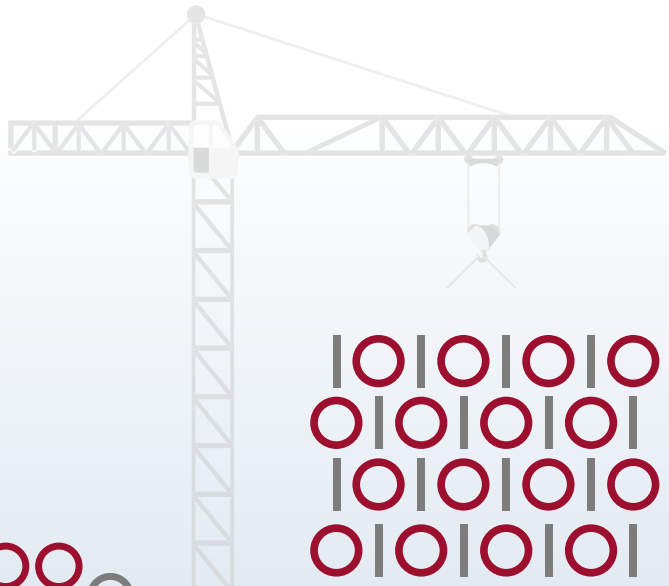
Integrated Digital Project Delivery

The Way We Build

Gammon

The Way We Build ...

The way we build today is not only about employing new, more sophisticated electronic tools but changing the mindset of people. In these pages, we describe how Integrated Digital Project Delivery, IDPD, is helping us to make a difference in today's world.



The Way We Think

Our Chief Executive on how digital tools are revolutionising Gammon and the construction industry.

The Way We Innovate

The application of data and creativity to make construction more efficient and cost-effective.

The Way We Connect

Collaboration and communication on our BIM journey from 3D to 10D.

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Gammon initiatives that are making construction faster, safer and smarter.

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The impact of our initiatives on the construction industry of tomorrow.

The Way We Think

In 2018, we at Gammon are celebrating our 60th anniversary and the many years we have been contributing to the development of Hong Kong, Singapore and Southeast Asia.

Thomas Ho, JP
Chief Executive

Video: IDPD

In the years ahead, our vision is to transform Gammon by pushing back the boundaries of technology for the benefit of our clients and the construction industry at large. Central to this vision is a new way of thinking about how to build for increased productivity, safety, quality and sustainability.

We call this approach Integrated Digital Project Delivery, or IDPD.

"Over the next 10 years, Hong Kong will complete or embark upon HK$3 trillion in construction projects."

Although IDPD has only been recently introduced in Hong Kong by Gammon, it is currently being practised in Singapore, the UK, Finland and Sweden, where it is known as integrated digital delivery. This is the direction in which the global industry is headed, and we believe it is incumbent upon us not only to follow but to lead this process of digital transformation.

The digital tools underlying IDPD – Building Information Modelling (BIM), laser and drone data clouds, communication platforms, IoT sensor output and more – are already in use in the local construction industry. What is different about IDPD, however, is the way it ties all of these tools together to achieve greater efficiencies in construction as well as increased communication and collaboration.

But what exactly is IDPD? In short, it is an approach for managing construction projects that fully integrates processes and people over the entire course of a project, from the initial planning and design stages through to facilities management.

The backbone of IDPD is BIM, which enables us to plan for a project more efficiently, track its progress and share information with clients up to the end of construction. The BIM model is then handed over as a digital asset – rather than a paper one – to the client for managing and maintaining the finished project.

Although BIM has been in use at Gammon for several years, we are currently taking the entire BIM process into new dimensions of productivity. From its current application as a tool for generating 3D models, we are utilising its power to plan in 4D for more advanced progress tracking and decision-making all the way to 10D for planning automation and automatic modelling with Artificial Intelligence (AI). To learn more about our 10D journey, please refer to page 8 of this book.

Another important aspect of IDPD is the way a project is delivered through Design for Manufacturing and Assembly, or DfMA (also known as Modular Integrated Construction). By manufacturing building components offsite rather than in-situ, DfMA offers a number of major benefits, including significantly shortened construction programmes, improved quality and enhanced worker safety.

In Singapore, we used DfMA extensively on the Global Switch data centre project, where we produced over 60% of the Mechanical, Electrical and Plumbing (MEP) services offsite and 70% of the precast components for the external structure. Indeed, the project made such extensive use of offsite manufacturing that it has become a showcase project for Singapore's Building and Construction Authority.

Over the next 10 years, Hong Kong will complete or embark upon HK$3 trillion in construction projects. Yet during this period, the industry will also have to deal with chronic labour shortages, rising material prices and relatively low productivity rates. It is my firm belief that the IDPD initiative we are currently undertaking is the best solution for overcoming these challenges and delivering greater value to our clients.

I hope you enjoy reading this book and learning about the steps we are taking to lead Gammon into the new and exciting digital world of the future.

Thomas Ho, JP
Chief Executive
Gammon Construction Limited

November 2018

The Way We Innovate

Ten years ago, we established the Innovation Department to encourage new thinking and inspire creative ideas that add value to our clients' projects and the industry.

The alternative solutions developed by the talented engineers in our Innovation Department have enabled us to achieve higher rates of productivity and workplace safety, reduced material and labour costs, and far greater efficiencies than in the past.

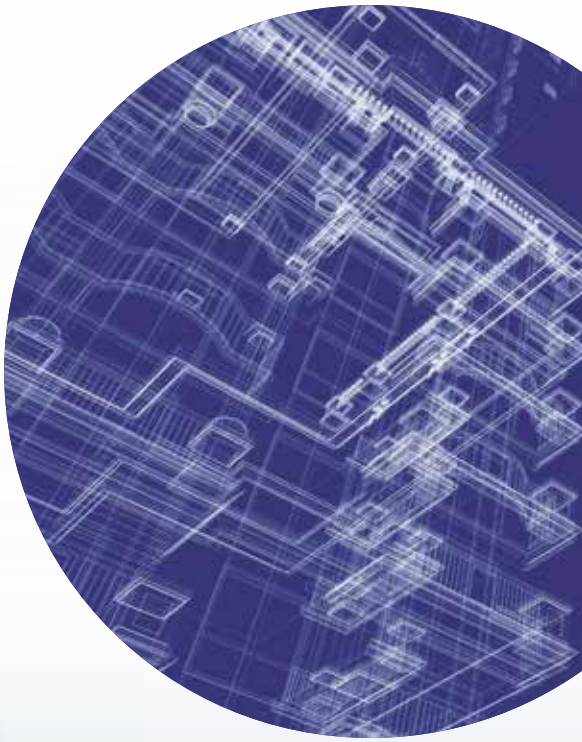
The work of the Innovation Department is overseen by a steering group, consisting of the Executive Committee, Chief Information Officer and Director of Engineering. We also have subject-matter experts from across our organisation, who contribute ideas in areas such as Virtual Design and Construction (VDC), Virtual Reality and Augmented Reality (VR/AR), digitisation, robotics and Design for Manufacturing and Assembly (DfMA). In addition to these specialists, we encourage our young professionals to discuss and identify novel solutions that benefit society.

To strengthen our Innovation Team and our technical experts, we are emphasising BIM training. This includes core foundation BIM technical training for all engineers, as well as additional training for staff responsible for planning, quantity surveying and estimating.

Another group, established in 2018, is an entity called Digital G. The mandate of this team is to exploit commercial opportunities for the innovations we develop.

"We are modifying existing technologies to meet the demands of the construction industry for faster, safer, more productive ways of working."

digitalG



Harnessing the Power of Data

In Gammon's push to innovate, we are modifying existing technologies to meet the demands of the construction industry for faster, safer, more productive ways of working. Virtual Reality, robotics, drones, RFID tags and QR codes, e-forms, mobile apps, 3D laser scanning and smart meters are just some of the many technologies we have adopted for our projects.

One of the key elements in our approach to innovation is the Digital Transformation Team, which started with just three engineers in March 2017 and has since tripled in size. Led by Terence Lui, Head of Digital Transformation, the team brings skill sets that are completely new to both the Company and the Hong Kong construction industry. They have been charged with the task of showing how the construction business can be transformed with the introduction of digital technologies and, in particular, through a cloud collaboration platform we call Digital Project Management, or DPM.

DPM, which is based on a lean development approach, is now being implemented on a small number of trial project sites. Taking this approach, we can capture and integrate data from different parts of the project with the aid of IoT sensors, Bluetooth beacons, GPS, Gambot™ and mobile apps. With the data that has been collected, the project team is able to track plant and equipment, labour, productivity and work progress in near real time so that resources can be allocated more effectively. That information is then uploaded to a cloud server, where it is accessible to all members of the project and client teams. This allows for cross-disciplinary collaboration and well-informed decisions to be made, taking project management to the next level.

Once the information has been uploaded to the Cloud, we can know the progress of any project and receive a full record of what was done each day. From there AI can continue learning, or we can go back in time using Virtual Reality to find areas for improvement on future projects.

Digital: The Missing Piece of the Jigsaw Puzzle

As Ian Askew, Director – Lambeth, Innovations, Virtual Design and Construction, points out, "digital has been the missing piece of the jigsaw puzzle. It's the big game changer."

As a result of the digital tools we now have, projects can be done collaboratively, with all parties working together to optimise the design. The ultimate goal, he says, is to fully automate the data capturing process during construction using technologies such as Artificial Intelligence to gain maximum value out of the data collected.

"We can use these tools to give people insights we never had before," Ian says.

"Digital transformation must not add complexity. It must make life easier for our staff."

Although Gammon is making tremendous progress in the transformation to digital construction, it must be implemented for the right reasons. "Digital transformation must not add complexity. It must make life easier for our staff and provide a return on investment."

Video: Digital Project Management

As Alan Wan, Contracts Manager (Foundations), says, "we could never be sure of our production rate in the past. Today, because of all the data we have in the Gammon Cloud, we can compare different projects, including productivity from one site to another, and have a better understanding of the plant and labour resources we need."

This does not mean that automation will take over the human element, however. Creativity and critical thinking will still be needed for interpreting the data received from a computer and making judgements.

In the meantime, getting buy-in from people who may be used to traditional methods presents another challenge. "When I started the digital transformation project," says Terence Lui, "I reminded our senior management that this is not about transformation through technology.

It's actually the transformation of people and mindset, the culture, the way we see data, the way we interact with it, and the way it affects our decisions."

Safer Construction with Digital

During the redevelopment of Somerset House in Taikoo Place, Hong Kong, Alan Mo, Senior Project Manager (Building) has been making extensive use of a software robot known as Gambot for the construction of this 48-storey office building. As the project will have a workforce of 1,400 during the peak construction period, safety has been a huge concern for Alan – a concern he has been addressing through the automation of safety inspection records.

Normally, these Daily Risk Assessments (DRAs) would be done manually by safety officers and frontline workers to identify critical safety risks. Preparing the DRAs by hand, however, was a time-consuming task, especially when inserting photos, and not always accurate.

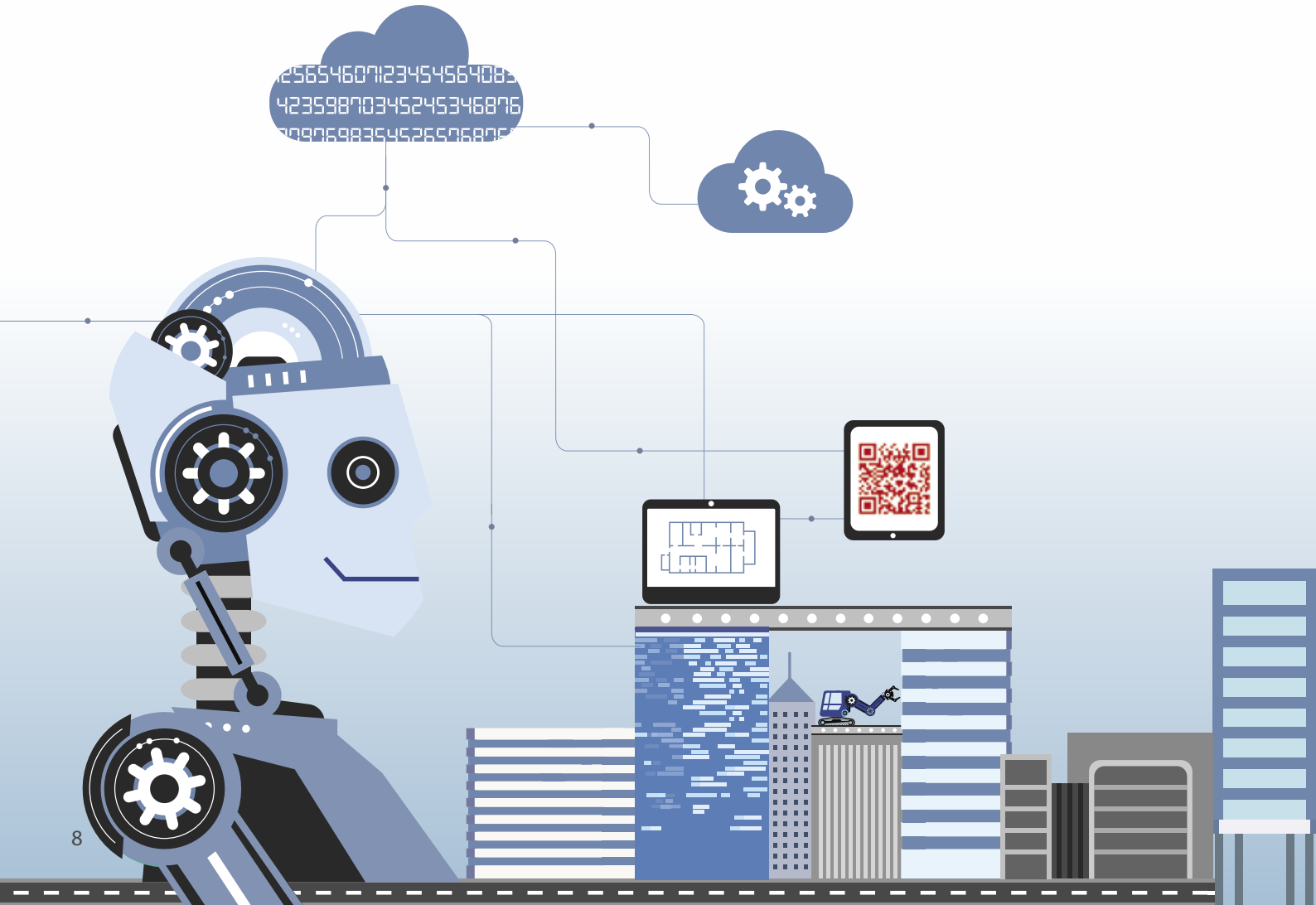
Using Gambot, the entire process is automated with bespoke conversational (chatbot) technology, which captures site information, uploads it via a mobile device and instantly generates a report. It can also recommend actions to take for minimising risk, recognise potentially dangerous objects and areas, and log all 'near-miss' incidents.

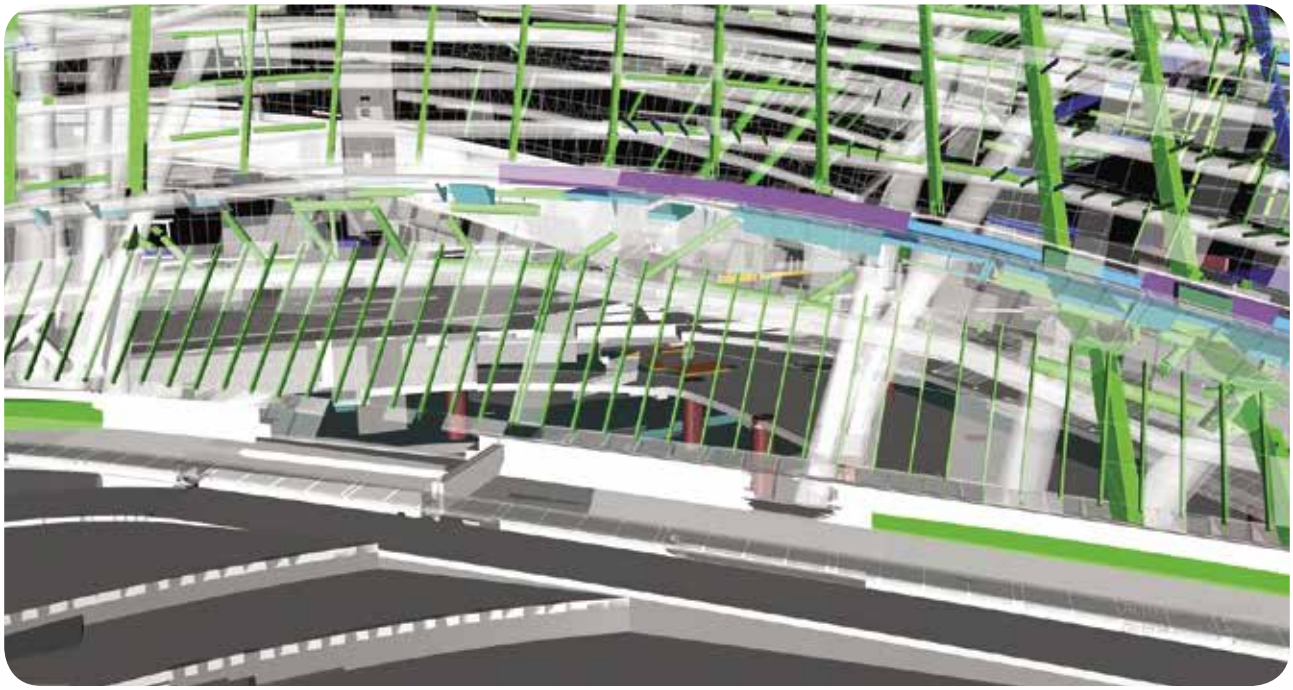
Horace Chu, Director & Chief Information Officer, summarises the impact of digital on construction safety: "Before, safety observations were done by safety officers. But now, all the frontline operational people are doing it. This has made a huge difference in Gammon's safety culture."

Gambot also comes with state-of-the-art AI Planning and Computer Vision Technologies that automatically and intelligently monitor and report on site productivity and safety issues.

The Way We Connect

To promote greater collaboration and communication, Gammon is taking construction into a new dimension of productivity by extending BIM from traditional 3D applications to 10D.





10D BIM: Our Roadmap to IDPD

The path we are taking to achieve IDPD in our projects is guided by Building Information Modelling, not only in the **third dimension** as it has been traditionally applied in the past, but in 10 dimensions. (Our roadmap for facilitating collaboration and communication among stakeholders within the 10D BIM model is shown on the following two pages.)

The **fourth dimension** is integrated with planning, using software such as Synchro PRO (a digital construction project management platform). With a fully integrated scheduling engine and 3D capabilities, this platform tells us how construction activities will affect the sequence of works.

The **fifth dimension** is quantification, whereby all materials and cost estimates are generated automatically. The **sixth dimension** allows us to meet our sustainability objectives while the **seventh dimension** gives clients the digital tools to manage their facilities more effectively. The **eighth dimension** focuses on design collaboration and enables stakeholders to work together to achieve project goals.

The **ninth dimension**, robotics, is concerned with the way BIM controls robotic devices such as drones and Computer Numerical Control (CNC) machines, while the **tenth dimension** is the use of Artificial Intelligence (AI) for automatic modelling, planning and scheduling.

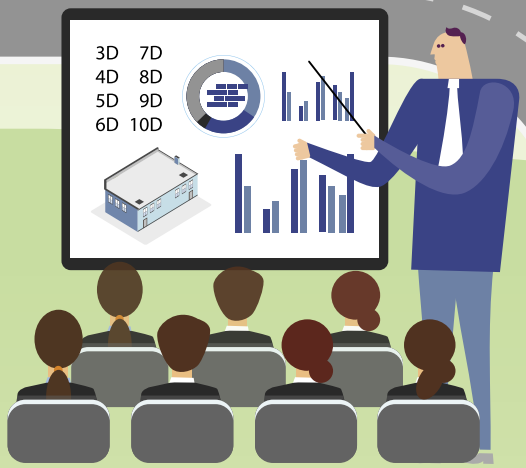
This 10D BIM method of delivering projects is revolutionary in scope, allowing Gammon and our clients to work together in a way that is open, transparent and far more cost effective.

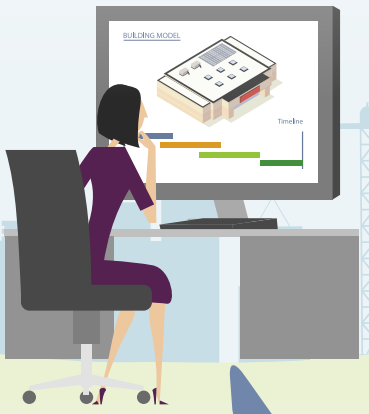
- 3D Geometry
- 4D Planning
- 5D Quantification
- 6D Sustainability
- 7D Facilities Management
- 8D Design Collaboration
- 9D Automation & Robotics
- 10D A.I.

10D BIM: Our Roadmap to IDPD

3D Geometry

Data-rich 3D models provide the underlying framework for all BIM dimensions.



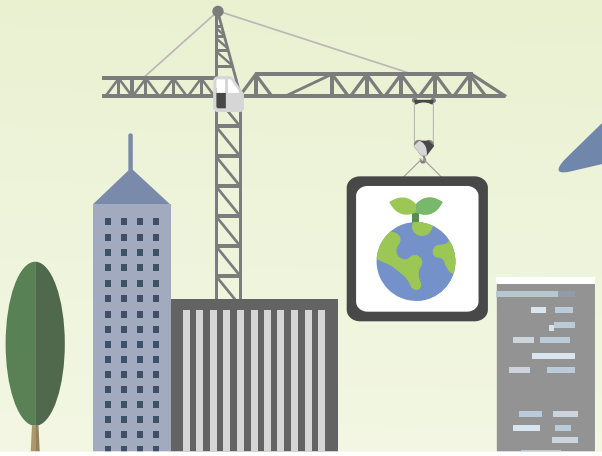


4D Planning

BIM is integrated with the construction programme and actual progress capturing to support visualisation and decision-making.

5D Quantification

Automatic quantity take-off allows for better cost analysis and digital procurement.



6D Sustainability

Gammon's sustainability strategy can be delivered with fully-integrated environmental solutions.

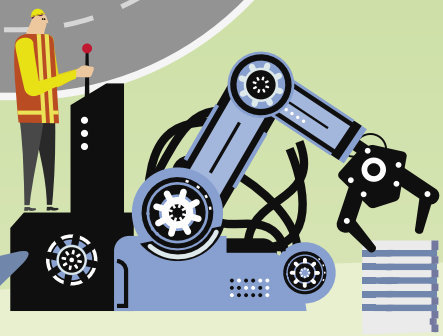
7D Facilities Management

Clients can make full use of BIM after construction for facilities management.

8D Design Collaboration

An open collaboration platform improves efficiency and quality of communication among all stakeholders.

BIM modelling is automatically optimised.



9D Automation & Robotics

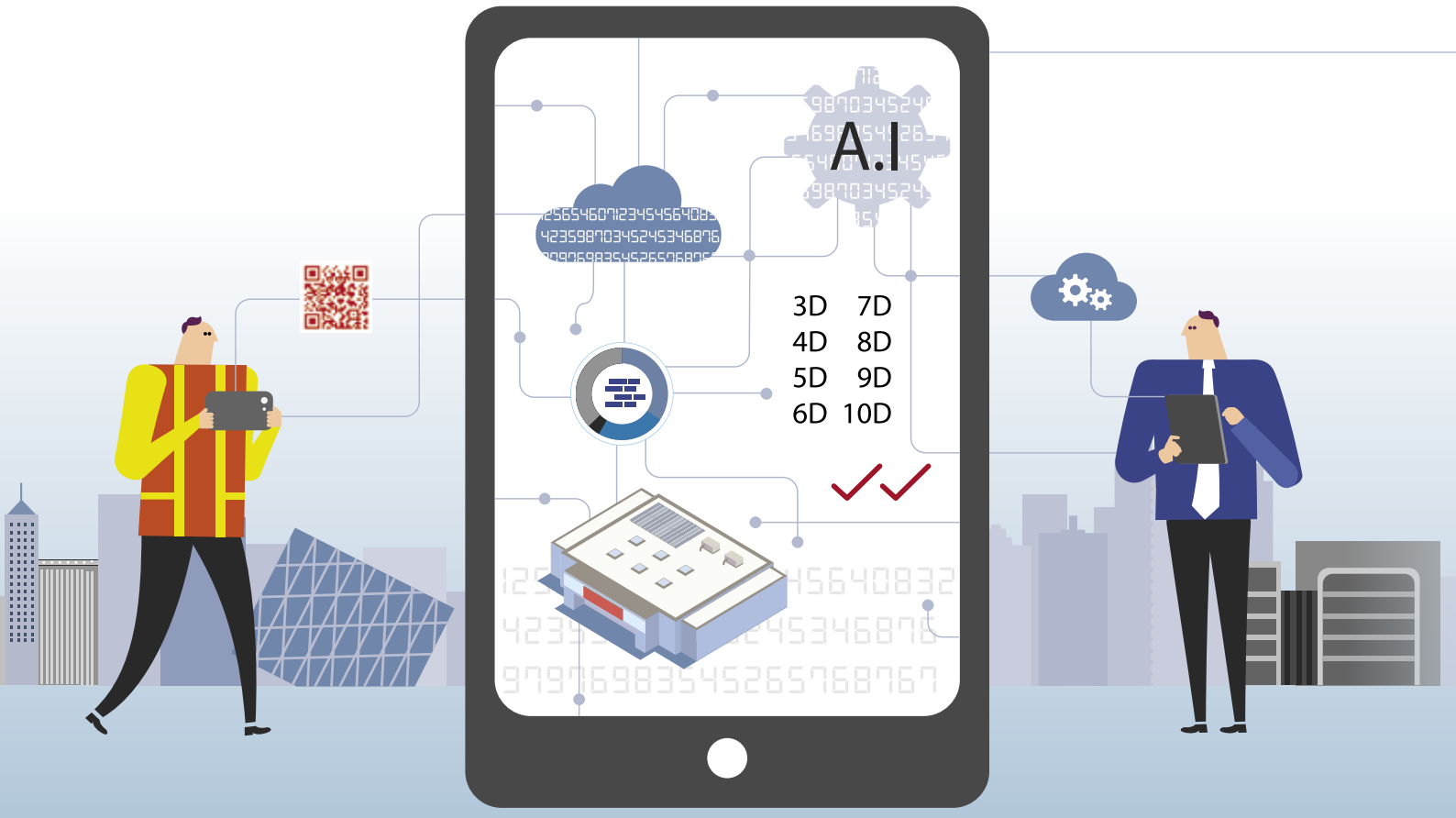
BIM information is used to control drones and machinery at offsite fabrication hubs.

10D A.I.

Artificial Intelligence applied to BIM allows for autonomous design modelling.

The Way We Lead

Gammon is revolutionising the construction industry in Hong Kong and Singapore by adopting and integrating advanced technologies to achieve greater efficiencies, quality and safety.



"IDPD makes use of digital technologies to integrate and accelerate the entire construction lifecycle."

Gammon's approach to construction is inspired by a concept known as Industry 4.0, a term first coined by the German government to describe a fourth industrial revolution based on the digitisation of manufacturing.

As defined by consulting group Deloitte Touche Tohmatsu Limited, Industry 4.0 "marries advanced production and operations techniques with smart digital technologies to create a digital enterprise that would not only be interconnected and autonomous but could communicate, analyze, and use data to drive further intelligent action back in the physical world. It … is marked by the emergence of capabilities such as robotics, analytics, artificial intelligence and cognitive technologies."[1]

In the same way that Industry 4.0 is having a profound effect on the manufacturing sector, we are deploying IDPD on our project sites to take the industry to the next level and point the way to an exciting new era of digital construction.

The IDPD Advantage

Similar to practices that have been adopted in factories across the developed world, IDPD makes use of digital technologies to integrate and accelerate the entire construction lifecycle, with more control and flexibility, through the use of smart technologies and advanced communications.

The IDPD process invariably begins with a highly-detailed, data-rich Building Information Model (BIM).

This model will contain all the physical elements of the project – such as concrete walls and steel beams, windows and doors, as well as the time element – over the duration of the construction programme. As the project gets underway, frontline staff, design engineers, project managers and senior management will fully embrace BIM to coordinate the works and communicate with one another, then hand over the completed project to the client as a digital file rather than a paper asset.

At all stages of construction, the client is kept constantly apprised of the project's progress, secure in the knowledge that IDPD is helping to deliver it with reduced risk, a higher level of quality and a digital model containing all project information after its completion.

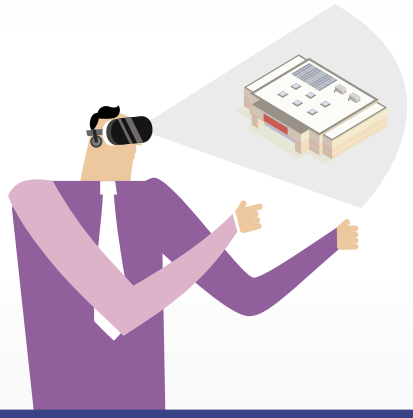
The lifecycle of a typical project based on IDPD would look much like this:

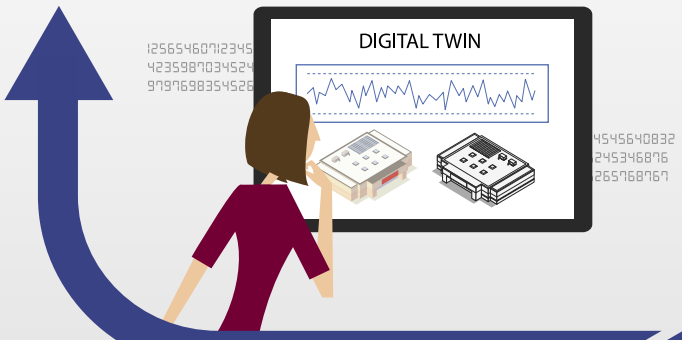
Design collaboration:

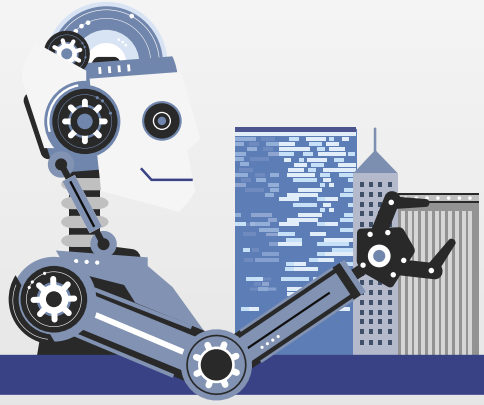
All stakeholders work out the design, planning and materials quantification collaboratively through a Common Data Environment comprising a BIM model, which serves as a digital communication platform for coordination.

Rehearse:

Walkthrough software such as Fuzor helps stakeholders understand how the project will look by testing it in a 3D environment, including AR/VR and Hololens. The use of 4D BIM software such as Synchro PRO can be used for project programming and scheduling.







Facilities management:

At the end of a project, the BIM model with its record of all project assets, including electrical and mechanical equipment, is passed on to the building manager for maintenance, future amendments to the building or live security checking.

Inspection and commissioning:

Data are recorded directly into tablets and uploaded from the worksite into the BIM model to give a complete and accurate picture of the entire project.

Manufacturing:

From the digital design, data are fed directly into CNC machines for the manufacture of building elements such as facades and ductwork. Other elements can be brought together as modules for production according to DfMA principles.

Just-in-time delivery:

All building elements are brought together on site, efficiently and in the proper sequence, through the use of information in a digital format. Data captured with the help of tools such as Gambot, QR codes, RFID tags and sensors are coordinated on a cloud platform with the actual site situation for just-in-time delivery.

Installation:

On the project site, both physical robots and exoskeletons enable the frontline to work more safely and efficiently. Sensors attached and embedded throughout the site identify the location of workers and key components and monitor the behaviour of structures. Automatic updates of work progress are recorded in the digital model.

Digital project management:

Gammon's data visualisation and analytic platform, the ACE Dashboard (with Tableau software as its backbone), pulls together all the information needed to make smart decisions in real time and rectify issues whenever they arise.

"BIM allows us to work collaboratively in real time."

The main benefits of IDPD are its ability to provide better coordination for the production and delivery of factory-made building parts, speed up construction, improve construction quality and reduce noise and disturbances to neighbours around our construction sites.

What's more, all information about a project will be communicated through the BIM model and a cloud server, allowing all parties to become more involved in the design, building and post-construction maintenance.

An additional advantage is IDPD's ability to suggest improvements. One of the champions of IDPD at Gammon, Ian Askew, Director – Lambeth, Innovations, Virtual Design and Construction, says, "By digitally disassembling a project in the virtual world and reverse engineering it into its components, you might find a better way of building the project when putting it back together in the digital model."

BIM: The Beating Heart of IDPD

Since its introduction more than 40 years ago, BIM has evolved far beyond its original application of visually representing a project in 3D or identifying clashes.

As one writer defined it, "BIM is both a best-practice process and 3D modelling software. By using it, designers can create a shared building project with integrated information in a format that models both the structure and the entire timeline of the project from inception to eventual demolition."[2]

At the beginning of a project, we will typically use BIM to create a 3D model then show it to clients in a virtual reality environment that makes the design come to life. Alan Yan, Contracts Manager (Civil), says clients "can see all the details, walk around the project, go through the doors and make comments on the design, such as asking for more headroom in a passageway. This makes for easy changes, which need to be minimised once construction gets started."

"All parties can work together using the BIM model as the 'single source of truth."

Before the start of construction, the project team might also look at this 'digital twin' of the physical project to try out different design options, see where it is appropriate to use precast and modularised components, and identify design errors. BIM can also be used to generate fabrication drawings and machine codes automatically for materials estimation and production.

But this is only a small part of what BIM can do. As information is fed into the BIM model from sources such as sensors, QR codes, RFID tags and mobile apps in the field, projects become more information driven. As a project gets underway, this information is constantly updated through a cloud-based platform that can be seen anywhere by anyone. Members of the project team, the client, consultants and suppliers can all track progress, check the positions of plant and installations, and make corrections on the go.

"BIM allows us to work collaboratively in real time," says Paul Morris, Head of Innovation. "We are not waiting for one team to finish before they pass it on to the next team. All parties can work together using the BIM model as the 'single source of truth.'"

Other digital tools also come into play to make BIM even more powerful. These include software such as Synchro PRO, which records in real time where we are on a project with visual updates, and 3D printing to create prototypes of complex components that demand high levels of precision and assembly efficiency.

Another is photogrammetry via drones. According to Billy Wong, Head of BIM at Gammon, this is one of the most important tools being used to integrate the virtual reality model with BIM. In collaboration with the Hong Kong University of Science and Technology and a private firm, he helped to develop a solution specifically for photogrammetry that processes big data four times faster than conventional BIM measurement tools.

"This was especially helpful for the Ocean Park Water World project, as the site formation was very challenging," says Billy. "Our solution was capable of uploading all the data we collected at Ocean Park in just three hours with parallel cloud computing technology. It saved us a tremendous amount of time and is Gammon's most successful example of photogrammetry to date."

Once a project is completed, the BIM model can be explored going back in time to find areas for improvement. Software such as the Archibus property management platform can also be linked to BIM for facilities management by the owner, who will receive the final BIM model and all the populated asset registers.

While BIM has become widely accepted at Gammon, not everyone is currently up to speed on this way of working, particularly within the supply chain. "It's not quite there yet in Singapore because of a lack of understanding of what value it adds, since there is an upfront cost," says Michael O'Connell, Head of Architecture/BIM (Singapore). "But each year, more and more vendors are taking it on board because the Government is driving it."

The use of BIM will also grow in Hong Kong, as the Government has stated that it will require BIM on all major government works projects starting in 2018.

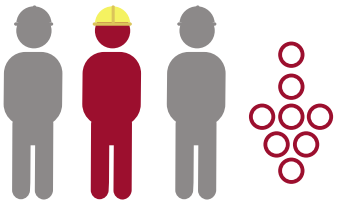
Although BIM is in some ways still in the embryonic stage in Hong Kong, it is a key element of our IDPD strategy and widely acknowledged within the Company as the way of the future. As Billy Wong says, "Five years ago, BIM was seen as an innovation and visualisation technology. Today, it is considered a must for our daily project lifecycle management. It helps us to bring value to projects for our clients, increase productivity and data resolution, while also helping to advance the AEC [architecture, engineering and construction] industry as a whole."

From the Factory to the Worksite: DfMA

Design for Manufacturing and Assembly (DfMA), also known as Modular Integrated Construction (MiC) in Hong Kong, applies the principles of assembly line manufacturing to construction for significantly reduced programmes, enhanced quality and improved safety on site.

In DfMA, integrated modules and other components of a building are fabricated off-site in a factory, complete with finishes and fittings, by highly efficient robots and intelligent machines operated by skilled labour, then transported to the site for rapid and precise installation. Successfully adopted by Gammon on several projects, the concept has the backing of the Hong Kong Government, especially for public projects, as well as the Building and Construction Authority (BCA) in Singapore, where it is mandated.

"The greatest benefit of DfMA is the increase in on-site productivity through the use of standardised building components selected from libraries of commonly-used parts."



In part, the adoption of DfMA at Gammon has been driven by rising construction wages and the ageing of Hong Kong's workforce. However, with DfMA, the amount of onsite labour could be reduced by as much as 80%. Another reason is that DfMA allows us to more easily accommodate design enhancements.

But perhaps the greatest benefit of DfMA is the increase in on-site productivity through the use of standardised building components selected from libraries of commonly-used parts. These components can also be designed so that they fit into standard containers for transport to the site, just in time, and in the right order – an especially critical factor in Hong Kong's congested urban environment. Additionally, animations can be produced showing workers with lower skill levels how to install the parts correctly at the worksite.

As Ian Askew points out, this approach is "an example of the IKEA mentality, where you make installing building components as simple as possible. With the same standard kit-of-parts applied to not just 1 building, but to 5 hospitals, 250 schools, 10 libraries, and 5 prisons, that will be transformational for the industry."

Many of our projects are already making extensive use of DfMA, including the Global Switch data centre project in Singapore. Michael O'Connell says that "for new contracts, the Building and Construction Authority have a buildability score you have to meet, which could require 60% of your building being precast. We were required to precast 50% of the entire structure, but with our DfMA mentality we pushed that to 70%."

To produce the modules for the Mechanical, Electrical and Plumbing services, over 60% of the components were manufactured offsite. "I don't think there's another single project in Singapore that has the level of prefab modular DfMA that has been used on this job," Michael says.

As DfMA becomes increasingly common in construction, some fear that automation could do away with many of the jobs now being done by human workers. But we believe that is not likely to happen. Craftsmen with specialised skills will always be needed, and people will continue to work together with machines just as they do today in the world's most advanced car factories.

Beyond Human: Robotics and Automation

Gammon is stretching the limits of human capability by making use of the latest advances in robotics and automation. On the ground at our worksites and in the skies above Hong Kong and Singapore, the construction technologies we have embraced are making our projects more efficient and the lives of our workers less strenuous and safer.

Vincent Yeung, Innovation Manager, says robotics and other forms of automation are necessary not only to improve productivity but to fill the gaps in an industry dealing with the challenges of an ageing workforce and chronic labour shortages.

Since older workers are more prone to injuries and health problems, the advent of robotics in the form of exoskeletons on our worksites has been especially welcome. "Originally, they were developed for the medical industry," Vincent says. "But the construction industry showed an interest in them because of the ageing workforce worldwide."

One example of an exoskeleton in use at Gammon is the ZeroG robotic arm, which allows workers to lift heavy objects without the need for electrical power. This device, which is clamped onto a mobile platform, allows workers to use heavy equipment such as drills with very little effort, thereby reducing fatigue and the chance of injuries.

"The construction technologies we have embraced are making our projects more efficient and the lives of our workers less strenuous and safer."

Another example is the Chairless Chair, originally designed for assembly line workers in Germany's automobile factories. Adapted for our construction sites, it enables workers to perform long hours of repetitive tasks without tiring. "We are the first construction company in the world to use these devices," Vincent says. "They are now in our concrete production plant and structural steel factory in China."

Yet one more example is an exoskeleton developed in partnership with The Hong Kong Polytechnic University that is not worn on the body but installed onto a jackhammer. This passive device needs no electricity, costs much less than similar devices, reduces vibration by 90% and increases productivity (breaking power) by 30%. Having won first prize from the Construction Industry Council in 2017 for safety, it has attracted the interest of other companies, including a local utility that recently placed a large order for this innovative new tool.

"In the next two to three years, we hope to launch many more proposals for other robotics devices."

We are also looking at ways to automate tasks. In Singapore, Paul Moss, Senior Project Manager, says they have developed a computerised hacksaw that "can cut through channel iron so it's exactly square, perfectly set, and produce 10 finished pieces in just 15 minutes. That gives Gammon a strong competitive edge."

Automation is also addressing the challenge of labour shortages in trades such as welding. "We are developing a welding robot with a brain," says Vincent Yeung. "The robot will see a gap, or an irregular shape, and make the weld accordingly even in environments with dust, different ambient temperatures, weather and air flow."

And this robot, the first of its kind on a construction site in Hong Kong, is just the beginning. In the next two to three years, we hope to launch many more proposals for other robotics devices.

All of these devices exemplify the spirit of innovation at Gammon. Yet being innovative is more than just taking up electronic tools, says Alan Gibson, Director, at Gammon in Singapore.

"It's about improving productivity and output, keeping your costs to the absolute minimum and becoming more competitive while improving your quality. To me that is real innovation."

1 Case Study: Added Value, from First to Last

7D BIM (BIM for Facilities Management) at Global Switch Data Centre Hong Kong

When K C Lau, Senior Construction Manager (E&M), was assigned the Electrical & Mechanical services contract for Global Switch Data Centre Hong Kong, he knew he had a tremendous challenge ahead of him.

One of the world's leading operators of large-scale data centres, Global Switch had planned to build a HK$5 billion data centre development in Tseung Kwan O. The list of E&M requirements was so extensive, however, that a number of less experienced contactors had been deterred from tendering proposals.

Data centres are much more challenging than conventional E&M projects, as they need to fit almost four times the amount of services in about the same space as conventional projects. The challenges of this project were even more daunting as the client targeted a PUE of less than 1.5, the lowest of any facility in Hong Kong.

PUE, or Power Usage Effectiveness, is a ratio for describing how efficiently a data centre uses power. In the United States, "the average PUE for data centers … is a little bit of a debate, but the number seems to be somewhere between 1.8 and 2.0. This, in itself, is quite an accomplishment."[3]

K C Lau was confident he could not only meet the client's PUE target of 1.5 but committed to bringing it even lower, to 1.43, and feels it could realistically come down even further to 1.23. While the difference in these figures may seem tiny, the potential savings in electricity costs are staggering. A 1.23 PUE vs a 1.5 PUE, for example, could reduce annual electricity costs by as much HK$140 million, based on a total IT load.

K C Lau says, "The Global Switch project is pioneering the use of BIM in Hong Kong, from design and construction through to operation and maintenance. Every element in the building is covered in the BIM model, including ceiling and floor tiles, doors, and all the E&M services."

For Global Switch, Gammon is responsible for all Planned and Preventive Maintenance (PPM) duties during the first two years after completion, following which the client's operations team will take over.

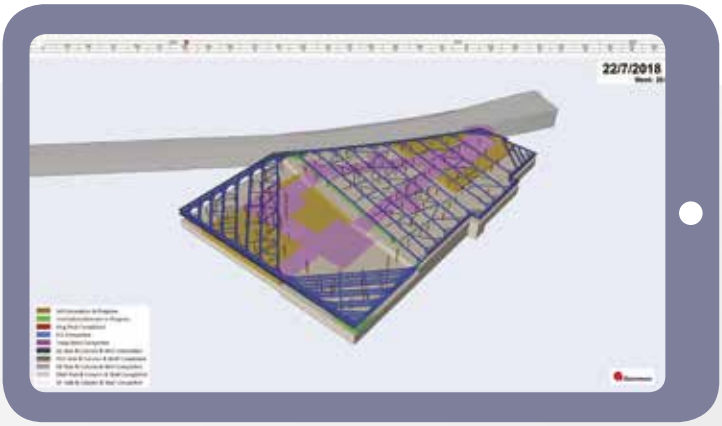
In line with the maintenance requirements, Gammon will be supplying sensors and a sophisticated console to monitor all the installed assets. For the asset register, a bar code will be placed on components such as CCTV cameras, each with a unique ID, and tied in with the BIM model. All equipment has a bar code label attached with a unique ID and linked to the asset register, which is also tied in with the as-built BIM model.

"When you open up the BIM model," K C Lau says," you will find, for example, a camera symbol representing a CCTV camera that you can click on. All the asset information will then come up, including maintenance schedules, such as when a camera must be replaced, how long it takes to order, if there were any previous problems, and information on the supplier and cost. The same information can also be accessed by scanning the bar code label on the equipment."

What's more, when the data centre is in operation, the PUE can be improved by adjusting the settings on the equipment. "With sensors and meters installed all across the building, we can collect the data and understand the whole system profile. By analysing the data, we can identify when the equipment is running most efficiently and fine tune the settings to reduce energy consumption."

"A 1.23 PUE vs a 1.5 PUE could reduce annual electricity costs by as much HK$140 million."

2 Case Study: Singing the Praises of Digital Construction



IDPD and the Lyric Theatre Complex

One of the most compelling examples of IDPD in action is the HK$1.5 billion contract for the Lyric Theatre Complex and Extended Basement of the West Kowloon Cultural District (WKCD) development, a world-class cultural centre on the Hong Kong waterfront. The contract is the third to be awarded to Gammon by the West Kowloon Cultural District Authority.

From the start of construction in early 2018, Brian Gowran, Contracts Manager (Civil), and his team of engineers have been deploying all the digital tools and methods available to them for bringing the project to completion. These include BIM, DfMA, 3D scanning and printing, drones, sensors and more, all integrated under the IDPD approach to construction.

These tools have come into full play at the site, which is tightly constrained by Victoria Harbour and the Western Harbour Crossing Toll Road on one side and the MTR Airport Express tunnels on the other.

"We have a BIM model that we share with the client," says Brian. "It was used to find problems with the design such as clashes and, now that we're constructing, to record the as-built situation on a monthly basis."

The team also printed a 3D model which contains all the critical elements of the project and sits on a table at every meeting. "The 3D printed model is a wonderful tool to ensure everybody is talking about the same thing," Brian explains. "It will help sub-contractors visualise what we're building."

Also critical to the success of the project is knowing precisely where the works are in relation to the Airport Express tunnels, since a disruption to railway service would be disastrous. Although MTR uses sensors to record the position of these floating tunnels, their devices are hard wired and must be checked manually. To detect movements in the tunnels, Gammon proposed a better and safer solution.

"The sensors we are using are about the size of a 50¢ Hong Kong coin," says Brian. "They were installed in one night and can talk to each other through a wireless signal to provide continuous readings throughout the day."

Other digital recording tools include GPS on the concrete trucks, which notes when each truck arrives and leaves a site, cameras that count all plant and labour going in and out, and an automated site diary system for subcontractors to register what they are doing each day.

As Brian notes, "we are among the first to integrate the latest technology and bring it all together digitally to allow machines and computers to look at and analyse things, find trends and make improvements. The client is very enthusiastic about this digital technology."

3 Case Study: Ready-Made and Ready to Go

MiC and the Future of Construction

Some day soon, the home you live in, the office where you work, or the hotel you booked for your vacation may have been built not on a construction site, but inside a factory. If that sounds implausible, Gammon recently proved otherwise with a demonstration project commissioned by Hong Kong's Construction Industry Council (CIC).

The project was almost entirely built using components assembled offsite in a process called Modular Integrated Construction (MiC).

Located at the CIC's Zero Carbon Building, which was also constructed by Gammon, the three-storey building is the first demonstration project in Hong Kong to show how MiC can improve construction quality, productivity, safety and sustainability. It contains 10 modules representing rooms found in a typical hotel, hostel, two-bedroom home, three-bedroom home and a home for the elderly.

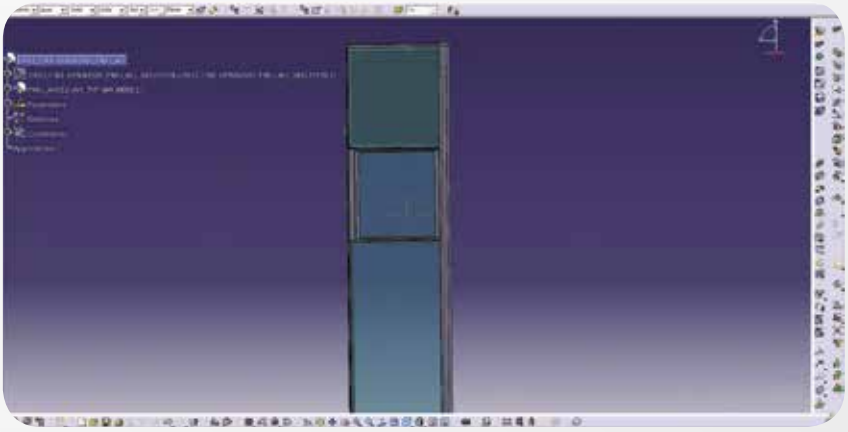
Using the MiC approach, 70% of the project was constructed offsite. The modules were fully decked out with everything from electrical wiring through to fixtures, fittings and even wallpaper, then delivered and installed at the site in Hong Kong. Only the structure's foundations, frame and stairwells were constructed on site.

In addition to the much-improved speed, cost and efficiency made possible by MiC, the factory-controlled process improves quality, generates less waste, creates fewer disturbances, and provides a safer working environment.

The completion of the project couldn't have been more timely. In December 2017, the Hong Kong government gave its support to MiC by issuing guidelines on its implementation. And we at Gammon showed we are ready to share our knowledge and expertise on this innovative building method of the future.

"The factory-controlled process improves quality, generates less waste, creates fewer disturbances, and provides a safer working environment."

4 Case Study: The Changing Face of Building Technology



Entasis and Design for Manufacture and Assembly

Developers today are looking for solutions that satisfy their aesthetic requirements while also saving time and money. But this can be extraordinarily difficult to achieve, especially for building facades using regular design and construction methods.

In 2013, Gammon set up a division specialising in unitised curtain wall design and installation – Entasis Limited. The company, now with 90 professionals on board, has pioneered the use of new technologies to address the challenges of frequent design changes and tedious manual operations. Among these are digitisation, automation, Artificial Intelligence and, most notably, Design for Manufacture and Assembly (DfMA).

The reason for relying on DfMA, as noted by Ben Wong, Construction Manager (Facade) at Entasis, is its ability to ensure the accuracy of supplied materials for a project. "If materials do not meet standard, this causes delays and cost overruns."

This is also why Entasis works closely with a trusted manufacturing partner for the profiles, aluminium and stainless steel panels, as well as other suppliers for curtain wall materials such as glass, thermal insulation and bracketry.

"The greatest advantage of DfMA," Ben adds, "is its ability to eliminate human error, optimise the use of materials, and minimise wastage."

These are especially important when changes are made on time-constrained projects, a typical feature of many Hong Kong developments. "If there is a change in the material section profile, I only need to amend certain details and the system automatically updates the relevant components."

Entasis has also established a curtain wall system library, in which every curtain wall unit is labelled with an RFID tag. This not only saves up to 30% of the time in a design cycle but can also be used in a facilities management system for replacing parts once the building is in operation.

For example, if a pane of glass needs to be replaced, it's simply a matter of retrieving its number or tag. "DfMA enables us to generate all the glass information with just a few clicks along with the warranty information and immediately forward it to the supplier for a quotation. In just a couple of days, the procurement orders of all the glass panes, brackets, gaskets and sealer will be placed."

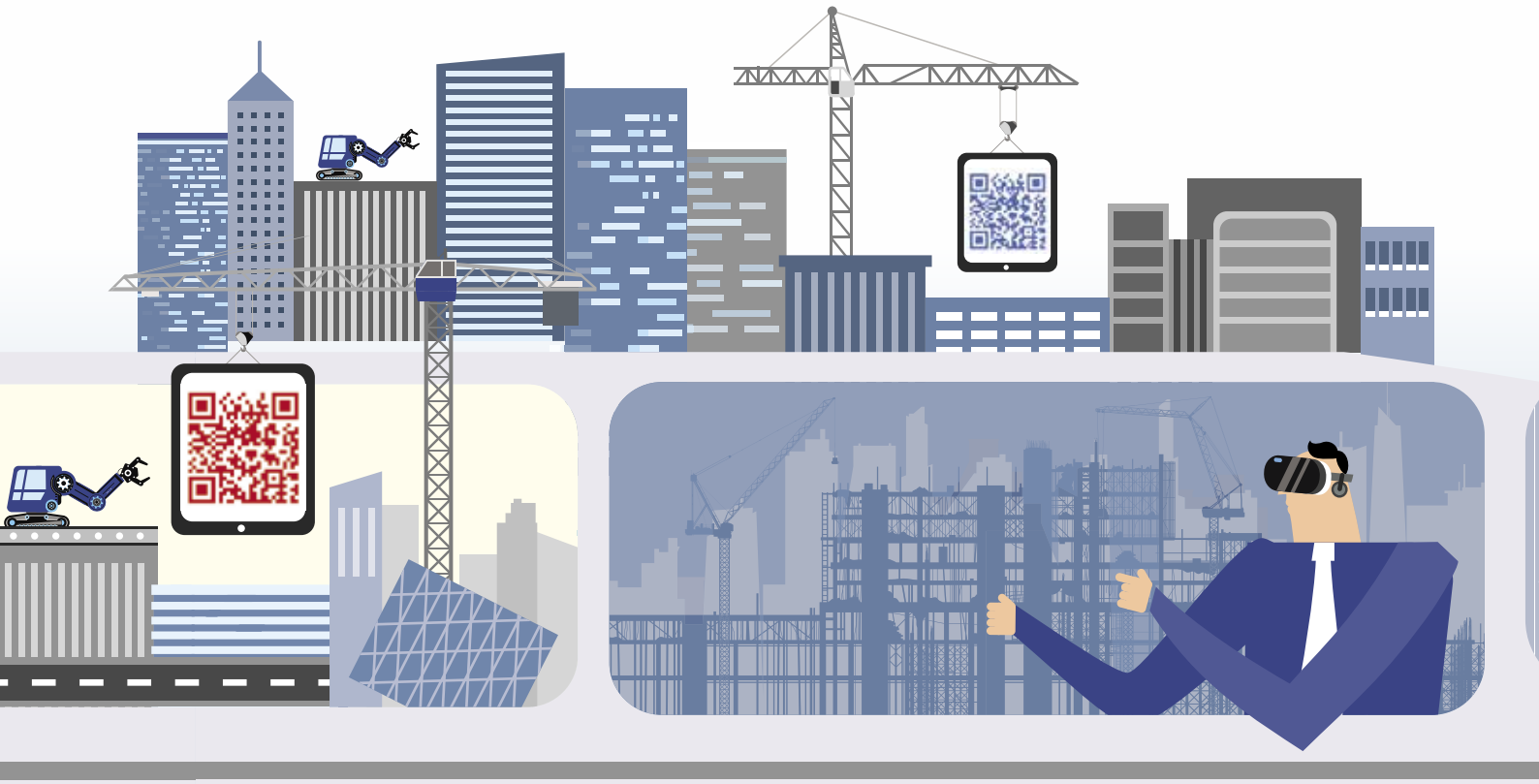
With the old method of digging up 2D drawings and product information, a similar replacement order would often take up to two to three weeks.

Seeking to improve the system further, Ben and his team have hired a consultant to develop their own DfMA software. It will help with material take-off and clash analysis, generate fabrication drawings automatically, and work with a CNC machine to produce the parts in the factory, eliminating the need to work out 2D fabrication drawings by AutoCAD.

Although still in the trial stage, the DfMA software is expected to be ready for full implementation in the second quarter of 2019.

The Way Ahead

"Disruption is accelerated by a variety of factors – new technologies, cultural changes, demographic trends, geopolitical events, and globalization – that often work in tandem. Organizations that choose to embrace this disruption rather than taking a strictly defensive posture are those best positioned to generate long-term value for their stakeholders."[4]



The digital tools we are using at Gammon are already bringing about dramatic changes in the way we build, work together and add value to our clients' projects.

As we have discussed in these pages, it is not the tools themselves that are changing the way we build, but the way we integrate them to deliver projects more efficiently, safely and at less cost.

In many respects, IDPD is a case of 'creative disruption', which has been defined as innovation that displaces "an existing market, industry, or technology and produces something new and more efficient and worthwhile."[5]

We are convinced that IDPD is indeed a more efficient and worthwhile method of construction. It is allowing us to be more productive and provide new business opportunities along the supply chain, safer conditions for frontline staff, and valuable new skills for our engineers. For developers, it means substantial reductions in the time and cost to complete a construction programme and, for facilities managers, dramatically improved maintenance regimes, particularly with regard to electricity and water consumption.

We have been demonstrating just how effective IDPD can be on projects both in Hong Kong and Singapore. To amplify the power of IDPD, we will continue working in partnership with universities and leading global manufacturers to improve or develop new technologies in areas such as Artificial Intelligence, robotics and sensors.

We will also continue to work with our staff, suppliers and subcontractors to ensure they have the necessary skills and knowledge to succeed in the new digital environment, and to offer clients the insights they need to fully benefit from this new approach to construction. IDPD, we believe, is the way of the future and aligned with best practices in delivery as seen elsewhere in the world, including the UK, Singapore and Finland.

In Hong Kong, our IDPD journey is still ongoing. We invite you to join us on this journey and to work with us in making our vision for the digital future of construction a reality.

Footnotes

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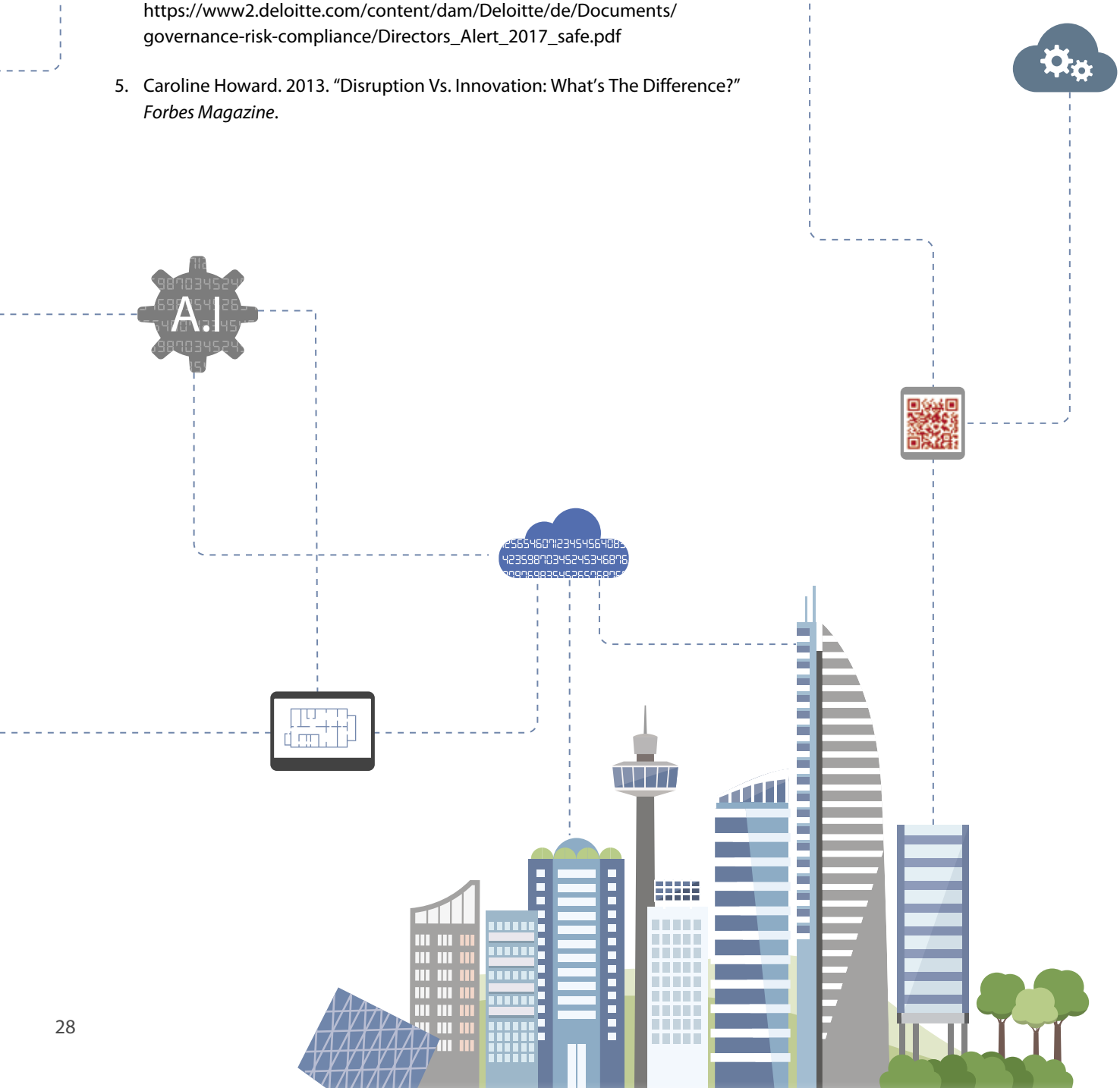

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