

TORBEN BIILMANN

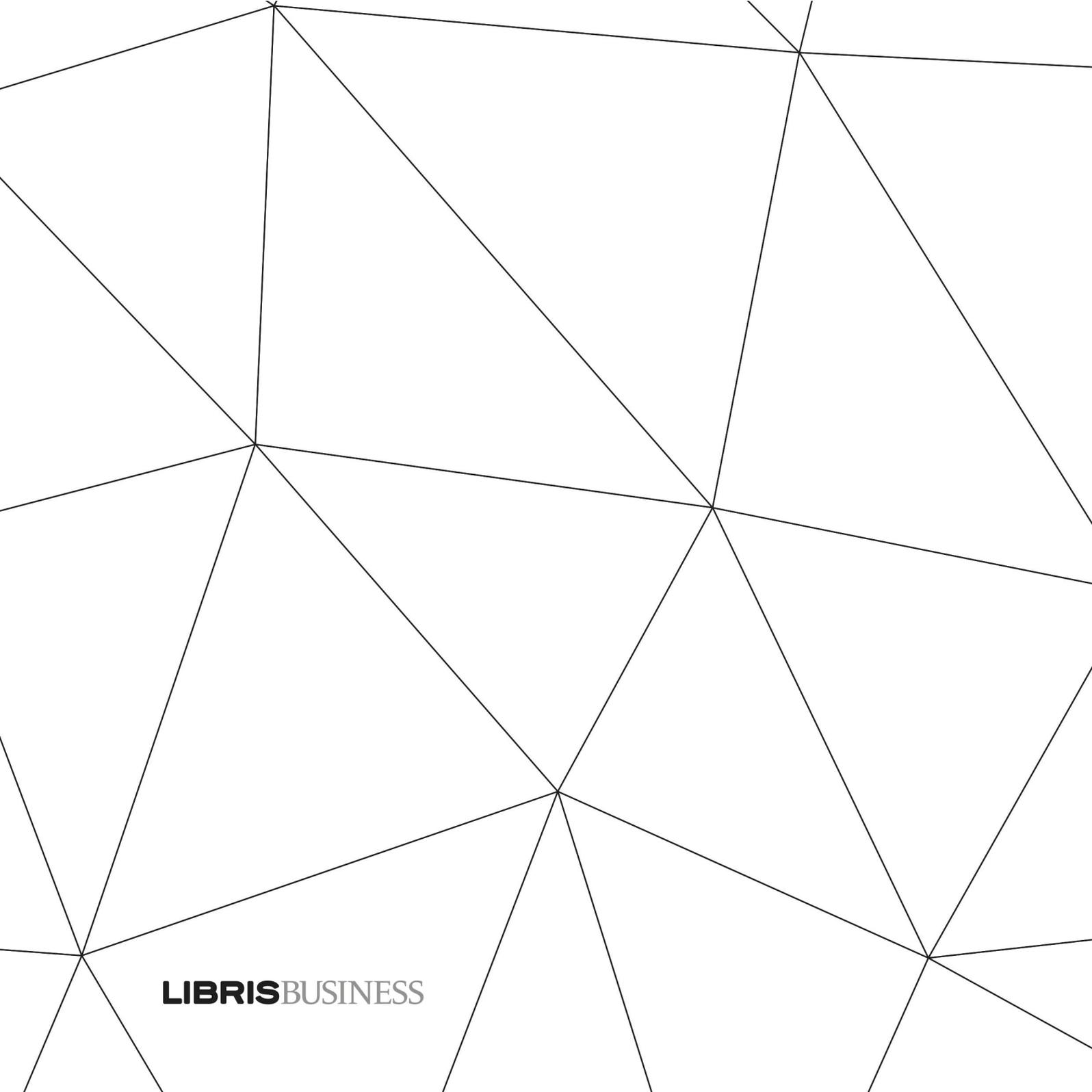
---

# BUILDING THE FUTURE TODAY

---

– a vision for new productivity

**LIBRIS**BUSINESS



**LIBRIS**BUSINESS



## **Building the future today**

1. edition, 1. issue 2015

Copyright © Libris Digital A/S and the author, 2015

Carl Jacobsens Vej 16

2500 Valby

[www.libris.dk](http://www.libris.dk)

Author: Torben Büllmann

Editor: Mette Bove-Nielsen

Back cover photo: Lizette Kabré

Cover: Per Ole Lind

Graphic layout: PubliShare ApS

ISBN: 978-87-7853-648-8

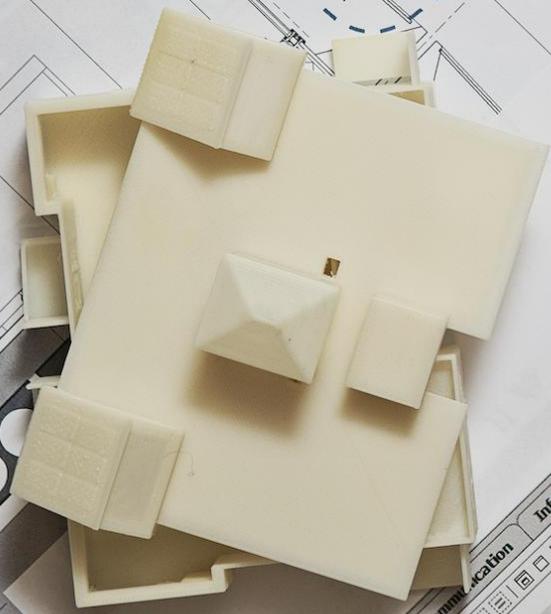
# CONTENTS

<b>1: PREFACE</b> .....	<b>7</b>
<b>2: AN INCIPIENT REVOLUTION IN THE CONSTRUCTION INDUSTRY</b> .....	<b>15</b>
<b>3: WILL THE CONSTRUCTION INDUSTRY BE HIT BY DRAMATIC CHANGE?</b> .....	<b>27</b>
<b>4: VIRTUAL DESIGN &amp; CONSTRUCTION</b> .....	<b>38</b>
<b>5: NEED FOR GREATER COHESION AND COLLABORATION</b> .....	<b>50</b>
<b>6: CHANGE REQUIRES LEADERSHIP</b> .....	<b>63</b>
<b>7: EPILOGUE</b> .....	<b>72</b>
<b>8: ABOUT THE AUTHOR</b> .....	<b>76</b>

Udvendigt glaslag -  
lamineret glas

Naturligt ventileret  
hulrum

Spalte til ventilation



File Model Checking Communication Information Takeoff +

Model Tree

K.12.V.N.9.KO.US.0001

K.05.B.N.9.KO.XX.0002

K.12.V.N.9.KO.XX.0001

K.05.B.N.9.KO.XX.0001

3D

# PREFACE

## FROM SILO TO COLLABORATION

With technology as the pivotal point, several industries have been affected by dramatic changes. Traditional value chains have been challenged, products and types of jobs have disappeared entirely and even illustrious enterprises like Nokia and Kodak have seen their business models fail because they did not succeed in adapting to the new reality in time. They were hit by what Harvard Professor Clayton Christensen was the first to call “disruptive innovation”.

Now time has come to the construction industry. And about time, too. The improvement potential is huge, and technologically, we are ready. If we are willing to break away from conventional industry practice, we can offer customers a wider range of options and more value for money, while at the same time increasing industry profitability and reducing the industry players’ exposure to risks and conflicts.

### **Goodbye to a trade – and welcome to a collaborative industry**

The construction industry is known for low productivity. It is an industry characterised by mistrust where budget overruns, delays and defects have been taken for granted. At the same time, it is an industry divided into silos with a fragmented value chain where suppliers, architects, consultants, contractors and other players operate in relatively autonomous environments and engage in large-scale suboptimisations – to optimise their own profits in a notoriously small-margin industry.

I envisage a break away from these silos. With technology as the pivotal point, the Chinese walls between the players will be broken down to provide a new division of roles adding more value to and involving the customer.

Instead of talking about a construction industry divided into silos, which in the conventional way of thinking consists of architects, consulting engineers and contractors, I wish to talk about a collaborative construction industry which also includes suppliers and professional customers. By regarding the parties as a united whole working together towards a common goal, we can make quantum leaps towards productivity improvement.

It requires an effort from all parties involved, and we need to break free of conventional thinking and demolish decades of traditions to build up new productive structures in the construction industry. With a professional market totalling DKK 175 billion each year in Denmark, the potential of making the industry more productive is huge. An improvement will benefit all parties and have a positive impact on our competitiveness and on our general welfare.

### **The first steps**

In all the industries which have undergone dramatic change and have seen substantial productivity improvements in recent years, technology has played an important role. In our industry, technology is also one of the prerequisites for creating the necessary changes.

But change is not brought about by technology alone. Technology is worthless if we do not possess the skills and expertise to understand it and the processes to use it. Change is brought about by people, and if we are to change the construction industry from within, we must be prepared to change ourselves. Therefore, this book is not only about the new technological opportunities within building and civil engineering. It is also about new ways of collaborating, about leadership and about changing the entire mind-

## PREFACE

set which has kept the industry in low productivity for decades.

To transition from low to high productivity, it is essential that we identify the factors that make the industry low productive and agree to do something about them. The barriers to setting up business in the construction industry are few and small. A low-productivity environment with players with little skills and expertise has limited potential for development. But today, the professional construction industry consists of well-educated people with well-developed skills and expertise. They just need to be brought into play.

The industry players have each developed and regularly increased their capabilities over the past decades, but we have not succeeded in converting this progress into a high-productivity environment. In isolated terms, many Danish players perform well internationally. Suppliers such as Velux, Grundfos and Dan-

foss are global players, Danish architects are renowned internationally, our firms of consulting engineers are at the forefront of the global market, and when it comes to facility management, we have ISS as one of the top players internationally.

So when the construction industry is still suffering from low productivity, I see it as a sign of our failure to exploit the common potential. If we succeed in changing the industry's common mindset, we can exploit our many different capabilities to create optimal processes and financially, socio-economically and environmentally sustainable solutions to the benefit of the customers, the industry and society as a whole, thus ensuring that we transition from low to high productivity.

The silos between the different parts of the construction industry greatly contribute to maintaining a low-productivity environment. Part of this book is dedicated to explaining how we can develop a

new joint approach to projects which is firmly rooted in technology. When we break down the boundaries between the different disciplines, we will bring the relevant knowledge into play at the right time. For example, we should not bring in the lift manufacturer only when the design of the entire house is finished, and we just want the lowest bid. He must be invited to the table when we plan the best solution for the customer, because his experts know more than architects and contractors about how to create the right flow of people in high-rise buildings and can share his unique knowledge to better match the customer's needs. If we continue to label each other in the industry as "those who deliver components," "those who design," "those who calculate," and "those who build," we will continue to suffer from low productivity many years into the future.

### **Asking the right questions**

The customers play an important role in changing the collaborative culture in the construction industry as often the customer and his adviser will set the framework for the individual construction projects. The customers must demand better and more value-adding solutions, and they must demand a process that requires all project partners to work together in an effort to optimise the overall solution – and to document it.

In my opinion, the easiest way to show customers the added value that is available is to use technology. Using tools such as Virtual Design & Construction (VDC), we extend the options available to the customer, and the price to quality ratio become far more transparent.

We, the players in the construction industry, must therefore help each other and the customers ask the right questions

## PREFACE

before they start on a building or civil engineering project. It requires a break from competitive tendering as I believe that the existing competitive tendering culture promotes a division into siloes and a practice of suboptimisation which simply maintains the low level of productivity and gives the customers more expensive and poorer projects. We must therefore be better at showing the value which is generated when players from across the entire industry work together from initial concept to deliver the best solution to the customer.

Increased collaboration may also help us not to regard every single project as unique. Far too much time and effort are being spent by the industry trying to develop unique solutions in areas where tried and tested solutions already exist.

With a number of tried and tested standard solutions and repetitions, we can increase quality and efficiency. We can

manufacture several part elements at our factories across the industry and thereby ensure ongoing product development because we do not need to invent new ways to do things for each individual project. This does not mean that we will have to revert to the boring modular buildings of the 1970s, and it certainly does not mean that we will have to curb the creativity of the architects and the engineers. On the contrary.

With an increased use of technology and standard solutions, architects and engineers will have time to concentrate on more value-adding exercises. Instead of spending their time on trivial details or extensive calculations, they can divert their energy to the areas most in need of creativity and to adding value to customers, users and society in general. Most of us probably know that it is difficult to be creative if you have to repeat the same exercise 100 times in one day. If archi-

pects no longer have to waste energy on details that other players in the industry know more about and which are moreover invisible to the naked eye, they will have time and energy to innovate, e.g. coming up with ideas such as ski slopes down the sides of a waste incineration plant, and generally take the next steps into the new international golden age that the Danish architectural industry is part of these years.

### **Change of culture required**

Changing the way an entire industry collaborates requires a major change of culture. The only way to succeed is to have a strong management focus where the employees who are to implement the changes in practice are shown the way and the necessary trust and see the rewards of their efforts. I have heard managers say that they would very much like

to test new methods for inviting tenders, but when the job reaches the employees, the existing culture and practices imply that the employees simply carry on as usual because it is the safe and well-known procedure when things are busy at work. The reason may be that the employees lack the experience to ask for new collaborative ways of working or that the employee thinks that if I do things the way I usually do, then I run no risks. Therefore, this book is just as much a call-out to leaders, both in the construction industry and at public and private decision-makers because this is where the Danish competitive tendering culture is defined. And this is where the framework for construction and thus the potential for productivity improvements are defined.

If we are not up to the job and fail to improve productivity in the Danish construction industry, we can be sure to see new players from abroad enter the mar-

## PREFACE

ket and create dramatic change – helped along by international investors who will demand standardised and efficient solutions at reasonable prices. I would rather see us create this change from within, building our strong experience, culture and the good values developed over many years.

If you as customer would like to have greater realisability and freedom of choice in your building and civil engineering projects and better value for money, I hope that you will read this book and consider my thoughts.

The change will require a break away from tradition and a focused effort by all parties. The journey has begun, and we are already seeing the first results. Now we can manage the process and gain momentum so that we can enhance productivity in the Danish construction industry and ensure that we will maintain our competitive edge on the international scene, also in the 21st century.

*Torben Büilmann*  
*Søborg, September 2015*



## CHAPTER 1

# AN INCIPIENT REVOLUTION IN THE CONSTRUCTION INDUSTRY

A revolution is underway in the construction industry. It has the potential of creating substantial improvements in our buildings and infrastructure and in the way we work together. But it is a revolution which is invisible in many ways because it is driven by digitisation, data, new technologies, new collaborative and knowledge-sharing practices and new production methods.

The revolution is also invisible to most people because industry players do little to support it. But if we seize the opportunity, we have the prospect of realising an unparalleled productivity within the Danish construction sector. The result will benefit society through the buildings and civil engineering works we create and through the socio-economic gains we achieve by increasing productivity in an industry which has a significant impact on employment rates and the profitability of society's investments. Here it is important

to add that buildings and civil engineering works are Denmark's most important assets, representing more than 80 per cent of the real capital in Denmark according to the Knowledge Centre for Housing Economics. If we do not seize this opportunity, we risk losing a historic chance to generate growth and productivity in the Danish construction sector and to be overtaken by international players and other industries.

As in all other industries, technology is becoming increasingly central to the construction industry, both in product and in processes. When we build schools, hospitals and corporate headquarters today, we incorporate technology that keeps an eye on energy consumption and automatically adjusts it to the environment. We are increasingly able to ensure that lighting, heating and ventilation are automatically adjusted to how many people are in the room, which means, for example, that the

ventilation system will change the air flow in the filled conference room and thereby reduce the CO<sub>2</sub> level, thus enabling workshop participants to better concentrate.

In the USA I have seen how people use sensors and smartphone- and Internet-based devices to make their homes more intelligent and to communicate with the home while they are away. With these products, we approach a future where technology provides for a house that adapts to our needs as the day and the year progress and where for example energy supply, cleaning and switching alarm systems on and off no longer require our attention. The latter is already more or less in widespread use in Denmark.

The exciting aspect of this development is that we will increasingly see technology as an integral part of our buildings and our civil engineering works. Build-

ings with advanced IT systems incorporated for operation, maintenance and monitoring purposes bring about significant savings on operation and maintenance costs and give us a far better understanding of the overall economy. An example from the USA is the Weber State University, which was one of the first buildings in 2013 to have the new operative system for buildings, BuildingOS from the Lucid Design Group. The system makes it easy for both users and maintenance managers to monitor energy consumption in buildings, using their smartphones, tablets or big-screen monitors. By streamlining and visualising consumption data, it has become possible for the University to save 33% each year on energy consumption. BuildingOS is far from the only participant in the race to deliver operative systems for buildings. For years, Microsoft has been working on a similar product and, in recent years, both Google

and Apple have invested massively in this area. They all have the ambition to own the central nervous system in the intelligent buildings of the future.

Technology also opens up new possibilities for the infrastructure. We are already seeing smart motorways which monitor traffic flow and re-route traffic to provide more lanes in the direction with the heaviest traffic. With lane management, the use of the lanes changes through the day, and it also saves the construction of new lanes.

Technology is already a reality for an increasing number of homeowners and property managers worldwide. Data and intelligent systems are moving into our buildings and roads at full speed, and it is changing the way we interact with our buildings.

It creates value by generating savings and making better use of buildings and civil engineering works. Our buildings

become smarter and more intelligent in the same way as our cell phones and our cars. For many years our cars have been equipped with an operative system which automobile repair shops have used for trouble-shooting and optimisation. But the operative system has been for mechanics only. In recent years, the operative system now features more prominently in many cars. My car now has a touch screen that allows me to interact with it, and with automatic braking/collision avoidance and lane-keeping assist, we are approaching the era of self-driving cars.

Car manufacturers no longer produce cars with chips, but chips with wheels. Many new cars have far more than 50 microprocessors that make the car safer, more efficient and more entertaining. The moment the car manufacturers decide to move into the software area, they will suddenly clinch with the large software companies such as Google and Apple which

are now also experimenting with self-driving cars.

As the car manufacturers are in the process of transitioning to production of technology on wheels, we in the construction industry must get ready for a future where technology will play a far greater role in how we design and build our products. Clients – and society – will become aware of the benefits that technology offers. And the day when technology becomes the decisive parameter when selecting a building or civil engineering project, the construction industry must be prepared to be challenged by new and so far unknown players, just like in the music, telecommunications, hotel, taxi and other industries.

### **A foundation of data**

Data will be an increasingly important factor in the building and civil engineer-

ing sector. In the products, the use of data plays an increasingly important role, which is illustrated by a report published by the former Ministry of Housing, Urban and Rural Affairs in Denmark, showing that 50% of Denmark's local authorities are currently working with Smart City activities, and the majority of them expects to expand these activities in the years to come. It is a sign that urban planners and public clients are already focusing on the role to be played by technology in the building and civil engineering projects of the future.

Smart Cities offer the potential to create better and cleaner energy supply and more flexible and cleaner transportation systems in our cities. The potential can be fulfilled in step with an increasing part of our possessions being connected to the Internet and exchanging information. When everything from street lamps and bicycles to the dog's collar is connected

digitally, we will have entirely new ways to interact with the city, digitally, socially and physically, and we can better calculate the best transport routes, decide the location of buildings and stations, link traffic lights and create entirely new forms of transportation and much more. The local authority of Albertslund is currently involved in an experiment with intelligent street lighting so we are not that far away from some of this potential leaving its imprint on our everyday life.

For the construction industry, there are two important points to take from this observation. Firstly, we must do already today what we can to enable our building and civil engineering projects to produce the necessary data. For example in the form of data on energy consumption in buildings, the number of people using lifts at various times and the number of vehicles on roads and bridges – which we can already do today. This again means

that we need to incorporate intelligent systems into our projects already in the planning phase.

The other point is that we need to build up the skills and expertise to interpret the data so that we can improve our projects based on the specific knowledge provided by the data. We are not only to carry on as usual, but to exploit the new technological opportunities to be at the leading edge.

When we are able to collect and process these data volumes, we will learn a lot about how we may come up with an even better framework for our everyday life. This means that the foundation of the construction industry will no longer be made of concrete, but of data. Intelligent buildings and roads are developed and made on the basis of data, and as opposed to concrete, data is a substance under constant change. It makes great demands on us in the construction industry to adapt

to this reality. Data is a new currency that we can use to secure dramatically higher project profitability. That is the key to delivering better buildings to the client and society in general and to ensure smooth projects with better collaboration between the players.

### **The digitised building process**

Data will also play a greater role in the execution of building and infrastructure projects because the processes will become increasingly digitised and automated. Machines have more or less replaced pure muscle power, and even though excavators still need human operators, they are now assisted by GPS for better, quicker and more accurate excavation.

In the design phase, architects long ago replaced pen and ruler with advanced digital design tools. Contractors use complex digital solutions to simulate, visualise

and calculate project execution from start to finish, incorporating both time and cost. And where collaboration is at its best and matches the model advocated by me, clients, operation and maintenance organisations, contractors, engineers, architects and suppliers work together to model and optimise the operation and maintenance of the buildings over a 30-year period. This is the reality of several of the PPP projects we are currently working on.

So even today, we are very dependent on data. But the potential is greater if we become better at understanding, sharing and using data back and forth between industry players and processes. We must be prepared to consider loss of data or failure to use data in the construction process as a waste of resources which could have been used on welfare. We cannot build the future without a strong foundation of data.

**Our ambition is to integrate the digital construction process in all parts of our construction projects. As a public client, we would like to lead the way.**

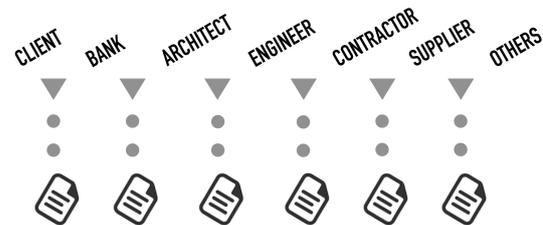
Gyrithe Saltorp, director of the Danish building and property agency

In the near future, the contractor will deliver a "smart building" or a "smart bridge" to the client on project completion. These structures will be intelligent and produce minute-by-minute data – data which makes life easier for those building or living in the building and increases investor profitability.

Historically, the construction industry has been driven by craftsmanship. But it is now increasingly being driven by technology and data. This development is gaining momentum these years and will change the industry forever.

### You can count on technology

Computers are everywhere in construction projects. When the project is formed as an idea in the customer's head, the process begins on the computer. When a customer has decided to launch a project, it is often kicked off by the architect's or the engineer's first digital lines on a computer screen. But data, documents and knowledge are lost with each hand-over from one party to the next in the process. So far, the industry has lived with and from this loss of knowledge and the resultant suboptimisation.

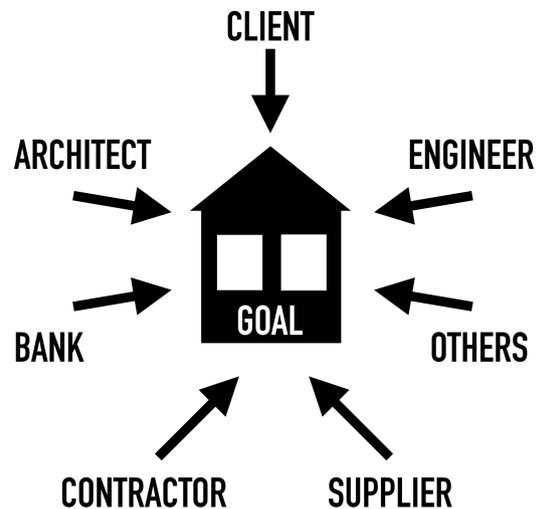


*Loss of knowledge and suboptimisation*

But it does not have to be like this. The construction industry must come up with an entirely new collaborative framework in order to prevent loss of data in the traditional hand-over processes. If everybody joins in in time, all systems throughout the process can in fact talk to each other. With the right forms of collaboration and the right structure, the knowledge of the supplier, the operation and maintenance organisation and the engineer can be incorporated from the outset, and changes made by the architects can be traced directly to the contractor's simulation and vice versa. If we do it right, we can identify the right solutions swiftly and simply and deliver unique results to our customers and society in general, while at the same time improving our competitive edge internationally.

In the industry, we must embrace technology and we must use technology as a

pivotal point to new ways of collaborating so that we are the ones who use technology to create disruptive innovation in the industry – and not outside players. Consequently, we must build a new value structure and be at the leading edge of technology.



*A new value structure. Many parties – one goal*

The new value structure must ensure that we all work together to optimise the overall project – instead of suboptimising – and that all parties take ownership and deal with the risks they are to deal with.

If such a value structure is to work, it is necessary to have the right IT structure and the right processes to support it. Therefore, we must be at the leading edge of technology to have the best possible view of what the world will look like in the years to come. It is not necessarily as difficult as it may sound because technology and technological phenomena are in fact quite predictable because historically, they follow some fixed regularities. For example, it is possible to predict relatively accurately developments in processor speed, broadband speed and network value. For example, network broadband speed triples every twelve months. This knowledge is said to form the basis of estimates as to when high-quality video

and TV streaming would be possible, which enabled companies like YouTube and Netflix to plan their services and time them to the market before the technology was really in place. A classic example of how the value of a network increases is the fax machine which was worthless in a system with only one user, but where the value increases with the number of other users. While the traditional economy typically experiences a declining yield rate, technologies subject to this regularity experience increasing yield rates, the greater the number of users of the system. Within the construction industry, I am convinced that we will also see an increase in value as the number of players connecting in new networks and sharing data and knowledge increases.

**It is important to us that we focus on the project together with our collaborative partners and become efficient together. It requires that we can trust each other and learn from each other throughout the project.**

**Christian Poulsen – CFO at Copenhagen Airports**

These three regularities are a kind of digital laws of nature which have for decades been just as predictable as gravity. There is no mystery or magic involved - only mathematics and technological logic. To the construction industry, technical science, logic and mathematics are essential, and we can use this knowledge and these regularities to simulate construction projects in many dimensions, and we can use it to predict the future.

I believe that the near future will bring a revolution in the construction industry. We will be hit by dramatic change. The

difference in impact on individual players will depend on whether they passively await the effects of change or exploit the opportunities brought along by change.

## POINTS

- The construction industry will be hit by a technological revolution that will affect both products and processes.
- Full exploitation of the opportunities offered by the technological revolution requires new forms of collaboration.
- New technology gives us a historic chance of creating growth and productivity in the Danish construction sector.



## CHAPTER 2

# WILL THE CONSTRUCTION INDUSTRY BE HIT BY DRAMATIC CHANGE?

In 1853, Elisha Otis invented the world's first safe lift in the USA, thereby acting as a catalyst for a revolution in the construction industry. Now it suddenly made sense to build very high buildings that people wanted to live and work in. The result of the new technology invented by Otis was a radical change of the way houses were built, a dramatic change in the value of sites, new production materials, new suppliers, urban planning, economy and new business models.

The lift is an early example of a disruptive technology, dramatically changing our working practices in construction projects and the way we think buildings.

In the past decade, disruption has truly been on the corporate agenda worldwide. The technological development challenges and changes and it creates new threats and opportunities. The develop-

ment accelerates, in particular digital and technological advances.

Digitisation has become a competitive parameter and a new reality. It has closed down whole industries and strong brands which did not grasp the significance of digitisation, and it has spawned new enterprises which have grown at incredible speed. The physical reality faces competition from the virtual reality. Technological developments and the virtual reality affect all industries, and many industries have been hit by dramatic changes.

Ten years ago, no one in the telecommunications industry could have predicted that the world's strongest telephone manufacturer, Nokia, would more or less disintegrate because the alternative computer manufacturer, Apple, entered the market and had eight years later sold one billion telephones and claimed Nokia's spot as market leader. And who would have thought that in only seven

years, a hobby project called Airbnb would grow into a virtual hotel chain with a higher number of bed days and a greater market value than the international hotel chain Hilton - and without owning even a single building?

### **Disruption gaining momentum**

Disruption often starts small. With small technological advances that do not look much, but suddenly become dramatic. A development that seemed linear is perhaps really exponential. And there is a world of difference between linear and exponential development. If you take 30 linear steps, you end up about 30 meters from where you are now. But 30 exponential steps correspond to 26 times around the world. It is quite incredible. But the truth is that many technological phenomena develop exponentially. For example, the amount of “horse power” in

computers has doubled every 18 months over the past 50 years, and the development seems to continue for at least another 10-15 years. This means that computer processing power makes it still easier to implement software that underpins the new value structure and makes the industry capable of simulating construction projects in virtual reality before they are built in reality.

Common to all trades and industries affected by disruption is that customers become more powerful. The value chain will be challenged, and the parts that are not of immediate value to customers will be cut out. A result of digitisation is that a large number of traditional gate keepers have lost if not their entire footing, then at the very least a sizeable part of it. Newspapers and television are no longer channels that enterprises or politicians need to get their messages out to the consumers, musicians no longer need record compan-

ies to distribute their products, and can anyone even remember that not too many years ago you had to contact a travel agency to buy a flight ticket? In this context, it is worth noting that the three industries are not extinct. The players fought to adapt to the new reality, and the best have established successful niches.

### **From 2.7 to 2,700 options**

The question is not whether the construction industry will also be hit by disruptive innovation, but when. And only one thing is certain. In future, the customers will demand much more influence on the end product than they have today.

Traditionally, customers have surprisingly little say over the final design of a building or civil engineering project. When the architect or the engineer has presented his visions to the customer, very few details will be changed. The cus-

tomers will generally fine-tune only some minor things and will then feel that she leaves a decisive mark on the final product. Studies show that on average, we consider only 2.7 options before making a decision in a construction project. With the digital tools available today, however, we can easily multiply that number by a thousand. When we feed the computer with all data available on variables such as earth stratum, ground water and statistical weather conditions and ask it to suggest the best location of the building on the site, it will consider all alternatives and present the best options based on the input given. Maybe we will still only consider 2.7 options, but we will make our choice on a far more qualified basis. We can of course make similar calculations on all areas where we have the data in any building or civil engineering project.

With the software and the computer processing power available today, we can

also build the project in virtual reality before building it in reality. To customers, it has the great advantage of giving them far more influence on the end product. Traditionally, changes are difficult already early in the process, but with digital tools, it is easy to simulate how the changes will affect appearance, price and time schedule. In a construction project, the advantages are immediate because the customer can see the significance of factors such as balconies, extra floors, a change of roof slope or an alternative location on the site to aesthetics, view from windows and other details that decide the market or rental value of the building.

But also in civil engineering projects, there are a number of ways to increase the value of using computer simulation of projects. For example, a bridge across a motorway can be built in many different ways, and the simulation can show whether steel or concrete is the optimal

solution, the significance of the various choices to the time schedule, the costs of future maintenance, traffic flow during construction and health and safety issues just to mention a few examples.

**Contemporary is also digital. Therefore, we work in "Living labs", testing the solutions we intend to use. and when we are sure, we roll them out.**

Niels Carsten Bluhme – director in the local authority of Albertslund

The digital tools will give the customer the freedom to ask whether there are other and better alternatives to the products initially suggested by the architect, the engineer or the contractor. Initially, it may be an exaggeration to call this "disruption" within the construction industry. But it is certain that once the customer is comfortable being in control and is used to the number of options available, it will

be possible to break away from the fixed roles in the traditional value chain in a building or civil engineering process. The customers will go to those who add value to their project, and they will increasingly expect the project partners to work together to fulfil their needs. If they do not find that in one "value chain", they will quickly look elsewhere to find another value structure (see above) capable of delivering. That this is the case can already be seen in Denmark where several major customers, who can probably be seen as *first movers*, have asked us to establish such a structure as the basis of the project design and execution.

### **The winners are in the construction industry of the future**

I believe that the construction industry must prepare itself for disruptive innovation in two tracks. And the winners of the

future will be those who succeed in getting the two tracks to meet.

The first track is the customer-focused track. As already discussed, trades or industries will be hit by dramatic change when customers can have a better product or a better service in an easier way. More and better options through Virtual Design and Construction (VDC), as elaborated in further detail in the next chapter, is a major step in the right direction. In the construction industry, we must all, including professional customers and urban planners, use our common knowledge about matters such as developments within sustainability, life, payback period and the rate of technological development to implement the building and civil engineering projects of the future.

When we erect buildings today, we expect them to have a life of 100 years and an economic payback period of 30 to 50 years. Therefore, we must make an

effort to predict changes in living patterns and design our buildings, cities and infrastructure works so as to make them adaptable to a new reality.

Imagine if our cars really become self-driving in ten or twenty years. In large cities there is often a requirement for a specific number of parking spaces to be established when new properties are being built. This means that a great many expensive multi-storey and underground car parks will be built over the next decade. But what if we will have far fewer cars in the future or the cars drive to a car park outside the city themselves and then pick up us later when we use our phones to inform the car that we are ready to go home? In that scenario, a lot of expensive and attractive square metres will be left unused unless we consider already now how to make them flexible and adaptable to other functions in future at an affordable price.

Another good example is energy supply. Not too many years ago, it was necessary to stock large amounts of coke, wood pellets or oil in tanks at your home. Since the 1980s gas furnaces and district heating have been the predominant heat sources, but district heating may soon be affected by the growing opposition to burning large volumes of waste for recirculation or conversion to gas. It will probably not take many years before wind turbines and solar cells can produce cheaper energy than the traditional sources of energy, and then we will find ourselves in a situation where electricity, which we used to do all we could to avoid using for heating purposes, is now the predominant heating source. A building not prepared for having its energy supply converted to accommodate alternative sources of energy may prove to be a poor investment.

Customers and investors must be presented with options for how to carry

out building and infrastructure works so as to make them convertible to the scenarios we can predict with our technological insight.

The other track is about the way we carry out the projects in the construction industry. Also here technology intervenes in our daily processes. Pre-fabricated buildings have already proven their worth to many clients, in terms of time, convenience, cost and sustainability. This applies, among other things, to the renovation of façades where panels are prefabricated in a factory complete with windows, sockets and wood fillets, which enables the builders to renew a façade on a flat in a few hours and consequently only inconvenience the residents very little. When we combine the industrial approach with modern technology, the perspectives are huge.

In March 2014, a giant 3D printer from WinSun rolled into a construction

site in China and began printing. 24 hours later the printer had finished and printed ten houses, while a couple of the company's workers had installed windows and doors. The price per unit was USD 5,000. The printer, which is the result of twelve years of technological development, uses a mixture of concrete, recycled construction waste and fibre glass, which makes the price per cubic metre of material even cheaper than concrete. The houses are simple, with raw concrete walls, but they are said to comply with the building regulations in force.

I do not imagine that 3D printers will be building whole buildings or bridges of a quality that will meet North-European standards in my life time. But the development within 3D printing may speed up the use of prefabricated building elements to reduce construction time on the sites. It may have many additional advantages, including for example such as better

health and safety because a larger part of the demanding processes is carried out under safe conditions.

The more we industrialise our building and civil engineering processes, the more we can use tried and tested standard solutions so that we do not need to reinvent the wheel for each individual project. Form, function and appearance may still be unique to each single construction project and tailored to meet the customer's requests. But a lot of what is invisible to the naked eye can be produced faster, better and more safely in an industrialised process. It will increase productivity in the industry tremendously to the benefit of both customers and society as a whole.

Surely, no one is in doubt that the professional construction industry is undergoing great technological change. You might not take notice of minor changes such as the conventional surveyor's rod having

been replaced by a GPS. But when we see the first fully automated excavator, we will most likely take notice. Or when we see a robot at the construction site casting the foundation for a new building with greater accuracy than a human.

Even at consumer level, there are great changes. The 3D modelling software Sketchup, which was originally developed by Google, is so simple that anyone can design their own house. The 3D modelling software is integrated with open databases, where dimensioned products from different suppliers can be used in the drawings. In principle, this may mean that a private family can easily design their own house and be their own architect. Or that an architect on the other side of the world can design a house for my family and deliver dimensioned drawings to a contractor in Denmark.

The digital tools we use in the established construction industry today follow

## WILL THE CONSTRUCTION INDUSTRY BE HIT BY DRAMATIC CHANGE?

more or less the same principles. They are more advanced and draw on larger databases. But with the technological development, it is possible that in future, we will see far smaller players heading even large and complicated building and civil engineering projects. Or use these tools to create a new type of platform that better meets the customers' needs than is possible for us in the industry today.

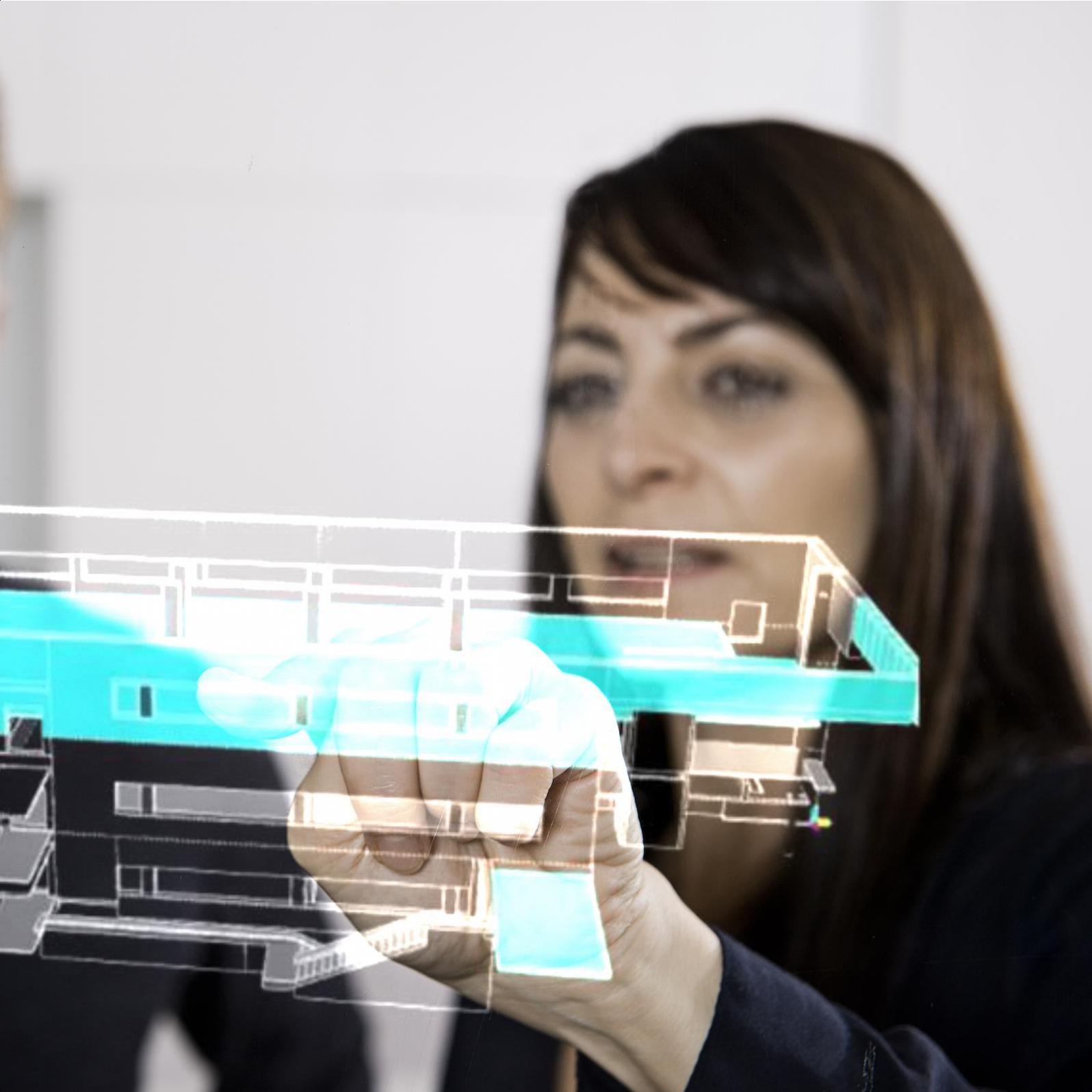
It is my firm belief that in the construction industry, the winners of the future are those who succeed in combining the two tracks. In controlling internal processes and collaboration, thereby quickly and safely delivering building and civil engineering projects of high quality, and with a platform and a structure making these processes available to customers in a way that allows customers to make decisions about their project at an early stage and on an informed basis.

That platform is in fact available already today. It is called Virtual Design & Construction.

## POINTS

- Digitisation changes the construction industry from within and from without at both product and process level.
- Collaboration in the construction industry will change dramatically because customers will contact those who add most value to their projects and they will increasingly expect the project partners to work together to fulfil their needs.
- Great changes in energy supply and modes of transport may bring about dramatic change to the construction industry and must be incorporated into future buildings already today.
- The winners of the future will provide a decision-making platform to customers and have at the same time adapted the underlying structures, processes and systems.





## VIRTUAL DESIGN & CONSTRUCTION

### DIGITAL CONSTRUCTION IS CHANGING THE INDUSTRY

Can you imagine deciding to buy a car if you knew nothing about its driving properties? Or if you had not tested other alternatives? The answer is probably no.

But nevertheless, that is how we have bought construction projects for many years. Admittedly, architects have built models for years to give the client a notion and idea of architecture and form. Very few people would buy a new car for several hundred thousand Danish kroner without taking it for a test drive, but even so clients have for years initiated construction projects worth millions without having the full picture of the end result, operating costs or price. Because it has not been technically feasible to simulate the result in advance. But now it is, and the opportunities are far greater than most people think.

Most clients are aware of the existence of 3D building simulation tools. Similarly, clients are aware of the conventional con-

sultative architectural models that architects build at an early stage of the process.

But building simulation goes much further today. And in the many decisions to be taken by the client, building simulation may make the difference between a satisfactory project and a unique project. It is also about aligning expectations, about buildability, aesthetics, practicalities in relation to future use, economy in execution, long-term value and construction time.

The opportunities are presented by Virtual Design & Construction (VDC). VDC is a method to creating and thinking through the projects digitally before they are executed in reality. It is a platform that provides analyses of data and opportunities. And it is a valuable tool to ensure a unique project, good collaboration and a good process.

### **Digital and physical prototypes**

Nothing is more difficult to understand than something that is intangible. Therefore, many trades and industries make use of prototypes. In everything from car manufacturing to the software industry, prototypes are an absolute necessity to secure a good end product. Prototypes can be digital and physical, and both types can be valuable tools in complex projects.

A prototype or model is a visual or physical embodiment to serve as the basis for discussion, alignment of expectations and decision-making. There is a world of difference between discussing something intangible and discussing something tangible. In the construction industry, we therefore work with both digital and physical models. This includes, for example, 3D-printed building models which are accurate, and rugged plastic models which

form the framework for conversation and discussion about the final building.

When you hold a physical prototype or model and can sense the detail and understand the proportions, you literally have a much better feeling of the structure. 3D models are down-scaled models of the completed construction project based on the exact building data in the computer. This means that proportions are right and form an accurate basis on which to discuss the building. But the 3D printed models constitute only a very small part of the quantum leap presented by VDC.

### **VDC simulates the entire building**

Before the construction project takes form, it may be difficult to imagine the result and the entire process towards the goal. There are many people involved, and many decisions must be taken. Consequently, it is important to think

everything through right down to the last detail beforehand. This has not been possible until now.

But with VDC, we can simulate everything for the customers, from the facade, location of the building in terms of the amount of daylight received by the building, the view from the windows, to location relative to sewerage, ground water, etc. In the execution process, we can simulate the execution itself and the related logistics in order to optimise the process in a safe, buildable and expedient manner.

With VDC, it is possible to test countless different solutions at an early stage of the project. If, for example, the customer wishes to add a floor, change window panes or choose a different roof, change the façade or something entirely different, we can use VDC to see how this would affect economy, time schedule and sub-

sequently, operation and maintenance costs.

### **From 3D to simulation of time, price and O&M costs**

VDC takes simulation much further than just 3D. We simulate in several dimensions. It means that in addition to the three physical dimensions of the building, we add time and cost throughout the process and information on subsequent operation and maintenance. The advantages of 3D are well-established, and it is common knowledge to professional customers in the construction industry that they can gain spatial awareness of their project interactively with the surroundings. Modern software takes it to the next level, virtual reality having progressed to such an extent that customers or end users can now use an iPad or special glasses to get a

feeling of what it will be like to move around between the different rooms.

We generate one of the most important simulations when we add the time schedule to the 3D models. Professional contractors already use location-based planning to plan work in terms of time and location, thus creating a better workflow in the construction process as the overview makes it easier for more disciplines to work side by side several places at a construction site. By adding the time schedule to the elaborate 3D models, the time schedule becomes even more accurate, and the software can help to further optimise the time schedules. This translates into major advantages for the contractors actually carrying out the work, but advantages which are passed on to the customers. It also reduces construction time and makes it possible to predict construction time more accurately – and as the perhaps most important point, it is

possible to calculate within a very short space of time how change requests made along the process will affect construction time.

**The traditional forms of collaboration may be challenged in large and complex projects. One of the prerequisites for success is good tender documents and a good and carefully prepared project without any obvious flaws or defects. Realistic time schedules and solutions are quite essential, and therefore, we are interested in early involvement of the contractor, because the contractor represents the real world and knows what is feasible.**

Peter Forsgrau – project manager of Odense university hospital

We also carry out simulations where we add both time and cost to the 3D models. The overall VDC project includes even the smallest components and elements such as taps and door handles and contains exact calculations of quantities of soil, steel, concrete, etc. Consequently, the price calculations are very accurate, and we avoid waste of building materials. And if the customer wants different windows or to change the roof structure at the last minute, it is easy to calculate the impact of the change requests on the price.

When enough data is available, we will also be able to calculate the future operation and maintenance costs. When we add cost simulations to the 3D project model, we will have an entirely different overview of projects' total cost of ownership than we have today. For example, we know that schools and hospitals must tolerate a different form of cleaning than a corporate office. Even though we know

that it is worthwhile to buy expensive quality products instead of cheap replicas, we often lack the data to strike the perfect balance.

With fully implemented VDC, we can simulate the exact life of a building or a civil engineering work. So far we have the tools for the economic simulation where we can simulate the development in time and cost in the design and execution phases as the project progresses. And we can rewind time and change building parameters, add and remove – and fast forward again to see the effects on time and cost.

### **Technology frees up resources**

Defective simulation and lack of data may cause construction projects to exceed budgets. Conversely, the right simulation and the right data may make it possible to think out of the box, while at the same

time building within the limits. Technology takes over many of the processes that engineers used to spend many hours calculating. Software generates quicker and more accurate calculations, which enables us to present customers with a wider range of options than previously, simply because many man hours were needed to try to calculate how a change would affect price, quality and time.

From a human perspective, the best of it all may be that it certainly does not make architects and engineers unemployed. On the contrary, we will free up time from routine calculation jobs, and that time can be used to find innovative architectural and engineering solutions where the need for their expertise is greatest. We can develop our ability to deliver more complex structures – and we can quickly test the new suggested solutions in the simulation tools.

VDC thus differs markedly from traditional planning and design by integrating economy and the subsequent operation. It provides a unique opportunity to gain a clear overview of the total cost of ownership before construction start-up – and even before the choice of design and solution – and to understand the impact of minor and major changes on the project and on what is buildable and what is not buildable.

### **A platform for change**

I believe that VDC is the platform that will generate very positive and much needed disruptive innovation in the construction industry. We have the technology required, and we have gained initial experience. But as an industry we are not yet capable of making all advantages presented by the platform available to our customers. To build this capability, it is

essential that we change the way we collaborate in the industry. For VDC is just as much a mindset as it is a technological platform.

At industry level, we must understand how VDC will affect the way we work. How will it affect buildability, project economy and collaboration? And we must learn to use it – together. We will not enhance industry productivity by continuing to do things the way we have always done things. We have tried that for many years, in vain.

To the client, the advantages are obvious: far more options and better insight into the opportunities and limitations of the construction project give a much better understanding of the process, the economy and the end result. In short, the more processes are well-thought-through before the first machine arrives at the construction site, the greater the chance that the project will match the client's wishes

and will be handed over without defects or industrial accidents.

To the industry players, the advantages are that productivity is improved and that productivity improvements, experience, knowledge and capabilities are brought into play at the right time. But it requires that we become better at working together within the industry. Not only between different disciplines, but also at a technological level. Our systems must be able to communicate to make us better at exchanging data.

Exchanging data and making calculations are basically about file format and processor speed, but as in all other contexts, the final output depends on the input fed into the system. To benefit fully from the technology, we must also change the entire collaboration process. We must become far better at agreeing on shared goals than we are today and at building up trust between the parties. Silos and

suboptimisation must be replaced by a desire to constantly help the customer see opportunities and then collaborate to realise the customer's final requests.

The customer and her project must therefore take centre stage while a common project database should constitute a platform for knowledge sharing and realisation. All parties must feed information into this database. The days when holding on to information equalled power and "ownership" of the customer are over. In future, collaboration and knowledge-sharing will equal power and success. And as described in chapter 1, the value of a network increases with the number of collaborators. Therefore, I am convinced that the value of VDC will increase exponentially as the industry partners contribute actively to the collaboration and the platform.

The supplier must fill up the database with as detailed descriptions of their

products as possible to allow all parties to draw on the database. The architect must share his designs well before they are entirely finished and have been signed off by the customer and then share parts of it with the other players to enable consultants and contractors to immediately offer their experience on buildability, sustainability, life, etc. In particular the major industry suppliers play a vital role in making VDC a success as the quantity of components contributes to determining the range of options that we can present to customers.

To the individual customers, options, quality, time and price are vital when they stand at the threshold of a new project. When all industry players join the process from the very beginning, we can achieve more value-adding results in shorter space of time, both for ourselves and for our customers. When we have completed a number of projects, we build up an

aggregate knowledge base to draw on in subsequent projects. Therefore, the value will increase, and it will benefit both customers and all players.

### **New collaborative framework**

Changing the way we share knowledge and information in the industry takes time. Old practices and experience stand in the way of new forms of collaboration. A way we can try to change these practices is to change the physical framework. Consequently, some of the leading players build actual VDC laboratories to give customers, suppliers, architects, consulting engineers and all other parties the opportunity to work together on the same systems and with shared goals. Creativity is key. The parties involved are allowed to experiment and propose alternative solutions, but the process is controlled and effective.

The whole idea of VDC laboratories is to gather human capabilities and the most advanced technology in the same place to facilitate the simulation of a project from start to finish with input from all relevant parties. In such a creative process, it is important to think carefully about everything from facilitation of the meeting process to interior layout. In the VDC laboratories, the parties can go through the entire process from discussion of the initial concept to an actual decision-making platform for the customer in the form of a virtual reality building or civil engineering project.

The VDC laboratories are not a universal solution to how we create the collaboration forms of the future. We can learn as we go along – or we can be overtaken on the inside by players whom we have not even thought of yet. But at this stage, the VDC laboratories are a symbol that if we are to change the way we work

in the construction industry, we need to do so on a strategic basis.

VDC has set the course for where we are heading in the industry, and it is possible to manage the process in a realisable direction. The direction requires collaboration – and therefore the VDC laboratories must be open to all parties in the industry. If we do not work together to exploit the opportunity and disrupt ourselves from within, you can be sure that clever people from the outside will do it for us, and then even old illustrious enterprises within the construction industry risk being reduced to secondary players – at best. If, however, we succeed in greater industry collaboration, we can create a small cultural revolution that will make the cake bigger and tastier for all – not just our customers, but also society as a whole.

From our collaboration with international players in the USA, Germany and

other countries, I know that technologically, we are doing well in Denmark at present. If we maintain our momentum, we have the opportunity to become internationally competitive within this field and thereby make the entire Danish construction industry more competitive. It will help us both internationally and domestically.

But customers also play an important role in changing collaboration between industry players and creating the optimal platform in the form of VDC collaboration. Customers must ask their questions in entirely new ways, and that requires a break with the competitive tendering culture in Denmark. That is the topic of the next chapter.

## POINTS

- VDC gives clients the opportunity and time to compare a number of alternative solutions on a well-informed basis, resulting in greater freedom of choice and more value.
- VDC gives the construction industry the tool to collaborate on project optimisation, increasing the value added to clients and society in general, while at the same time increasing the parties' own profits.
- The value of VDC increases with the number of participants in the collaboration.
- VDC gives the Danish construction industry the opportunity to increase our competitiveness internationally.
- Technology will free up resources to bring the capabilities across the industry into play.
- VDC has the potential to create disruptive innovation in the construction industry.

3D 4D 5D 6D

PROCES

OPTIMERING

VDC/BIM

PRODUKTIVITET

Automated  
Planning

Fully  
Automated  
Monitoring

ubox

## CHAPTER 4

# NEED FOR GREATER COHESION AND COLLABORATION

Some years ago there was a TV commercial for low-energy light bulbs in which a customer was buying a bulb. The shop assistant presented two options to the customer: an expensive one and a cheaper one. The customer asked for the cheaper option and then the shop assistant said something along the lines of “then you need this one and took the expensive bulb” – the easy-to-understand morale being, of course, that the low-energy bulb is cheapest in the long run. The same analogy can be applied to the construction industry where the concept of the “low-energy bulb” has not yet caught on.

If one asks a poor question, one must expect a poor answer, and unfortunately, the questions are often wrong, when public and private clients build new projects. The way questions are being asked is rooted in the Danish competitive tendering culture, which, in my opinion, is

instrumental in maintaining a low productivity in the construction industry.

VDC will make it easier to ask the right questions, but it requires a change of culture where we in the industry must lead the way and show customers that it pays to ask differently. To this end, we also need brave customers who dare lead the way and challenge firmly rooted habits in the construction industry.

It may be that several industry partners will feel offended by the following paragraphs. But I believe that if we are to improve productivity and earnings in our industry and at the same time give our customers better value for money, we have to break away from many of the inappropriate aspects of the old trade. Therefore, we also need to expose those inappropriate aspects.

Unlike many other industries, and as already discussed, there is not yet a coherent value chain and certainly not a value

structure in the construction industry where the processes cohere in an optimal fashion and where the players collaborate towards a shared goal and share data and knowledge as we should. Today, we are not yet an industry, but a trade divided into silos.

Far too often this results in suboptimisation by architects, consulting engineers and suppliers. Everyone wants the greatest possible yield for themselves, even at the expense of the other players and greater good. For example, the consulting engineer does not have much incentive to “sacrifice” an additional 100 hours on making some extra calculations that may save one million kroners worth of steel and concrete on the project which the client could use to pay for the beautiful and robust floor tiles suggested by the architect. No one takes ownership, and therefore costs are being pushed around,

and the end result is a poor solution or a dispute.

The consequence is that silo thinking costs customers money as well as time and quality. The division into silos deprives customers of the possibility of being presented with alternative solutions which may be better and cheaper. At the same time, a lot of data and information is lost between the different players. That affects quality, time and cost – and in a greater perspective, it also reduces Denmark’s competitiveness.

If customers are to have more and better buildings for their money and if we are to enhance industry productivity, we must change the way we act dramatically: competitive tendering and collaborative practices must ensure timely use of capabilities, and a dedication to working towards a shared goal – with the greatest possible use of data.

### **Collaboration agreements make for better buildings**

Among the most progressive clients, it has become more popular in recent years to enter into collaboration agreements where the client works together with the architect, the consulting engineer and the contractor to jointly optimise the project and does not enter into a contract until all parties agree on the design of the building, that the project is buildable and who is responsible for what. In that way, the experience of the relevant parties is employed when different solutions are discussed, and all parties have approved the project and each other before the client commits himself to a solution. In future, suppliers must also be invited to take part, and no one will care about disciplinary divisions. We will merely view ourselves as one construction industry which is to deliver the best project possible to a cus-

tommer. Collaboration agreements secure the client the best benefits from turnkey contracts and main contracts as he can be involved in the detailed project planning phase and at the same time have one supplier who is responsible for the entire contract, including design.

This model contrasts sharply with conventional competitive tendering in Denmark where the client approaches an architect who draws a dream house. Then the client hires a consulting engineer who scrutinises the architect's drawings and divides the project into one or more contracts, each of which is described in as much detail as possible. Then the contractors are invited to bid on these contracts. We call it cardboard box tendering because the specifications are often so elaborate and extensive that they are carried around in cardboard boxes and because the procedure is closed and does not allow involvement or dialogue. When

the tender documents are described in such detail by the consultants, it does not allow contractors and suppliers to bring their expertise into play.

Good ideas and proposals for project improvement often risk falling outside the scope allowed in competitive tendering, and the value-adding processes fail to happen. Worst of all are the situations where the contractor or the supplier suggests obvious improvements of the total cost of ownership through optimisation of energy consumption, extension of the life by using alternative materials or similar measures. Because even though it is economically advantageous to the client and makes sense in a socio-economic perspective, competitive tendering does not leave room for taking long-term financial gains into account as it would make it more expensive to erect the building and the client would therefore decide against the contractor or the supplier. The elaborate

specifications also open up for various disputes when the project starts up and reality does not match the specifications.

### **Total cost of ownership is an important element in productivity improvements**

The clear-cut focus on the establishment price in competitive tendering in Denmark has contributed to a low-productivity environment with many disputes and small profit margins for years. At the same time, many of the completed buildings have too high operation and maintenance costs because the customer has been so clearly focused on the establishment price. In times of crisis, we have seen even major contractors bid on projects with a price and risk model where the chance of completing the project at a profit is next to nil. The money must be earned elsewhere, and therefore the tender documents are scrutinised to find errors and

gaps in order to recoup the profit on extra work. The contractors know that it is virtually impossible to take into account all small details in a large project in advance, and the project is priced on the assumption that the profit can be earned on extra work.

**We would like our collaborative partners to join the process from the very beginning. From initial concept to finished project. We are happy to involve the contractor at an early stage, but it requires a contractor who can provide consultative services on an equal basis with other collaborative partners and not just a contractor who is to build a house.**

*Michael Bruhn, director at PFA ejendomme*

This tendency to recoup the profit on extra work has fostered a culture of mistrust and suspicion, where far too many projects have ended in arbitration pro-

ceedings to determine who was liable for the costs of extra work.

When the parties share the objective of achieving a good result and review the project together before tenders are invited, it tremendously reduces the risk of forgetting simple details such as sub-flooring or gravel under the car park in the tender documents. It becomes a win-win situation instead of a game where the parties compete against each other. In fact, all these problems can be solved by working together and doing so on a common digital platform ensuring that knowledge and data are not lost, but instead collected and added on top of existing data from other projects so as to constantly expand our knowledge base.

### **Invitation to tender – one contract or several subcontracts?**

As a professional adviser to the client, there may be many advantages associated with inviting tenders for as many subcontracts as possible. It results in a larger management assignment, increased responsibility for the project and closer contact with the customer. Among public clients, there is understandably a strong desire to use local enterprises from the area where the project is to be built, and a way to accommodate this desire is to divide the contract into subcontracts. At the same time, the theory is that the many subcontracts give a more transparent pricing structure as virtually every single part element of the overall project will be priced and exposed to competition – which generally results in lower prices.

Having several subcontracts also result in many interfaces, and in large building

and civil engineering projects, these interfaces are floating. When the contract is awarded purely on the basis of a price which only just makes the contractor come out of it with a profit, it is important to get that interface as far into your own court as possible. And if two or three parties share the same interfaces, and everybody tries to stop ten metres before the centre line, this will create a no man's land.

In this no man's land, the consultants must now scrutinise their drawings, re-design the project and negotiate with the contractors about who is to carry out the overlapping work. It costs a lot of unproductive management, architectural and engineering hours which the client is to pay for, and even though this is where the contractor can earn his extra money, it also leads to a lot of frustration and costs for the contractors. It costs money and administrative hours, and it adds a num-

ber of costs to the construction project which definitely do not increase the quality of the project or productivity in society.

**Today it is all about using other people's knowledge in the best possible way considering the challenges in the individual project, and here it is often an advantage to eliminate the conventional disciplinary boundaries.**

*Jens Nyhus, CEO of Carlsberg Byen*

The major reason for many of the enormous budget overruns we see in public construction projects is an abundance of interfaces and a lack of control of them. The budgets do not make allowances for the interfaces, and every time a problem of that calibre arises, it costs more in terms of revising the project plan, negotiations and project management than the actual construction work. At the same

time, the construction work also becomes costlier than if it had been included in the original contract where the solutions could have been optimised together with the other structures as the contractor has every opportunity to exploit the fact that the client has to buy the work from him.

It is possible to overcome many of these problems by inviting tenders for the works in one turnkey contract instead of dividing it into subcontracts. The turnkey contractor will then be responsible for the interfaces and bear the liability associated with handling them, which contrasts with the costs imposed on the client when the consultants are to rectify defects or misunderstandings caused by interfaces and the subsequent costs of remedying them. In this way, local enterprises will also benefit as major turnkey contractors typically use small subcontractors to carry out many of the specialised jobs, and here it always makes good sense to look for local capab-

ilities, subject to the proviso that quality in execution is more important than the registered address of the subcontractor.

On large projects such as hospital or motorway construction projects, many jobs must be executed several times during the construction process. Therefore, there are many efficiency gains to be made by using the same contractor for the work – the method will be refined and standardised, tried and tested solutions will be used, and the number of errors will be minimised.

But if we really want to enhance productivity in the construction industry and get more quality for money, we must take a step further and look at what tendering methods are most appropriate.

### **Function-focused tendering**

An often expedient way to specify the contract put out to tender is the so-called

functional tender process which is currently gaining ground within a number of public service contracts. In a functional tender process, the client makes a number of functional requirements (targets) to be met by the project as opposed to the conventional invitations to tender which specify in detail how the work put out to tender is to be performed.

A classic example of the difference is that the conventional invitation to tender may specify that the grass is to be cut once every other week, whereas the functional invitation to tender specifies that the maximum grass length is 3 cm. The intention behind both tendering processes is the same. But the functional invitation to tender leaves scope for the supplier to use his knowledge and experience to perform the contract in the best possible manner. A facility management company may for example choose to invest in research and

subsequent planting of slow-growing grass that only needs mowing once a month.

That type of tendering fosters creativity, innovation and regular improvements because there is an inbuilt incentive to carry out the work in the best possible manner and to keep optimising processes and products. In construction, we see this type of tendering being used for road maintenance, and we partly see it in PPP projects where a handful of schools have been built in public-private partnerships.

At schools built in public-private partnerships, the contractor (typically together with a partner) is also responsible for the operation and maintenance of the building for 25 years. It provides the incentive to use high-quality materials such as more hard-wearing floors and walls that tolerate daily cleaning. The materials may be more expensive initially, but will give a lower total cost of ownership over the life of the school.

Functional tendering can be used with advantage for far more construction projects. Already today the largest and most professional private clients take advice from contractors early in the process and demand collaboration between all parties involved to achieve the best solution aligned with future needs. Here we as a society can increase the return on our investment considerably if public clients also become better at describing their expectations to a future school, bridge, road or hospital and then leave the project partners enough scope to decide on the execution of the project.

At the same time, it will have the beneficial effect of giving the players an incentive to be innovative together. All parts of the value chain will be allowed more scope to be creative and think innovatively. It will open up for research into new methods and new types of material. If we take a historical view of Danish industry,

we have done well in pumps, windows and insulating material. A conventional tender process entails a risk that this development comes to a standstill as far too many sub-elements are described down to the last detail, and contractors and suppliers are not rewarded for being innovative.

Functional tendering will also contribute to increased collaboration as a successful process requires all parties to work together towards a shared goal and to manage the risks and opportunities associated with the project. It will create the opportunity for big profits which can be used partly as competitive strength by giving large parts of the profit to the client to land the order, but also by keeping some of the gain yourself to enable the enterprises involved to research into and further develop the recommended solutions. In such collaboration, VDC simulations

will be ideal to submit the optimal tender in a functional tender process.

Accordingly, there is a definite connection between the VDC line of thinking and the transition to functional tendering.

### **Are we ready when the customer asks the right questions?**

As I mentioned at the beginning of this chapter, one must expect a poor answer if one asks a poor question. As an industry, we must be prepared to give good answers when a public customer asks us how the construction industry can increase the learning level in primary schools most rationally instead of asking us what it will cost to renovate the school or build a new one. I am sure that if we break away from silo thinking and share our knowledge and experience, we will be able to amass and use the capabilities required to answer this

question with solutions which are at a significantly higher level than today.

In the public sector, there are major gains to be made for society by asking the right questions and planning tender processes to bring the right skills and expertise into play at the right time and to promote long-term and systemic thinking.

The tendering methods must keep up with the times and match the complexity and the opportunities offered by a modern and increasingly digitised society. Therefore, it is my opinion that the public sector has an obligation to lead the way and support the initiatives enhancing productivity which are so important to enable us to break away from 20 years of productivity drought in the Danish construction industry – and to create a productive construction industry.

## POINTS

- The tendering methods are essential to the range of opportunities available to the construction industry to secure value creation and productivity in the projects so as to enable us to break with twenty years of productivity drought.
- As an industry we must help each other ensure that our customers ask the right questions.
- VDC simulation provides the platform for collaboration on the turnkey contracts, functional invitations to tender and collaboration models of the future.
- Turnkey contracts, functional invitations to tender and collaboration agreements are three tendering methods that support collaboration and improve productivity in the industry.





## CHANGE REQUIRES LEADERSHIP

We are good at building in Denmark. And we can become even better. The digitisation has already changed the construction sector. But we use only a fraction of the opportunities offered by digitisation.

With standard solutions and for example prefabricated façades which have become very popular in Danish renovation projects, we can root out some of the causes of low productivity.

But the biggest gains – not least in connection with digitisation – lie in a more open collaboration between the industry partners. In the conventional process within the construction sector, drawings and ideas are taken from silo to silo between architects, clients, engineers, contractors and suppliers. Every time the project is handed over from one party to the next, knowledge, information and data are lost.

A significant barrier to productivity in our industry is the failure to collaborate and to exchange and hand over data. Today, all parties use computers, and when we reach the stage where everybody is prepared to share data across databases and share their information freely with each other, we can reap substantial benefits.

**It makes good sense to invite relevant capabilities to the table from the very beginning – and in that respect, the contractor naturally plays a crucial role, possessing practical experience and knowledge about economy, planning and buildability.**

**Erik Skotting – Technical Director at Metroselskabet**

We have the tools today, but even though demand and incentives are lacking, we will not wait. Both the public and the private sectors use large sums of money on construction projects every year, and

from a socio-economic perspective, it will consequently benefit us all if we improve productivity in the construction industry. MT Højgaard employs a number of business PhDs who have created the basis of analyses ascertaining some very clear productivity benefits on projects using BIM Execution Planning. BIM Execution Plans specify the digital collaboration platform for the customer's project. The first steps have thus been taken, but we are still in infancy in terms of the benefits provided by a full implementation of the VDC line of thinking.

In reality, the biggest obstacle is probably the innate human opposition to change. Not least because the change prompted by knowledge sharing of this nature can significantly alter the roles played by the industry partners so far.

Just as the major conventional players in the car manufacturing industry would be wise to fear Google and Apple because

cars will probably end up just being a technological element of an advanced infrastructure system, architects, engineers and contractors need to look ahead and try to predict who will be the preferred partners of the clients in the future. Who will add what value to the customer?

One thing is certain: the customer want more and more intelligent options. And the industry players can deliver that today by sharing information with each other. When data about the suppliers' windows, pumps and ventilation systems are fully updated, the architect can incorporate these objects into his own drawing material. Technical calculations will be easier to make when all information on building elements are constantly updated and maintained, and the contractors make sure that the databases contain only building elements of a quality that meets the customer's requirements.

If one party changes a building element, or if the architect changes the type of window used, then it will come through in the drawing material of all parties and the economic implications will show. In the initial phase, it will therefore be far easier to ensure that the project is both buildable and realisable within the customer's budget as prices are linked to the building elements.

**There are great savings to be made if we trust each other.**

**Michael Bruhn, director at PFA ejendomme**

What we are dealing with here is, on the one hand, a simple exchange of data. But on the other hand, it is about us – the project partners - dividing the tasks between us differently.

It requires trust between the project partners to share information, also at an early stage. On the other hand, it opens up for great opportunities for enhancing

efficiency with all parties in the construction industry. The architect can virtually at first go ensure a buildable house that can be realised within the customer's budget so that the engineer and the contractor will save many rounds of revised project plans, reversals and new calculations which either cost the customer more money or drain away the already small margins. The greatest benefits will be enjoyed by the customers as the competition between the many industry partners will ensure that a significant part of the benefits is used to improve competitiveness. There will be far more options, the risk of budget overruns will be minimised, the project will be buildable from the beginning, and the time schedule will be realistic.

Higher productivity and more innovation in the construction industry are not only about programmes, hardware and data flows. In recent years each single part

of the value chain has focused strongly on developing their own capabilities, products, processes and technologies as a means of improving productivity. It has generated results, but there is a limit to how much more the individual player can achieve. At the same time, the individual player's own efficiency improvements result in inappropriate practices by other participants of the value chain. Improving efficiency and simplifying processes at one point risks creating complexity elsewhere. For that reason, the necessary paradigm shift in the industry also requires particular focus on developing the behaviour, mindset and collaborative practices in the industry.

### **The industry has already moved**

Of course, we can keep on improving efficiency within our separate silos – but only through increased transparency, curiosity

and an understanding of the larger picture can we seriously create change in the industry. We should not wait for external disruption to force us into rethinking our industry. We must be brave and curious enough to create disruption ourselves – a change that we control instead of a change that controls us.

This change must be driven at two levels: coherence must be achieved in the individual organisations and also at industry level.

First and foremost, we as an industry must understand that we are basically one united system and not separate independent entities. The word 'system' originates from Greek and means "a whole composed of several parts" or "to stick together". One of the characteristics of a system is that the different parts have an inner coherence and relations. This coherence is tied together by communication. Through better communication, we

## CHANGE REQUIRES LEADERSHIP

as an industry must strengthen our trust in each other and our forms of collaboration. In that way, we can rethink how a building process works from start to finish.

In the individual organisation, it requires that the top management develops strategies and business models based on foresight and true innovation instead of narrow-mindedness and tradition. Because in a few years, the historical traditions and ground rules of the industry will be a thing of the past. Within the industry, we must get used to our strategies and business models interacting with those of other parties in new ways. We must see our products and services in a social perspective where we try to be at the leading edge of developments. Some players will probably survive by continuing to deliver niche elements. But if you want to claim the front seat, the strategy must include the products' life cycle from the very first signs of new needs arising in

society to the impact of the total cost of ownership over many years of operation.

But a change of strategy is not enough. A new mindset focusing on collaboration and innovation must permeate the organisation. It must unfold throughout the entire organisation as quickly and forcefully as possible.

Speed and resilience are essential to making the importance clear. In this process, values and culture are central accelerators, but also potential stoppers that top management must influence in the right direction. Employees must be rewarded for embracing new forms of collaboration and sharing their knowledge with other players, and in public administration, for example, there must be room to try new methods for inviting tenders. At the same time, it is necessary to ensure that corporate managers have the necessary scope, the right skills and expertise and not least the right attitude to change.

Transparency and the ability to think and implement change of a technical and organisational nature will be key capabilities of the managers in the construction industry.

It will be a major change. At industry level, at organisational level and at personal level, development will be a goodbye to something known – and a hello to something new that we are not yet quite sure exactly what looks like.

### **Understanding the building blocks of change**

All forms of change undergo the same four phases. It begins with denial. The entire VDC line of thinking as presented in this book may well be met by a shake of the head.

The next phase is resistance. It is also a natural part of the change we are facing. For everybody, it will require courage and

an extra effort which we would prefer to be without in the short run, but which is inevitable in the long run. Our unique opportunity lies in choosing to be proactive rather than being forced to be reactive.

The third phase is curiosity and exploration, and it is my ambition with this book to create a curiosity, exploration and common movement towards a construction industry which increasingly contributes to Denmark's overall growth and development.

The final phase is dedication and commitment. During a day at work, I meet more and more employees who are extremely dedicated and committed to making VDC the platform of the future construction industry. But we want more to join in. We want to create a dedicated and committed industry characterised by collaboration, communication, exploitation of digital opportunities, increased

productivity and not least better solutions for our common customers.

We must keep in mind that it will not be a linear journey from A to B. It will be process where we experiment and sometimes face challenges and setbacks.

In that way, it is clear that we are not only changing the industry using technology. Technology is a tool and a common reference that we need to orchestrate correctly. And if technology is our hammer, we are as an industry, as organisations, as leaders and as employees the arm that will lift, swing and transmit the hammer's energy towards a shared goal.

## POINTS

- Change requires leadership as we need to break away from "carrying-on-as-usual" and foster a new productivity-focused culture.
- Change requires us to deal with the resistance that change will inevitably meet, e.g. by encouraging employees to go new ways.
- Change requires a vision – in this context, a vision for improvement of productivity.





# EPILOGUE

## TOGETHER WE CREATE A HIGH-PRODUCTIVITY CONSTRUCTION INDUSTRY

It takes four things to go from a low-productivity construction industry to a high-productivity construction industry: Technology, collaboration, new tendering methods and leadership.

### **Technology**

The potential of the technological development has not yet been fully exploited in the traditional construction industry. But we have the technology our disposal, and with VDC simulation of all phases of the construction project, we have the technological platform to increase productivity markedly.

### **Collaboration**

Technology never makes a difference in itself, and it requires new forms of collaboration to exploit the potential of technology. It also requires a break with the

conventional roles in the industry. We must demolish the silos between the different disciplines and players and share data and knowledge in entirely new ways. We must view ourselves as one united industry working towards a shared goal of creating better projects for our customers, while at the same time minimising risk and cost for ourselves and for society.

### **New tendering methods**

The collaboration must also include customers and decision-makers. The Danish tendering method contributes to keeping the industry in low productivity, and whereas several of the largest professional clients are now increasingly looking towards collaborative models and functional tendering, there are still too many Danish construction projects that are put out to tender based on price alone. To achieve the improvements, we as an

industry must help customers ask the right questions to allow our knowledge and experience to improve the quality and the total costs of ownership in their projects, while at the same time increasing productivity. This will benefit customers, industry partners and society as a whole.

### **Leadership**

Changing everything from the division of roles in the industry to tendering methods requires courage, will and ambition to change. We will not succeed without strong leadership. Industry leaders and public and private clients must encourage their employees to try new tendering methods and to dare enter into new forms of collaboration. And they must be equipped to meet the opposition that change will inevitably encounter.

### **Winners of the future**

In the construction industry, the winners of the future will be those who succeed in combining these elements and providing customers with an efficient decision-making platform, while at the same time being in control of the underlying structures, systems and processes. VDC may well prove to be the tool that unites the industry and provides customers with the platform which, interactively with the new forms of collaboration, will help customers benefit from increased productivity in our industry.

The value of VDC increases when we collaborate – with strong management support. Therefore, I wish to use this book to invite all industry partners to embrace the collaboration and exploit the opportunities of technology to raise productivity in an industry that has not seen any

appreciable productivity increases in  
almost twenty years.



## ABOUT THE AUTHOR

Torben Biilmann is President and CEO of the MT Højgaard Group and one of the leading figures when it comes to changing the construction industry.

Torben Biilmann started his career at the then Rasmussen & Schiøtz (later NCC) as project manager in 1984. At Rasmussen & Schiøtz he delivered strong results which led to regular promotions until he was appointed CEO of NCC Construction Denmark and joined NCC's group management in 2006.

In 2012 he took up the position as President and CEO of MT Højgaard to head a large-scale turnaround. He succeeded in turning around the untenable development and delivering strong results in only three years.

He is a member of the Council, the Executive Committee and the Industrial Policy Committee of the Confederation of Danish Industry (DI) and chairs the Special Committee of Construction Policy of

the Confederation of Danish Industry (DI).

Throughout his career, Torben Biilmann has actively sought to develop the construction industry. He has constantly updated his strategic capabilities by completing executive programs at IMD and INSEAD, which has inspired him to new forms of collaboration, productivity-enhancing initiatives, technology and management.

*Portrait photo: Thomas Hommelgaard*



Torben Biilmann is CEO & President of MT Højgaard and one of the leading forces shaping the change of the construction industry.

In Denmark, the professional construction industry carries out construction projects worth around DKK 175 billion each year. Nevertheless, the construction industry is known for its low productivity.

The book's author, Torben Biilmann, CEO & President of MT Højgaard, takes off the gloves and discusses what the industry can do about it. Using modern technology as a tool, the parties' accumulated expertise as ballast and with an eye to the potential for productivity improvements, the author believes that the construction industry can evolve from a low productivity industry to a high productivity industry, giving customers a wider range of options and more value for the money, while at the same time improving the earnings potential for all parties in the industry. Torben Biilmann focuses attention on the technology-driven change that the industry is facing and on how the parties can rise to the challenge from within through collaboration, shared visions and a common mindset.

