STANDARDS Australia 100

CELEBRATING 100 YEARS 1922-2022

Discussion Paper

Digital Engineering

SHIFTING THE PARADIGM IN THE CONSTRUCTION SECTOR

Contents

ABOUT STANDARDS AUSTRALIA

Standards Australia is an independent, non-government, not for profit organisation. We are the nation's peak non-government standards development organisation.

The work of Standards Australia and our staff, stakeholders, members and contributors enhances the nation's economic efficiency, international competitiveness and contributes to a safe and sustainable environment for all Australians.

Standards Australia's vision is to be a global leader in trusted solutions that improve life – today and tomorrow.

Preface

Over the last few years, a conversation has been emerging as to how we can better integrate our physical and virtual environments. New concepts like smart cities and digital twins have emerged, as part of the fourth industrial revolution while substantial work continues in established areas like building information modelling.

There can be no real integration of the physical and digital built environments without consideration being given to the construction process and how that process, ultimately, could become a layer of a rich and connected digital environment.

Over the next few months, we look forward to a conversation about how we might be able to do better in linking our physical and digital built environments, and what practical things we could do to make this achievable, real and scalable.

1.0 Introduction

The engineering and construction sector simply has no comparison. In terms of scope and scale, it is truly nation building. It provides the foundation for societies to grow and humanity to flourish. Collectively this sector now forms the world's largest industry, worth around $11.5 trillion a year or 13 percent of global GDP.

The engineering and construction sector has a strong history of scientific innovation and technical prowess. It has conquered some of the world's greatest challenges, building cities and connecting communities across the globe. It continues to enjoy record investment and it attracts some of our brightest minds – yet this sector it is now sitting at crossroads.

The world is currently changing at a rapid pace, with all aspects of our personal lives becoming digital. Over the past decade, society as a whole has now progressively shifted online and life as we know it has changed irreversibly. Digital transformation has taken hold and the pace of change is only accelerating.

All sectors are beginning to capitalise on the opportunities of this technological revolution, however the pace of change has not been even. The engineering and construction sector has been relatively slow to move, with comparative studies

highlighting the generally low maturity across the sector. Digital technologies can significantly improve how projects are planned, delivered and operated – however many organisations have remained unchanged.

We now have an opportunity to create a new, digitally enabled vision for the engineering and construction sector. A vision that is pragmatic, embraces change, and maximises the opportunities presented by this technological revolution.

Standards Australia is commencing a new program, to bring this vision to life, through a series of thought-provoking papers. This paper presents the first step in shaping a new, more digital future for the engineering and construction sector. The intent is to open up a new conversation with the sector, that challenges the status quo and creates new opportunities to explore. Future papers may include of topics such as the drivers for industry change, foundational data management and the future of smart infrastructure - just to name a few.

2.0 The digital transformation of everything

2.1 The future has arrived

We live in an age of great innovation. Advanced technologies have become ubiquitous, and now form essential parts of our daily lives. The pace of change is moving faster than any time in human history, as new technologies evolve in leaps and bounds. The world has become smaller and we are now more connected than ever before.

Increasing proportions of our lives are spent online, and modern societies have been profoundly transformed. New digital frontiers spring to life, global communities thrive and the race for online platforms to hit 100 million subscribers is accelerating. The future is here and there is no turning back.

The business world has also fundamentally changed. Through the rise of online technologies, productivity has exploded, new markets have emerged, and exponential growth has continued unabated. Those who were once disruptors must continue to grow, adapt and change – or also risk being left behind. Acceleration is the new constant. Disrupt, or be disrupted!

Since the discovery of the transistor in 1947 and the integrated microchip in 1956, society has entered a new era of technological revolution. Over the past 50+ years computers have steadily become smaller, cheaper, more powerful, better connected and embedded everywhere. Moore's Law (that predicted the doubling of computing power roughly every two years) has been a driving powerhouse of growth through our society, enabling the futuristic technologies of tomorrow to becoming consumer tech of today.

Technological change over 50 years - from Apollo to Apple

	Apollo 11 Guidance Computer (AGC)*	iPhone 11 Pro Max	
COMPUTING			**CHANGE**
Memory	4KB	4GB	1,000,000x
Storage	32KB	512GB	16,000,000x
Processor	43KHZ	2.49GHz	58,000x
No built	42	47.5 million sold	1,131,000x
Cost	$1,500,000(USD 2019)	$1,350(USD)	(0.09%) 1/1111x
Dimensions	61cmx32cmx17cm	158x77.8x8.1mm	(0.30%) 1/333x
Weight	32kg	226g	(0.71%) 1/142

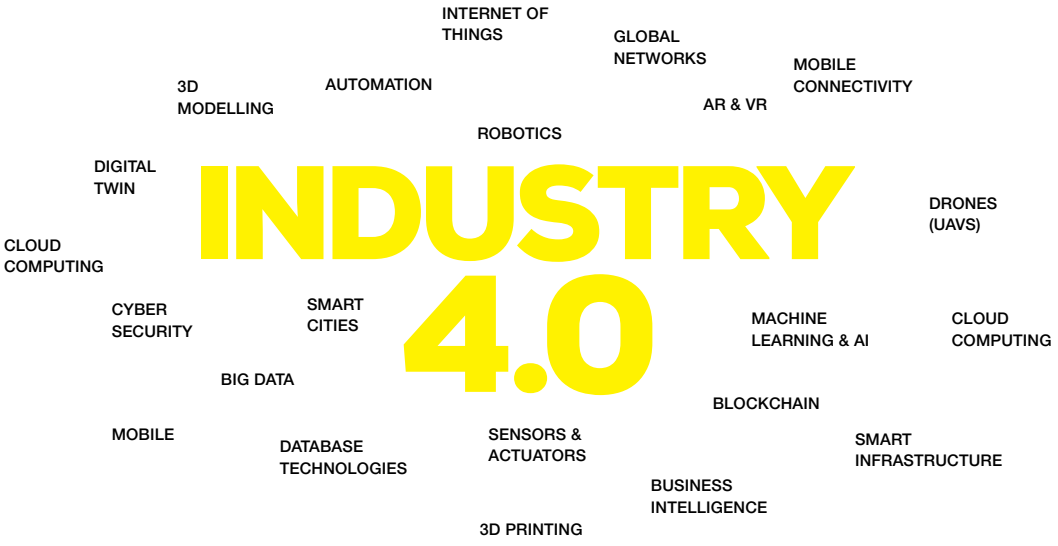
* Does not include the army of IBM System/360 Model 75 mainframe computers at Goddard Space Flight Centre

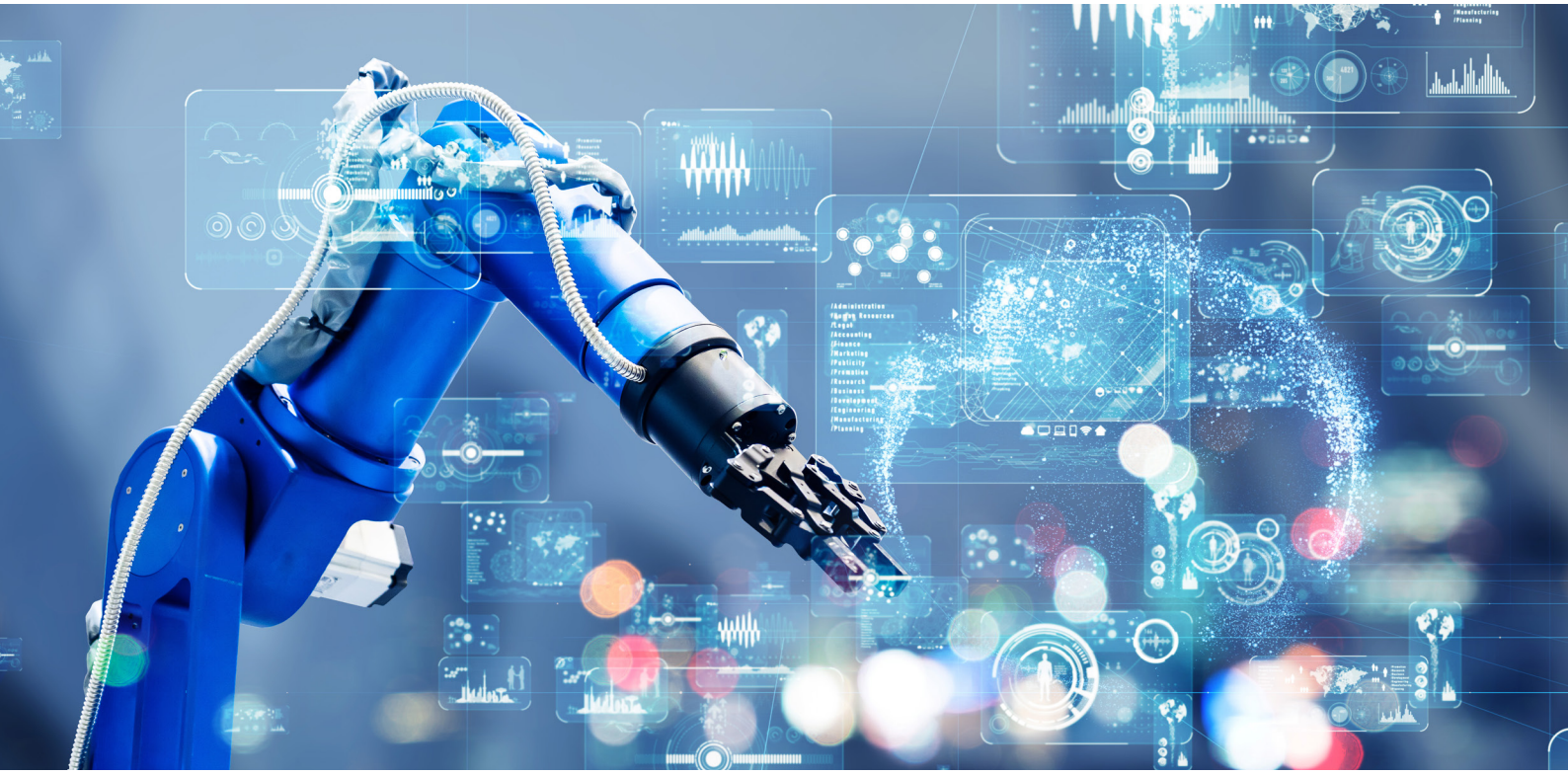
In this relatively short period of time, we have achieved unprecedented computing power, wireless technologies, the internet, artificial intelligence, as well as advances in display technologies, mobile communications, transportation, genetics, medicine and space exploration – just to name a few.

2.2 The revolution will be digital

The 21st century has been dominated by socio-technical systems, that have emerged through the rapid growth of ubiquitous internet and digital technologies. The next phase of global society has arrived, and it has fundamentally changed all aspects of economic, political and social structures.

This phase represents the next revolution of global industrial production. And like all revolutions of the past – once the genie is out of the bottle, things can never be the same again.





The Fourth Industrial Revolution is a term used to describe the rapid growth of online, digital technologies that have emerged over the past decade or so. Otherwise known as Industry 4.0, this phase builds on prior advances in computer technologies, and describes the current trend of automation and data exchange, supported by a seemingly endless supply of computer storage and processing power. It includes cyber-physical systems, the Internet of Things, cloud computing and cognitive computing.

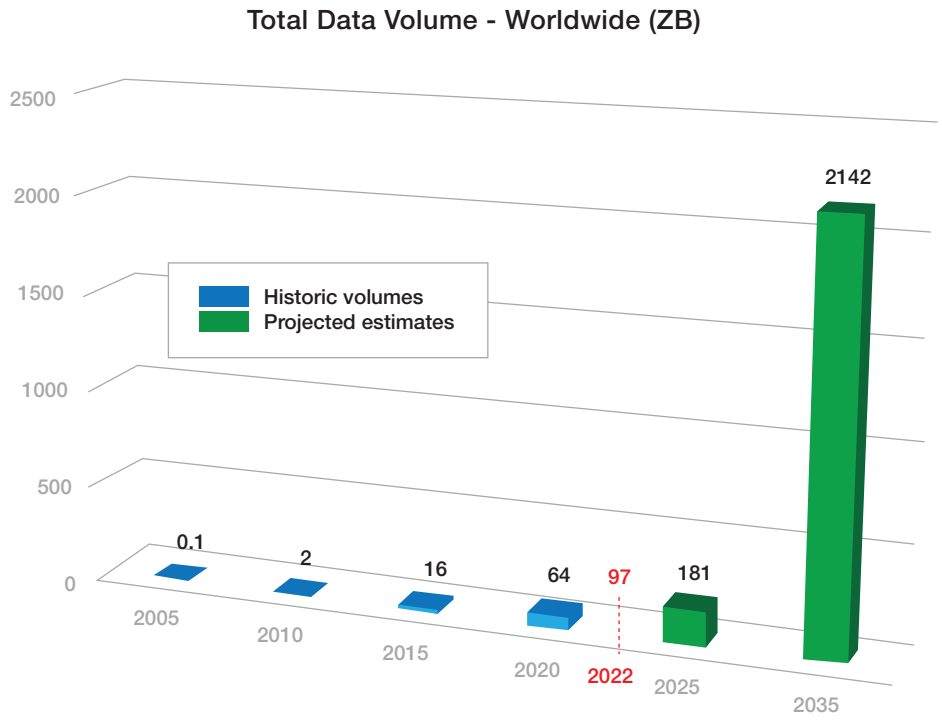
Industry 4.0 also presents a vision of the future, where physical and digital technologies are integrated and data enables new opportunities for value creation and optimized production processes. It is widely seen as a powerhouse for increasing productivity, efficiency, and flexibility; and creating new business models and value chains that are geared to quickly respond to changing customer demands.

2.3 The century of data

Our modern society collects, processes, shares and uses staggering volumes of data. Data that is personal and non-personal, public and private, structured and unstructured. We use it all, and our collective appetite only wants more.

Human activities, as well as our systems and machines, have now been restructured around a critical reliance on data. Data underpins and reflects virtually all economic sectors and social activities. Policy-making at local, national and international levels, is also now fundamentally underpinned by data.

Around the world we are experiencing stratospheric growth in the production and consumption of data. The global “datasphere” has truly entered the age of the zettabyte (i.e. 1 ZB = 1bn TB), with world storage levels estimated to have exploded from approx. 0.1ZB in 2005 to close to 100ZB today (i.e. approx. 1000x growth). Future projections currently predict this is likely grow to over 20 times this level by 2035 (2142 ZB); however with the rise of electric vehicles some groups estimate the 2035 level may soar above 15,000 ZB (almost 7 times other estimates).



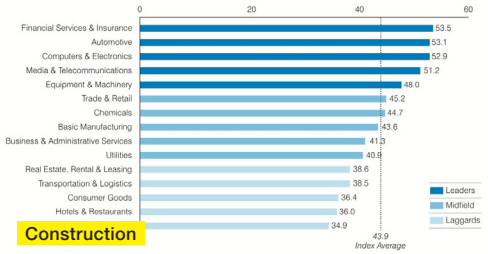
The business landscape is also shifting rapidly in this age of data. Business models across all sectors have been transformed, with new value chains and information pipelines built around the accelerating flow of data. Statements such as ‘data is the new oil’, ‘data is an asset’ and the ‘need for data-driven decisions’ and have now become common place in the business world.

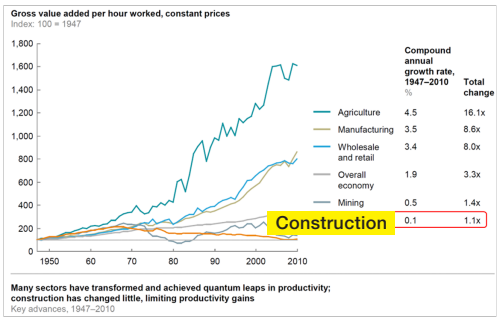
This highlights the general recognition that data is of critical business value and if utilised correctly, can unlock significant opportunities and sizeable returns. The distribution of this data-led transformation has not been equally spread across all sectors.

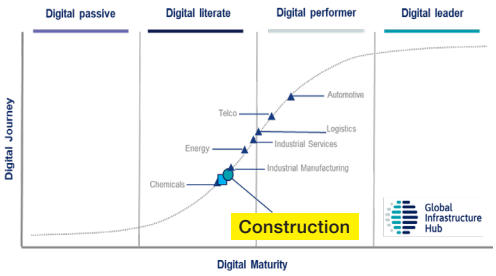
2.4 Digital maturity of the engineering and construction sector

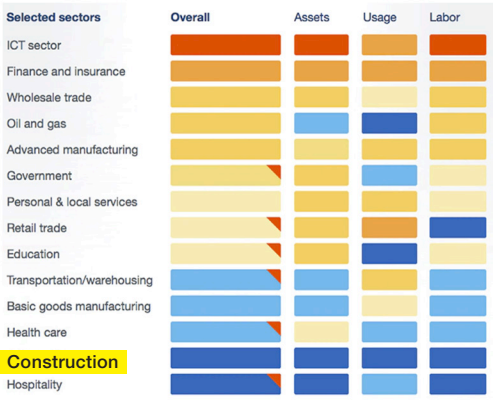
“The future is already here – it’s just not evenly distributed.” — William Gibson

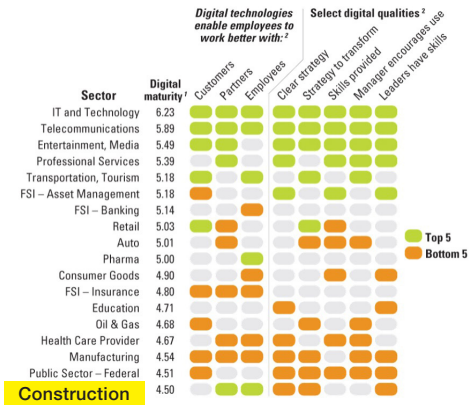
All industries have been shaped through this digital revolution – however the relative pace of this transformation has not been evenly spread. Over the past few years there have been numerous studies that compare digital maturity and technological advances across the economic landscape (see below list).





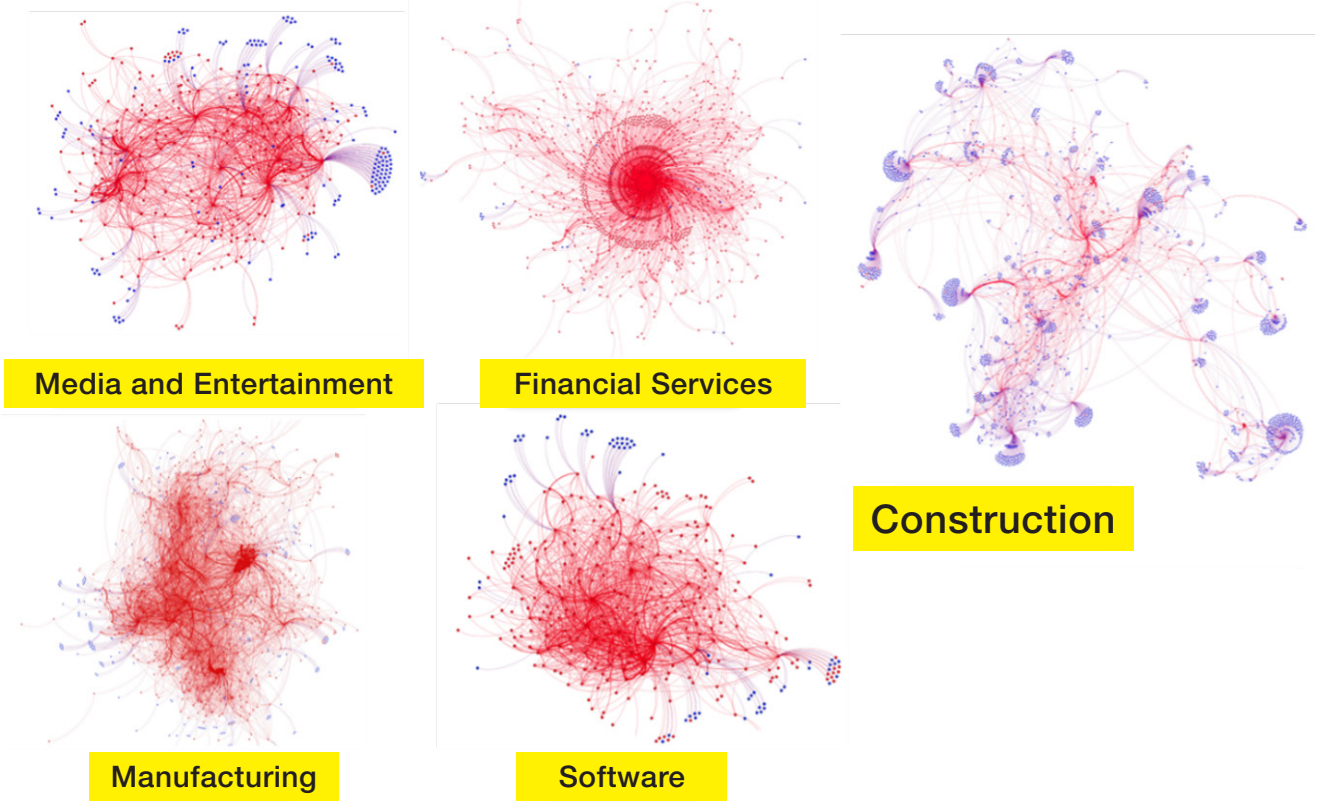






In virtually every study, using a wide range of comparative measures, the construction sector is persistently shown to be at the bottom of the ladder. The engineering and construction sector has been a laggard, and is largely being left behind.

In a 2014 study titled Mapping the Information Economy: A Tale of Five Industries (Box, 2014), graph techniques were used to visualise business interactions, by mapping the flow of data in five different sectors. The resulting 'collaboration graphs' presented a unique window into each sector and provided new insights into the nature of data exchange between businesses. These include aspects such as the flow of communication (centralised or decentralised), the segregation of business teams and the overall levels of business collaboration.



KEY

- Red Node: Individual company user
- Blue Node: Individual external user
- Red Edge: Connection from internal user
- Blue Edge: Connection from external user
- Edge Weight: Thicker edge represents more frequent connections between users

The most important observation however is the overall patterns that these graphs present and how, most notably, the engineering and construction sector is very much the outlier in the group.

The other sectors all demonstrate high levels of collaboration amongst teams and individuals, with frequent data exchange throughout the overall business network. In contrast, the engineering and construction graph presents a relatively weak network of isolated teams, that have high levels of segregation and low levels of digital collaboration. The study goes on to report that the ability to share documents is the top factor affecting collaboration.

2.5 Engineering is from Mars, Digital is from Venus

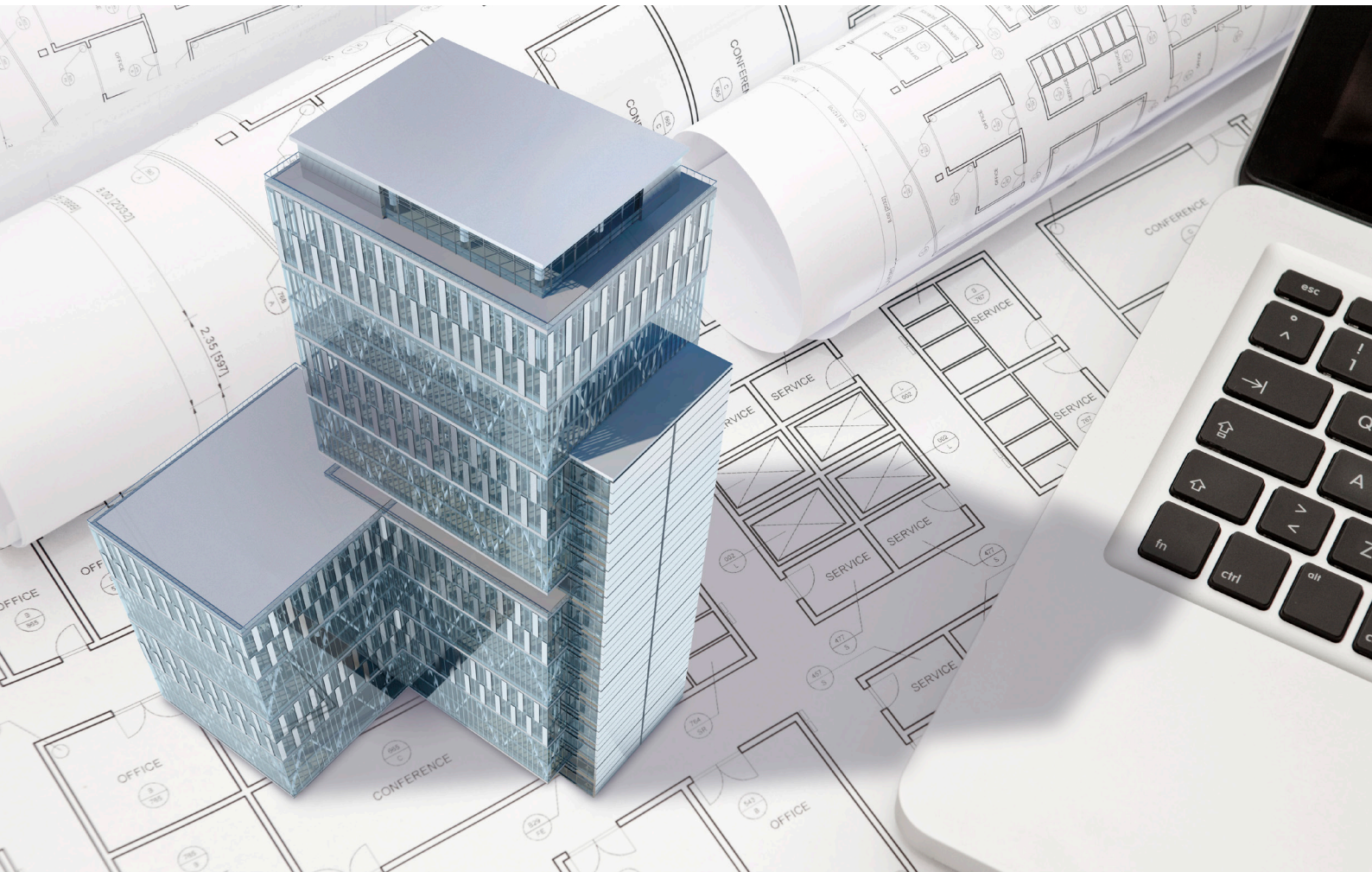
In the 1990's best seller "Men are from Mars, Women are from Venus", it is suggested that relationship problems are often the result of fundamental differences in how both parties communicate, and how they respond to external pressures. When considering the engineering and construction sector and its rocky relationship with digital technologies, there are many parallels.

Over the past 20 years the digital world has erupted with technological change and rapid innovation, as Industry 4.0 has completely transformed everything it touches. The landscape is evolving at a rapid rate, and most other sectors are capitalising on advances with Machine Learning, Artificial Intelligence and Data Science.

Meanwhile over this same period, the engineering and construction world has remained relatively unchanged. Traditional methods of project and asset management have generally prevailed, and sector-wide digital transformation has stubbornly remained out of reach.

If nothing changes, it seems that these two worlds may forever remain apart.

That is not to say the sector has been completely resistant to change. Over the past 2 decades the engineering and construction sector has led numerous attempts to improve data and information management capabilities. These initiatives have introduced a variety of new standards, terminologies, processes and acronyms – all with varying levels of success. The most notable of these initiatives, that has taken the world by storm, is generally known as building information modelling or BIM.



3.0 The Engineering and Construction sector

3.1 The epic rise of BIM

BIM (or Building Information Modelling) may be understood as a combination of processes and technologies that generally aim to improve information management on capital projects. This definition however is intentionally broad, and caters for the wide range of interpretations that currently exist throughout the engineering and construction sector.

BIM has its roots in 3D computer-aided design (CAD) and was originally a term used to describe data-rich 3D modelling. When BIM first entered the market, the ability to visualise projects and work collaboratively across project disciplines was in stark contrast to the traditional world of 2D CAD drawings. This level of project visibility was a game changer for the engineering and construction sector and it quickly grew in popularity. The broad definition of BIM also grew beyond 3D modelling, to become a more general, catch-all expression for information management within the engineering and construction sector.

Over the past 20 years the global market of BIM exploded, as demand for BIM deliverables (typically data-rich 3D models) has steadily continued to grow. This in-turn has been a catalyst for more specialist BIM technologies, new BIM training and employment opportunities, and new BIM service lines and new accreditation bodies for engineering and construction sector.

The engineering and construction sector would generally agree that BIM has been its answer to digital transformation, due to its global recognition, sustained investment and technological innovation. In 2018, BIM reached the pinnacle of industry recognition with the publication of the ISO 19650 suite of standards. The rise of BIM, from 3D CAD through to the globally recognised movement it is today, was complete.

In reality however, the general uptake and experience with BIM has been mixed.

Many asset owners still coming to terms with the tenets of BIM, despite its entry into the engineering and construction sector over 2 decades ago. Procurement of BIM

on projects can typically deliver mixed results, and many are still grappling with the challenges of integrating BIM throughout the end-to-end asset lifecycle. Moreover, BIM technologies and capabilities have remained a specialist domain, while general sector-wide capability with BIM has remained relatively low. In short there is still much work to be done for BIM to truly become mainstream.

3.2 Next generation technologies

In recent years the engineering and construction sector has begun to witness a new wave of digital innovation, enabled through the rise and convergence of industry 4.0 technologies. This next generation of technologies comprise a range of new concepts such as the digital thread, digital twins, smart infrastructure and smart cities. Some of these terms have been years in the making however, through growing attention from around the globe, the sector is now beginning to define how these nebulous concepts may finally become reality.

Each of these concepts are revolutionary in their own right, with wide ranging goals such as boosting productivity, enhancing asset performance, promoting sustainability and generating new ways to improve customer experience. They have also established fertile ground for new industries, such as the circular economy, modular construction, predictive maintenance and management of embodied carbon just to name a few. The central theme however through these digital innovations is the general aim to harness the transformational nature of industry 4.0 based on solutions that are truly integrated, reliable, automated and real-time.

3.3 The next frontier

“The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn and relearn” — Alvin Toffler (US writer, futurist, and businessman)

Whether we like it or not, the engineering and construction sector is rapidly being thrust into this next frontier. The fast-paced world of Industry 4.0 may be unfamiliar territory for many in the sector, however things are only just getting started. The next generation of digital technologies are now pushing the envelope even further, with a whole new set of terminologies, systems, expectations and players entering the market. The world is changing rapidly and the bar for entry is now being set much higher than ever before.

As seen in all other sectors, Industry 4.0 does not represent incremental change such as rebranding existing technologies and basic upgrades adjustments to business processes. This level of change represents a fundamental shift in how sectors function through the creation, convergence, integration of new technologies – all rolled into one.

Pioneering organisations in the engineering and construction sector are beginning to respond and are taking lessons from other more digitally advanced industries. New teams centred on data management are beginning to emerge, and are bringing new skills such as data governance, data architecture and data literacy just to name a few. In time these specialist skills will become more diverse, and the general uptake will become more mainstream.

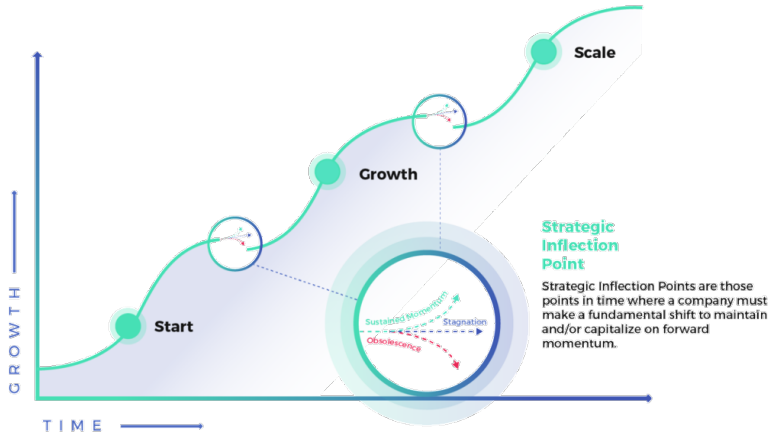
The transformation of our sector has begun.

4.0 Digital Engineering

4.1 Pivoting into the next growth cycle

“The difficulty lies not so much in developing new ideas as in escaping from old ones.” — John Maynard Keynes, economist

Industry 4.0 is not like anything we have ever experienced in the past. It presents seemingly endless opportunities for sector-wide growth and transformation, that have already been realised in many other sectors. These transformational opportunities are significant, and are a proven accelerant to growth, innovation, improvement and change.



Leading sectors on the path of digital transformation have experienced continuous cycles of reinvention, being constrained by only their curiosity, imagination and willingness to change. With each new cycle of reinvention, technologies improve, sector capabilities build, new opportunities emerge, long-term horizons expand and the overall vision grows. Then the cycle starts all over again. This pattern of growth and reinvention is key – and represents the true power of Industry 4.0

4.2 A new hope for the engineering and construction sector

It is now time for us consider a new future for the engineering and construction sector, that is no longer limited by assumptions or decisions of the past. It is time for us to take a new approach with a clean sheet of paper, an open mind, some blue-sky thinking and the licence to fundamentally change the rules of game.

Through sector-wide collaboration, this will create a completely new vision, that reimagines the engineering and construction sector as new leaders of the digital revolution. A vision where reinvention is possible, learning is encouraged, new opportunities are explored, and a bold new journey begins.

This will enable us to bridge the divide between the worlds of Engineering and Digital, and build new data management capabilities throughout the engineering and construction sector. This will foster modern data literacy, establish a new data-driven culture and generate business intelligence for all.

It is time for a new beginning with Digital Engineering.

5.0 Next Steps

In this paper we have touched on a wide range of concepts that revolve around digital transformation of the engineering and construction sector. In subsequent papers we will explore these concepts further, to understand the journey so far and to consider the road ahead.

As a prelude of things to come, here are some of the questions we will consider over the course of this program:

- How have other sectors been so successful at mastering this new world of digital transformation?
- How does the engineering and construction sector differ from other sectors?
- What capabilities that will greatly assist the sector in accelerating growth and change?
- And can we quickly become new leaders of this digital revolution?

This will be an exciting program and we look forward to you joining us on this journey.

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