Construction 4.0 Strategic Plan (2021–2025)

Next Revolution of the Malaysian Construction Industry

Ministry of Works Malaysia

CIDB MALAYSIA

Construction 4.0
Strategic Plan (2021-2025)

Strategic Plan for Construction Industry:
Gearing Up for the Fourth Industrial Revolution

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CIDB Malaysia

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Foreword

Construction 4.0 Strategic Plan is a roadmap for the Malaysian Construction Industry to embrace the Fourth Industrial Revolution (IR 4.0) in ways that would transform its productivity and competitiveness.

Through the Strategic Plan, we envision to be the leading country in the implementation of IR 4.0 for Construction industry in the Southeast Asia Region. This can be achieved by transforming the Malaysian construction industry towards embracing smart construction.

The Construction 4.0 is created to be aligned to the Shared Prosperity Vision 2030 (SPV 2030) and the implementation of the National Policy on IR 4.0 (Industry4WRD). The Strategic Plan also supports and compliment the National Internet of Things (IoT) Strategic Roadmap, the Malaysia Smart City Framework and the Digital Economy Blueprint, among others. It covers twelve emerging technologies and its implementation plan within the short, medium and the long term.

The emerging technologies ranges from Prefabrication and Modular construction, which is currently being implemented, to more cutting-edge technologies such as artificial intelligence, 3D printing and additive manufacturing.

The Strategic Plan implementation will be fuelled by four enablers, namely; people, integrated technologies, economy and governance. The four enablers must work in synchronicity in developing a future-ready workforce from the grassroots and give rise to home-grown technologies. Most importantly, the existing legal framework surrounding construction must be strengthen and reviewed to encourage the adoption of new emerging technologies.

The Construction 4.0 transformation will certainly not happen overnight. The industry players must be convince and the necessary investments must be made by both the private and the public sector towards technology adoption. As a nation, we must strive to be at the forefront of technological advancement or we risk being left behind.

I urge all construction industry stakeholders to play an active role and collaborate with the industry players towards ensuring the achievement of all Construction 4.0 objectives and goals, thus creating tremendous positive impact to the construction industry in Malaysia.

Thank you.

Dato' Sri Haji Fadillah bin Haji Yusof
Senior Minister of Infrastructure, Minister of Works Malaysia

Foreword

Fourth Industrial Revolution has created a paradigm shift and shaped industrial sectors towards digital transformations. To be aligned with this transformation, the Ministry of Works through the Construction Industry Development Board (CIDB) and in collaboration with industry stakeholders have developed the Construction 4.0 Strategic Plan (2021-2025). The purpose of the document is to be a framework which will drive the construction industry towards embracing the digital revolution in construction.

With the tagline, Empowering the nation towards Digital Construction, the Strategic Plan is divided into four strategic thrusts. They are Capacity Building, Excellence in Research, Innovation, Commercialisation and Entrepreneurship (RICE), Smart Integrated Technologies, Innovation and Infrastructure and Enhanced Business Environment.

To deliver these transformations through Construction 4.0 Strategic Plan, a harmonised strategic partnership between the Government, industry, academia and society is essential. Through this strong partnership, which we call the Quadruple Helix, we must work hand-in-hand to deliver all the nine strategic objectives outlined in the strategic plan, which includes preparing a future-ready workforce, create mechanisms which support innovators and technology adopters, ignite holistic ecosystems through government interventions and promote foreign direct investments.

With the Construction 4.0 Strategic Plan, let us strive to place the Malaysian construction industry to be highly productive and competitive globally, through the adoption of emerging digital technologies.

Thank you.

Dato' Dr. Syed Omar Sharifuddin Syed Ikhsan
Secretary General
Ministry of Works

Foreword

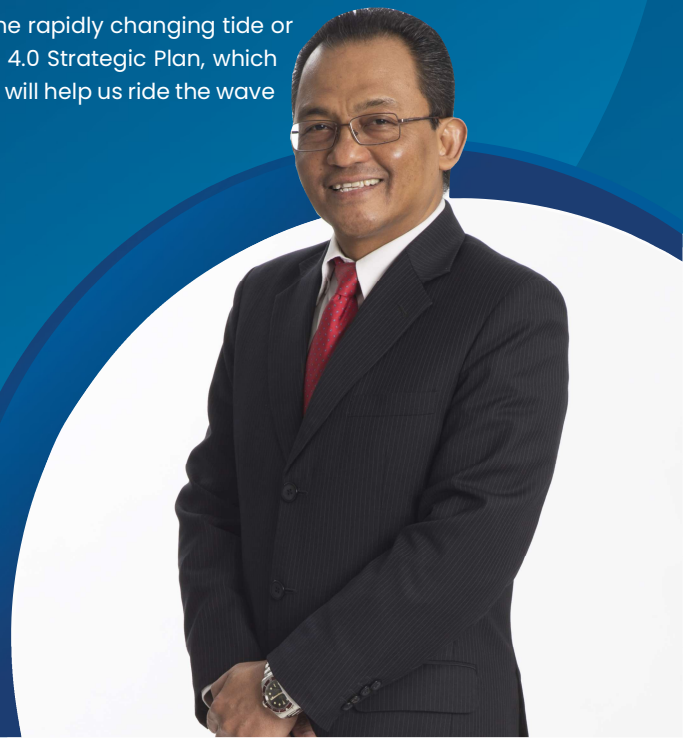
The Construction 4.0 Strategic Plan (2021-2025) is a roadmap on how the Malaysian construction industry can navigate the rapidly-changing business environment by making full use of the digital revolution, more popularly known as Industrial Revolution 4.0.

This Strategic Plan is a next step in the construction industry transformation journey after the completion of the Construction Industry Transformation Programme (CITP) 2016-2020. The CITP had focused its transformation initiatives within four strategic thrusts; Quality, Safety and Professionalism, Sustainability, Productivity and Internationalisation and Competitiveness. In the Construction 4.0 Strategic Plan, we laid out how digital technology can play a central role in Quality, Safety, Sustainability, Productivity and Competitiveness in construction.

This document will not have all the answers, as technology will continue to evolve and revolve at a rapid pace, even as we speak. But what we can offer is a framework on how the Malaysian Construction Industry players from across the supply chain can embrace the technology to enhance their service delivery.

There will come a time when we will either be swept away by the rapidly changing tide or be lifted to a higher ground. We believe that the Construction 4.0 Strategic Plan, which has been developed in collaboration with industry stakeholders will help us ride the wave and thrive in the era of technological revolution.

Thank you.



Datuk Ir. Ahmad 'Asri Abdul Hamid
Chief Executive
Construction Industry Development Board Malaysia (CIDB)

Executive Summary

The Construction 4.0 strategic plan is developed to enable the Government, industry, and academia within the construction industry to respond to the rapid changes towards the Fourth Industrial Revolution (IR4.0). This document aims to provide a pathway to transform the Malaysian construction industry towards the next industrial revolution by developing a series comprehensive Strategic Plans and Strategic Thrusts. By amalgamate the five core values of Construction 4.0, along with the strategies of well-being, productivity, sustainability, integrity, and safety and health; providing a holistic approach for the future. In addition, this document explains the four Strategic Thrust based on approaches and recommendations to facilitate the commencement of Construction 4.0 for the period of 5 years from 2021 to 2025, by shaping the local needs and global demands.

Changes in current practices are essential – not only to improve the skills in the current workforce talents but also to increase the diversity of the workforce; ability to create new opportunities; and boost the economic growth as part of efforts to re-shape the industry for the future. By following these initiatives, efforts on the action plans which been covered in strategic priority able to harmonise the existing reference models and overseeing the development of an underlaying construction as substantial aspect of representation of digital aspect of Construction 4.0 strategic map.

This strategic document covers three sections including the industrial revolution overview, the construction 4.0, and the strategic plan. This was developed in collaboration with experts from a multi-disciplinary and intra-disciplinary group of stakeholders, aimed along the construction value chain, including suppliers of building materials, construction equipment, contractors, engineering, architecture, and planning firms, as well as project owners and developers. The Government is another target audience, as an impact towards the industry via regulation and acting as the main procurer of most infrastructure projects. As a result, this strategic document will be benefit stakeholders whom would be interested in the possibility in adopting emerging technology and moving ahead towards the next construction industry revolution, Construction 4.0.

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Datuk Ir. Ahmad 'Asri Abdul Hamid
said "the move was to encourage digital adoption by industry players as Malaysia was set to launch the Fourth Industrial Revolution"
(Source: Bernama, 2019)

(Source: https://www.optionstheedge.com/topic/culture/join-now-malaysiaku-pictures-photo-contest)

Construction 4.0 Strategic Plan

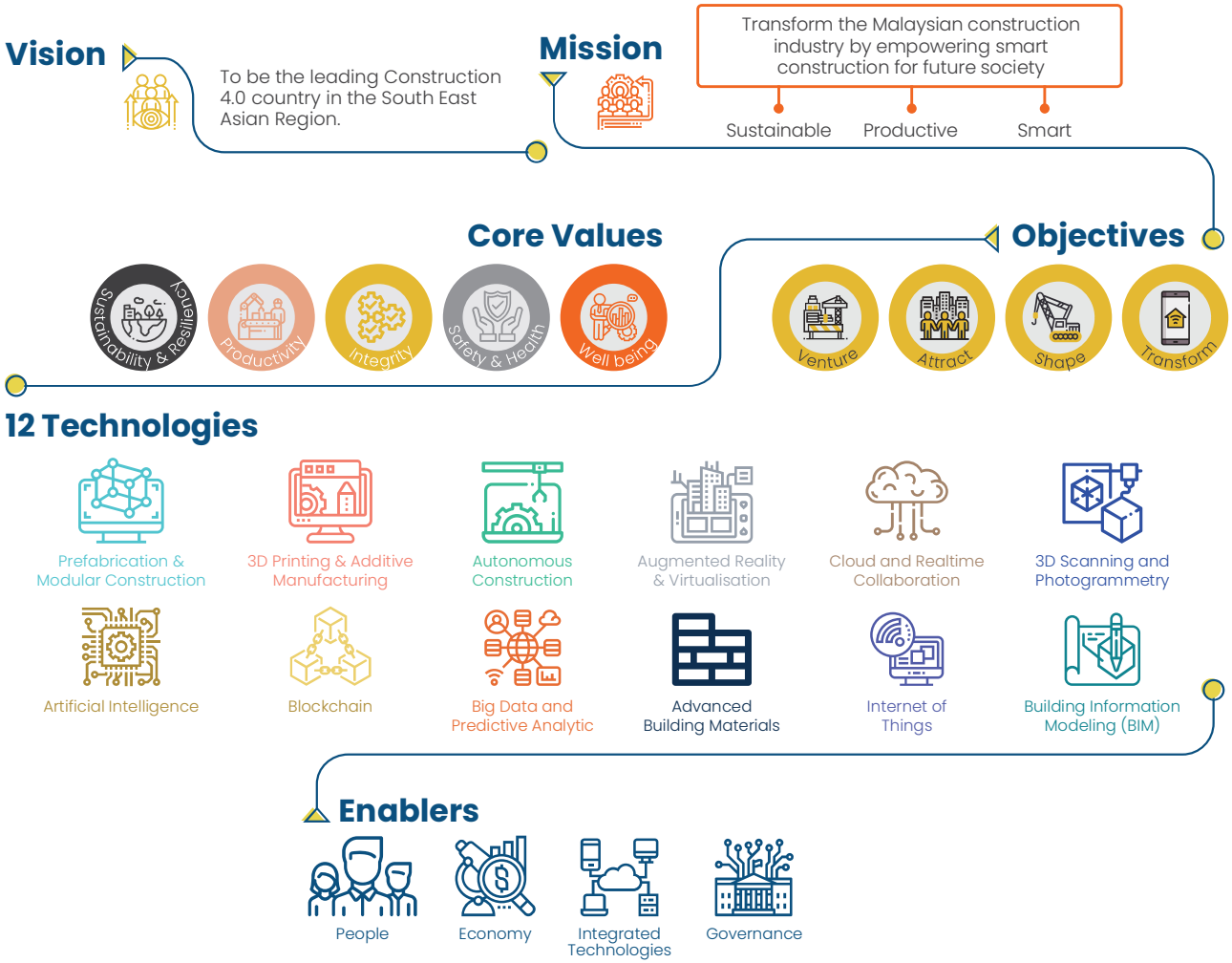
Construction 4.0 brings new technologies such as Cloud Computing, Mobile Information, Data Analytics, Artificial Intelligence (AI), Augmented Reality (AR) and 3D printing, will play a vital role in collaboration, coordination and communication in real-time among construction stakeholders. The concept of Construction 4.0 is mainly to enhance current and future technologies for the construction industry to achieve higher productivity, better safety and towards a more sustainable approach – incorporating whole life cycle analysis. Upon reflection, looking into the mom-and-pop shops of half-a-century ago, which have now been replaced by large-scale modern entities with global supply chains and increasing digitised distribution systems; representing a new level of client-customer-consumer trichotomy that has changed the construction industry, and continuing to do so. Strategically, adopting this technological progression will have an immense impact and will potentially change the operational processes of all construction organisations covering the small and medium-sized enterprises (SME). This document summarises the industry's earnest ambitions in reshaping the dynamics of the construction industry in the years leading up to 2025; taking into consideration the 12th Malaysian Plan agenda and Shared Prosperity Vision 2030.

Construction 4.0

A leading industry that is known for its talented skills, diversified workforce and sustained economic growth for the future through smart digital construction transformation.

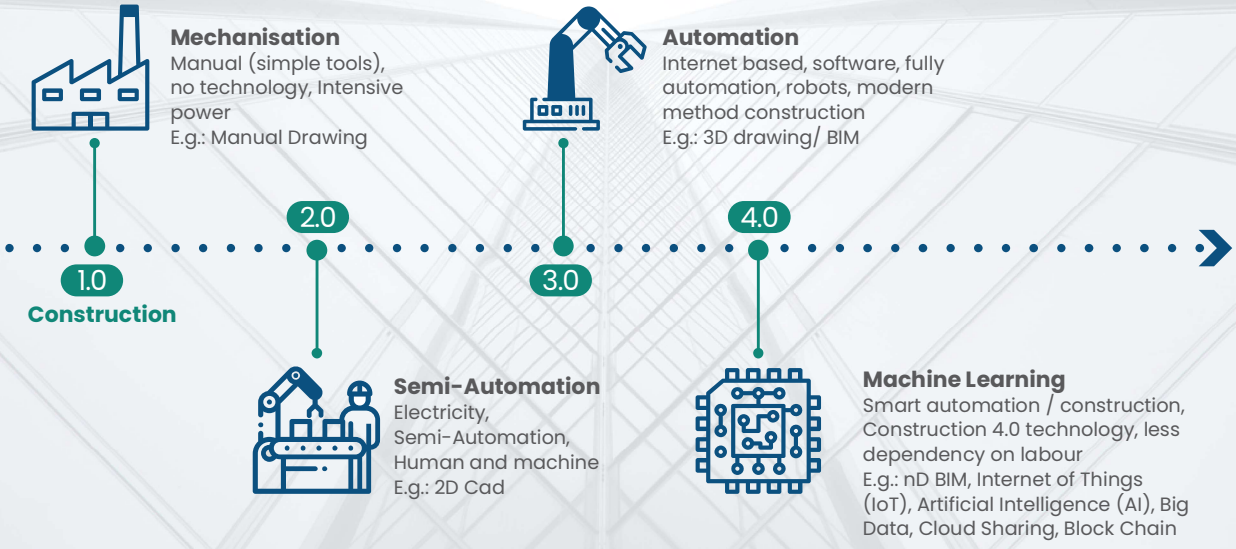
A Glance of Construction 4.0
Strategic Plan 2021-2025

In order to realise the potential and benefits of Construction 4.0, a five-year strategic plan was developed in collaboration with multiple stakeholders in the construction industry. This section will outline the overarching strategic framework for Construction 4.0



Revolution of Construction
Strategic Plan 2021-2025

Construction 4.0 is defined as the process to implement modern technology in order to encourage the digitisation of the construction industry and its supply chain[1]. Whilst, it also gives a definition of the transformation of the construction industry towards the Fourth Industrial Revolution, from automated production to a greater level of digitalisation[2].



[1] Focus Group Discussion (FGD) 1 (2019)

[2] Gravero et al. (2019)

Strategic Review Mechanism

Leading up to the Fourth Industrial Revolution (IR4.0), an agile approach to govern emerging technologies through new business models and societal interaction structures are essentially vital. The complexity, transformative and distributed nature of IR4.0 have created a new demand of governance to address the dynamic pace, fusion of disciplines and synergistic nature of emerging technologies; transnational impact of technologies and broader societal implications; and the political nature of technologies is needed[3]. To ensure the success of this transformation, a new flexible form of governance is required.

Agile governance has been identified as a mechanism that fundamentally provides robustness to anticipate and facilitate rapid technological changes. The concept of agile governance is to change the way policies are generated, deliberated, enacted and enforced. This approach is used in this document to enable strategy that is more inclusive and "human-centred" by involving various stakeholders. To maintain the relevant checks and balances, the agile approach would emphasize on shared responsibilities between public and private sectors and the society. Several stages in using agile governance have been introduced and tasks are presented in **Figure 1**.

[3] World Economic Forum, 2018a

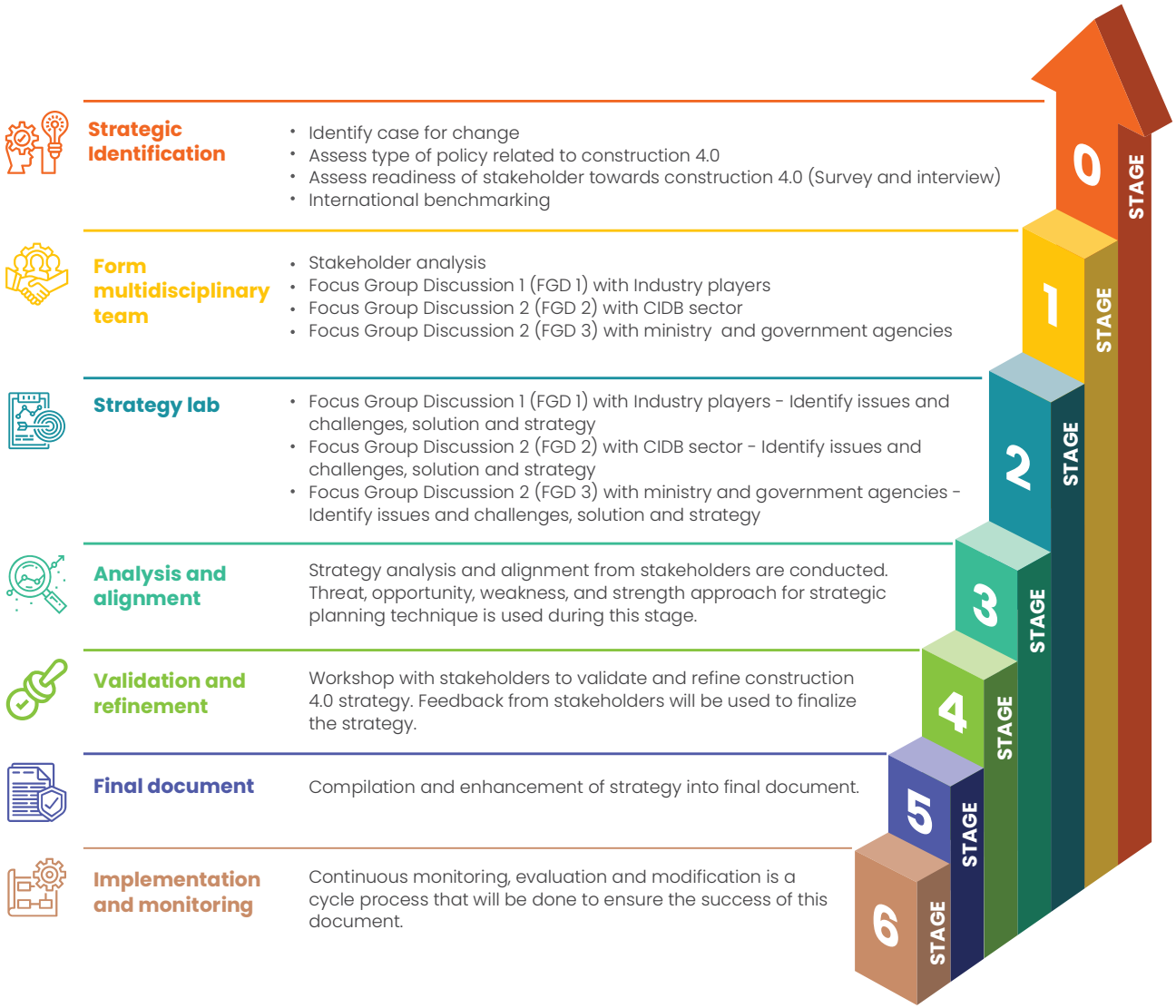
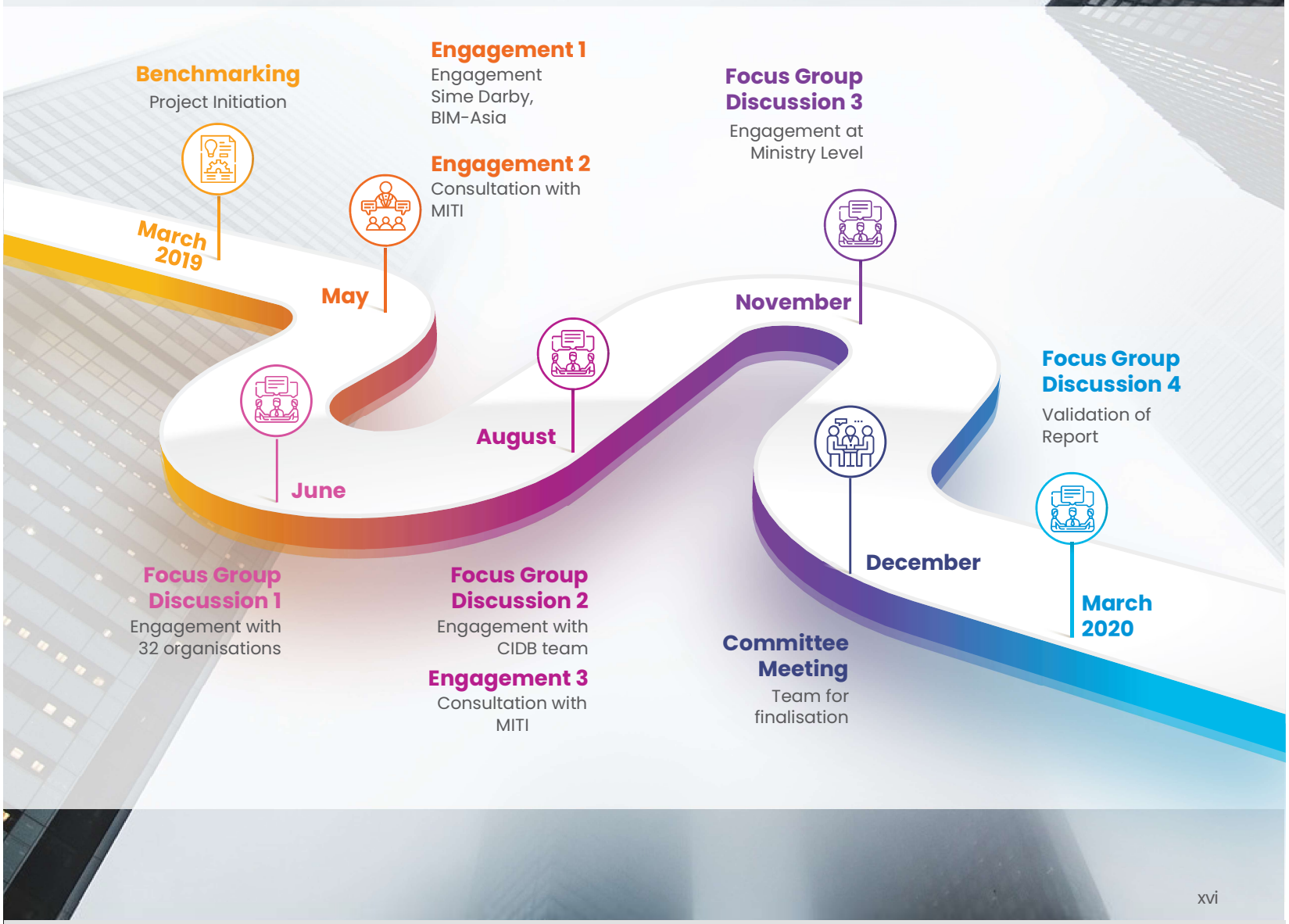


Figure 1. Stages and tasks in using agile approach for development of Construction 4.0 strategic plan

Timeline of Construction 4.0 Strategic Plan (2021-2025)



Industrial Revolution Overview

SECTION

01

What is included in this section:

Background of the Industrial Revolution

The word "industry" represents the production of goods or services through technology and commercial organisational advances[4]. While "industrialisation" denotes the development of industries on a wider scale[5], revolution on the other hand is defined as an abrupt and radical change[6]. Given the definitions, Industrial Revolution will literally define the development or changes in the way of goods or services being produced and work being organised. Human life changed drastically due to the transformation made, invention and innovation created throughout the period of revolution. The world economy that was once being monopolised by agriculture and textile industry, operated mostly by hand, has significantly marked a large turning point in the mid-18th century. The industry as a whole was literally transformed into mechanism manufacturing due to large market demand. This revolution significantly transformed economies that had been based on agriculture and handicrafts into economies that are based on large-scale industries, mechanised manufacturing, and the factory system. At the early stage of the revolution, a protest towards the new system occurred show that the magnitude of change strikes home[7]. However, the unstoppable economy blooming failed these efforts, forcing redefinition of protest itself.

Nonetheless, this revolution was proven to have the ability to deliver beneficial economic development across all industries involved. The main features involved were technology, socio-economic changes, and culture.

The technological changes included the following[8]:

1. The use of new basic materials, mostly iron and steel.
2. The use of new energy sources, such as coal, the steam engine, electricity, petroleum, and the internal-combustion engine.
3. The invention of new machines, prompted the increased production with a smaller use of human energy.
4. A new organisation of work known as the factory system.
5. Massive developments in transportation and communication, including the steam locomotive, steamship, automobile, airplane, telegraph, and radio.
6. The immense increase of application of science to the industry. These technological changes significantly resulted in the increased use of natural resources and the mass production of manufactured goods.

[4] Mark Skilton and Felix Hovsepian, "The 4th Industrial Revolution: Responding to the Impact of Artificial Intelligence on Business" (Switzerland: Springer Nature. 2017), https://books.google.com.my/books?id=UMJADwAAQBAJ&printsec=frontcover#v=onepage&q&f=false

[5] Skilton and Hovsepian, "The 4th"

[6] Klaus Schwab, The Fourth Industrial Revolution (Switzerland: World Economic Forum, 2017), 6

[7] Peter N. Stearns, "The Industrial Revolution in World History" (Boulder, CO, United States: Taylor & Francis Inc, 2018) https://books.google.com.my/books?id=ARdWDwAAQBAJ&dq=The+Industrial+Revolution+in+World+History&q=revolution#v=snippet&q=magnitude%20of%20change%20strikes%20home&f=false

[8] The Editors of Encyclopaedia Britannica, "Assembly line" Retrieved on 22 December 2019 from https://www.britannica.com/print/article/39246

Phases of Industrial Revolution

The first three industrial revolutions came about as a result of mechanisation that is driven by water and steam power, use of mass labour and electrical energy and the use of electronic, automated production respectively[9]. We are now witnessing the rise of the fourth revolution, where the real and the virtual world are to be seamlessly connected giving rise to what is known as the cyber-physical production systems[10]. **Figure 2** describes the evolution of each revolution generally.

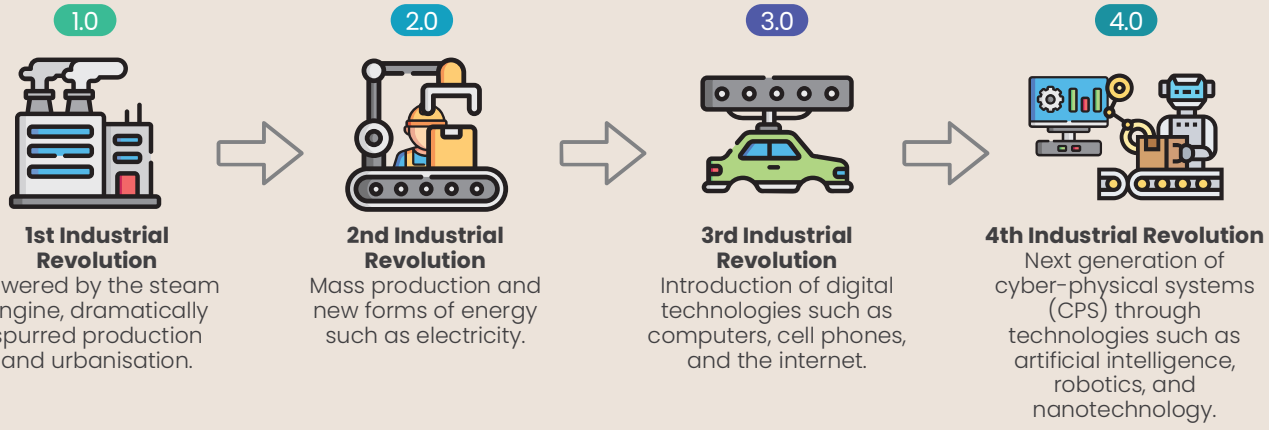


Figure 2. Industrial Revolutions difference[11]

Although all the revolutions were defined by innovation, the most significance impact is on humanity and society. Fast moving periods of technological and industrialisation have created tectonic shifts in societies throughout history. Therefore, a change of habits and mindset is needed in fulfilling the integrative demands of both concepts.

[9] Hugh Boyes, Bil Hallaq, Joe Cunningham and Tim Watson, "The industrial internet of things (IIoT): An analysis framework", Computers in Industry, 101 (2018), 2

[10] Wilfried Aulbur, Arvind Cj and Rishi Bigghe Skill Development for Industry 4.0, (Munique: Roland Berger GMBH, 2016), http://www.globalskillsummit.com/Whitepaper-Summary.pdf

[11] Romina Bandura et al., Beyond Technology: The Fourth Industrial Revolution in the Developing World (Washington: Center for Strategic & International Studies, 2019), https://csis-prod.s3.amazonaws.com/s3fs-public/publication/190520_Runde%20et%20al_FourthIndustrialRevolution_WEB.pdf

What is the Fourth Industrial Revolution?

The term "Fourth Industrial Revolution" was first proposed in 2011 during the Hannover Fair in the context of the goal of developing the German economy and later the terms as been spread to other parts of Europe. **Table 1** summarises the definitions of the Fourth Industrial Revolution (IR4.0) by a myriad of researches. Various descriptions and arguments were used to define this revolution. In short, it can be summarised as a set of technologies or an era of digitalisation that formulates the integration of all actors in the entirety of the value chain.

IR4.0 will bring fundamental changes in the way we live and work, and the interrelation between both. This is a new chapter in human development, enabled by new technological advancements. These advances merge the physical, digital and biological worlds in ways that create both endless opportunities and potential threats. The speed, breadth and depth of this revolution will enable us to reassess how countries develop and organisations create value.

IR4.0 is more than just technology-driven change; it is an opportunity to help everyone – leaders to policy-makers, researchers to operators, people from all income groups and nations – to harness converging technologies in order to create an inclusive, human-centred future. The real opportunity is to look beyond technology but to harness the impact towards the modernisation of humanity. This revolution could empower business leaders to better control and understand aspects of business processes and operations to allow them to leverage real-time data to boost productivity, improve methods, and drive growth.

Author : **World Economic Forum, 2016**	Author : **Klaus Schwab & Nicholas Davis, 2016**	Author : **Klaus Schwab, 2017**	Author : **Pranjal Sharma, 2017**	Author : **Antonella Petrillo, Raffaele Cioffi & Fabio De Felice, 2018**
Definition	**Definition**	**Definition**	**Definition**	**Definition**
Advent of "cyber-physical systems (CPS)" involving entirely new capabilities for people and machines. While these capabilities are reliant on the technologies and infrastructure of the Third Industrial Revolution	A new chapter in human development, on par with the first, second, third Industrial Revolutions and once again driven by the increasing availability and interaction of a set of extraordinary technologies	Digital revolution which characterised by ubiquitous and mobile internet, by smaller and more powerful sensors that have become cheaper and by artificial intelligence (AI) and machine learning	Clutch of distinct yet connected technologies that are growing and evolving at a rapid pace	Integration of IT system and physical systems to get a cyber-physical system (CPS) that brings the real world in a virtual reality (VR).

Table 1. Definitions of the Fourth Industrial Revolution

Emergence of IR4.0 will affect all business industries and their wider supply chain. The combination of technologies will play an essential role in this transformation and will inadvertently restructure entire industries. Figure below shows the potential technologies that will drive the digital transformation for this revolution.

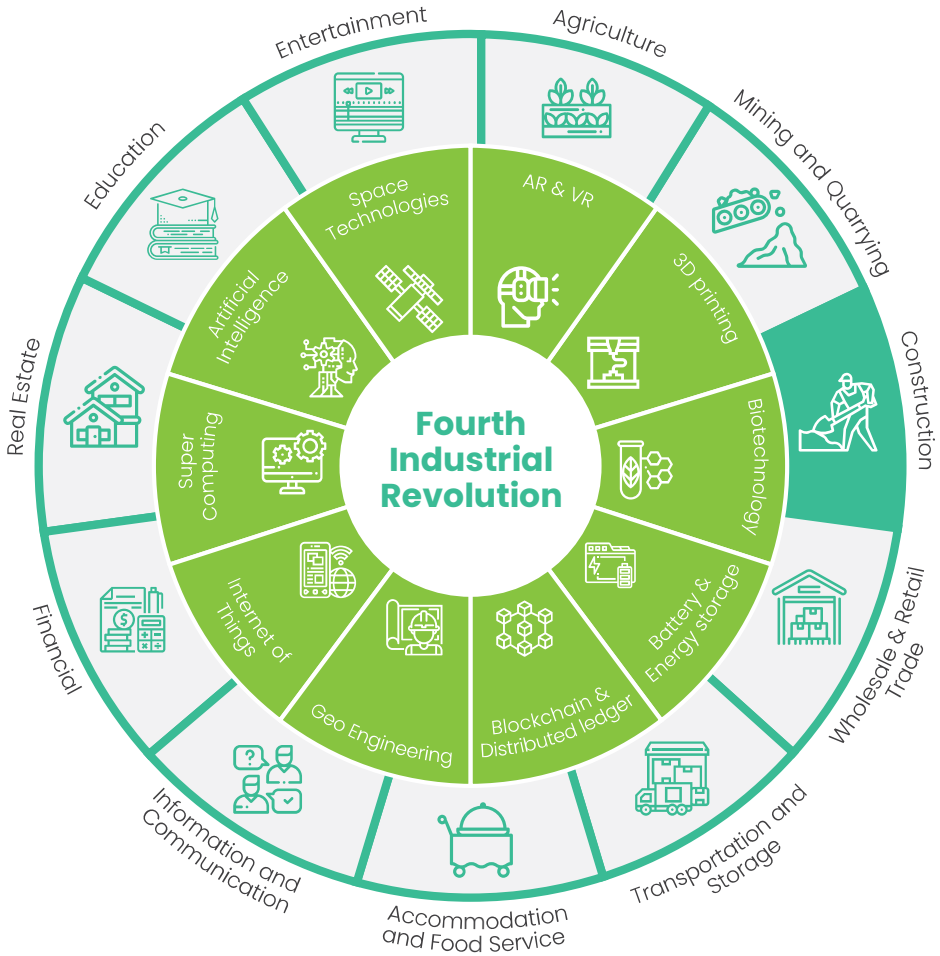
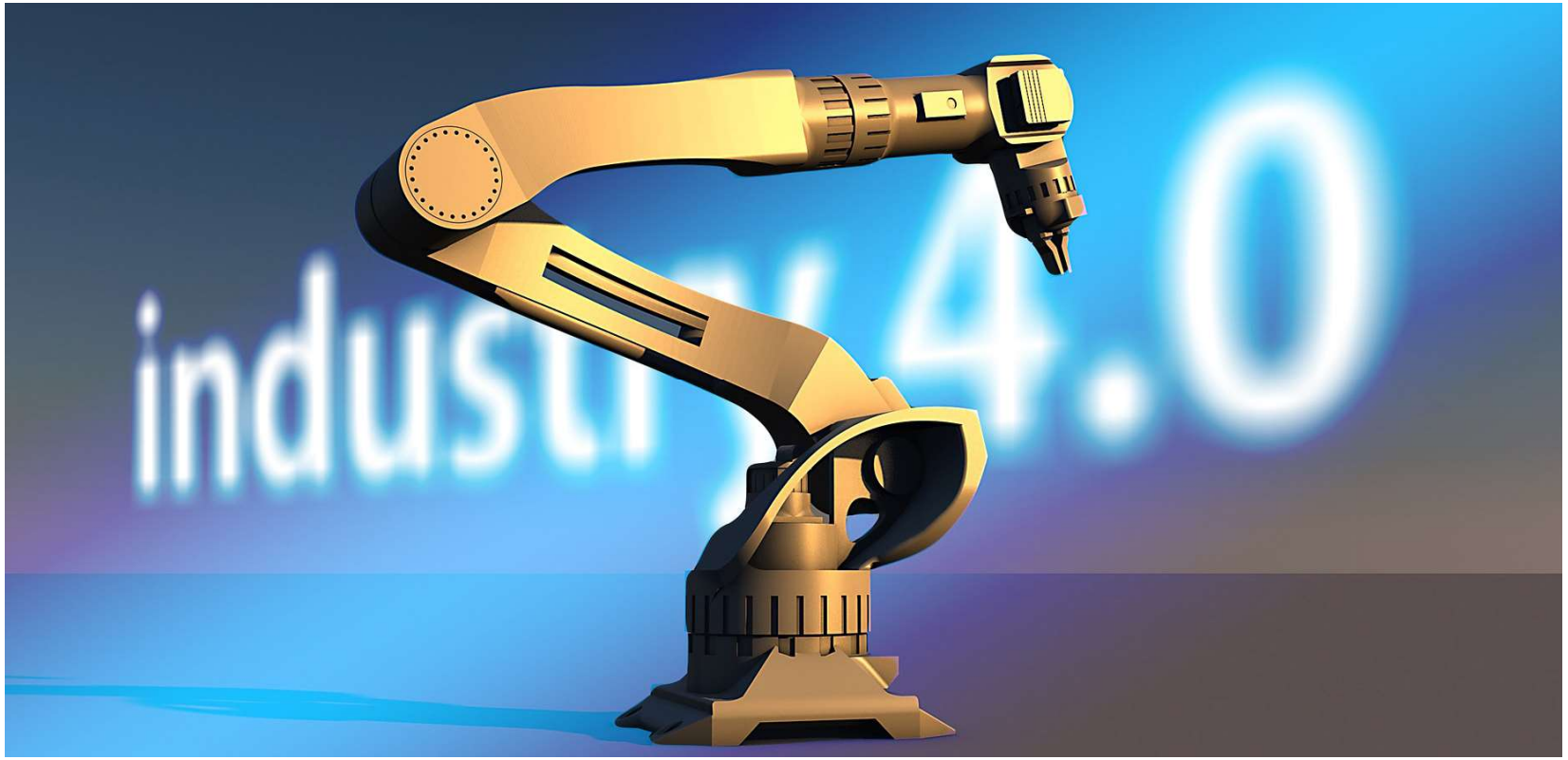


Figure 3. Technology and Industry that affect Fourth Industrial Revolution (IR 4.0)



"The Fourth Industrial Revolution, finally, will change not only what we do but also who we are.

It will affect our identity and all the issues associated with it: our sense of privacy, our notions of ownership, our consumption patterns, the time we devote to work and leisure, and how we develop our careers, cultivate our skills, meet people, and nurture relationships."

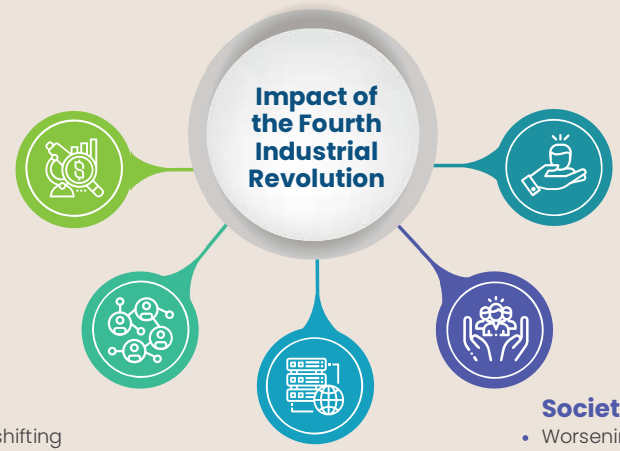
—Klaus Schwab, The Fourth Industrial Revolution

Impact of the Fourth Industrial Revolution

IR4.0 will bring changes to our culture and environment of the way we live, work and communicate. Transformational technologies, such as artificial intelligence, Internet of Things (IoT), big data and robotics, have and will continue to drive major changes for the construction industry, and beyond. The impact of the vast technological change will not only affect the economic growth but fosters a more empowering, collaborative, and sustainable foundation for our sociality.

However, the previous three revolutions had both positive and negative impacts on the industry, thus, the new emerging revolution should acknowledge these factors in ensuring IR4.0 will have greater value in liberating workers from automated tasks, freeing and focusing on addressing more complex business issues into one coordination, while being able to provide workers with radically new methods with the aim of achieving more constructive and creative solutions.

Source: Klaus Schawab, 2016



Economy

- Increase economic growth
- Unemployment (Unskilled labour substitution by automation)
- Impact on developing economies (Past phases have not reached many of world's citizens)
- Change the nature of work

The Individual

- Rise some of morality and ethical questions.
- Human connection (Affect social skill and ability to empathize.
- Managing Public and Private Information (Increasing the degree of interconnectedness, concerns privacy)

Business

- Customer expectation are shifting
- Product are being enhanced by data, which improves asset productivity
- New partnerships are being formed as companies learn the importance of collaborations
- Operating model are being transformed into new digital models.

National Global

- Shifting government to a modernise structures and functions
- Significantly change the traditional concepts of work and pay
- Impact the nature of national and international security

Society

- Worsening inequality (the tendency of new global technology platforms to dominate winner-takes-all markets could exacerbate inequality and social fragmentation)
- Community (Enable greater interaction across social, economic, cultural, political, religious and ideological boundaries.

World Benchmarking for the Fourth Industrial Revolution

How prepared are economies around world adapting to IR4.0? Is the world ready for a new revolution? Which countries can better adopt and explore digital technologies leading towards the transformation of businesses?

According to Institute for Management Development (IMD) World Competitiveness Ranking 2019, The United States (US) is ranked first as the world's most digitally competitive economy, followed by Singapore, Sweden, Denmark, Switzerland, Netherlands, Finland, Hong Kong SAR, Norway and Republic of Korea, completing the Top 10 countries. Malaysia is ranked 22nd. IMD World Competitiveness Ranking ranks 63 countries worldwide by 5-year trends of three digital competitiveness factors: knowledge, technology, and future readiness.

Several Asian economies; Hong Kong SAR, Republic of Korea, China and Taiwan, notably climbed up the ranking as compared to the previous year[12]. Hong Kong SAR and the Republic of Korea managed to stay in the Top 10 positions. Both countries demonstrated outstanding progress in terms of technological infrastructure and the agility of their businesses. **Figure 4** presents the 2019 overall ranking for the 63 economies covered by the World Competitiveness Yearbook (WCY). The economies are ranked from the least to the most competitive and the scores shown to the right are indices (0 to 100) generated for the unique purpose of constructing charts and graphics.

[12] The IMD World Competitiveness Center, IMD World Digital Competitiveness Ranking (Lausanne, Switzerland: International Institute for Management Development, 2019, https://www.imd.org/wcc/world- competitiveness-center-rankings/world-digital-competitiveness-rankings-2019/

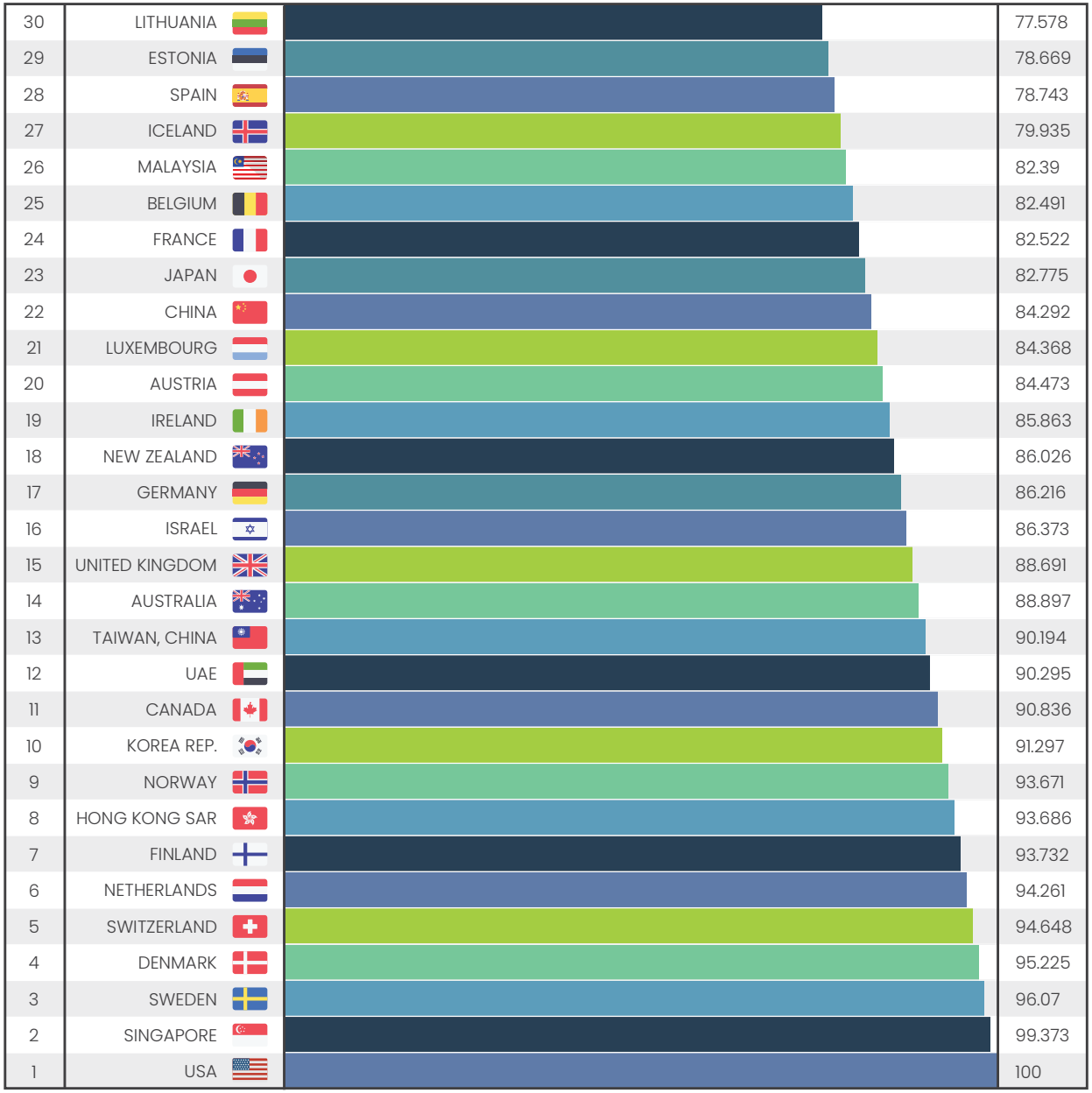
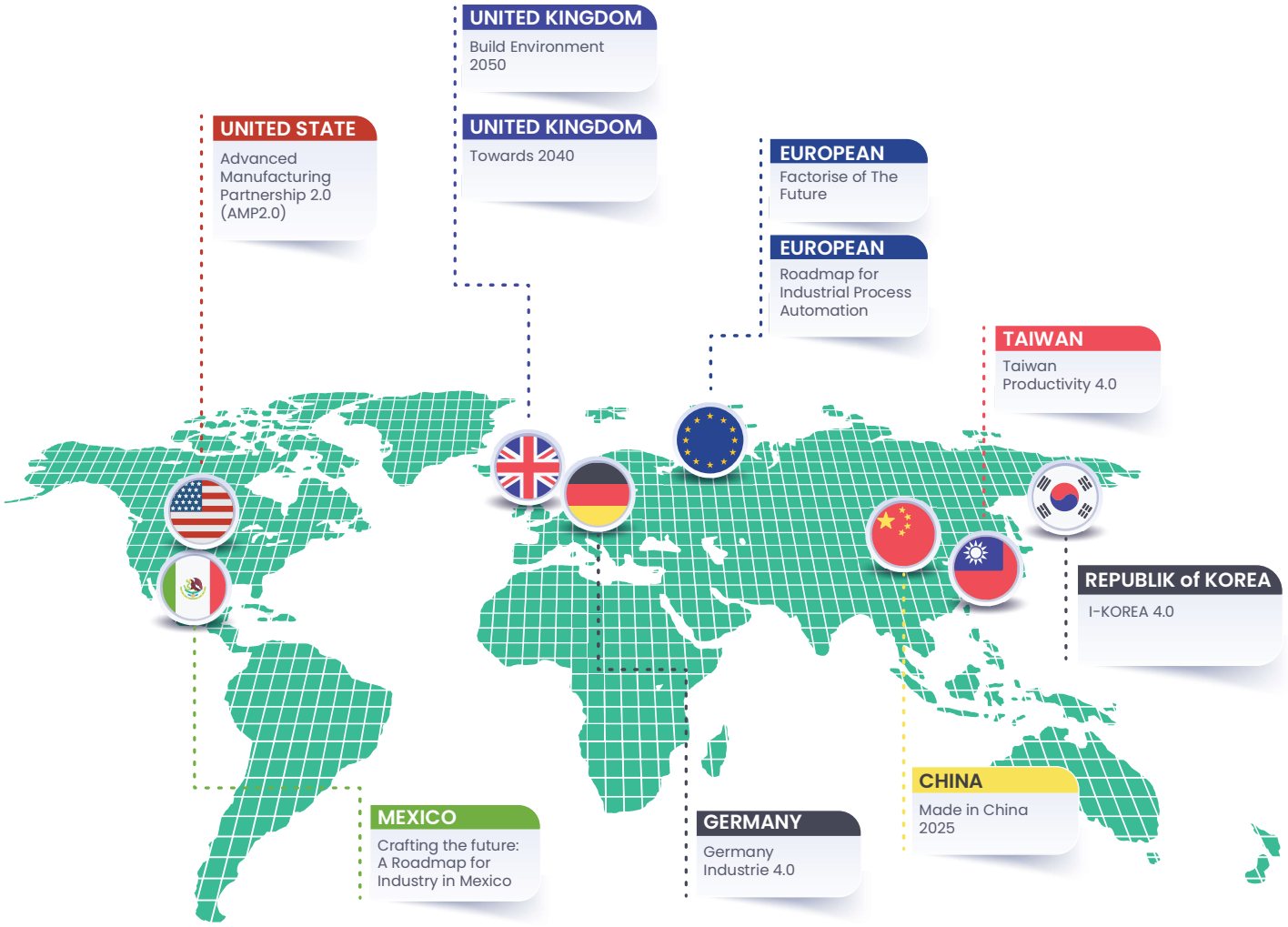


Figure 4. Digital Competitiveness Ranking [13]

[13] IMD World Digital Competitiveness Ranking (2019)

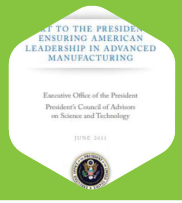

UNITED KINGDOM
Build Environment 2050
UNITED KINGDOM
Towards 2040
UNITED STATE
Advanced Manufacturing Partnership 2.0 (AMP2.0)
EUROPEAN
Factorise of The Future
EUROPEAN
Roadmap for Industrial Process Automation
TAIWAN
Taiwan Productivity 4.0
REPUBLIK of KOREA
I-KOREA 4.0
CHINA
Made in China 2025
GERMANY
Germany Industrie 4.0
MEXICO
Crafting the future: A Roadmap for Industry in Mexico

The objectives and process of creating a good environment for effective use of benchmarking for measuring and improving performance able to improve the overall process. Therefore, several documents from different countries are developing technology roadmaps to envision research and development, technology needs and goals to foster a new cycle of re-industrialisation. **Table 2** presents the documents that were analysed.

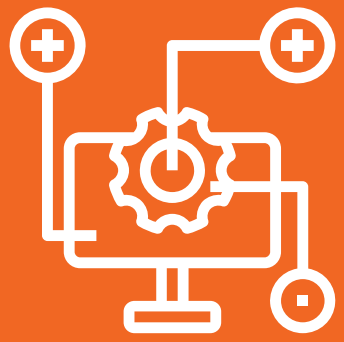
Country	Key Focus Area	Core Technology	Focus Industry
Germany Industrie 4.0 	a. Autonomy b. Interoperability c. Sustainability	a. Cyber-Physical Systems (CPS) b. Internet of Things (IoT)	a. Industrial production (Manufacturing, mining and utilities)
European: Factories of The Future 	a. Advanced manufacturing processes b. Adaptive and smart manufacturing systems c. Digital, virtual and resource efficient factories d. Collaborative and mobile enterprises e. Human-centred manufacturing f. Customer-focused manufacturing	a. Advanced manufacturing processes b. Mechatronics for advanced manufacturing systems c. Information and communication (ICT) d. Manufacturing strategies e. Modelling, simulation and forecasting methods and tools f. Knowledge workers	Manufacturing

Table 2. Summary of Fourth Industrial Revolution initiatives

Country	Key Focus Area	Core Technology	Focus Industry
European – Roadmap for Industrial Process Automation 	a. Sustainable production b. Competence management c. Trust, security, safety and privacy	a. Artificial intelligence and big data b. Autonomous plants and remote operations c. Platform economy d. Cyber security e. Safety-human, machine and environment f. Human-machine Interfaces and machine-to-machine communications	a. Pulp and Paper (including forestry) b. Metals c. Mining and Minerals d. Chemical e. Energy and Power f. Pharmaceutical g. Food Production and Processing h. Infrastructure i. Mobile platforms j. Oil and Gas
United Kingdom – Build Environment 2050 	a. Education and Skill b. Technology and Process c. Culture of Integration	a. Building Information Modelling (BIM) b. Radio-frequency identification (RFID) c. Telemetry spines integrated d. Self-assembly e. 3D printing f. Self-procuring g. Advanced robotics h. Autonomous vehicles i. Self-healing materials	Construction
United Kingdom – Towards 2040 	a. Product roadmap b. Technology roadmap	a. Electrical energy storage b. Electric machines c. Power electronics d. Thermal propulsion systems e. Lightweight vehicle and powertrain structures	Automotive

Country	Key Focus Area	Core Technology	Focus Industry
United State – Advanced Manufacturing Partnership 2.0 (AMP2.0) 	a. Enable Innovation b. Secure the talent pipeline c. Improve the business climate	Manufacturing technologies	Manufacturing
Mexico – Crafting the future: A Roadmap for Industry in Mexico 		a. Big Data Analytics b. Modelling and Simulation c. Robots d. IoT	a. Manufacturing b. Automobiles
China – Made in China 2025 	a. Research and Development (R&D) b. Technological Innovation	a. Networking b. Smart Manufacturing c. Industrial foundation d. IoT e. Intelligent products f. New production models	a. Information Technology b. Robotics c. Green energy and green vehicles d. Aerospace equipment e. Ocean engineering and high tech ships f. Railway equipment g. Power equipment h. New materials i. Medicine and medical devices j. Agriculture machinery

Country	Key Focus Area	Core Technology	Focus Industry
Taiwan – Taiwan Productivity 4.0 	a. Smart machinery b. Asian Silicon Valley c. Biotech and pharmaceutical industry d. Green energy e. National defence f. New materials and circular economy	a. IoT b. Smart robotics c. Big data	a. Agriculture b. Commerce c. Manufacturing
Republic of Korea – I-KOREA 4.0	a. Structural change of the public research system b. Exploratory and high-risk research c. Interdisciplinary research d. Business innovation policy strategies e. High-performance computing		None specifically targeted



SECTION

02

Construction 4.0: (A) Global Context

What is included in this section:


4.0
INDUSTRIE

Future of the Construction Industry

The future of the construction industry will be highly dependent on the adaptation of new technologies and innovations to current processes. Adoption of new technologies with new innovative methods will see a shift in how buildings and infrastructure projects being delivered. Projects will not solely focus on better-performing buildings and infrastructure, but also the prospect of improving the quality of life for society. The demand for projects is predicted to become more complex and interconnected, the construction industry should now leverage on new technologies and innovative processes to deliver better value. However, technology adoption is only a primary disruptor that will have a major impact on the construction processes and productivity for construction.

Based on the perspective of participants in the construction industry, listed below are the megatrends that will shape the future of the Malaysian construction industry.

Changes Towards Construction 4.0

In depth analysis of the construction industry shows that business models and operations were highly dependent on manual labour over the past decades, which results to persistent poor productivity. The Malaysia Productivity Report 2018/2019 reported the construction industry as the lowest contributor towards national Gross Domestic Product (GDP) at 4.9%[14], compared to the other industries, such as services, manufacturing, mining and quarrying and agriculture. The GDP contribution mirrors the current poor productivity of the industry. To improve this, the industry is encouraged to adopt and implement the myriad of technologies, improve current business and operations and reduce the reliance of low-skilled labour throughout the construction industry and supply chain. Simply, they must be ready to adopt the next industrial revolution (IR4.0), through a high-tech strategy.

Even though, Industry 4.0 term originally applied to manufacturing, however digital transformation in the era of IR4.0 is slowly but strongly changing the construction sector too[15]. Construction 4.0, coined from the term Industry 4.0, has gained attention by industry leaders to embrace digitalisation for the construction industry. It is a new concept using the Internet of Things (IoT) for the integration of information among different platforms and adopting new technologies like laser scanning, drones, 3D printing with the expectation of enhancing the ability to monitor construction projects at the design, construction and in use stages towards delivering sustainable and smart buildings[16].

[14] Malaysia Productivity Corporation, "26th Productivity Report 2018/2019" Retrieved from http://www.mpc.gov.my/wp-content/uploads/2019/09/Productivity-Report-18_19-latest-as-at-250919-1.pdf

[15] Patrick Dallasegaa, Erwin Raucha and Christian Linder, "Industry 4.0 as an enabler of proximity for construction supply chains: A systematic literature review", Computers in Industry, 99. (2018)

[16] Temidayo. O. Osunsanmi, Clinton Aigbavboa and Ayodeji Oke, "Construction 4.0: The Future of the Construction Industry in South Africa", World Academy of Science, Engineering and Technology, International Journal of Civil and Environmental Engineering 12, no. 3 (2018)

From a broader view, the tools to drive the technology advancement depend on the technology capability and contractor adaptability. The implementation of this technologies is only to response towards implementation of technology capability. There are several benefits in implementing Industry 4.0 concepts in construction. Transformation of construction industry towards IR4.0 will have significant effects by decreasing construction budget; on the environment, by optimising the use of limited materials or by constructing facilities supplementary eco-effectual[17]. Reduction of labour costs can be achieved through robotics, reduction with material costs through an embedded-sensors (e.g. RFID), achieve time savings by prefabrication and additive manufacturing, improve building performance with BIM, and increase collaboration among organisations through cloud computing. On the other hand, the scarcity of the most advanced technologies that is able to interact in between several assets and processes; such as big data and virtual safety training in Smart Helmets, Smart Glasses and Smart Clothes; will be able to assist in enhancing safety for workers. The combination of wearables, visualisation and mobile devices can help increase understanding, standards and certainty of the project.

Ethical responsibility is also a key indicator as a successful driver of IR4.0. The construction industry has enormous potential to embrace its obligations and effectiveness not only through digitalisation but becoming a pioneer of technologies and modern methods for construction.

[17] Wesam S Alaloul, Mohd Shahir Liew, Noor Amila Wan Abdullah Zawawi and Bashar S Mohammed, "Industry Revolution IR 4.0: Future Opportunities and Challenges in Construction Industry", MATEC web of conferences, vol. 203. (2018)

World Benchmarking for Construction 4.0

Few countries have specific strategic documents focusing on the digital transformation of the construction industry. However, there is a gap in strategic thinking as less emphasis are given towards the construction industry. The benchmark shows several digital construction strategic plans that encourages the use of new emerging technologies as the way forward.

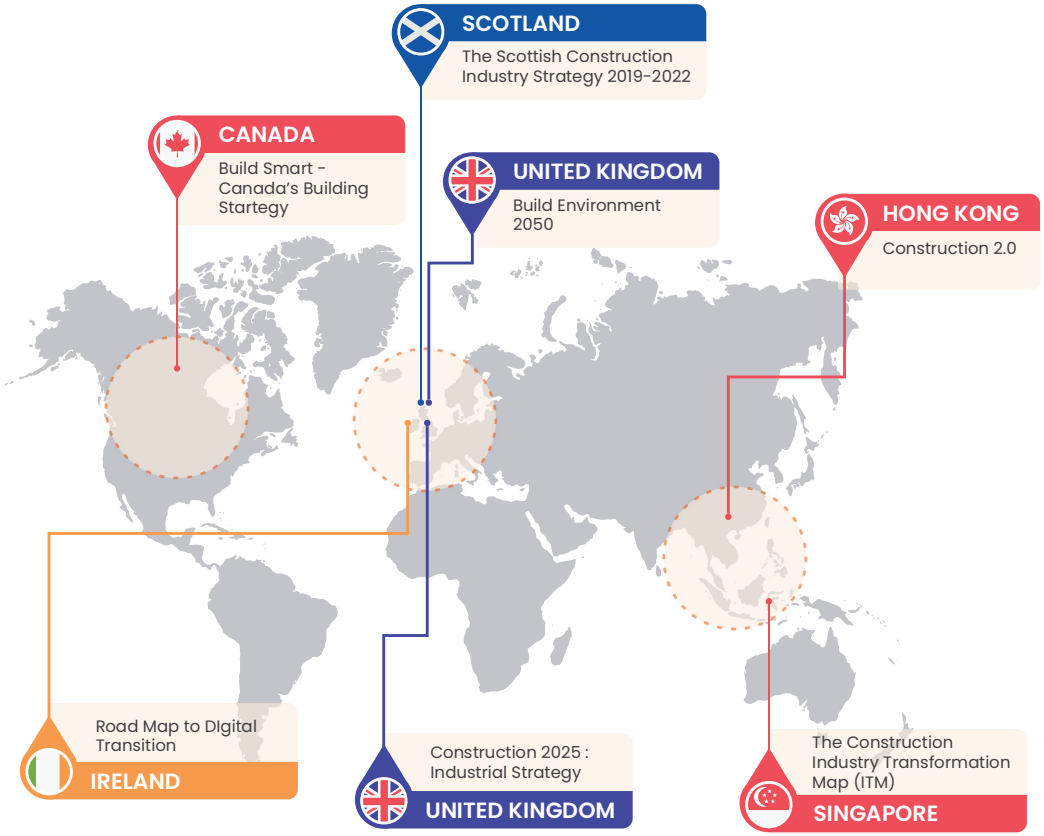


Figure 5. Benchmarking other countries strategy on the digital transformation of construction industry

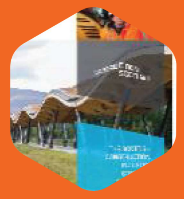
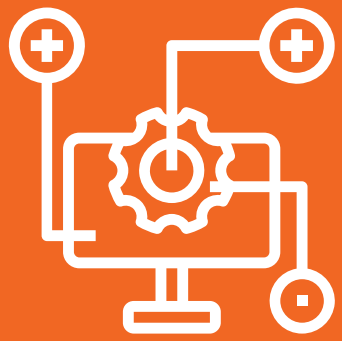
Document & Country	Key Focus Area
Built Environment 2050, United Kingdom 	a. Culture of Integration b. Education and skills c. Process and technology
Construction 2025 Strategy, United Kingdom 	a. Smart construction and digital design (smart technology) b. Low carbon and sustainable construction (green construction) c. Improved trade performance (overseas trade)
Ireland's Roadmap to Digital Transition for Construction, Ireland 	a. Leadership b. Standard c. Education and training d. Procurement
The Scottish Construction Industry Strategy 2019 – 2022, Scotland 	a. Procurement b. Skills c. Quality and standards d. Planning and building regulations e. Growth opportunities f. Productivity and Innovation

Table 3. Global construction strategic planning

Document & Country	Key Focus Area
Build Smart Canada's Buildings Strategy, Canada 	a. Getting Net-Zero Energy Ready b. Bringing Buildings Into the Future c. Setting Energy Data Free d. Being equipped for the future e. Financial incentives
The Construction Industry Transformation Map (ITM), Singapore 	a. Design for Manufacturing and Assembly (DfMA) b. Building Green c. Integrated Digital Delivery (IDD)
Construction 2.0, Hong Kong 	a. Innovation b. Professionalisation c. Revitalisation



Construction 4.0: (B) Malaysian Context

SECTION

02

What is included in this section:

Malaysian Construction Overview

The Malaysian construction industry continues to play an important role in the economic growth of the country, as well as facilitating the development of socioeconomics of the society at large. Supported by strong fundamentals, the Malaysian economy is projected to remain resilient despite the world economic uncertainties. The Shared Prosperity Vision 2030 (SPV 2030) has set the vision for Malaysia's sustainable development pathway, which emphasised on equitable economic distribution, inclusive at every level of the supply chain, ethnicity and geographical divide in order to create a sense of harmony and political stability among Malaysians.

The government has aim to reach the Gross Domestic Product (GDP) goal of RM3.4 trillion by 2030 with the country's GDP grows at an average growth rate of 4.7% annually from 2021 to 2030

The GDP growth of the Malaysian economy is contributed by several primary industries, including the construction industry with 4.5% contribution for fourth quarter 2019. Literally, the adoption of technology will become the direction towards the evolution of the economy into higher-value and technology-driven sectors. The government's effort to improve access to affordable housing and quality physical infrastructures are expected to push the construction industry to shift towards a greater adoption of new technologies and new construction methods. The industry's expansion will be driven by the resurgence of several new building and infrastructure projects, as well as productivity enhancement to support the economy. The outlook for adoption and implementation of new technologies and new construction methods is immensely positive.

Malaysia's Overall Ranking

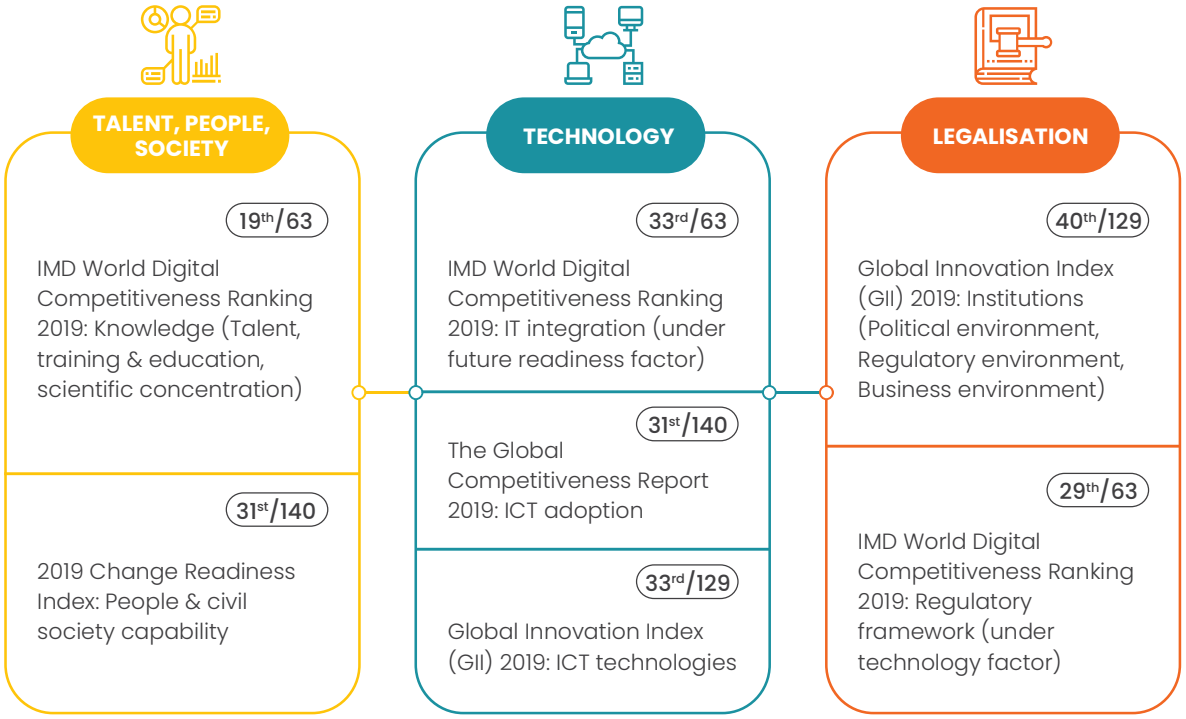
The ranking listed below presents the 2019 overall ranking for Malaysia from several perspectives, such as national competitiveness, innovation index and global capacity and readiness to adopt and explore digital technologies, which are covered by the World Economic Forum (WEF), World Intellectual Property Organisation (WIPO) and The International Institute for Management Development (IMD) respectively.

Malaysia readiness based on performance

Looking on the Global Competitiveness Report 2019, Malaysia is ranked second in ASEAN; behind Singapore (1st), Thailand (40th) and Indonesia (50th) with the total mark of 74.6. From a global ranking perspective, Malaysia is ranked 27th, down two places from 2018 but still showing positive impact in terms of competitiveness among the ASEAN countries. Regarding its performance, there is a 10 points gap between Singapore and Malaysia, demonstrating a considerable room for improvement.

Focusing on the Global Innovation Index 2019, Malaysia is ranked 35th globally with the score of 42.68. Malaysia is still ranked second in ASEAN behind Singapore. Both Singapore and Malaysia have considerable leads compared to other ASEAN countries such as Vietnam, Thailand, Philippines, Brunei Darussalam and Indonesia.

IMD World Competitiveness ranking only included 63 countries, in which Malaysia managed to secure the 22nd place. Malaysia has been on the same rank since the last assessment. The countries in the list are based on the availability of comparable international statistics. The scoring assessment is solely based on the competitiveness of countries by taking into account the evolution of the global environment and new research. By doing this, WCY would be able to keep track of the changes in national environments and the rapidly changing technological revolution. Malaysia is ranked mid-table in terms of global ranking and placed second in ASEAN for competitiveness and innovation. This demonstrates that Malaysia is ready to embrace this new construction revolution.



Source: World Economic Forum (WEF), World Intellectual Property Organization (WIPO) and The International Institute for Management Development (IMD).

Key Facts and Figures (2018)

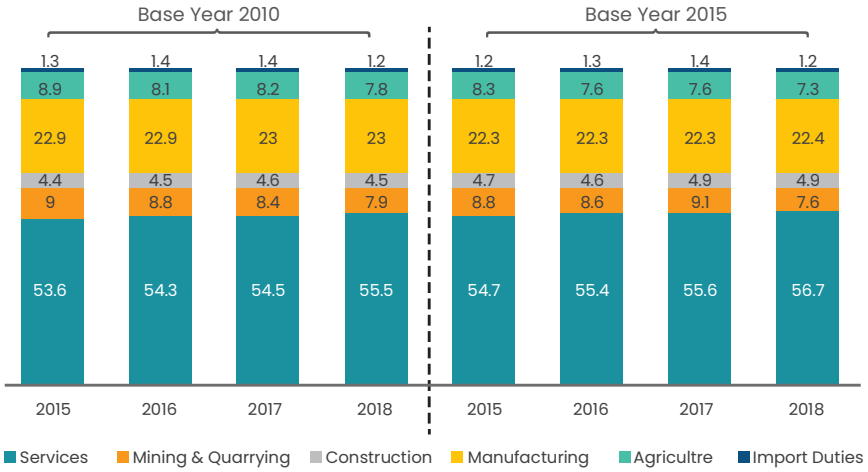


Figure 6. Percentage share of GDP by sector

*Source: Department of Statistics Malaysia (2020)

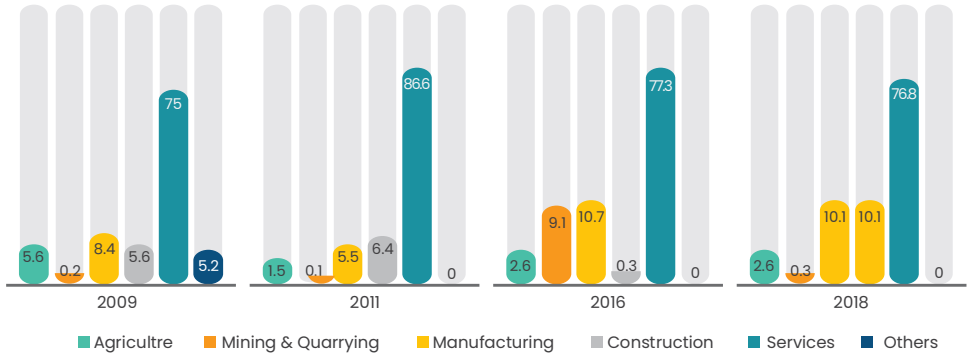
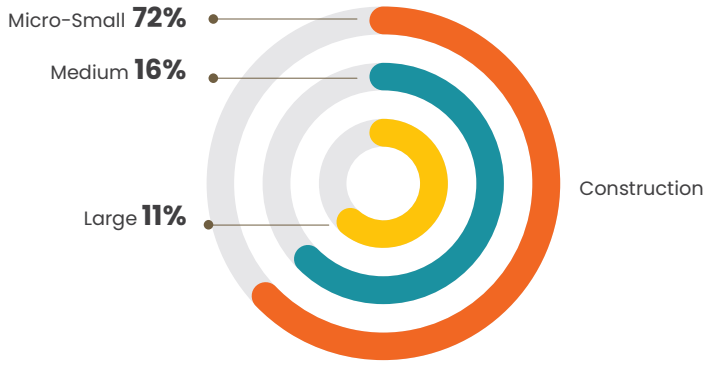


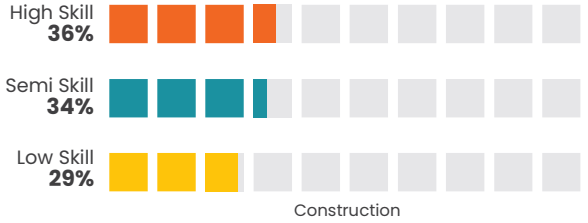
Figure 7. Distribution establishment by sector in Malaysia (2009-2018)

*Source: (National Employment Returns (NER) 2018, Institute of Labour Market Information and Analysis)



*Establishment: Business entities that employ workers

Gender Ratio by Empolyees by 2018



Distribution of Employess by SKill Level 2018

Figure 8. Distribution establishment by size 2018

*Source: (National Employment Returns (NER) 2018, Institute of Labour Market Information and Analysis)

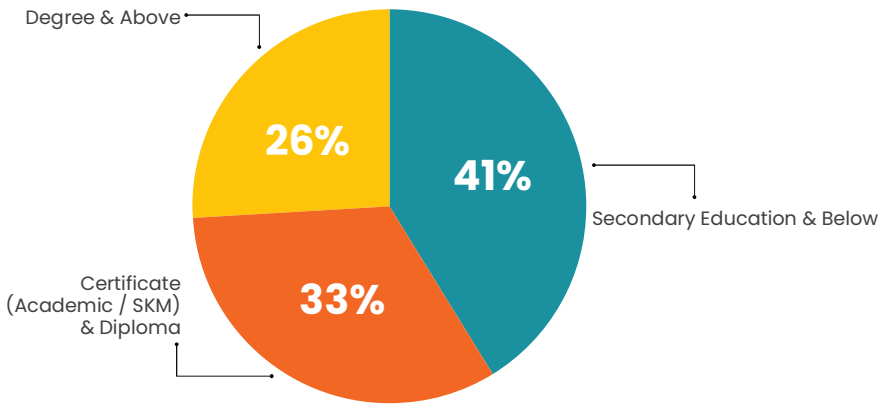


Figure 9. Highest Education Level of Full-Time Malaysian Employees 2018

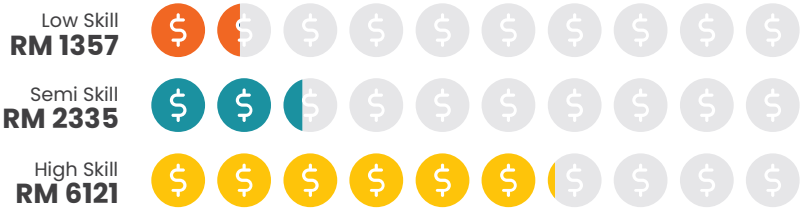
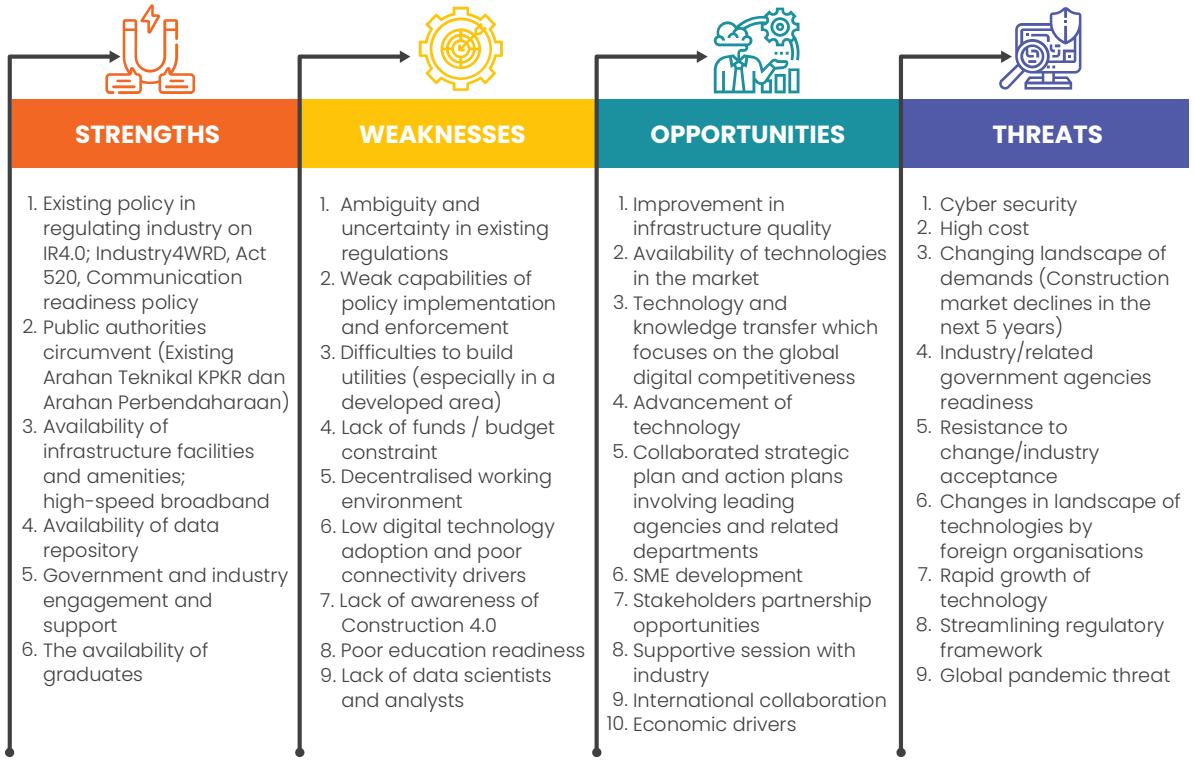


Figure 10. Median of Monthly Basic Salary by Job Category 2018

*Source: (National Employment Returns (NER) 2018, Institute of Labour Market Information and Analysis)

SWOT Analysis for the Strategic Plan

SWOT analysis is a tool used to develop strategic plans by assessing internal and external factors. By acronym, SWOT stands for Strengths, Weaknesses, Opportunities and Threats. Strengths and Weaknesses are classified as internal factors, while Opportunities and Threats are classified as external factors. This analysis gives an overview of the construction industry scenarios in Malaysia, as well as the positive and negative factors that would influence the success of Construction 4.0. New strategies is then be established by leveraging strengths and opportunities to overcome weaknesses and threats.



STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
1. Existing policy in regulating industry on IR4.0; Industry4WRD, Act 520, Communication readiness policy 2. Public authorities circumvent (Existing Arahan Teknikal KPKR dan Arahan Perbendaharaan) 3. Availability of infrastructure facilities and amenities; high-speed broadband 4. Availability of data repository 5. Government and industry engagement and support 6. The availability of graduates	1. Ambiguity and uncertainty in existing regulations 2. Weak capabilities of policy implementation and enforcement 3. Difficulties to build utilities (especially in a developed area) 4. Lack of funds / budget constraint 5. Decentralised working environment 6. Low digital technology adoption and poor connectivity drivers 7. Lack of awareness of Construction 4.0 8. Poor education readiness 9. Lack of data scientists and analysts	1. Improvement in infrastructure quality 2. Availability of technologies in the market 3. Technology and knowledge transfer which focuses on the global digital competitiveness 4. Advancement of technology 5. Collaborated strategic plan and action plans involving leading agencies and related departments 6. SME development 7. Stakeholders partnership opportunities 8. Supportive session with industry 9. International collaboration 10. Economic drivers	1. Cyber security 2. High cost 3. Changing landscape of demands (Construction market declines in the next 5 years) 4. Industry/related government agencies readiness 5. Resistance to change/industry acceptance 6. Changes in landscape of technologies by foreign organisations 7. Rapid growth of technology 8. Streamlining regulatory framework 9. Global pandemic threat

Table 4. SWOT analysis for development of Construction 4.0 strategic plan[18]

[18] Focus Group Discussion (FGD) CIDB with Ministry Level (2019)

Assessing Issues and Challenges for Implementation

Global investments in construction industry is estimated at USD10.3 trillion by 2022, which contributes almost 13% of global GDP. This scenario has brought upon a tremendous difference in which the development of Smart Construction will create a large gap between Gen Y and Gen Z in user and demand. Hence, the issues and challenges brought by technology advancements of IR4.0 will focus on four key domains namely People, Governance, Economy and Integrated Technologies. This may start with collaboration and integration with the innovation ecosystem, as well as technology upgrading. Therefore, tackling the issues and challenges may be improved as it was based on the benchmarking on a country's readiness.

ISSUES & CHALLENGES FOR CONSTRUCTION 4.0

Assessing Issues and Challenges for The Implementation of Construction 4.0

While majority of the industries have undergone tremendous changes over the past few decades, the construction industry has been reluctant to fully adopt the latest technological and innovation opportunities; causing its productivity to stagnant or even decreased over the last 50 years. Addressing the issues and challenges that could potentially hinder Construction 4.0 transformation is absolutely vital. The issues and challenges are shown in **Figure 11**.

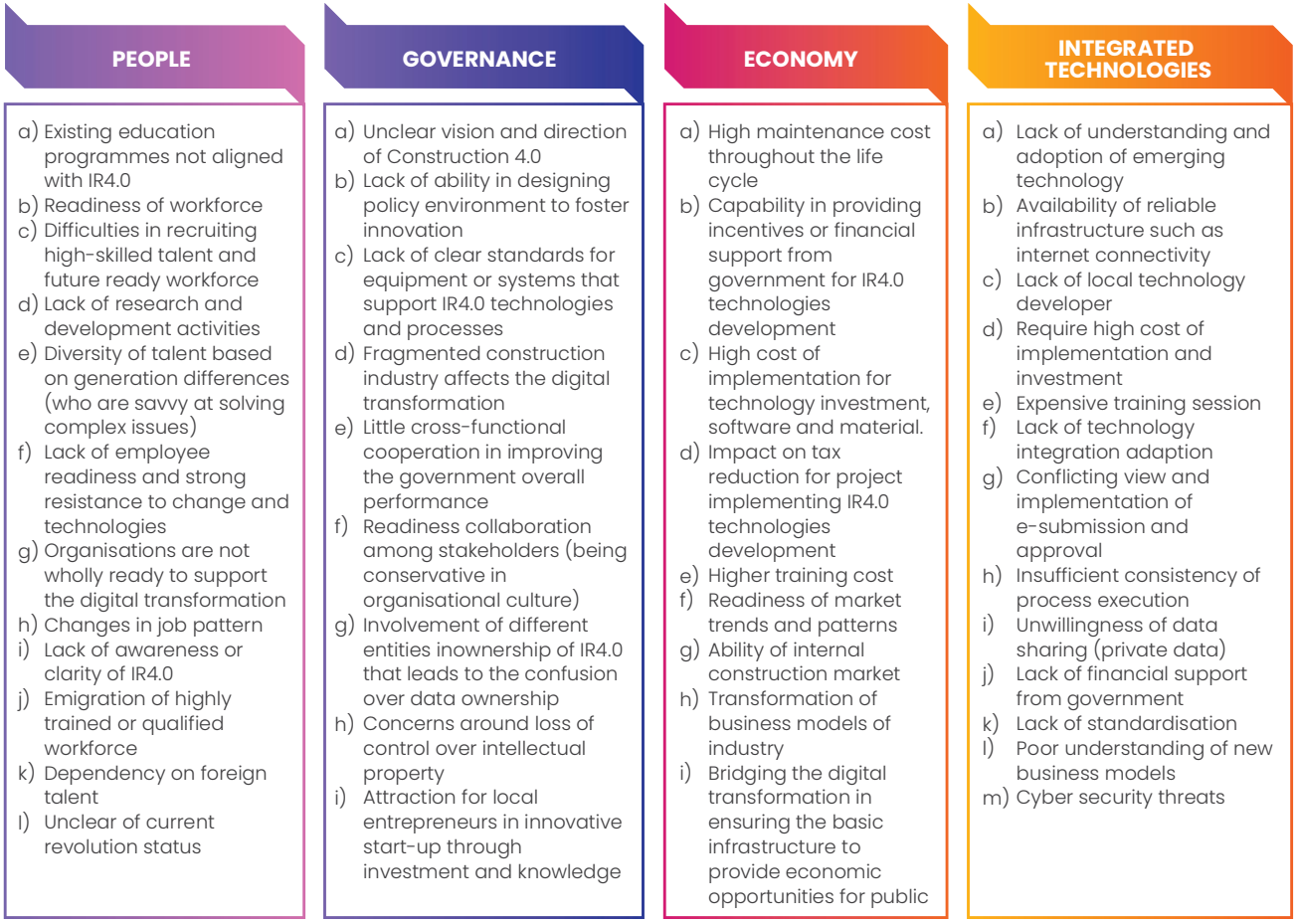


Figure 11. Issues and challenges for implementation of Construction 4.0[19]

[19] Focus Group Discussion (FGD) with Construction Industry (2019)

Emerging Technologies

Utilising emerging technologies in construction industry will provide a key driving force by optimising human interventions throughout the project lifecycle and the management of projects. An appropriate balance between economic, social and environment issues will lead to better utilisation of real-time monitoring technology and will contribute towards the optimisation of building operation and maintenance.

12 Emerging Technologies

Transforming Construction Industry

This section shows emerging technologies in construction based on the Focus Group Discussion (FGD) conducted among construction industry in Malaysia. The information presented explains each technology briefly with duration and planned targets for the technologies to be adopted in Malaysia.

Short-Term (less than 1 year)

Prefabrication & Modular Construction

A completed manufacturing process for volumetric units of building construction systems that generally assembled in factory to form as a component prior to final installation on site.

Building Information Modeling (BIM)

A central repository which requires integration of fragmented disciplines of architecture, engineering and construction, and to optimise the lifecycle performance of buildings.

Autonomous Construction

Automatic assembly method of construction tasks by applying robot that is controlled using computer process and mechanisation.

Augmented Reality & Virtualisation

An interaction between human and computer which would enable an individual to distinguish both virtual and real-world object.

Cloud and Realtime Collaboration

Internet centric to provide free flow of Manufacturing information for construction professionals and offering a huge amount of storage resources.

3D Scanning and Photogrammetry

A data acquisition and mapping tool with the ability to interpolate a photograph to become 3D models for changes monitoring.

Medium-Term (less than 3 years)

Big Data and Predictive Analytic

Efficiently handle large amounts of projects data by efficiently storing, managing and process using a commodity server.

Internet of Things

It is the development of Internet of Things (IoT) that enables in detecting the surrounding environmental conditions which sense by objects and devices.

Long-Term (less than 5 years)

3D Printing & Additive Manufacturing

A process to create or recreate a physical object that modelled in digital version by depositing layers of materials.

Advanced Building Materials

Development of new materials for the industry by integrating new technologies and processes to create a new or improved product.

Blockchain

Distributed ledger of database in which information, records of transactions, internet protocol and others can be maintained across a network of computers.

Artificial Intelligence

Allow machines to imitate the human cognitive functions to enable machines to conduct tasks that is usually performed by humans via a set algorithm.

Technology Clustering

Simulation & Modelling

Building Information Modelling

Cluster 1 (C1) involves simulation and modelling, a central part of Construction 4.0. As every construction project is unique, increasing with complexity and influenced by external factors (eg weather, labour performance and supply fluctuations, etc.), simulations can be applied to improve the construction operations and manage risks. Cluster 2 (C2) offers a wide range of simulation-tools, models or framework for project planning, resource planning and/or the management of projects.

Digitalisation & Virtualisation

IoT, Blockchain, Big Data, 3D Printing, Predictive Analysis, AR, VR, Cloud, Realtime Collaboration

Cluster 2 (C2) is related to digitalisation and virtualisation technologies. This concept focuses on the interoperability of digital project data, information management or digitalisation in general.

Smart Factory

Advanced Material, Autonomous Vehicle, Big Data, Prefabricated / Modular

Cluster 3 (C3) comprises a wide range of technologies and concepts to automate the construction process and to create a "Smart Factory" for the construction industry. The corresponding technologies of this cluster would fit the "end-to-end digital integration of engineering" which is described as one of the key features of Construction 4.0.

IR4.0 initiative was established as a result of the growth of technological innovations. Based on global competitiveness and readiness for technology, it shows there is a need in controlling and understand every aspect of technology in boosting the productivity, improve processes, and drive growth. Figure below shows the adoption rate based on the existing technology in assisting users in the adoption of IR4.0 for construction industry.

Figure 12. Government-industry perception on technology needs.

Emerging Technologies

in Construction Supply Chain

The following section illustrates the application of some emerging technologies along the construction supply chain. The application of each technology can be used at different phases in project lifecycle. The figure also explains the vertical and horizontal integrations of emerging technologies in a project.

Construction Project Lifecycle (Horizontal Integration)

Adaptation from RIBA Plan of Work, 2020	**Stage 0-1:** Strategic Definition; Preparation and Briefing	**Stage 2-4:** Concept Design; Spatial Coordination; Technical Design	**Procurement Route:** Procurement Strategy needs to be considered from early stage	**Stage 5:** Manufacturing and Construction	**Stage 6-7:** Handover and Use
Adaptation from Ozorhon, Abbott and Aouad, 2010)	**Conceptual**	**Planning & Design**	**Procurement**	**Construction**	**Operation & Maintenance**
Actors (Vertical Integration)					
Owner / Client Architect Engineer Contractor Manufacturer Facility Management	Client defined value, data driven design, evaluation of alternatives, virtual migration of physical built environment.	Collaborative design, simulation and analysis, integrated models, join reviews and clash detection, design for production.	Lean and BIM based procurement.	Model based collaboration, lean and BIM for production and control.	Facilities management systems integration with BIM.
Technology Cluster					
Simulation & Modelling	Building Information Modeling (BIM)				
	Augmented Reality & Virtualization				
Digitalisation & Virtualisation	Cloud and real time collaboration, Artificial Intelligence, Block Chain, Internet of Things				
		Big Data and Predictive Analytic			
				IoT	
Smart Construction	3D Scanning and Photogrammetry				
				Autonomous Construction	
		3D Printing & Additive Manufacturing			
	Prefabrication & Modular Construction				

Strategic Planning: (A) Drivers of Change

SECTION

03

What is included in this section:

Our Mission

Transform the Malaysian construction industry by empowering smart construction for future society

*What Is smart construction?

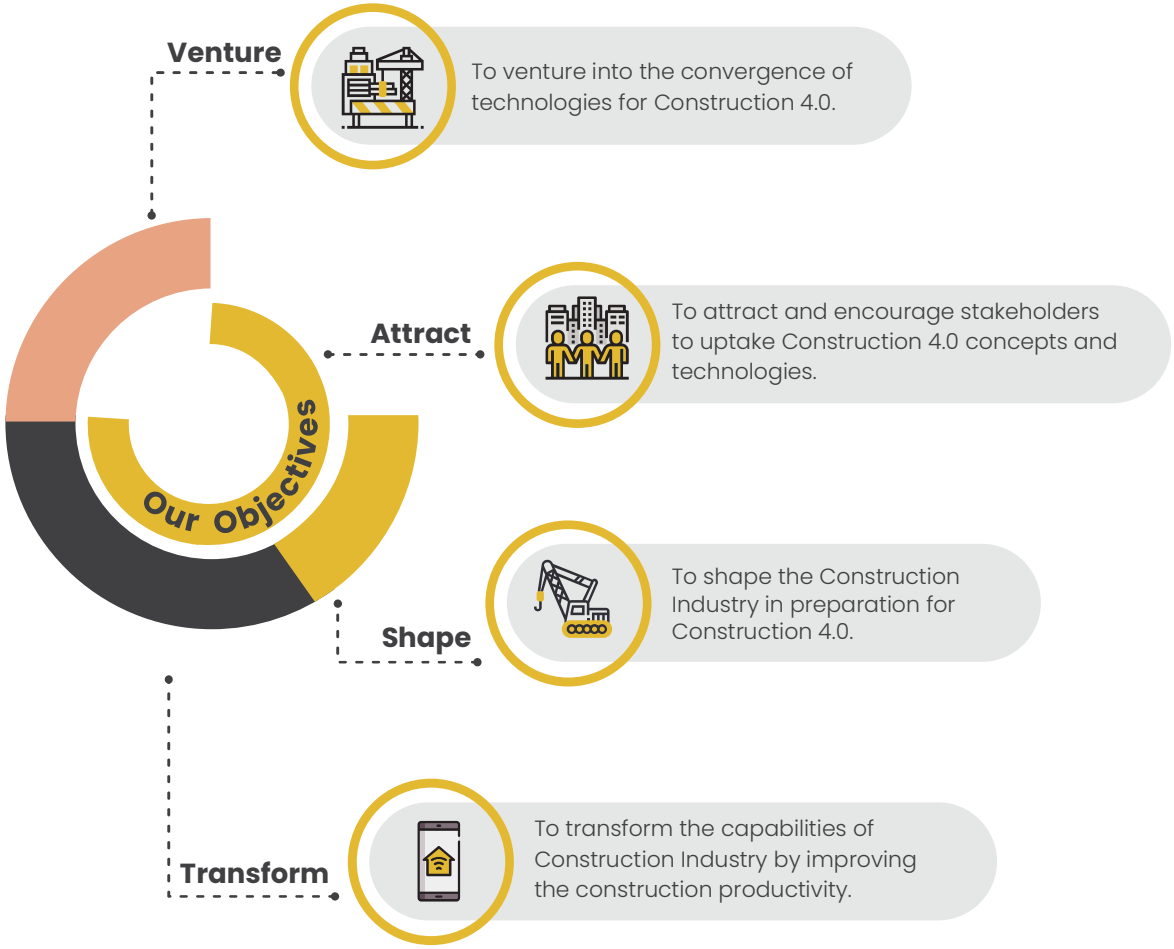
Smart construction is building design, construction and operation that through collaborative partnerships fully utilise digital technologies and industrialised manufacturing techniques to improve productivity, minimise whole life cost, improve sustainability and maximise user benefits.

(Construction Leadership Council, 2018)

Our Vision

To be the leading Construction 4.0 country in the Southeast Asian region

This vision statement aims to support digital transformation in Malaysia for the construction industry. Combined with the country's experience and digitalised ecosystem, it is expected that Malaysia will become a hub for digital transformation for the construction industry. This digital hub would be able to create a network among Southeast Asian members across disciplines to jointly discuss, develop and execute construction strategies towards digital transformation. The multiconcerted efforts will benefit industry participants and prepare the region for this revolution.

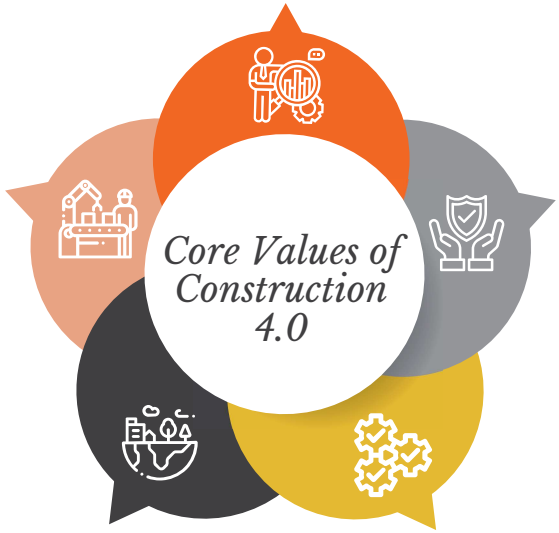

Venture
To venture into the convergence of technologies for Construction 4.0.
Our Objectives
Attract
To attract and encourage stakeholders to uptake Construction 4.0 concepts and technologies.
Shape
To shape the Construction Industry in preparation for Construction 4.0.
Transform
To transform the capabilities of Construction Industry by improving the construction productivity.

Well being

Improving wellbeing will have a positive impact on performance. Having a work-life balance can provide a happy and healthy working environment and experience.

Productivity

Productivity in construction will improve the overall performance rate. This includes quality of work and efficiency of labour to finish on time. Productivity performance measurement includes methods, efforts and effectiveness of a system to be able to dictate the performance of Construction 4.0.



Safety & Health

An effective safety & health program may prevent accidents on construction sites. This core value must be instilled in all participants as this has direct relation to fatalities, injuries and diseases that indirectly affect the community's surrounding safety.

Sustainability & Resiliency

Sustainability in construction is reflected by reducing its impact on the environment. This includes using recyclable resources, reducing energy consumption and waste, creating an environmentally friendly workplace and protecting the nature of **environment**. On the other hand, resilience is reflected towards the ability to withstand against natural and manmade disasters and disturbance. It also emphasizes on resiliency against the growing threats towards technology (such as cybersecurity). So, it is important to protect the industry from threats without disrupting business innovation and growth.

Integrity

Integrity is reflected towards the behaviour of organisations when conducting business. Excellent ethical practices by stakeholders often lead to a business integrity. Therefore, the value of a construction industry is to bring the heart of integrity especially in deal in the era of IR 4.0

Enablers for Construction 4.0

The strategic plan of Construction 4.0 for 2021-2025 highlights a five-year strategy for the construction industry to shift towards digital transformation. Transitioning to adopt Construction 4.0 is outlined as key enablers, the foundation for the industry's digital transformation. The four (4) key enablers that support the strategy are explained below.

01

People

Do we prepare the people for tomorrow's workforce?

Construction 4.0 is not only about technology, but the ability to allocate the right people at the right place and at the right time to ensure the transition is successful. The technological adoption to construction processes requires the future workforce to be equipped and ready with new skills to enable them to adapt to the changing industry environment. Human capacity is critical as Construction 4.0 advocates the values of growth and resilience. The readiness of participants in the industry to be aware of the latest technological advancement and receptive to change is vital to ensure continuous competitiveness of human capital. The industry would be able to achieve the next level by adopting the next set of strategies, such as educating potential candidates, deliverable of knowledge, training and upskilling the existing employees. Without the participation of new talents, Construction 4.0 would suffer from slow progress and risk missing the digital transformation.

02

Integrated technology

What technologies were used in delivering value in complex project?

Disruptive technologies are becoming a daily occurrence. This brings specific technological innovation or complex disruption stemming from an integration of technological and/or non-technological trends.

Technology means scientific knowledge used in practical ways in industry. By integrating this technology, it may lead to successful connection and work could be carried out easily with higher success rate and completion. Thus, integrated technology is a combination of two or more technologies to help increase productivity, improving the success rates and enjoying benefits throughout the whole life cycle of the project.

03

How does governance drive the overall Construction 4.0 process?

Maximising the value in transforming the construction industry towards digitalisation requires strong governance in order to achieve efficiency and better productivity. This governance includes new and improved policies and processes. These must be responsive in delivering Construction 4.0 and substantially conducted by incorporating knowledge with the value chain, which comprises of client, contractor, sub-contractors, consultants, suppliers and others.

In realising the full potential of Construction 4.0, it is important to engage and coordinate all participants in the industry to gain the full benefits of moving from conventional process to an advanced technological approach. Digital technologies of the Construction 4.0 will create a more inclusive, innovative and resilience industry. Data-driven advances are now set to reshape regulatory frameworks of a country. With this, a clearer decisionmaking framework must be supported and leverage the control aspects, such as the contractual parties, process, risk associates and others.

04

How does economy helps to drive the overall Construction 4.0?

Digitalisation has currently become a new imperative for business growth and performance. To drive this strategic plan, it must address opportunities for improvements and leverage efforts to create a business climate that attracts investment; and, provide a mechanism to evaluate investments and redirect policies where needed. The result will help ensure that economic growth in our community creates opportunities and lifestyle improvements for our residents and business community.

This effort can act as an enabler to enhance the Construction 4.0 ecosystem, to step and speed up the adoption process. It will lead to a new transformation in the global economy and will bring upon massive impact to the countries.

Strategic Plan: (B) Future Direction

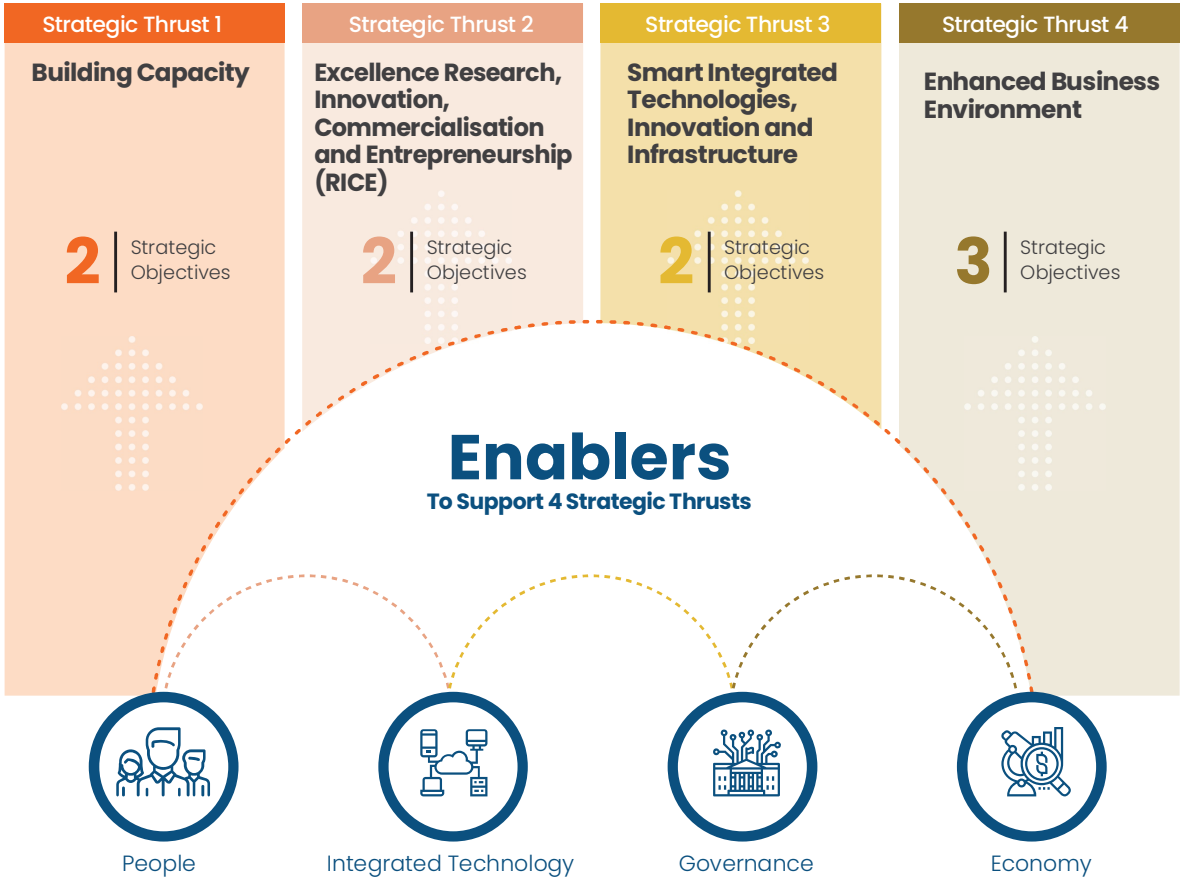
SECTION

03

What is included in this section:

Strategic Priorities
for Construction 4.0

Strategic thrusts highlighted will drive the digital transformation for the construction industry. The primary focus of these key focus areas will be supported by four (4) enablers as the foundation for this transformation process. Each of the key focus areas hold different number of strategic priorities.



Strategic Thrust 1

Building Capacity

Strategic Objectives :

1. Preparing future workforce for Construction 4.0
2. Create mechanisms to support innovators and technology adopters

Strategic Thrust 2

Excellence Research, Innovation, Commercialisation and Entrepreneurship (RICE)

Strategic Objectives :

1. Government - Industry - Academia-Civil Society partnership for Construction 4.0 innovation and technology transfer
2. Driving research and innovation in Construction 4.0

Strategic Thrust 3

Smart Integrated Technologies, Innovation and Infrastructure

Strategic Objectives :

1. Improve government policy intervention in applying specific technology
2. Enhance collaboration of disruptive technology and data center repository

Strategic Thrust 4

Enhanced Business Environment

Strategic Objectives :

1. Enhance domestic and international business partnership to increase the growth of the industry
2. Creating collaborative governance ecosystems through government intervention
3. Promote the foreign direct investment or collaboration that act as a vehicle for local construction organisations to gain access to international markets

Strategic Thrust 1

Building Capacity

Rationale:

The rapid growth of technological changes requires current and future talents to be competent and well trained. The construction industry requires an agile workforce, whom are bright, ready and willing to deliver this transformational change. Strategies to nurture talents for all construction stakeholders should be the foundation of a comprehensive workforce ecosystem.

Initiative

Building Capacity

Current state

- As of 2019, the construction industry vacancies are dominated by low-skilled jobs. Competent digital talents are scarce. Malaysia lack a proficient, conversant and experience vendor education system to educate and train employees in the latest digital trends. The industry often recruits foreign experts from the United Kingdom, United States or Singapore to offer expert training to employees.
- In Higher Education, curriculum in tertiary institutions are not kept in-pace with the rapid changes taking place in the industry. Very few universities have robust industry–linked curriculum or research programs to meet the needs of the industry. This led to the lack of skilled talents to fill technical and digital posts.

STRATEGIC OBJECTIVES	ENABLERS	CASE FOR CHANGE	AIMS	TIMELINE
1 Preparing future workforce for Construction 4.0	People Governance	• Inadequate highly skilled talents • Readiness of students for IR4.0 workplace • Difficulties in recruiting talented and future ready workforce • Lack of employee readiness as well as strong resistance to changes and new technologies • Potential of emigration of highly trained or qualified people • Dependency of foreign talents	Develop and deliver Construction 4.0 awareness and programme for stakeholders	• 2021 Short Term
			Develop apprenticeship program for construction 4.0	• 2021 Short Term
			Enhanced skills programme for construction supply chain towards Construction 4.0 implementation (Training module and competency)	• 2021 Short Term
2 Create mechanisms to support innovators and technology adopters	Economy Integrated Technologies	• Education syllabus is not in sync with the increasing demand of the industry • Lack of financial support	Establish Technopreneurship Development Initiatives and Programme (TDIP) for construction industry players to shift towards digital transformation process.	• 2023 Medium Term
			Prepare graduates for Construction 4.0 technologies by integration of STEM (Science, Technology, Engineering and Mathematics) and Technical and Vocational Education Training (TVET).	• 2021 Short Term
			Nurture an active community of integrated technology adopters.	• 2021 Short Term
			Provide high impact program with supporting initiative in Construction 4.0. By: Awards/Incentives/Competition/Conference	• 2021 Short Term
			Readiness assessment to gauge the Construction 4.0 level of competency for stakeholders	• 2021 Short Term

Strategic Thrust 2

Excellence Research, Innovation, Commercialisation and Entrepreneurship (RICE)

Rationale:

A strategic programme for innovation is required with the aim to support RICE activities. Recognising the importance of RICE in Construction 4.0, a holistic RICE programme that covers all research deficiencies will ensure significant potential and benefits in transforming construction industry. A collaborative research effort between industry, academia and the government will produce an impactful research portfolio with potential to move towards an applied approach.

Initiative	**Excellence Research, Innovation, Commercialisation and Entrepreneurship (RICE)**
Current state	Based on National Survey of Research and Development (R&D) in Malaysia 2017: • Among the 11 selected Asian countries, Malaysia ranked 6th with 1.4% of R&D expenditure per GDP. Singapore ranked 4th with 2.1%. Malaysia was ranked higher than Indonesia, Philippines, Thailand, Hong Kong and India in terms of the ratio of R&D expenditure per GDP. Business enterprises accounted for 56.6% of total R&D expenditure spent in 2016 for Malaysia. • Many businesses have commented that the R&D process is burdensome, decision-making periods were too long and research not suitable for their needs. The findings of the survey also indicated the lack of collaboration by all the organisations. While, the impact of research is poor and could not be maximised due to unavailable research findings. It can be due to publication fees or articles processing charges (APC) are expensive.

STRATEGIC OBJECTIVES	ENABLERS	CASE FOR CHANGE	AIMS	TIMELINE
1 Strengthen Quadruple Helix: Government - Industry - Academia - Civil Society partnership for Construction 4.0 innovation & technology transfer	Governance Economy	• Lack of collaboration among stakeholders • No specific incentives or financial support from government for IR4.0 technologies development	Attractive incentive to encourage the sustainability of the RICE programme	• 2023 Medium Term
			Utilise high-impact R&D output in technology innovation for commercialisation	• 2025 Long Term
			Create financial mechanism for R&D funding linked to Construction 4.0	• 2021 Short Term
2 Driving research and innovation in Construction 4.0	Integrated Technologies People	• Uncertainty of environmental sustainability effect in the future • No clear national policy, guidance or framework • Potential of emigration of highly trained or qualified people	Improve evidence-based approach for the construction industry	• 2021 Short Term
			Utilise leading talent to stimulate creativity and innovation	• 2021 Short Term
			Enhance home-grown technology labs to trial and showcase local innovation	• 2023 Medium Term
			Develop and improve R&D in order to promote, deliver and provide smart construction initiatives with technological changes to build a competitive industry	• 2023 Medium Term

Strategic Thrust 3

Smart Integrated Technology, Innovation and Infrastructure

Rationale:

Construction 4.0 is changing the traditional way to design, construct and maintain buildings, which in the past had been carried out independently and without reference to the multiple stakeholders. This could be possible if technologies are integrated in a common platform along with the project whole life cycle. The use of new digital technologies makes it possible to gather and analyse data across the design team and supply chains - enabling faster, more flexible, and more efficient processes to produce higher-quality buildings or infrastructures at reduced costs. This change would be highly dependent on complex tools, powerful infrastructure networks and reliable security networks.

Initiative

Smart Integrated Technology, Innovation & Infrastructure

Current state

Construction 4.0 embodies digitalisation - speed, complexity and the profound impact of digital technologies are integrated into orthodox industries on a massive scale. As the process of digitalisation in Malaysia lags behind other major industrialised countries, the lack of leadership, direction and readiness will leave the country further behind. Besides, previously the main issues addresses is the interoperability barriers by implementing appropriate and advanced industry standards, in close consultation with the industry is still low in adoption.

As Malaysia moving towards Construction 4.0, many projects are still adopting the conventional approach. Taking BIM as an example, the implementation of BIM is still in the preliminary stage and the number of adopters are still low.

STRATEGIC OBJECTIVES	ENABLERS	CASE FOR CHANGE	AIMS	TIMELINE
1 Improve government policy intervention in applying specific technology	Governance People	• The lack of enforcement for current / available technology policies • No available policy to support IR4.0 • Lack of clear standards for equipment or systems that support IR4.0 technologies and processes	Improve multi-stakeholder partnership to enhance Construction 4.0 infrastructure	• 2021 Short Term
			Review and strengthen existing legislation, policies, guidelines for a holistic digital construction ecosystem by adapting strategy workforce planning	• 2021 Short Term
			Incentives for Construction 4.0 innovation scheme to encourage the early implementation and adoption	• 2023 Medium Term
			Enforcement of new technology implementation for local companies	• 2025 Long Term
2 Enhance collaboration of disruptive technology and data centre repository	Integrated Technologies Governance Economy	• Lack of understanding in emerging technologies • Lack of technology integration adoption • Lack of collaboration among stakeholders • Poor availability of reliable infrastructure such as irrelevance of internet connectivity • Confusion over data ownership • Concerns about the loss of control over intellectual property • Government requirement hinders the esubmission strategy • High cost for implementation such as for technology investment, software and material	Identify the needs of upgrading existing infrastructure towards implementation of Construction 4.0	• 2021 Short Term
			Leverage and enhance the integration of existing data platform for construction data sharing.	• 2025 Long Term
			Encourage the usage of real-time data for monitoring update and utilise big data analytic for decision making process and insights	• 2025 Long Term
			Infuse emerging technologies in construction practices	• 2021 - 2025 Short Term
			Enhance CIDB CONVINCE platform as digital integration hub	• 2021 - 2025 Short Term

Strategic Thrust 4

Enhanced Business Environment

Rationale:

Business development serves the purpose of 'developing' the business in some way, which can be conducted by any organisation (small, medium or large) or non-profit or for-profit enterprises. A strong business development strategy allows construction organisations to create strong relationships with potential businesses and generate revenue. Enhancing business environments for the industry can be done through identifying symbiotic customers and partnerships, building relationships and developing solutions that could be realised in truly equitable terms.

Initiative

Enhanced Business Environment

Current state

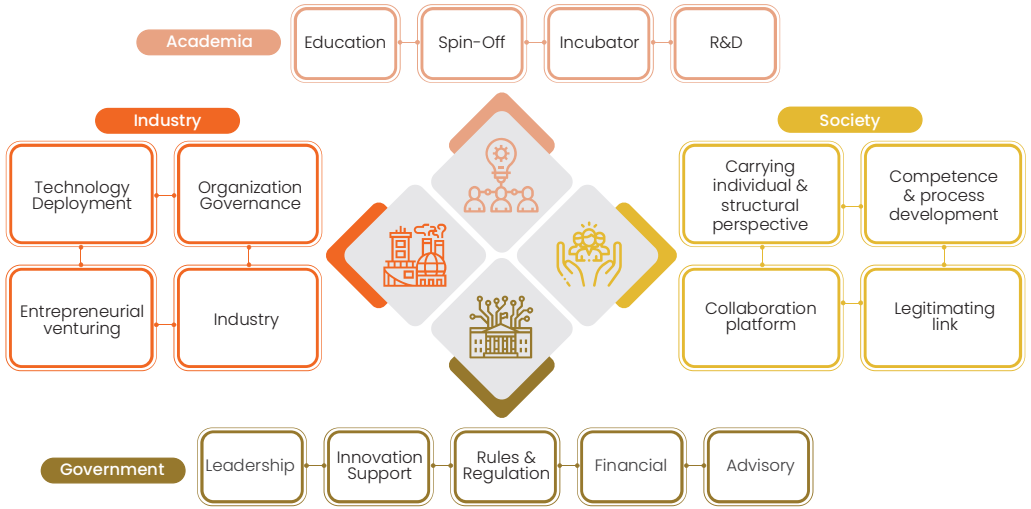
- Malaysia's construction industry contracted by 1% in real terms in 2019, following an average annual growth of 6.7% during the preceding four years. This decline can be attributed to many factors, such as the global economic slowdown, a halt in several construction mega projects, and an increase in the country's unsold housing stocks.
- There is participation in several international projects by Malaysian contractors, however limited strategies have been developed concerning the process of internationalisation of the construction industry.

STRATEGIC OBJECTIVES	ENABLERS	CASE FOR CHANGE	AIMS	TIMELINE
1 Enhance stakeholders' local and international partnerships to increase the business growth of the construction industry	Governance, Economy	• Lack of collaboration among stakeholders • Undeveloped internal construction market • Concerns over poor or non return on investments	Develop collaborative business model for local player towards Construction 4.0	• 2021 Short Term
			Establish local workforce competency through technology transfer and collaboration with international entities	• 2023 Medium Term
			Benchmarking programme to identify the gaps of technology with the Construction 4.0 leading country	• 2021 Short Term
			Business matching programme to business opportunity by covering the whole life-cycle value	• 2021 Short Term
			To establish outreach programme to increased utilisation of local technologies and innovation	• 2023 Medium Term
2 Creating collaborative governance ecosystems through government intervention	Governance	• Fragmented industry affects the digital transformation	Diversify of funding sources by tapping alternative finance instruments for stakeholders including SMEs	• 2021 Short Term
			Increase the utilisation of local technologies and innovation	• 2023 Medium Term
			Provide incentives for building start-up companies (SMEs)	• 2021 Short Term
			Increase competency of local stakeholders through technology transfer and collaboration with international entities	• 2023 Medium Term
3 Promote the role that foreign direct investment or collaboration that would play as a mechanism for local construction organisations to access the international market	Governance, Economy	• Undeveloped business models locally and abroad • No strategic plan or framework to assist Malaysian contractors to venture overseas	Develop collaborative business models for local organisations to be involved in high impact programs	• 2021 Short Term
			Strengthen public-private partnerships to improve ease of doing business locally and internationally	• 2023 Medium Term
			Establish multi-national organisation partnerships with other countries	• 2025 Long Term

Way Forward:

Roles and Responsibilities of Government, Industry, Academia and Society in Implementing Construction 4.0 (2021-2025)

Next Revolution of the Malaysian Construction Industry



Interactive Roles and Responsibilities of Construction Industry Stakeholders

The success of implementing Construction 4.0 strategic plan, shall be dynamic and holistic in its approach. The interactive quadruple helix actions will ensure smooth measurable deliveries.

Key performance Indicators (KPI) and stepwise strategies shall be highlighted in the Implementation of Strategic Plan document which will be published later.

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ABBREVIATIONS AND ACRONYMS

Abbreviations and Acronyms

AI	Artificial Intelligence
AR	Augmented Reality
ASEAN	Association of Southeast Asian Nations
BIM	Building Information Modelling
CONVINCE	Construction Information for Your Convenience Portal
CPS	Cyber-Physical Systems
C1	Cluster 1
C2	Cluster 2
C3	Cluster 3
DfMA	Design for Manufacturing and Assembly
FGD	Focus Group Discussion
GDP	Gross Domestic Product
Gen Y	Generation Y
Gen Z	Generation Z
GII	Global Innovation Index
ICT	Information and Communications Technology
IDD	Integrated Digital Delivery
IIoT	Industrial Internet of Things
IMD	Institute for Management Development
IoT	Internet of Things
IR4.0	Fourth Industrial Revolution
IT	Information Technology
MITI	Ministry of International Trade and Industry
RFID	Radio-Frequency Identification
RICE	Research, Innovation, Commercialisation and Entrepreneurship
R&D	Research and Development
SAR	Special Administrative Region
SME	Small and Medium-Sized Enterprises
SPV2030	Shared Prosperity Vision 2030
STEM	Science, Technology, Engineering and Mathematics
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TDIP	Technopreneurship Development Initiatives and Programme
TVET	Technical and Vocational Education Training
UAV	Unmanned Aerial Vehicle
VR	Virtual Reality
WCY	World Competitiveness Yearbook
WEF	World Economic Forum
WIPO	World Intellectual Property Organization

GLOSSARY

Glossary

Advanced building materials	Development of new materials for the industry by integrating new technologies and processes to create a better product.
Advanced manufacturing processes	Use of innovative technologies to create existing products and the creation of new products. Advanced manufacturing can include production activities that depend on information, automation, computation, software, sensing, and networking.
Artificial intelligence	Allowance for machines to imitate the human cognitive functions to enable machines to conduct tasks that is usually performed by humans via a set algorithm.
Augmented reality	An interaction between human and computer which would enable an individual to distinguish both virtual and real-world object(s).
Autonomous construction	Automatic assembly method of construction tasks by applying robot that is controlled using computer process and mechanisation.
Big data	Efficiently handle large amounts of projects data by efficiently storing, managing and process using a commodity server.
Blockchain	Distributed ledger of database in which information, records of transactions, internet protocol and others can be maintained across a network of computers.
Building information modelling (BIM)	A central repository which requires integration of fragmented disciplines of architecture, engineering and construction, and to optimise the lifecycle performance of buildings.
Cloud and realtime collaboration / cloud computing	Internet centric to provide free flow of information within the construction professionals and offering a huge amount of storage resources.

Glossary

Construction 4.0	Process to implement modern technology in order to encourage the digitisation of the construction industry and its supply chain.
Cyber security	Measures taken to protect a computer or computer system (as on the Internet) against unauthorized access or attack
Data analytics	The process of collecting, organising, analysing large data sets to discover different patterns and other useful information.
Distributed ledger	A novel and fast-evolving approach to recording and sharing data across multiple data stores (or ledgers). This technology allows for transactions and data to be recorded, shared, and synchronized across a distributed network of different network participants.
Distributed production	Management of distributed suppliers to a central assembly process, it is increasingly used to refer to the production of objects closer to the point of use.
E-submission	Economic operators to respond to calls for tenders by preparing their tenders electronically in a structured and secured way and submitting their tenders electronicall.
Human-machine interfaces	User interface or dashboard that connects a person to a machine, system, or device. The term can technically be applied to any screen that allows a user to interact with a device.
Industrial revolution	The development or changes in the way of goods or services being produced and work being organised.
Information and communication (ICT)	Synergy between computers and communication devices and forms an important part of the modern world.

Glossary

Information technology	Technology which uses computers to gather, process, store, protect, and transfer information.
Intelligent products	A product that has part or all of the following five characteristics: Possesses a unique identity, capable of communicating effectively with its environment, can retain or store data about itself, deploys a language to display its features, production requirements etc. and capable of participating in or making decisions relevant to its own destiny.
Internet of Things (IoT)	Is a system that enables in detecting the surrounding environmental conditions which sense by objects and devices and have an unique identifiers (UIDs) or ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.
Laser scanning	A method of high-accuracy mapping or reality capture that uses laser beams to quickly capture complete detail of the entire building construction project - much like a camera taking a 360-degree photo, but with an accurate position for every pixel.
Machine learning	A field of computer science that studies algorithms and techniques for automating solutions to complex problems that are hard to program using automating solutions to complex problems that are hard to program using conventional programming methods.
Machine-to-machine communications	Information and communications technologies (ICT) able to measure, deliver, digest and react upon information in an autonomous fashion, ie., with no or really minimum human interaction during deployment, configuration, operation and maintenance phases.
Mixed reality	Merge real and virtual worlds to create a new context of interaction where both physical and digital objects co-exist and interact consistently in real life.

Glossary

Mobile information	Systems that rely on wireless communications and support mobile applications that typically run on wireless devices such as smartphones and mobile phones.
Modelling and simulation	A process of driving a model of a system with suitable inputs and observing the corresponding outputs.
Nanotechnology	The design, characterisation, production and application of materials, devices and systems by controlling shape and size in the nanoscale.
Platform economy	Any type of digital platform that uses the internet to connect dispersed networks of individuals to facilitate digital interactions between people.
Prefabrication and modular construction	A completed manufacturing process for volumetric units of building construction systems that generally made/assembled in factory to form as a component prior to final installation on site.
Radio-frequency identification	A remote identification system using radio waves of different frequencies.
Robotics	Mechanical or electrical engineering coupled with computer science used to design, construct, operate, and apply robots. It also includes the computer systems for their control, sensory feedback, and information processing. Where a robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks.
Self-assembly	A process in which a disordered system of pre-existing components forms an organized structure or pattern as a consequence of specific, local interactions among the components themselves, without external direction.

Glossary

Self-healing materials	A material that is capable of repairing itself back to the original state.
Smart construction	Smart construction is building design, construction and operation that through collaborative partnerships will fully utilise digital technologies and industrialised manufacturing techniques to improve productivity, minimise whole life cost, improve sustainability and maximise user benefits.
Smart clothes	A high-tech clothing, smart garments, or electronic textiles, defined as 'clothing items that have been enhanced with technology to add functionality beyond that of the traditional use'.
Smart glasses	Wearable computer glasses that add information alongside or to what the wearer sees.
Smart helmets	A new type of human machine interface that connects in between people, data and machines and able to redefining the future of work by empowering workers with the latest in augmented reality and Internet of Things technologies.
Smart manufacturing	A technology-driven approach that utilises Internet-connected machinery to monitor the production process.
Smart sensors	A sensor that provides functions beyond those necessary for generating a correct representation of a sensed or controlled quantity.
Space technologies	Technology developed by space science or the aerospace industry for use in spaceflight, satellites, or space exploration.
Super computing	High power and performance computers that are made for performing very specific tasks, that require huge amounts of computations.

Glossary

Virtual reality	A simulated experience that can be similar to or completely different from the real world a simulated experience that can be similar to or completely different from the real world.
Wireless Monitoring & Connected Equipment / Unmanned Aerial Vehicle (UAV) / Drones/ Autonomous Vehicles/ Autonomous Plants	Is an intelligent autonomous systems that able to operate complex task in a dynamic and uncertain environment using wireless communication support, monitoring targets of interest, serving a wireless sensor network, and collaborating with ground robots.
3D printing	A process to create or recreate a physical object that modelled in digital version by depositing layers of materials.
3d scanning and photogrammetry	Data acquisition as point cloud data and mapping tool with the ability to interpolate a photograph to become 3D models for changes monitoring.
4D printing	A renovation of 3D printing wherein special materials to print objects that change shape post-production.

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