
efca
Representing
FIDIC in Europe
FUTURE TRENDS
IN THE CONSULTING ENGINEERING INDUSTRY
June 2018

FUTURE TRENDS IN THE CONSULTING ENGINEERING INDUSTRY

CREDITS

Sergio Pessolano has granted to the authors the rights to his photograph for use on the cover. Any reproduction is forbidden.

Title: Tunnel of Innovation

"The Tunnel of Innovation is like an open channel towards the world of archetypes, a progressive and exponential illumination which broadens our collective conscience, an unstoppable and necessary connection with the other dimensions of the universe, God's third eye open on the absolute."

Information on the European Federation of Engineering Consultancy Associations can be found on the internet at: www.efcanet.org

Published by the European Federation of Engineering Consultancy Associations, 2018
Publication date: June 2018

ISBN: 9789075085051

Preface

We are in the midst of a technological revolution. A revolution in the way we design, construct, operate and manage not only our infrastructure but also the way we design, construct, operate and manage our business's. The speed of the current breakthroughs has no historical precedent. Using these new tools and processes to carry out the same, mundane tasks faster and cheaper would be a shameful waste of such exceptional opportunities. A paradigm shift is required to reinvent how we utilise the future.

In this first Annual EFCA Future Trends Booklet, we explore the trends that will disrupt the Global AEC Industry. It is irrelevant whether we as a Federation support, embrace or encourage these trends, The future is inevitable. The only constant is change and the rate of that change is increasing uncontrollably. Our goal is to expose the European AEC Community to the possibilities and opportunities that this inevitability will create and the consequence of ignoring it.

These new forms of organisation structure place more trust on the integrity of all those involved in the journey. They can only succeed with the preservation of the core ethical principles which lie at the heart of our profession. Without these failure is inevitable.

EFCA challenge's our Industry to have the courage to transform ourselves, to abandon preconceived frameworks, to embrace new models and try new experiences that will allow us to truly evolve as an industry and society. The transformation won't be easy. There will be many challenges and obstacles as we try to reconcile these future trends with the legal, regulatory and liability precedents which have both constrained and protected us for many years. Shattering the status quo is always disruptive.

Kevin Rudden - EFCA President

Kevin Rudden
EFCA President
Maurizio Boi
Chair Future Trends Task Force
Nikola Matić
Vice-Chair Future Trends Task Force

Maurizio Boi - Christophe Castaing- Maximilian Grauvogl
Nikola Matić - Kevin Rudden - Jan Van der Putten
Future Trends Task Force Members

Table of Contents

PREMISE

> "The future is already here.
> It is just not evenly distributed yet."
> (William Gibson)

What some technologies in the disruptive phase and on-demand services are telling us loud and clear is that we are in for massive changes in work, business, and the economy. These new technologies and processes include:

- BIM
- Cloud Computing
- Artificial Intelligence
- 3D Printing
- Virtual reality
- Internet of Things
- Blockchain Technology

What makes the above truly amazing is:

- They represent the forces shaping the future business landscape
- They seem unbelievable at first
- They are changing the way the world works
- They are generating an ecosystem of new services, jobs, business models and industries

We do not intend to predict the future but rather to enhance the dialogue on new technologies and organizational models in engineering consultancies because we are aware that *"the future is already here. It is just not evenly distributed yet." (William Gibson)*

In this digital era, we cannot forget our core values of trust, transparency and integrity.

COLLABORATIVE ENGINEERING & NETWORKING

We analyse “platform business”, its impact on the engineering industry and whether this industry is suited to Networking. We also figure out how to address mass collaboration and collective intelligence through online platforms.

Engineers cannot hold onto the past but must extend and expand their knowledge by “*networking*” with colleagues from diverse backgrounds and from other nations. The mind of the professional, in the era of networking and global connectivity, needs to shift from competitive to collaborative, so as to reach the highest target audience.

Collaborative Engineering is a new peer-to-peer model in which highly qualified resources converge and intercept in order to provide a smart world of engineering. This is possible through BIM.

BIM represents the informatic tool which allows the application of the new art and science of collaboration (called Wikinomics) to projects and engineering works.

The Network Imperative

In the contemporary world non-tangible and digital resources prevail over tangible and physical resources. To manage, exchange and share this type of resource we use the Network. The Network is a system of connections that allows a combination of interactions between people and things, in order to share information, exchange products, services, and even intuitions.

The challenge is: how can we benefit from its positive effects?

Firstly, we must understand how online tools can actively amplify *collective intelligence*. Secondly, we must draw attention to the fact that bringing together the expertise of groups of experts to address humanity’s fundamental problems can bring tangible benefits to all citizens of the world. Thirdly, we always recommend using contracts that support integration and collaboration.

In general, we identify 4 business models at the moment:

1. **Asset Builders:** manufacture and sell physical things (for example BMW and Moët & Chandon)
2. **Service Providers:** deliver value by tapping the efforts of skilled workers to provide services to clients (i.e. JACOBS and AECOM)
3. **Technology Creators:** generate value through ideas, developing and selling intellectual property related to software, pharmaceuticals, bio-technology, etc. (i.e. Microsoft and Samsung)
4. **Network Orchestrators:** produce value by facilitating connections between networks. They create platforms and invite participants to interact or transact with many other network members (i.e. Facebook and YouTube.)

"Today's leading organizations are network-centric and are creating remarkable economic returns by capitalizing on network advantages, such as co-creation with their customers (Facebook); digital platforms (Amazon); shared assets (Uber and Airbnb); and big data insights (Netflix and Google). Leaders and investors who want to participate in the network revolution need to envision their future, and the future of their industry, based on intangibles and networks or risk falling behind."

Libert M. Beck, J. Wind, The Network Imperative: How to Survive and Grow in the Age of Digital Business Models.

Network Firms	Market Value
Uber	• $60-70B valuation • No cars, more than 1M drivers
Airbnb	• $24B valuation • 1.5M+ homes for rent, none owned
WeChat	• $84B estimated value • 650M users • 0 miles network fiber
Alibaba	• $200B market cap • 0 retail locations

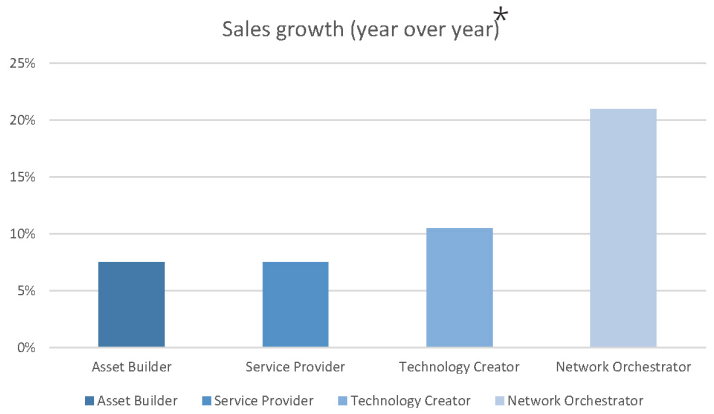
Traditional Firms	Market Value
Hertz	• $7B market cap • Estimated 350K cars
Starwood	• $12.2B purchase price in Nov. 2015 • 1.270 Hotels properties
AT&T	• $207B market cap • 122M phones subscribers • 1M miles of network fiber
Walmart	• $190B market cap • 11.000 retail locations

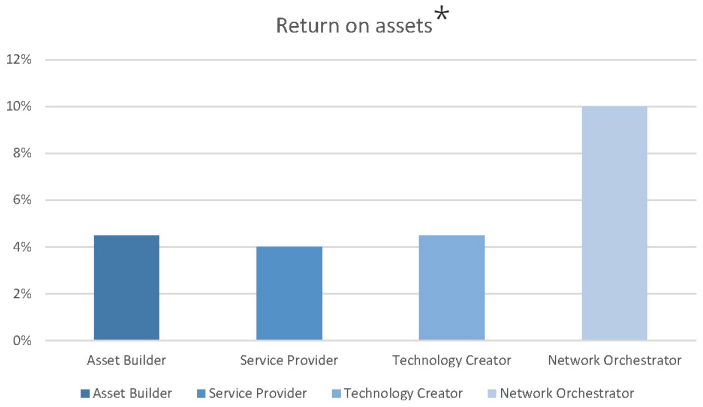
*

Online networking improves our problem-solving skills, allowing us to go beyond the limits of offline collaborative methods and amplifying the effects of collective intelligence. By widening the scope of our cooperation through the use of online tools (the cloud, BIM, Blockchain technology, Smart Contracts), we can expand the variety of skills available, explore ideas in greater depth, and produce cheaper, better and faster solutions.

The challenge for the engineering industry is that of being in a position to imagine and offer high added values in the provision of services within the network based on these new technologies before the contractors do so.

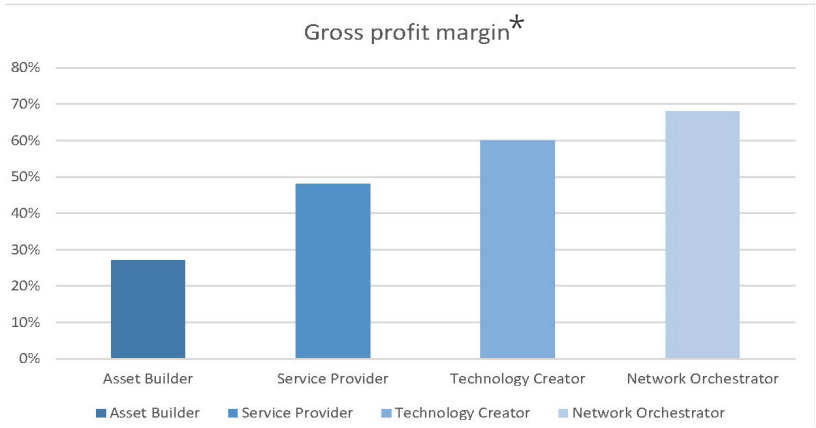
Via online platforms, engineers can connect, interact, exchange value units, co-create and collaborate.

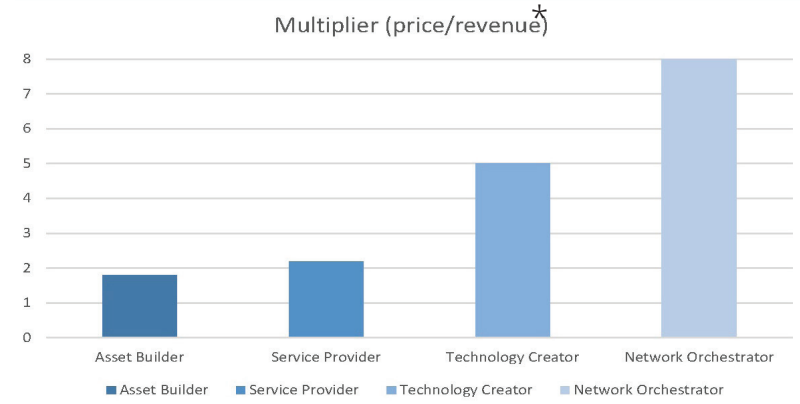




The aim of the business platform is to:

- Allow engineers, architects and other industry professionals to enter the construction-related production system;
- Allow small and medium-sized engineering and architecture firms and professional partnerships in general to come together in order to reach more important markets previously outside their scope, including international ones;
- Allow all economic operators to find the appropriate partner for every situation.





"*Multisided*" platforms equipped with dedicated algorithms and relational contracts can facilitate both interaction and collaboration between participants. The key is to target the peculiarities of a project and create a Network capable of managing all specific needs.

When engineering is network-centric the values created increase, particularly when both "knowledge and system engineering" are adopted.

Why is the Engineering industry perfectly suited to Networking?

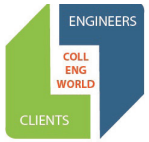
- It can provide the huge numbers of team players required

- The team can vary based on the project

- It can provide the necessary high level of expertise

- The Network can make recruitment easier and quicker

- Online platforms can facilitate collaboration



* Graphics from "The Network Imperative:
How to Survive and Grow in the Age of Digital Business Models." Libert M. Beck, J. Wind.

BUSINESS MODEL EVOLUTION

Analysis of the possible evolution of engineering business models

The logical business model evolution in the engineering sector follows these typical steps:

1. Professional engineering;
2. Engineering firm;
3. Exponential engineering organization;
4. Engineering Open Networked Enterprise;
5. Engineering Distributed Autonomous Enterprise (DAE).

In an engineering context, business transactions originally began to take place when *"individual professionals"* started to use all their personal skills to create excellent projects: their tasks were always rigorously aligned with their specific knowledge and their place of work. Given the extent to which specializations have diversified and our current ability to communicate globally, it is evident that this model has been completely superseded.

Over the years, it became necessary to command skills of an increasingly multidisciplinary nature. This led to the transition of engineering firms, which solved the multi-specialisation problem for a time. However, the technological levels reached today tend to render this model increasingly wanting in terms of costs and insufficient from a numerical standpoint.

Hence, we are seeing the emergence of Exponential Organisations. These organisations have introduced community-based practices where a required resource can be engaged at the exact time when it is needed. This represents a sort of service aggregator, a centralised system that finds people, contractors and suppliers, then aggregates and coordinates them.

The Networked Open Enterprise represents a further step forward:
as the role of the service aggregator disappears, the project organisers themselves join together to form a vast network, a large enterprise, with the individual participants as its owners.
They build the organisation with the aim of working in the public interest.

At this level, the Blockchain is already a crucial element because it creates a prerequisite of trust, thus ensuring effective collaboration.

With this model – which is a perfect fit for the network-friendly engineering sector – work can be centred on BIM and the cloud, allowing all collaborators to participate, interacting freely without hierarchies (i.e. adhering to peer-to-peer principles) and respecting set rules. It is important to develop a good reputation, because payments can be issued automatically according to the effort applied. This includes partial work packages, since Blockchains can also handle micro-payments.

Optimising this model further brings us to the Distributed Autonomous Enterprise, a reality that does not yet exist, but represents a goal to which we can aspire in the coming years.

It is a mixture of people, automation and innovation: through algorithms that prevent every possible redundancy, the system is streamlined by automatically connecting all the operational mechanisms using Smart Contracts, thus automating the vast majority of the activities with no loss of time and minimal costs.

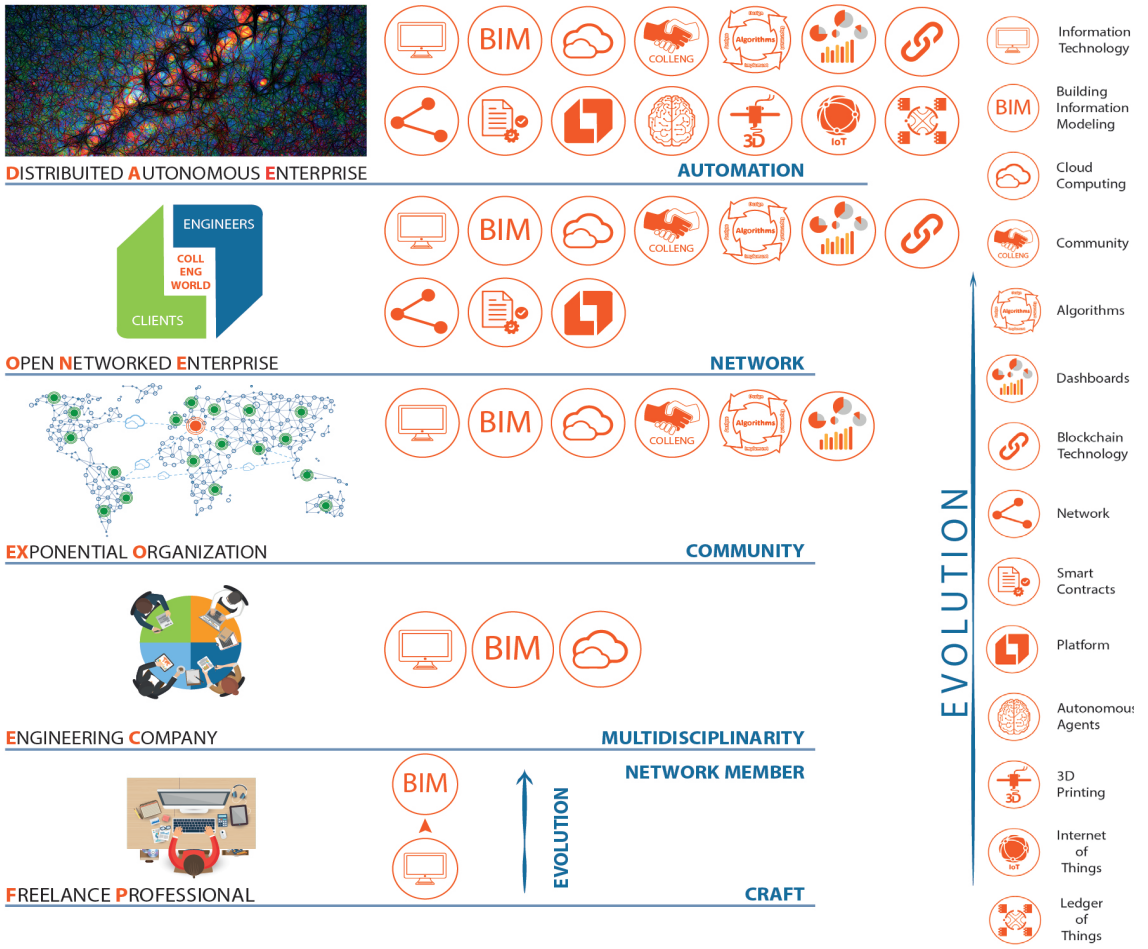
At the highest level of automation, the system would actually become utopian, in the sense that it would suffice to enter the required performance specification in a codec language in order for the entire design and construction process to proceed automatically.

Obviously, human participation would be needed to define the specification of the envisaged structure; there must be a broad underlying vision open to the foreseeable innovations of the future and the fulfilment of the needs of users and of humanity in general.

In short, people and machines could work together, speedily performing their tasks, avoiding unnecessary steps and eliminating errors.

Instruments and technologies as the business model evolves from the freelance professional to the engineering firm, the network and the DAE.

With the evolution of the business model from freelancer, to Engineering to Network and to DAEE new approaches, tools and technologies become more and more necessary.



Graphics from "ENGINEERING ^{n} - Engineering the Future or the Future of Engineering?"
By Maurizio Boi and Patrizia Boi - 2017

CONSTRUCTION TECH TRENDS

Focus on cool construction tech trends

In the field of works supervision, as we have seen in design work, we can renew and implement the approach to construction site governance through a monitoring plan that also exploits a set of "ingredients" offered by technology:

- Cloud;
- Platform;
- Dashboard;
- Design using BIM;
- Blockchain technology;
- Smart Contracts;
- Internet of Things;
- Ledger of Things.

The goal is to give works supervision a new organisational model, or better still, to launch the "*Works Supervision Office*" and apply these new tools to transform the construction site into a "*Works 4.0*".

New interpretative insights for works supervision 4.0

Using the innovative technologies outlined above, we can undertake works supervision by means of certain significant elements, which we shall now analyse in detail.

Cloud

Today, the process of project dematerialisation – the transition from paper to digital media – is firmly established. Throughout the design phase, recourse to analogue data is often just a formality carried out after the final project approval, that is directly performed in a digital format by the responsible professionals. For the various phases of procurement tenders, the default approach is to publish the design and administrative documents and have them digitally signed to make the digital media legally valid.

It is therefore easy to imagine that in the near future we will be able to consult the hard-copy design documents (floor plans, layouts, elevations, sections, construction details, etc.) and, in parallel, review the entire project in the form of a BIM model. From BIM we could then extrapolate any specialist design specification and also a whole host of freely editable and filterable information depending on our objective.

Likewise, it is straightforward to foresee that the BIM model will be accessed through a cloud platform with the required capacity and processing power, through which all the documentation pertaining to the tasks to be performed and the works to be completed will be available in real time for all the participants involved, each with their respective roles in the construction process.

The cloud could therefore streamline the handling of paper documents until they are eliminated, thus helping to solve the confusion often caused on construction sites by overwhelming volumes of paperwork.

Platform

The availability of a cloud – albeit an enormous one – will not in itself guarantee the streamlined use of information by all users, as it will generally be necessary to distinguish between the access and editing permissions assigned to the various operators and project stakeholders according to their roles and responsibilities.

For these reasons, all documentation, notifications and information exchanges must be managed by a specific platform that utilises the cloud to coordinate all processes in real time by means of a reliable and controlled system.

The challenge for the engineering industry in solving the platform ownership issue is that of guaranteeing the sustainability of these new technologies and the security of the relative data and metadata for at least five years.

Dashboard

Successful construction projects must also have a useful dashboard that provides real time information that the team can use to adjust its delivery process midstream. Once you have determined your goals and what you measure, you can use Deming's Plan-Do-Study-Act cycle to continuously improve the work processes to achieve better outcome.

Projects managed with BIM

In order to qualify as "*works supervision 4.0*", the project must be undertaken using a BIM system.

As we know, BIM offers many advantages, including the following:

- the ability to update project accounting records in real time, thus saving time during the selection process and avoiding the detailed development of costly over-budget solutions;
- the possibility of immediately examining each task listed in the programme of works, its dates of execution, the relevant 3D views, its evolving cost over time, etc.;
- the ability to produce all documents related to works supervision within a single model, which in turn incorporates all the modifications and additions that occur as the work proceeds;
- the possibility of visualising the finished structures on-site in the exact position where they will be erected by means of a tablet or a 3D viewer – essentially an in-situ virtual representation of the project design;
- the ability for all participants to enter the same "3D model", to communicate via a single platform, and to make observations and report on specific aspects of the work to be done, highlighting relevant issues in real time and accelerating their resolution.

Blockchain Technology

With Blockchain technology (BCT), we can record all construction site events on non-editable media (a Ledger of Things), thus preventing any tampering which could jeopardise the integrity of the documentation around which the entire contract is structured.

Such a system facilitates the payments made to all those involved in the project, since they are handled automatically on the basis of predefined targets and fixed time frames.
The Blockchain, whose construction site database is not centralised but distributed across all the system nodes, thus prevents fraud, secures the work environment, ensures the prompt payment of each worker and thereby fosters a climate of mutual trust.

Dedicated devices ensure that all site data is automatically gathered and recorded in the decentralised database, thus eliminating the need for subjective data associated with the personal experiences of construction professionals. For example, when laying a road subgrade, there would be no need to elicit the qualification certification of a technician who performs tests and inspections and issues certificates of conformity, since the relevant data would be archived in the database and could be retrieved at any time through a dedicated platform application linked to the Blockchain.

Blockchains may also implement consensus algorithms to resolve issues by majority decision. As such, contrary to conventional centralised organisations, which enforce decisions based on the resolutions of specific institutions or professional bodies, a decentralised Blockchain can operate a consensus mechanism by executing an algorithm.

For example, we may need to determine the load bearing capacity of a floor slab; during construction, the contractor would install dedicated sensors as detailed in a specific Smart Contract, and these would automatically relay the data to the platform.
By processing this data through an appropriate algorithm, the platform could release the required structural conformity certification without the input of any human professional. We can therefore say that the Blockchain "*decentralises trust*"; the concept of trust expressed by an operator performing a given task is transferred from a human broker to the computer network of a decentralised organisation.

Smart Contracts

As already pointed out, a Smart Contract executes and enforces its clauses without external intervention since it is written in a language executed by a computer. The Blockchain's mission is to manage work packages that are triggered automatically, because the Smart Contracts are actually generated during the initial design phase in BIM.

We therefore have a mechanism that not only performs the construction site accounting that governs the ongoing cost scenario, but also handles all the Smart Contracts (which will form an integral part of the Special Contract Specifications), thus ensuring compliance with rules and prompt payments between all those involved in the project's design, construction and management phases.

Therefore, specific Smart Contracts can be implemented to govern any work to be carried out or any supply schedule. They define goals and partial and final payments, and they are triggered automatically to ensure execution at the established times, respecting the estimated costs and expected quality levels.

The Internet of Things

This concept involves embedding processors, sensors and internet connectivity in physical objects, as if miniature computers were incorporated into everyday things: a watch could check airline schedules online and alert its owner in case of delays; an umbrella could monitor online weather forecasts and alert its owner of imminent rain at the door on the way out, and so on.

The application of devices like these in the work of professionals such as engineers and architects is a concrete reality. We can now expect that future works supervisors and construction phase safety coordinators will be assisted by these technological aids, which will greatly facilitate their work.

For example, holograms could illustrate as yet unfinished parts of the structure to construction site operators on a day-by-day basis.

We can thus foresee that, one day, dedicated sensors or automatic devices will determine the characteristics of a particular type of flooring (hardness, sliding coefficient, etc.), thus acquiring the parametric data required for its certification.
Drones making successive flight passes could measure soil movements and terrain configuration. Excavation work could be performed by numerically controlled machines according to project design specifications, but these machines would also be equipped with sensors capable of detecting buried plant in advance.

Increasingly sophisticated smart devices will be available in the near future, i.e. devices capable of monitoring position, integrity, age, quality or any other relevant parameter applicable to a multitude of structural contexts (railway and electric lines, waterways, ports, etc.). The smart aspects of these devices will include the ability to analyse critical conditions, automatically solve problems, and provide quick answers with accurate estimates of the associated costs.

All the data from these devices could also be recorded on the Ledger of Things, allowing for trends and events to be logged over time.

Ledger of Things

All the information generated during the course of a construction project, including that obtained through the Internet of Things, could be acquired – in the form of a shared real-time log – by a large number of computers linked by Blockchain technology, thus mitigating any fraudulent misuse of the recorded data.

With such a log, it would be a simple matter to seamlessly produce any type of certification and expedite the timely resolution of all disputes. This would be guaranteed by the documents being permanently accessible to all the interested parties, with no possibility of tampering since they would be stored on a number of computers so vast as to render a comprehensive breach highly unlikely.

Crowdsourced Justice

Should disputes arise, rather than appealing to the conventional judicial system, justices of the peace or civil arbitration, an alternative could be the crowdsourced justice approach. Litigation could be resolved much more quickly and with little controversy, because a considerable number of experts with appropriate reliability ratings would rapidly express their opinion on the dispute in question.
Indeed, the large number of participants involved, akin to a very extensive people's jury, would function as a guarantee that the judgement passed was correct.

Conclusions:

We can conclude by affirming that all these tools for construction site management could indeed facilitate the construction work itself. However, we must note that today, the manner in which construction site supervision and controls are implemented is dated.

This is partly because the required documentation dates back to the past century, but also because, wherever it has been updated, nothing has been done to change the general verification methods. With the technology already available to us today, construction sites could be transformed into places where all events can be traced and logged, just like the evolution which will begin to impact our daily lives very shortly.

Moreover, Blockchain technology allows the mass of data gathered to be disconnected from the identities of those involved, thus providing a guarantee in terms of privacy norms.

NEW PROFESSIONAL PLAYERS

Focus on the following new professional practices:

- Exponential Project Manager
- Network orchestrator
- Manager of works 4.0
- BIM Manager
- Augmented Designer

"In just the past 20 years, buildings and infrastructure have become vastly more complex than they were for most human existence. Advances in mechanical, electrical, plumbing, conveying, information, and other systems have led to rapidly increasing specialization, dramatically increasing the coordination required to engage the many specialists in a timely, efficient, and effective manner. Construction projects also suffer from variability, unpredictability, and uncertainty, such as which specific system will eventually be selected, who is involved in the building process, how facilities and their systems and parts are produced and assembled, and a host of external factors such as weather, market conditions, and so on. Each project brings together different set of players who might or might not have worked together before; every project is unique in some way. The knowledge and experience of each professional and each company is not integrated in a consistent and timely manner, and consequently innovative ideas and opportunities are missed, overlooked or ignored. Current contractual agreement, rather than reinforcing the need to bring the team members together to create innovative solutions, drive them apart to work in independent silos."

(from Integrating Project Delivery –IPD by authors: Martin Fischer, Howard Ashcroft, Dean Reed, Atul Khanzode)

The exponential project manager

The work style of the traditional Project Manager is suitable for managing processes in which the components of uncertainty are marginal. This type of approach consists in the search for solutions for continuous improvement, through the review and optimisation of individual processes and the introduction of new technological, digital and communication tools. Unfortunately, however, nowadays managers find themselves managing projects with higher levels of uncertainty, especially if we are talking about important infrastructure and work of social importance that require long periods of time to complete. Here are some uncertainty factors:

Uncertainties due to changes in the ecosystem:

- Market in continuous and sudden development
- Changes in social needs that are difficult to forecast
- Infrastructure resilience due to changing climatic conditions
- Growing and unpredictable needs for environmental sustainability

Uncertainties related to exponential technical growth:

- Disruptive technologies
- Effects of digitisation
- Disruptive tools

Uncertainties related to project profitability:

- Consequences of excessive price reductions in awarding public tenders

The Exponential Project Manager is able to work with a disruptive approach. This second type of approach completely distorts traditional organisational and business models. In the world of industry and engineering this approach is recognisable in Start-up and Integrated Project Delivery (IPD) activities.

The start up:

- is continually geared towards innovation, which implies an openness to seeking ideas everywhere
- has the culture of experimentation, provided it occurs with rapid and iterative cycles
- is oriented towards viewing smart failures as physiological, necessary to make real innovation possible, as they allow you to quickly see how far you are from the objective set

Lean Start-up style represents a way, if not the only way, to maintain the role of engineers / architects who innovate through ingenuity and creativity.

IPD: Integrated project delivery is an innovative way to excel your construction planning reducing waste, cutting costs and improving productivity. The Integrated Project Delivery main goal is to create a team effort integrating owner, architects, engineers, managers and subcontractors.

By using this style, professionals try to go beyond project standardisation, creating "*disruptive*" solutions, which make hiring them worthwhile, since their professionalism will no longer be indispensable for standard projects. Because standardised projects, whether we like it or not, will be available in catalogues in the near future to millions in their BIM models, and they will be available to be used freely by customers, builders and public administration, who will simply "*print*" the work using a 3D printer.
For many existing projects, they will simply, probably automatically (let's remember algorithms design), adapt the models to the site and to the external environment.

In summary, the start-up is an organisation that aims to look for a business model that is scalable and repeatable, and it is characterised by operating in conditions of extreme uncertainty.
The first thing we should consider is that the traditional Project Manager "suffers" when forced to operate in conditions of extreme uncertainty. It is here that the Exponential Project Manager comes into the picture.

Exponential Organisations have learned to handle situations of extreme uncertainty through:

- Preliminary assumption of work hypothesis;
- Setting up experiments to test hypotheses in the quickest and cheapest way possible;
- Analysing the results by reading the data;
- Making decisions guided by data reading (data driven decision making);
- Implementing the resulting strategies.

In the process we have just described, the ability to innovate is amplified through:

- Engagement actions (necessary to form Communities);
- Communities (which facilitate the collection of ideas);
- Algorithms (decisive for process automation);
- Dashboards (essential for data monitoring).

The substantial difference compared to normal project management consists in the fact that in addition to the traditional parameters to be managed **Quality - Time - Cost**, two more parameters need to be added: **Degree of innovation - Uncertainty.**

The Network Orchestrator

As we have just demonstrated, engineering lends itself to being network-centric. Thus, the need arises to introduce a new figure necessary to manage the network, this figure is the Network Orchestrator.

The Network Orchestrator is the manager / entrepreneur who must manage the Network, and this is one of the most interesting professions of the future based on Platform Business. In fact, as we have seen, the most effective way to become network - centric is to operate through digital platforms and generate artificial ecosystems that aspire to create the "perfect market" that can be precisely managed by the techniques of the Network Orchestrator.

In summary, it is how to manage the economic aspects through the ability to orchestrate market behaviour, through a platform dedicated to the specific line of business. Examples of success in various sectors are Facebook, YouTube, Airbnb, Uber, etc. Thus, in the Platform Business, value is created by orchestrating external activities in vibrant communities rather than managing internal company activities. In fact, it is much easier to climb higher by means of the masses, than by means of your internal co-workers only. Therefore, knowing how to manage the external world is becoming a fundamental capacity for management. If we refer to the engineering world, it is a matter of creating and managing the appropriate platform suitable for manage the massive projects between the operators in the sector.

The Network Orchestrator must implement the contents of the platform, eliminating the friction existing between operators in the sector and managing their behaviour using standardisation, systematisation and automation, to optimise results. Optimisation starts with the reduction of so-called "*Transaction Costs*" and "*Coordination Costs*" that is, the costs of taking part in an interaction that could be divided into three categories:

1. Research and information costs for, for example, forming a temporary grouping in a competition (reduction obtained using a match algorithm)
2. Costs for reaching and drafting contractual agreements (reduction obtained using smart contracts)
3. Costs associated with managing the reliability of the parties involved (reduction obtained using an effective reputation system).

There are techniques for coordinating massive online collaboration both "*by peers*" (wikinomiks) and hierarchies, such as the creation of Flash Teams. Expert Crowdsourcing with Flash Teams are teams created dynamically to solve complex and interdependent problems, through structured online collaboration between experts engaged in the collaborative platforms. In order to achieve their objectives, the Flash teams operate using a sequence of connected tasks, usually lasting a day, which can be combined in blocks up to the size of large organisations thanks to their modular nature. The collaboration is structured through algorithms and automatic data collection, within a general ecosystem that favours organisational behaviour.

Manager of works 4.0

Up to now, the construction site context has often been constrained by the improvised approach of the works contractors, while the role of the works supervisor has been far from what it should be: a *"works orchestrator".*

In the case of engineering and/or architectural works, the works supervisor has neither an interpretative role nor the function of "*orchestrating*" the cues of the various participants involved in the construction process – these roles are performed by the contractors themselves as they coordinate on-site resources, subcontractors, suppliers, site procurement, etc. The mission of this role is to exercise control. While works supervisors do not direct their 'orchestras' as such, they must ensure that the "*score*" is faithful to the project design and that the quality of execution complies with the relevant contractual commitments.

This requires a great deal of organisational effort ahead of the work itself; the project design must specify every detail, every technical and performance characteristic related to the materials used and the items supplied. The works supervisor should also possess all the tools required to verify the execution quality as well as schedules covering even the most elementary tasks, operations that must be executed as a priority, and any critical issues. Above all, works supervisors should be assisted – especially for more complex and multidisciplinary projects – by an "*orchestra*" of specialists.

Works supervisors should, indeed, handle all the problems of a construction site by carrying out their tasks within an organised system. Instead, they are required to behave like clerks who approve what has been concluded and duly authorise payments according to the works progress report. When solving critical issues, they proceed by trial and error – just like designers, they cannot be fully versed in every discipline.

In a world where technology is racing forward, even though they cannot be knowledgeable about everything, they are supposed to perform like omnipotent supermen: in short, like gods. Furthermore, whenever there is backup from other support figures (operations directors, site inspectors, etc.), the responsibility for everything that happens on-site – all criminal, civil and third-party liability, in the event of a collapse, accounting errors, incorrect pricing or payments – is not equally shared among the collaborators, but all falls on their shoulders.

These are legacy practices from when construction projects were simple, but construction engineering today has become very complex. We have to take a multitude of decisions and control enormous amounts of data, as well as having multiple skills. Works supervision should therefore also be organised differently; it cannot be simply limited to tallying and bookkeeping, nor can it be reduced to a single person going on-site to check on everything. If anything, we should be able to count on the assistance of a team of experts working in synergy.

However, we would now like to focus on a concept derived from Blockchain technology. We envisage a system which is not controlled at a central point but is distributed across multiple nodes, one which indisputably establishes the truthfulness of events through a decentralised consensus mechanism that runs on nodes and/or miners. Insisting on the centralised operation of a construction site based on the role of the work supervisor – an omniscient master of all disciplines, capable of controlling every process, qualified to perform any technical assessment, to validate the quality and origin of the materials, and so on – means presuming that one person alone can be so knowledgeable as to be able to do everything, but this is manifestly impossible.

Instead, as in the case of the designer, an appropriate alternative would be to relinquish the centralised concentration of all responsibility in the hands of a single person and to vest this role in a distributed system of nodes and/or miners.

In practice, this solution would be based on the collaborative effort of a team endowed with superior skills thanks to a network that encompasses the knowledge of many.

It would be more effective if the quality of the work were to be verified in a distributed and non-centralised manner through the efforts of several professionals linked by a Blockchain who would perform the checks, each applying their own skills.

In the field of works supervision, we can implement a set of new technologies:
Cloud - Platform - Dashboard - BIM - Blockchain technology - Smart Contracts - Internet of Things - Ledger of Things - Crowdsourced justice.
The goal is to give works supervision a new organisational model and apply these new tools to transform the construction site into a *"Works 4.0"*

BIM Manager

Presently, construction industry is dealing with numerous software and new technologies made available under the BIM umbrella. Introducing BIM in the building life cycle approach has changed the way of running projects exponentially from the old-fashioned design story-telling to completely interactive information model – a BIM model.

Striving to create additional value to the Project, engineers have made room for a new post in the team - a BIM Manager with duties and responsibilities which shall embrace skills in communication, planning, design, delivery and apparently know-how in new technologies.
In construction industry renowned for tight deadlines, high quality and low profit margins, the push for change and innovation needs to be well compiled and well considered, and the BIM Manager is fundamental here.

For many companies a BIM Manager is an essential player recognized as a driver for changes well informed about digital transformation. What is clear is a 'BIM Manager' cannot be identified by a uniform set of tasks. This is a role that varies across sectors and from company to company. Moreover, the role of a BIM Manager is in constant flux as working practices change to meet the ever-evolving demands of the digital construction revolution.

The BIM Manager's job is, as you would expect to 'manage', but this is not a management role in the traditional sense.

The main role is about change management, getting advantage of the technology, process change in ways of working to deliver the outputs needed for collaborative construction.

The BIM Manager's job is not about to prepare the Design, but to blend and create the model, and to communicate conflicts in the model of all BIM logistics, including Contract documents, the Design, Communication and Information sharing.

Augmented Designer

The modern AEC (Architecture, Engineering, and Construction) industry needs a new kind of innovative designer capable of:

- Working within the learning cycle PDSA (Plan-Do-Study-Act)
- Managing integration and lean practices with VDC (Virtual Design and Construction);
- Focusing on the MDO (Multidisciplinary Design Optimization) process;
- Using with confidence the IPD (Integrating Project Delivery) approach;
- Understanding network-centric organisations such as ExO (Exponential organizations), ONE (Open Network Enterprise), and DAE (Distributed Autonomous Enterprise)

This new category of designer is called an "*Augmented Designer*".
They form a cross-functional and multidisciplinary "*Augmented Team*" that has the knowledge to deliver high-performance buildings/infrastructures as a product.

The VDC method can be used to predict the performance of buildings for definite performance criteria, and MDO can be used to create simulation models to evaluate millions of alternatives and choose the optimal solution design from many perspectives and make faster and better-informed decisions.Today this is possible through Parametric BIM and parallel computing.

Role of the Augmented Designer

The Augmented Designer *"will spend more time doing more creative activities that require significant expertise and judgment, such as formulating design problems, defining the range of options to explore, and selecting appropriate analytical representations. Machines will take care of the more routine tasks of modelling and generation and analysis of alternatives. This shift should help good designers and engineers to demonstrate their value in the marketplace more clearly" (from Integrating Project Delivery –IPD by authors: Martin Fischer, Howard Ashcroft, Dean Reed, Atul Khanzode)*

BLOCKCHAIN TECHNOLOGY

Focus on decentralized systems mathematically managed by a network of computers with the aim of helping or replacing intermediaries, especially in the public sector.

What is a Blockchain?
A Blockchain is a huge file which stores data in a logical, historical, secure and immutable way.

What we can do with a Blockchain?
Blockchain is such a young technology that future developments will open up endless possibilities.

Some visionaries believe this is the Internet of the future, a kind of version 3.0!
The blockchain does not need a third party to operate since every node has a constantly updated copy of all the transactions that have ever happened!
Everyone can contribute to the validation of transaction, so it becomes immensely difficult and not economically convenient to cheat.
A blockchain is basically a "*thrustless system*". You do not need to know anything about the other users or trust them as individuals to initiate a transaction.
The task of blockchain technology is to verify the truthfulness of facts, of data, of processes or events; without having to rely on centralized systems, managed by human beings, but rather on a decentralized, approved system, mathematically managed by a network of computers.

Smart contracts

In brief, Smart Contracts are programs run by a network of peer to peer nodes whose consensus mechanism guarantees the correctness of the execution. When a certain programmed condition is triggered, the software underlying the Smart Contract simply executes the terms of the contract.
This can be seen as a traditional contract, but without the need for a lawyer to draft complex legal clauses, a notary to witness the signatures, or a guarantor to register a copy of the contract: in essence, it is just a piece of software code. The underlying principle of any Smart Contract is that it allows companies or people to automate tedious and expensive processes.

Possible applications of Blockchain technology in Engineering

The following are the main applications identified in the field of engineering:

1. The creation of an interconnected system of public and private Blockchains. This enables the creation of an ecosystem that simplifies and optimises the interaction between all the involved parties, who thereby benefit greatly from interoperability. Moreover, decentralisation – which can be achieved by automating most decisions – reduces the power of central authorities and increases the possibility of users contributing to the process.

2. The creation of a Blockchain platform aimed at establishing an engineering marketplace where all engineering stakeholders can interact with the goal of achieving the desired efficiency of the Fourth Industrial Revolution.

3. The creation of a public digital procurement system that could benefit from the use of Blockchain technology. This would consist of an automatic or semi-automatic public procurement tender system that would not require adjudication commissions and where decisions would be the outcome of previously implemented mathematical consensus mechanisms.

The following benefits would ensue:
- standardisation and transparency of procedures;
- simplification and elimination of discretionary power and corruption;
- real-time awarding of contracts;
- swift and automatic resolution of any disputes;
- exponential reduction in procedural costs;
- application of meritocratic criteria;
- guarantee of obtaining optimal quality from the assignee contractor.

4. The creation of a DAEE (Distributed Autonomous Engineering Enterprise) that streamlines, simplifies and automates business processes through a private Blockchain platform.

5. The organisation of the Works Supervision function (W.S. 4.0) through a decentralised management, testing and monitoring approach made more effective by the application of Blockchain technology.

6. The implementation of a specific new node/miner service dedicated to engineering works and designed to assist the General Contractor in all the crucial design, construction and management phases. This service will create, implement and manage all the consensus algorithms needed to ensure the achievement of the set goals throughout the various phases.

7. A Sidechain Platform aimed at optimising the management of individual projects hosts the Smart Contracts that implement a decentralised project management solution. The main steps are validated by miner nodes and recorded in the ledger, while micro-payments are issued subject to specific consensus algorithms linked to the BIM model.

Through a new platform, the following Smart Contracts are in experimental stage:

- Work packaging, used to define work packages and their contractual aspects;
- Project management support, used to define milestones and lay contractually down the relevant verifications executed via the network. The protocol is designed to ensure that the project manager has the support needed to ensure timely intermediate verifications and a high level of reliability;
- BIM packaging, used to trace and measure activities developed in the BIM model by individual BIM operators;
- Smart collaborative engineering services, essentially a Smart Contract template currently under development for public and private clients. The system is designed to automate the project implementation process with extremely short and reliable lead times by decentralising the intermediate verification steps via the multidisciplinary network.

BIBLIOGRAPHY

Boi Maurizio and Boi Patrizia, Engineering ^{n} - Engineering the Future or the Future of Engineering?, Te.x 2017.

Boi Maurizio and Boi Patrizia, Ingegneria elevato ^{n}, Ingegneria del Futuro o Futuro dell'Ingegneria?, Dei Merangoli Editore 2017.

Ismail S., Exponential Organizations: Why new organizations are ten times better, faster, and cheaper than yours (and what to do about it), Diversion Books 2014.

Kelly K., The Inevitable: Understanding the 12 Technological Forces That Will Shape Our Future, Penguin 2016.

Libert M. Beck, J. Wind, The Network Imperative: How to Survive and Grow in the Age of Digital Business Models, Harvard Business Review Press 2016.

Martini P., Blockchain Fast and Simple - What It Is, How It Works, Why It Matters: Understand the Basics, Join the Revolution, independently published 2016.

McAfee A. and Brynjolfsson E., Machine, Platform, Crowd: Harnessing Our Digital Future, W W Norton & Co Inc, 2017.

Mougayar W., Buterin V., The Business Blockchain: Promise, Practice, and Application of the Next Internet Technology, John Wiley & Sons 2016.

Nielsen M., Reinventing Discovery: The New Era of Networked Science, Princeton University Press 2012.

O'Reilly T., WTF?:what's the future and why It's up to us, Cornerstone Digital, 2017.

Parker T., Smart Contracts: The ultimate guide to Blockchain Smart Contracts – Learn how to use Smart Contracts for cryptocurrency exchange!, CreateSpace Independent Publishing Platform 2016.

Ramsey S., Blockchain: Quick start guide to understanding Blockchain, the biggest revolution in financial technology and beyond since the internet, CreateSpace Independent Publishing Platform 2016.

Raskino M., Waller G., Digital to the core: Remastering leadership for your industry, your enterprise, and yourself, Routledge 2016.

Ries E., The Startup Way: How Modern Companies Use Entrepreneurial Management to Transform Culture and Drive Long-Term Growth, Currency 2017.

Rifkin J., The zero marginal cost society: The internet of things, the collaborative commons, and the eclipse of capitalism, St. Martin's Press 2014.

Rogers D. l., The digital transformation playbook: Rethink your business for the digital age, Columbia University Press 2016.

Schwab K., The Fourth Industrial Revolution, Crown Publishing Group 2017.

Susskind R., D. Susskind, The Future of the Professions: How Technology Will Transform the Work of Human Experts, OUP 2015.

Tapscott D., Tapscott A., Blockchain revolution: How the technology behind bitcoin is changing money, business, and the world, Penguin 2016.

Thiel P., Masters B., Zero to one: Notes on startups, or how to build the future, Crown Publishing Group 2014.

Williams D., Tapscott D., Wikinomics, Atlantic Books Ltd 2011.

Williams A. D., Tapscott D., Macrowikinomics: New solutions for a connected planet, Atlantic Books Ltd. 2011.

Chapter Photos: www.unsplash.com

European Federation of Engineering Consultancy Associations
Avenue des Arts 3/4/5 - B - 1210 Brussels - Belgium
T. +32 2 209 07 70 - F. +32 2 209 07 71 - efca@efca.be

www.efcanet.org

efca

Representing FIDIC in Europe