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# Innovation Project EPC 4.0

## ‘Unleashing the hidden potential’

### Extract of the Final Report May 2019

A joint study of ProjectTeam®, Tiba, maexpartners, M8International and d1g1tal AGENDA

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# INDEX

<b>1</b>	<b>Introduction .....</b>	<b>6</b>
<b>2</b>	<b>Executive summary .....</b>	<b>8</b>
<b>3</b>	<b>Situation and trends .....</b>	<b>10</b>
3.1	The EPC market .....	10
3.2	The Performance of EPC sector against other Industries .....	12
3.3	Megatrends in EPC sector require new responses .....	14
<b>4</b>	<b>Targets and methods .....</b>	<b>16</b>
4.1	Reduce CAPEX by 50% – utopia or real potential? .....	16
4.2	Learning across the silos .....	17
4.3	The four dimensions of business transformation .....	18
4.4	Methodology .....	19
<b>5</b>	<b>Strategy and overall concept .....</b>	<b>20</b>
5.1	Is there an 4th Industrial revolution in EPC sector? .....	20
5.2	Game changers and challenges .....	21
5.3	A house built on industry 4.0 .....	21
5.3.1	Foundation of digitalization .....	22
5.3.2	Pillars: changing the organization, processes and methods .....	22
5.3.3	Roof: The human factor .....	23
<b>6</b>	<b>The Opportunities of digitalization .....</b>	<b>24</b>
6.1	Building information modelling as collaboration foundation .....	25
6.2	The next level: Automated collaboration .....	33
6.3	Potential of big data .....	36
6.3.1	Data analysis across projects .....	36
6.3.2	Data analysis across operations .....	37
6.4	Applications of blockchain .....	38
6.4.1	Distributed ledger technologies for EPC projects .....	40
6.4.2	Smart contracts and supply chain applications .....	41
6.4.3	Blockchain for open data markets .....	41
6.5	Application of digital technologies .....	43
6.5.1	Predictive maintenance .....	43
6.5.2	LiDAR and 3D data capturing .....	44
6.5.3	Virtual and augmented reality .....	45
6.6	Summary and recommendations .....	46
<b>7</b>	<b>Collaboration by partnership .....</b>	<b>47</b>
7.1	Partnering as business model .....	47
7.1.1	Integrated team approach investor – contractor .....	48
7.1.2	Project management and EPC as consultancy or service .....	49
7.1.3	The project developer .....	49
7.1.4	Early involvement of O&M .....	51
7.2	Contractual models .....	53
7.2.1	Relational contracts or alliances – guide to standard contracts .....	54
7.2.2	Aspects of tendering and contracting .....	56
7.3	Summary and recommendations .....	60
<b>8</b>	<b>Flat supply chain .....</b>	<b>62</b>
8.1	Integration of strategic suppliers .....	63

8.1.1	Leveraging Innovation from suppliers .....	64
8.1.2	Radical lead time reduction (RLTR) in integrated supply chains .....	64
8.1.3	Building a consistent supplier integration model .....	64
8.1.4	Mastering complexity and risk .....	65
8.2	Lean procurement for standard supplies .....	66
8.3	Reducing transaction costs with relational contracts .....	67
8.4	The alternatives to buying .....	67
8.4.1	Pay-per-use .....	68
8.4.2	Financing with pay-per-use credits .....	69
8.4.3	Leasing with pay-per-use leasing .....	69
8.5	Alternative supply contracting models .....	69
8.6	Summary and recommendations .....	70
<b>9</b>	<b>Flexible organization .....</b>	<b>71</b>
9.1	Standardization of processes, methods and roles .....	71
9.1.1	Standardization in project management and EPC .....	72
9.1.2	Standardization in qualification profiles .....	73
9.1.3	Modularization of work .....	73
9.2	The scalable organization .....	74
9.2.1	Integration of partners and subcontractors .....	75
9.2.2	Integration of external personnel .....	75
9.3	Agile project management in EPC business .....	76
9.4	Summary and recommendations .....	80
<b>10</b>	<b>Focus on core competence .....</b>	<b>81</b>
10.1	Disaggregating the competencies along the value chain .....	81
10.2	Assigning risks to most competent party .....	84
10.3	Driving technical innovations .....	85
10.3.1	Performance improvements by learning from operational experience .....	85
10.3.2	Flexible plant concept .....	86
10.3.3	Modularization .....	86
10.3.4	Standardization – technology platform .....	87
10.3.5	Miniaturization .....	87
10.4	Innovative financing models .....	88
10.4.1	Rising capital without banks? .....	88
10.4.2	FinTech – a game changer? .....	89
10.4.3	Investment funds .....	89
10.4.4	Private equity funds .....	90
10.5	Summary and recommendations .....	91
<b>11</b>	<b>The human factor .....</b>	<b>92</b>
11.1	About trust and leadership .....	92
11.2	Changing human behavior? .....	96
11.3	Transforming organizations .....	98
11.4	Developing the right competencies in a new culture for change .....	100
11.5	Summary and recommendations .....	101
<b>12</b>	<b>Implementation and way forward .....</b>	<b>102</b>
12.1	Overall savings, limitations, and conditions .....	102
12.2	Investors and operators: Take the lead! .....	104
12.3	Contractors: Get prepared! .....	104
12.4	Supply chain: Get involved! .....	105

# 1 Introduction

The financial crisis in 2008 and the oil price crash in 2014 severely hit the profitability of operations in the oil and gas, chemical, energy, and other associated industries, and consequently the engineering, procurement and construction (EPC) business that is built on the investments in these industry sectors. Low commodity prices in recent years have continued to discourage investors from financing industrial production. The industry is still suffering even after a full decade, but not only because of this crisis. Low productivity growth, low degree of digitalization, low investment in R&D has disconnected this industry from the positive evolution that other industries have experienced over the last ten to 20 years – the stock market is celebrating successes elsewhere. While the Dow Jones Industrial Average increased in the ten years from 2008 to 2018 by more than 80%, the Dow Jones Construction Index fell by 30% in the same period.

But here's the good news: The world needs industrial plants! And managers and engineers are still highly passionate about executing such ventures with success. The world population is growing; production output will continue to grow on a global scale, and the need to build new production facilities will do, too. The backlog of ten lost years for the EPC industry is immense. Brownfield investments to revamp existing facilities add to this huge market. The engine of EPC business has started up again. But nothing will be the same as before 2008. Because the traditional business model in EPC has no future.

Prominent voices are calling on the industry to cut its CAPEX by 40 to 50%. This doesn't just mean fine tuning of performance; this ambitious target necessitates radical changes. Within the entire value chain from CAPEX to OPEX, from the EPC of industrial plants to their operation and maintenance, we waste money as a result of disastrous project planning and execution, and inefficient operations. We spend money that does not add any value to our basic business objectives. The CII (Construction Industry Institute, Texas) determined that 40% of project costs are just transactional costs – imagine the potential of cutting these down! A radical business transformation that would put the EPC business on par with the efficiency of the automotive or aviation industry would unleash money from investors. There is no lack of money. The EPC sector is simply not effective enough to attract it! In May 2018, a German think-tank kicked off an innovation initiative to develop practical guidance for EPC contractors as well as for investors, owners and operators on how to approach innovative business models for industrial projects and operations, from EPC to O&M.

## The Partners of innovation project EPC 4.0



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The objective of this initiative is to describe concrete measures capable of unleashing the hidden potentials in our industry and to save up to 50% of CAPEX along the entire value chain. This report is aimed at

- providing insights into the latest developments in the EPC sector
- providing a comprehensive overview of current initiatives working on innovative business models that may be of relevance for the EPC sector
- developing blueprints that describe practical guidelines for EPC companies as well as for investors, owners and operators on how to approach innovative alternative business models for the value chain from EPC to O&M of industrial plants,
- supporting these with examples based on real cases/ best practices, including examples from other industries
- providing references that indicate the potential economic impact.

The partners of this initiative are Tiba Managementberatung (the German project management pioneers and consultants for the automotive industry), maexpartners (consultants of the aviation industry and authors of a joint study about digitalization/Industry 4.0 with the German Mechanical Engineering Industry Association, VDMA), M8International (a network of high-profile industry leaders and contract management advisors), and d1g1tal AGENDA (the innovation manufacture for communication in the digital space). Leader of this initiative is ProjectTeam®, the Global Expert Network organization for the EPC industry.

May this report trigger further thoughts and discussions with-in this industry to unleash the hidden potential in the EPC sector.

*Munich, 27 May 2019*

## 2 Executive summary

The traditional way of performing EPC business doesn't work anymore. The way we manage the Engineering, Procurement, and Construction (EPC) of industrial plants (and other businesses) today has not changed very much in the past 50 years. And the plants we build are technically not much different from the ones built a half century ago. The oil and gas industry is world champion – in avoiding digitalization. The EPC industry as a whole is spiritless in driving innovations, compared to the automotive or even the IT sector. It is an open secret that productivity has not increased for 20 years. Consequently, in the global competition for investments, the EPC business is clearly the loser.

The starting point of our initiative is a comprehensive analysis of the performance of the EPC industry against other industries and the observed megatrends in EPC that require new responses. We reference a large number of reports generated by the big names in global consulting such as McKinsey, PwC or BCG that have been published in the last few years and that all come to the same conclusions. We have discussed with other international initiatives in this field, such as the ones driven by the European Construction Institute (ECI) in London, or the Construction Industry Institute (CII), US state of Texas, and found out that there is consensus among the experts about the potential levers to help this industry get out of the downward spiral. Industry leaders and executives are careful not to harm their business with pessimistic statements, but if questioned anonymously, a majority does agree about the need for radical transformation.

***The question to 80 EPC executives in India: “Are you in the comfort zone continuing the traditional way with continuous improvement or do you feel the need for radical transformation” was answered 0:80 for radical transformation.***

*EPC Industry Top Management Seminar by CEP/IMP2M in New Delhi on December 12, 2018*

The objective of our initiative was to challenge statements voiced by prominent investors, owners/operators as well as EPC companies with regard to cutting CAPEX by 40 to 50%. Is this utopia, or is this a challenging but achievable goal? The hypothesis that we established as a starting point of our analysis was: If this industry worked as effectively as the automotive or aviation industry, we could save up to 50% CAPEX along the value chain. Our team included experts with hands-on experience in the EPC industry as well as experts

with a cross-industry perspective, willing to learn from best practices from other industries, and willing to understand what hinders us from applying these lessons to EPC.

What is the conclusion of our studies? Are we able to save up to 50% CAPEX along the value chain? The answer is – Solomon's judgment – yes in principle, but ...

First of all, our business is complex, and every business, every project is special. There is no standard solution that fits all. Solutions that may work in one business case might fail in the other, as ownership structures, regional aspects, technical conditions or the markets are completely different.

Second, no individual player within the value chain will accomplish this target on their own. CAPEX is the total of capital expenditures, including the costs of project development, the costs of engineering/procurement/construction, the cost of project management and project governance. Such a radical reduction may only be feasible if developed along the entire value chain, and here the first link in the chain is the investor. The investor defines the strategies for the project development, and decides between the traditional 'LSTK' approach or an innovative partnership approach that takes on board the experience and competence of all parties involved from the very first moment.

There are success factors and reasons for failure that follow a larger pattern, and the goal of our report was to capture and evaluate these factors, and to give structure to the overall pattern in a holistic approach. The model we used is a holistic model for business transformation developed by Till Balser covering four success-critical dimensions, 'People', 'Organization', 'Processes & Methods', and 'Technology'. The basic principle of this model is the experience that any business transformation needs to be balanced across all four dimensions. Initiatives that limit the effort to cover only one or two of these dimensions will fail if the other dimensions are neglected.

Our recommendations are assembled in a format symbolized by a 'temple', with digitalization as the leading (and potentially disruptive) technology foundation. On this foundation we define four pillars of organizational and process/methods-related changes, covered by the roof of human behavioural changes – the people dimension and ultimately the most challenging part of all.

**Digitalization** is the foundation. Ten years ago, most experts would have agreed to the thesis that we should first define the processes, and then select and define the corresponding IT solutions. In the age of Industry 4.0, we recognize

that IT is developing new solutions and new opportunities at a speed that our business processes are hardly capable of following. We are too slow in evolving our business processes to give them the lead; digitalization is the driver that imposes changes, sometimes disruption on traditional business models. In other industries this is already reality, and we should not exclude the same happening in the future in the EPC of industrial plants. The title of our initiative 'EPC 4.0' references Industry 4.0 as a 'fourth' industrial revolution driven by (software) releases.

We have identified four major fields of action to address changes in organization and in processes and methods, which are all linked to each other:

**Collaboration by partnership** makes reference to the public infrastructure sector, suggesting specifically that investors/owners/operators consider contractual models different to the traditional EPC LSTK (Lump-Sum-Turn-Key) approach, such as alliance contracts or lean IPD (Integrated Project Delivery) models.

**Flat supply chain** references examples of supply chain integration from the aviation and automotive industry, suggesting partnerships with strategic suppliers that go beyond the capital project horizon and into the field of operation and maintenance.

**Flexible organization** advocates standardization of project management, engineering, procurement and construction processes as well as standardization in qualifications to enable the EPC sector to adjust flexibly to the business cycles with organizational structures scalable to market needs.

**Focus on core competences** finally suggests that all participants share work scope and associated risks with the party who is best capable and competent of managing these. This focus releases resources for urgently required innovations: Innovations in plant technology, such as modularization, innovation in state-of-the-art information technology to increase productivity and reduce non-conformance and underperformance costs.

**The human factor** All these changes will not be successful without the support of the people working in our industry. The magnitude of changes triggered by Industry 4.0, in organizations, in processes and methods, requires a transformation programme driving a cultural change in the behaviour of our human resources. There are well-established tools and methods to guide organizations, companies, or project teams to work towards a change in attitude and mindset.

A reduction of up to 50% CAPEX? What at first glance may look like utopia may not be impossible if broken down into smaller elements where we are wasting money in our capital projects today. Planned CAPEX and the as-built CAPEX in reality differ significantly – the cost overspend in megaprojects ranges between 30 to 50% on average! But even when we analyse the planned CAPEX: The cost of lost productivity, transaction costs that do not add value, such as the costs of mark-up fees, the cost of duplicating project organizations for project governance, the cost of bidding, the cost of claiming and penalties, the cost of risk contingencies in CAPEX ... All in all, we come to the conclusion that up to 50% of the money we spend on capital projects is avoidable and does not contribute to the value of the assets we build.

The holistic approach is not complete without continuation of these thoughts into OPEX. A minor additional investment in CAPEX can trigger significant savings in OPEX. Lifecycle asset management does not start with the handover from the EPC contractor to the operator, lifecycle asset management starts during the pre-development phase of the project.

We invite all concerned players along the value chain of EPC and O&M to discuss the thoughts expressed in this report with the authors. We invite investors/owners/operators to challenge us. We invite EPC companies, construction companies, companies in the supply chain to discuss our approach. We do not claim to have any patent solutions. But we endeavour to understand what works well in other industries and we have the imagination to adapt good practices to the specific requirements of our industry. We have access to the experts who have the best subject specific know-how in the fields of action covered by this report. Now, it is up to the decision-makers in the EPC industry who have the courage to simply do it. The ones who succeed will be the leaders of tomorrow in EPC business.

***We have the choice: Take the lead or lag behind.***



## 3 Situation and trends

### 3.1 The EPC market

15 September 2008 is a historical milestone that marks a turning point in our industry. The day Lehman Brothers collapsed and stock exchanges around the world lost billions of dollars was the starting point for a lost decade in EPC business. The price of crude oil is the most prominent indicator determining overall economy performance. The World Bank publishes its outlook [Worldbank, 2018] of commodity prices quarterly, and owners/operators of industrial plants producing commodities carefully plan their investments in step with this prognosis. The oil price had climbed to an unprecedented spike in 2008, driven by the rapidly increasing demand in the emerging economies, but also production cuts by the OPEC, before it collapsed as a consequence of the global recession triggered by the financial crisis in 2008.

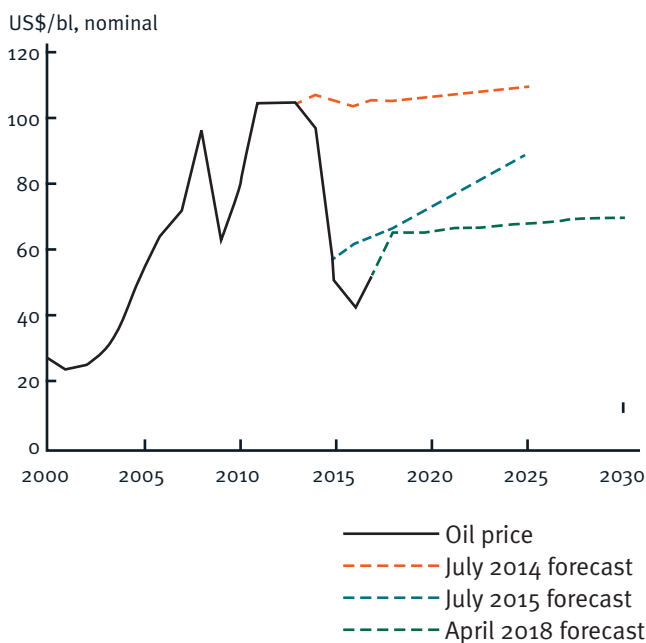


Figure 3.1: Commodity markets outlook, April 2018 [Worldbank, 2018]

Economic recovery sent back the oil price to levels above 100 to 125 USD between 2010 and 2014, before it suffered another steep drop in 2014. This second drop was caused by the same economies that fuelled the oil price with their massive demand the years before, and then struggled to maintain their growth, above all China, followed by India, Russia and Brazil. The high oil prices in 2010 to 2014 prompted North America to expand its own capabilities to extract the black gold from their oil sands, further contributing to the negative effect of low demand. Last but not least, Saudi

Arabia continued to exploit its resources with high production levels. All in all, the oil price collapsed to levels down to 40 USD and has not recovered since. The World Bank forecast has been corrected to lower levels in recent years, and the pressure remains on all investors to plan their business based on continuously low commodity prices, putting high pressure on CAPEX as well as OPEX.

As a consequence of the collapse not only of the oil price, but also of the price of other commodities such as natural gas, owners put their investments on hold. The result was a dramatic decline in order intake for those companies that were relying on orders from industrial plant operators, EPC contractors, the supply chain of manufacturers, but also service providers in all fields, including operation and maintenance.

**Global investment in production and exploration fell from 700 billion in 2014 to 550 billion USD in 2015.**

*Kenneth Rogoff, Harvard University, 2016*

The strong decline in order intake hit developed economies such as Germany especially hard. The VDMA (Germany's Mechanical Engineering Industry Association) determined that the order intake for large EPC projects by German companies dropped from 33 billion euros in 2008 down to 19 billion euros in 2016 [VDMA, 2017]. Companies with low capital assets collapsed, others were forced to merge, and yet others were subject to acquisition by healthier competition, often based in Asia.

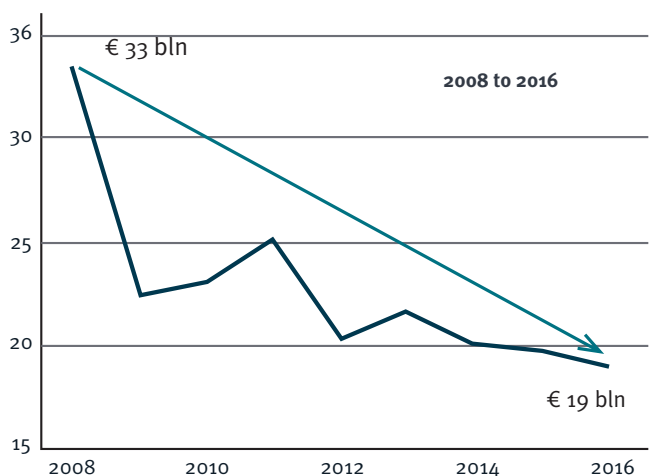


Figure 3.2: Order intake for large EPC projects in Germany 2008 to 2016. Source: [VDMA, 2017]

The rise of China is another game-changing factor for the global economy, and specifically in the EPC business. While western economies are lacking long-term strategies, western governments acting from one election to the next, and western companies acting from one quarterly report to the next, China's strength is long-term planning. China is investing where the ROI may not pay back before five, ten or even 20 years, while western companies are struggling with the massive decline in their business and consequently cannot release the cash to invest.

Global competition has always been strong, and companies have their strategies to face this competition. Competition from China, however, is felt as the toughest-ever threat to European companies. There is only one way out: European companies have to remember their strengths, have to invest in the fields of their strengths and have to defend – or regain – their leading position. Without investment into long-term strategies, this contest will be lost by European companies.

The good news is: After a lost decade for the EPC business, after a decade of low demand for industrial production facilities, this market is starting up again. The backlog of one lost decade is immense, and the growing world population will guarantee a continuous demand for new capital projects. The market is big enough for it to require all available engineering resources in this world.

There is no precise definition of 'EPC industry', consequently there are no reliable reports that determine the size of the global EPC market. Many reports refer to the global construc-

tion market, which is estimated to be a 10-trillion-USD market today, and is expected to grow to 15 trillion USD by 2030 [Global Construction, 2015]. Growth is driven primarily by the economies in China, India, the US and SE-Asian economies such as Indonesia, while the traditional players in Europe or Japan may recover but will not surpass the levels prior to the financial crisis in 2008. The construction industry includes real estate and infrastructure, which make up the largest part of the market, but it can be assumed – depending on the definition of EPC industry – that our business has a share of 6 to 10% of this market.

A global market size for EPC projects of 600 to 1000 billion USD per year, and a market growth of 50% over the next 15 years requires all players in this market to organize themselves more effectively to be in position to execute all these projects. Considering that we are currently executing our projects with an average cost overspend of more than 30%, there are huge opportunities in this market that would justify massive investments into the companies that execute these projects.

The reason why investors are reluctant to pump money into this business is the poor performance of the EPC industry compared to other industries.

***“There is no lack of money. There is a lack of attractiveness to collect it.”***

*Frank-Peter Ritsche, ProjectTeam*

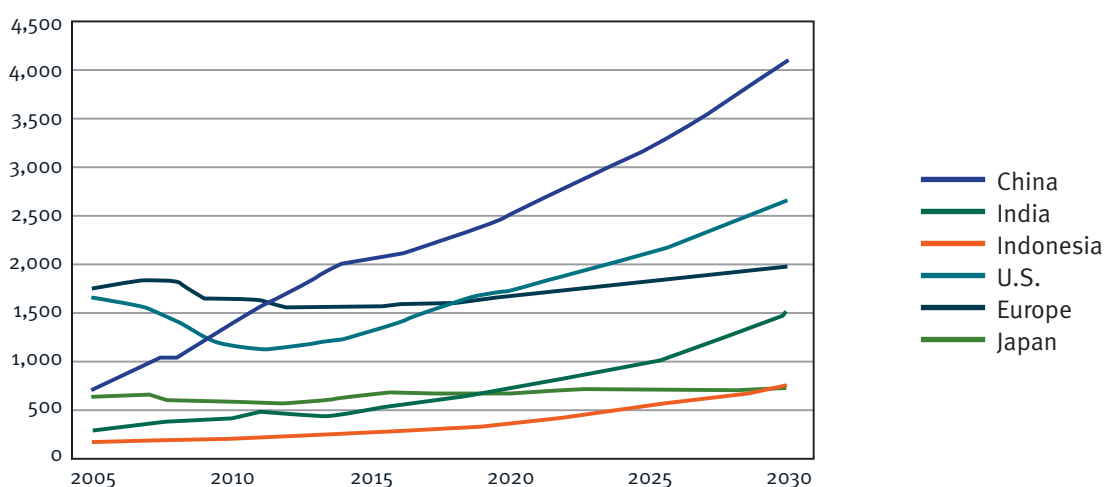


Figure 3.3: Forecast for the global construction market up to 2030 [Global Construction, 2015]

### 3.2 The performance of EPC against other sectors

Investors are driven by the leading financial indicators. The Dow Jones Industrial Average dropped dramatically with the financial crisis in 2008, however, it managed to recover to previous heights within five years. Within one decade (01/2008 to 01/2018), the DJIA increased by 86% – fun for those who invested their money in this market.

The Dow Jones US Heavy Construction Index is a leading indicator for the construction industry in general, and (to certain extent) can be taken as an indicator for the EPC industry. The DJCI suffered a dramatic drop in 2008 as well, but even after five years it still remained 30% below its pre-crisis level. Another five years later, its performance had still not improved. While investors celebrated the record heights of the Dow Jones Industrial Average, those investing in the market represented by the Dow Jones US Heavy Construction Index suffered 30% losses after one lost decade.

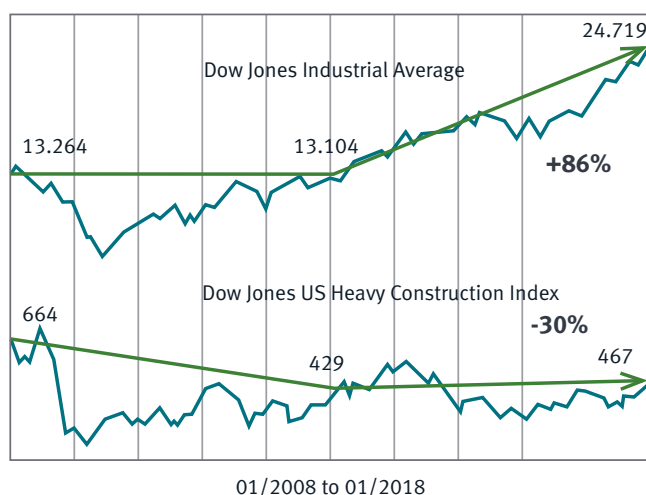


Figure 3.4: Dow Jones IA vs. construction index 2008 – 2018

There are several reasons for the massive underperformance of this sector, and there is a wealth of studies and reports by all major business consultants that come to very similar conclusions. From all these studies, three major factors are highlighted here:

**Poor performance in the execution of capital projects.** Studies, for example by McKinsey [McKinsey, 2017-1], conclude that capital projects are completed with an average of 37% cost overspend and 53% schedule overrun. The magnitude varies from sector to sector, but the oil & gas downstream business seems to hold the record with an average of 53% cost overspend.

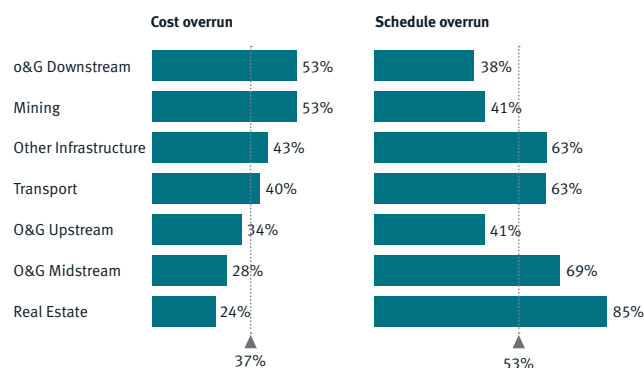


Figure 3.5: Performance of megaprojects [McKinsey, 2017-1]

“The failures in the core processes of project under-performance are well understood: Post-project reviews generally audit the systems, process, and project management root causes for overruns. However, the disruptive influence of failures in project leadership, ineffective culture of the project organization, failed mechanisms of collaboration between multiple parties involved – and their increasing importance as the scale and complexity of projects increase – are typically not examined to the same extent.”

*“Looking at construction projects today, I do not see much difference in the execution of the work in comparison to 50 years ago.”*

*John M. Beck, executive chairman, Aecon Group, Canada*

The report for the World Economic Forum in May 2016 prepared in collaboration with Boston Consulting Group [BCG, 2016], citing John Beck as above, refers to these reasons for failure:

- Lack of innovation and delayed adoption
- Informal processes or insufficient rigour and consistency in process execution
- Insufficient knowledge transfer from project to project
- Weak project monitoring
- Little cross-functional cooperation
- Little collaboration with suppliers
- Conservative company culture
- Shortage of young talent and people development.

While the objective of our innovation project ‘EPC 4.0’ report is not to create another version of studies that have been well documented by other major business consultancies, we acknowledge the massive opportunity for those companies

on the market that are able to overcome the deficiencies that lead to this underperformance in capital project execution.

**Poor productivity growth compared to other sectors.** Productivity has grown continuously over the last few decades, between 50 to 70% for the overall economy within the past 20 years. Manufacturing has been leading productivity growth, almost doubling its real gross added value per hour worked by person employed between 1995 and 2015 [McKinsey, 2017-2]. Productivity in construction registered only minor growth during the same period.

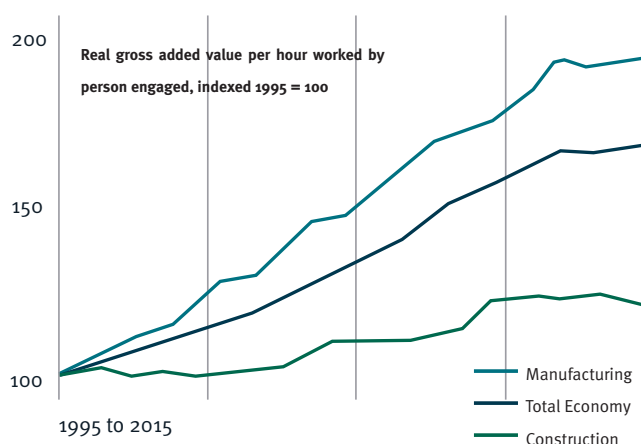


Figure 3.6: Productivity in construction [McKinsey, 2017-2]

Again, the reference to John Beck above serves as sufficient explanation for the overall performance of this industry.

**Low level of digitalization.** Another explanation for the massive productivity gap of our business in comparison to other industrial sectors is the low level of digitalization. Again, we can refer to several analyses performed by major business consultancies, in this case the TOP 500 study 2014 by Accenture [Accenture, 2014].

**Oil and gas is world champion — in avoiding digitalization, followed by the number two: Construction.**

While the elimination of the deficiencies that lead to massive under-performances in the execution of projects is an obvious measure to be taken by all companies in this sector, our report focuses on the opportunities expected from closing the gap in the industry ranking (first) in digitalization, resulting (second) in the productivity growth that this industry needs to compete successfully for investors' money in the global market.

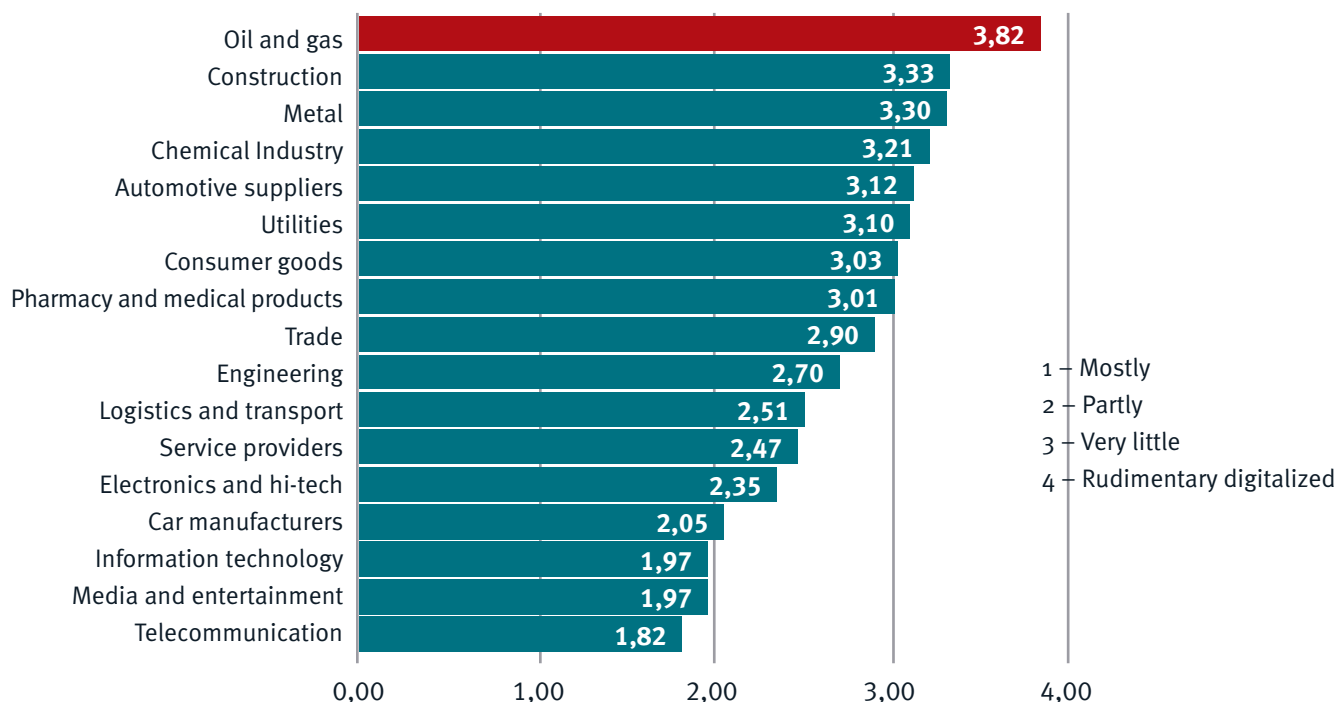


Figure 3.7: Digitalization by industry sectors [Accenture, 2014]

### 3.3 Megatrends in EPC require new responses

The starting point of this ‘EPC 4.0’ initiative was a white paper ‘Time for Change – A vision for EPC 4.0’ issued by ProjectTeam® in November 2017 [ProjectTeam, 2017]. From the variety of studies and reports that analyse the situation in the EPC sector, and from the variety of issues that are addressed by speakers at conferences held over the globe, we have identified some megatrends that we have used as the initial project charter for our own analysis:

#### Collaboration between O/O and EPC contractor

- The traditional approach in the EPC business of executing a project based on a lump-sum turn-key (LSTK) contract between the owner/operator and EPC contractor is adverse to the idea of joint collaboration. The LSTK contract causes each contractual party to focus on its claims against the other party and adds additional contingencies to budgets and schedules to protect against claims and to deal with uncertainties.
- There is a trend for investors to think about strategies on how to marry CAPEX and OPEX and form one integrated project team with the key players for the execution of the CAPEX project. Project alliance contracts are one model in which each party is incentivized to optimize both the CAPEX and the OPEX of the plant. Uncertainties and the consequential contingency costs are reduced owing to open books. Sustainable long-term-goals should prevail before short-term deadlines.

#### Collaboration with the supply chain

- The traditional approach contracting the work from top (owner/operator) to bottom through several levels to the EPC contractor, subcontractors and their sub-suppliers in a contractual hierarchy generates losses of 40% of project costs as transactional costs. Relational contracting rather than roll-up contracts will flatten the supply chain, replacing the contracting hierarchy with a network.
- Modularization and standardization are good measures to improve the integration of the supply chain into the plant design, but standardization to cut CAPEX should not compromise any optimization of OPEX. Many components, however, are over-specified, and costs can be saved by eliminating these over-specifications. Scalable and agile platform strategies such as in automotive

design permit standardization without eliminating necessary variances.

- The traditional approach is to buy and own the equipment. A different approach is to lease equipment over a period of time, which levels CAPEX costs. Alternatively, equipment may be paid-per-use, with the equipment supplier remaining the owner and maintaining the equipment over its lifetime. This option could be attractive for suppliers of complex machinery, not only because of the profit generated in service contracts, but also because of the opportunity to feed experience from operation and maintenance back into design improvements.

#### Flexible resourcing and ‘agile’ EPC collaboration

- Labour markets in high-cost countries do not provide sufficient qualified resources, with the consequence of further increasing labour costs. Companies with global hubs are shifting qualified work to low-cost countries. Fluctuations of staff (e.g. job-hopping), as experienced in Asia, will become common in high-cost countries, too. Highly qualified staff is not willing to accept cuts, but moves on to where the work seems more attractive.
- Companies are taking the approach of replacing hierarchies with network organizations that develop the flexibility to upscale and downscale their capacities to accommodate the huge upturn and downturn cycles in EPC business.

#### Digitalization and Industry 4.0/data and knowledge sharing

- Potential new players might position themselves as providers of EPCaaS (EPC as a Service) and/or PMC. They would offer a software-based solution and apply building information modelling (BIM) to manage the development and construction of a capital project.
- The opportunities of digitalization and Industry 4.0 will require the EPC contractor and the owner/operator to build a partnership over the asset lifecycle. The real value can be generated when the technology provider shares his engineering data with the operator, and the operator shares his O&M data with the technology provider. The analysis of big data from multiple plants leads to plant and process improvements that both technology provider and operator benefit from.



### Project management and competences

- Projects fail because the established and known project management methods and tools are not applied. This is not about innovation; this is about bridging the gap between theory and reality, between knowing what's wrong and doing what's right. The problem is not that processes and tools must be invented; the problem is the change of mindset in the organizations and their people, and how to manage a culture of change.
- Agile project management methods are successfully applied in other industries, especially in innovation-driven businesses, such as IT. There may be a conflict between the necessity to digitalize the project management processes with controlled data workflows that may lack flexibility and the trend to agile project management methods. This conflict needs to be addressed and resolved.



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## 4 Targets and methodology

### 4.1 Reducing CAPEX by 50% – utopia or achievable goal?

Today, industries are under permanent pressure to change and adapt. Innovative technologies, products and services brought to market by companies in global competition create a race for leadership in all sectors of the economy. European companies in the EPC business cannot escape this pressure and aspire to catch up in this global race. However, much remains to be done, as the EPC business in Europe has fallen far behind in recent years and must now make even greater efforts.

In recent years, studies have repeatedly revealed the gaps in European EPC businesses in terms of innovation, productivity, profitability, and business agility. European companies in the automotive, aerospace, mechanical, and electrical engineering as well as automation industries have worked continuously to improve their performance in recent years and are now among the global champions. It is essential for the European EPC business to catch up and dramatically improve its performance. This is not a question of a marginal improvement, but a quantum leap.

Prominent voices in the European EPC business are calling for significant changes, for example the Global EPC Manager of Shell, Paul van Weert, who advocated during the ECI Annual Conference '18 [ECI, 2018] in Amsterdam:

***“We need to halve the cost of capital projects to enable them to do twice as many projects with the same allocated budget, not through putting more cost pressure on supply chains, but through fundamentally rethinking the delivery model.”***

*Paul van Weert, global EPC manager of shell*

In summary, a step change in the way projects are executed is needed to secure improvement of up to 50% in cost as well as 30% in schedule. That won't be achieved by squeezing the margins of suppliers, but calls for much deeper collaboration, more rigour in scoping projects, relying more on what the industry has on offer, standardization, less prescriptive standards from the client and using digital twins more effectively from design through construction to the operation phase.

Stephen Mulva, Director of the Construction Industry Institute (CII), paints a dramatic picture of the situation and argues that the transactional costs are too high [CII, 2018]:

“For the past several decades, our industry has emphasized the planning, technical, managerial, and work process dimensions of our projects – at the expense of the numbers and the assets keeping us in business. **Forty percent (40%)** of the cost of creating a new asset **is currently wasted on transactional costs**. It's not a sustainable model. We have to employ the best business, financial, and accounting concepts and we've got to do it now.”

Transactional costs may be defined as costs associated with the exchange of goods or services, including payments to banks and brokers, search fees as well as service fees to process these transactions. In the EPC business, transactional costs may also include financial fees, legal fees, dispute resolution costs along with logistics and communications costs. It also includes foundational work such as the cost of sourcing quotes, cost and schedule benchmarking, assurance reviews and so on and so forth. Unfortunately, in EPC projects, transactional costs thrive owing to both lack of integration, and to contractual and operational frictions between the multitude of stakeholders involved during the project lifecycle.

Mr Mulva advocates a new approach, called ‘Operation System 2.0’ [CURT, 2018]. This vision is a multi-industry, collaborative, research-supported effort that aims to reorganize industry procedures and standards and replace them with a standardized, technology-enabled platform that accommodates future changes and makes capital projects more financially viable and sustainable. In an interview with digital AGENDA [dA, 2018], he points out the impact: “The existing business model is essentially like a pyramid: At the top you have the owner, followed by the EPC, a series of subcontractors, a series of suppliers, and they are working on the contract, both upwards and downwards. This model is very slow and expensive. With computers and AI, we are basically able to put everybody on what we call the ‘Thin Platform OS 2.0’. Impact can reach up to **35% cost reduction, 50% cycle time reduction, 57% better ROCE and 250% more projects.**”

In 2017, an in-depth report by McKinsey experts examined the role of technology in shaping modern industries [McKinsey, 2017-3]. The authors conclude that digitalization is driving a ‘radical reordering of traditional industry boundaries’, leaving whole sectors ripe for disruption. “The mobile Internet, the data-crunching power of advanced analytics, and the maturation of artificial intelligence have led consumers to expect fully personalized solutions, delivered in milliseconds. Ecosystem orchestrators use data to connect the dots – by, for example, linking all possible producers with all possible customers, and, increasingly, by predicting the needs of customers before they are articulated. The more

a company knows about its customers, the better able it is to offer a truly integrated, end-to-end digital experience and the more services in its ecosystem it can connect to those customers, learning ever more in the process.”

In another McKinsey report concerning ‘The art of project leadership: Delivering the world’s largest projects’ [McKinsey, 2017-1], it is stated that “troublingly, large capital projects that are completed on schedule and within budget are the exception, not the rule. We reviewed a dataset of more than 500 global projects above 1 billion USD in resource industries and infrastructure and found that only 5% of projects were completed within their original budget and schedule. **In completed projects, the average cost overspend was 37% and average schedule overrun was 53%.**” It is pointed out that the disruptive influence of failures in project leadership, ineffective culture of the project organization, failed mechanisms of collaboration between multiple parties involved are some of the levers for improving the performance of large projects, especially as scale and complexity of projects are increasing.

Last but not least, it is essential that the productivity gap in the EPC business is dealt with. Reports [McKinsey, 2017-4] point to the fact that in the construction industry the annual productivity growth during the last two decades has been only 1%, that **the industry is lagging behind overall economy productivity by 50%** and that in total a boost in productivity of approximately 50 to 60% could be achieved, which amounts to 1.6 trillion USD additional value. “Construction is among the most fragmented industries in the world, the contracting structures governing projects are rife with mismatched risk allocation, and owners and buyers, who are often inexperienced, must navigate a challenging and opaque marketplace. The results are operational failures within firms, including inefficient design with limited standardization; insufficient time spent on planning and implementing the latest thinking on project management and execution; and a low-skilled workforce. In addition, the construction industry is highly volatile and has bottom-quartile profit margins compared with other sectors, constraining investment in the technology and digitalization that would help raise productivity.”

Summing up all the findings, there is a real potential for the EPC business to improve its overall performance. All reports show measures for drastically reducing costs as well as scheduled times, for improving the overall productivity by learning from good practices and other industries, performing systematic organizational change and by using modern technologies to the optimum extent. Our report provides an integrated view of the changes necessary for achieving quantum leaps.

## 4.2 Learning across the silos

A faster way of improving the EPC business is to analyse what other industries, sectors, and firms are doing and to apply the lessons learned. The situation, challenges and solutions may differ and certainly there is no ‘silver bullet’ to tackle the situation in EPC business. However, it’s very insightful to see how EPC is applied in the nuclear industry compared to renewables, infrastructure, construction, oil & gas or industrial solutions. The business, operation activities and projects differ between EPC and automotive or aerospace, however, the way the latter two industries are improving productivity, applying new (digital) technologies and performing agile and collaborative practices is an example, the EPC business can definitely learn from.

In this report, we provide several examples of cross-fertilization, which allows learning from good practices in other industries, sectors and firms. However, this may just be a starting point, as cross-fertilization should be done systematically. It begins with learning from projects and applying the lessons in other projects, utilizing them in operations, for sales purposes and even to iterate the strategy of the company. Benchmarking within and between organizations is an invaluable tool for improving the performance and identifying innovative solutions, including but not limited to new technologies, products, services or business models. Visiting conferences, extracting value-adding ideas from presentations and discussion means learning. However, it means doing this consciously, following defined learning goals and focussing on narratives with benefits for one’s own business.

Our observation is that the EPC business is rather introvert, traditional and conservative towards innovation and change. Industry leaders often say the opposite, but when talking with people in the trenches, they admit that they are ‘captives of the own world’. Therefore, achieving significant progress requires leaders to look ‘outside of the box’, to be open to new approaches and explore the possibilities, to be risk-tolerant and try things out before bluntly rejecting them. For example, the automotive industry is challenged by disruptive technologies. Instead of blocking these trends, the leaders are flying to Silicon Valley, talking to disruptors, learning from them and applying the lessons learned in their own companies. Recently, Volkswagen Commercial Vehicles hired a top manager from Apple to boost autonomous driving features and ‘Mobility as a Service (MaaS)’ applications. Over the last couple of years, the aerospace industry has hired several managers from the automotive industry to cope with the increasing production numbers. What is the EPC business doing to inject experts or experiences from other industries, sectors or companies? The way we see it, there is room for improvement.



### 4.3 The four dimensions of business transformation

Owing to the magnitude of change necessary in EPC business, it is not enough to make just a few tweaks, a holistic approach is needed. Tiba Managementberatung developed a holistic model for business transformation (see Figure 4.1), covering four success-critical dimensions, 'People', 'Organization', 'Processes & Methods' and 'Technology' [Tiba, 2008]. This model was used during the analysis and development of recommendations, following the objectives of achieving quantum leaps in EPC business.

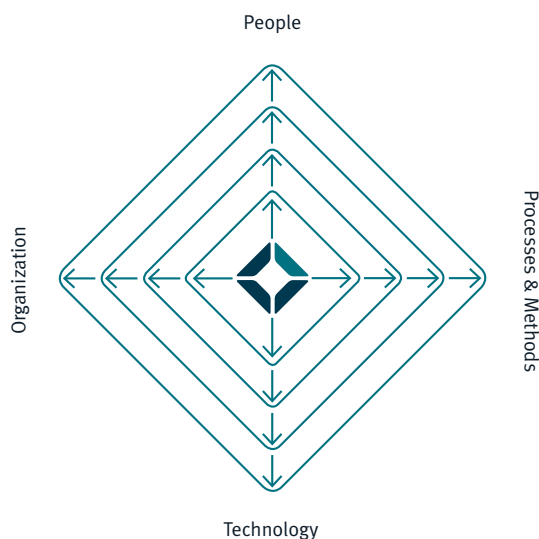


Figure 4.1: 'Holistic' model for business transformation (Source: Tiba Managementberatung)

The **People** dimension is certainly the most important dimension as the human factor is key to success in EPC business. The focus is on aptitude, skills and experiences of people performing their tasks in EPC business. To keep pace with the steady increase in the overall complexity of the business and specific requirements of the tasks, people need to continuously develop skills, and organizations are required to support them with coaching, training and other development measures. A supportive culture is necessary to foster collaboration among the various stakeholders. Leaders on all levels play a crucial role in helping to develop such a culture, e.g. through a supportive leadership style, giving space to people to perform tasks and self-organize in the context of a project. Intercultural skills play an important role in EPC business, working with teams across the supply chain spread all over the globe.

**Organization** highlights the fact that all people in the EPC business need to understand their roles, i.e. their tasks, accountabilities, and authorities. The latter is an important issue as too often only the first two are defined. The organizational structure within one of the players of the EPC business and also between the players need to be defined and should clearly foster performance, agility, and flow. Too often, the organizations involved in the EPC business are hierarchically structured and focus on internal optimization. However, a continuous flow is needed, from the O/O through the EPC and the subcontractors to the supplier base, which requires them all to be externally oriented, align their organizations to the requirements of the project and change the setting as needed during certain phases of project execution. Governance, procedures for decision-making across organizational levels, and entities, interfaces, communication and information flows, regulations for escalations and akin must be optimized in order to cope with the many challenges facing EPC business.

With the **Processes & Methods** dimension, the necessary tool set is provided. There's not one tool to meet all requirements, typically a set should be made available to allow the most appropriate one to be chosen to match the specific requirements of the EPC project. Tools should be tailored to the needs of every phase of project execution, building on existing standards. However, all processes and methods need to be orchestrated, integrated and aligned with each other, including but not limited to processes of systems engineering, product management, engineering, purchasing, programme and project management, value, benefits and risk management, contract and claims management as well as supply chain management.

Finally, the **Technology** dimension addresses all aspects concerning (IT) tools used in business. This may be software used to enable processes, collaboration and communication, technologies and approaches for delivering products and services, solutions for automation, digitalization and artificial intelligence (AI), dealing with big data, data analytics and the like. Technologies may be used in projects for planning, controlling, reporting and documentation, for engineering, purchasing, and the delivery of services rendered under the contract, and certainly for construction, commissioning and logistics. It is important for an EPC business to regularly scan the horizon for new or disruptive technologies, to apply technologies that add value and improve performance, aligned with the overall strategy of its organization.

#### 4.4 Methodology

During our research, we focussed on qualitative methodology rather than on quantitative figures to capture the nuances of practice and provide insights from practitioners for practitioners. Wherever this report refers to quantitative figures, these values need to be interpreted in the context of a specific use case only. They give an indication of a scale of magnitude of the ‘hidden potential’ of such figures and should not be misunderstood as statistic values.

Based on our own practical experience, an in-depth analysis of the present situation, the challenges and the need for change was conducted, scanning a multitude of reports, articles, conference proceedings, and literature in the field of EPC businesses. Ideas on how business could improve were developed and validated in in-depth interviews with

about twenty industry representatives. During conferences and intensive workshops, potential solutions were discussed and refined, before an online survey captured some figures about the magnitude of cost reductions in each area. Case studies were identified for each improvement area, highlighting the realization of improvements in practice and discussing advantages together with disadvantages.

However, this report is not the end of our efforts to move the EPC business forward. In several workshops in 2019 with leaders in the EPC business we want to discuss the results and define an action plan. This action plan may act as blueprint for companies to change their way of conducting their EPC business. Special training curricula, coaching and consulting offerings will be derived from the report, and through publications we want to advocate our ‘case for change’ and potential solutions towards a sustainable future.



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## 5 Strategy and overall concept

### 5.1 Is there a 4th industrial revolution in EPC business?

This paper, comprising the report of the innovation project ‘EPC 4.0’, references a ‘fourth’ industrial revolution. Industry 4.0 has become a buzzword that is associated with the disruptive nature of digitalization. Three industrial revolutions in human history have generated such radical changes to the life of human beings that they deserve the title ‘revolution’. So, we understand we are in the middle of a new industrial revolution, which is associated with cyber physical (autonomous) systems, while EPC still is working on revolution number 3 – computers and automation.

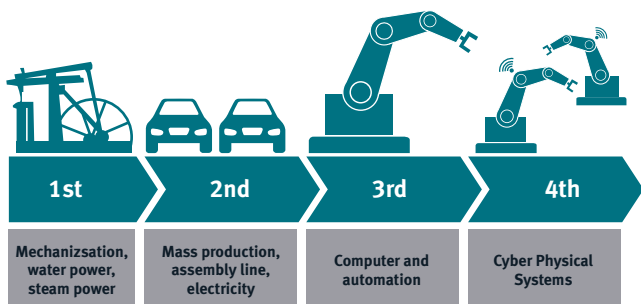


Figure 5.1: The four industrial revolutions

This report entitled ‘EPC 4.0’ examines the potential impact of Industry 4.0 on the business of engineering, procurement, and construction of industrial plants. It will not end up describing the problems and challenges, it will give guidance in a discussion that sometimes is characterized by the fuzzy definition of the current situation and the expected future, and it will provide solutions.

But is it ‘revolution’? The EPC industry has been using digital solutions for more than three decades, since drawing boards in the engineering offices were replaced with computer screens. We manage our engineering data in 3D models, we use databased scheduling software, we plan and control costs in SAP. We have been discussing the integration of these digital silos for 20 years, and today we are still sinking millions of euros in underperforming IT systems that many users feel are ineffective on the real basis of work. New systems bring new bugs; upgrades or replacements of IT systems bring additional risks for projects and increase the number of grey hairs of one or the other project director.

The digital revolution will change our way of life, and we see its disruptive potential in numerous examples in other industries. Computers know, learn and can forecast our be-

haviours, creating completely new business models that we could not imagine before they suddenly appeared without warning. Cryptocurrencies based on blockchain technology are turning the financing sector upside down, mobility-as-a-service solutions question the traditional car-selling concept of the automotive industry. But the EPC industry, still very much embedded in its tradition and conservatism? Industry leaders were asked about their expectations at the last Engineering Summit of the VDMA (German Mechanical Engineering Industry Association) in November 2018, and the clear statement was that no disruption was expected but rather a gradual evolution [VDMA, 2018]. The digital revolution is happening everywhere else, but not in EPC!

Industry 4.0 and digitalization are seen as additional business opportunities. There are surveys that ask questions such as “How much turnover does your company generate with digital technologies?”. The percentages remain low, and expectations remain moderate, as this question bypasses the fundamental goal of digitalization. Digitalization must enable our companies to enhance their performance in their core business, digitalization is not there to be satisfied by its own existence, digitalization is the lever to higher profitability! The correct question is “How much did your profit increase thanks to digital technologies?”. Digitalization as the lever to higher profitability? This is where in our daily project execution we are struggling to overcome the gap between theory and reality.

The team of innovation project ‘EPC 4.0’ has been examining the disruptive potential of digitalization in the EPC sector, and to be honest, by limiting the disruption to pure technological aspects it is difficult to identify digital technologies that may impose a radical change on our traditional business model. The disruptive elements become apparent when expanding the technology-focussed view toward the other dimensions of a business transformation model: processes and methods, organization, and the human factor.

Building information modelling (BIM) is one example of the digitalization trends that sooner or later will find their way into the EPC industry. BIM was imposed by public tendering procedures on projects in the infrastructure sector ten years ago. The parties participating in these projects quickly found out that BIM creates transparency and visibility of desired and undesired information (as a matter of perspective) that was contradictory to the traditional contracting models such as LSTK. Consequently, BIM caused the parties to develop alternative ways to collaborate in infrastructure projects, such as alliancing or IPD (Integrated Project Delivery) models.

*BIM as an IT-based approach is not a radical change, the way it has caused a change in the way we collaborate, however, is radical!*

Is there a 4th industrial revolution in the EPC business? We believe the answer is simply yes. The technologies themselves tend to be evolutionary rather than revolutionary, but in consequence our team expects that these technologies will cause radical changes to the way the different parties involved collaborate in capital projects, the EPC contractor, the owners/operators, the supply chain, the financing institutions. The objective of this report is to generate a vision of how this may happen, and we derive our vision from learning across the silos, from observing what is happening in other industries.

## 5.2 Game changers and challenges

When analysing observations from other industries, when learning from experience or best practices in business cases beyond the characteristics of EPC, two fundamental questions have to be answered. First: What are the success drivers and what are the causes of failure in these specific use cases? And second: What are the barriers or challenges to overcome so as to apply these findings to the EPC industry? This section elaborates on three (of many) fundamental game changers and challenges that should be considered.

### Trust and transparency instead of claims and blames

The fundamental and most ambitious challenge is the cultural and behavioural change that is required of all parties. Human nature tends to be 'bad' and 'egoistic'; wherever one human spots an opportunity to beat another they'll go for it. Sports are designed like this, and the humanitarian ideologies of socialism failed because of the self-centred attitude of those taking the leadership. Is it realistic to change human behaviour? Probably not, but ignoring the problem is not the solution. Transformation strategies can address human behaviour, can incentivize cooperation and punish adverse behaviour. EPC projects, specifically those executed in LSTK contracts, are characterized by claims and blames between the contracting parties. Major effort is spent on something that does not generate value for the project. Experience from (some) projects executed in partnering and alliance models show that it is possible to create a project environment where trust and transparency replace claims and blames, rewarding the parties with lower costs and shorter schedules.

### Protecting intellectual property and confidentiality

The downside of transparency is full visibility that includes the exposure of information that we may consider confidential. Not all information we like to protect as confidential deserves this classification. We do not disclose our commercial calculation in a lump-sum contract, but we accept full disclosure in an open-book approach. Consequently, the contractual model we select determines the level of transparency.

Intellectual property and patent rights on technologies is another factor that prevents the disclosure of data to the extent that may be required to support a building information model approach. In a time where infringement of property rights is a common phenomenon and owners' rights are increasingly difficult to enforce around the globe, IT vendors are required to develop IT solutions that enable the protection of IP in shared data applications. When sensitive engineering drawings are stored in a cloud, we need to be 100% sure that these drawings are not found on Wikileaks a couple of days later.

### Cyber security

Which leads to the risk associated with cyber security. With the increasing level of digitalization, our vulnerability to outside attacks is increasing. The effort spent on protecting our data and the operations of our IT systems is growing more and more. The question is at what time this effort will supersede the benefits earned from digital solutions. Cyber security is a major field, it affects every industry, but cyberattacks are certainly a massive threat to global EPC projects that rely fully on electronic data exchange. The industry, and first of all the IT vendors, are obliged to develop solutions that are constantly ahead of the developments of threats. Going back to pen and paper is not a solution.

## 5.3 A house built on top of Industry 4.0

Just to correct any exaggerated expectations: The glorious one-fits-all business model for EPC 4.0 of the future does not exist. Every company has a distinct business model that deserves a distinct approach to cope with future challenges. Every EPC project is unique by nature. There is no standard solution, no recipe to follow, no checklist in the attachment to this report. The world is complex and consequently our view of this world is probably fuzzy.

The objective of our report is not to invent any new revolutionary academic thesis. What we have done is pick up good practices from other industries, ask questions, get answers and try to give structure to complexity.

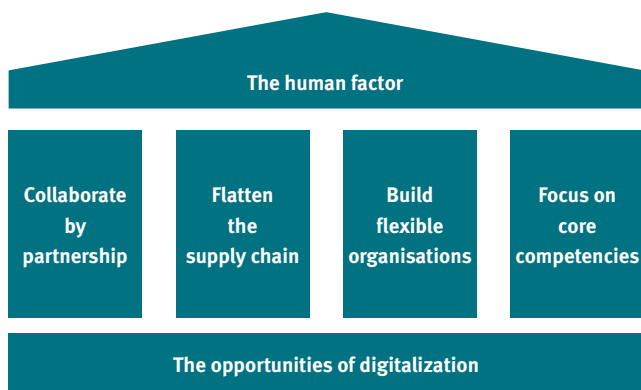


Figure 5.2: The transformation model of EPC 4.0

This is our model, a ‘temple’ built on the four success-critical dimensions of the holistic business transformation model [Tiba, 2008]: IT technologies as the ‘foundation’, the human factor as the ‘roof’, and in between the ‘pillars’ of organizational and process-related changes.

### 5.3.1 The foundation of digitalization

Ten years ago, we would have built our house on the foundations of good processes, and attach the IT technologies as an enabler following the lead of our working processes and procedures. Ten years later we recognize that digital technologies develop at a speed that leaves our processes tagging behind the opportunities of IT. The driver that determines the transformation of our business towards the future in the age of Industry 4.0 is digitalization, and that’s why we are starting to build our approach on this foundation.

We have been applying digital technologies for many decades. But we should be careful with the use of buzzwords like ‘Industry 4.0’, the use of ‘state-of-the-art’ digital technologies today is not a digital revolution. There are tools and IT environments that have evolved during the past decades and that are ready for use today, but they are only slowly entering into the real world of project execution. The investment required to apply these technologies must be justified by the value added, and too often, the benefit is not that obvious. Unfortunately, it is a painful lesson learned in many companies that the introduction of new IT solutions is far more expensive and behind schedule compared to the original plan when the investment decision was taken. IT solution providers are required not just to develop the most sophisticated software, but also to execute IT projects to

planned cost and schedule, and to guide the users into the brave new world.

Digital technologies can be categorized in three groups, related to their maturity:

1. Mature technologies that exist and that are already applied by some companies who have taken the lead. Reference cases exist and prove the value of these technologies. All it takes is an investment decision based on the expected value that these technologies bring to the specific business or specific project. And what adds value in one project may not be equally beneficial in another project, owing to different organizational constellations, different labour requirements, different qualifications available. Laser scanning in brownfield plants, use of virtual or augmented reality in design, digital solutions for predictive maintenance are examples of mature technologies that are in the process of capturing their market.
2. Existing technologies that still have to proof their practical relevance in our business. We have identified two technologies that may have the potential to change our business: Building information modelling (BIM) and blockchain. Companies that experiment with these technologies may not immediately get a return on their investment, but it is worthwhile exploring the opportunities of these technologies. Those who are able to turn such investments into success will be leading the way in the future.
3. Technologies that are under development or that – theoretically – can be envisaged in combination with today’s technologies, but do not yet exist as ready-to-use applications. This category covers the whole potential of automated and autonomous systems supported by artificial intelligence, such as automated construction management or automated engineering. Many tasks in our projects are completed by engineers, planners, supervisors, coordinators that – with some imagination – could be performed more efficiently with the aid of computers.

### 5.3.2 The pillars: Changing the organization, processes and methods

The implementation of digital technologies as described above will change our organizations and will change our way

of working, our processes and methods. We have identified four major areas of change, the four pillars of our house, which are all interconnected and have to be understood as an integrated set of measures:

**Collaboration by partnership.** This measure refers to how primary partners in a capital project should interact, basically the EPC contractor and the owner/operator, but also other key players in the project, such as the construction companies. The fundamental principle is to create a contractual environment where all parties are aligned to the same common goals, share risks and pain, but also share opportunities and gains, on the basis of contracts that reward the achievement of these common goals for all parties. These collaboration models require the establishment of trust and transparency, and should avoid the claims and blame games that are a common phenomenon in traditional LSTK contracts.

**Flat supply chain.** This measure refers to the way the supply chain should be integrated. Learning from best practices in the automotive or aviation industries, strategic suppliers can play a much bigger role in capital projects, by driving technological innovations in their field or participating in leasing, pay-per-use models or otherwise participating in the operation and maintenance of the assets. Flattening the supply chain means eliminating the intermediate levels and reducing transaction costs. Standardization and modularization are success drivers to streamline the interface to the supply chain, both towards strategic suppliers of complex modules and towards standard supplies that can be procured off-the-shelf with a high degree of automation.

**Flexible organization.** This measure refers to the way we can integrate internal and external resources to create an organization that is scalable and flexible enough to adapt to the cyclical changes in EPC business. The success driver is (again) standardization, this time standardization in processes and qualifications, to enable quick onboarding of external resources. HSE is an example of a highly standardized area, where owing to globally well-established standard processes the recruitment of external personnel or external service providers is common practice in the industry. The more global standardization is achieved in other fields such as engineering or construction management, the easier it will be to create an agile organization. Local specific standards or corporate specific standards are the barriers that must be overcome.

**Focus on core competences.** This measure refers to the way all parties along the value chain from engineering/procurement/construction to operation and maintenance should interact. The goal is that each party should contribute with the scope of work and the associated responsibilities and liabilities where the party is the most competent party in the project set-up. Risks should be managed by the most competent party, and risks should not be transferred to a party that will just add contingency money to their cost, instead of being able to define the appropriate mitigation actions to address the risks. Focus on core competences should encourage the parties to invest in the fields where they have the best know-how, in order to improve performance beyond average. The target is to be best in class. This will drive investments in technology; this will drive investments in professional project and construction execution, with the objective of achieving the quantum leap in performance that this industry requires.

### 5.3.3 The roof: The human factor

All ambitious transformation processes fail if one crucial factor is ignored: human behaviour. The introduction of new digital technologies, changes to organizations, to processes and methods, to the way we collaborate and interact will not work if the human resources are not supportive of these changes. This goes beyond standard training and education, the magnitude of change that we expect within the next years will require a cultural change, a change in behaviour that our human resources need to be prepared for. There may be standardized principles on addressing transformational change to organizations and their human capital, but finally every individual deserves an individual approach. There are people who are open to change and adapt easily, but there are also people who are afraid of change and do not adapt easily. Often, not always, those afraid of change are the older ones — and consequently the more experienced ones. We need to understand their fears, we need to address their reservations, and sometimes their reservations may prevent us taking wrong decisions. We need leaders who are able to listen; we need more time for personal interaction, more direct communication in a time where WhatsApp and email tend to replace the spoken word. Soft skills have never been so important than in our projects today. The behavioural skills of leaders as well as all members in a team determine the success or failure of a project.



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## 12 Implementation and the way forward

It has been made clear throughout the report that only significant changes will put the EPC business back on track. This report contains a multitude of recommendations, which should be discussed in detail and implemented based on agreed-upon roadmaps or action plans. Depending on the level of involvement in EPC business, the focus could be different. We recommend following the eight accelerators described by John P. Kotter [Kotter, 2014] for implementing improvements:

- Create sense of urgency
- Build a guiding coalition
- Form strategic vision and initiatives
- Enlist a volunteer army
- Enable action by removing barriers
- Generate short-term wins
- Sustain acceleration
- Institute changes

The improvement activities should be managed like an agile project and accompanied by sound change management. People need to understand the urgency and the purpose of the activities; they should be involved as much as possible in order to accept the changes and apply them in their daily work. This may require coaching and training for a sustainment of the changes and finally, someone, who takes care of the application of new practices on a long-term basis.

### 12.1 Reduce CAPEX by up to 50%? – Overall savings, limitations, and conditions

This section is not aimed at proving the feasibility of saving up to 50% CAPEX. The savings potential is limited by the nature of the business case, market conditions, owner's structure, region of project execution and operation and many other factors that impact the cost breakdown of CAPEX. But this section invites investors, owners and contractors to explore the savings potential for their specific business cases if the measures described in this report are implemented successfully.

Below, we provide a random example of a CAPEX cost breakdown, with a 13% share of the owner's costs, and a 87% share of what in a LSTK set-up would be the EPC contractor's share. We are aware that some projects come with owner's costs as low as 10%, while in others the owner's costs make up a share up to 30%. Costs of engineering can vary in a range from as low as 5% to as high as 30%, depending on the degree of engineering re-use and depending on the location of the engineering team in a high- or low-salary region. The share of construction costs, specifically construction labour, may be significantly higher if the project is executed in a high-cost region, e.g. the US or Northern Europe. The share of equipment and (bulk) material costs depends on the technology of the plant. Consequently, the figures below are not representative for "EPC projects" in general, as they can illustrate one dedicated example only.

Cost element	Cost break-down before savings	Team integration	Productivity	Transaction costs	Schedule accel.	Total Savings	Cost break-down after savings
Owner							
Project management							
Construction & start-up management							
Engineering							
Equipment							
Bulk materials							
Construction labour							
Other construction costs (e.g. site logist.)							
Contingency							
Special costs (legal, travel, etc.)							

In the calculation above, the cost breakdown can be read as absolute figures, representing a project with a total budget of 100 million euros, or as a percentage. The individual savings are multiplied to determine the total saving, and it is important to understand that the levers in each saving category must be different and independent from each other. In this example, we have identified four major (and independent) levers to achieve savings: Team integration, productivity, transaction costs and schedule acceleration.

**Team integration:** The total number of personnel involved in the management, supervision and governance of the project, traditionally (more than) duplicated in parallel project organizations for the owner, for the EPC contractor, for the construction company and lower-tier subcontractors may be halved just by forming integrated teams based on contractual schemes supporting partnership.

**Productivity:** Exploiting the full potential of digitalization, such as BIM or automation in construction management, the reduction of claims and claims defense, the integration of suppliers and the early involvement of all parties may lead to a significant increase of the productivity of owner's management, project management and construction and start-up management up to 30%. Possible productivity gains in engineering, in the manufacture of equipment and in construction (labor productivity) in the range of up to 30% may be achieved through the reduction of waiting times, reduction of changes and a higher professionalism in coordination and supervision. It can be noted that these savings are still conservative if compared to the overall productivity gap between construction industry and other sectors of 30 to 80%.

**Transaction costs:** Reducing transaction costs (that according to CII may sum up to 40% of the project costs) is a significant lever. It must be noted that duplication of project organizations for governance (see 'team integration') or reduction of claims (see 'productivity') are also transactional costs, but not considered here. In the above example an additional reduction of up to 10% may be achieved by flattening the contracting pyramid, eliminating double mark-ups in equipment supply and in construction (management, labor, bulk material and site logistics). Another major factor is the reduction of (double) risk contingencies by a half across all levels of tier organizations from a total of up to 7 to 8% down to a range of 3 to 4%. Finally the category 'special costs' includes positions such as travelling, but to a significant share also legal costs (in some projects up to 10%!) or other costs that are associated with defending contractual positions which do not add value to the overall project. Ap-

plying the partnership approach in contracting may eliminate up to 80% of these 'special costs'.

**Schedule acceleration:** McKinsey [McKinsey, 2017-1] determined an average of 53% schedule overrun on megaprojects, and the executing contractors consider this experience to certain degree in their project schedules. While this report highlights the potential saving in terms of cost (CAPEX), the same levers (such as digitalization, collaboration, productivity gains, etc.) will also translate into shorter project execution times. A reduction of 20% in overall project duration and in construction duration, as considered in the above example, will directly reduce the time-dependent cost positions, e.g. owner's and project management, engineering, and construction costs (management, labour, site logistics).

The calculation above shall illustrate the potential impact of the different levers identified and described in this report to a sample cost breakdown. In this specific example, if we consider a CAPEX of 100 Mio EUR before savings, the aggregation of all potential savings will drive CAPEX down to 50 Mio EUR after savings, a reduction by 50%!

Overall, the saving potential in CAPEX may well be in the range of 30 – 50% of the planned costs, and this potential does not include the elimination of non-conformance costs, as these costs never enter a budget, but result in cost overspend. Just to recall: McKinsey [McKinsey, 2017-1] determined an average of 37% cost overspend on megaprojects. Finally, it must be mentioned that the recommendations given in this report, such as supplier integration, operations readiness or predictive maintenance, also help to drive OPEX down. Finally, the improvements in CAPEX and OPEX will result in a significant better financial model for the business case, leading to better financing conditions, higher margins and finally an attractiveness for investors that can compete with other industries.

*It should not be forgotten that part of the story of 'collaboration by partnership' is sharing the success. Higher margins belong to all parties: The owner as well as the contractors and suppliers.*

## 12.2 Investors and operators: Take the lead!

This report has cited prominent speakers who have set the target of reducing CAPEX by up to 50%. Such an enormous CAPEX reduction only works if systematically applied along the entire value chain, from the investor and operator to the EPC contractor down to the supply network – one party alone will not make this change. This very ambitious target is not achievable without the investors and operators selecting the right set-up for their capital project from the very beginning. The business model that we have described in this report is built on partnership and collaboration, in the contractual sense as well as in a change of behaviour. It is the investor and operator who decides on the scheme – and sets the tone – from the very beginning. Instead of investing time and money in working out detailed enquiry specifications for a lump-sum contract on his own before getting potential contractors involved, the investor should get potential partners (and we call them partners rather than contractors) on board at the earliest possible stage. That means that the selection process follows different criteria. Not the price is the most determining factor, but other parameters that should lead the evaluation. The capabilities and references of contractors can be judged based on a defined set of weighted criteria, but most important of all is: trust. Is the potential EPC partner willing to share the same behavioural values that are the foundation of successful collaboration? Obviously, it is much easier to answer this question on the back of a successful project, starting a new relationship is much more difficult. But this is about building strategic partnerships; these relations go beyond the horizon of a single project.

There is a lot of learning available from alliance or partnering contracts that have gone wrong in the past two decades, primarily in the public infrastructure sector. Today, with all these experiences, good concepts are available on how to approach such collaborative models more effectively. As different as investors'/owners' structures are, as different as projects are, as different the overall concept will be, there is no one single solution that fits all. But whatever the individual situation is: The investor/owner/operator is the lead and defines the direction.

## 12.3 Contractors: Get prepared!

What if the investor is taking the lead in a collaborative approach, but they don't find any contractor capable of understanding this role model? In a world where EPC LSTK has been the standard contract for decades, EPC companies are not yet ready to switch to a different behaviour. Contractors need to get prepared, and we know of companies that were surprised by clients enquiring about 'integrated project delivery' – what the hell is that? Expect a client asking to share data in a building information model – are you ready to live with the transparency that such a BIM creates? Getting prepared for these situations is a culture revolution for many traditional companies, something that does not happen overnight, and something that requires the guidance of organizational and behavioural transformation management.

An EPC contractor is in a sandwich position. On the one hand, contractors are being made accountable for the delivery of the EPC solution in time, in budget and to set specifications. On the other hand, contractors are also responsible for engaging the supply chain and making them deliver products and services in time, in budget and according to specifications. However, this provides the contractor with a huge influence on both, the investors and operators as well as the supply chain. It is the contractor who should set the scene for the new approach in delivering EPC projects.

During the early project phases, the EPC contract should provide information to the investor or the operator about alternative solutions as well as combinations with advantages and disadvantages for setting the project in scene. In addition, contractors should identify and evaluate the best option for engaging the partners in the supply chain following our recommendation in this report and other studies mentioned.

Our recommendations also point to the fact that the contractor should carefully analyse his own organizational structure, processes and culture whether they fit in with the needs of EPC business. Project-friendly and supportive structures, processes and cultures are a key success factor for EPC projects, otherwise the organization ends up in conflicts and crisis or at least inefficiency.

Last but not least comes digitalization as the foundation that our model is built on. EPC companies need to invest in their digital capabilities, increase productivity, decrease non-conformance costs. Competition in the era of Industry 4.0 will be decided on who is the frontrunner in effectively capitalizing on the opportunities of digitalization.

## 12.4 Supply chain: Get involved!

Suppliers involved in EPC projects may have less influence in the project set-up, nevertheless they can improve the performance by applying the recommendations of this report. Like the contractors, they may improve their own organizational structure, processes and culture to better fit the needs of EPC business. In general, they should build on project-friendly and supportive structures, processes and cultures, reaching out to the structures, processes and culture of the contractor and operator as well as other suppliers. Suppliers should be pro-active, strongly influencing the project set-up and the decision-making of the operator and the EPC contractor. It's all about building trustworthy relations based on transparency and commitment to the performance targets agreed. And these relations go beyond the horizon of the capital project; there is enormous potential for suppliers to move into operation and maintenance. Suppliers no longer only serve the EPC contractor; they serve the operator and thus build a much stronger base for their future business. In the network of relational contracting, the operator may decide on the supplier based on operational experience, not the EPC contractor based on price.

The suppliers are in a key position to utilize digitalization for EPC business, organize in a flexible way as well as focus on core competences and the human factor. There is room for improvement and suppliers should lever the potential in productivity to be attractive for investors, operators and the contractor of an EPC project. It should not be the contractor only telling suppliers what to do, they should be proactive themselves and offer innovative solutions to become increasingly competitive. Other industries have already chosen contractors with a high-performance network of suppliers, because they believe that those companies will be able to deliver what is expected and excel in what they are doing. For example, in the automotive industry, the most competitive supply chain will always be ahead of the crowd and win the race.

However, this is not a one-off improvement activity, rather a continuous process of reinventing one's own business and company, utilizing lessons learned from all previous projects and making them immediately available to the ongoing projects. Organizational learning, providing time as well as resources for innovation and investments are necessary for suppliers to catch up in global EPC competition.





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**Innovation Project „EPC 4.0“ is a joint study of ProjectTeam®, Tiba, maexpartners, M8International and digital AGENDA.**

In May 2018, a German think-tank kicked off an innovation project to develop practical guidelines for EPC companies as well as for investors, owners and operators on how to approach innovative business models for industrial projects and operations, from E-P-C to O&M. Initiators of this project include leading consultants of the EPC, automotive and aviation industries to enable learning from across boundaries.

We invite experts to share their opinions and provide feedback on our concepts and findings or to provide insights into innovative practices.

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