensuring digital continuity across the life cycle and are not delivering an innovation return on investment levels.
 - Numerous discontinuities are still remaining along the development cycle:
 - “Inside Engineering,” between the various disciplines
 - “Inside the Company”: Engineering – Manufacturing engineering – Manufacturing – Aftersales
 - “Outside the Company”: Company – Suppliers

- Combining hardware and software (IT) development cycles and configuration management is a fast-growing issue
 - Product development IT landscape must evolve progressively within a “run-to-build” journey to take full advantage of new/enhanced PLM solutions and new digital technologies
 - “Digital twins” (the complete digital documentation for every individual product) will drive manufacturing performance to the next level
2. Build the capabilities needed to capitalize on servitization opportunity:
- Smart, connected products are transforming competition from products to services
 - Open, extended ecosystems will be crucial to provide new value-added products and end-to-end services
 - Usage data (from smart, connected products) and customer feedback (from social/professional networks) will fuel innovation and new product/service development

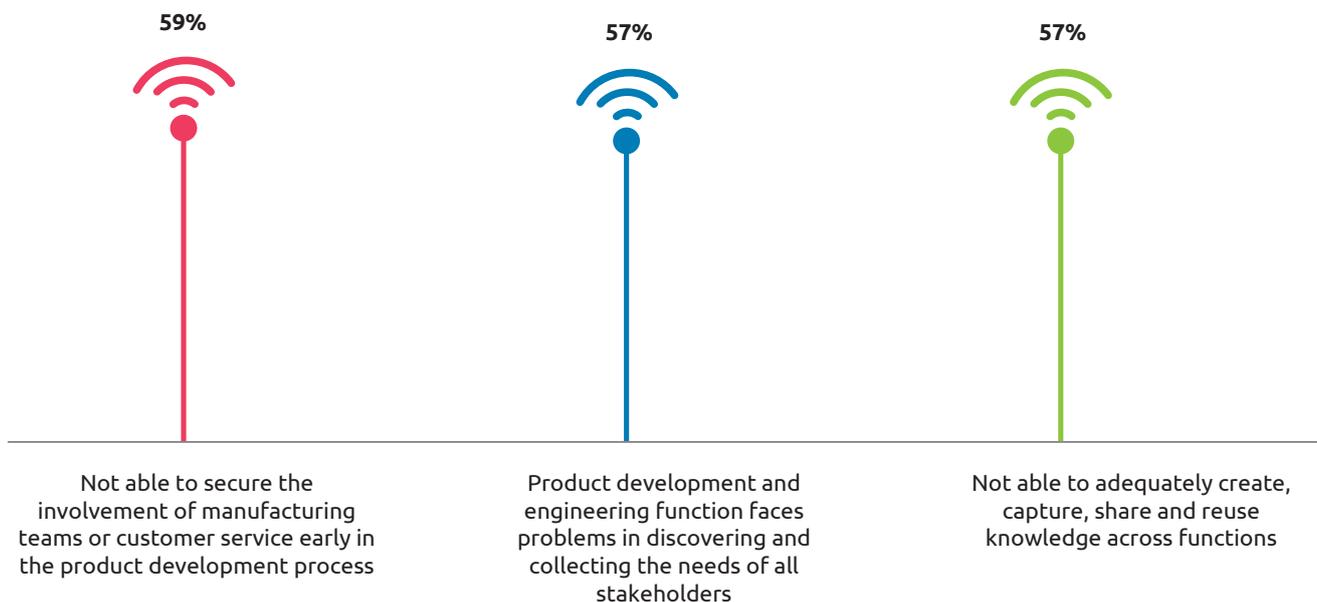
1. Reboot needed – legacy approaches are not delivering an innovation return

R&D lacks teeth: Manufacturing is the world’s stand-out R&D contributor – in 2017, the industry was responsible for 58% of global R&D spend.¹ Despite this R&D commitment, only 19% of discrete manufacturers feature in Forbes’s list of the most innovative companies.² This dichotomy highlights the need to rethink current approaches to product innovation and engineering.

There is little data-sharing or “digital continuity” across the product lifecycle: A unique, authoritative and consistent stream of information running across the product life cycle – from engineering to manufacturing and then to services – is critical to optimize innovation and accelerate product development.

However, current engineering processes do not support seamless data sharing across functions. Lack of integration between legacy systems restricts effective mining of data for product development and improvement. Limited view of product utilization limits manufacturers’ ability to quickly respond to market demands. In our research, we found that six out ten organizations are unable to synchronize different functions’ activities early in the design and development stage (See Figure 2). Around the same number of organizations also find it difficult to create, access, and reuse information on how a product was designed, manufactured, and serviced.

Figure 2: Key challenges in maintaining digital continuity



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

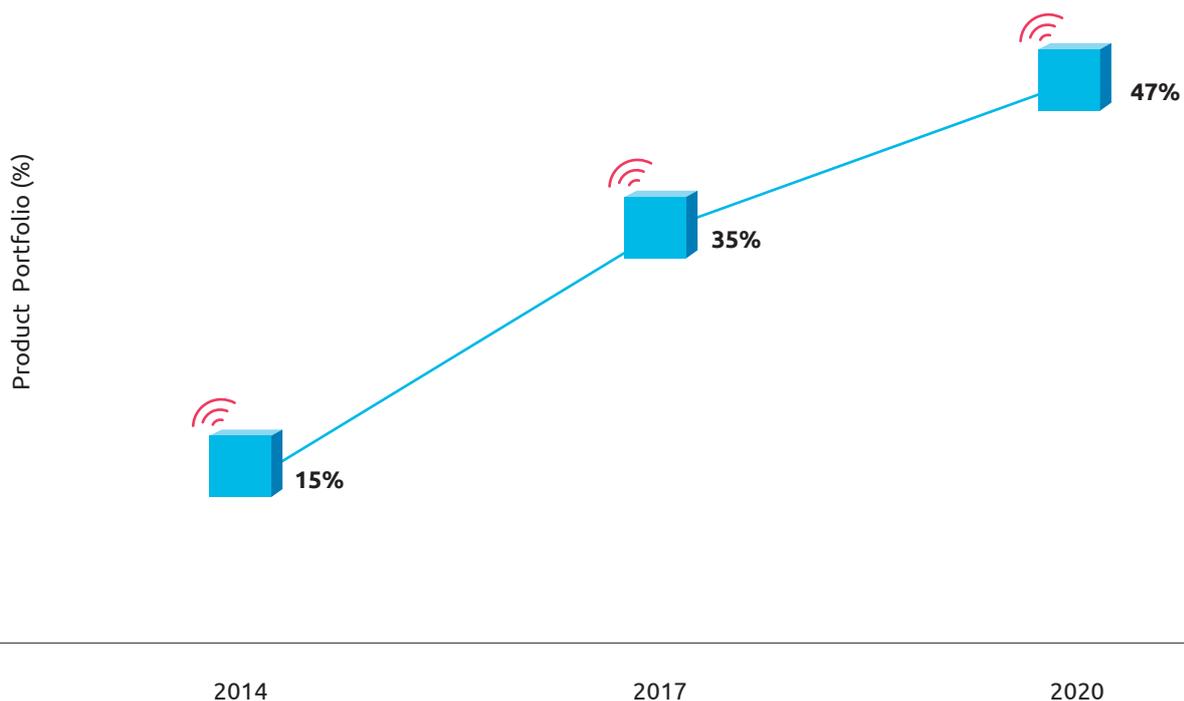


Manufacturers expect close to 50% of their products to be smart and connected by 2020

2. Capitalizing on the servitization opportunity require enhanced capabilities

Our research shows that manufacturers expect close to 50% of their products to be smart and connected products by 2020. This would represent a dramatic increase: in 2014, that figure was just 15% (see Figure 3).

Figure 3: Percentage of products that are smart, connected



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

The size of the connected products prize: \$519 billion to \$685 billion by 2020

Using a conservative scenario, our estimate is that smart, connected products will add \$518.9 billion or 6.63% to manufacturing value-added in our surveyed countries.

In an optimistic scenario, where manufacturers accelerate their smart, connected product efforts, it would potentially add up to \$685.6 billion to manufacturing value added in 2020. This would amount to 8.76% of manufacturing value-added in the nine surveyed countries.

	Factors used for estimation	Conservative Estimate	Optimistic Estimate
A.	% Smart, connected products in the portfolio -2017 (From survey)	35%	35%
B.	% Smart, connected products in the portfolio -2020 (From Survey)	51%	67%
C.	Incremental revenue increase for every 1% increase in smart, connected products over three years (2017-2020) (analysis from survey data)	0.47	0.51
D.	Cumulative revenue growth rate for manufacturing from smart, connected products. (2017–2020) (B – A) x C	7.52%	16.22%
E.	Estimated CAGR for incremental revenue from smart, connected products (derived from D)	2.45%	5.14%
F.	Total incremental value added to manufacturing due to smart, connected products, 2017–2020 ($\$6.89^1 \times D$)	\$518.6 billion	\$ 685.6 billion ²
G.	Average annual contribution (2017–2020) F/3	\$172.9 billion	\$ 228.5 billion
H.	As a % of manufacturing (value added) for survey countries (2020) ($F/\$7.82^3 \times 100$)	6.63%	8.76%

1 Manufacturing GDP is \$6.895 Trillion for survey countries as per world bank estimates of 2017.

2 We have capped the growth rate to 3.21% which is the global GDP growth rate of 2016 as incremental value added to manufacturing from smart, connected products cannot exceed demand growth.

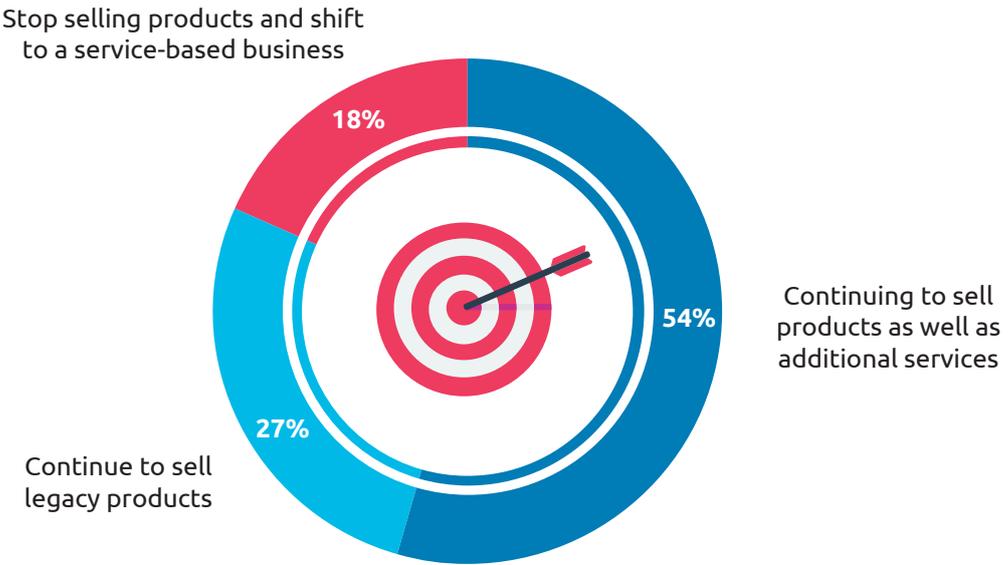
3 Manufacturing Value Added is estimated at \$7.82 Trillion for 2020 using World Bank estimates for 2016 and world GDP growth rate of 3.21% for 2016

Smart, connected products offer a significant opportunity (see “The size of the connected products prize: \$519 billion to \$685 billion by 2020”). Close to one in five manufacturers plan to embrace this opportunity wholeheartedly, with 18% saying they plan to abandon products and move to a pure service-based business model. Around half (54%) plan to continue to sell products as well as additional services (see Figure 4). “We want to bring value to the market by shifting our business model toward service-based and cloud-connected architectures. It is a key way to differentiate our value proposition in the market of pure hardware players,” says Antoine Destribats, Vice President – Industrial Operations at Schneider Electric.

To make the services model work, manufacturers need to fundamentally rethink how products are designed, developed, and controlled. Two areas will be key:

Firstly, as products shift to being software-driven, manufacturers must adapt to the demands of frequent upgrade cycles – a common phenomenon in the software world. Our research shows that manufacturers consider the role of software and IT in products as one of the top three factors impacting on their businesses (see Figure 5).

Figure 4: What are your ambitions with relation to smart, connected products over the next 3 years?



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N= 1013). Percentages may not total 100 due to rounding

Figure 5: Top 3 trends affecting businesses of manufacturing firms

1	Maintaining digital continuity
2	Software and IT as an integral part of products
3	Shift from product to service-based business models

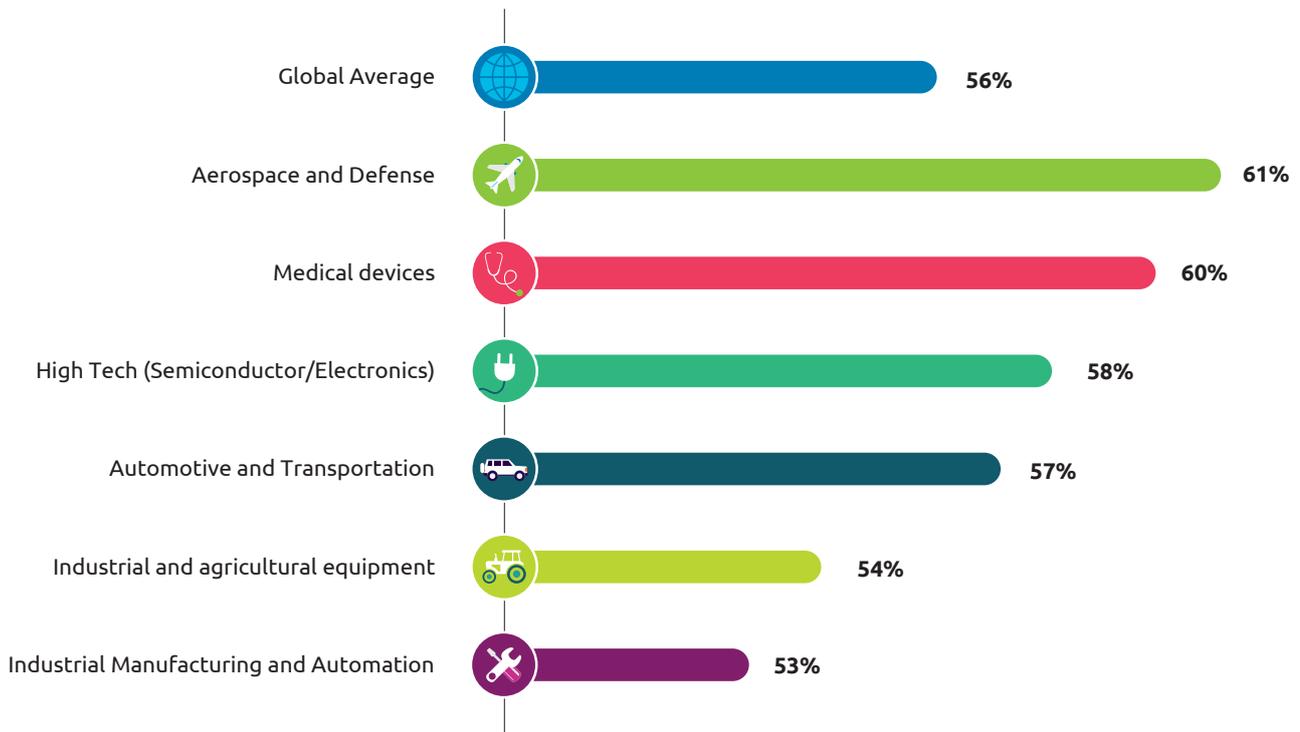
Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

The role of IT has extended to a broader set of functions. "A few years ago, IT was an independent department," said Gunter Beitinger, vice president of Manufacturing at Siemens. "Now, we see IT running through all our functions – product development, quality management, production, maintenance, business excellence. In fact, we now have more people on board with IT knowledge in our departments than ever before."

Secondly, manufacturers need to capitalize on the data generated by connected products if they want to sell services. "We are constantly working on a goal to collect and use all the data that we have to help us take the critical business decisions of selling new services," says a senior executive,

Head of Department, Product Development and Production, Thales. But conventional approaches to data aggregation, sharing and analysis are inadequate to extract the full value from data. For example, in a typical manufacturing set-up, the responsibility of storing and analyzing data usually lies with individual functions, with very little data sharing between different departments. In our research, we found that 56% of organizations say they do not have a culture of data-driven decision making (see Figure 6).

Figure 6: Share of manufactures who agree they do not have a data driven culture.

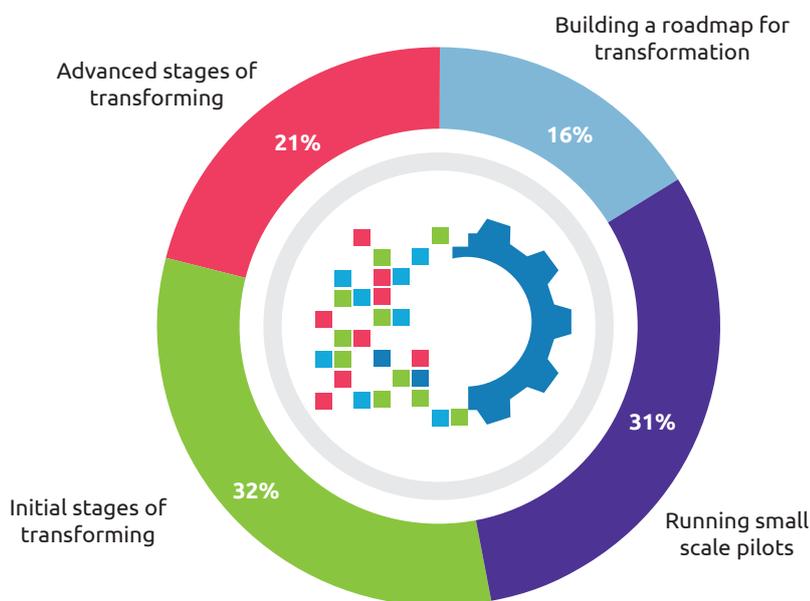


Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

How manufacturers are transforming product innovation and engineering

Few organizations are at an advanced stage when it comes to transforming innovation and engineering. Most are at an early stage – with close to a third still running pilots – and only 21% characterize themselves as being at an advanced stage in the journey (see Figure 7).

Figure 7: Current state of transformation of product development and engineering function



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

And, regardless of where they are in their transformation journey, all manufacturers are showing uneven progress in addressing two priorities: using digital tools/methodologies to accelerate and secure the development of legacy products and building critical services and product-as-a-service capabilities.

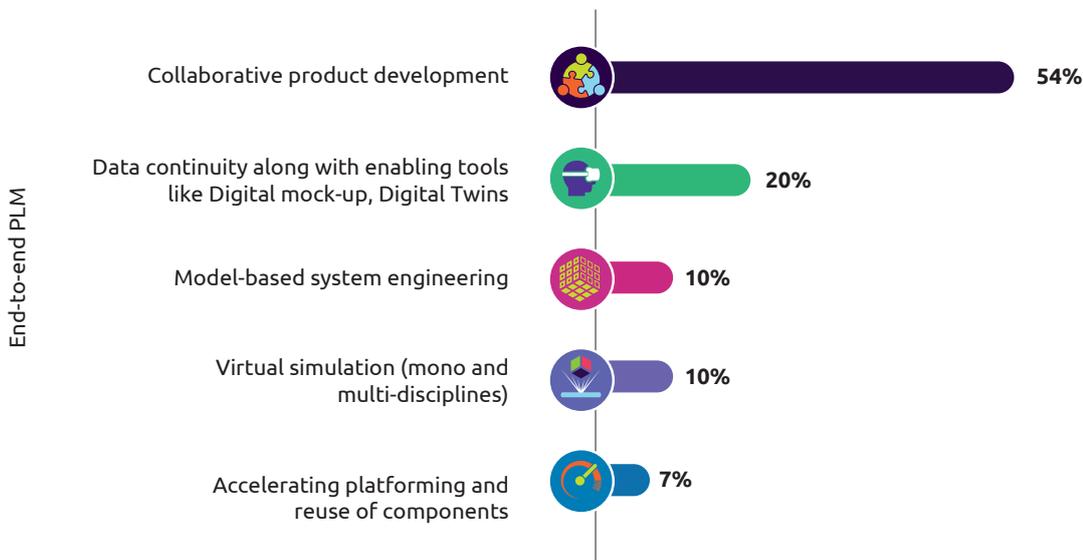
Priority 1 – Using digital tools and methodologies for legacy products

Using PLM (product lifecycle management) platforms and technologies – such as digital twin, augmented reality, and virtual reality – can make the product development process more efficient and cost effective. Manufacturers are responding enthusiastically to this and are rebalancing their IT investments. Around 50% aim to spend more than 100 million euros in PLM platforms and digital solutions, while we found that the proportion of IT budget earmarked for maintaining legacy systems has dropped significantly (from 76% in 2014 to 55% in 2017).

However, when we take a closer look at usage of different digital technologies, we find that this enthusiasm for digital investments is not necessarily translating into real progress. For example, very few manufacturers are using all the features of a PLM platform at scale. Except for collaborative product development, the use of features – such as model-based

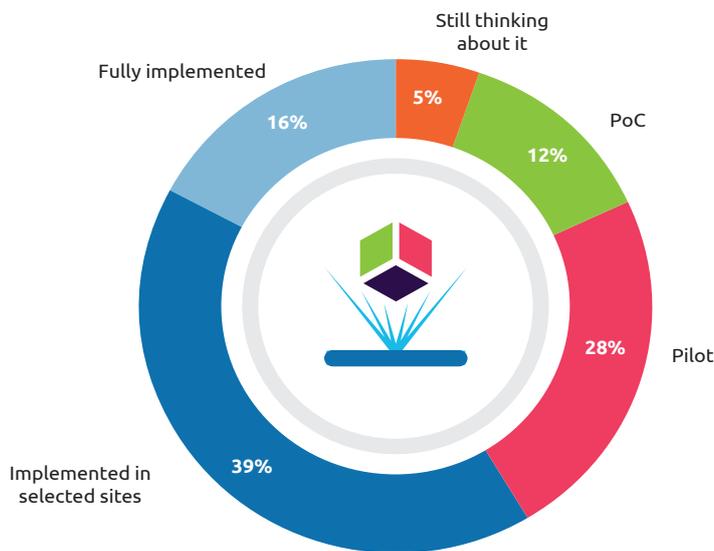
system engineering, data continuity, and virtual simulation – is low (see Figure 8). In addition, only 16% have fully implemented digital twin, with 45% not beyond pilot stage (see Figure 9).

Figure 8: PLM Features and tools used by manufacturing organisations at scale



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

Figure 9: Different stages of Digital Twin implementation by manufacturers

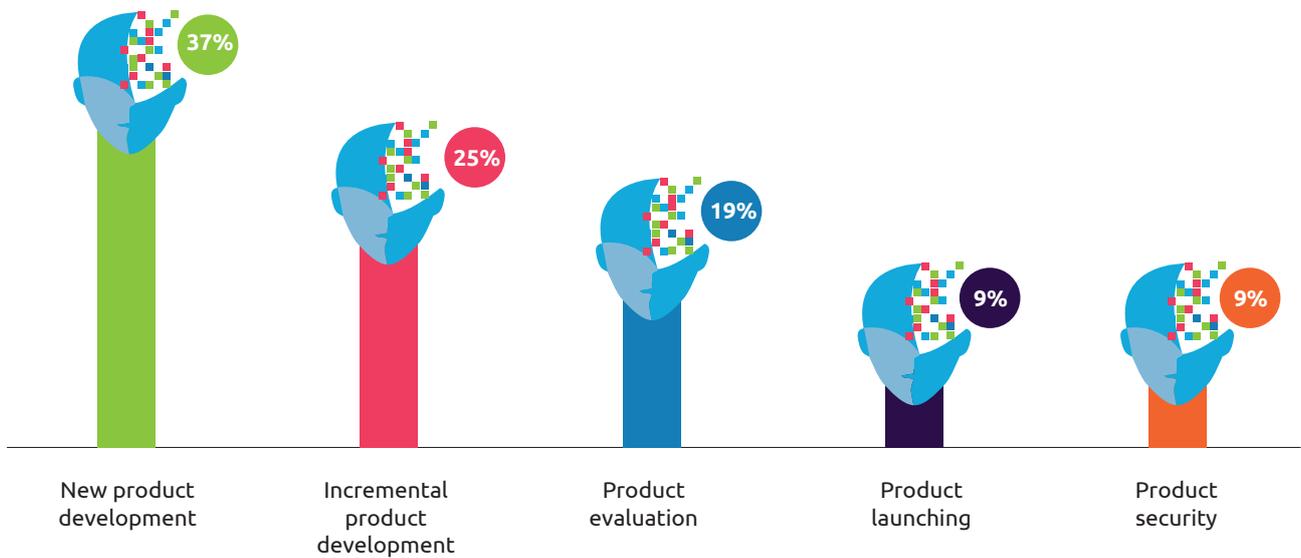


Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

Manufacturers also lacked the capability of using AI technologies for product development and evaluation. For example, only around two out five manufacturers use it to analyze customer communication in social media channels and contact centers for new product development. This

suggests that lot of manufacturers are losing out on the opportunity to use AI technologies for making appropriate design specifications and for product innovation (see Figure 10).

Figure 10: Organizations leveraging artificial intelligence in the following areas



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

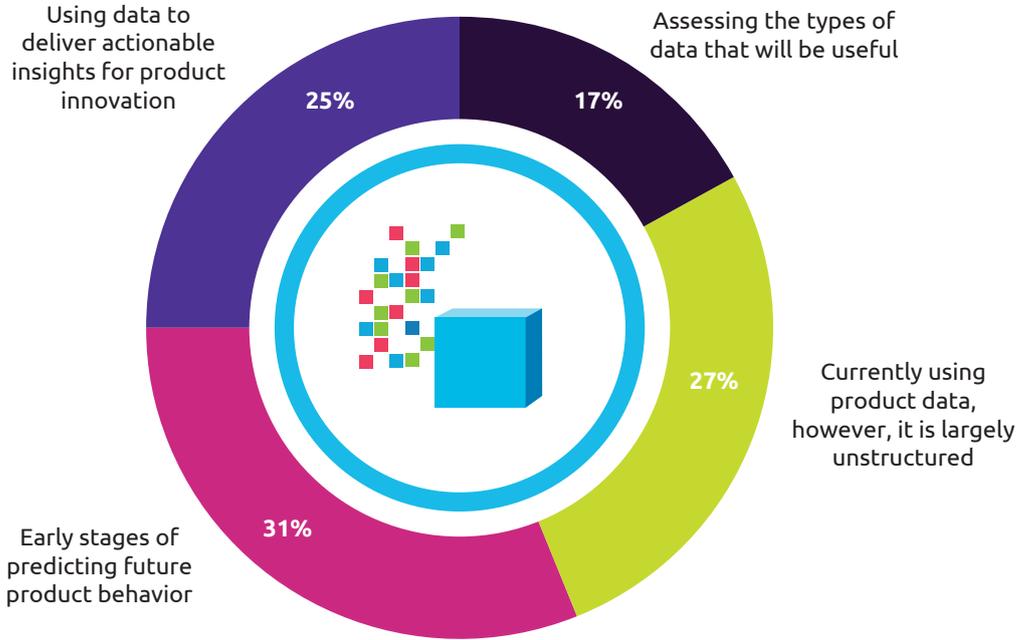
56% of manufacturers agree they do not have a data driven culture

Priority 2 - Developing servitization capabilities

Manufacturers are struggling to tap data from products and customers to drive innovation

Usage data from connected products – as well as customer feedback from social channels – is increasingly replacing traditional market surveys and fueling product and service innovation. “We collect various types of usage data ranging from the duration of use to the frequency of usage. This gives us data to analyze product performance and enables us to develop the next generation of products or services,” said Jan Willem Ruisch, head of Product Management at Signify (formerly Philips Lighting). However, our research finds that only a quarter are using data to deliver actionable insights for product innovation (see Figure 11).

Figure 11: What best represents your organization's use of data generated from smart, connected products?



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013)

“We collect various types of usage data ranging from the duration of use to the frequency of usage. This gives us data to analyze product performance and enables us to develop the next generation of products or services,”
Jan Willem Ruisch, head of Product Management at Signify (formerly Philips Lighting)

Few organizations are routinely co-developing products with ecosystem partners

As they deliver the services business model, manufacturers are working with an extended partner ecosystem to co-create products and services, including start-ups (see Figure 12).

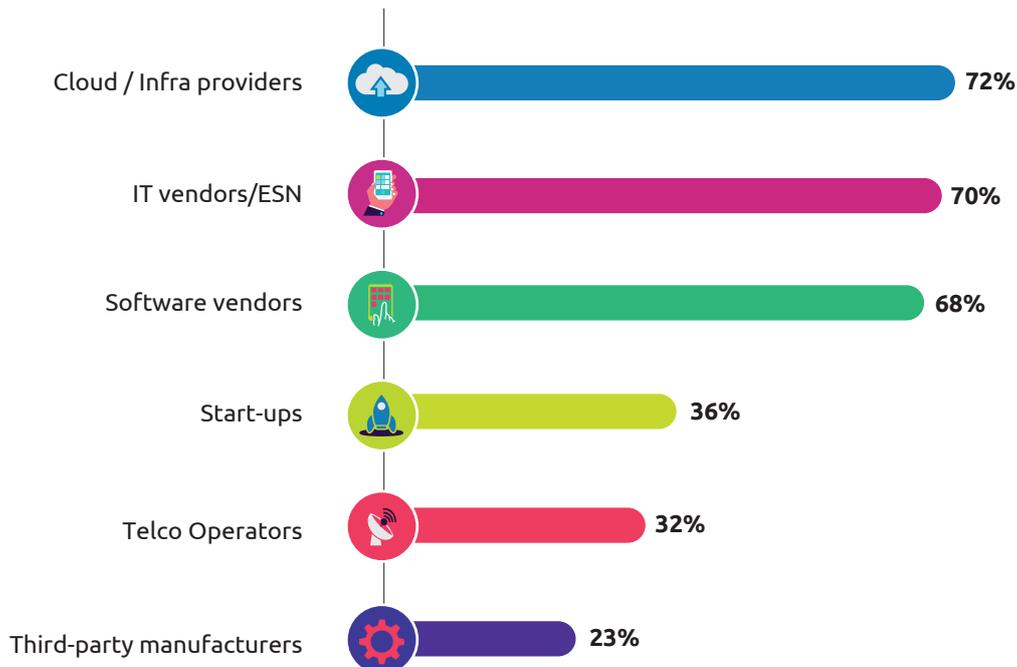
“We work with our suppliers – right from the design initiative stage with transparency,” says Magnus Dahlen, senior director of Engineering at Autoliv. “Suppliers have access to our PLM system, with more information than they traditionally have got through the drawings and CAD models. Such close collaboration has helped a lot in early detection of design issues.”

Our research shows that most organizations (54%) have instituted programs to foster collaboration with start-ups, third parties, and suppliers (see Figure 13). However, less than a third have used this sort of program to co-develop products with the partner ecosystem.

“Suppliers have access to our PLM system, with more information than they traditionally have got through the drawings and CAD models.”

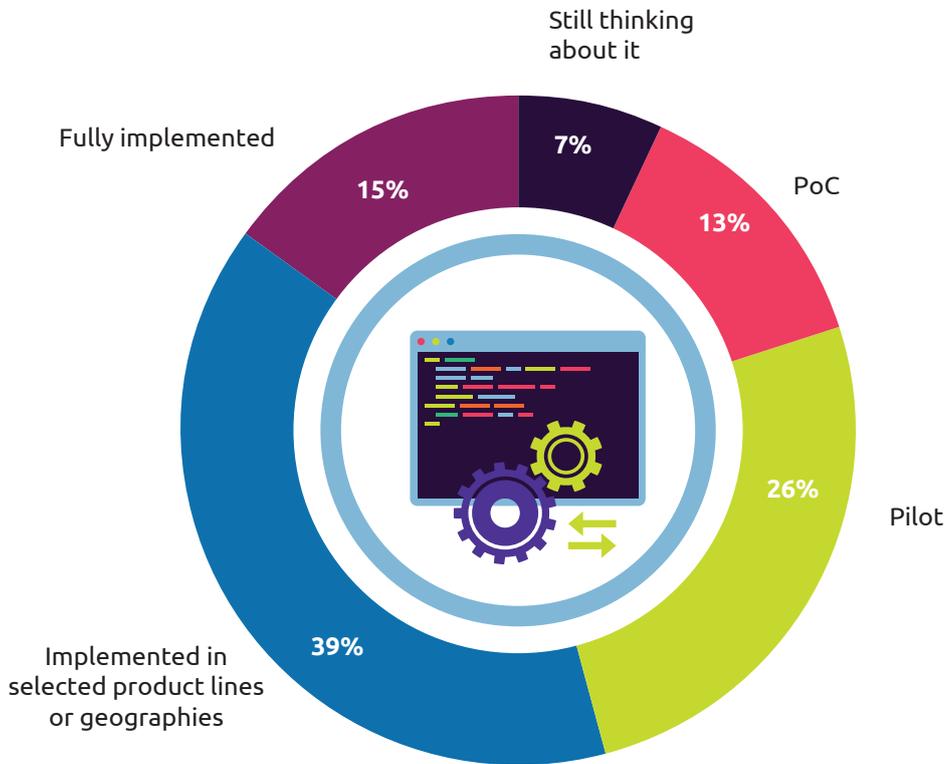
Magnus Dahlen,
Senior Director of Engineering at Autoliv

Figure 12: Breakdown of partners that manufacturers are working with to drive collaboration



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

Figure 13: Different stages of implementation of a formal program to partner with external ecosystem



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

Need to shift talent focus to non-physical skills

The prevalence of tech in products is disrupting the traditional talent mix. For example, in 2014, non-physical skills – such as HMI design, data analytics, AI, apps design, and cybersecurity – formed 20% of the talent portfolio. In 2017, that stands at 34% and manufacturers expect it to increase to 47% by 2020 (See Figure 14).

Structure and culture key to meeting priorities

To accelerate progress against these two priorities, manufacturers are changing their organization structure and evolving their culture.

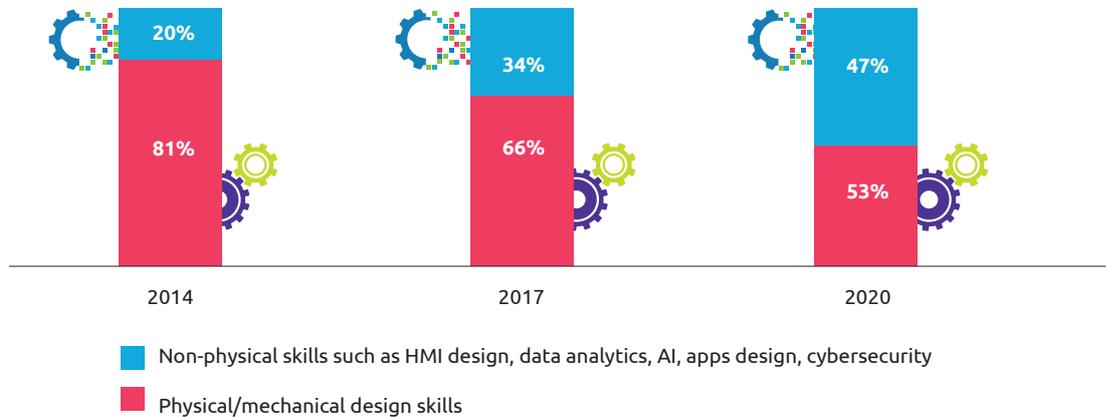
Revamping traditional organization structures

Manufacturers are changing their organization structures to drive both investments in new services and continuous improvement of legacy products:

- As Figure 15 shows, 45% of manufacturers have created a new independent unit focused on developing smart and connected product. For example, Autoliv – a leading auto safety system manufacturer – span off its electronics business segment to create a new, independent publicly traded company. The unit is focused on the opportunities offered by connected and autonomous cars. The new entity’s offering will include safety electronics, sensors, and software for active safety, advanced driver assistance systems (ADAS), and autonomous driving (AD) as well as advanced brake control solutions.³

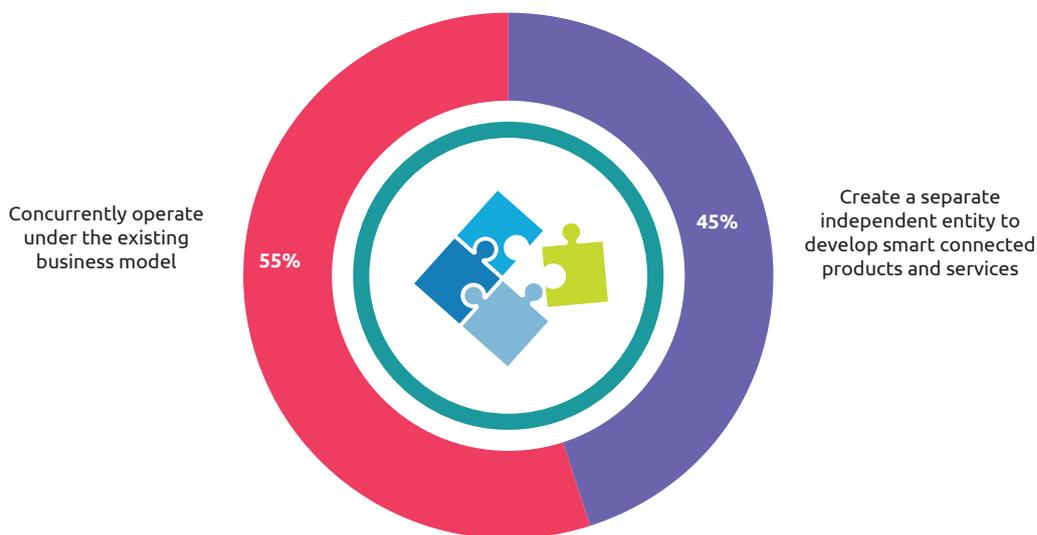
Deciding on a separate entity versus persisting with the existing business model is a critical tradeoff. While a spin-off is complex and takes time, it has clear advantages over the unified approach. A separate entity focuses the organization and its capabilities on delivering the connected products strategy. In addition, the difficult changes required during product innovation and engineering transformation may be harder to implement in a business-as-usual environment.

Figure 14: Talent breakdown between physical and non-physical skills



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013). Percentages may not total 100 due to rounding

Figure 15: Breakdown of options manufacturers are exploring to restructure their organization



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 669).

Creating a culture of innovation and agility

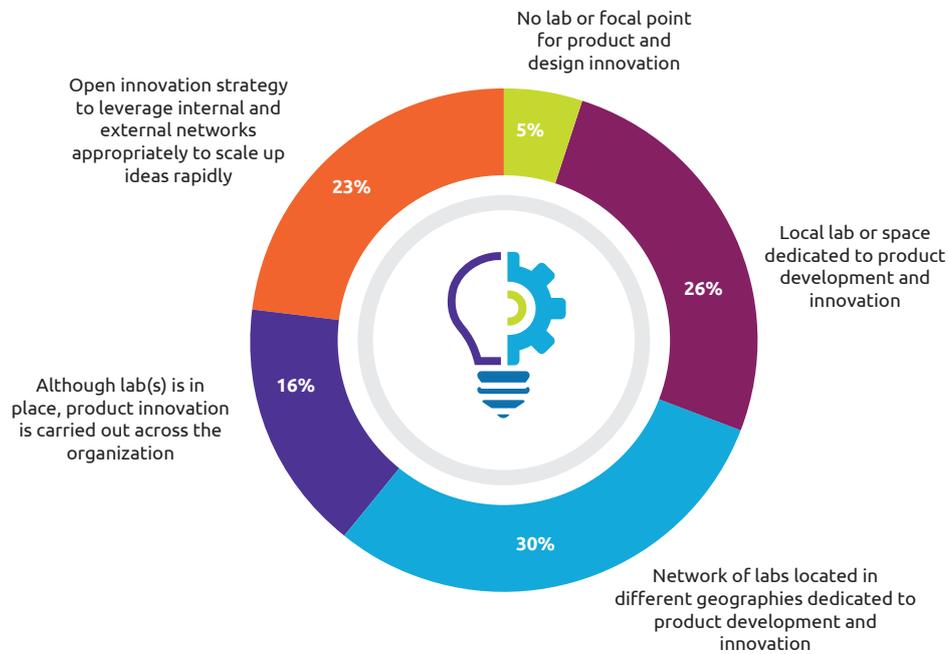
Innovation thrives on new thinking and experimentation. An innovation lab can create an environment where this sort of creativity flourishes. But in our survey, we found that less than a third of manufacturers have put in place a lab network across their geographic footprint (see Figure 16).

By adopting an open innovation strategy, organizations are able to secure support from its supplier community, academics, or even its customers to solve key research

problems. We found that only around two out of ten organizations prioritize an open innovation strategy to leverage both internal and external partners to scale up ideas (See Figure 16).

To be able to fully explore the potential of open innovation strategies, organizations will need to put the right model in place to support sharing and protection of intellectual property (IP) in the eco system. An IP model that appropriates value for each ecosystem partner is critical in driving successful collaborative product design and innovation initiatives.

Figure 16: Breakdown of actions manufacturers are taking to promote innovation culture



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

45% of manufacturers are exploring to restructure their organization by creating a separate independent entity to develop connected products

Learning from leading organizations

To understand what levers manufacturers need to pull to transform, we identified a cross section of companies that have made a success of transformation (see “Who are the successful companies?”). These leading organizations constitute only 10% of the survey sample.

A closer look at the initiatives favored by successful companies versus the less successful reveals key differences. Successful organizations:

- Create a compelling digital vision and have a roadmap to monitor progress
- Value the contribution of their partner ecosystem as they collaborate to drive value
- Invest in, and deploy, new and emerging digital technologies
- Recognize the importance of digital skills in engineering transformation and are disrupting the talent mix
- Evolve their culture to driving transformation and support experimentation and agility.

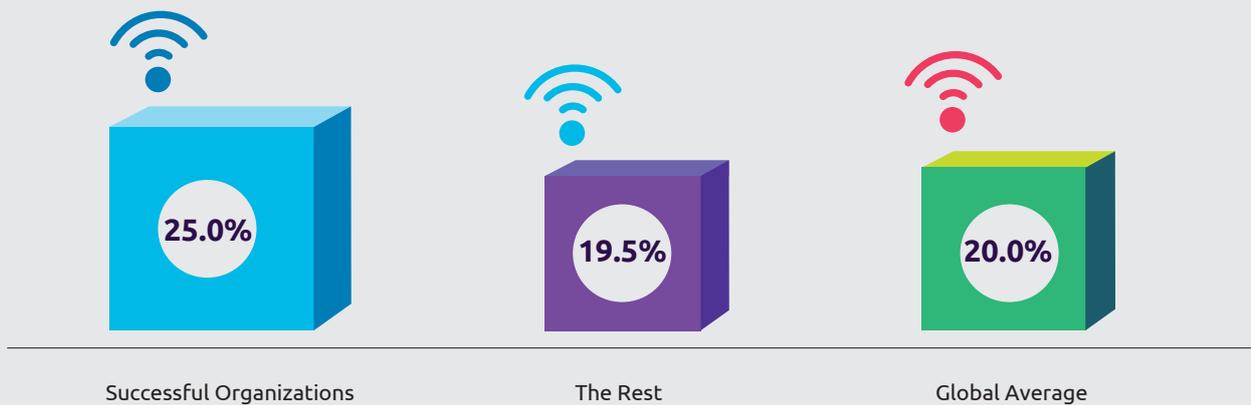


Who are the successful organizations?

We classified this cohort based on self-assessment of performance across four areas:

- They have a higher percentage of smart and connected products portfolio (Figure 17)

Figure 17: Composition of smart, connected products in portfolio mix (incremental change in 2017 over 2014)



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

- They derive higher incremental revenues from smart, connected products (Figure 18).

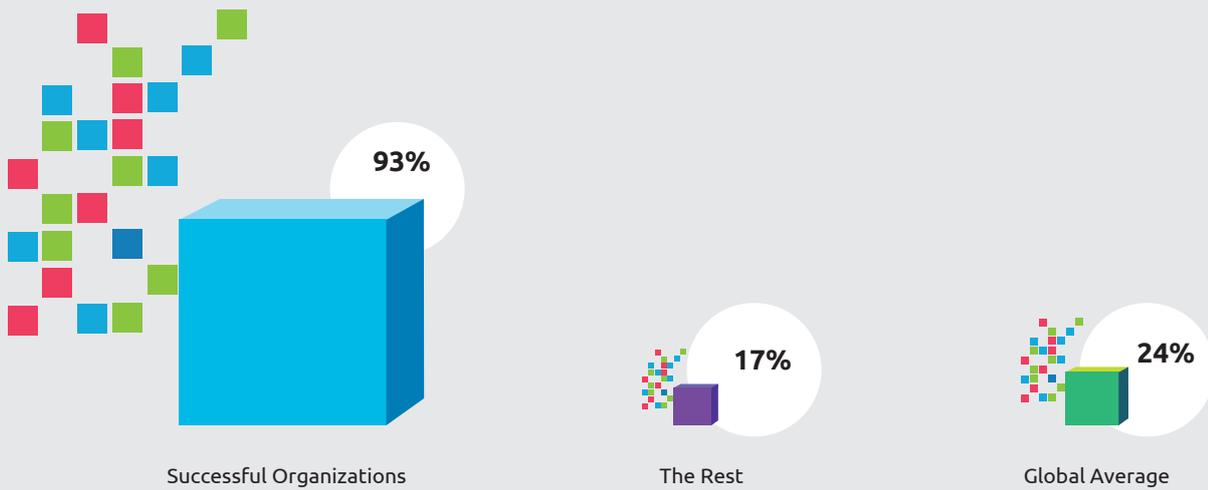
Figure 18: Revenue from smart, connected products (incremental change in 2017 over 2014)



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

- They have mastered the use of data generated from smart, connected products (Figure 19)

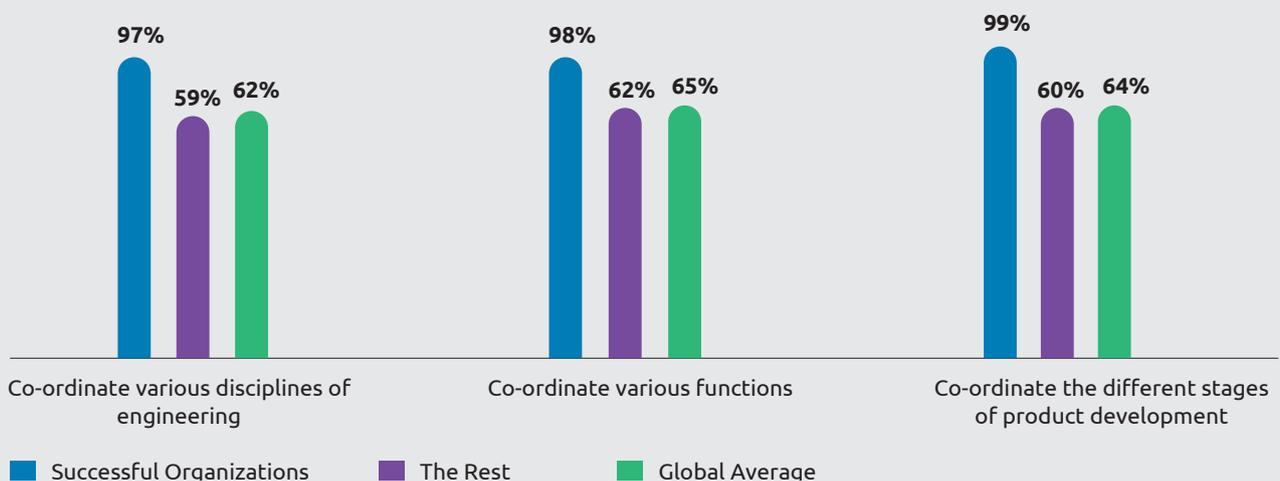
Figure 19: Utilization of data from smart connected products to build actionable insights



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

- They maintain digital continuity across product life cycle (Figure 20).

Figure 20: Digital continuity and coordination among various facets

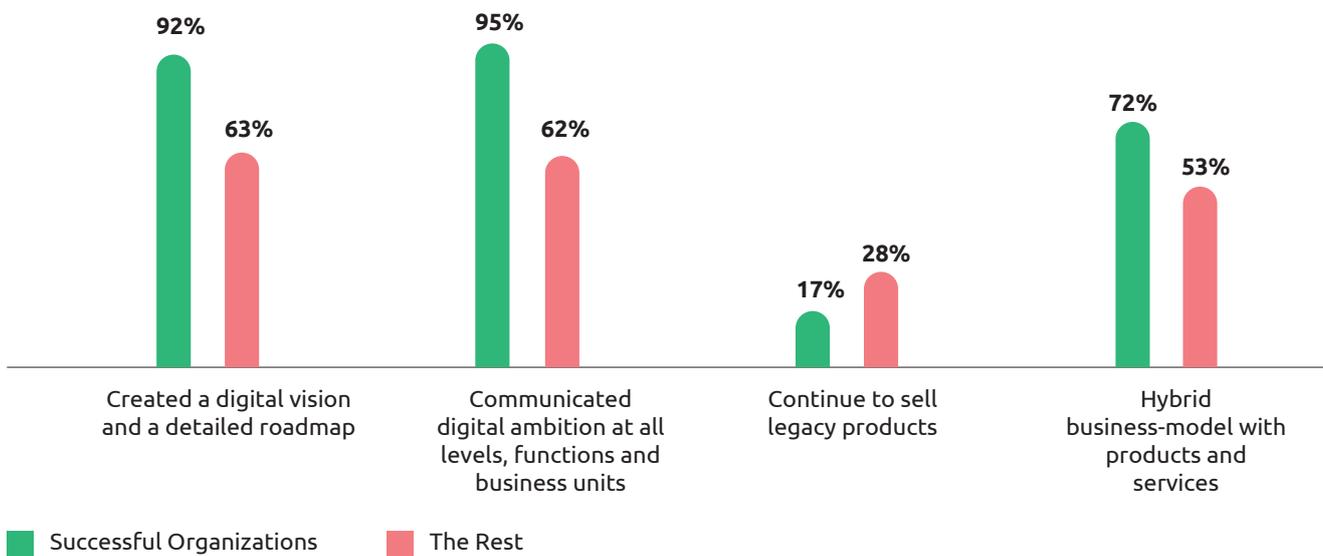


Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

Successful organizations have a vision and roadmap for product innovation and engineering

We found that 92% of successful organizations have not only created a digital vision, but also have a roadmap to monitor progress. We noticed a stark difference in priorities between the successful and the rest. For instance, 28% of the rest want to continue to sell legacy products in the next few years, but this drops to 17% for successful organizations (see Figure 21).

Figure 21: Successful Organizations have a clear vision and ensure to communicate these ambitions



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

92% of successful organizations have not only created a digital vision, but also have a roadmap to monitor progress

Successful organizations make better use of the partner ecosystem

These organizations value the contribution of their partner ecosystem and are set up to collaborate and drive value. While 87% of successful organizations said they are prepared for an open and collaborative ecosystem, this drops to 66% for the rest (see Figure 22). There are number of reasons why they are well prepared:

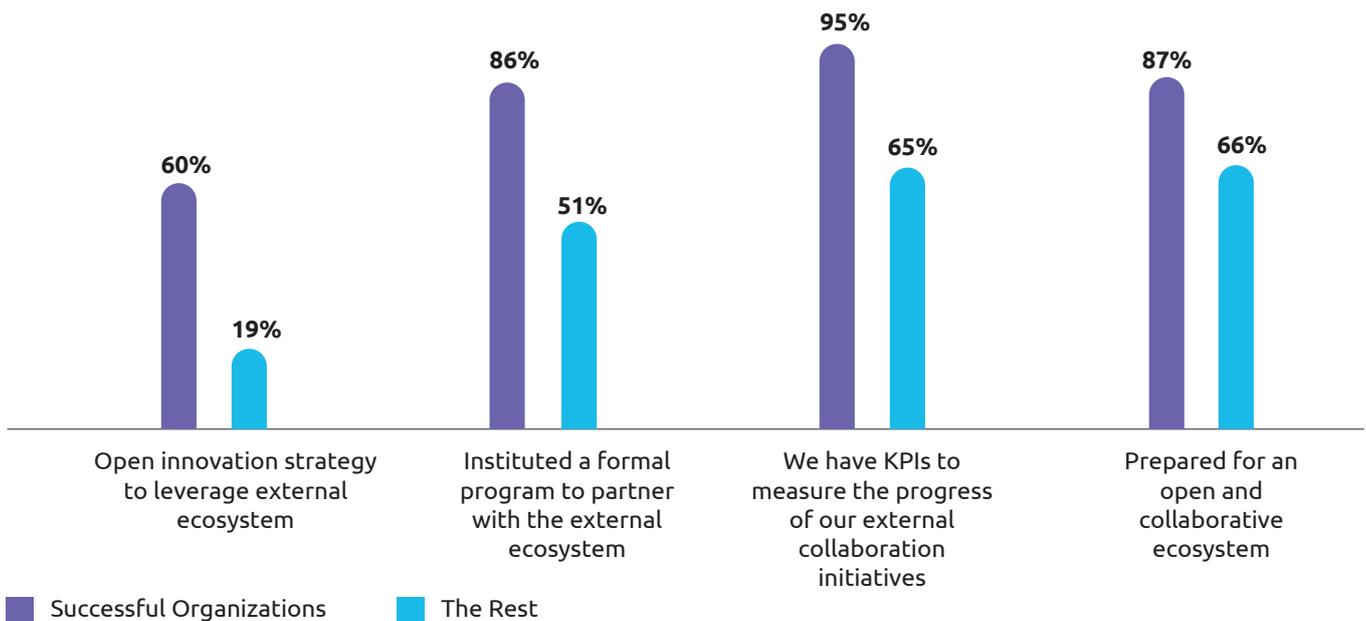
- They provide the right environment for external partners to contribute. We found that 86% of successful organizations have a formal program for external collaboration compared to 51% for the rest. And 60% of successful organizations

have an open innovation strategy to tap into their external network (see Figure 22).

- They back their strategy with effective program management: 95% of successful organization constantly track the progress of external collaboration initiatives (see Figure 22).

Ecosystem partners play a leading role for successful organizations, with 90% acknowledging that partners contributed significantly to the overall value of product/ services portfolio. This compares to 49% for the rest of the organizations.

Figure 22: Successful Organizations are more collaborative with their external environment



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

Successful organizations invest more in digital tools

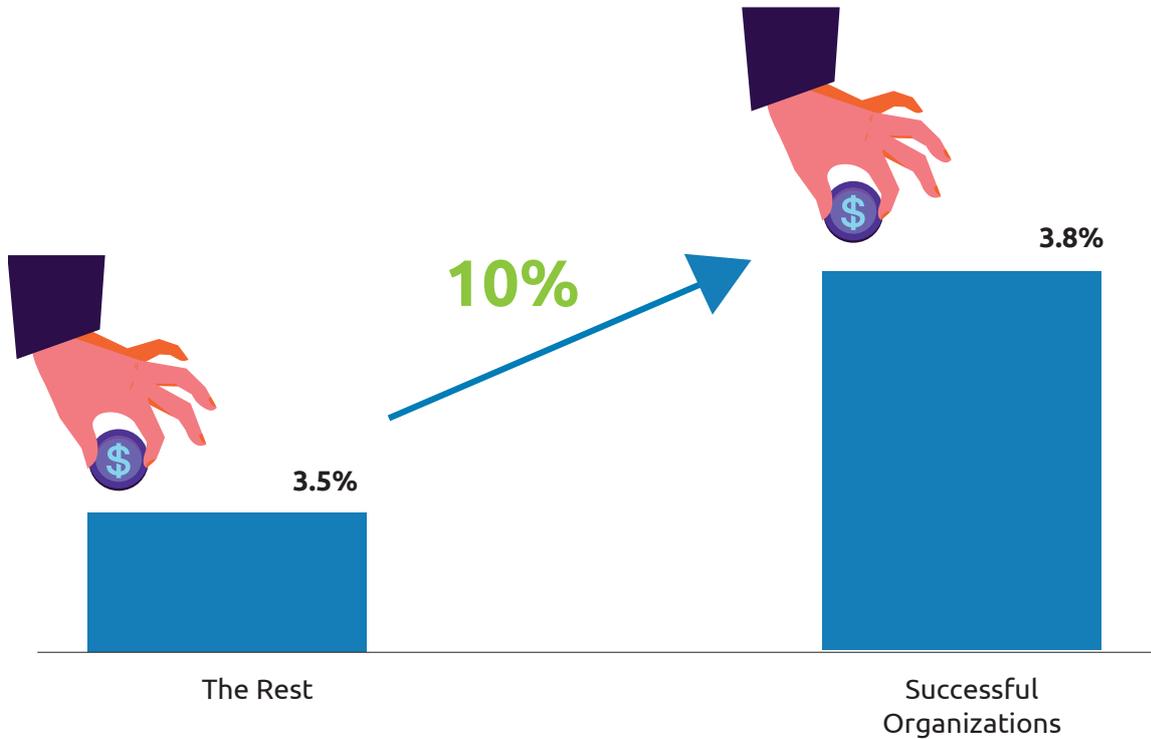
Successful organizations are likely to invest more in digital technologies. For instance, as a percentage of revenue, they have apportioned a higher budget to spend on end-to-end PLM platforms and digital solutions in the next three years – 10% more than the rest (see Figure 23).

Our results indicate that the successful organizations are also using a variety of digital technologies at scale compared to the rest of the sample. For example, 45% of successful

organizations are using digital twin capabilities at scale, while only 13% of the rest are. Successful organizations are also ahead in terms of deploying and using IoT platforms for generating new service-based revenues and providing feedback to the product design and development process (see Figure 24).

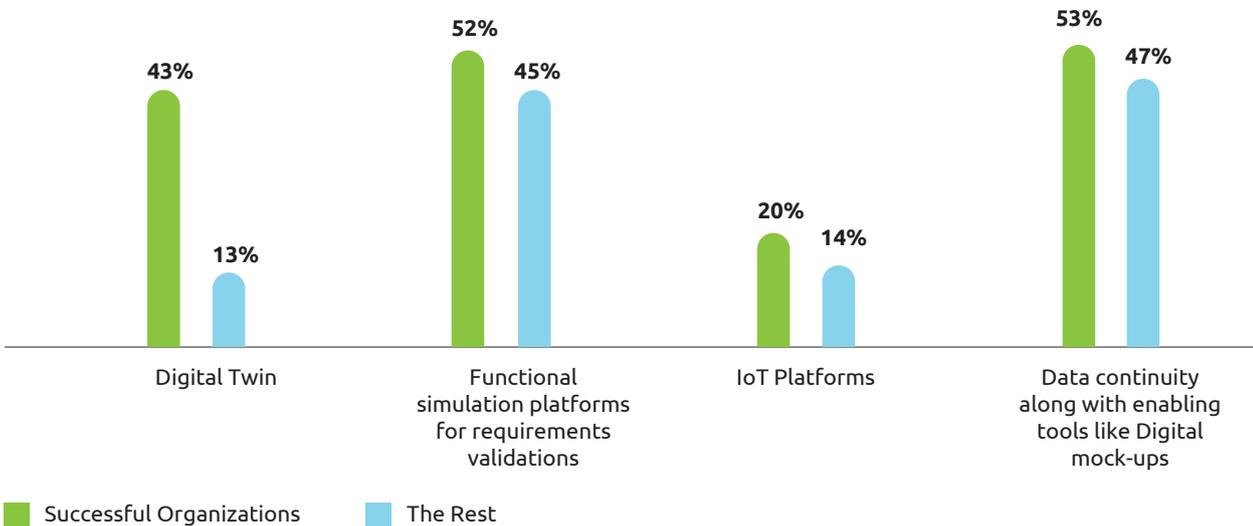
In 2017, Airbus launched an IoT platform – Skywise – that centralizes datasets sourced from both aircraft, maintenance, and information systems. The platform is hosted on a secure cloud infrastructure and comes with advanced predictive

Figure 23: Investment in end-to-end PLM and digital solutions as a percentage of revenue



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

Figure 24: Digital technologies implemented at scale by organizational category



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

analytics capabilities, and aircraft connectivity. The platform serves two objectives:

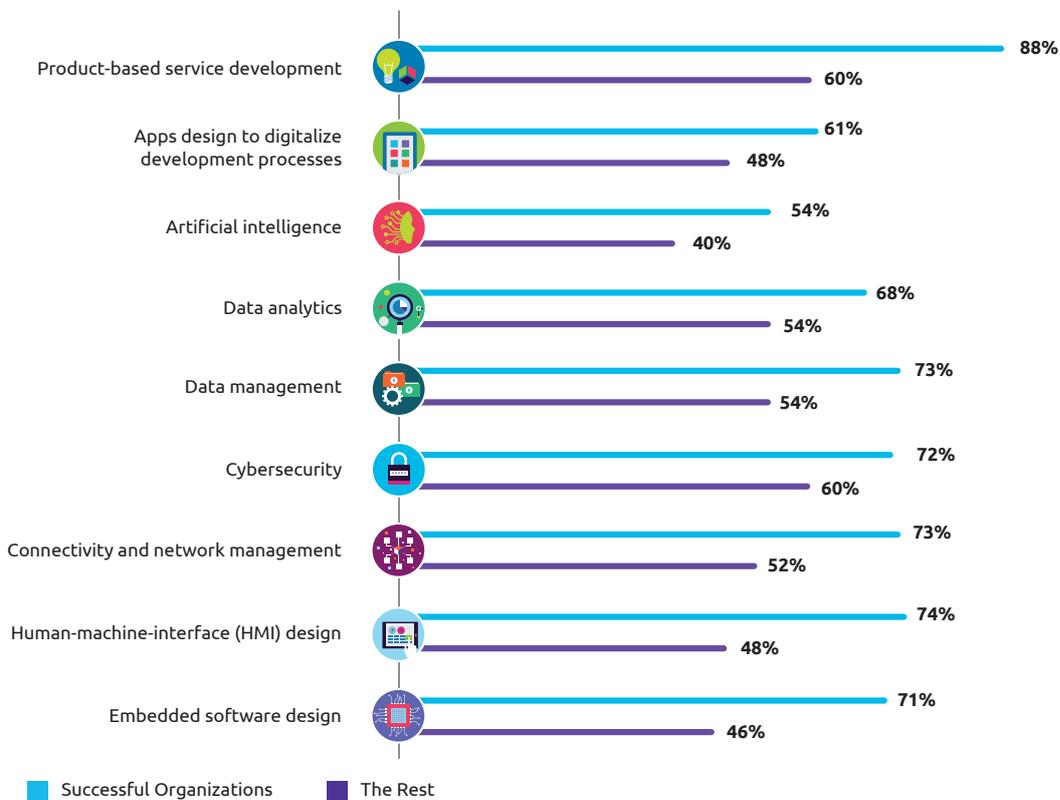
- Making its customers' operations more efficient and productive by reducing maintenance costs and preventing breakdowns.
- Feeding back into the design of the next generation of cabins and aircraft for the company.⁴

The platform has already been adopted by several airlines, including Delta, JetBlue, AirAsia, and Emirates. Some of the early results are also encouraging. For instance, Emirates has seen a one percent improvement in operational reliability by using the platform.⁵

Successful organizations build capabilities in new skill areas

Successful organizations have already begun to invest in the digital skillsets required for engineering transformation. "We are pursuing improvements on all the man-machine interfaces and the software technologies, which we believe is a key element to the future," says a senior executive, Product Development and Production, Thales. Training will be critical to build key skills. "We assess the competencies of our staff very frequently and identify digital skills where we lack basic competency," says Jan Willem Ruisch, senior director - head of Product Management at Signify (formerly Philips Lighting). "We have training programs to get them back on track or to get them where they want."

Figure 25: Breakdown of actions manufacturers are taking to promote innovation culture



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

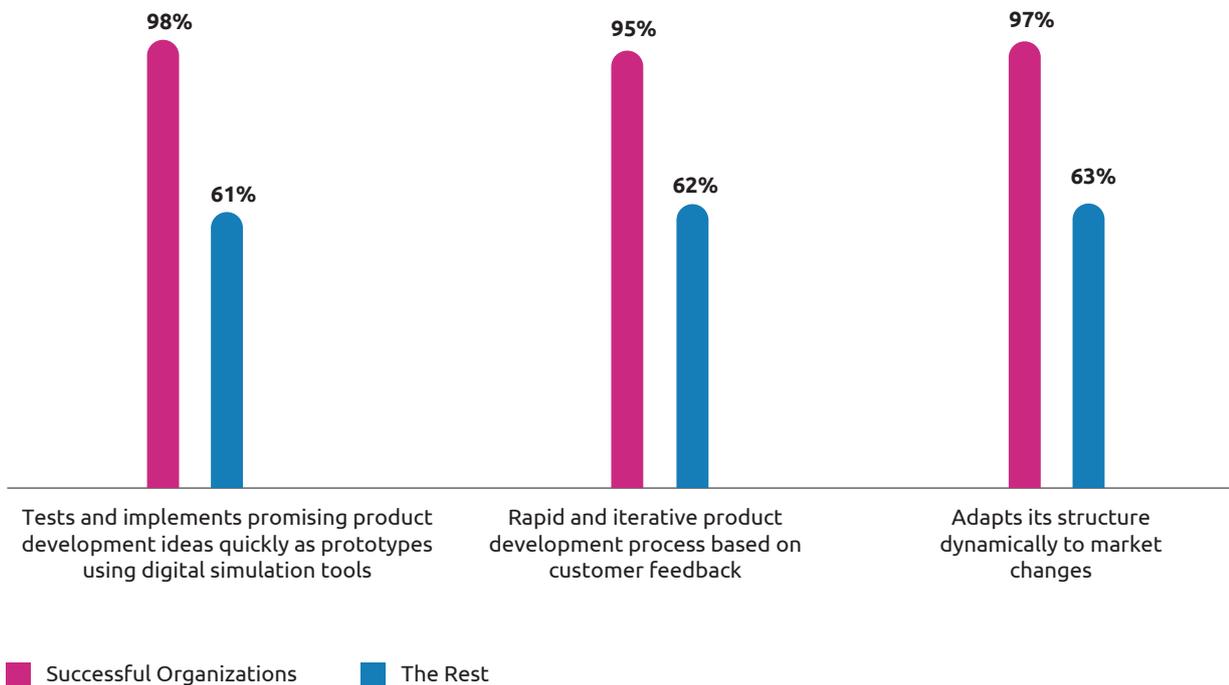
Compared to the rest, successful organizations are more likely to have the new skills needed for transformation (see Figure 25).

Successful organizations create a culture of experimentation and agility

Successful organizations recognize the importance of culture in driving successful transformation and have focused on cultivating agility, flexibility and innovation. For instance, almost all of them have a rapid product development process based on customer feedback (see Figure 26).

As product lifecycles shrink with higher frequency of product upgrades, rapid prototyping of new ideas is a necessity. Successful organizations also lead in their ability to experiment, develop and test prototypes quickly (see Figure 26). They are able to do this using tools and empowering employees to contribute their ideas. For example, at 3M, technical as well as non-technical employees are encouraged to come up with creative ideas during their normal working hours. Irrespective of departments, employees are encouraged to devote up to 15% percent of their working hours to independent projects.⁶ Using this approach, the company creates a pool of practical ideas that are then

Figure 26: Successful organizations are more innovative and agile compared to the rest



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

adequately resourced to develop into a commercial proposition. The company boasts of more than 100,000 patents, many of which are attributed to its 15 percent program.⁷

How to overcome the challenges on the road to transformation

Engineering transformation is a major endeavor and comes with significant challenges. “First, you must overcome the challenge of balancing short-term priorities against long-term priorities,” explains a senior executive in a global medical devices company. “Then you must clarify the goal of where you want to be. This needs to be followed by a detailed roadmap to get there. You also need to find the people who can execute it. So, transforming engineering is not that easy actually.”

The transformation roadmap will vary depending on the maturity of individual organizations. But, in our research, we found that manufacturers fell broadly into four camps:

1. The Front-Runners – 17%

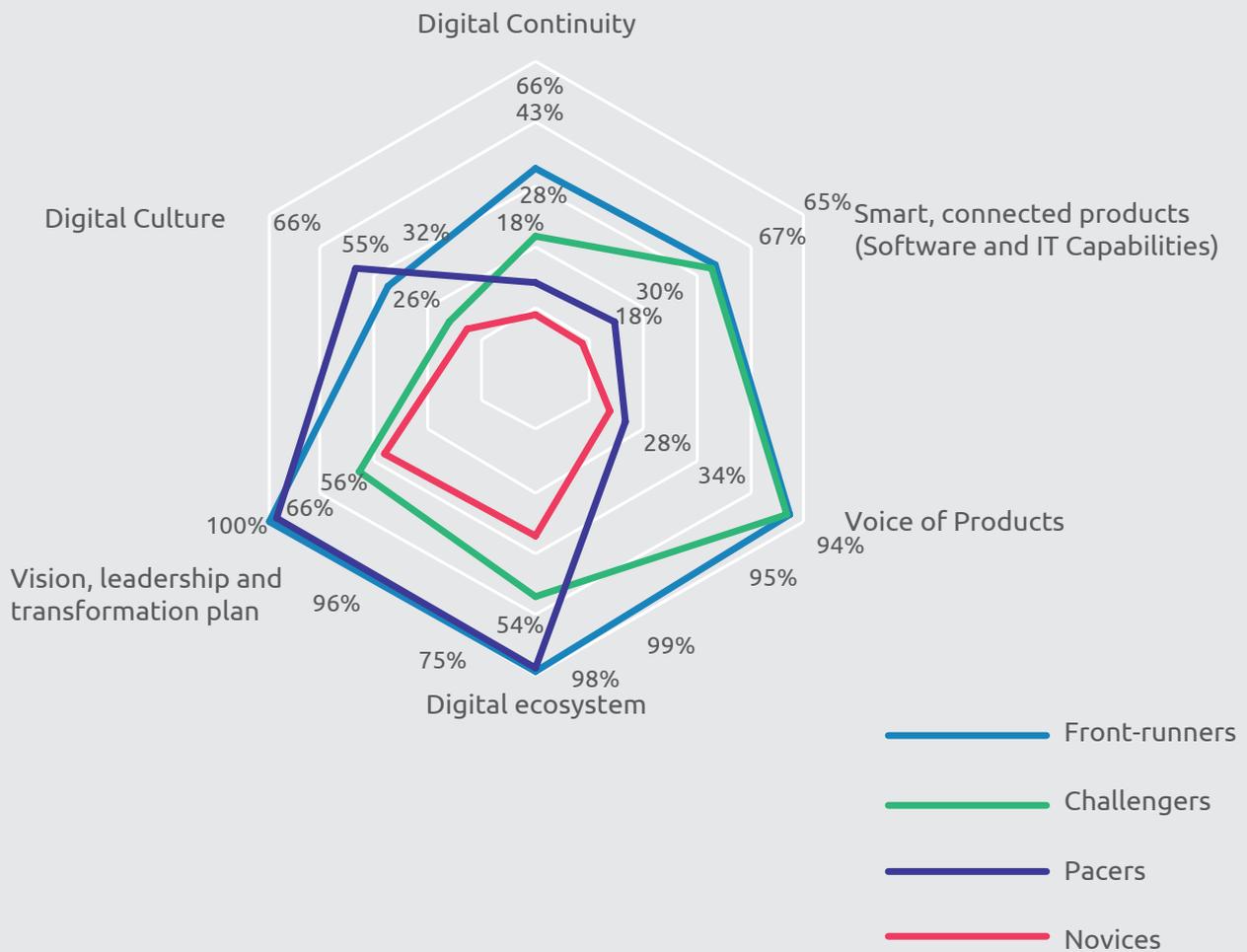
The transformation roadmap: defining the four groups

To understand the maturity of manufacturers as they tackle product innovation and engineering transformation, we assessed them against six criteria. These represent core transformation capabilities (such as software and IT capabilities) and transformation enablers (such as vision and leadership). The six areas are:

- **Digital ecosystem:** working closely with start-ups and partners across boundaries, both around products and services
- **Vision, leadership and transformation plan:** clearly articulating the transformation vision, getting leadership backing, and communicating the vision across all levels of the organization
- **Digital culture:** having a digital culture of openness, experimentation, flexibility, agility, and collaboration
- **Smart, connected products (software and IT capabilities):** having the right set/balance of capabilities to take full advantage of the smart, connected product and services revolution
- **Digital continuity:** using tools and methodologies to ensure digital continuity across the entire product lifecycle
- **Voice of product:** being well equipped to take full advantage of usage data from smart, connected products.

We found that high levels of maturity are rare. Only 17% of manufacturers – the Front-Runners – have made substantial progress across all the six dimensions (see Figure 27 below). A large number of manufacturers (50%) are Novices and have made little progress in terms of capabilities or transformation enablers. Refer to the Appendix A at the end of the report for more on the segmentation approach and description of each cohorts.

Figure 27: Performance on six dimensions of engineering transformation maturity



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

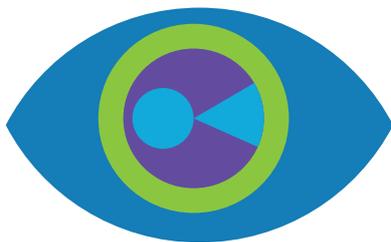
2. Challengers – 16%
3. Pacers – 17%
4. Novices – 50%.

Below, we explore how each of the three categories can look to emulate the achievements of the most mature group – the Front-Runners.

“Novices” need a clear vision, strong leadership capability, and a focus on bridging gaps in both technology and talent

Novices lag on multiple fronts: leadership capability to lead and execute transformation, tools to enable digital continuity, and advanced analytics capability to make better use of product data. They also lack the talent in new digital technologies

Novices will need to establish a compelling vision that provides the enterprise with a clear direction



(AI, cybersecurity, apps design) and the ability to build new service-based businesses models. Over half (51%) also admit that they do not have clear transformation vision. In comparison, 97% of Front-Runners said that they have a digital vision with detailed roadmap and clear milestones.

“Novices” will need to take the following steps:

- **Establish a compelling vision that provides the enterprise and its people with clear direction.** For example, the leading consumer electronics and home appliances company in Asia, Haier, has set a vision to transform itself from a traditional home appliances manufacturer to a smart connected home solution provider.⁸ Its vision is to turn an entire household in one connected system,⁹ providing comprehensive solutions for air, water, clothes care, security, voice control, health, and information. In line with this ambition, Haier has developed an IoT platform called U+ which manages communications between consumers, third-party services, and all the connected devices in the home, regardless of whether Haier made them. The platform already supports more than 100 different brands of connected devices.¹⁰ To further advance this vision to external collaboration, Haier has setup the Haier Open Partnership Ecosystem (HOPE) program.¹¹
- **Ensure that their leaders strike a balance between technology and operations knowhow, as well as business and leadership acumen.** Two-thirds admitted that their leadership lack the capability to lead and execute transformation initiatives. Strong understanding of IT – particularly in the areas of agile development, DevOps capabilities, digital twins, advanced PLM features, and IoT platforms – will help leaders align technology initiatives to transformation priorities. Equally important is to inspire a culture of innovation and collaborate with a broader Make investments in areas such digital twin, virtual simulation, and IoT platforms to enable seamless digital continuity. As demonstrated above, successful organizations are already deriving a value from their digital technology investments.
- **Make investments in areas such digital twin, virtual simulation, and IoT platforms to enable seamless digital continuity.** As demonstrated above, successful organizations are already deriving a value from their digital technology investments.
- **Address gaps in the IT/software skills needed for smart, connected products development – 86% do not have the sufficient availability for data management, 95% for app design, and 94% for artificial intelligence.** They will need to hire experts from outside in application

engineering, systems integration, data management, AI, cybersecurity, and software design. But, hiring from outside alone will not be enough to fill all the talent gaps at once. Current employees will need training in new digital technologies and tools and the new collaborative ways of working.

“Pacers” need to focus on building a partner ecosystem and a digital culture

Pacers are making progress on several fronts: using digital technologies to promote digital continuity, making better use of product data, and building IT talent to support a smart, connected products strategy.

However, they are lagging in terms of developing a digital culture of innovation and agility – one of the critical pillars for transformation. Only 60% implement and test innovative product ideas compared to 96% of Front-Runners. They are also not able to fully leverage the partner ecosystem for product innovation and development.

A number of initiatives can help address this shortfall:

- **Engage employees in the culture change journey.**

Only 56% clearly communicate their digital vision to employees compared to nearly all front-runners. Clearly communicating on new ways of working and behaviors – such as creative problem solving and design thinking – is also vital.

The leading automotive manufacturer, Daimler, designed a program called DigitalLife@Daimler to support its vision of transforming from an automobile company to a mobility services provider.¹² The program aims to better engage its employees and ignite an innovative and open culture in the organization. This is done through a series of events, from hackathons to roadshows. For example, Daimler organizes workshops to create an environment where employees from all over the organization can come together to collectively brainstorm new products and services ideas. The DigitalLife@Daimler program also promotes collaboration and sharing of ideas among employees through a social intranet platform.¹³

- **Set up innovation labs to spark culture change.**

For example, Caterpillar has set up a Data Innovation Labs to engage university students to solve real problems. These labs bring together resources from diverse fields such

as engineering, computer science, operations research, and statistics, to drive innovative development through advanced data analysis. The labs provide an innovative agile project management and for university students to collaborate with Caterpillar’s internal analytics team and start-ups to execute projects.¹⁴

- **Engage properly with partners and suppliers to drive value from the partner ecosystem.** We found that only half of Pacers said external partners contributed significantly to their overall product and services portfolio. For Front-Runners, it is 90%. Launching formal partner collaboration programs to better integrate suppliers and partners can drive better engagement.

For example, Samsung has recently launched an end-to-end collaboration program – SAFE – to create design solution from conception to manufacturing. Through this program, Samsung works with its customers (OEMs), semi-conductor design companies and start-ups to deliver competitive and robust design solutions¹⁵.

“Challengers” must develop talent and build on data competencies

Challengers are more likely to have a clear transformation vision and roadmap, and the leadership capability to execute on it. They are also able to inject a culture of innovation and collaboration as well as derive better value from their partner ecosystem.

However, their progress is slowed down by lack of digital continuity, absence of digital skills to capitalize on servitization opportunities, and ability to optimally use data from smart, connected products (only 12% of Challengers use data to build actionable insights compared to 60% of Front-Runners).

A number of steps will be critical:

- **Build expertise in managing usage data to maximize the revenue opportunities of a service-based business model.** Given the growing volume and complexity of data, it is no longer feasible for each function, including engineering, to build its own analytics capability to manage data. Many companies are creating dedicated Centers of Excellence for data analytics. These CoEs consolidate data management and analytics and are responsible for making insights available across functions. For example, Ford

created a centralized data science team called the Global Data Insights and Analytics (GDIA) unit to drive optimized data driven decision making across the organization – from engineering to production to supply chain and customer service. One of the core objective of the unit is to better understand customers’ preferences and usage of connected cars to guide future service-driven strategy¹⁶.

- **Build and retain the talent pool needed to exploit the opportunities presented by smart, connected products.** Expertise in software, systems integration, HMI, data analytics, AI, and cyber security is a crucial driver of transformation. Challengers can take inspiration from the strategies of Front-Runners for bridging the skill gap:
 - Develop in-house talent by focusing on training and development, which Front-Runners use for human-machine interface design and data analytics
 - Add new talent through merger and acquisition, which Front-Runners do for system engineering
 - Involve start-ups where there is acute skills gap, which Front-Runners use for artificial intelligence and product-based service development.

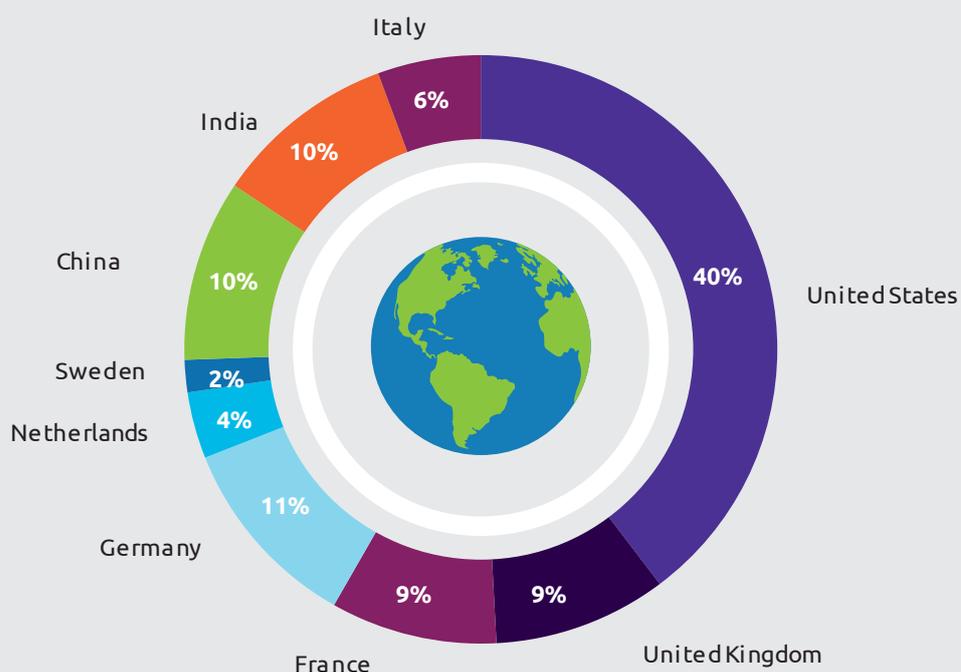


Research Methodology

Quantitative survey

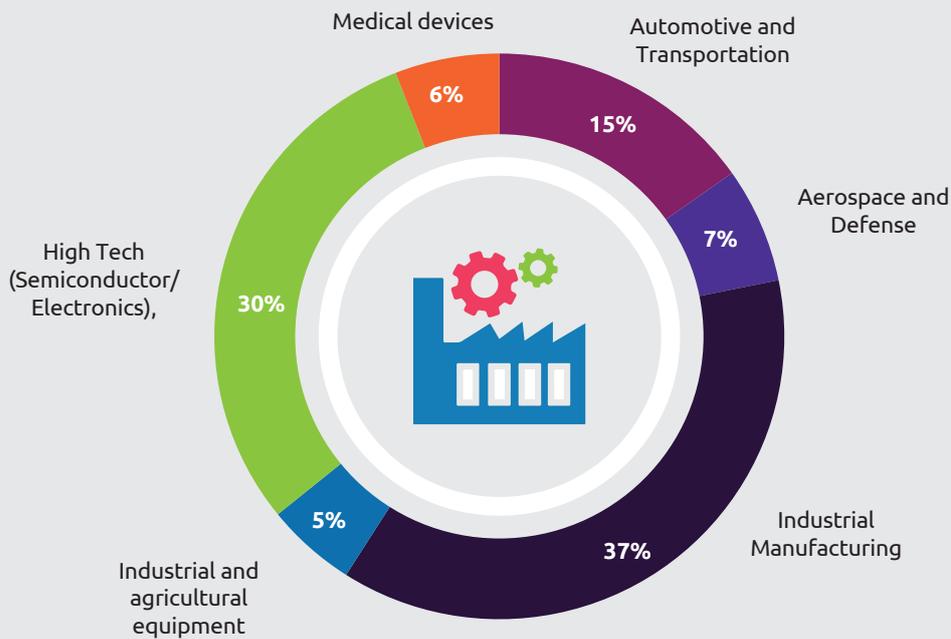
We surveyed 1,000 senior executives from global manufacturing organizations across nine countries. Segments included automotive and transportation, aerospace and defense, industrial manufacturing, industrial and agricultural equipment, high-tech, and medical devices. Of the organizations, 62% had global revenues greater than \$2 billion.

Split of manufacturing organizations by country



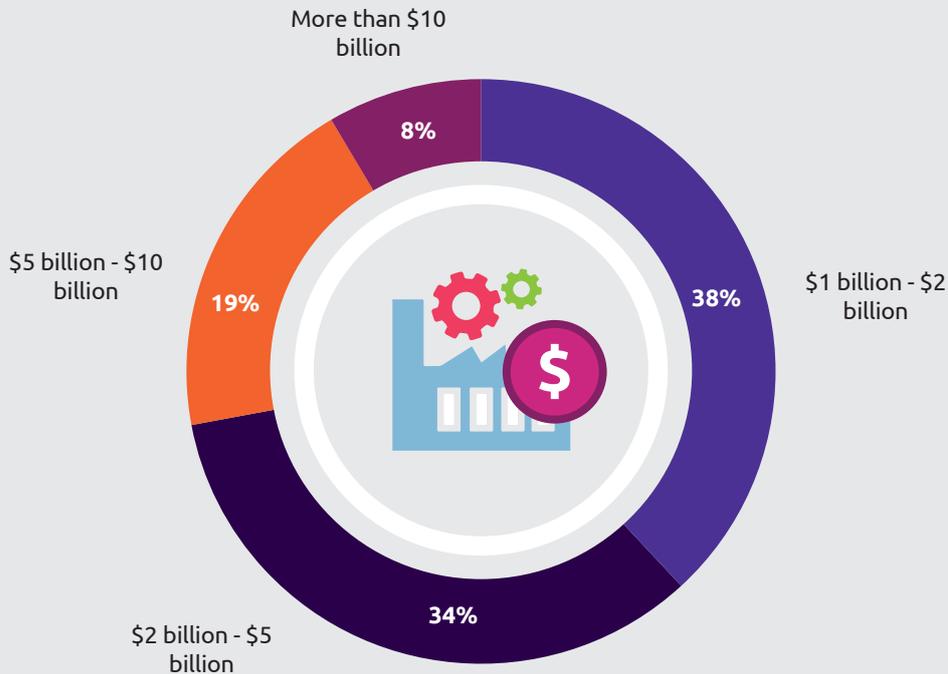
Source: Capgemini Transformation Institute, Digital Engineering Survey, April–May 2018 (N = 1013). Percentages may not total 100 due to rounding.

Split of manufacturing organizations by sector



Source: Capgemini Transformation Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

Split of manufacturing organizations by revenues



Source: Capgemini Transformation Institute, Digital Engineering Survey, April–May 2018 (N = 1013). Percentages may not total 100 due to rounding.

Focus Interviews

In addition to the quantitative survey, we held in-depth discussions with nine senior executives from leading companies across the world. The aim was to understand the approach each organization took to engineering and product innovation transformation, including their vision and objectives.

Appendix A

Engineering and product innovation transformation maturity

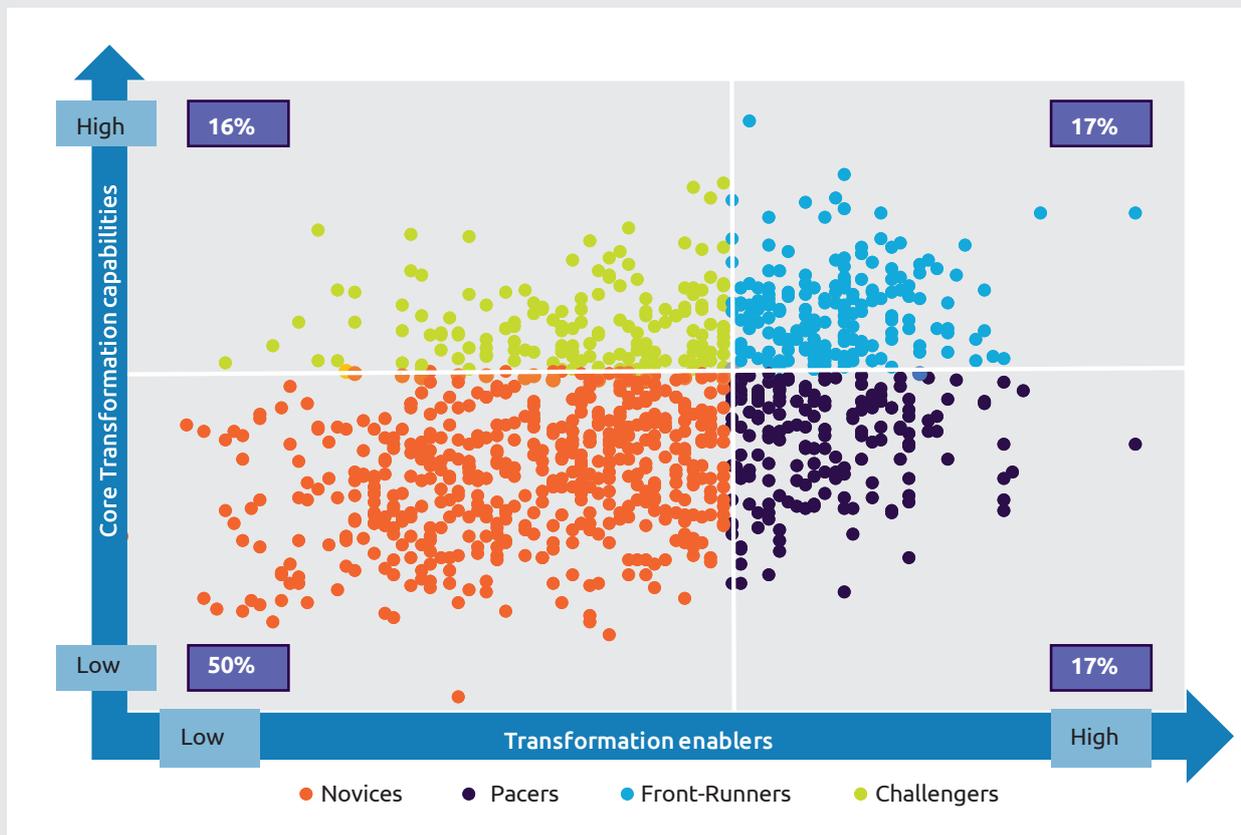
We assessed maturity against six criteria. These represent core transformation capabilities (such as IT capabilities) and transformation enablers (such as vision and leadership).

The six areas are:

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- **Voice of product:** well equipped to take full advantage of “usage data” from smart, connected products.

This assessment segments organizations into four groups, ranging from “Front-Runners” to “Novices.”

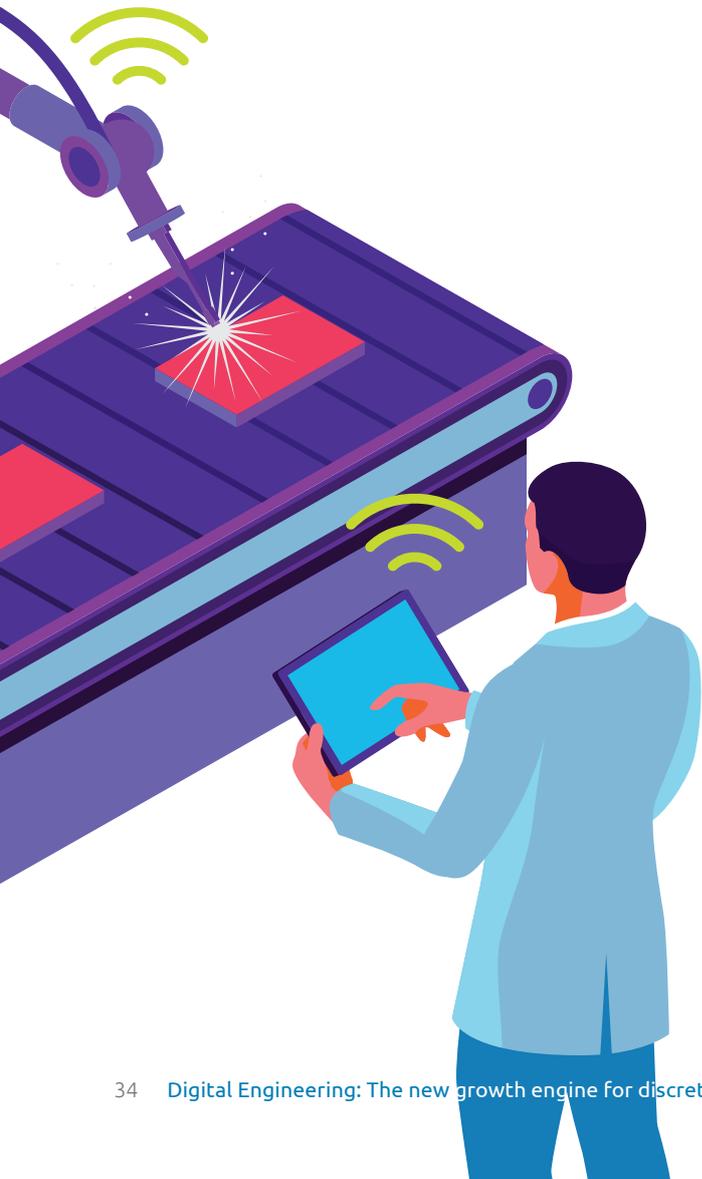
Product innovation and engineering transformation maturity matrix



Source: Capgemini Research Institute, Digital Engineering Survey, April–May 2018 (N = 1013).

Detailed description of each of the four groups are as below:

- **Front-Runners:** Only 17% of companies are what we call Front-Runners, which are those firms that score high on core transformation capabilities and transformation enablers. They are at an advanced stage in building data capabilities, narrowing digital talent gaps, and creating efficient processes. Front-Runners also have a strong foundation of vision, leadership and culture.
- **Pacers** score well on transformation enablers but fall short on transformation capabilities. Their lower scale of digital technologies and data usage and higher levels of digital discontinuity limits the progress on transformation.
- **Challengers** score high on transformation capabilities but fall short on transformation enablers. This group has progressed on using digital technologies in engineering and product innovation and maintaining digital continuity across various functions and engineering disciplines. However, this effort lacks a clear vision, leadership, digital culture traits and a partner ecosystem to progress meaningfully in their transformation journey.
- **Novices** score low on both transformation enablers and transformation capabilities.



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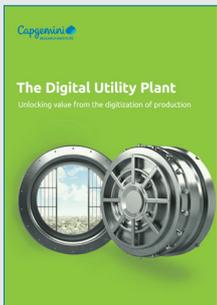
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