Seizing opportunities in times of disruption

How the consulting engineering industry can overcome the challenges of digitisation, harmonisation, and sustainability – a disruptive scenario analysis

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Preface

In the last couple of years, the engineering consulting industry has been dramatically impacted by both external challenges and industry-specific trends. As such, the future of the industry remains somewhat unclear, which highlights the need to think in scenarios. In last year's report, we identified "project demand" and "openness to markets" as the two main dimensions, which resulted in four distinct future scenarios that engineering consultants could face. Since then, several key trends have continued and point towards a more digitised, sustainable, and at least partly harmonised future for the industry. Internally, continued industry consolidation, the adoption of new technologies and more widespread interdisciplinary project collaboration drive harmonisation. Attractive financing conditions combined with a fight for talent and market share significantly accelerated industry consolidation, with M&A (mergers & acquisitions) volumes exceeding even pre-pandemic levels across all E&C (engineering & construction) segments[1]. Digital and technological advances have made significant inroads and are in some domains becoming increasingly adopted and standardised. Furthermore, digitisation will act as a key enabler to integrate and diffuse disciplines of the architecture, engineering, and construction industry, which provides both opportunities and challenges for consulting engineers. As companies integrate digital technologies into key workstreams, they continue to grapple with skilled labour shortages[2] and their level of maturity and adoption consequently still varies among EU member states[3]. Externally, central efforts by the EU stimulate development and growth in the industry. Investments from the EU recovery fund are providing a short-term boost[4], while the European Green Deal will increase demand for green and sustainable construction projects in the medium to long-term by establishing a regulatory framework. Nonetheless, prevailing supply shortages, increasing worries about inflation and an increased frequency in globally disruptive events such as the Ukraine war, mean that the degree to which project demand will develop is somewhat difficult to foresee. Consequently, both, the "valley of tears" and "rise of large-scale construction firms" scenarios, that we described in last year's report, are a possibility, which is why we want to discuss their potential implications in this report.

Digital transformation is reshaping industries on a global scale, as it enables them to significantly increase their reach and collaboration with suppliers as well as with logistics providers, to become more efficient and to secure substantial financial benefits. While the

1 *PwC (2022): Engineering and construction: Deals 2022 outlook*
2 *Deloitte (2022): 2022 Engineering and construction industry outlook*
3 *European Construction Sector Observatory (2021): Digitalisation in the construction sector*
4 *ING Think (2022): EU Construction outlook*

engineering consulting industry has in the past been rather slow to adopt digital solutions, as a majority of the products and services are of a physical nature, it is on the cusp of not only a digital transformation, but a digital disruption. As projects are becoming increasingly more complex and expensive, engineering firms, construction companies, investors and other stakeholders across the value chain are realising the potential that digitisation brings to the table. New construction-focused hardware, innovative software solutions as well as analytic capabilities help bring assets, people and processes into one collaborative platform, which in turn makes development, construction and maintenance smarter, more efficient and more transparent. This disruption will also harmonise a currently fragmented industry, which, coupled with a regulatory push to make the industry more environmentally friendly, might result in a digitised, harmonised, and sustainable engineering consulting industry.

The three core drivers – digitisation, harmonisation, and sustainability – will undoubtedly impact the entire industry, which presents both challenges and opportunities for incumbent engineering consultants. EFCA's Future Trends Committee in collaboration with the Centre for Strategy and Scenario Planning at HHL Leipzig Graduate School of Management in Germany, has built on last year's report by interviewing 20 executives and high-level experts of leading European engineering companies and other industry-related organisations. In this report we explore how digitisation, harmonisation, and sustainability might impact the industry and which strategic options engineering consultants have to navigate in an increasingly disrupted world. We wish you an insightful read.

We thank our interview partners for their valuable insights on which this study is based. Besides, I am very grateful for the teamwork and the strong support of Sue Arundale, Serhan Bakir, Maurizio Boi, Lucas Cornaro, Inés Ferguson, Maximilian Grauvogl, Magnus Höij, Despina Kallidromitou, Antoine Pigot, Géraldine Tondreau, Nikola Matić, Marcin Mikulewicz, Philip Mundlos, Richard Resvoll, Jan Van der Putten and Torsten Wulf. Without their great commitment, this report would not have been possible.

Jeffrey Seeck

Chair of EFCA - Future Trends Committee, Member of Verband Beratender Ingenieure (VBI, the German Association of Consulting Engineers).

Scenario description: A digitised, harmonised, and sustainable ecosystem for consulting engineers in 2030

Overview – the world of consulting engineers in 2030

The environment, in which consulting engineers operate in 2030, is characterised by full digitisation, based on common BIM (Building Information Modelling) and other digital collaboration standards across European countries. All construction projects that have started over the last few years share a focus on sustainability, climate resilience and decarbonisation, which has also strengthened the position of consulting engineers as advisers. Harmonisation of rules and regulations across Europe has progressed, but full harmonisation has not yet been achieved. Since the mid-2020s rules and regulations have been eased, thanks in part to the prioritisation of green investments such as those in the energy sector; and approval authorities have largely moved to the digital arena. The consolidation that the industry is facing across borders has also made the access to other European countries simpler, especially for large players in the consulting engineering industry. At the same time, engineering consultants are being challenged by software companies, contractors, as well as technology start-ups that are all making inroads into the traditional playing field of consulting engineers, thus reducing the attractiveness of the traditional consulting engineering business. This is stimulating a re-think, in order to create new, future-proof business models, which can secure and even improve the market position of consulting engineers.

In order to master these profound change processes, agility and team spirit have become anchored in the corporate culture of consulting engineers. Through implementing more agile work approaches, consulting engineers are able to detect and respond faster to changes in the market, adding value to the client in a continuous way. New Work, as a collective term, is used in various forms. Flexible working hours, locations and workplaces are enabling flexible working adapted to different situations. A modern management and leadership culture with flat hierarchies is fostering teamwork at eye level and quick decision-making. Structures and processes are designed in such a way that they can be adapted to unforeseen events or new requirements. With New Work, a persistent shortage of engineers and a greater demand for personal fulfilment has significantly transformed the employer-employee relationship. Remote work has in large parts become the standard, which has led to a rise in free-lancers and self-employed staff not necessarily based in the company's home country. Thanks to digitised work processes and environments, work is becoming more flexible, effective, and transparent. Employees set their own performance and learning targets as well as working hours and are involved in strategy development. Such work environments also promote creativity.

As rules and regulations between European countries have become more harmonised and easier to deal with, entry barriers for international competitors are slowly diminishing. While Anglo-Saxon competitors have been in the market for quite a while, Chinese players are now also starting to enter the market. Nevertheless, black swan events such as the prolonged Covid-19 pandemic, the Ukraine war and global supply chain disruptions slowed down the internationalisation process and kept the activities of many engineering companies more tied to the European market.

In view of increased competition, digitisation, and harmonisation consulting engineers have been challenged to rethink their market positioning. Some have taken on the competition, especially from software companies and become data engineers and engineering specialists. Others have concentrated on niches as auditors or test engineers, while a large group of consulting engineers (exclusively or additionally) focus on new business areas such as creative sustainability advising or asset management. In all positions they are closer to the customer than ever before and enjoy a central position in their industry.

Let us explore this picture of the future in more detail.

DIGITISATION: STATUS AND DEVELOPMENTS UNTIL 2030

In 2030, the planning and execution of infrastructure projects is fully digitised – this is true for new projects and increasingly also for the refurbishment of existing infrastructure. Traditional companies are competing and cooperating with tech companies founded in the early 2020s in the UrbanTech, ConTech and PropTech sectors. Through venture capital (VC) investments, traditional companies actively participate in the development of tech companies and together they have fundamentally changed the industrial landscape.

For new projects BIM and parametric design modelling tools have become the standard planning requirement for geometric, time, cost, sustainability, and facility management aspects. Object databases are largely standardised. Here, large infrastructure players such as the European railway companies (e.g. Deutsche Bahn), the motorway operators (e.g. Autostrade per l'Italia) and the airport operators (e.g. Istanbul Airport) set standards by defining important guidelines, rules, and standard objects for BIM databases (such as service stations, bridge construction, technical equipment etc.). Overall, public authorities, political legislation and customers are the ones who define the standardisation processes, although customers – especially those organised as private companies or PPPs – are the main drivers behind defining use cases for digital models.

Standardisation has eased the automation of design projects, with AI solutions gaining importance. Software providers such as Autodesk, Bentley Systems and Nemetschek have largely automated pre-planning based on their growing object and product databases in combination with AI (Artificial Intelligence), which has increased efficiency in the design phase by more than 30 percent[5]. The software providers have not actively forward integrated into project planning, as they lack respective competencies and people. However, they have constantly added new applications to their software so that important elements of the design process are largely automated. Through common standards, design compatibility between software solutions permits cross-system collaboration. Additionally, BIM standards such as IFC (Industry Foundation Standards) prevail in Europe. This has increased the compatibility and standardisation between different planning and design software, so that planning has more or less become a commodity and proceeds much faster than in the early 2020s.

Standardisation also has advantages for the implementation of construction projects: on the one hand, it allows for the ordering of larger quantities of prefabricated objects such as building elements, bridge components etc.; on the other hand, BIM modelling tools foster the seamless coordination of sub-tasks on construction sites. Also, the monitoring of construction sites happens largely remotely, e.g. through drones, IoT (Internet of Things) sensors and virtual reality performed by companies such as DATUMATE and CONXAI. Other advantages of digital collaboration and BIM modelling software are increased quality as well as faster and safer construction (reduction of exposure hours). Logistics has become an integrated part of the construction process as transportation companies are being integrated into digitalised working systems. Construction sites are significantly more automated with cranes and robotic assembly lines reducing the necessity for a large physical worker presence.

Additionally, standardisation and digitisation have paved the way for much more efficient workflows and the emergence of autonomous machines and robots on construction sites. The first of these machines are already active today (albeit not fully autonomous). However, their use in road and rail construction will be significantly more prevalent in the early 2030s. These machines are operated and surveyed (if at all) remotely.

Finally, engineering companies and their clients increasingly use standardised digital twins to

5 Estimated efficiency gains by interview partners

manage and operate their facilities, to predict maintenance needs and to optimise TCO (Total Cost of Ownership). Many assets (real estate, industrial or infrastructure assets) are highly digitised (IoT, sensors, etc.) and generate massive data. This is considerably widening the market for the smartest engineering companies, as standardised data presents new opportunities in the area of asset management, where asset maintenance and refurbishment have gained particular importance.

The advantages of digitisation, BIM planning, design, logistics and assembly, are now obvious to anyone in the industry – the construction market is automated, geographically decentralised and integrated into the production line:

1. First, in the short-term, standardisation and automation have led to tremendous productivity increases in infrastructure projects through prefabrication, automation and robotics, assembly approach, but also through seamless communication and coordination between different disciplines, i.e. process parallelisation and improved process efficiency. Construction projects have turned into a form of "open-air flow production". One important side effect is that most construction projects are finished on time and within budget.

2. Second, in the long-term, digital twins and the respective databases allow for comprehensive documentation of assets including all resources that have been built into these assets. In view of increasing reporting requirements, this documentation has become vital. Additionally, it allows for a more exact valuation of assets.

3. Third, digital twins enable constant monitoring as well as predictive maintenance which prevents disasters (such as the bridge collapse in Genova in 2018) and reduces cost. Cost savings result from more accurate calculation of future expenses, optimised resource allocation by comparing cost-effectiveness of different materials, better timing of material purchases at low market prices as well as weighing the cost of prefabrication against those of building on-site. Digital twins allow for more seamless application and management of the circular economy methodology, so that structures are well planned and can subsequently be disassembled and circulated more efficiently. Furthermore, the more widespread adoption of AR (augmented reality) and VR (virtual reality) technologies is unlocking further untapped value of digital twins and digital assets. Digital and virtual spaces such as the Metaverse project 3D virtual environments in which people can interact with each other. This fosters remote collaboration, improves prototyping and makes BIM coordination more efficient.

These advantages of digitisation for new projects have fostered the digital capture of the existing infrastructure stock. Through extensive laser scanning and georadar investigations important elements of this infrastructure (e.g. major bridges, wastewater plants, train stations etc.) have been captured digitally and entered into respective databases. This has facilitated comprehensive documentation of Europe's infrastructure stock and eased asset management through predictive maintenance and refurbishment projects.

Given the widespread adoption of BIM across the industry, the development and implementation of new large-scale software solutions as well as in-house customised adaptation is accelerating. Despite increased standardisation and harmonisation, some issues remain with regards to data management and ownership. While baseline standards both in regulatory form or ones that developed organically over time are widely accepted, regulatory standards continue to lag behind and struggle to cope with the rapid evolution of new digital transformation. Consequently, the industry largely relies on a set of

standardised APIs (Application Process Interfaces), as they can develop and source the necessary software or processes, while at the same time continuing the support for the defined set of APIs. With regards to ownership, it has been established that the physical asset owner also owns the digital twin model. This gave rise to a new industry segment which focuses on the management and commercialisation of digital assets and properties, for which digital twins as well as peripherally collected data such as laser scans, are increasingly being licensed through legal marketplaces on certain platforms. Subsequently BIM's value has become even greater, as it not only achieves savings potential for single projects but also leverages economies of scale on a multitude of projects by using and reusing designs and components of existing digital assets. Such digital BIM marketplaces are hosted on platforms (similar to Facebook, YouTube, Spotify) and integrated into the ecosystem of software companies.

In this new, digital world, the consulting engineers face increasing competition, which has forced them to change their role in the construction industry. The challenges come on the one hand from the software companies that, at least partly, automate the planning process, particularly pre-planning. Additionally, software and existing object and product databases allow for the automation of the planning process for bridges, tunnels etc. by building on existing designs. Secondly, technology companies that use sensors, drones and cameras in combination with AI and IoT technologies are threatening the position of consulting engineers in the monitoring of construction sites. The use and management of such complex data calls for an ever increasing need to employ and integrate IT specialists and data scientists. Finally, contractors and construction companies have made inroads into the playing field of consulting engineers, by strengthening their design competencies. More powerful software has helped them in this regard. Thus, consulting engineers are under pressure from three directions.

These disruptions have by 2030 completely changed the new project segment. Projects for the renovation and refurbishment of the infrastructure stock have not been disrupted in the same way. Here, smaller consulting engineering companies, that employ traditional, hybrid (analogous and digital) planning processes, still exist. Nevertheless, it is foreseeable, that full disruption will also take place soon in this segment.

SUSTAINABILITY: STATUS AND DEVELOPMENTS UNTIL 2030

New infrastructure projects, but also the renovation of the existing infrastructure stock require huge investments, that are partly financed by public investors, while private investors – alone or as part of PPPs – have become increasingly important. The latter have not only increased the pressure to integrate technology into projects, but efforts to ensure environmental sustainability have also become key in all projects. These efforts are not altruistic, but clearly driven by customer requirements as well as efficiency and financial considerations.

For large investors, such as Norway's Storebrand Group, integrating sustainability solutions is a "ticket-to-play" for consulting engineers. Additionally, the EU's Green Finance system dominates the financial markets. This means that project financing is only granted by banks and other financial institutions, if the project meets sustainability criteria as defined in the EU's taxonomy. The EU taxonomy is a classification system, which provides companies, investors, and policymakers with a list of environmentally sustainable economic activities. Only such activities are eligible for funding. The aim of the EU taxonomy is to create security for investors, protect private investors from greenwashing, help companies to become more climate-friendly, mitigate market fragmentation and help shift investments to sustainable economic activities.

On the one hand, green finance requires that projects meet different types of ESG criteria

which (in scope 3) force companies to engage suppliers and partners (e.g. cement or steel producers) who provide products or services that, for example, produce fewer emissions and have reduced energy consumption. Very often, such efforts require a more holistic consideration of infrastructure projects, that, for instance, also include energy generation or waste management. Consequently, sustainability considerations also have the benefit of leading to new business models or the inclusion of new technologies, such as inductive charging on motorways, promoted by companies such as Stellantis (with the "Arena del Futuro, Turin") or Magment (with the "Electric Highways" initiative).

On the other hand, green financing requires certification and auditing as well as more comprehensive reporting. While reporting is ensured by the above-mentioned BIM planning and designing databases, consulting engineers play a critical role as auditors, advisers, monitoring consultants and eco-designers.

While economic and financial factors act as a significant catalyst in developing more environmentally friendly projects in the short-term, in the long-term green building and infrastructure projects will be also driven by greater emphasis on resource efficiency, technological abilities and societal pressures. Given the increasing sensitivity to the construction industry's majority share of greenhouse gas emissions, sustainability will no longer be purely financially driven but internalised in the entire value chain.

HARMONISATION: STATUS AND DEVELOPMENTS UNTIL 2030

The harmonisation of rules and regulations in the construction industry in Europe has been promoted by efforts towards digitisation and sustainability. However, differences in regulations between member states of the EU have not fully vanished. Particularly, in some Eastern European countries legislative barriers prevail which make these markets less attractive for international companies. At the same time, these countries have become a gate for Middle East and Asian players, e.g. from Turkey and China.

Nevertheless, the rules for financing infrastructure projects – driven by Green Finance criteria according to the EU taxonomy – are largely similar across Europe. Common BIM standards prevail thanks to interdisciplinary control and governance initiatives such as GAIA-X, that ensure safe data transfer and storage, which in turn have harmonised design and planning processes. Additionally, approval processes for construction projects have been eased. Authorities across Europe accept digital instead of printed plans, and on-site visits have been replaced by virtual visits enhanced by VR (Virtual Reality) technologies.

Other types of regulation, however, still differ across countries which makes it hard for international players to directly enter specific markets in the EU. Consequently, larger European engineering companies as well as some international players, mainly from Anglo-Saxon countries, but increasingly also from Asia, are driving the consolidation of the industry, by acquiring smaller companies in different European countries, thus creating a European network.

Nevertheless, regulatory, language and cultural differences still hamper the development of the European construction market. This is all the more problematic as local or national firms are not able to meet the enormous demand that is coming from climate protection projects, especially from the need to refurbish the infrastructure.

Implications for consulting engineers

The competitive landscape in a digitised, harmonised, and sustainable industry

In this new, digitised, sustainable, and partly harmonised construction industry, consulting engineers face strong disruption: software has, at least partly, automated the planning process, particularly pre-planning, and existing databases allow the standardisation of designs. Furthermore, as activities become more data-centric, digital and collaborative, more software companies are entering the market and challenging incumbents. Additionally, technology providers are entering the segment of

site supervision with solutions that use sensors, drones, robots and cameras in combination with AI. Finally, contractors and construction companies are strengthening their design (and build) competencies. These developments have increased competition in those areas of the value chain that have traditionally been dominated by consulting engineers. Thus, consulting engineers face increasing competitive threats from different angles and the consulting engineering industry has become less attractive as it is being threatened by different forces.

A closer look at the use cases of digital technologies shows that they impact the entire value chain, which presents both threats and opportunities for consulting engineers.

Digitisation and harmonisation have reduced or eliminated traditional entry barriers in many areas of the value chain. Advances in both hardware and software as well as access to readily available cloud solutions have fostered the proliferation of software companies and international players in the **concept, design** and **engineering** segments of the value chain, which threaten the position of incumbent consulting engineering companies. Large software companies can make use of their diverse portfolio of CAD software programmes, which allows customers

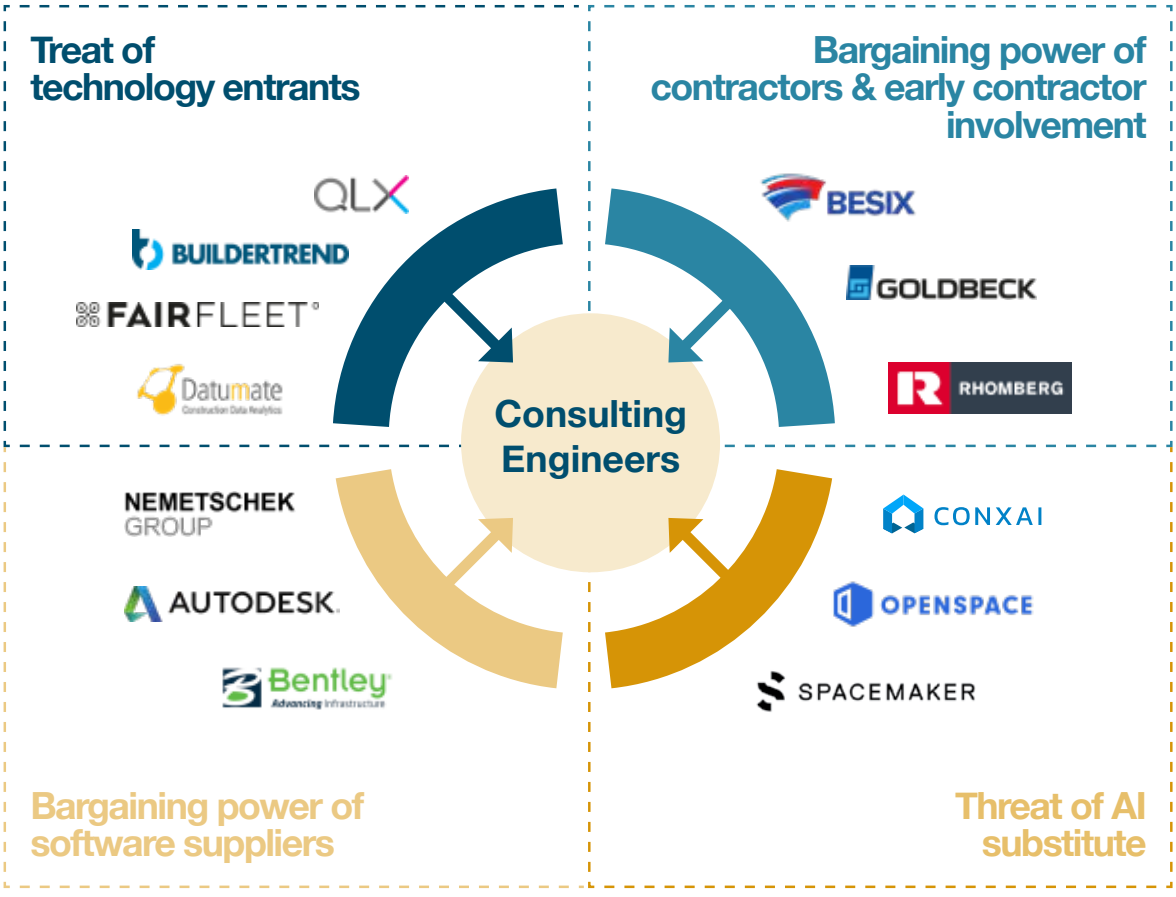

Figure 1: Competitive challenges for consulting engineers

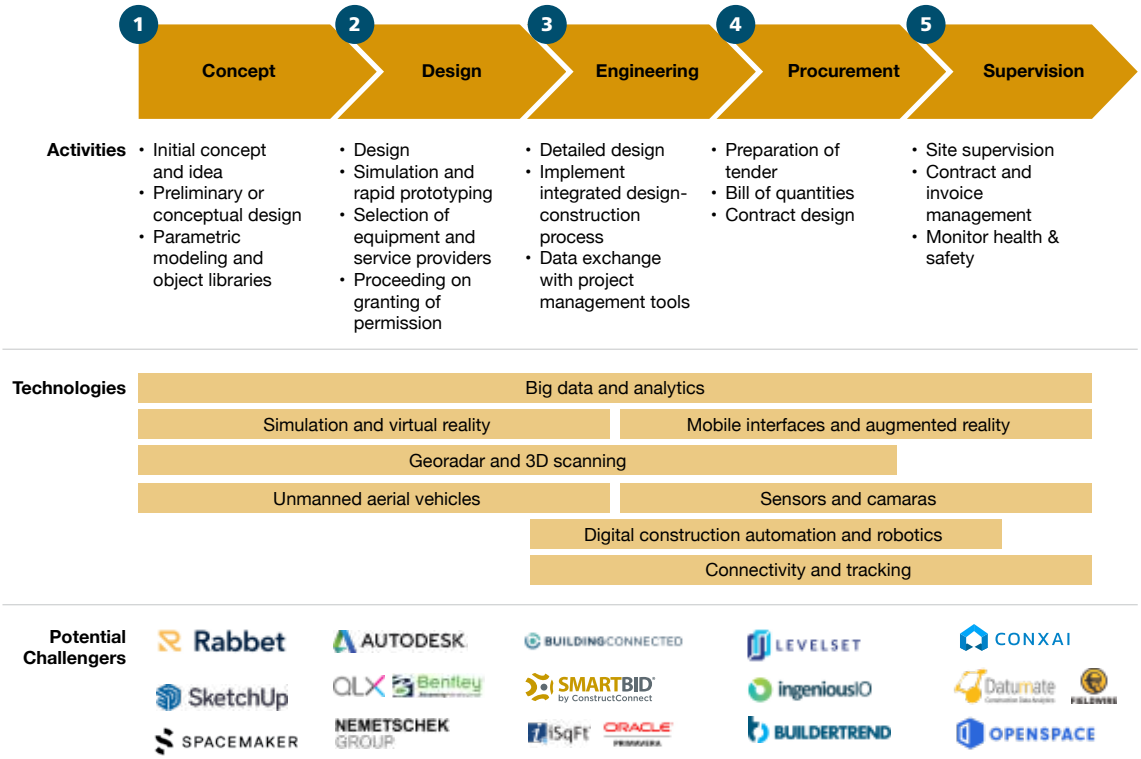

Figure 2: Digital technologies and challengers along the value chain of consulting engineers

to explore new design ideas based on existing asset catalogues, visualise these concepts and simulate how these designs will perform in the real world. This cements the dominant market position of the software companies, which they share with a few larger generalist engineering companies, which are able to offer their own planning and design software.

The **procurement** segment of the value chain is being threatened, primarily by general contractors since the work is still currently done largely on-site and in person. Nonetheless, general contractors use digital solutions to make the procurement process more dynamic, connected and safe. Since databases of manufacturers, contractors and prefabrication companies are connected, pricing of their goods and services has become more transparent. This ultimately reduces both time, costs and uncertainty for procurement. Furthermore, there is already a clear trend towards procurement and fulfilment models with minimal physical interaction, as other industries have already adopted e-commerce solutions, where sales teams handle most of the contracts remotely through digital solutions. Connected construction - through the use of sensors - assists in tracking materials and resources and has made the whole process leaner and more efficient.

AI and ML (Machine Learning) have the potential to disrupt existing business models in the **supervision** segment of the value chain. Here, AI companies face very low entry barriers. Every construction site becomes a potential data source, as all data points such as images, georadar, drone videos and building sensors,

that are gathered through BIM modelling tools or other collaborative working methods, can be analysed. As such, advanced algorithms and AI-developed analytics are providing valuable insights into the operation and performance of a building, a bridge, a road, a rail track, or any other construction project. AI and other advanced analytics software can be used to optimise fleet management, monitor developing problems, determine when preventative maintenance needs to be made, or even direct human behaviour for optimal security and safety. Since construction sites will have an ever-increasing focus on health and safety of workers, a connected data environment allows construction managers, schedulers, and operators to gain holistic real-time insights, identify potential bottlenecks and risks and subsequently reduce work hazards.

STRATEGIC OPTIONS FOR CONSULTING ENGINEERS

Currently, digitisation and a partial harmonisation significantly reduce the entry barriers to value chain activities that have traditionally been dominated by engineering consultants. Coupled with the continued consolidation, supply chain disruptions and sourcing challenges that affect project delivery and put a further strain on margins, new competitors such as software companies and international players are significantly threatening the current position of consulting engineers. Nonetheless, these changing industry dynamics also offer new opportunities, which engineering companies need to proactively address in order to not only remain competitive, but to improve their core competencies.

Engineering companies possess three general options to react to these changing market dynamics:

1. They can **face the competition** and offer a superior value proposition as focused or general engineering specialists.
2. They can **focus on less competitive niches** in the value chain to become service providers.
3. They can enlarge their activity scope and **differentiate into new activity areas** by extending the value chain, e.g. towards creative or environmental advising at the front-end of the value chain or into asset management at the downstream end of the value chain.

The **first strategic** option for engineering companies is to double down on operational excellence and **face the competition.** On the basis of their own software applications or in close cooperation with software providers, these consulting engineers could turn into **engineering specialists** who act as highly efficient digital project planners and supervisors that automate processes and thereby increase efficiency. Some of these engineering specialists will rely on outsourced design centres or independent / freelance engineers and developers to reduce cost and ensure the availability of skilled labour. As **general engineering specialists**, large engineering companies could build a vertically integrated platform with a carefully composed customer-centric product portfolio that comprises solutions for all types of activities. Through this digitised platform, customers will be accompanied along the entire value chain, from the initial project setup, through design, engineering, construction, and maintenance. Through the end-to-end journey, generalist engineering companies would be able to gather operational data and continuously refine their existing software, design, and methods. Furthermore, through the insight of their own operations, they would also be able to look for further strategic vertical integration opportunities to gain even better control of the value chain in the form of an integrated engineering consulting company. One prerequisite for taking on the role of a general engineering specialist is that engineering companies already enjoy a large degree of economies of scale and scope.

Some smaller engineering companies could rather take on the role of a **focused engineering specialist**, where they have distinctive expertise and core capabilities in market niches. Here, identifying and investing in segments with strong demand or where the company has a competitive advantage will be key. Furthermore, raising the level of customer intimacy will help them better understand customers' primary needs, which will not only increase customer loyalty, but will also iteratively improve the existing value proposition.

For both, general engineering specialists and focused engineering specialists, a clear positioning towards sustainable and environmentally friendly engineering and construction will be a large value driver. While there are already general and focussed engineering specialists, the changing industry dynamics and crowding out of incumbents by new entrants mean that consulting engineers need to be clear and decisive in their strategic focus, as otherwise it will be difficult to continue developing core competencies and keep a competitive advantage. Consulting engineers already have the opportunity to take on a leader role when it comes to ensuring climate resilience and to become prominent enablers, contributors, and enforcers of the solution to reducing the impacts of climate change. General engineering specialists already have the potential to combine both technological and analytical abilities with strong communication and interpersonal skills, in order to develop solutions for a variety of projects, setting new construction standards and ultimately creating both a better understanding as well as public presence and perception for the issues at hand. Focused engineering specialists could use their domain specific know-how to develop more environmentally friendly products or methodologies. In both instances, taking a clear and active stance in ensuring their value proposition is more sustainable and would ultimately make them a visible and important contributor to the solution.

The **second option** for engineering companies to position themselves in this disruptive scenario would be to focus on and develop a competitive advantage in **less competitive or very specific niches** in the value chain. Concentrating on existing projects that face less disruption in the medium-term, such as renovation and refurbishment (in which they already have a strong foothold) or focusing on service-dependent disciplines like **sustainability auditing** and certifying different sustainability aspects, could give smaller companies a competitive position in certain niche market segments. Charging for advisory services would change the commercial model from a per-hour to an outcome-based model, which would make them more resilient to external pricing pressures. Furthermore, these companies could improve their position by investing or partnering with software companies to streamline parts of their organisational processes.

Lastly, engineering companies could also counter the threat of increased competition by **differentiating into new activity areas**. There are three aspects that will play an increasingly important role in the engineering ecosystem: 1) building new business models around data, 2) retaining and capitalising on customer centricity and 3) completing the circular economy by focusing on asset maintenance, service, and disassembly.

Given the increasingly important role that data and information management plays in the industry, consulting engineers could establish new activity areas by acting as **data engineers**. They are able to take care of all processes related to the generation, storage, maintenance, preparation, enrichment and dissemination of data and, at the same time, they understand the design and engineering requirements. Data engineers would concentrate on the construction, monitoring, maintenance and expansion of the entire hardware and software infrastructure. This also includes selecting, acquiring, and setting up the right tools, services, and databases, as well as sourcing / licensing the relevant BIM components from digital BIM marketplaces. In addition to managing and monitoring data and data sources, data engineers could act as the interface between the

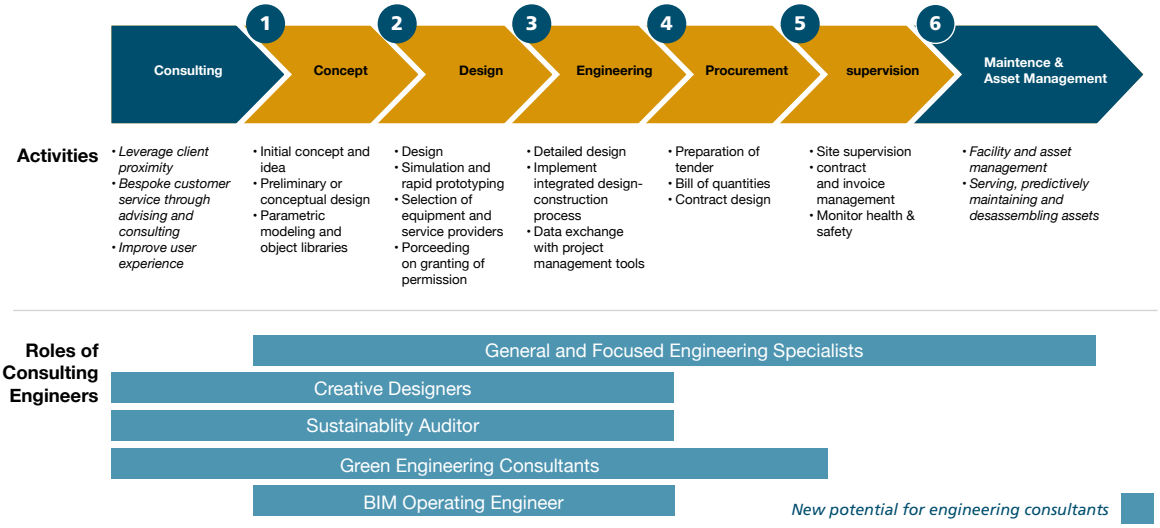

Figure 3: New roles of consulting engineers along the (extended) value chain

data and all other entities responsible for data analysis and further use. In this context, data engineers would be responsible for selecting the right data sets and for optimising algorithms. Last but not least, data engineers could take care of the security and stability of the entire system as well as of compliance with data protection and data security. Going hand in hand with the increase of data management, **BIM operating engineers** could play an imperative role in managing the design, visualisation and digital modelling of construction and infrastructure projects to develop cohesive construction plans. BIM operating engineers could ensure that the information is always up-to-date and correct, and that the different models (architectural, structural, etc.) have no interference or errors. In this way, all problems could already be addressed and solved in the design phase (preconstruction), avoiding waste of time and resources on-site.

Digital and technological developments are advancing at an accelerated pace, through which businesses are becoming more data focused. Nevertheless, despite such a shift in orientation, it is imperative that customer relations are not neglected but rather fortified. Capitalising on their customer proximity means that consulting engineers need to take on the role of a **solution architect** at the beginning of the value chain. Given clients' growing desire for sustainable operations, spatial flexibility, greater energy efficiency, as well as better user experience, engineering companies are able to translate and enhance their clients' requirements into a digital model and clearly advise on best practices as well as communicate the project's potential. Specifically, consulting engineers could become **creative designers** who act as the interface between the investor and the technology. They would provide ideas and guidance for their clients in construction projects and improve the overall offering of the software (both of inhouse-developed or licensed software). Furthermore, they could curate the product offering of inhouse designed BIM components, that are being hosted and licensed on digital BIM marketplaces. Consequently, they would be in close contact with both data engineers and BIM operating engineers to not only understand requirements of own projects but also to analyse and communicate new products and demand shifts on digital BIM marketplaces.

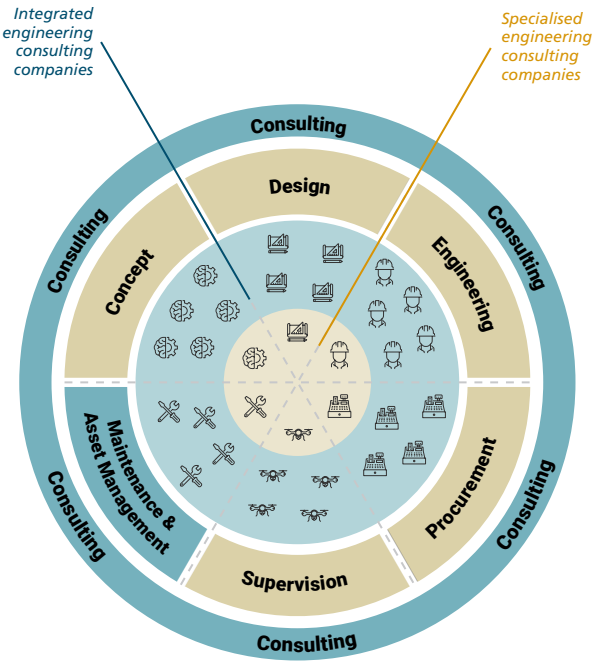

Figure 4: Options for the organisational setup of engineering consulting companies

Furthermore, in a world driven by green finance requirements, consulting engineers could take over the role of **green engineering consultants** at the interface between the investor, construction companies and financial institutions. They would provide ideas and initiate partnerships with suppliers that would ensure efforts towards sustainability in construction projects. Such bespoke customer advice goes along with higher margins, that certain clients are willing to pay.

Lastly, engineering companies could expand the end of the value chain by focusing on **asset servicing, maintenance, and disassembly**. Here data will also play a critical role and enable reactive as well as predictive maintenance. While this segment may in part already be catered for by general contractors, the increased use of and dependency on data management offers a clear opportunity for consulting engineers to leverage their capabilities.

FUTURE SETUP AND ECOSYSTEM OF CONSULTING ENGINEERING COMPANIES

As we have demonstrated in our scenario, the consulting engineering industry might be disrupted by a variety of developments, which will result in engineering companies having to reconfigure and recalibrate their position in the industry. In order to ensure that consulting engineers have a strong foothold in the value chain, they should focus on the roles and disciplines described in the previous chapter. An accelerated rollout of digital solutions and digital BIM marketplaces by software companies coupled with continued industry consolidation means that "business as usual" will not work anymore and will force incumbent engineering companies to improve their value proposition in order to remain competitive. The changing industry dynamics mean that in order to remain competitive, not only the roles and disciplines will evolve, but also the pressure to choose a clearer strategic positioning will become more pronounced. We suggest that incumbent engineering consulting firms should define their roles as either an **integrated engineering consulting company** with a clear customer-centric focus that offers a variety of services along the value chain or a **specialised engineering consulting company** that caters for specific industry needs.

Integrated engineering consulting companies are generally large and vertically integrated along the value chain. They fuse together engineering know-how with IT capabilities, which promotes efficiency through transparent and collaborative software solutions. Importantly, their position as a one-stop shop means they have greater control over design and execution of individual projects and will furthermore be more involved when it comes to deciding future standards. In terms of strategic orientation, integrated engineering consulting companies cover the breadth of the value chain by leveraging their data engineering and engineering specialist expertise and combining it with ancillary services such as creative designing, green engineering consulting and

asset management. They address the beginning of the value chain by leveraging an extensive digital asset catalogue from previous projects, that helps clients visualise potential designs. Proprietary planning and design solutions make it easier for clients to communicate their ideas more effectively with creative designers during the concept and design stage. Furthermore, this enables integrated engineering consulting companies to comprehensively build a digital twin model and apply BIM modelling standards systemwide, as well as licensing components on digital BIM marketplaces. Once the preliminary concept is agreed upon, inhouse green consulting engineers could make sure that the project fulfils all ESG criteria, which would subsequently improve the chances of further funding. During the engineering, procurement, supervision and maintenance stage, sensory / monitoring hardware and software further feed into the digital twin model, providing the client with comprehensive and integrated asset information at all times.

Despite continued consolidation, new solutions mean that fragmentation in the industry will remain high. While technology platform companies – be it engineering or software companies - will be well established, this fragmentation will create an opportunity for smaller integrated engineering consulting companies to focus on the needs of specific industry subsegments. Although larger integrated engineering consulting companies offer a very broad and diversified spectrum of solutions, the disrupted nature of the industry means that they will still have to collaborate with focused engineering specialists in a number of situations. While the trend toward consolidation and platform development is clear, there are still opportunities for such **specialised engineering consulting companies** that offer distinctive solutions. Specialised engineering consulting companies will typically be smaller than integrated engineering consulting companies and have a competitive advantage in a specific activity. These activities could include general or regulatory consulting for a specific industry or geographic subsegment, offering engineering services for smaller construction projects, undertaking remote monitoring and maintenance activities, or pioneering specific products and services like onsite 3D printing or construction drone and electric vehicle docking. Given the accelerating changes both in customer preferences and government regulation, specialised engineering consulting companies have the opportunity to develop foundational technologies in the construction industry. They are needed as frontrunners to scale major disruptive solutions such as smart, automated solutions for repetitive construction tasks as well as the underlying tech infrastructure. As both the scale and scope of hardware and software solutions continues to increase, specialised engineering consulting companies will be able to offer the corresponding supporting solutions, such as developing specific IoT communication and connectivity capabilities or data quality / security management, as well as to license their specialised components on digital BIM marketplaces. Furthermore, given the changing administrative and legislative landscape – that will considerably impact financing of new construction projects – there is a clear need for regulation specialists. It is expected that regulations will regularly change as the industry and legislators come to terms with new construction technologies and methodologies. As such, smaller consulting engineers will be able to specialise in helping larger construction and engineering companies to cope with local authorities. While in the short-term integrated engineering consulting companies might have an advantage in terms of scale over specialised engineering consulting companies with regard to the digital transformation, increased commercialisation and value of digital components traded on digital BIM marketplaces will reduce the size advantage in the long run.

This kind of relationship is shown in the graphic below. Here, specialised engineering consultants cover specific niche areas along the value chain such as prefabricated noise barriers, on-site 3D printing, and certain regulatory consulting. Due to their comparatively smaller size and product offering, they will be less present in the concept stage of the value chain and more active in the latter stages, where bespoke technologies and engineering know-how is warranted. As such,

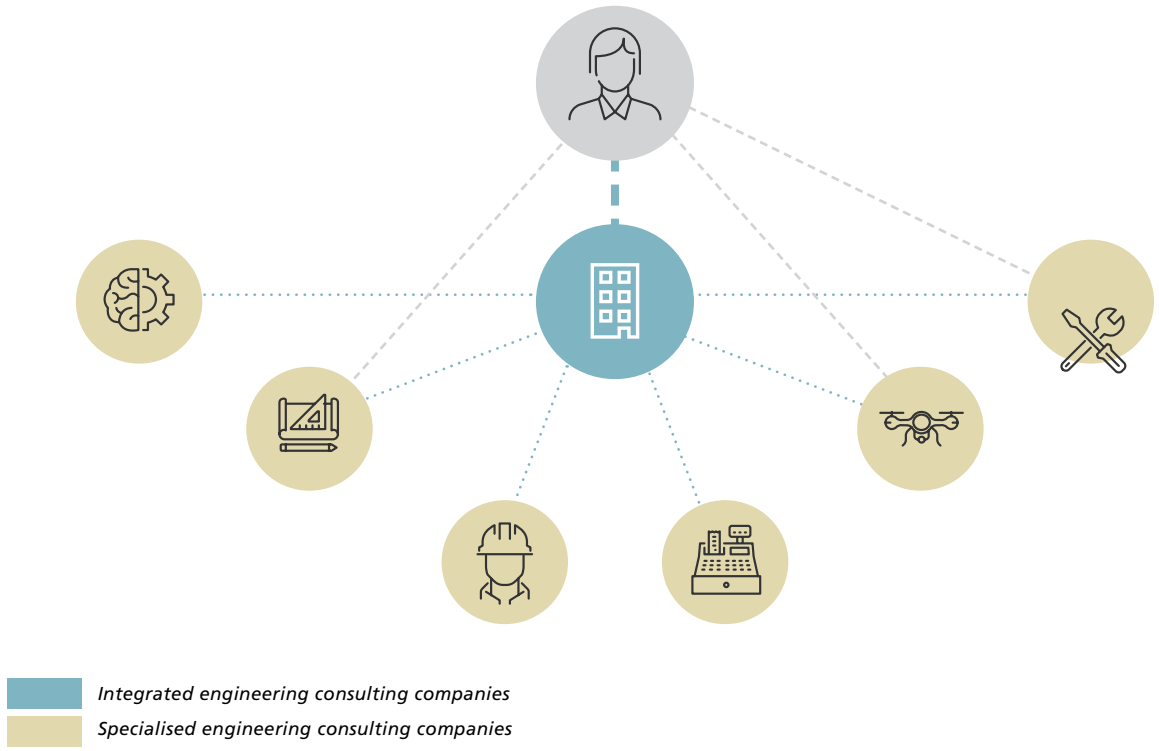

Figure 5: Cooperative ecosystem of integrated and specialised consulting engineers

the interaction with the customer will be limited to particular aspects of the overall construction project. Integrated engineering consulting companies, in contrast, will cover the breadth of the value chain and accompany the customer end-to-end, which manifests itself through a strong and stable relationship. Nonetheless, integrated engineering consultants will need to draw on the expertise of specialised engineering consultants to further develop and improve their product offer. Cooperation between incumbents with new entrants similar to the one between Bechtel and the drone start-up Skycatch will help to implement new digital solutions more quickly than developing these solutions inhouse. As such, integrated engineering consultants will be the predominant link between customers and specialised engineering consultants.

As mentioned earlier, data management will be one of the major future value drivers in the AEC industry. However, as of now integrative technologies connecting digital solutions with physical constructions are still limited. This field will be a tremendous opportunity for both integrated and specialised engineering consulting companies alike, as real-time data collection on assets combined with bespoke planning, designing, engineering and maintenance software has the potential to generate further added value. Furthermore, pairing data collection with data analysis will unlock even more value streams. Developing predictive analytics solutions has the potential to improve not only the accuracy of an asset's total cost of ownership, but also salvage more value in the later stages of the asset's lifecycle. This will tap directly into the circularity potential, enabling not only more effective renovation and maintenance and change of use of assets, but also the recovery of certain materials (those suitable for recycling/ re-use) in the case of eventual demolition/ deconstruction. This massive opportunity is completely aligned with current EU policy on the Circular Economy and given the central role that data management will play in the industry, there is the need for both integrated and specialised engineering consulting companies to develop core competencies in the field.

Conclusion

While many other industries have reaped the benefits of digitisation, engineering consultants have been slow to implement digital solutions, often reverting to analogue planning and designing methodologies. This worked in the past, as the whole construction industry still largely relied on physical interactions and manual labour. However, the construction industry is likely to experience disruption in the coming years, as an accelerated rollout of digitised, novel, data-oriented solutions, coupled with a growing demand from customers and regulators for more environmentally friendly and sustainable construction projects will lead to new industry standards and a higher degree of harmonisation, that further reduce entry barriers. As these trends will likely impact the entire construction industry, engineering consultants have to reconsider and adjust their strategic position in the industry in order to not eventually be crowded out. In order to seize the opportunity of this disruption, consulting engineers need to change their mindset and actively engage with new business model opportunities. Some key considerations to take when weathering this new industry landscape are:

INVEST IN CORPORATE CULTURE

Turbulent and transformative times call for management to implement agile, flexible, and collaborative work practices, in order to embrace and leverage the benefits of a fast-changing environment. The ability and the willingness of the staff to adapt, to change and to continuously transform will be the key precondition for successful development. It also forms the safety bracket to make the considerable investments in people, hardware and software successful. Retaining and attracting the right employees will only succeed with a sustainable corporate mission and a corporate culture that is adapted to the continuous challenges of change.

INVEST IN TECHNOLOGY

New technologies like BIM, Metaverse robotic assembly or 3D on-site printing are becoming increasingly important. Nonetheless, engineering companies have been somewhat reluctant to fully embrace these solutions as they require large initial capital expenditure and because the return on investment is still somewhat distant and difficult to quantify. However, the proliferation of such technologies is only going to grow, and consulting engineers should actively engage, invest, adopt and ideally also develop new digital solutions and technologies so they can strengthen their existing core competencies. This will enable them to better scale future digital value streams and ultimately strengthen their market position. BIM will be the leading process and data pool. Consulting engineers must be responsible for this strategic hub. They must be the managers of BIM and accompany it together with the client.

INVEST IN SKILLS

Rapid industry advances especially in regard to implementing digital technologies into key workstreams will likely exacerbate existing labour shortages and skill gaps. Engineering consultants should begin to develop and train existing employees on new tools and technologies as well as hire new candidates with technical expertise. A potential promising avenue to fill the skills gap more quickly could be to hire candidates from other industries that have already undergone a digital transformation.

ENGAGE WITH CUSTOMERS

Customer preferences are not only changing with regards to sustainability of the completed asset but also in terms of the overall expectation of the client journey. Forward-thinking consulting engineers should leverage their customer proximity and provide exceptional client experience across the entire customer life cycle in order to create genuine differentiation and sustained competitive advantage.

COLLABORATE WITH EXPERTS FROM OTHER DISRUPTED INDUSTRIES

While the consulting engineering industry has been slow to adopt digital solutions in the past, digitisation already disrupted many other industries. Engineering consultants should partner with experts who have experienced a digital disruption in their industry and were able to innovate their business models to secure more revenue streams. Particularly with regards to navigating the IP and digital asset ownership issue, one can learn lessons from the manufacturing, software or even music industry. In that way, key competitors could also become strategic partners, whereby collaboration could result in new value propositions, that are co-created.

DARE TO THINK OUTSIDE THE BOX

Why don't you start to think about becoming a specialised contractor that can design, deliver, and assemble a specialised project? Cooperate and actively engage with start–ups, prefabrication and logistics companies to make projects more efficient and integrated with suppliers. Strengthening your data analytics capabilities by hiring data scientists could provide new perspectives on new as well as existing projects.

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