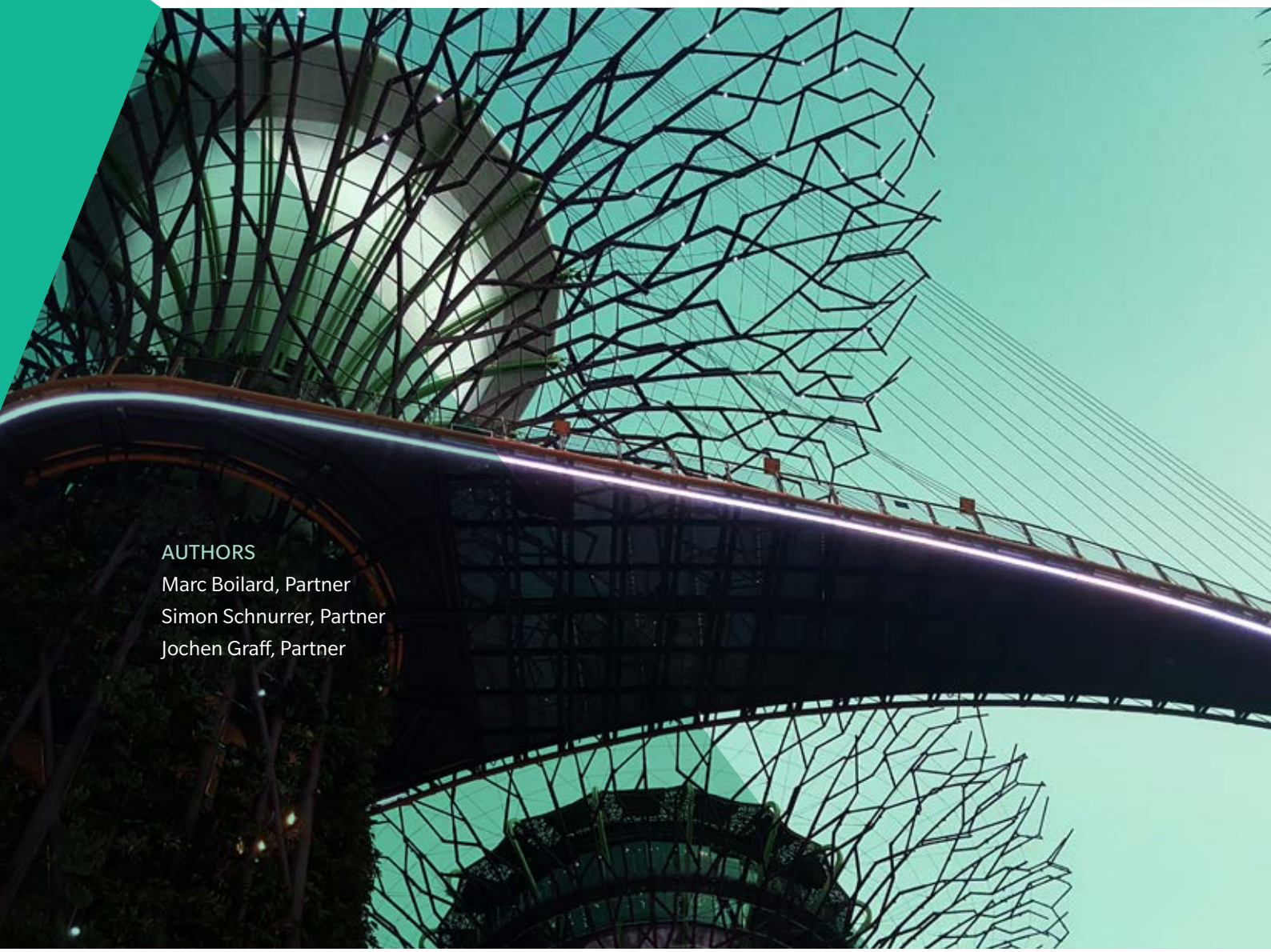
OLIVER WYMAN

Operations

ENGINEERING 2030

SIX MEGATRENDS THAT WILL SHAPE ENGINEERING



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MARSH GUY CARPENTER MERCER OLIVER WYMAN

MARSH & McLENNAN COMPANIES

“We’re building at the same time the house and the crane to build the house: it’s a leap into the unknown”

VP ENGINEERING

OLIVER WYMAN'S GLOBAL ENGINEERING SURVEY

A global study identifying the trends that will shape the future of engineering

CONTEXT

More than €700 billion is spent annually in research and development (R&D) and engineering, according to the European

Commission, which looked at 2,500 companies in the Americas, Europe, and Asia. Investment is growing across the globe (see the following pages). Across all industries, software and digital technologies are putting pressure on engineering teams to transform their practices, become more agile, reduce time to market of new products, and work more openly with external partners (engineering service providers, IT specialists, consulting, startups, ...).

To explore these trends, Oliver Wyman's Operations practice recently conducted a global study on the evolution of engineering to better understand the current transformation.

Dozens of interviews were held with R&D/ engineering leaders from various industries around the world, complemented by extensive desk research.

Exhibit 1: Interviews panel

Breakdown per industry, in percentage

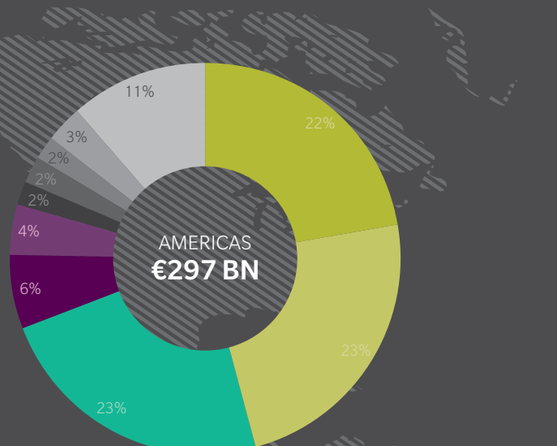
Source: Oliver Wyman

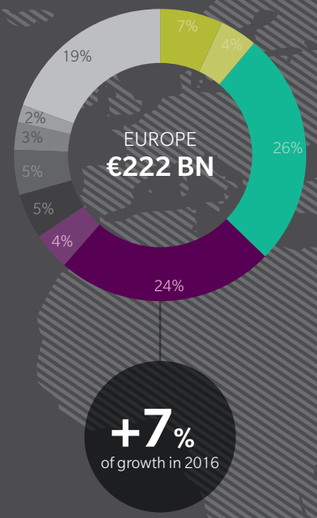
Source: European commission, Oliver Wyman

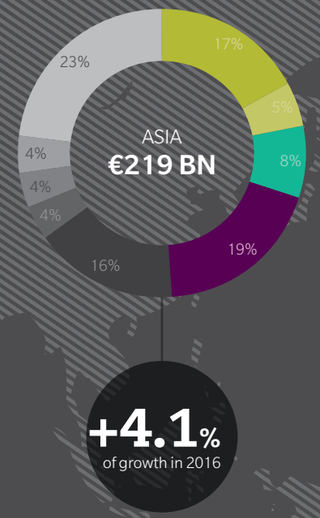
Company R&D spend

R&D INVESTMENTS ARE VERY WELL BALANCED BETWEEN AMERICAS, EUROPE, AND ASIA

R&D SPEND 2016/17
BY INDUSTRIES AND REGIONS[1]







Technology Hardware & Equipment
Software & Computer Services
Pharmaceuticals & Biotechnology
Automobiles & Parts
Aerospace & Defence
Electronic & Electrical Equipment
Industrial Engineering
Chemicals
General Industrials
Other

1.Africa: €1 BN and Oceania: €4 BN
Source: 2017 EU Industrial R&D Investment scorecard, Oliver Wyman analysis

+5.8%
of growth in 2016

€740 BN
invested in R&D

87 COMPANIES CONCENTRATE 50% OF THE GLOBAL R&D SPEND

AMERICAS
€163 BN

Alphabet	12,864
Microsoft	12,368
Intel	12,086
Apple	9,529
Johnson & Johnson	8,628
General Motors	7,684
Pfizer	7,377
Ford Motor	6,925
Merck US	6,483
Oracle	5,843
Cisco Systems	5,748
Facebook	5,615
IBM	4,939
Qualcomm	4,887
Bristol-myers Squibb	4,595
General Electric	4,537
Gilead Sciences	4,427
Celgene	4,241
Eli Lilly	4,184
Boeing	4,094
Abbvie	3,903
Amgen	3,614
Dell Technologies	2,692
Western Digital	2,316
United Technologies	2,217
Hewlett Packard	2,180
Honeywell	2,033
Caterpillar	1,851
Biogen	1,835
Procter & Gamble	1,778
AT&T	1,564

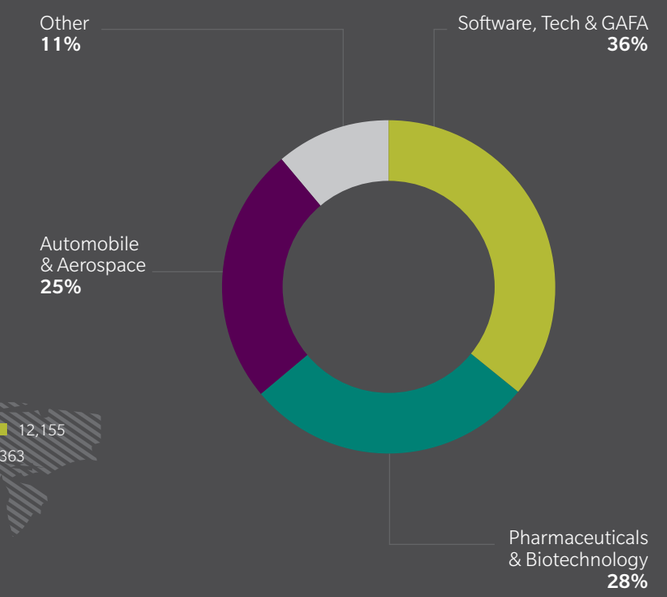
EUROPE
€125 BN

Volkswagen	13,672
Roche	9,242
Novartis	8,539
Daimler	7,536
Robert Bosch	5,587
Astrazeneca	5,358
BMW	5,164
Sanofi	5,156
Siemens	5,056
Nokia	4,904
Bayer	4,774
Fiat Chrysler Automobiles	4,219
Glaxosmithkline	3,953
Ericsson	3,295
Airbus	3,281
Boehringer Sohn	3,112
SAP	3,037
Continental	2,917
Renault	2,690
Allergan	2,676
Peugeot (PSA)	2,269
Medtronic Public Limited	2,080
Philips	2,008
Novo Nordisk	1,996
Merck DE	1,972
ZF	1,893
Nestle	1,860
Volvo	1,839
BASF	1,834
Telecom Italia	1,748
Banco Santander	1,726

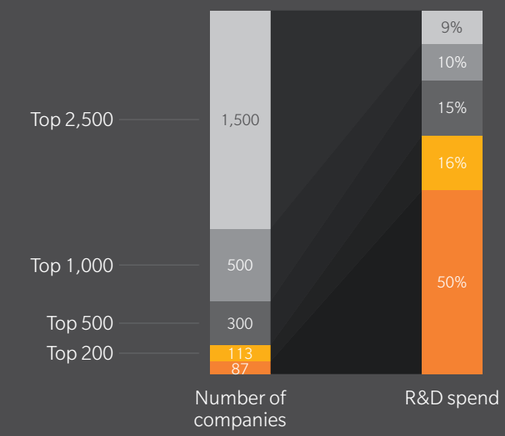
ASIA
€85 BN

Samsung Electronics	12,155
Huawei	10,363
Toyota Motor	7,500
Honda Motor	5,360
Nissan Motor	3,983
Panasonic	3,852
Sony	3,634
Denso	3,324
Takeda Pharmaceutical	2,727
LG Electronics	2,725
Hitachi	2,631
Broadcom	2,537
Canon	2,456
Toshiba	2,400
Alibaba Group Holding	2,329
Taiwan Semiconductor	2,092
ZTE	1,861
Hyundai Motor	1,763
Daiichi Sankyo	1,741
NTT	1,719
Astellas Pharma	1,690
SK Hynix	1,647
Mediatek	1,636
Tencent	1,617
Teva Pharmaceutical Industries	1,601

INDUSTRY BREAKDOWN OF TOP 50% R&D SPEND
€ BILLION, IN 2016



SHARE OF TOP 50 COMPANIES R&D SPEND[2]
€ BILLION , IN 2016



2. Based on the top 2500 companies R&D spend
Source: 2017 EU Industrial R&D Investment scorecard, Oliver Wyman analysis

A VISION OF ENGINEERING IN 2030...

Megatrends and the challenges ahead

A NEVERENDING PRODUCTIVITY RACE

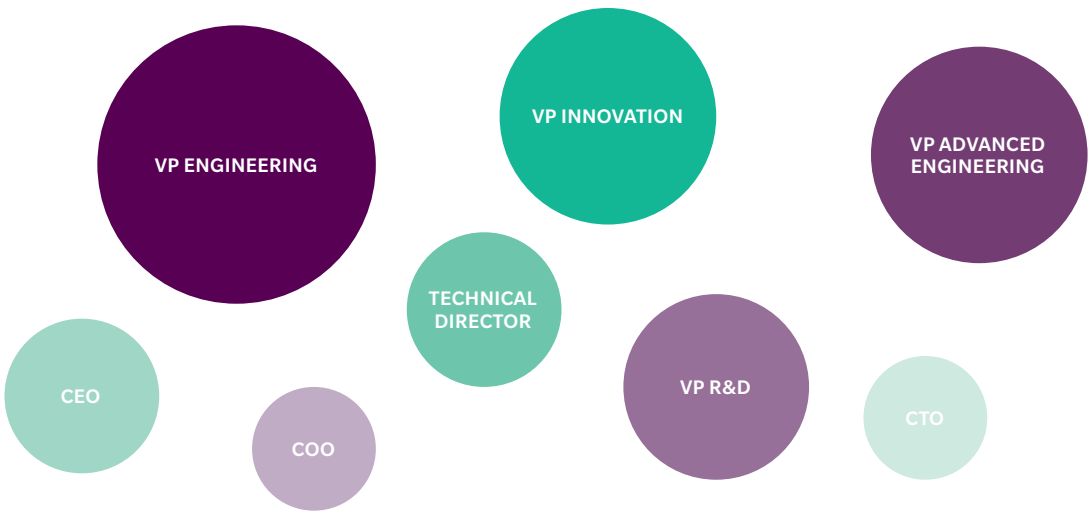
On the whole, engineering executives are planning on a continuous race to reduce costs and time-to-market of new products, and are targeting significant savings in the next decade.

There is, however, no expectation that budgets will decrease, even with greater productivity. There will constantly be a substantial need for new technology development to absorb savings done on regular engineering work. Instead, executives are aiming to keep their budgets in check while closely observing new technology advancements.

A COMPLETE TRANSFORMATION OF ENGINEERING WORK

There is a general consensus on six mega-trends that will reshape the engineering organizations in the next 10 years. Most of them are already at work but they are just emerging and will take-off in the next decade.

POSITIONS OF INTERVIEWEES



Development cycle time reduced by

50%

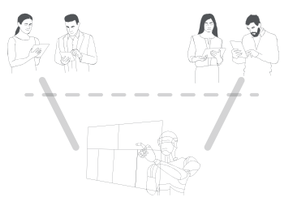
New products development costs divided by

two

Engineering megatrends

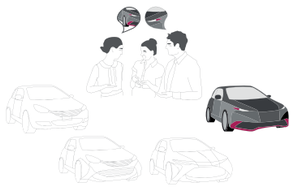
SIX MEGATRENDS WILL SHAPE ENGINEERING

6 POLARIZATION OF ENGINEERING SKILLS

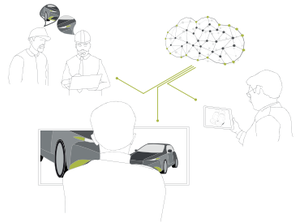


1 WORK IN OPEN ENGINEERING ECOSYSTEM

5 CUSTOMER CENTRIC PRODUCT DESIGN

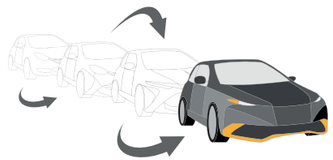


2 PDM AND SYSTEM ENGINEERING TOOLS BASED DESIGN



4 MASSIVE USAGE OF PRODUCT DATA TO OPTIMIZE DESIGN

3 FULLY AGILE & DIGITAL DEVELOPMENT PROCESS

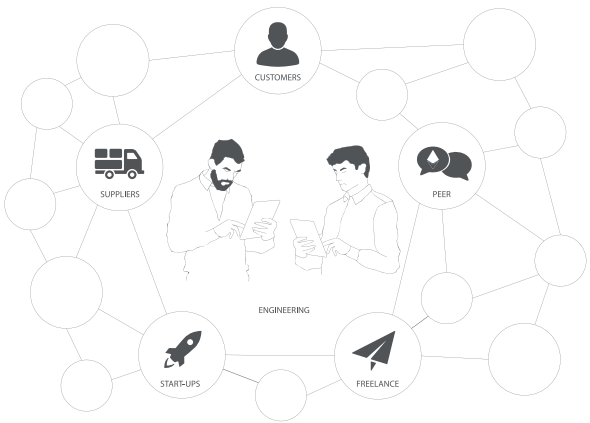


Megatrend 1

WORK IN OPEN ENGINEERING ECOSYSTEMS

All the executives interviewed recognized they will be relying more and more on external partners to develop products. Most in-house engineering organizations lack the necessary resources and skills in software, artificial intelligence, and cybersecurity. They will likely outsource more of their legacy work to focus their own resources on new technologies and core business activities.

This rising "open ecosystem" brings several challenges. Many executives noted the difficulty of finding the right partners for software development, combining not only technical expertise but also reliability and traceability in their design methodologies. For example, car manufacturers must maintain control of all developments done by external suppliers and must be able to prove the robustness of their design in case of prosecution (such as the "Volkswagen diesel-gate"). The rise of autonomous vehicles will place even more responsibility on their shoulders.



Source: The Big Innovation Centre – Realizing the Value of Open Innovation, Oliver Wyman analysis

Major companies leverage ecosystems in

50%

of their engineering projects

Often, these large, rigid organizations have struggled to find the right collaborative mode with startups, which by nature are smaller and more agile. Many executives become discouraged interacting with such partners.

Working efficiently with external players requires a common language and standard IT tools that do not exist yet in many industries. Thus, there is a greater need for expanded interoperability.

As engineering organizations become more open, they face the increased risk of cyber attacks and thus need to engage in appropriate preventative action.

"The most challenging is to find the right ecosystem for software development"

EVP ENGINEERING, DEFENSE INDUSTRY

Megatrend 2

PDM AND SYSTEM ENGINEERING TOOLS-BASED DESIGN

Most of the organizations surveyed have spent millions of dollars implementing sophisticated IT tools to support various tasks: customers' requirements management, complex systems engineering modeling, and product data management (PDM). These systems are meant to bring several benefits. For example, PDM tools should promote companywide data sharing and break down functionality siloes. This can drastically accelerate new product development with a more parallelized process.

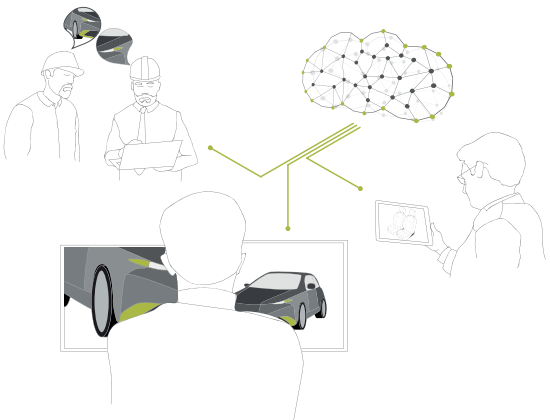
It is striking, however, to see the gap that exists between functionalities theoretically offered by IT engineering tools and the low adoption rate on the part of engineers.

The main reason is human: engineers are often reluctant to adopt the new tools that go against their ingrained habits, with the pace of change very much driven by top management. Simply providing the right data in the right place would save substantially on time.

Seamless integration of data reduces design cycle by

+50%

Another reason is technical: many engineers criticize the high rigidity of these tools and their poor user interfaces, which make it difficult for engineers to accomplish their work. While much has been done to improve the ergonomics of plant workstations for blue-collar workers, little has been done by software editors to make their tools more user friendly. Instead, the engineers, who must struggle with these tools daily, are struck by the contrast between their cumbersome tools and the user-friendly experiences they have every day with their smartphone apps.



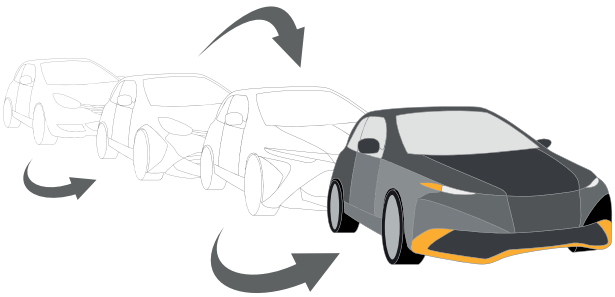
"One day we will wonder how we could engineer new products without it"

EVP ENGINEERING, AUTOMOTIVE INDUSTRY

Source: Siemens customer case studies, Oliver Wyman analysis

Megatrend 3

FULLY AGILE AND DIGITAL DEVELOPMENT PROCESS



Among the interviewed companies, there was no doubt about the future of product development processes: The processes will be digital and more agile to broach the next level of efficiency.

The growing importance of software for engineering new products has promoted agility in "old fashioned" engineering organizations. Software's advantages are manifold: greater team empowerment and customer centricity, with key users permanently involved. The next challenge will be to "convert" hardware engineers who are used to V-cycle developments to become more accustomed to digital development, and synchronize hardware and software development.

Digital tools and processes will become mandatory to manage a complexity of data that surpasses human capacities. Process digitization will also bring efficiency and help break functional siloes. In fact, many experts believe we have reached the limits of efficiency in any given function. The next wave of efficiency gains will be driven by greater cross-function integration.

Pushing the idea to the limits, engineering activity will move from a range of sequential (and sometimes administrative) processes to a "de-processed" organization based on cross-functional, parallel projects.

Over

90%

of agile projects deliver faster than waterfall-based ones

"Engineering organizations will have to kill their processes to make a leap in efficiency"

EVP ENGINEERING, TRANSPORTATION INDUSTRY

Source: DeltaMatrix – Why is Agile Time to Market (TTM) Delivery 50% Faster? Oliver Wyman analysis

Megatrend 4

MASSIVE USAGE OF PRODUCT DATA TO OPTIMIZE THEIR DESIGN

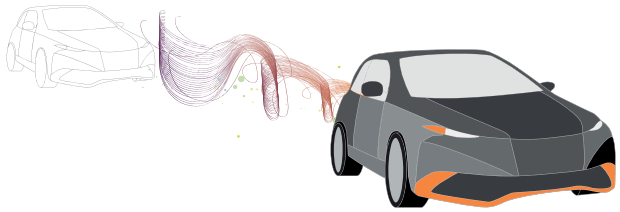
With the cost of sensors and data processing rapidly decreasing, almost any object will be able to produce actionable data.

Such data will provide valuable information to engineers on how their products are used

in real life and the constraints they experience. Engineers will learn in fine detail how technical margins might be optimized for safety and reliability. A given product's cost can thereby be optimized.

The principle is already widely applied in aircraft engine development, where these machines send gigabytes of data to their developers for further use. The potential of optimization is great for many other such technical objects.

For engineered product manufacturers, it will be critical to generate such data themselves; otherwise, competitors will.



Equipment manufacturers could gain

$10 BN/year

from IoT-derived improvements in the design of their equipment

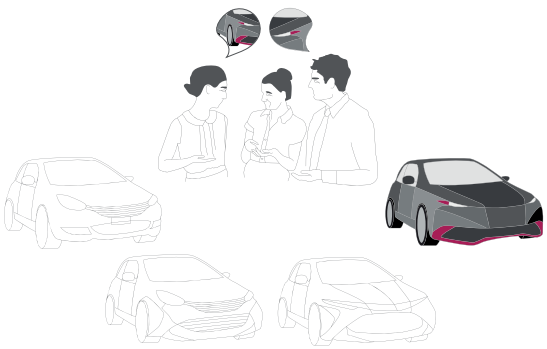
"If we don't create data, we will not survive"

CTO, AEROSPACE INDUSTRY

Source: Oliver Wyman analysis, Lopez Research, Building smarter manufacturing with the Internet of Things (IoT), part two, January 2014.

Megatrend 5

CUSTOMER CENTRIC PRODUCT DESIGN



Future organizations will not resemble the clichéd image of the engineer obsessed with technical perfection, all the while forgetting what is most important: the customer's needs.

With the growing emphasis of software in new product design, engineers are discovering the importance of agile development rules and of the final customer in development work.

Furthermore, the emergence of digital giants, capable of pre-empting the final customer relationship and of raking in profits without industrial assets, is shaking long-held beliefs among manufacturing companies.

In selling to OEMs, B2B suppliers are increasingly focusing their innovation efforts on the needs of the final customer and are acquiring more and more user experience (UE) capabilities.

New engineered products must not only match technical / functional specifications but a lso provide a unique emotional "experience".

60%

of outperforming Companies intensively collaborate with customers

"My dream would be to have 20 clients present throughout the development process"

VP DIGITAL ENGINEERING, AUTOMOTIVE INDUSTRY

Source: IBM – The Customer-activated Enterprise; Oliver Wyman analysis

Megatrend 6

POLARIZATION OF ENGINEERING SKILLS

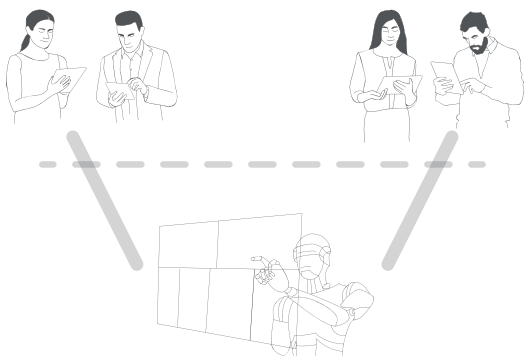
A desperate need for high-level system engineers and technology experts. Robotization of detailed design tasks.

Executives were unanimous: the greatest challenge they face revolves around human capital and competencies. Most companies already struggle to hire skilled engineers in software, artificial intelligence, and data science. But the HR challenges will go way beyond a scarcity of digital skills.

Many predict a polarization of engineering skills needs in the future:

- On the one hand, the increasing technical complexity of products will require more and more highly skilled systems engineers and architects capable of embracing the full range of product sophistication. They will have to mix several engineering disciplines, design the right product architecture, and efficiently leverage complex system-modeling tools. This kind of experience is rare, but critical.
- At the other extreme, the increasing technical sophistication of products will require more and more scientific specialists able to bring the necessary expertise to a narrow and highly specialized scientific field.
- Between these two extremes, the more simple and detailed design tasks are likely to be supported by IT tools and artificial intelligence systems. It is highly probably that these systems will become fully automated, replacing engineers just as robots have replaced manual workers in plants.

The combination of such drivers will cause a massive transformation of the engineering workforce that will have to be carefully handled.



25%

of engineering work will be automated

"Many engineering white collars will be commoditized in the future"

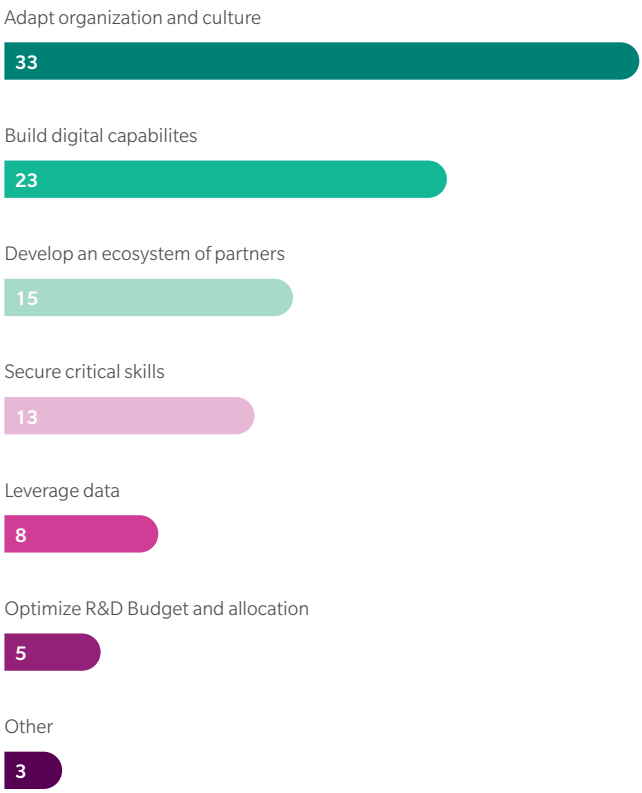
ENGINEERING VP, RAILWAYS INDUSTRY

Source: Oliver Wyman - Mercer, Workforce For The future, 2018

How to move forward?

MASTERING DATA, UPSKILLING TEAMS, AND CHANGING CULTURES WILL BE KEY TO SUCCEED

Exhibit 2: What are the top 3-5 challenges for the next years?
Percentage of appearance in interviews



Source: Oliver Wyman analysis

THE TIME TO ACT IS NOW

The companies surveyed all pointed out that digital transformation will be their greatest challenge in the coming years.

They will need to leverage new ways of using data. This will involve everything from reviewing core business elements and IT foundations, to setting up new organizations. Hence, the ability of HR to deal with complex issues, such as securing those critical engineering skills, will be a key factor going forward. Across all industries, building an ecosystem of partners will be necessary to promote value and to keep up with the revolutionary transformation.

Engineering organizations must start on this journey sooner rather than later to secure their competitiveness.

WHAT WOULD ENGINEERING EXECUTIVES DO IF THEY HAD A MAGIC WAND...

"I would launch as many as proof-of-concepts as possible on new technologies"

HEAD OF DIGITAL ENGINEERING, AUTOMOTIVE INDUSTRY

"I would make a bigbang changing radically the skillsets"

VP ENGINEERING , AEROSPACE INDUSTRY

"I would establish Data as our new moto"

VP INNOVATION, TRANSPORTATION INDUSTRY

"I would kill and replace our engineering tools"

CTO, AUTOMOTIVE INDUSTRY

"I would create a world in which engineers can collaborate very effectively, have access at the right data at the right time at the right cost"

DIRECTOR OF ENGINEERING, RAILWAYS INDUSTRY

"I would build a real data backbone"

DIRECTOR INNOVATION, AEROSPACE INDUSTRY

"I would build a complete ecosystem fully integrated"

VP ENGINEERING, AEROSPACE INDUSTRY

Oliver Wyman is a global leader in management consulting. With offices in 50+ cities across nearly 30 countries, Oliver Wyman combines deep industry knowledge with specialized expertise in strategy, operations, risk management, and organization transformation. The firm has more than 4,700 professionals around the world who help clients optimize their business, improve their operations and risk profile, and accelerate their organizational performance to seize the most attractive opportunities. Oliver Wyman is a wholly owned subsidiary of Marsh & McLennan Companies [NYSE: MMC].

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