TSE is going fully digital in Feb 2021! See page 09 for details.

THE MAGAZINE OF THE INSTITUTION OF ENGINEERS, SINGAPORE

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THE INSTITUTION OF ENGINEERS - SINGAPORE -

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PLUS

IES UPDATE: Setting the standards in railway engineering

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PUBLIC SECTOR CONSTRUCTION DEMAND

TO SUPPORT THE SECTOR'S RECOVERY

The BCA-REDAS Built Environment and Property Prospects Seminar 2021, held on 18 January 2021, presented the opportunities, challenges and prospects for Singapore's built environment in 2021.

Mr Desmond Lee, Minister of National Development, was the Guest-of-Honour at the event which was organised by the Building and Construction Authority (BCA) and the Real Estate Developers' Association of Singapore (REDAS).

Speaking on the occasion, Mr Lee said, "Even as we continue to keep an eye on the pandemic, we must reflect on the lessons that we have learnt, and take decisive steps to transform our sector, so that it can emerge as a much stronger sector after this crisis. First and foremost, we need to build in more resilience into our system, and significantly reduce our over-reliance on foreign guest workers. We have been emphasising the need to adopt Design for Manufacturing and Assembly (DfMA) technologies. This is not new. BCA has been working very closely with the industry on this over the past few years. With DfMA, we can prefabricate building components in a more productive way, by moving more construction work off-site and enabling automation of manpower-intensive processes. We will work with you and adopt a more aggressive approach to drive DfMA across our entire sector in the coming years".

"Integrated Digital Delivery, or IDD, complements and enables DfMA to materialise. It is like a digital spine that brings together the entire building lifecycle and its various parties, covering construction all the way to facilities management. This facilitates greater integration and collaboration among stakeholders across the value chain, and reduces abortive work by resolving design conflicts upstream", he added.

"To drive IDD, the industry-led Digitalising Built Environment Alliance for Action, or AfA, was formed in June last year under the Emerging Stronger Taskforce to accelerate digitalisation of our built environment sector. I am glad to announce that the AfA will be launching industry-wide Common Data Environment Data Standards, which have been established to drive the adoption of digital platforms. The AfA targets to invite 300 leading firms in the industry to start adopting digital platforms based on the set of Data Standards. Firms can take advantage of funding from the Productivity Solutions Grant to do so. This will have a multiplier effect, as these firms will in turn bring the companies in their supply chains on board the digitalisation journey", Mr Lee continued.

CONSTRUCTION DEMAND

BCA projects the total construction demand in 2021 (i.e. the value of construction contracts to be awarded) to range between SGD 23 billion and SGD 28 billion. This is an improvement from the preliminary estimate of SGD 21.3 billion, for 2020, achieved during the ongoing COVID-19 pandemic.

The public sector is expected to drive the construction demand in 2021, with a contribution of between SGD 15 billion and SGD 18 billion, propelled by an anticipated stronger demand for public housing and infrastructure projects.

Some of the upcoming major public sector projects scheduled to be awarded this year include various contracts under the Jurong Region MRT Line, the Cross Island MRT Line Phase 1 and the Deep Tunnel Sewerage System Phase 2.

Private sector construction demand is projected to be between SGD 8 billion and SGD 10 billion in 2021. BCA projects the bulk of this demand to comprise development of the remaining en-bloc residential sites, major retrofitting of commercial developments as well as construction of high-specification industrial buildings to meet business needs.

Due to the impact of the COVID-19 pandemic, which disrupted project implementation schedules, the preliminary figure for construction demand in 2020 indicated a decline of 36.5% to SGD 21.3 billion. This was within BCA's revised forecast of SGD 18 billion to SGD 23 billion.

Public sector construction demand dropped from SGD 19.0 billion in 2019 to SGD 13.2 billion in 2020, as some major infrastructure projects, that required more time for the assessment of the pandemic's impact on resource management and project schedules, were postponed. Meanwhile, private sector construction demand decreased from SGD 14.5 billion in 2019 to SGD 8.1 billion in 2020, due to market uncertainties amidst the COVID-induced economic recession.

FORECAST FOR THE PERIOD 2022 TO 2025

BCA expects a steady improvement in construction demand over the medium term. It is projected to reach between SGD 25 billion and SGD 32 billion per year from 2022 to 2025.

The medium-term construction demand projection excludes any potential awards of construction contracts for the development of Changi Airport Terminal 5 and its associated infrastructure projects as well as the expansion of the Integrated Resorts, as their construction

timelines are still under review due to the impact of the COVID-19 pandemic.

The public sector is expected to lead the demand and contribute SGD 14 billion to SGD 18 billion per year from 2022 to 2025, aided by a demand of similar proportions coming for building projects and civil engineering works. Besides public residential developments, public sector construction demand over the medium term will continue to be supported by large infrastructure and institutional projects such as the Cross Island MRT Line (Phases 2 and 3), the Downtown Line Extension to Sungei Kadut, the cycling path networks, the relocation of Singapore Science Centre, the Toa Payoh Integrated Development, the Alexandra Hospital redevelopment and a new integrated hospital at Bedok.

The private sector construction demand is expected to improve steadily in the medium term to reach between SGD 11 billion and SGD 14 billion per year from 2022 to 2025. This is in anticipation of a gradual recovery of the global economy, contingent on the successful deployment and effectiveness of COVID-19 treatment and vaccines, as well as easing of lockdown restrictions.

CONSTRUCTION OUTPUT

Based on the contracts awarded in the past few years and considering the construction demand forecast for 2021, the total nominal construction output in 2021 is projected to increase to between SGD 24 billion and SGD 27 billion, from the estimated SGD 19.5 billion in 2020. An anticipated improvement in construction demand in 2021 and clearing of the backlog of remaining workloads impacted by COVID-19 during 2020 will support the projected pickup in total construction output.

ACCELERATING INDUSTRY TRANSFORMATION THROUGH DIGITALISATION

Although 2020 was particularly challenging for the built environment sector, the industry has shown great resilience. The COVID-19 pandemic has necessitated a rethink on the way buildings are designed and constructed, to overcome the challenges. BCA will continue to work with industry partners, including trade associations and chambers (TACs), to accelerate industry transformation.

The Emerging Stronger Taskforce's (EST) Alliance for Action (AfA) on Digitalising Built Environment, an industry-led and government-supported coalition, has identified digitalisation as an important enabler to help the industry build smarter. One of the initiatives introduced by the AfA is the introduction of a set of data standards for the Common Data Environment (CDE) to facilitate more seamless information flow for building projects across digital platforms shared by various building professionals and companies along the value chain.

The successful management of timely, accurate and complete information based on a set of data standards can affect a project's outcome.

A CDE allows project teams to create, organise and share information to foster collaboration, make timely decisions and take early interventions during the project's delivery and building maintenance lifecycle.

Data Standards specify what information is required for a building project and how it can be structured to facilitate sharing and collaboration among project team members using a CDE.

Year	Construction Demand (Value of contracts awarded, in SGD billion)			Construction Output (Value of certified progress payments, in SGD billion)
	Public	Private	Total	Total
2020 *p*	13.2	8.1	21.3	19.5
2021 *f*	15 - 18	8 - 10	23 - 28	24 - 27
2022-2025 *f*	14 - 18 per year	11 - 14 per year	25 - 32 per year	-

p: Preliminary. *f*: forecast.
Note: Construction demand forecast in 2022-2025 excludes any potential awards of construction contracts for the development of Changi Airport Terminal 5 and its associated infrastructure projects as well as the expansion of Integrated Resorts as their construction timelines are still under review due to the impact of the COVID-19 pandemic.

Estimates and forecasts of Construction Demand and Construction Output for 2021 and beyond.

More information on the Data Standards can be obtained from https://go.gov/bca-cde-data-standards.

ALLIANCE FOR ACTION (AfA) ON DIGITALISAING BUILT ENVIRONMENT

The Alliance for Action (AfA) on Digitalising Built Environment was convened under the Emerging Stronger Taskforce (EST), led by Mr Lim Ming Yan, Chairman of the Singapore Business Federation. It aims to accelerate the digitalisation of Singapore's built environment so that it can emerge stronger from the COVID-19 pandemic, by:

- Establishing industry-wide Data Standards for CDE.
- Encouraging the adoption of CDE Data Standards to enable the industry to collaborate digitally, working towards an interoperable and connected IDD ecosystem from end-to-end.

To that end, BCA and the AfA hope that more firms and professionals will undertake the following:

- Digitalise when working collectively on projects with team members and across different organisations.
- Harness appropriate CDE and digital solutions to improve their productivity.
- Encourage more firms and professionals to digitalise their work as part of the sector's transformation.

BCA and the AfA will also work closely with Real Estate Developers' Association of Singapore (REDAS) and all other developers to encourage their industry partners (i.e. contractors, consultants), especially smaller consultants and subcontractors, to digitalise and adopt the data standards in their future projects, with the help of training courses and funding support.

Training

BCA Academy has developed training courses covering CDE data standards. More information can be obtained from https://www.bcaa.edu.sg/what-we-offer/courses/certification-courses?CourseId=dfe2d103-2639-4f0d-81c5-b2af5b9b98c6.

Funding

SMEs can tap on the Productivity Solutions Grant (PSG) to defray the costs of adopting digital solutions pre-approved by the Infocomm Media Development Authority (IMDA) for the Construction and Facilities Management sector.

The funding will cover up to 80% of the qualifying cost until 30 September 2021, and subsequently, up to 70% until January 2023. SMEs can make multiple applications for use of different digital solutions subject to a firm level cap of SGD 30,000.

"Even before COVID-19, the Future Economy Council Built Environment (BE) Cluster had already embarked on its digital transformation journey through various measures including industry digital plans to uplift small and medium-sized enterprises, building digital infrastructures and capabilities, and fostering digital innovation for transforming service delivery and growth. COVID-19 has exposed the vulnerability of the industry's current work process and dependence on manual labour and presented an opportunity to turbo-charge digital transformation. The development of CDE data standards is our opportunity to facilitate and enhance digital collaboration across the value chain to enable large and small businesses to optimise operations to manage increasing complexities and scale of projects. This is part of the first step to embrace digitalisation as a collective, for improved processes, and greater resilience and efficiency", said Mr Lim Ming Yan, Chairman, Singapore Business Federation.

"The first phase of CDE data standards seeks to help companies along the BE value chain - from developer, contractor, project officers to engineers - operate more efficiently. Establishing CDE data standards is key to achieving enhanced interoperability across digital platforms, and integrated work processes and workflows for industry players. We look forward to deepening our participation in this important initiative and together drive the goal of building a digitalised and sustainable BE Cluster", said Mr Lee Chee Koon, Group Chief Executive Officer, CapitaLand.

"While COVID-19 has negatively impacted the BE value chain, it has accentuated the need for businesses to transform and step up on our digitalisation efforts. This requires the public and private sector stakeholders to do so together. REDAS is supportive of the Alliance for Action on Digitalising Built Environment's initiatives, including the development of the CDE data standards, and welcomes the opportunity to work alongside government agencies and industry players within the BE Cluster to shape the future of the BE ecosystem. Our extensive network of real estate developers will be able to contribute their development expertise and generate a 'pull' effect to galvanise industry players to come forth as one, to catalyse digital transformation for greater resilience and efficiency", said Mr Chia Ngiang Hong, President, Real Estate Developers' Association of Singapore (REDAS).

"HDB has been progressively harnessing technology and digitalising many design and construction project activities to foster greater collaboration with our stakeholders, and raise construction productivity. For example, we have implemented Virtual Design and Construction (VDC) with Building Information Modelling (BIM) software in our public housing projects, which enables us to run through BIM models, and review building designs with consultants and contractors using virtual reality tools. Such use of technology aids us in making faster and more precise decisions when resolving design issues. With the new CDE data standards, communication with various partners across the different project stages will be more efficient and seamless. Going forward, HDB plans to digitalise more of our design and construction-related activities", said Dr Johnny Wong, Group Director (Building & Research Institute), Housing & Development Board (HDB).

MR CHALY MAH APPOINTED CHAIRMAN OF SURBANA JURONG GROUP

Surbana Jurong Group has announced the appointment of Mr Chaly Mah Chee Kheong as its Chairman, with effect from 1 January 2021. Mr Mah succeeds Mr Liew Mun Leong, Surbana Jurong's Founding Chairman, who retired in September 2020.

The appointment follows the board's approval of a recommendation by the company's Executive Resource & Compensation Committee.

Mr Mah will bring extensive board and leadership experience to the role of Chairman of the Surbana Jurong Group.

Mr Tan Gee Paw, one of the board's longest serving directors, commented, "The Board was pleased that Chaly agreed to join us and serve as Chairman, because we see his experience and vision as critical to continuing the journey that Surbana Jurong started under Liew Mun Leong's leadership. Chaly's leadership credentials and his desire to see Surbana Jurong continue its growth journey, delivering sustainable social and economic impact for our clients, appeal to us all".

Mr Mah said of his appointment as Chairman, Surbana Jurong Group, "I am deeply honoured and humbled to be entrusted with this responsibility. Five years after its formation, Surbana Jurong Group continues to fulfil its essential purpose of building cities and shaping lives. It has grown from strength to strength, expanding its influence and presence globally. For this, I would like to thank Mun Leong who, with the SJ leadership team, was the driving force behind Surbana Jurong's growth strategy. I look forward to working with the board and management to leverage on this strong platform to advance the group into a leading global player".

Mr Wong Heang Fine, Group Chief Executive Officer, Surbana Jurong Group, said, "On behalf of the leadership team and all colleagues, I warmly welcome Chaly and look forward to working with him to take Surbana Jurong to its next phase of growth. In the face of unprecedented challenge, the over 16,000 colleagues in the group have continued to deliver on our commitments to create value for all our stakeholders. Chaly's deep experience and insights will benefit us greatly as we continue to grow our portfolio of speciality consulting skills and expand our capabilities for the built environment, anchored on sustainability and technology for the future".

Mr Chaly Mah

Mr Mah, 64, is Chairman of Singapore Tourism Board, the Singapore Accountancy Commission and NetLink NBN. He is a member of the Board of Trustees of SG Eco Fund, National University of Singapore (NUS) and Chairman of the NUS Business School Accounting Advisory Board. He also serves on the boards of the Singapore Economic Development Board, Monetary Authority of Singapore, Flipkart Private Ltd and CapitaLand Limited.

Mr Chaly Mah

Mr Mah served on the board of Singapore Land Authority from 2007 to 2014 and was its Chairman between 2010 and 2014. He was Chairman of the Singapore International Chamber of Commerce between 2015 and 2017, and an external member of the Audit Committee of the Asian Infrastructure Investment Bank from 2017 to 2020.

In 2016, Mr Mah retired as CEO of Deloitte Southeast Asia and Chairman of Deloitte Singapore. He was with Deloitte for over 38 years, including five years in its Melbourne office. During his tenure, Mr Mah led teams serving multinational and local companies across a wide spectrum of industries, specialising in financial services, telecommunications & technology, real estate, private equity and manufacturing, and in advising companies on mergers and acquisitions and corporate finance. Mr Mah was also the CEO of Deloitte Asia Pacific and served as the Vice-Chair of Deloitte's Global Board of Directors.

Mr Mah is the Singapore Non-Resident Ambassador to Papua New Guinea. In 2014, he was awarded the Public Service Medal (PBM) for his contributions to public service.

Surbana Jurong Group

Surbana Jurong Group is a global urban, infrastructure and managed services consulting firm, with a 70-year track record in successful project delivery.

Headquartered in Singapore, the group, comprising Surbana Jurong and member companies AETOS, Atelier Ten, B+H, KTP, Prostruct, RBG, SAA, Sino-Sun and SMEC, operates from 120 offices in over 40 countries. A talent pool of 16,000, comprising architects, designers, planners, engineers and other specialists, delivers sustainable solutions that cover the entire project life cycle, from planning and design, through to delivery and management, as well as decommissioning and closure.

ALSTOM RECOGNISED AS A TOP EMPLOYER 2021

Being certified as a Top Employer in the mobility sector cements Alstom's dedication to a better world of work and achieved through its Human Resources (HR) policies and people practices.

The leading transportation company has received the Top Employer 2021 certification in 14 countries and regions, including, in the Asia Pacific region, Australia, China, Hong Kong China, India and Singapore.

The Top Employers Institute programme certifies organisations, based on the participation in and results of their HR Best Practices Survey. This survey covers six HR domains, consisting of 20 topics such as People Strategy, Work Environment, Talent Acquisition, Learning, Well-being, Diversity & Inclusion and more.

"At Alstom, we believe that we are only as good as the passion and ambition of our people driving the company. The coveted Top Employer 2021 honour - a first for Hong Kong and Singapore - puts Alstom in the company of not just the Asia Pacific region but also the world's best workplaces. It underscores our strong belief in building the right environment for our employees to continue excelling in their respective domains, while reflecting the company's approach towards these talents and the opportunities we offer them", said Olivier Loison, Managing Director for Alstom in China & East Asia.

The concept of a quality work environment has long taken root at Alstom, in Hong Kong and Singapore, right from the beginning. Besides providing a competitive compensation package and a safe and inclusive work environment, the company's policies at these locations are also directed towards building a healthy and engaged workforce.

In Hong Kong, Alstom promotes corporate volunteerism and participates actively in community outreach projects. In recognition of its commitment to caring for the community and employees, Alstom was also named a Caring Company by the Hong Kong Council of Social Service for two consecutive years (2018/2019 and 2019/2020).

Alstom's diverse workforce in Singapore, comprising close to 20 nationalities, contributes to upholding a high-performance work culture. From implementing a structured programme for new entrants to the workforce, to constantly seeking employee feedback, the Singapore team wholeheartedly supports a cohesive onboarding experience for employees.

The Top Employers certification is fully in line with the Alstom In Motion strategy. Through collaboration with Top Employers Institute, Alstom will be able to benchmark its practices and internal processes to those of other companies from a variety of industries and determine its key strengths and lines of improvement. It will also serve to attract new talents, promote high levels of employee experience and give everyone the means to grow in their careers.

Employees interacting at Alstom's Singapore office. Image: Alstom / Rob Waller.

"Despite the challenging year we have experienced, which has certainly made an impact on organisations around the globe, Alstom has continued to demonstrate the power of putting their people first in the workplace. We are proud to share this year's announcement and congratulate all the organisations who have been certified in their respective countries through the Top Employers Institute programme", said David Plink, CEO, Top Employers Institute.

Alstom

Leading societies to a low carbon future, Alstom develops and markets mobility solutions that provide the sustainable foundations for the future of transportation. Alstom's products portfolio ranges from high-speed trains, metros, monorail, trams and e-buses to integrated systems, customised services, infrastructure, signalling and digital mobility solutions. Headquartered in France, Alstom is now present in 70 countries and employs 75,000 people.

Top Employers Institute

Top Employers Institute is a global authority on recognising excellence in People Practices. The institute helps accelerate these practices to enrich the world of work. Through the Top Employers Institute Certification Programme, participating companies can be validated, certified and recognised as an employer of choice. Established 30 years ago, Top Employers Institute has certified over 1,600 organisations in 120 countries/ regions. These certified Top Employers positively impact the lives of over 7 million employees globally.

SETTING THE STANDARDS IN RAILWAY ENGINEERING

Dr Richard Kwok

Dr Richard Kwok, IES President, elaborates on the setting up of the Technical Committee (TC) on Railway Systems, its objectives, the initiatives taken and the challenges ahead, in this email interview with 'The Singapore Engineer'.

Question: What are the main drivers in the establishment of the Technical Committee (TC) on Railway Systems? What are its broad objectives?

Answer: With the expansion of the railway network in Singapore, there has been a continual increase in the demand for engineers and engineering technicians to maintain and operate the lines. By 2030, the railway network in Singapore will increase to 360 km and be further extended under the Land Transport Master Plan 2040.

The mission of the TC on Railway Systems is to develop, advance and promote nation-wide use of the Singapore Railway Standards (SRS) to enhance the safety, efficiency, reliability and interoperability of systems, products and services in transport, and maintain railway excellence in a sustainable manner.

The TC aspires to support the delivery of world-class service to our commuters across all modes of transportation. We are driven to achieve through the 'One Team, One Committee and One Singapore Railway Standards' approach.

Sustaining railway excellence requires work standardisation and integrated common work processes for the whole lifecycle of railway asset management. With design, building, operations and maintenance personnel working hand-in-hand, we can expect to make advancements in our journey to harmonise, standardise and digitalise through the SRS platform.

The SRS can also establish good benchmarks for adoption by the regional and international industry. This will enable Singapore to strengthen our leadership position in the railway and transport sector in the world.

Q: What has been the progress in the work undertaken by the TC, thus far?

A: A Railway Standards strategic planning workshop was held shortly after the launch of the TC on Railway Systems, at the IES 56th Annual Dinner on 10 October 2019. With the support of colleagues from ESG, IES-SDO, LTA, SBST, SMRT and SIT, the workshop laid down an important foundation for the identification of pain points encountered by regulators and operators when operating the railway system. Since then, we have made significant progress.

First, we have established a strong team with expertise in different areas of the railway ecosystem necessary for developing the SRS. It comprises members from the Singapore Standards Council, LTA, railway operators, Institutes of Higher Learning (IHLs), equipment suppliers and professionals.

Through thorough segregation of all the pain points and Codes of Practice that operators are required to comply with under their licence to operate, the team has identified four thematic Readiness Groups, to address:

- Asset Readiness
- Maintenance Readiness
- Safety & Security Readiness
- Service Readiness

Shortly after, four Working Groups were formed to cover the following four areas of standardisation:

- Railway Asset Lifecycle Management
- Sustainability
- Safety and Security
- Operations and Reliability

Each Working Group consists of two co-conveners and core members from public transport operators, relevant government agencies, original equipment manufacturers (OEMs), IHLs and professional organisations, who are working together to lead and facilitate the development of the SRS.

Second, the Working Groups had identified 12 standards for the first batch of implementation across all four Working Groups. Currently, the team is collating feedback from the public, which will be used in completing the development of six to eight standards.

The standards are carefully crafted by the Working Groups and go through rigorous rounds of technical reviews, proofreading, checking and public comments,

before they are implemented as a system. It is a time-consuming and arduous activity involving many rounds of reviews, meetings and checks with the relevant consultants and authorities. But it is well worth the effort, as the end result will be a set of well-developed standards.

The TC is committed to completing 60 standards over the next five years.

Q: What are the main benefits in the adoption of standards in the context of railway systems? What are among the challenges?

A: A set of national standards for Singapore's railway system will strengthen the competency of our railway engineers. It will also enhance safety, cost-effectiveness and reliability. Adoption of a common language and methodology would also strengthen communications and collaboration among all the key stakeholders.

In essence, the three main benefits, also known as the three 'C's, are:

- Consistency through standardised work
- Competency through documenting best practices into standards
- Continuous improvements through standardised and stabilised systems

This initiative aims to create a sense of unity, in terms of standards and procedures, that is pivotal in building a robust ecosystem to support and sustain our railway industry.

Furthermore, the process of establishing local standards for national needs and adopting relevant international standards will strengthen the competency of our railway engineers and prepare them to venture beyond Singapore.

The SRS also aims to establish a more open, transparent and interoperable market that will further enable local SMEs to participate in the railway and transport industry, in areas from systems and subsystems to equipment and components. Documenting standard practices through the SRS also opens up more overseas business opportunities as there are potentially many countries that are willing to learn and adopt Singapore's standards and practices.

Q: Could you comment on the opportunities generated by the requirement of trained manpower to operate and manage railway engineering systems in compliance with the specified standards? What are some of the challenges in recruiting, training and upskilling of manpower?

A: The developed SRS can serve as a benchmark as well as a living knowledge library for all railway professionals. Mastery in SRS is an essential competency in the railway industry. With the established SRS, it will be even easier for researchers, developers, designers, and engineers to work together to create and implement innovations and upgrades to help the railway network become safer, smoother and more cost-effective.

As demand for the standards grows, the demand for trained personnel will also increase. However, expertise takes time to develop. We need to ensure that the railway workforce is properly trained for assuming the important role of drafting standards. The creation and adoption of standards will enhance engineering competencies for the local railway industry. In the near future, railway engineers can elevate Singapore's standards, which are currently meant to meet local needs, to be also adopted by other countries.

Moreover, as the adoption of digitalisation continues to accelerate, we need to adapt quickly to familiarise ourselves with existing technologies and bring in new technology to improve the efficiency of the railway system. OEMs can look for opportunities to digitalise their work processes and move towards Industry 4.0. In addition, the exchange of technical knowledge between OEMs and international railway operators can lead to more collaboration opportunities.

An MoU on recognising, benchmarking and developing railway engineers was signed on 29 May 2015.

Q: Any other information that you would like to provide?

A: Prior to establishing the Singapore Railway Technical Committee, on 29 May 2015, IES, LTA, WDA, SBST and SMRT signed a MoU to recognise, benchmark and develop engineers for the railway and transportation industry. The IES Chartered Engineer Programme for Singapore's railway and transportation engineering professionals was an important component of that agreement, which was signed with the then Senior Minister of State for Finance and Transport, Ms Josephine Teo, as witness.

Chartered Engineers will have their experience, expertise and practising competence validated and recognised. This initiative will contribute to elevating the professional standing of railway engineers and enhancing their opportunities for practice here and abroad.

The collaboration has also provided support for national-level efforts driven by SkillsFuture, to build a sustainable pool of highly skilled and proficient railway engineers. These efforts have also assisted individuals to advance their careers and mastery by equipping them with relevant skills.

This MoU also included the setting up of a platform for establishing a common set of standards in the railway industry. Together, the signatories are working towards providing a platform for the continual development of professional standards and accreditation in operations, maintenance and regulatory work.

Furthermore, the agreement has also made possible the following:

- Expansion of the Singapore Workforce Skills Qualifications framework
- Certification for Public Transport by WDA
- Building a foundation to support the SkillsFuture objectives of an integrated, high-quality system of education and training.

Through all these efforts, the TC on Railway Systems aims to provide a platform for technical experts from various organisations to learn from, and share with, one another, so that we can create a world-class transport system for Singapore.

THE SINGAPORE ENGINEER MAGAZINE GOES FULLY DIGITAL

As part of IES' effort to go green and do its part for environment sustainability, The Singapore Engineer (TSE) magazine will be going fully digital starting Feb 2021, with TSE Jan 2021 being the last print issue. You will still be able to access it through our monthly emails (both PDF and the interactive reader version on ISSUU), through the ISSUU mobile app, or online at ies.org.sg.

With the digital magazine, you will be able to:

- Keep up with engineering news curated from local and international sources
- Share interesting articles easily on social media (through ISSUU)
- Enjoy an optimised browsing experience for your various devices (e.g. mobile phones, tablets and monitors)
- Help us reduce our carbon footprint for a more sustainable future

Thank you for your continuous support of TSE.

IES PRESTIGIOUS ENGINEERING ACHIEVEMENT AWARDS 2020:

RECIPIENTS AND PROJECT DESCRIPTIONS

The winning projects are in four categories - Applied Research & Development, Engineering Projects, Technology Innovation, and Young Creators.

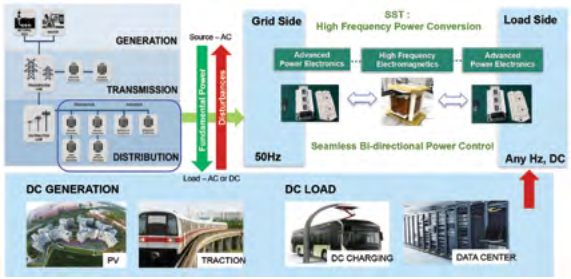
At the conclusion of the National Engineers Day on 21 November last year, the winners of the IES Prestigious Engineering Achievement Awards 2020 were also announced, recognising the outstanding contributions of local engineers to advancing engineering and enhancing quality of life of Singaporeans.

A record number of 50 submissions were received for consideration, an indication of the expanse of engineering innovations being developed in Singapore.

The winning projects demonstrated excellence in impacting lives, society and economy, and were judged based on the resourcefulness in the planning and solving of design problems; pioneering use of materials and methods; innovations in planning, design and construction; as well as unique aspects and aesthetic values.

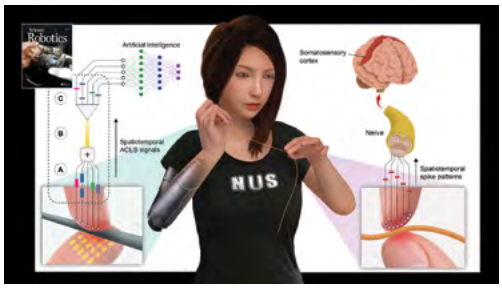
All photos and images have been adapted from submissions by the project teams, which were broadcast during the NED 2020 – EIC Prize Announcement Ceremony livestream on 21 November 2020.

CATEGORY: APPLIED RESEARCH AND DEVELOPMENT



Solid State Transformer for Energy Grid 2.0 by Energy Research Institute @ NTU

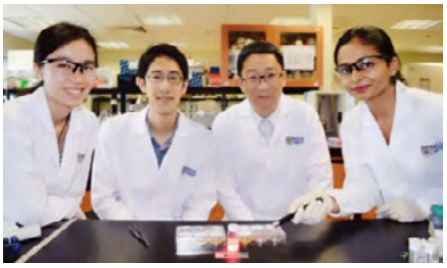
From AC-generation and AC-loads, the distribution power grid is rapidly transitioning to AC/DC distributed generation and DC-loads. This shift will create massive power imbalances at distribution networks leading to frequent disruptions. Solid State Transformers (SST) developed at NTU will seamlessly integrate loads and energy resources irrespective of these being AC or DC. These multi-functional SSTs will decouple DC-generation or loads from the main grid and prevent them from causing any power transfer or power quality issues.

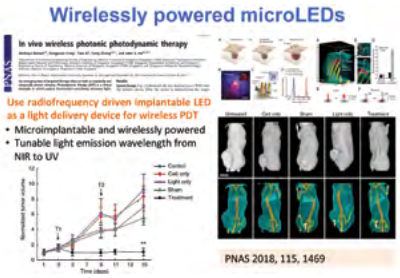


Neuro-inspired Electronic Skin Nervous System for Intelligent Autonomous Robotics by NUS Engineering

Benjamin Tee and his team at NUS have developed an artificial nervous system called ACES that enables ultrafast electronic skins. The system can touch and discriminate object properties 10 times faster than the blink of a human eye and can scale to hundreds of thousands of sensors without sacrificing speed. This technology will impact lives by advancing prosthetics and robotics technology.

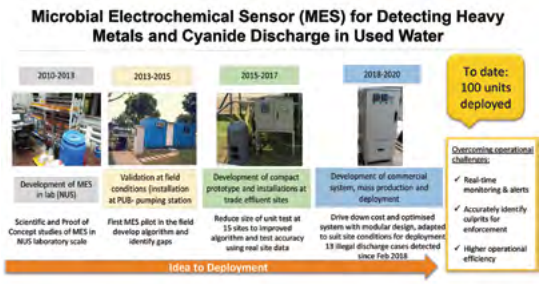
CATEGORY: APPLIED RESEARCH AND DEVELOPMENT





Small-Scale Wireless Bioelectronics for Remote-controlled Phototherapy by NUS Engineering

Current phototherapy is limited to treating diseases near the body surface due to the low penetration of light through biological tissues. Professor Zhang Yong and Dr John Ho from NUS have developed a way to wirelessly deliver light into deep regions of the body to activate light-sensitive drugs for photodynamic therapy. This approach provides significant advantages for treating diseases using light in previously inaccessible regions of the body, which may lead to more effective ways to treat cancer and other diseases.

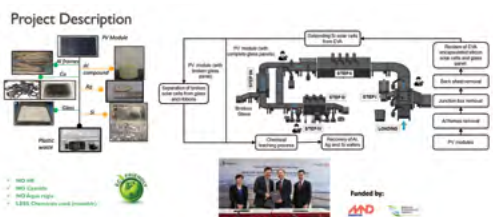


Microbial Electrochemical Sensor (MES) for Detecting Heavy Metals and Cyanide Discharge in Used Water by PUB

Pollutants such as heavy metals and cyanide are tightly regulated in Singapore, as these can affect the downstream biological treatment processes in our water reclamation plants. PUB's monitoring approach comprises routine sampling as well as ad-hoc inspections to ensure that any discharge complies with regulations.

In this R&D project, the team developed a real-time toxicity sensor for heavy metals and cyanide through a rigorous process of scientific testing in the laboratory, field trials, and eventually development of a compact system the size of a mini-fridge.

Today, the MES system has been deployed in 100 industrial sites in Singapore as part of the continuous water toxicity monitoring regime in PUB.



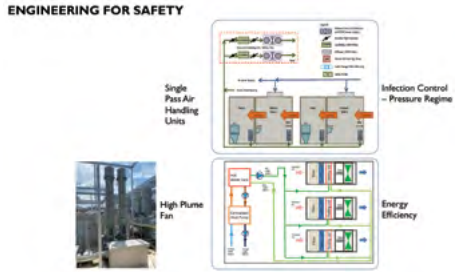
Development of End-to-end Pilot Scale Recycling Process for Recovery of All Materials from Full-size Discarded Photovoltaic Modules by Singapore Polytechnic

Currently, majority of the end-of-life or defective modules end up in landfills, posing potential danger to the environment due to the leaching of toxic heavy metals (such as lead and silver) into ground water.

The team has successfully developed a patented technology for recovering all the valuable materials from crystalline silicon PV modules with green chemistry. Having been demonstrated in the laboratory with full sized commercial modules measuring 1.7 m x 1 m, the solution is ready to move beyond the laboratory, and into pilot testing with funding support from the Ministry of National Development and the National Environment Agency.

CATEGORY: ENGINEERING PROJECTS

From Left:
Soh Meng Tiong — Senior Vice President, M&E Division
Patrick Lam — Senior Consultant
Lui Chong On — Senior Principal Engineer
Peter Chong — Principal Engineer



National Centre for Infectious Diseases, Singapore by CPG Consultants

The National Center for Infectious Diseases (NCID) is a purpose built healthcare facility to handle infectious outbreak. The building services design is challenging as an isolation facility and also meeting the prevailing Green Mark standard. To handle air borne infections, single pass air-conditioning is provided to avoid contamination within the facility and also to the occupants in the neighbourhood.

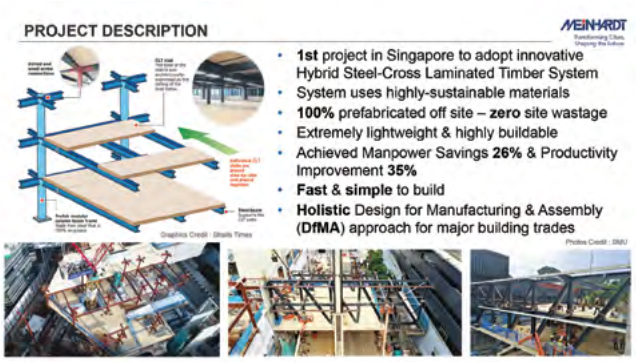
Hunter Armoured Fighting Vehicle by Defence Science and Technology Agency (DSTA), Singapore Army and ST Engineering

The Hunter Armoured Fighting Vehicle (AFV), locally designed and developed by DSTA with the Singapore Army and ST Engineering, is the Army's first fully-digitalised fighting platform. It is the most advanced AFV in its weight class and provides Singapore's armoured forces with greater firepower, survivability, mobility, and networked warfighting capabilities, while enabling a four-fold increase in area of influence and requiring less manpower to operate. In the pursuit of these objectives, the team introduced many first-of-its kind innovations and spearheaded new design paradigms, while transforming the Army's processes and the local defence industry.

T226 of Thomson East Coast Line, Marina Bay Station by Kiso-Jiban Singapore

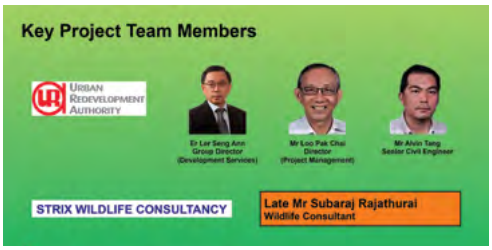
Project T226 of Thomson East Coast Line, Marina Bay Station, will create an enormous benefit of connectivity for the public, by integrating three MRT lines. In addition to the presence of existing MRT structures and the need to maintain train services, this complex engineering project posed tremendous challenges to engineers as the site is located on reclaimed land and the new tunnels are deep, up to 40m below ground. The team successfully implemented innovative solutions like Horizontal Jet Grouting, purpose-built Rectangular Shield Machine and Ground Freezing which is the first to be used for a rail project in Singapore that is also environmentally friendly.

CATEGORY: ENGINEERING PROJECTS



Singapore Management University Connexion by Meinhardt Singapore

The fast track project optimised the principles of Design for Manufacturing and Assembly (DfMA) for Civil & Structural, Mechanical & Electrical and architectural facade work, resulting in substantial improvement in manpower productivity and enabling timely completion. The primary structural solution adopted an innovative hybrid steel-cross laminated timber floor system that advocates 100 per cent fabrication off-site, is highly buildable, sustainable and new in the local built environment. The extensive use of pre-fabrication for the M&E systems and facade further enhanced construction productivity and safety on-site.



Largest Wildlife Shepherding in Singapore Using Innovative Engineering Solutions by Samwoh Corporation

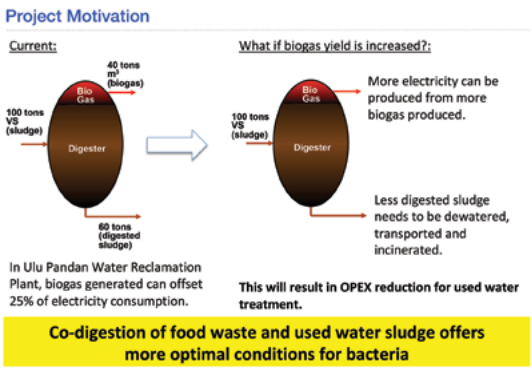
In 2016, Urban Redevelopment Authority (URA) collaborated with Samwoh to conduct land preparation work of a 300,000 m² secondary forest in the vicinity of Yio Chu Kang and Lentor Drive. Knowing that it was the natural habitat of the wildlife, the project team put in due care and consideration of the animals' safety and wellbeing.

The deployment of numerous innovative engineering solutions, meticulous planning and systematic execution of the project team contributed to the successful execution of the largest wildlife shepherding initiative in Singapore with no animals being harmed over this 11-month operation. In the process, two endangered Sunda pangolins were handed over to the Singapore Zoological Gardens and some animals were released safely to the neighbouring habitats.

CATEGORY: TECHNOLOGY INNOVATION

Recycling Various Wastes into High-Valued Engineering Aerogel Materials by NUS Engineering

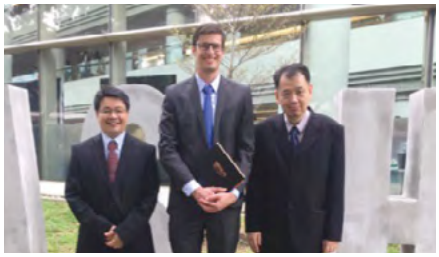
Aerogels from various wastes can be produced continuously and 18 times faster than current methods. Aerogels can be reused and recycled. During manufacturing, no toxic solvent is used; much less energy is being consumed; and no toxic waste is disposed into the environment. Manufacturing cost can be 10 times less than current methods.

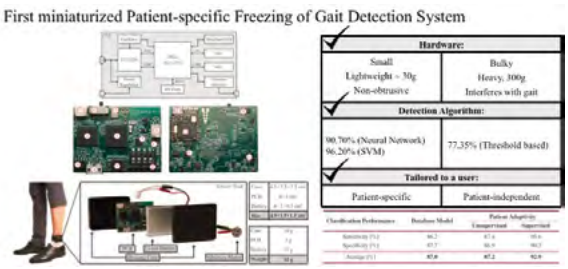


Co-digestion Technology of Food Waste and Used Water Sludge to Enhance Biogas Production by PUB

This project conducted by PUB, in collaboration with NEA, EDB and Anaergia Singapore, aimed to harness the synergistic effect of co-digesting food waste and used water sludge to increase biogas production and decrease amount of sludge to be dewatered in PUB's Water Reclamation Plants. This provides the opportunity for the Water Reclamation Plants to generate enough electricity for process usage, and can potentially allow them to achieve energy self-sufficiency. Through this demonstration, the team validated the synergistic effect of co-digesting food waste and used water sludge in the Singapore context, and will implement this in the upcoming Tuas NEXUS project.

CATEGORY: YOUNG CREATORS





A Wearable, Patient-Adaptive Freezing of Gait Detection System with Biofeedback Cueing for Parkinson's Disease Patients by NUS Engineering

Freezing of Gait (FoG) is a common motor-related impairment among Parkinson's disease patients, which substantially reduces their quality of life and puts them at risk of falls. In this work, a wearable patient-specific FoG detection system is developed to provide timely biofeedback cues and hence help them regain control over their gait. To achieve such an integration, features with low computational load are selected and dedicated hardware is designed that limits area and memory utilisation. In addition, the system is capable of learning in real time and thus allows the system to adapt to a patient during run-time.

Air Leakage Vacuum-Assisted Detection System without Aircraft Cabin Pressurisation by Republic Polytechnic

This project focuses on the design and development of a vacuum-assisted air leakage detection system that is capable of detecting air leaks around doors, windows and access panels of cabins without air pressurisation. Apart from the new Reusable Flexible Vacuum Blanket with Seal, four innovative methods including Particle Velocity, Infrared Thermography, Ultrasound and Smoke Streamlines have been designed and validated in a demonstration aircraft cabin. These newly-developed methods can greatly benefit the aviation industry and aircraft maintenance centres, as well as other industries (e.g., transportation, shipyard and buildings) by providing more effective and time-saving air leakage detection on windows and doors of trains, buses, ships, and buildings.

Interweave by Singapore Polytechnic and NUS Architecture

The Interweave aims to disrupt the construction of new buildings in Singapore by utilising the Continuous Multi-Objective Computational Approach for a more environmentally and socially sustainable future. The team formulated a leading-edge Multi-Objective Continuous Computational Workflow approach that uses readily available or self-sourced datasets with various software to automatically iterate, compare and decide on the best approach between various disciplines, namely Civil, Mechanical, Electrical and Plumbing, and Architecture, not only enabling more environmentally friendly buildings in the future, but also providing an industry of professionals an environment to work in an interdisciplinary system. The Interweave plans to set a precedence of buildings that engages the community, yet is commercially-viable and functional, with businesses and offices beneficial to one another, for instance, in technology trials, or material production.

PUB TESTS NEW PORTABLE FLOOD BARRIER

FOR USE IN THE MONSOON SEASON

The modular nature of the product enables easy installation at driveways and entrances of residential, commercial and industrial premises.

PUB, Singapore's National Water Agency, is adding a new flood protection device, Floodgate, to its suite of flood barriers that can be deployed quickly to protect homes and buildings in the event of flash floods, caused by heavy rainstorms during the monsoon season.

Floodgate is made from high-strength steel frames, wrapped in a waterproof rubber sleeve.

The side panels of the Floodgate barriers can be extended with a wrench to achieve a watertight seal against the doorway. They are available in different sizes to suit apertures with widths ranging from 770 mm to 1520 mm, and weigh between 13 kg to 21 kg, depending on their size.

Designed to hold back floodwaters as high as 680 mm, each Floodgate can be deployed by one person within minutes and packed away easily when not in use. Floodgates can be used for wider openings such as the entrances of shopfronts, as units can be linked together to create longer sections.

In September 2020, PUB purchased 20 pieces of Floodgates from UK-based Floodgate Limited, for performance testing and validation, with 15 pieces currently on loan to residents at Upper Paya Lebar Road for the monsoon season.

A range of flood protection systems

In 2019, PUB introduced the use of portable flood protection devices such as Dam Easy Flood Panels (DFPs) and Portable Flood Barriers (PFBs), to enhance the nation's flood response capabilities, and also loaned them out to homes and shophouses in flood-prone and low-lying areas.

As at end-December 2020, 65 pieces of DFPs and 155 pieces of PFBs had been loaned out. Users generally found it easy to install them and were assured of the protection they offered during heavy downpours.

More intense rainfall events observed

The wet phase of the Northeast Monsoon in the region typically brings about heavy rainstorms more frequently. Flash floods may occur if the rainstorms temporarily overwhelm the capacity of the drainage system, especially in low-lying areas that are more prone to flooding.

The list of flood-prone areas in Singapore can be found at www.pub.gov.sg/drainage/floodmanagement.

In 2020, there were seven days when flash floods occurred at various locations in Singapore due to very intense rainfall within a short period of time.

The most recent flash flood event, in 2020, occurred on 7 November, when heavy rain overwhelmed the roadside drains along Aljunied Road, causing runoff to accumulate on the road for about 20 minutes.

According to the Meteorological Service Singapore, the highest daily total rainfall recorded that day was 100.2 mm at Tanjong Katong. This was the second highest total rainfall recorded in a day for the first half of November 2020.

Mr Yeo Keng Soon, PUB's Director of Catchment & Waterways Department, said, "PUB has made significant progress in improving the drainage system over the past 50 years, which greatly reduced the size of flood-prone areas in Singapore, from 3,200 hectares in the 1970s to 28 hectares today. Flash floods, these days, are more localised and typically subside within 30 minutes. However, we are also seeing more frequent rainfall events that are not just bringing increased rainwater but also more intense storms. With climate change, we must be prepared to deal with, and enhance community resilience to, flash flood occurrences, as it is not always possible to widen or deepen our drains to eliminate floods".

"PUB is constantly looking out for new solutions and devices to better enable residents and businesses to respond to flash floods and minimise potential damage to their premises. In the past, we used heavy and bulky one-time-use sandbags against floodwaters. Now, modern flood protection barriers such as Floodgates and Dam Easy Flood Panels can be quickly deployed by residents and shop owners themselves, when there is the possibility of flooding", he added.

Flood monitoring and stakeholder engagement for the monsoon season

Temporary flood barriers are just one of the measures to better protect residents and businesses. PUB also uses an array of digital technologies and products, such as an extensive network of CCTV cameras, online water level sensors in drains and radar systems, to carry out round-the-clock weather monitoring, so as to enable quicker response to the needs of flood risk areas.

PUB's Quick Response Team (QRT) is also on standby, ready to proceed to areas where flash floods may potentially occur.

In addition, PUB actively engages relevant stakeholders to adopt suitable flood protection measures and reminds

them of the need to keep the drainage system clean and free-flowing. For example, PUB officers go door-to-door to issue flood advisories to residents and educate them on what they can do to protect themselves and their homes when a flash flood occurs. PUB also works closely with public agencies and Town Councils to step up the maintenance and cleansing of public drains and vertical drain gratings, so that stormwater can be conveyed away quickly in case of heavy rainfall.

Throughout the year, PUB officers also conduct routine inspections at construction sites with major drainage works, at least twice a month, to ensure that proper earth control measures and drainage measures are carried out, and that the drains are free from obstruction.

In 2020, PUB inspected 27 such construction sites. During the monsoon season, PUB will also step up its checks at other construction sites around the island. PUB completed checks for 77 such construction sites. Action will be taken against contractors that cause interference with the drainage systems in and around their construction sites.

FEATURES OF THE FLOOD PROTECTION DEVICES

Floodgate

The Floodgate barrier consists of a 25 mm thick steel frame, wrapped in a waterproof 7 mm thick rubber sleeve, that can be installed at doorways or entrances to protect premises from floodwaters. It is able to expand horizontally and vertically, creating a waterproof seal against the doorway. It is also extendable, with the addition of extra units, to help protect wider entrances.

Dam Easy Flood Panel

The Dam Easy Flood Panel (DFP) is an extendable panel with an inflatable seal that provides temporary flood protection for doorways. Each DFP is 0.6 m high and weighs about 20 kg. The panel is reusable and can be adjusted to fit securely within the door reveal ranging from 0.78 m to 1.10 m.

The flood panel allows for quick and simple installation without tools and, unlike conventional door barriers, does away with unsightly fixings that damage doorways. To install, the panel is positioned across the doorway and a lever is used to extend the side panels until it touches the doorframe. A pump is then activated to inflate a watertight seal around the panel.

Portable Flood Barrier

The Portable Flood Barrier (PFB) is a self-anchoring flood barrier which, when installed, creates a 0.5 m high dam that helps divert or contain floodwaters away from an area. It is lightweight and is designed for use on firm surfaces such as roads and pavements.

Each set of PFBs consists of 10 sections (each weighing about 3.4 kg). Due to its modular nature, it can be set up quickly via a coupling and locking mechanism, to protect buildings and key installations from water damage and to keep roads open. A complete set of PFBs extends to

The Floodgate barrier can be installed at doorways or entrances to protect premises from floodwaters.

The Floodgate barrier is placed between the doorway and the jack is expanded by using a ratchet wrench, to lock in the barrier horizontally (images on top). The wrench is then used to tighten the four bolts at the bottom, to lock in the barrier vertically (image below). After the flood has receded, the four bolts at the bottom are loosened and the jack is compressed to remove the Floodgate barrier from the doorway. Images: Floodgate Limited.

about 6 m in length. No tools are needed for installation and, when not required, the sections can be stacked up, to minimise storage space and for ease of transportation.

Inflatable Flood Bags

Inflatable flood bags are compact and lightweight alternatives to traditional sandbags. These sand-less bags are semi-porous and filled with biodegradable polymer crystals which inflate within minutes, upon contact with water. Inflatable flood bags are easy to move and can be stored away easily. It can absorb up to approximately 23 kg of water. Upon inflation, residents can arrange and stack them up to form as a barrier and reduce the flow of floodwaters into their properties.

All images by PUB, Singapore's National Water Agency, unless otherwise stated.

The Dam Easy Flood Panel (DFP) is an extendable panel that provides temporary flood protection for doorways.

The Portable Flood Barrier (PFB) is self-anchoring and can be used on firm surfaces such as roads and pavements.

An Inflatable Flood Bag before installation (left) and after absorbing water (right).

TRIALS OF AUTONOMOUS

ROAD CLEANING VEHICLES COMMENCE

Future deployment of the technology will pave the way for an innovative and transformed environmental services industry.

The National Environment Agency (NEA) has launched proof-of-concept (POC) trials of two Autonomous Environmental Service Vehicles (AESVs) for road cleaning. The trials, which will run until July 2021, will be conducted in designated small-scale testbed environments at one-north, Nanyang Technological University, and CleanTech Park at Jurong Innovation District. The projects are part of NEA's Environmental Robotics Programme and are in line with NEA's continual efforts to better optimise resources, drive innovation, push technology adoption, and improve productivity across the Environmental Services (ES) industry.

The Environmental Robotics Programme was launched by NEA in December 2017 as part of the National Robotics R&D Programme. It focuses on the development of robotics solutions to achieve the following:

- Enable productivity gains.
- Enable a sustainable manpower stream.
- Enhance current capabilities and enable new ones.

The POC trials follow the award of Research & Development (R&D) projects for the design, development and trial of AESVs for road cleaning by NEA and Ministry of Transport (MOT), in March 2019, to two consortia:

- Nanyang Technological University / Enway Pte Ltd / SembWaste Pte Ltd / Wong Fong Engineering Works (1988) Pte Ltd.
- ST Engineering / 800 Super Waste Management Pte Ltd.

The AESVs have been modified from existing mechanical sweepers with multiple sensors on all sides of the vehicles and computing units in the cabin.

They have been developed with support from the National Robotics Programme (NRP) and various public agencies.

The NRP is a national level programme that nurtures the robotics ecosystem in Singapore through funding research and development, to enhance the readiness of robotics technologies and solutions. Key considerations for NRP's R&D investments include potential for impactful applications in the public sector and potential to create differentiated capabilities for the industry.

The POC trials of the AESVs will be conducted in a progressive manner, starting with off-peak timings (i.e. weekends and evenings). Both AESV units have undergone rigorous safety assessments by the Land Transport Authority and have been approved for public road trials in small-scale testbed environments.

In line with the safety framework for autonomous vehicle (AV) trials, the AESVs are required to have a safety driver on board at all times, who is trained to take immediate control of the vehicle when needed, in accordance with strict operational protocols. The operation of each AESV will be monitored in real-time from a command centre, by an off-site operator cum cleaning professional, who can deploy the AESVs on different cleaning routes based on cleaning needs.

For easy identification by other road users and in line with the AV safety framework, all AESV test vehicles will display prominent decals and markings.

The application of AV technology to mechanical road sweepers will enable service providers to adopt more innovative technologies to raise the standards, productivity and professionalism of the ES industry. It will help foster an innovative ES industry equipped with a skilled and future-ready workforce, and create a more sustainable manpower stream by making these jobs more attractive to locals. The successful completion of the POC trials will pave the way for the pilot deployment of AESVs for road cleaning in the early 2020s.

Mr Patrick Pang, Chief Technology Officer of NEA, said, "The commencement of the Autonomous Environmental Service Vehicles road trials marks a key milestone in its R&D journey, which aims to augment manpower in the Environmental Services industry, particularly the cleaning sector. Such R&D work had started in 2019, bringing together academics and companies from various industries such as robotics, transportation, and environmental services, to jointly develop these vehicles. Successful trials will pave the way for downstream commercialisation and operationalisation. We look forward to greater innovations by the industry and together, we can push the frontiers of environmental technologies and solutions, and build a vibrant and sustainable Environmental Services industry".

Mr Daryl Yeo, Director (Futures & Transformation) of MOT, said, "The pilot deployment of AESVs will help shift cleaning activities to off-peak hours such as late night hours and reduce road congestion. This demonstrates the strong potential of autonomous systems to make our transport network more efficient and future-ready".

AESV DEVELOPED BY NTU-ENWAY-SEMBCORP-WONG FONG CONSORTIUM

Ranked amongst the world's top universities by QS, NTU Singapore has been named the world's top young university for the past seven years. Under the NTU Smart Campus vision, the university harnesses the power of digital technology and tech-enabled solutions to support better learning and living experiences, the discovery of new knowledge, and the sustainability of resources.

Principal Investigator Professor Wang Danwei from the School of Electrical and Electronic Engineering leads this AESV project which includes the development of novel technologies for off-site operations and robot cyber security solutions. Prof Wang is an expert on multi-modal sensing, perception, and autonomy of unmanned systems in unstructured environments.

Enway is a developer of autonomous software for heavy duty vehicles, focusing initially on the cleaning industry, with its Blitz class autonomous industrial sweeper launched in September 2019. Enway combines know-how in engineering, robotics, machine learning, computer vision and artificial intelligence with operational expertise that is unique in the professional cleaning industry. As Co-Principal Investigator, Enway is developing the AESV's navigation system and autonomous road sweeping functionality.

SembWaste is the waste management and recycling arm of Sembcorp Industries, a focused energy and urban development company offering sustainable solutions. A leading environmental services company, SembWaste provides waste management, public cleaning and recycling services, and is the operational partner for the public trials of the AESVs.

Wong Fong is a trusted provider of land transportation engineering solutions and systems. For this project, the company developed and manufactured the AESV's field infrastructure including the docking station and waste compactor for autonomous dumping.

Product features

The AESV makes street sweeping sustainable and efficient in the following ways:

- Zero carbon emission, less noise: The AESV is fully electric and has lower ambient noise output compared to conventional sweepers.
- Improves productivity:
  - Operations can be shifted to late nights/early mornings, avoiding rush hours and optimising road usage.
  - The system allows for dynamic route planning and remote operation to ensure the AESV can handle all situations it encounters.
- Precise cleaning: The ability to autonomously sweep along the kerb facilitates effective cleaning of heavy debris areas.
- Safety: The AESV is cybersecure, to guard against malicious attacks on its sensors and actuation systems.
- Tested on the NTU Smart Campus: A living testbed for innovative digital and tech-enabled solutions, the NTU Smart Campus is home to the Centre of Excellence for Testing & Research of Autonomous Vehicles - NTU (CETRAN), where public road trials for the AESV will be conducted in small-scale testbed environments.

The AESV developed by the NTU-Enway-Sembcorp-Wong Fong Consortium.

Product specifications

- 8 hours sweeping range and 2.5 hours charge time.
- Equipped with 3D LiDAR sensors and cameras for localisation, kerb following and traffic navigation.
- Sweeping speed of up to 12 km/hr.
- Vacuum-based debris collection system.
- Autonomous docking and hopper emptying.
- Remote monitoring and route planning.
- Cyber security functions.

AESV DEVELOPED BY ST ENGINEERING-800 SUPER CONSORTIUM

ST Engineering is a global technology, defence and engineering group with offices across Asia, Europe, the Middle East and the US, serving customers in more than 100 countries. The group uses technology and innovation to solve real-world problems and improve lives through its diverse portfolio of businesses across the aerospace, smart city, defence and public security segments.

ST Engineering has an established track record in autonomous systems development and deployment across diverse industry applications in Singapore and overseas.

The AESV system is developed by its Logistics Automation business which specialises in developing robotics and autonomous systems that enhance the efficiency and reliability of the transport, logistics, manufacturing, healthcare and hospitality industries.

800 Super is an established home-grown environmental services provider for the public and private sectors in Singapore. With a broad range of environmental solutions ranging from waste management and treatment, and cleaning and conservancy services, to horticulture and landscaping services, 800 Super has been a front-runner in the environmental services industry, since 1986. In 2019, the company further elevated its capabilities, to include cogeneration of renewable energy, and is the first and only carbon-neutral industrial laundry and steam heating facility in Singapore. 800 Super has since commissioned and operates a self-sustaining integrated energy and resource recovery facility that houses a biomass plant, sludge treatment plant, industrial laundry plant, animal feed processing and a third-party ISO tank container steam heating facility.

Designed and developed by ST Engineering in collaboration with 800 Super, the AESV performs pre-defined road cleaning operations, moving from one designated location to another. It uses a commercial Dulevo 6000 Series sweeper vehicle platform integrated with a Drive-By-Wire system and autonomous navigation capabilities based on LiDAR technology.

Product features

- Environment-friendliness:
  - The ability to completely eliminate fine particles compared to normal sweepers while saving up to 60% of water usage.
  - A unique mechanical filtering and suction system guarantees the total elimination of PM10 fine particles.
- Precise navigation and cleaning: Effective kerb detection capabilities allow the AESV to autonomously sweep along the kerb, allowing for highly effective cleaning.
- Safety: The platform is fitted with a suite of sensors, that provides all-round obstacle detection, thereby allowing the AESV to sense its environment to navigate safely during sweeping operations and when on the move. The AESV's speed is automatically adjusted, to maintain a safe distance between itself and external objects. Should an object enter its collision zone, the emergency brake will be activated to bring the AESV to a safe stop.
- Completed scenario-based public road trials in one-north under light traffic conditions. A series of scenario-based tests were also conducted in a controlled circuit environment at CETRAN before progressing to public road trials.

Product specifications

- Operating speeds:
  - Manual mode: 40 km/h
  - Autonomous mode: up to 15 km/h
  - With sweeping mode: 10 km/h
- Equipped with a Global Positioning System (GPS), 3D LiDAR sensors and front and rear cameras, for localisation, kerb following and traffic navigation.
- Localisation accuracy up to 5 cm.
- Stopping distance within 6 m based on the prevailing speed.

The AESV developed by the ST Eng-800 Super Consortium.

- Three emergency stop buttons, located at the rear left and right of the AESV, and next to the driver's seat in the cabin.
- Autonomous cleaning function facilitated by left, right and centre brushes with water jets.
- 6000-litre waste container capacity and the ability to operate in all locations including public roads.
- Unique mechanical suction filter system that enables the absorption of fine particulate matter of PM10/ PM5/PM2.5/PM1 size.

TRANSFORMING CLEANING OPERATIONS THROUGH INNOVATION AND TECHNOLOGY

NEA has been working with industry partners to transform the ES industry through various initiatives. This includes implementing the use of innovative technological tools that alleviate the manual workload of cleaners and increase their productivity. NEA also adopts outcome-based contracts. This places greater emphasis on the use of technology and automation when selecting service providers for awarding of cleaning contracts.

Outcome-based contracting, where a service buyer prescribes performance outcomes instead of headcount requirements, is an important contract mechanism to ensure that there is continuous strong interest among service providers to innovate and adopt new technologies.

Thus far, NEA's cleaning service providers have implemented the application of pavement sweepers for cleaning parks and pavements, mechanical sweepers for the cleaning of roads, and specialised truck-mounted machines that desilt and flush underground drain pipes.

NEA will continue to work with key stakeholders, including service buyers, to push for wider adoption of outcome-based contracting to improve productivity in the cleaning sector. This, in turn will spur service providers to invest and propose the use of technology and innovative solutions, as well as enhance processes that can improve productivity to meet the desired cleaning outcomes.

Successful implementation of cleaning equipment

The current range of cleaning equipment that NEA uses is operated by trained machine operators who have undergone training in the operation and safe handling of the machines. The cleaners' jobs have been redesigned in the process and made easier, safer and smarter, as they take on higher value-added tasks such as operating mechanised equipment. Cleaners also undergo upskilling to strengthen competencies to take on the redesigned job roles effectively.

All mechanical sweeper vehicles are equipped with a Cleanliness Performance Monitoring System (comprising GPS tracking system, cameras and sensors), which enables NEA officers to track the routes taken by the vehicles, and to monitor their cleaning performance by tracking the various cleaning functions of the vehicle.

With these devices installed, officers would be able to determine whether the vehicle is travelling at the right speed for optimal sweeping, or whether the broom and water sprayers are switched on during cleaning hours, or whether the vehicle is at the right place.

If any of the cleaning thresholds have been breached, the system will generate alerts so that officers can immediately request for the necessary rectifications from the cleaning service providers. The system also transmits video images in real-time, which will help to monitor the cleaning performance of these vehicles.

Normal road sweeper.

Specialised trucks are used to desilt and flush underground drain pipes.

The images were taken before the outbreak of COVID-19.

RECOGNITION

FOR EXCELLENCE

A total of 35 HDB Design, Construction and Engineering Awards have been presented this year to architectural and engineering consultants as well as building contractors, for projects which have demonstrated excellent design, engineering and construction. This is the largest number of awards given out since the inception of the HDB Awards in 2008.

PUSHING BOUNDARIES IN DESIGN EXCELLENCE

In 2020, 17 projects won the HDB Design Awards - the highest number of winning projects to-date in this category.

"The high number of HDB Awards given out this year affirms the high standards of our industry partners and the important role they play in helping HDB provide a quality living environment for residents. Our architectural and engineering consultants have displayed excellent consideration of site context and produced well-thought-out, attractive and creative designs, while our building contractors have innovatively overcome constraints and displayed high construction productivity and efficiency. We commend and congratulate them on their achievements", said Dr Cheong Koon Hean, Chief Executive Officer, HDB.

St George's Towers - an urban sanctuary

Among the award-winning projects, St George's Towers by LOOK Architects Pte Ltd stands out with its distinctive architectural features amidst surrounding lower-rise developments in the mature estate of Kallang / Whampoa.

Its eye-catching facade makes use of varied precast facade components with different window alignments that are repeated every six storeys. This, coupled with the painting of different building panels in varying colours, creates a dynamic rhythm and visual interest that add to the distinctive design of the development. Each of the three towering blocks has a sky terrace on the 24th storey, for a sense of openness, and residents can enjoy the fitness equipment and benches that have been provided, while taking in breathtaking views of the city as well as the Whampoa River.

St George's Towers, which is integrated with a Senior Activity Centre, comes with abundant communal spaces such as a central green, roof garden at the Multi-Storey Car Park, and rain gardens with seating areas lined along the waterfront to maximise views along the Kallang Whampoa Park Connector, providing plenty of opportunities for the community to gather and interact in a tranquil environment.

Heritage elements were thoughtfully woven into the development, that reflect the history of the area which used to be a swampland. Residents are welcomed at the porch by the first of a series of murals, which

With its towering blocks and unique design, St George's Towers creates an impressive facade along the waterfront. Image: LOOK Architects.

Residents can enjoy the myriad of communal spaces at St George's Towers. Image: LOOK Architects.

introduces some interesting facets of the history of Kallang / Whampoa. For instance, there are murals with images of brick kilns and sawmills that were a common sight in the past. The sand and soil along Kallang River were previously used for brickmaking in the brick kilns, while logs from nearby countries were transported to the sawmills to be shaved into planks and sheets. Along the sheltered walkway designed as a heritage walk, there are more murals, as well as precinct floor markers imprinted with heritage elements. These markers include depictions of egrets - white, long-necked birds commonly found among mangroves and lotus ponds.

Rejuvenation of Hougang Town Centre

Hougang Town Centre has been renewed with a fishing village theme. Image: SQFT Architects.

Besides adding vibrancy to Hougang Town Centre, the swamp-themed playground acts as a focal point to facilitate wayfinding. Image: SQFT Architects.

Another Design Award winner, SQFT Architects Pte Ltd, gained the recognition for the upgrading of Hougang Town Centre, under HDB's Remaking our Heartland (ROH) programme. The design concept was inspired by the history of Hougang which translates to 'the back of the river', as the area at the end of Sungei Serangoon was once a freshwater swamp occupied by the Teochew community, which subsequently became a busy fishing village. The rejuvenated town centre is hence enlivened with a fishing village concept, and the area is peppered with imagery of fishing activities such as fishing boat pavilions and a swamp-themed playground with a water ripple floor design. Such elements strengthen the identity of the area and help to increase residents' sense of belonging, while providing them with an upgraded retail environment in the heartlands, to meet their daily needs.

HONOURING EXCELLENCE IN CONSTRUCTION PRODUCTIVITY

The 10 housing projects conferred the HDB Construction Awards achieved CONQUAS scores above 90, as building contractors continue to help provide quality homes for residents.

Tampines GreenView and Meadow Spring @ Yishun were among the developments which attained the CONQUAS STAR with scores above 95 for exemplifying quality workmanship and good construction processes.

Tampines GreenView

For Tampines GreenView by Ho Lee Construction Pte Ltd, the project team raised construction productivity by tapping on Virtual Design & Construction (VDC), a 3D building visualisation platform which incorporates Building Information Modelling (BIM) - an advanced 3D modelling tool. Virtual reality mock-ups that were used to map out and review design plans enabled the team to coordinate construction activities holistically. This prevented abortive work during actual construction. Ho Lee also made use of a mobile application for efficient documentation and tracking of safety and quality inspections.

The use of collaborative technological platforms raised construction productivity in the Tampines GreenView project. Image: Ho Lee Construction.

Meadow Spring @ Yishun

Another HDB Construction Award-winning project is Meadow Spring @ Yishun by BHCC Construction Pte Ltd.

Instead of building with conventional precast slabs which are of the same size, the project team utilised customised large panel precast slabs so that fewer components and rounds of installations were required. This also increased construction productivity as it reduced the need for the pouring of concrete on site as well as manual work to complete precast assembly. Additionally, with the close proximity of the site to an international school, BHCC limited the hoisting of precast components to off-peak hours and installed a device to proactively monitor the noise levels and minimise inconvenience caused. Their use of efficient construction methods and good project management efforts garnered the judges' affirmation.

Customised large panel slabs were utilised to reduce the installations required in the Meadow Spring @ Yishun project. Image: BHCC Construction.

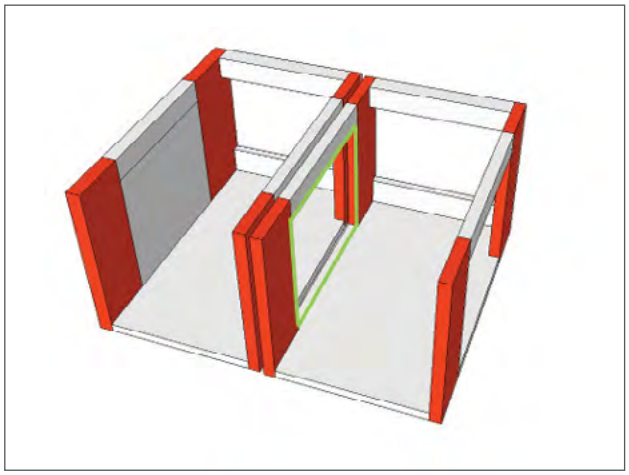
RECOGNISING ENGINEERING INNOVATION AND EXCELLENCE

This year, HDB also affirmed four consultants/contractors for engineering excellence in the development of building, infrastructure and land reclamation projects. The Engineering Award underscores the importance of innovative engineering solutions in laying the foundation for a quality, sustainable living environment.

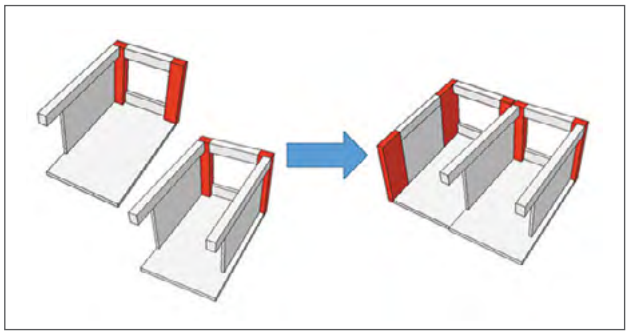
Tampines GreenGlen

For housing developments in its category, Tampines GreenGlen is the first housing project to be constructed using a new hybrid Prefabricated Prefinished Volumetric Construction (PPVC) system developed by HDB's Building & Research Institute. Conventional PPVC modules are box-shaped with columns at the four corners, resulting in double columns and double beams when put together. On the other hand, the hybrid PPVC system is based on two basic modules - one is box-shaped but with fewer columns, and the other is three-sided. The new modules are lighter and can be easily transported, lifted and installed.

The hybrid system allows for more flexibility, as the basic modules can be joined together in many ways to form different flat types. For larger flats, the three-sided module was used for the front of the living room and complemented a precast slab and precast wall for the back. Due to fewer and smaller columns and beams, homeowners have more usable space in their flats for renovation. The use of less concrete also contributes to environmental sustainability.



The assembling of conventional PPVC modules results in double columns and double beams, when the two components are put together.



Hybrid PPVC modules have fewer columns and can be put together in multiple ways.

Land reclamation works at Changi East

Another winning project that exemplifies engineering innovation is the land reclamation works at Changi East, led by HDB in consultation with various agencies and stakeholders. The contractor Hyundai Engineering and Construction Co Ltd used cutting-edge methods to overcome site constraints, including the use of high-pressure water jets to loosen the soil around angled steel piles in the seawall, and extracted the piles fully intact. Additionally, Hyundai specially fabricated a sand spreader barge to discharge sand at a controlled rate, in order to protect existing infrastructure.

The way ahead

Moving forward, HDB will continue to work closely with its industry partners to forge ahead with more innovative designs and leverage new technologies and smart solutions to create sustainable, vibrant towns and endearing homes for residents.

HDB DESIGN AWARD WINNERS

Design Award

Category	Consultant	Project	Address
Completed			
Housing	ADDP Architects LLP	Alkaff Vista	Blks 105A to 106B Upper Serangoon Road/ Bidadari Park Drive
	LOOK Architects Pte Ltd	St George's Towers	Blks 24, 25, 25A, 26A, 26B St George's Lane
Park	Surbana Jurong Consultants Pte Ltd	Common Green at Matilda Edge Park	Sumang Lane
Rejuvenation	Interconsultants Pte Ltd	Upgrading of Jurong East Town Centre	Blks 131 to 135 Jurong Gateway Road
	SQFT Architects Pte Ltd	Upgrading of Hougang Town Centre	Blks 804 to 811 Hougang Central

Innovative Design Award

Category	Consultant	Project	Address
To-Be-Built			
Housing	3PA Pte Ltd	Punggol Point Crown	Blks 435A to 438C Northshore Drive
	Building & Research Institute (HDB)	Tampines GreenGlen	Blks 662A to 663C Tampines St 64
	Design Link Architects Pte Ltd	Garden Vines @ Tengah and Garden Vale @ Tengah	Blks 228A to 238B Tengah Garden Walk, Tengah Drive
	DP Architects Pte Ltd	Plantation Village	Blks 123A to 129C Plantation Crescent / Tengah Drive
	Surbana Jurong Consultants Pte Ltd	Punggol Point Cove	Blks 441 to 448B New Punggol Road
Park	CPG Consultants Pte Ltd	Bidadari Park	Bidadari Park Drive
Rejuvenation	Kyoob Architects Pte Ltd	Upgrading of Admiralty Place	678A Woodlands Ave 6

Certificates of Merit (Design)

Category	Consultant	Project	Address
Housing	P&T Consultants Pte Ltd	Dawson Vista	Blks 78 and 79 Strathmore Ave/ Dawson Road
	Surbana Jurong Consultants Pte Ltd	Tampines GreenWeave	Blks 608 to 610C Tampines North Drive 1
Park	Surbana Jurong Consultants Pte Ltd	Park at Buangkok Square	Buangkok Crescent
To-Be-Built Housing	P&T Consultants Pte Ltd	Plantation Acres	Blks 111A to 114B Plantation Crescent
To-Be-Built Rejuvenation	CPG Consultants Pte Ltd	Upgrading of Limbang Shopping Centre	534 Choa Chu Kang St 51

HDB CONSTRUCTION AWARD WINNERS

Construction Award

Category	Contractor	Project	Address
Housing	BHCC Construction Pte Ltd	Meadow Spring @ Yishun	Yishun St 43
	Chang Hua Construction Pte Ltd	St George's Towers	Blks 24, 25, 25A, 26A, 26B St George's Lane

Construction Award

Category	Contractor	Project	Address
Housing	China Construction (South Pacific) Development Co Pte Ltd	Fengshan GreenVille	Bedok North St 4
	Chiu Teng Construction Co Pte Ltd	Alkaff Vista	Bidadari Park Drive
	Ho Lee Construction Pte Ltd	Tampines GreenView	Tampines North Drive 1
	Right Construction Pte Ltd	MacPherson Spring	Circuit Road
	Teambuild Engineering & Construction Pte Ltd	Valley Spring @ Yishun	Yishun St 42 and St 44
	Welltech Construction Pte Ltd	Bedok North Woods	Bedok North Road
Upgrading	Expand Construction Pte Ltd	Design & Build of Upgrading Projects - 22B	Blks 301 to 315, 317 to 319 Serangoon Ave 2 (HIP)
			Blks 231 to 237 Serangoon Ave 3 (HIP)
			Blk 316 Serangoon Ave 2 (LUP)
			Blk 406 Serangoon Ave 1 (LUP)
	Welltech Construction Pte Ltd	Design & Build of Upgrading Projects - 22A	Blks 223 to 230 Serangoon Ave 4 (HIP)
			Blks 101 to 108 Jalan Rajah (HIP)
			Blks 202-207, 211, 213, 214, 216, 217, 219 to 221, 224 to 226, 232, 234, Bishan St 22/23 (LUP)

Certificates of Merit (Construction)

Category	Contractor	Project	Address
Housing	BHCC Construction Pte Ltd	West Quarry @ Bukit Batok	Bukit Batok West Ave 9
	Kay Lim Construction & Trading Pte Ltd	Fernvale Woods	Sengkang West Ave
Upgrading	Kay Lim Construction & Trading Pte Ltd	Design & Build of Upgrading Projects - G20F	Blks 512 to 514, 535 to 542 Bukit Batok St 52 (HIP)
			Blks 324 to 325, 332 to 338 Clementi Ave 2/5 (HIP)
			Blks 362 to 365 Clementi Ave 2 (HIP)
	Thong Huat Brothers (Pte) Limited	Design & Build of Upgrading Projects - G25I	Blks 321 to 335 Serangoon Ave 3 (HIP)
			Blks 319 to 330 Ubi Ave 1 (HIP)

HDB ENGINEERING AWARD WINNERS

Engineering Award (Construction)

Category	Contractor	Project	Address
Completed/ Reclamation	Hyundai Engineering and Construction Co Ltd	Land reclamation at Changi East	Tanah Merah Coast Road

Innovative Engineering Award (Design)

Category	Consultant	Project	Address
To-Be-Built Housing	Building & Research Institute (HDB)	(3+2) Hybrid PPVC system at Tampines GreenGlen	Tampines St 64

Certificates of Merit (Engineering)

Category	Consultant	Project	Address
To-Be-Built Housing	LSW Consulting Engineers Pte Ltd	Punggol Point Crown	New Punggol Road, Northshore Drive
To-Be-Completed/ Infrastructure	Surbana Jurong Consultants Pte Ltd	Construction of Sentul Crescent extension and vehicular bridge over Punggol Waterway	Sentul Crescent

CONTRIBUTING TO BUILDING INFORMATION

MODELLING AND OTHER APPLICATIONS

Mr Gan Ta Loong

'The Singapore Engineer' learns about the solutions that Barco has to offer the Built Environment industry, from Mr Gan Ta Loong, Managing Director, Barco SEA and Vice President Immersive Experience, Barco APAC.

Barco is a world leader in Virtual Reality (VR) visualisation solutions.

Question: What are the solutions that Barco is offering the Built Environment industry?

Answer: The introduction of Virtual Reality (VR) in the industry has been a complete game changer, as BIM and digitalisation accelerate. VR offers a fast and inexpensive method of modelling, compared to the physical models of the past.

Barco's immersive Cave VR solutions consist of multiple projection walls, and can be customised to accommodate unique needs. Teams can be jointly immersed in the 3D experience, making it an ideal place to share experiences and facilitate collaboration among several stakeholders. The Barco Canvas solution brings VR into meeting rooms, enabling more people to experience group VR for team collaboration as well as for previewing and assessing buildings or designs before construction.

Also, technical master plans (dealing with, for example, HVAC and building materials) can continuously be simulated, evaluated, validated and improved. Projects designed in this way are not only better thought-through, but also advance a lot faster than traditional projects.

Q: How do these solutions help engineers and other professionals?

A: Building designs visualised in Barco's Cave and Canvas VR environments allow professionals an immersive and life-like environment to evaluate designs and make changes. Virtual prototyping of complete or partial designs allow teams to see the results of designs immediately and make adjustments in the early phases of a project, reducing overall costs. VR also provides an increasingly better idea of what to expect on-site, which reduces overall risk, and empowers more experimentation and new ideas.

Q: Could you briefly describe one or two actual applications of Barco's solutions?

A: At the Science Museum in Tokyo, Japan, Barco worked with a partner to upgrade the Synra Dome, which is a theatre that utilises 3D images to show views of the universe and of the sky, as seen from an observatory in America. The existing system was replaced with six Barco F35-AS3D projectors that deliver greater stability from less input and images that are more vibrant, to completely absorb the attention of audiences and bring science to life.

Belgium-based Reynaers Aluminium, a leader in developing innovative and sustainable aluminium solutions for residential, commercial, and industrial building projects, used Barco's laser projectors to create AVALON - a five-sided, immersive cave where architects, contractors, and investors could experience, discuss and fine-tune building designs.

New building designs are visualised in an immersive, five-sided Cave VR display.

Barco's Canvas VR solution enables teams to collaborate and visualise projects in 3D.

TOM! CEMENT PLANT 'TARGET OPERATING MODELS'

- MAINTENANCE 4.0 ELEMENTS

by Angus Maclean, EVP Construction & Building Materials EMEA, Proudfoot

Mr Angus Maclean

Businesses impacted by the recent global crisis have been finding innovative ways to bounce back and get ready for a new normal.

A key strategy to revitalise business and profitability is to identify ways to maximise business value.

Proudfoot, a global management consulting firm that focuses on value creation through operations and digital transformation, has just launched TOM!, the next generation Target Operating Models (TOM) for business transformation.

Proudfoot's TOM! service takes approximately 20 weeks to design, develop and implement, and optimises business operations to create maximum value.

Raw materials sourcing, production, maintenance, supply chain, outbound logistics, sales, suppliers, management processes and systems, strategy, and digital capabilities are all critical elements of a TOM.

Cement TOMs overcome the technical, operational, financial, commercial, digital, environmental and organisational challenges, that the cement industry currently faces, end-to-end, from the quarry to the client's site. TOMs allow firms to optimise, digitise and humanise.

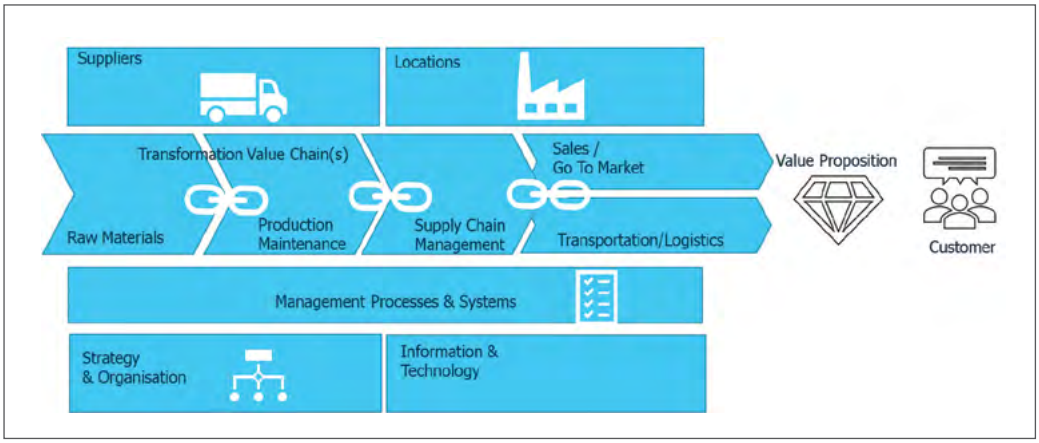


Figure 1: TOM components for an industrial firm.

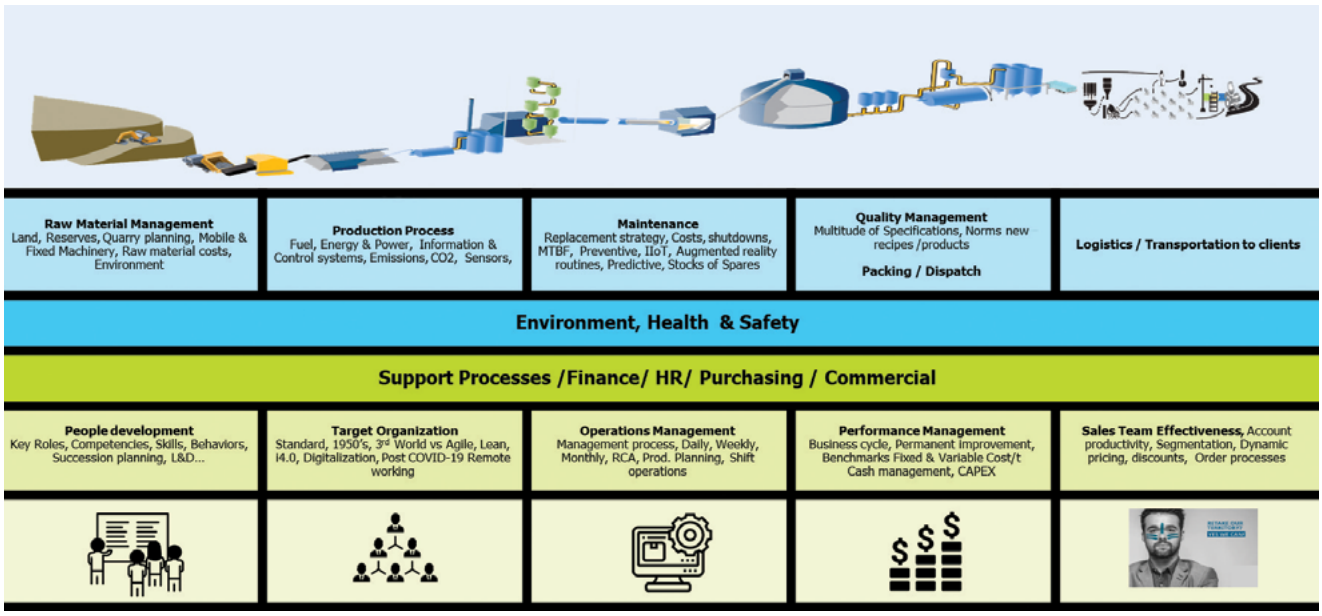


Figure 2: Visualisation of topics covered in a cement plant TOM.

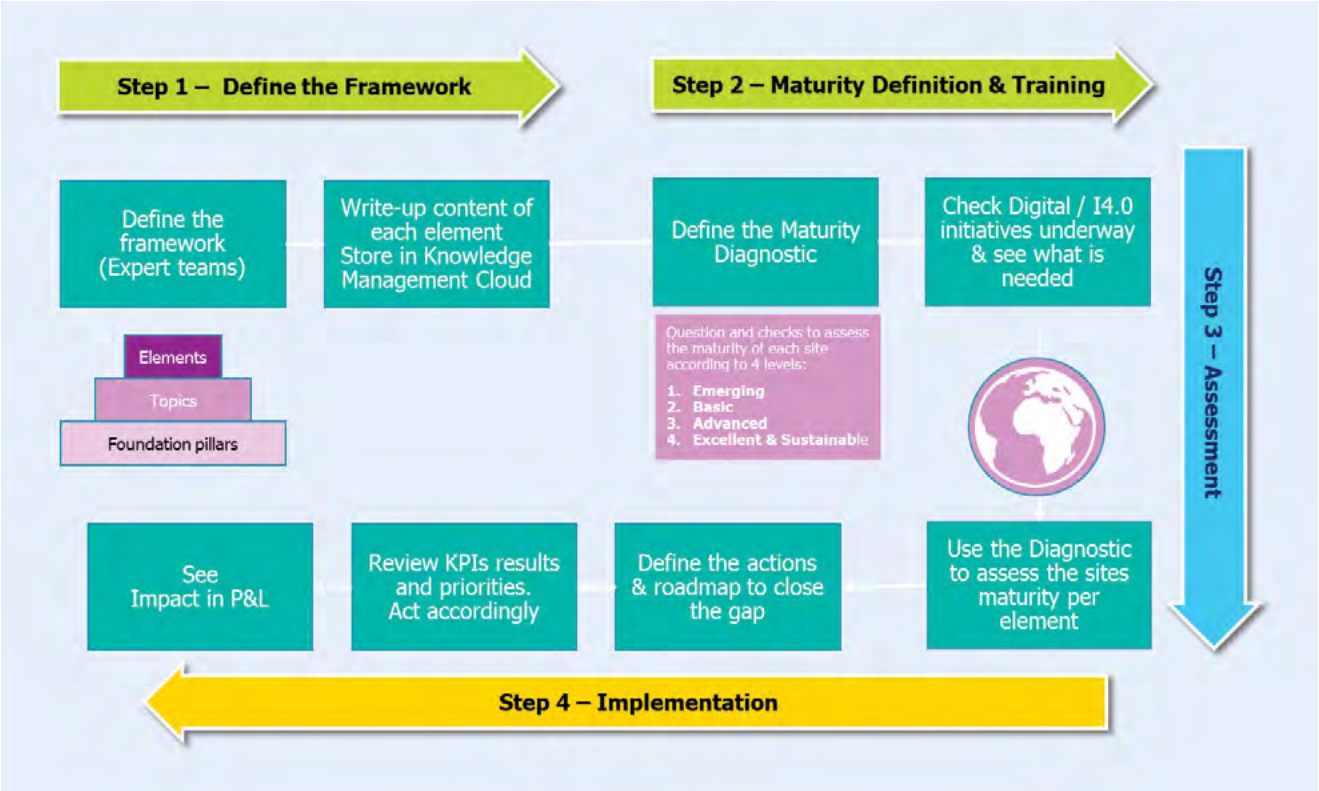


Figure 3: TOM design, development, assessment and implementation process.

TOM! OPTIMIZE: Maintenance 4.0 elements

Operating models are found in most enterprises, whether they are plant, supply chain, logistics, or commercial models. However, very few businesses have end-to-end operating models. Through digitalisation, leaders can achieve significant gains by having one global TOM model incorporating both globalisation and localisation (Glo-Cal) management elements. Another advantage of TOM! is its suitability for both new and old plants because, fortunately, technology does not impede this model.

TOM! provides visibility where firms have business continuity or resilience issues. By gaining visibility, management can see where to reduce costs and improve working capital and business forecasting.

TOM! is not a maturity assessment matrix, it is the IP and content that is stored in the cloud for each topic and element. Using the TOM! Framework, Proudfoot and client industry experts take anywhere from six to 12 weeks to determine the element content while it will only take an extra two days to develop the maturity assessment matrix for the content.

The critical steps in designing and developing the best-fit TOM! include the following:

- Defining the framework and the number of foundation pillars, topics and elements that are required. Once the framework is determined, the experts need to write up the content and the method to implement each element. This content is usually stored in KM (Key Management) clouds now, for ease of upgrading.
- Defining the maturity diagnostic and training the internal team. Questions are developed to enable the team assessing the business to assess the maturity level. Typically, there are between three to five levels of maturity. In this case we have four. They are:

  -Emerging

  -Basic

  -Advanced

  -Excellent & Sustainable

For a cement firm, once the maturity assessment matrix has been developed to assess its element content, a workshop format is used to check / assess all the digital / i4.0 initiatives that are underway and to see what is needed.

- Assessment of each of the cement businesses. Here the TOM maturity assessment is used to assess the maturity of sites.
- Implementation. The actions to improve and the road-map on how to achieve them are designed, i.e. the Transformation Program. We link them to performance KPIs to show the results, and the impact in the P&L / Balance Sheet is identified.

A cement TOM typically has four pillars:

-Operational

-Performance

-People

-Growth & Innovation

It covers 10 topics following the end-to-end process. Each topic is then broken down into multiple elements.

Initially, TOM design & development is typically done on Excel, for ease of use. As the model stabilises, we move them to cloud applications such as Concerto Analytics, a Proudfoot strategic partner, which allow simulation scenarios, multi-plant views, links to ERPs and cloud applications, and allow for live large screen or smartphone viewing.

Most often, the functions of TOM Maintenance 4.0 elements are to design, develop, implement or accelerate the new maintenance strategy and operating model, for example, to achieve the following:

- Optimise the maintenance cost per tonne.
- Increase equipment availability.
- Increase equipment reliability by raising mean time between failures (MTBF).
- Maximise the lifetime of equipment (optimal replacement CAPEX).
- Minimise spares & materials inventory value.
- Increase the 'discipline in execution'.
- Minimise external contractors and providing solutions for 'people' issues.

Figure 6 shows an example of a maintenance element, covering Reliability / RCA (Root Cause Analysis) / FMEA (Failure Mode and Effect Analysis). Probing questions are used, with an explanation on what best practice routines must be in place to reach a certain level. For the final score of the element, the lowest score is used. Each element is then linked to operational / financial KPIs and identified if it impacts the P&L or Balance Sheet.

Often our clients operate at two levels:

- Level 1 covers the key maintenance elements and is used in the overall business TOM.
- Level 2 allows the maintenance team to dive into much more detail and is often presented in the traditional maintenance pyramid format.

TOM! (TARGET OPERATING MODEL) CEMENT									
OPERATIONAL EXCELLENCE					PERFORMANCE MANAGEMENT EXCELLENCE		PEOPLE EXCELLENCE		GROWTH & INNVOVATION; COMMERCIAL EXCELLENCE
RESERVES, QUARRY OPERATIONS & RAW MATERIALS	CLINKER & CEMENT PRODUCTION, ENERGY MANAGEMENT	DISPATCH, TRANSPORTATION & LOGISTICS	QUALITY, ENVIRONMENT	ASSET MAINTENANCE 4.0 & UTILITIES	BUSINESS MANAGEMENT CYCLE; S&OP	PLANT MANAGEMENT OPERATING SYSTEM	HEALTH & SAFETY	PEOPLE, BUSINESS, ORGANISATION	GROWTH & INNOVATION; SG&A; COMMERCIAL

Figure 4: An example of a cement TOM.

Figure 5: An example of TOM 'live' on Concerto.

All our cement clients are experimenting with Maintenance 4.0 digitalisation IoT programs. Most are having trouble getting paybacks and most are having digital architecture, cloud confusion, network bandwidth and 'discipline in execution' issues.

Figure 8 illustrates some of the digitalisation initiatives we see during our projects.

How to optimise and digitalise value

There is a considerable difference between optimising and digitising, and businesses must differentiate between the two. Businesses must first start from scratch to identify and assess the numerous TOM elements and their value creation in the entire end-to-end value chain, and then prioritise the best-fit solutions - be they digital or other.

For example, suppose a Maintenance 4.0 programme, a reasonable CAPEX budget and the right digital solutions and resources do not improve sales. In that case, you should make a trade-off by investing in a sales-generating digital solution.

Similarly, we see a proliferation of cloud software from Microsoft Azure to Amazon Web Services, along the process value chains, among different teams, from

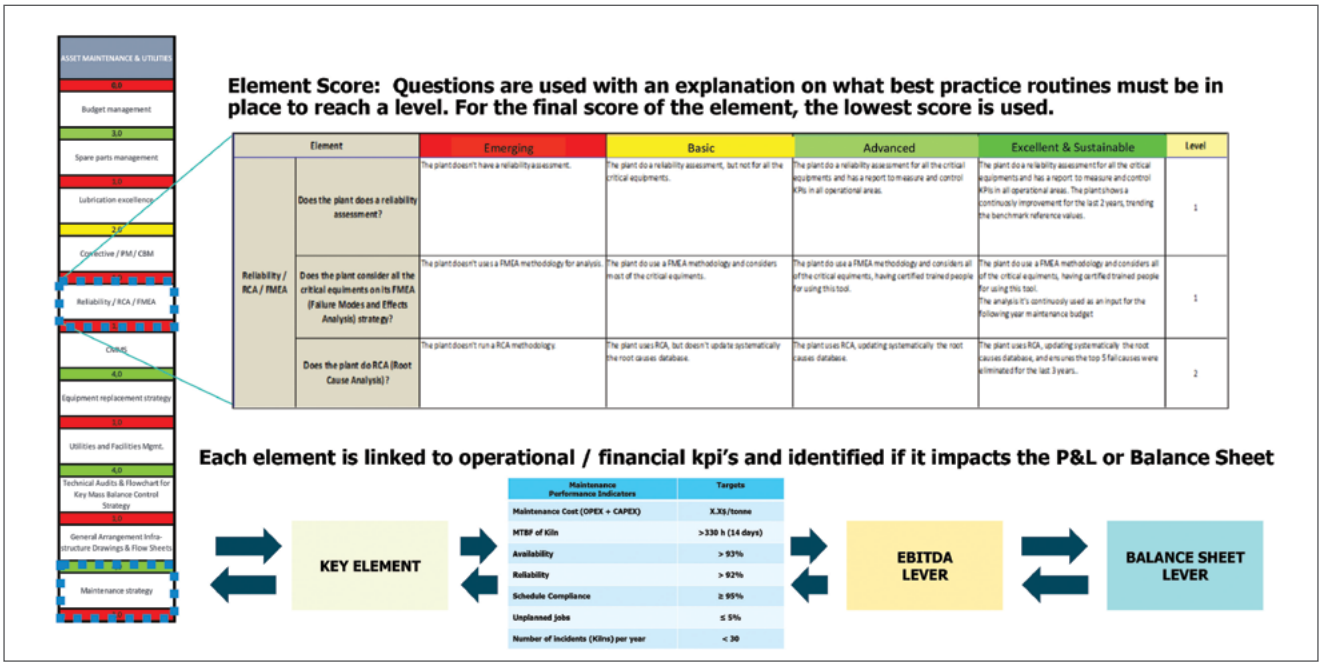


Figure 6: An example of a maintenance element, covering Reliability / RCA / FMEA.

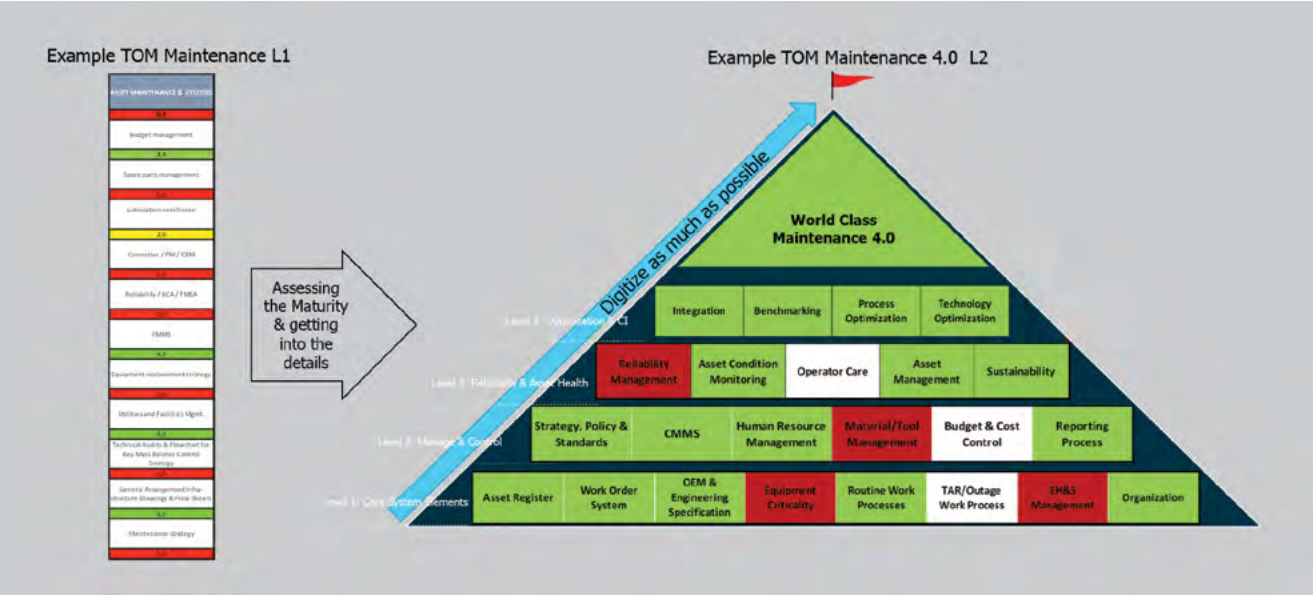


Figure 7: An example of a Level 2 Maintenance 4.0 pyramid.

programming, supply, production, third party logistics and sales. In the future, this might make data analysis complicated. Hence, after careful planning and consideration, companies must invest in the right solutions, with a robust TOM!

Businesses can then generate an improvement roadmap which helps to monetise and estimate the time-to-benefit, by mapping each initiative. Typically, we split them into four to five months, six to 12 months and one to two years, and then further into categories such as Smart Operations, Smart Assets, and Smart Workforce.

We have partnered with multiple digital and technology providers (big, medium and small) in order to be able to provide our clients with the appropriate digital solutions they need, i.e. we are IT supplier-agnostic.

A typical TOM! improvement program will generate a USD 3 to USD 5 per tonne improvement in Earnings Before Interest, Taxes, Depreciation, and Amortisation (EBITDA), thereby improving business operating performance.

Many teams have found that optimising and digitising is key to maximising value creation. Operating models are key to strategy and TOM! is easily customisable for various businesses to obtain the best value creation.

The numerical results in Figure 9 are based on the projects we have done over the last 10 years in cement plants in more than 60 countries. They are typically what we achieve during one of our projects. Some sites might achieve more and some less, as it all depends on where the base line is set. Our projects tend to include multiple plants and multiple countries as TOM! then gives multinational players a way of accelerating value creation rapidly across their entire organisation.

(More information on Proudfoot and the company's solutions may be obtained by emailing the author at amaclean@proudfoot.com).

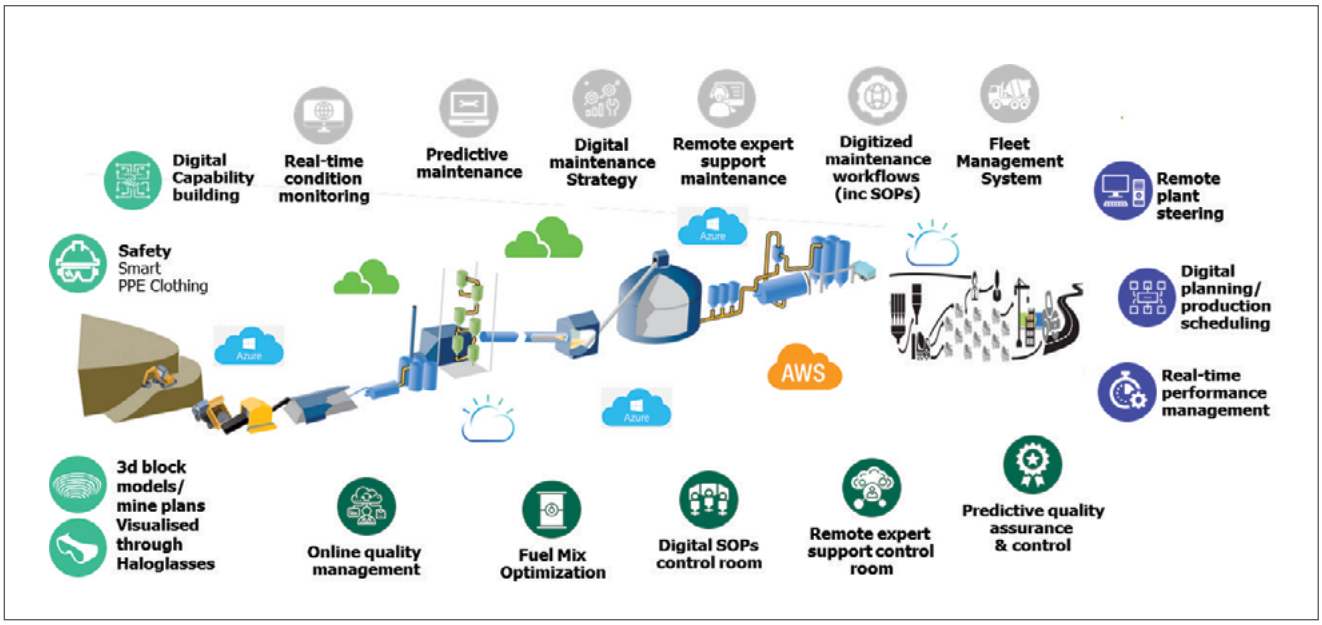


Figure 8: Maintenance 4.0 elements digitalisation initiatives.

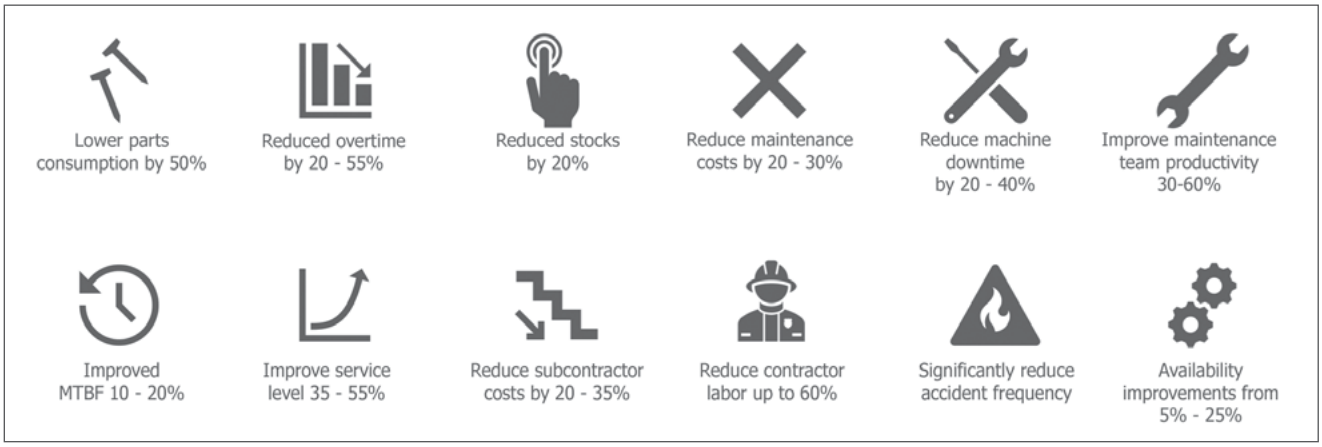


Figure 9: TOM Maintenance 4.0 - results you can expect.

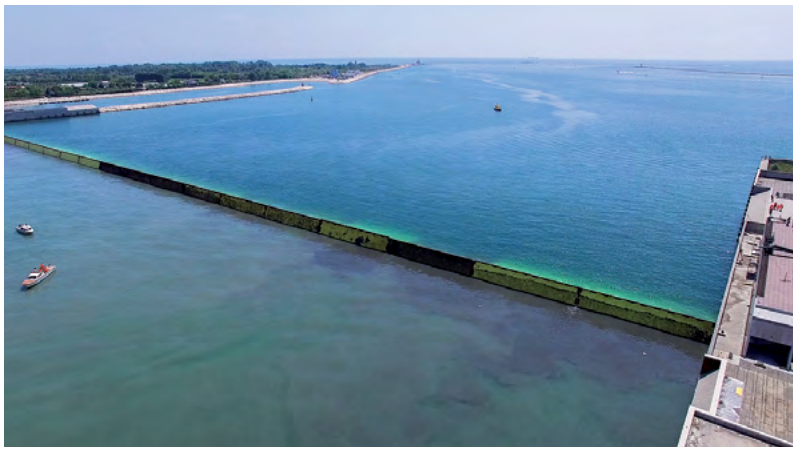
A BARRIER TO PROTECT

VENICE FROM FLOODING

Mose is a system of mobile dams that comes into service to isolate the lagoon from the open sea during high tide and protect the Italian city.

Specially designed construction chemical products were used in building the system.

Aerial view of the lagoons and the open sea.



The floodgates in the Mose system positioned at the northern entrance to the Venice lagoon.

The floodgates in the Mose system were raised on 3 October 2020. By 10:15 am, all the gates were in position and expectations were high as the system began its first real test under critical conditions. The 78 floodgates were raised and the difference in level between the sea and the lagoon rose to 40 cm. The level of the lagoon did not rise any further and Venice was not flooded.

That was the first official test for a structure that has been designed to protect Venice from high tide - an event that has become all too common.

A long-awaited project

Mose (Modulo Sperimentale Elettromeccanico) or Experimental Electromechanical Module is a hydraulic structure designed to hold back water if it rises above a certain level. The structure is like an automated dam with 20 m wide barriers of various thicknesses, that use their own weight and the force of gravity to help them operate.

The idea of using this kind of system was first suggested 40 years ago. Following numerous delays and public enquiries, construction work commenced 20 years ago and is scheduled to be completed by the end of 2021.

The system consists of the 78 mobile steel floodgates measuring up to 29 m in height, with each one operating independently. The system is able to isolate the lagoon from the sea during high tide. Other works have also been carried out in the area, such as reinforcing stretches of coastline outside the entrances to the port to alleviate the effect of normal tides, and raising quaysides and paving in the lowest areas of the inhabited areas around the lagoon.

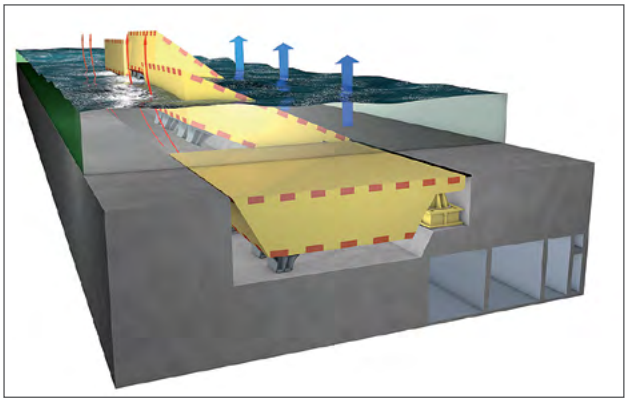
The floodgates are housed in concrete caissons positioned on the seabed at the entrances to the three ports on the lagoon - Lido, Malamocco and Chioggia - and are designed to be raised when the sea level rises due to high tides.

The Mose system is designed to protect Venice and the lagoon from high tides of up to 3 m and from a 60 cm rise in sea-levels over the next 100 years.

Outlets to the open sea

The Mose system is made up of four barriers positioned at the three outlets to the open sea. The widest outlet - which is the one closest to Venice - is positioned at Lido and is made up of two channels, each with a different depth. There are two barriers to protect this outlet - the north barrier which is made up of 21 floodgate modules and the south barrier with 20 modules. The two barriers are connected by an artificial island where the equipment used to operate and manoeuvre the system is located.

The entrance to the port of Malamocco is the deepest in the lagoon. This is the one used by ships heading to the industrial and commercial port, which is why a navigable basin has been constructed for the ships. The barrier at this entrance is made up of 19 floodgates.



The floodgates are housed in caissons sitting on the seabed. When there is high tide, they rise up and block the sea at the entrance to the lagoon.

The entrance to the port of Chioggia is used mainly by fishing boats and pleasure craft, and a sheltered port with a double navigable basin has been constructed so that boats can enter and exit the port, even when the barrier is closed. This opening is protected by 18 floodgates.

How the Mose system works

When the floodgates are in stand-by mode, they are completely invisible, full of water and sitting in caissons on the seabed.

When there is high tide that could potentially flood the surrounding area, compressed air is pumped into the gates to displace the water. As the water is expelled from the floodgates, they swivel on their hinges, rise up out of the caissons and block the entrances to the lagoon. On average, the time required for the floodgates to seal off the port entrances - including the time required to manoeuvre the floodgates into position - is 4 to 5 hours.

The gates only remain in this position during high tide. When the tide ebbs and the lagoon and the sea reach the same level, the floodgates fill with water and then retract into their housing.

Each floodgate is made up of a hollow metal structure which is attached to the caisson housing with two hinges.

Each floodgate is 20 m wide, while their height depends on the depth of the port entrance channel where they are positioned and their thickness also varies.

The caissons housing the floodgates and the mechanisms used to manoeuvre the floodgates form the base of the barrier and are connected to each other by an inspection tunnel.

The structure that connects the barriers to dry land is made up of large support housings which contain all the equipment and plants required to make the gates operate correctly.

The floodgates being manoeuvred into position at the entrance to the port of Chioggia.

Mapei provides solutions for the Mose project

Italian-headquartered Mapei SpA, a world leader in the production of adhesives, sealants and chemical products for the building and construction industry, took part in the Mose project as a technical partner, with a dedicated team that regularly interfaced with design engineers, works directors and contractors. The company's Technical Services, working in tandem with its Research & Development laboratories, proposed several high-performance products.

Grouting the joints

MAPEFILL MF 610 was specifically developed for this project and was used for grouting the joints and creating the watertight seal required, in order to connect them with matching fittings on the caissons housing the floodgates.

The caisson housings were positioned, in sequence, in a trench and were connected together with a special jointing system made up of two separate elements to form a watertight seal. The first element of the system is the so-called 'Gina ring-joint' that keeps the external part watertight and forms a temporary watertight seal between one caisson and the next one, while they are being installed. The second element is the 'Omega seal' which is installed inside the Gina joint during construction of the caissons and guarantees that the entire caisson remains watertight.

Rheoplastic concrete was required for this job to ensure it would maintain a high level of workability for around three hours, at high temperatures of around +35° C. The Gina collar used to house the joint was made from super-duplex stainless steel, an expensive material that left no margin for error during installation.

The Gina joint was connected to the concrete caisson by pumping MAPEFILL MF 610 into formwork.

This is a fibre-reinforced powdered grout made from high-strength cement, selected aggregates, special admixtures and polyacrylonitrile synthetic fibres. When mixed with water, it forms a fluid grout which does not segregate and is able to flow even into spaces with a complicated shape.

The product has low capillary absorption (complying with EN 13057), is highly impermeable to water, adheres strongly to iron and concrete, and is highly resistant to mechanical stress, including dynamic stress.

Thanks to its performance characteristics, MAPEFILL MF 610 fulfilled all the client's requirements during both the qualification tests and the application phase.

Reinforced concrete caissons being manufactured for use in the Mose project. The joint housings for the caissons were connected together with a jointing system made with MAPEFILL MF 610.

Preparing and positioning formwork on the caissons before pumping MAPEFILL MF 610.

The Malamocco site where the precast concrete caissons were manufactured.

Anchoring the hinges and waterproofing the caissons

The metal floodgates are anchored to the reinforced concrete caissons with a hinge mechanism which allows the floodgates to be raised and lowered.

According to Enrico Pellegrini, former Site Manager for Grandi Lavori Fincosit SpA, a great deal of design work and testing was done to identify the most appropriate products and technologies to fasten a metal component to concrete, so that the hinges could be successfully anchored to the caissons.

The metal floodgates are anchored to the reinforced concrete caissons with a hinge mechanism which allows them to be raised and lowered. The hinges were anchored using MAPEFILL MF, an expansive, fluid mortar especially designed for this site.

For this application, Mapei specifically developed MAPEFILL MF, an expansive, fluid mortar for anchoring elements in position with precision. The mortar was applied by injecting it into one side of the hinge and it then flowed to saturate all the gaps and free spaces, to form a single, solid body with the caisson it was anchored to.

The waterproofing system for the caissons, which were then placed on the seabed, also had to be carefully designed and thoroughly tested, in order to identify and specify products that would be long-lasting. After performing tests on site and in the lab, the external surface of the caissons was treated with MAPELASTIC FOUNDATION, a two-component, flexible cementitious mortar for waterproofing concrete surfaces subjected to both negative and positive hydraulic pressure.

The product chosen for the inside of the caissons, on the other hand, was MAPELASTIC, a two-component, flexible cementitious mortar. It was applied after treating the substrates with a specially designed version of PRIMER 3296.

This part of the work, as well as the challenge of anchoring the hinges, was closely followed by the Mapei Research & Development Laboratory in Milan, Italy, which carried out testing on the application of the products for the entire project.

PROJECT TIMELINE

1984
A team of experts is commissioned to carry out a feasibility study for a system to protect Venice from high tides.

1992
The Mose project is presented. The objective is to build it in three years. Construction of the mobile dams gets underway only in 2003 with a target completion date of 2016.

2013
The first gate is raised in October 2013, but enquiries and legal issues lead to stoppage of work on all the open sites, until work finally recommences in 2018.

2020
On 3 October 2020, all 78 gates are raised for the first time at high tide, to prevent the sea water from entering the lagoon.

2021
Completion of the Mose project is scheduled for end-2021.

This editorial feature is based on an article from Realtà MAPEI INTERNATIONAL Issue 83

PROJECT DATA

Project
Mose (Modulo Sperimentale Elettromeccanico) or Experimental Electromechanical Module, Venice, Italy

Owner
Italian Ministry of Infrastructures and Transport - Interregional Department of Public Works for Veneto, Trentino Alto Adige and Friuli Venezia Giulia Former Magistracy for the Waters of the Province of Venice

Design
Italian Ministry of Public Works
Technital

Period of construction
Ongoing from 2003

Malamocco site director
Enrico Pellegrini

Malamocco site main contractor
Grandi Lavori Fincosit SpA

Project costs
Construction cost - EUR 5.5 billion
Cost of repairing damaged and deteriorated structures - EUR 700 million
Cost of routine maintenance (estimated) - EUR 100 million/year

INTERVENTION BY MAPEI

Period of the intervention
2007-2015

Contribution by Mapei
Supply of products for grouting the Gina joints, anchoring the hinges and waterproofing the caissons

Mapei products used
Sealing Gina joints - MAPEFILL MF 610
Anchoring the hinges - MAPEFILL MF
Waterproofing caissons - PRIMER 3296, MAPELASTIC, MAPELASTIC FOUNDATION

Website for further information
www.mapei.com

Source of information in the article

Italian Ministry of Infrastructures and Transport - Interregional Department of Public Works for Veneto, Trentino Alto Adige and Friuli Venezia Giulia Former Magistracy for the Waters of the Province of Venice

SOLVING THE PROBLEM OF THE HINGES

Mr Enrico Pelligrini, former Site Manager for Grandi Lavori Fincosit SpA, the Main Contractor for the Malamocco site, elaborates on a major challenge in the project and how it was successfully addressed.

Mr Enrico Pellegrini

Question: Mr Pellegrini, what role did you have in the Mose project?

Answer: From 2005 to 2015, I was the manager of the site where the precast concrete caissons were manufactured for the inlets to the ports of Lido San Nicolò and Malamocco. The site was located on a 13-hectare artificial embankment, created specifically for the project on the island of Pellestrina.

Q: Which part of the work on the Mose project proved to be the most challenging, with regard to its design and the materials to be applied?

A: The structure of the Mose barriers is made up of two main elements - the reinforced concrete caissons which anchor the barrier to the seabed and the metal floodgates which are those big, yellow boxes which we can see rising up out of the sea to stop high tides. The two elements are joined together by a highly sophisticated device - the hinge.

The caissons are fixed permanently to the seabed, whereas the metal floodgates can be removed periodically to carry out scheduled maintenance work.

This means that the hinge element must allow the floodgates to be disconnected from the caissons, which is why it is made out of two parts - the female part which is fastened permanently to the caisson and the male part which is an integral part of the floodgate.

To anchor the steel female part to such an enormous reinforced concrete structure (the largest caissons are as big as a three-storey apartment block) with pinpoint precision was a really challenging design and construction matter, which we managed to overcome, by applying materials of the very highest quality and by planning the application procedures down to the minutest details.

Q: What problems did you have to overcome to anchor the hinges in place?

A: It was extremely important that the female hinges integrated with the foundation structure to perfection.

The difference between the two materials (reinforced concrete and steel), in terms of thermal and elastic behaviour, the difference in the design codes and construction methods applied, as well as the need to create a seal that would remain perfectly watertight at a great depth, required a very careful, in-depth study of the behaviour of the two elements when joined in one single element.

Which is why MAPEFILL MF was chosen - a product that would be able to guarantee the maximum level of adhesion between the two elements, with high mechanical properties, while maintaining sufficient elasticity and the ability to be distributed into any tiny gaps in the spaces left, to connect the two elements together.

Q: Any structure immersed in water must be fully waterproof. What were the most significant characteristics of this part of the work?

A: As I mentioned previously, while the floodgates will have to be extracted so their protective waterproofing system can be replaced and maintained at regular intervals, this won't be possible for the concrete caissons.

This made it extremely important to design one or several systems that would completely waterproof the structure. This is why, for the construction joints, three waterstop systems were provided, with the external one coated with a cementitious waterproofing membrane.

In spite of all these precautions, after carrying out a thorough analysis of the costs and benefits, the contractor decided on site to integrate these safety systems even further, by treating the entire surface of the caissons, from top to bottom, with a specially designed formula of MAPELASTIC FOUNDATION mortar, which was further integrated by applying a coat of a primer specifically designed by the Mapei R&D laboratories.

Q: Because of the new materials and technologies adopted, do you think the Mose site can be considered a pilot project for other sites of this type?

A: Obviously I can only speak for the work carried out on the site I was involved with, but I would say that, more than anything else, it was the way the project was managed from a technical point of view that could be used as an example of how to set up a major works site.

One such example is the care taken in choosing the right materials, which was dictated not only by the principles of affordability, but also by means of a long series of tests and cost/benefit evaluations.

Q: You worked very closely with Mapei Technical Services and the company's R&D laboratories in Milan. How did this team-approach work exactly?

A: I was in no doubt about MAPELASTIC's waterproofing capacity and elasticity, but I was still concerned about two factors - how strongly it would bond to the substrate and its durability.

That's why I personally wrote out a procedure which included an extensive range of tests to be performed on-site to demonstrate which would be the best technology to prepare the base, but also which was the best primer to apply in order to guarantee the highest level of adhesion for the membrane.

The Mapei product performed better than those of the competitors, thanks also to the direct and prompt interest shown by the company's R&D lab which made some slight modifications which greatly improved its final performance properties.

Besides, it was really comforting to be able to rely on an experiment carried out by the laboratory at the Polytechnic of Milan, which demonstrated that MAPELASTIC maintains its performance properties, even after a series of extended immersion cycles in seawater.

Also worth highlighting is how the Mapei lab followed our progress throughout the entire construction which lasted around one year, by coming to monitor and test the application of the product on a regular basis.

We found this to be very reassuring and it provided us with a further guarantee of the final quality of the work we carried out on site.

NEW CAT 657 WHEEL TRACTOR-SCRAPER

IMPROVES PRODUCTIVITY AND OPERATING EFFICIENCY

Featuring the field-proven, twin-power design to boost cycle times, the new Cat 657 Wheel Tractor-Scraper (WTS) improves productivity and operating efficiency, to deliver low-cost earthmoving. A 7% increase in fuel efficiency over the 657G WTS means more material moved per unit of fuel burned, and improved onboard payload estimating accuracy helps optimise productivity. The largest open bowl scraper in the Caterpillar line, with a rated load of 52 tons, now has a more spacious cab to boost operator comfort and efficiency in high volume earthmoving, highway construction and mining applications.

The 657 features on-the-go weighing through Payload Estimator, allowing the new WTS to achieve 95% load accuracy, so operators more easily reach target load goals. When working in colder climates, the unique Auto-Stall feature quickly brings the transmission to operating temperature at start-up, so the 657 gets to work faster. Ground Speed Control lowers fuel consumption by allowing the operator to set the desired top speed, allowing the machine to find the gear that works best for the engine and transmission.

The two-engine design includes the Cat C18 powering the tractor and Cat C15 in the scraper, both meeting stringent US EPA Tier 4 Final/EU Stage V emissions standards. Its Advanced Productivity Electronic Control System (APECS) allows the Cat 657 to better utilise engine power and torque, resulting in more material moved throughout the shift. The transmission features Electronic Clutch Pressure Control which improves shift quality and fuel efficiency. New hydraulic disc brakes improve braking performance and reduce maintenance.

A cab interior 21% larger than the preceding model, the 657G, improves operator comfort and provides good visibility to the bail, cutting edge and bowl of the new 657. The air suspension comfort seat adjusts and rotates 30°, to reduce fatigue, while the new Advance Ride Management adjusts damping to match ground conditions, resulting in a smoother ride for the operator.

The new Cat 657 Wheel Tractor-Scraper features a twin-engine design.

Automatic HVAC temperature control and defroster come standard for increased operator comfort. The new power access ladder enhances operator safety when entering and exiting the cab.

The new high-pressure steering system requires less steering input, which bolsters operator efficiency and productivity. Automatically engaging when the machine is in eighth gear, engine overspeed protection assists in slowing machine speed when approaching engine limits. Sequence Assist, a new option on the 657, automates many operator inputs, each cycle, to simplify machine operation.

The 657 tractor includes a new hydraulic on-demand fan that increases engine fuel efficiency. The machine also has draft-arm overflow guards which prevent material accumulation between the draft arms and bowl sides. Ground-level access for fuel fill and all daily maintenance points increase service efficiency and safety to increase machine uptime.

Integrated Payload Estimator and Cat Product Link technologies provide real-time payload, machine location, fuel usage and idle time information as well as diagnostic fault codes - all to significantly increase fleet management efficiency. A collective view of critical machine operating data is accessed via VisionLink, from anywhere there is an internet connection.

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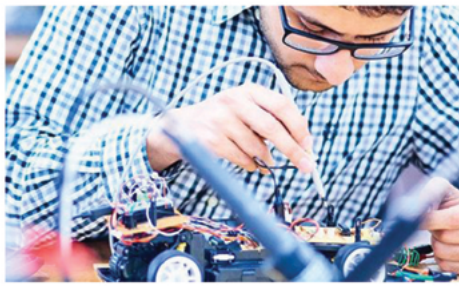

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