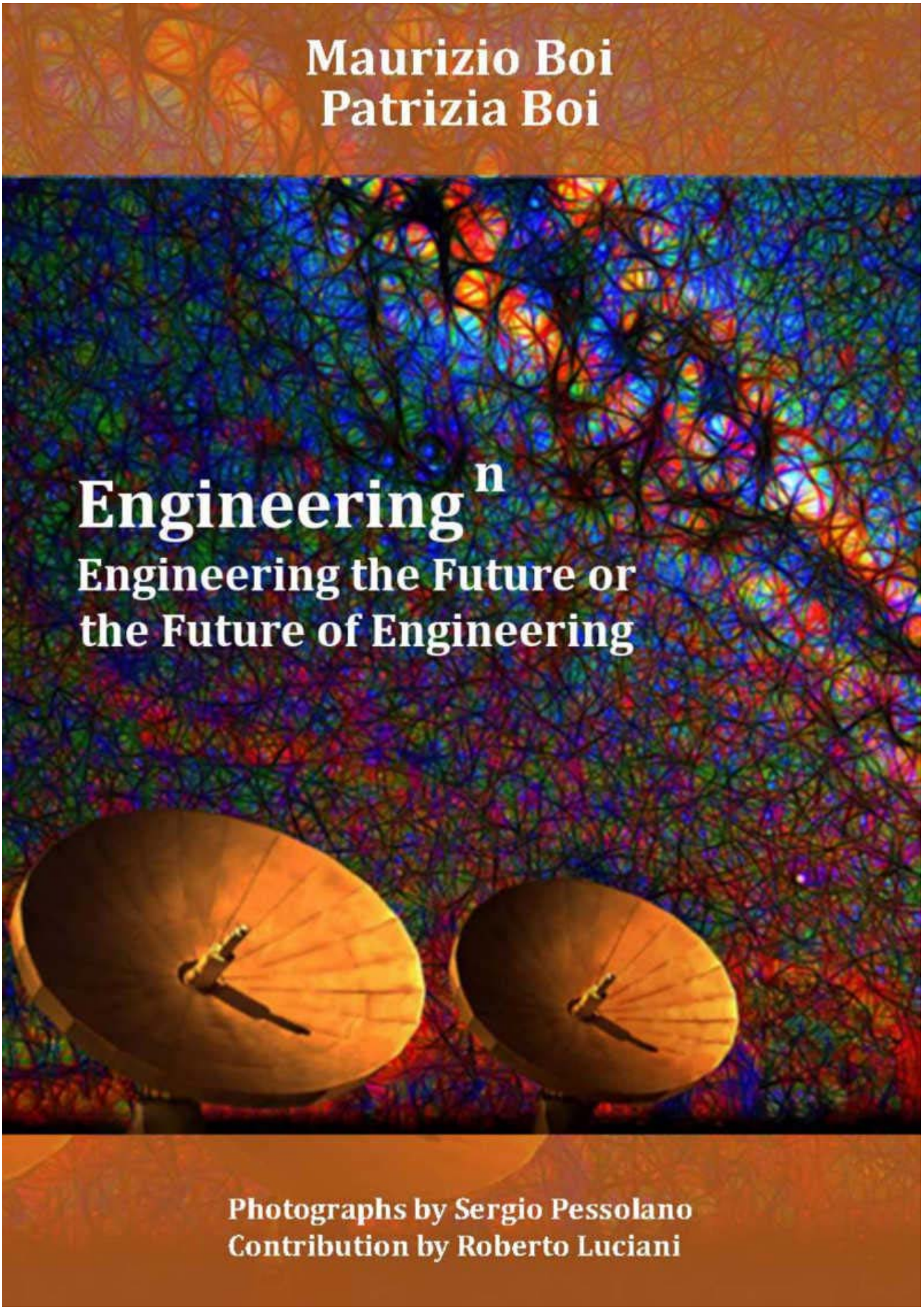
***PREVIEW:***


Maurizio Boi
Patrizia Boi
Engineering n
Engineering the Future or
the Future of Engineering
Photographs by Sergio Pessolano
Contribution by Roberto Luciani

**Engineering** $^{n}$

**Engineering the Future or the Future of Engineering?**

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**Maurizio Boi - Patrizia Boi**

# Engineering $^{n}$

Engineering the Future or the Future of Engineering?

*Prefaces*

**Alain Bentéjac**
FIDIC President-Elect

**Kevin Rudden**
EFCA President

**Jan Van der Putten**
EFCA Secretary General

**Patrizia Lotti**
OICE Past President

*Contribution by* **Roberto Luciani**

*This work is dedicated to our children, Marco Boi, Anita Guidi, Elena Pessolano, and Angelica and Anastasia Luciani, today's teenagers and tomorrow's professionals. It is through them that we had the opportunity to collaborate, and we wish them a future of openness and connectivity.*

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# Prefaces


## Alain Bentéjac

FIDIC President-Elect

*International Federation of Consulting Engineers*


I am delighted to write this brief preface to Maurizio Boi's book on engineering. I know Maurizio for some time, especially as Member of the Board of the European Federation of Engineering Consultancy Associations (EFCA), and I have always been impressed by his in-depth knowledge of our profession and his strong interest for the new technologies. Maurizio is genuinely an engineer, but his reflection on our industry goes far beyond the usual visions. His is passionate about the future of our profession, and the likely impact of new technologies on it This question is key, and must be addressed with great attention. This is why Maurizio's piece of work is so interesting and stimulating. In my opinion, the impact of new technologies on the engineering industry must be assessed in two distinct areas: the impact on professional practices in the one hand, and on our business models in the other.

Regarding the professional practices, it is obvious that the consequences are dramatic, and are drastically changing the ways engineers are doing their job. The innovations wiith an impact on our practices are numerous: 3-D Simulations, Building Information Modelling (BIM), collaborative design…More and more projects benefit from these new tools, especially BIM.

Maurizio Boi describes comprehensively and clearly this important distuption. Some segments of our business, like structural engineering design, will probably be more affected than others. The use of the new technologies will certainly improve the quality of the design for many projects, but it will require a lot of efforts from the engineering firms to meet this challenge: acquisition and utilisation of new softwares, huge training programmes for their employees, new methodologies encouraging collaborative engineering.

Many engineering companies are well aware of this disruption and have already invested heavily in softwares and human resources development.

This trend is likely to have an impact on the structure of the industry, with more mergers and acquisitions, since this effort of adaptation requires stronger human and financial capacities.

Another possible consequence of the introduction of the new technologies might be the disruption of the business models of the engineering firms. The big question is: will our industry be facing the same massive disruptions as some othe sectors, such as the banking industry, the hospitality sector, the transport, the travel agencies ...These industries have been deeply and quite suddenly disrupted by the "new economy".

As far as the consulting engineering sector is concerned, it is too early to make a clear prediction, but I am of the view that our industry is quite specific and will probably be impacted in a different manner. So far, the most disrupted industries develop B to C models whereas the engineering business model is pure B to B, with a "taylor-made "approach", due to the fact that each project is special. "One size fits all "is not an appropriate concept for our markets.

Another very important sign of a disruption in the market is the presence of new firms, with a completely different business model. These "start-up "companies are not very visible in our markets, at leats for the time being. It is perhaps a matter of time only, and it will be of great interest to observe the new trends in the market in the upcoming years.
Anyway, the managers of the engineering firms must remain vigilant and must follow with great attention all the developments in the market. FIDIC, the International Federation of Consulting Engineers plays a very important role in this respect, and, as a global organisation, can be of great assistance for the industry by dissiminating best practices and anticipating the future.

No doubt that Maurizio Boi's outstanding work will strongly contribute to this crucial prospective reflection.

**Kevin Rudden**
*EFCA President*
*European Federation of Engineering Consultancy Associations*

As Engineers in the modern world, we are facing a technological revolution. A revolution in the way we design, construct, operate and manage our infrastructure. The speed of the current breakthroughs has no historical precedent. The components we use are transforming. The way we design is transforming. These dynamics affect every single business, every industry, in every Country and frankly every human being on the planet in one form or another.

Billions of people connected by mobile devices, with unrivalled processing power, storage capacity, and access to knowledge, will create unlimited possibilities for our Industry. And these possibilities will be multiplied by emerging technology breakthroughs in fields such as; artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing. Are consulting engineers and associated professionals ready for such an opportunity?

Maurizio and Patrizia Boi demystify the technological revolution unfolding before our very own eyes; 3D printing, blockchain, Wikinomics and evolving organisational structures. The utter uniqueness of this book is highlighted by how these new concepts directly impact on the operation of a modern-day engineering consultancy business. They further integrate these concepts with the practical management of works on site and explore technological innovations in restoration.

Using these new tools 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 this technology, to re-invent the design process Ab Initio – from the beginning.
Today, the only constant is change. The rate of this change is increasing uncontrollably. Maurizio and Patrizia demonstrate how our competition is no longer the multinational multi-disciplinary practice with thousands of employees.

Instead, we are challenged by a new nimble exponential organisation that utilises the latest technologies and cuts superfluous expenses to create a fusion of minds in global collaboration in order to deliver flawless solutions with optimal cost efficiency.

This book examines two diverse visions rooted in diametrically opposed mind-sets. Firstly, Patrizia Boi provides us with the viewpoint of a person who perhaps rejects the sheer power of the virtual world and craves connection with the beauty of nature. The second vision expressed by Maurizio Boi embraces all the technological wonders of today's world. The technophobe versus the technophile; An intriguing contrast of mind-sets.

Throughout their extensive exploration of the latest technological advances, the Authors proceed to challenge the decidedly hierarchical nature of traditional consulting companies and compare them to the *Net Generation* approach. But they don't stop at the theory behind the concepts. Maurizio demonstrates how he has put his theories into practice as he takes us on the journey of the conception, birth and development of TE.x, his new innovative collaborative engineering concept. TE.x represent the evolution of engineering and architecture organisations in the Fourth Industrial Revolution. Experience and creativity synergies in a collaborative digital environment, experimenting with new ideas, smart engineering solutions and cutting-edge technologies.

Maurizio and Patrizia challenge future generations of engineers to breach their traditional boundaries of knowledge and become thinkers. It will become their mission to solve the problems of humanity with the passion and creativity of an artist. They give us 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.

There are many CEO in the established industry who will undoubtedly challenge some of the unique ideas put forward by the authors, dismissing them as far-fetched or futuristic. Shattering the status quo is always disruptive. Anyone can write about ideas that are readily acceptable to the masses, but writing as Maurizio and Patrizia do, about ideas that will become acceptable is true genius.

**Jan Van der Putten**
*EFCA Secretary General*
*European Federation of Engineering Consultancy Associations*

I first met Maurizio Boi some four years ago when he was nominated as the Italian candidate for the EFCA (European Federation of engineering Consultancy Associations) Board of Directors. Since his election, Maurizio has substantially contributed to the vision of the federation by enhancing the dialogue on new technologies and organisational models in engineering consultancies. My first impression of Maurizio was one of "An engineer and a gentleman" by analogy with the movie with Richard Gere.

Soon after his election as EFCA Director it became clear that Maurizio, a native from Cagliari in Sardinia, was into new business models. Over time he acquainted the EFCA Board with his views on collaborative engineering based on new technologies and networking, and new business paradigms. What he showed us are real eye-openers which should be seriously considered by each and every engineering consultant. As you read through the book of Maurizio and Patrizia you will understand why.

Back in 2009, EFCA assigned a Task Force to unravel the impact of the crisis on the market and industry, and to prepare the firms for the future. The Task Force's findings and results culminated in a publication entitled "Taking hold of our future", a briefing paper for the engineering consultancy industry that was intended to assist engineering consultancies' thinking about their future business model as business conditions change.

This book intellectually stimulates the readership to go much further: it explores new ways of collaboration and organisations, making use of leading-edge technologies.

Anno 2017, the world looks different. Challenges such as energy insecurity, the treat of scarce resources, booming and ageing populations, and an environmentally weakened planet require even increased firepower.

Many firms, especially small and medium-sized enterprises, in the engineering consultancy and architectural industry have fallen prey to financial and market pressures and have either closed or been absorbed by larger companies. To survive, and prosper, those remaining are having to take control of their own future, carefully assessing the markets, evaluating their own capacities, and giving themselves a strategic pathway to take them forward.

The EU strategy for sustainable growth, "Europe 2020" is encouraging all sectors to innovate, educate, and make full use of modern technologies to work towards 'smart', 'sustainable', and 'inclusive' growth.

As engineering consultancy firms gear up to take advantage of the opportunities, they have to be fully aware that this time business solutions must be sensitive to both planet and pocket. This demands real innovation and, more often than not, a change in mind-set when dealing with the technical, financial and human needs of both firms and markets. The engineering consultancy industry can join those in the forefront of these changes. Larger firms have already reacted with new strategies and movement into new areas. SMEs can do the same.

This book is giving food for thought for those firms coming to terms with the changing environment and to help highlight where the opportunities might lie.

Our strength as an industry lies in our people and their problem-solving abilities, their integrity and their creativity in producing timely and cost-effective solutions. Now, more than ever, we should be using these same skills for adjusting our businesses, taking responsibility and leading our clients into a more sustainable and profitable future.

Many readers of this book will challenge the ideas put forward, but Maurizio has demonstrated that his alternative approach to how a virtual engineering consultancy can operate with his company TE.x. TE.x is an exponential organisation of the new generation built on the Internet of Things and that embraces all new technologies for the benefit of clients and society.

Thank you, Maurizio and Patrizia, for acquainting us with these developments.

**Patrizia Lotti**
*Past President OICE*
*Italian Association of Engineering and Architecture Firms.*

I am bound to Maurizio Boi by profound feelings of friendship and, above all, respect, having worked with him for over 15 years as part of the Governing Council of *OICE*, the Italian Association of Engineering and Architecture Firms. I admire the dedication, determination and professionalism that has always accompanied his work in the continuous pursuit of the common good of our members.

I was, therefore, overjoyed to accept his invitation to write the introduction to this book, strongly driven by Maurizio but co-authored with his sister Patrizia, a professional engineer and author of short stories, fairy tales and scientific articles.

This work is not only about Engineering; rather, it examines everything we do in life from diverse perspectives. As such, the text could be said to have three interwoven souls: a lucid and attentive intelligence looks at the future possibilities of the profession; a creative literary mind seeks beauty and harmony in these opportunities; an enchanted observer sweeps his gaze over the lives of diverse peoples living on our planet and frames them for our contemplation. Only Maurizio Boi, Patrizia Boi and Sergio Pessolano could compose such a team.

For these reasons and many more, what emerges is a thorough and complex analysis that begins with an insightful study of the past and present roles of the Engineer and evolves into a projection of how this professional figure will shape our future. Our past, alas often neglected, is evoked to stir our pride as we initially recall Vitruvius and the master builders of Ancient Rome, whose unique legacy still astounds us with its modernity.

Then comes the Renaissance, expressed by the genius of giants like Da Vinci, Bernini, Brunelleschi and Michelangelo, who merged art and science to create works of unparalleled ambition that stand as towering achievements to this day.

According to Raymond Kurzweil, what we are facing today is "*a future period during which the pace of technological change will be so rapid, its impact so deep, that human life will be irreversibly transformed*" -- an inflationary technological and social *Big Bang* which is now dawning on us, so disruptive that it inevitably leads to the questions at the heart of this book: what will Future Engineering look like? What forms will it take? What will the Future of Engineering be? How will our profession be affected?

Following this preamble, the authors proceed to accurately describe the innovative technologies, the state-of-the-art tools, and especially the new organisational models that are currently evolving, including Exponential Organisations, *Wikinomics*, *BIM*, *3D Printing*, *Blockchain Technology*, *Bitcoin* and *Smart Contracts*. They also analyse the possible evolution of these phenomena, such as our approach to design, works management, architecture, problems related to restoration, and *Virtual* and *Augmented Reality*.

From all of the above, a key suggestion emerges to address the challenge of the future: the transition, in an Engineering context, from work carried out by individual professionals to the collective approach. "Collaborative Engineering" is the true cultural revolution. The mission to collaborate -- present in the "animal organisations" of nature in a simple yet significant form, as the authors observe -- and the willingness to expand our worldview may yet empower us as the makers and masters of our own destiny.

Established professionals should identify with this book, and I trust that reading it will encourage them to look to the future with curiosity and an increasing belief in the value of collaboration. However, it is also a book addressed to young people born in the digital age and having that instinctive "spontaneous" knowledge of current innovations, capable of looking to the future without fear of being overwhelmed by change and ever confident of their power to "dominate" it.

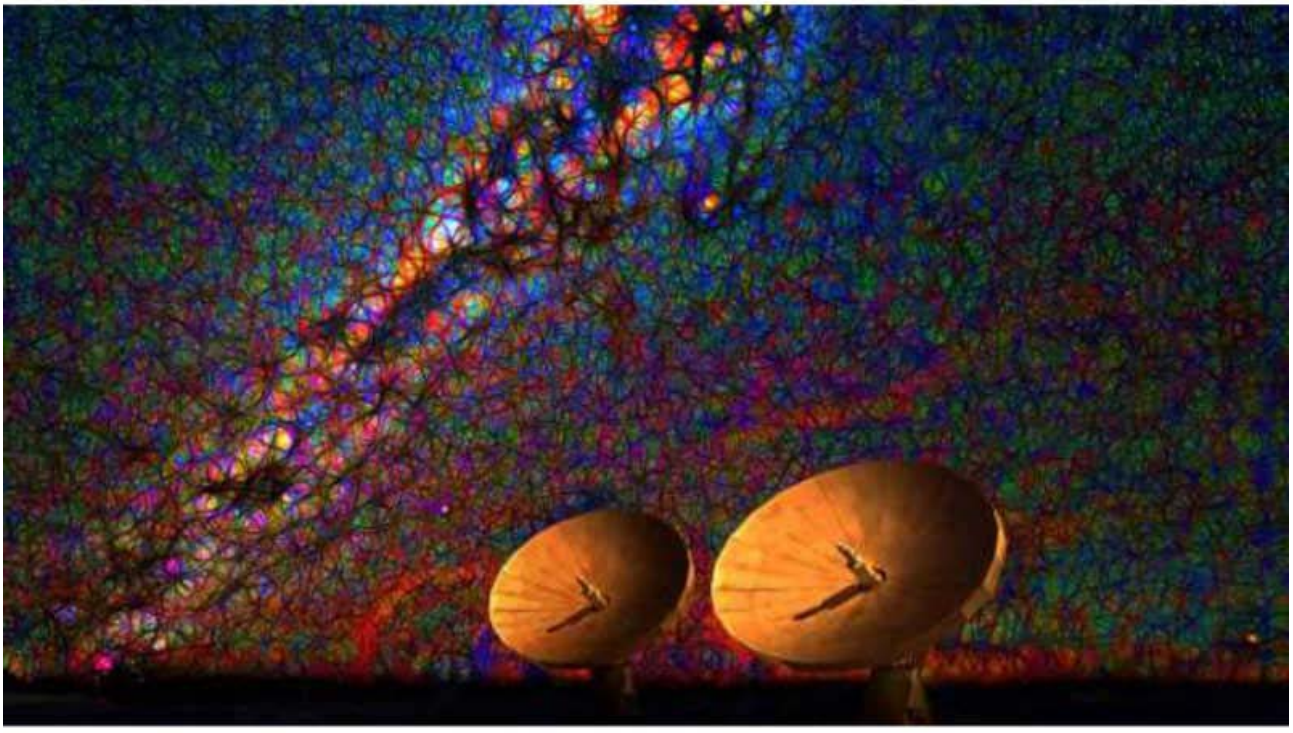
# Introduction

Today's engineering projects, whether simple or complex, depend on an extensive range of skills and expertise that can rarely be found in one individual alone. For this reason, we must find a way of collecting all the necessary skills in a container capable of integrating the various disciplines.
The increasing pace of technological innovation is also forcing us to change our design approach. Rather than simply considering the knowledge gleaned from the past and present, we must now envisage the future scenarios in which a constructed work will be used and design it accordingly.
It follows that it is becoming increasingly complex to carry out engineering works. While the last 50 years have seen the establishment of engineering that have successfully addressed the issue of multidisciplinarity, such organisations are now inadequate when faced with the exponential rate of technological progress today. Indeed, the costs of this organisational model, both in terms of staff and design tools, are no longer sustainable. To overcome these drawbacks, new organisational models such as *ExOs* (Exponential Organisations) have emerged which are based on the *community* approach, mass collaboration and collective intelligence.
The adoption of these new *business* models offers renewed growth prospects, and the new science of *Wikinomics* has evolved to govern their complexity. The metamorphosis of the *ExOs* has been made possible by new technologies – such as *Blockchain* and *Smart Contracts* – through which the *ExOs* can evolve into *Open Networked Enterprises* (*ONEs*). By further increasing the degree of organisational automation, an *ONE* can be converted into a *Distributed Autonomous Enterprise* (*DAE*).

Additionally, in order for these new organisational models to be implemented, other effective and targeted operating tools have evolved in engineering contexts: *Building Information Modelling* (*BIM*), together with *3D Printing*, *Robotics* and the *Virtual Assistant*. In the near future, such tools may profoundly change the designer's approach to works of Engineering and/or Architecture. One of the essential aspects when implementing all these innovations is the professionals' ability to transform their outlook, no longer thinking in an isolated manner, but adopting Collaborative Engineering techniques and exploiting the opportunities offered by *networks*. It is also necessary to ask how this innovation impacts project execution and, therefore, the relevant approach to the Supervision of Works – which could be defined as 4.0 – not only in the case of new constructions but also in relation to complex restoration sites.

The natural evolution of *business* models and the profession in general is a very interesting subject that can be addressed by analysing the two possible scenarios: it could be "Engineering the Future", i.e. something that will certainly happen, although we do not yet know 'how' and 'when'; on the other hand, it could be the "Future of Engineering", or the only way to continue doing Engineering. Indeed, technological evolution is inevitable and we must understand these transformations in order to enjoy their benefits. The logical path underpinning the overall approach of this study involves analysing and contemplating our history so as to understand and plan for a future based on collaboration and multidisciplinarity. Covering thirteen chapters and three appendices, this work is also imbued with further meanings, symbolic and otherwise, thanks to the extraordinary photographs of Sergio Pessolano. However, to show that we are not simply expounding argumentative speculation for its own sake, each chapter ends with a "conversation" between a professional accustomed to operating according to methods in use from 2000 to the present and another who, conversely, employs those technology aids that are already largely available today and that will be well-established from 2020 onwards.

# Engineering $^{n}$



Sergio Pessolano. *Dark Matter*.

*"I got an idea of what "dark matter" might be, or how it might look if we could observe it. I've taken the sky in this image, with the stars of the Milky Way crossing it as we would normally see it, and converted it to my idea.*
*Dark matter is defined as such because it does not emit nor absorb light or any other electromagnetic radiation at any significant level.*
*According to the standard model of cosmology, the total mass-energy of the known Universe is composed of 4.9% ordinary matter, 26.8% dark matter, and 68.3% dark energy.*

*It is therefore estimated that dark matter constitutes 84.5% of the entire matter of the Universe, while dark energy and dark matter would together account for 95.1% of the total mass-energy of the Universe. It is very embarrassing to admit that we do not know what 95% of the Universe is doing!*
*So why should we see it like that? Because the latest scientific research has shown that dark matter is similar to a spider's web that connects and "unites" all things in the Universe. In other words, dark matter is the Universe's "invisible skeleton". Likewise, dark energy, with its ever-increasing antigravitational force and its role in the expansion of the Universe, will be responsible for the death of the Universe itself in hundreds (or millions, or trillions) of billions of years – perhaps even 10 to the 10th power, in turn elevated to the 76th power. It will inevitably break apart all the structures of the cosmos, including atoms and sub-particles, and they will all collapse into photons in what scientists call the "Big Rip". At that point, in an immensely vast, dark and cold Universe, time will also stop, since the flow of time is determined solely by the transformation of energy and/or matter. Without the presence of energy or matter transformation will cease, just like "before" the Big Bang. And perhaps, just as it probably happened at the exact moment of the Big Bang, a fluctuation of this quantum vacuum with no space nor time and with zero entropy will again create everything from nothing – hard to believe in the total absence of a sentient design behind all that..."*.S.P.