

IES-SG50:

Top 50 Engineering Feats Winners Listing



Project Name:
ABC Waters at Kallang River
– Bishan-Ang Mo Kio Park

Project Owner:
PUB, the National Water Agency

The Active, Beautiful, Clean Waters (ABC Waters) Programme was initiated by PUB in 2006, to bring Singaporeans closer to water so that they appreciate and take ownership of Singapore's water resource. The flagship project is the transformation of the Kallang River at Bishan-Ang Mo Kio Park from a concrete canal into a naturalised river. Designed with a holistic sustainable approach, the project integrated the park with the river using the floodplain concept. During dry weather, the river with its gentle slopes and narrow stream in the middle, become recreational spaces for the community. During heavy rain, this same park land next to the river becomes part of the river to meet water conveyance functions. Soil bioengineering techniques, comprising vegetation, natural materials and civil engineering techniques, stabilise the river banks and prevent erosion. The edges of the bio-engineered river also form natural habitats that enrich the park's biodiversity.



Project Name:
Air Command and Control (C2) Hub

Project Owner:
Defence Science and Technology Agency

Developed to help the Republic of Singapore Air Force (RSAF) protect our skies, the Air C2 Hub tracks aircraft around Singapore airspace and provides warning on suspicious aircraft to preserve Singapore's airspace integrity. By processing large amounts of information from various radar and other systems, the Air C2 Hub's built-in decision support tools facilitates decision-making for the RSAF. The Air C2 Hub also serves as an effective tool to manage air traffic at Changi Airport and military airbases.



Project Name:
AIR+ Smart Mask

Project Owner:
Innospark Pte Ltd

During the 2013 haze period, ST Engineering was tasked to develop mask solutions for the children and vulnerable. AIR+ is the world's first micro ventilator that can be attached onto a mask to provide active cooling and carbon dioxide removal. Subsequently, Innospark focused the R&D efforts on a mask design that will provide better seal protection, breathing comfort and ease. The result is the AIR+ Smart Mask – a Smart Mask with superior fit that comes in three sizes that can be attached with a Micro Ventilator. Pushing the boundaries to improve the effectiveness of the mask was the development of an attachable, lightweight and battery-rechargeable micro ventilator. Incorporating a mini-fan, this innovation eliminates the unpleasant build-up of heat, moisture and carbon dioxide inside the mask by venting the expired air out. During the haze season in 2015, AIR+ emerged as the preferred choice for protective masks among Singaporeans, protecting them from the harmful effects of the haze.



Project Name:
ArtScience Museum at Marina Bay Sands

Project Owner:
Marina Bay Sands

Simple in design yet complex in form, the lotus-shaped ArtScience Museum (ASM) is an architectural and engineering feat designed by renowned architect Moshe Safdie and constructed by lead engineering firm Arup. The ASM hosts blockbuster international exhibits as well as permanent exhibits on three floors of gallery space across 6,000 square metres. There are 10 "fingers" that make up the building, with the tallest at 60 metres. The interior features 21 unique gallery spaces with natural lighting from the "fingertips". ASM also integrates sustainability into its design – the roof of the museum harvests rainwater which is then recycled and redirected to create a waterfall feature. The rainwater is recycled for use in the museum's bathrooms as part of Singapore's Green Mark programme. The engineering solution integrated a steel diagrid which provides lateral restraint to the asymmetric form, but concurrently frames the central orientation space for the building.



Project Name:
BIONIX Infantry Fighting Vehicle (IFV)

Project Owner:
ST Kinetics, Defence Science and Technology Agency

As the first armoured IFV designed and manufactured indigenously, the Bionix marked the first time that the Army received an IFV tailored to their needs. Providing the Army with a quantum leap in mobility, firepower and protection, the Bionix is a testament to the capabilities of local defence engineers who overcame significant challenges to ensure that its performance exceeded operational requirements. It also proved that Singapore was capable of producing a military fighting vehicle from conceptualisation to design, development and manufacture. Today, the SAF deploys several variants of the Bionix family.



Project Name:
Breaking the Arctic Ice - Asia's First Icebreakers

Project Owner:
LUKOIL-Kaliningradmorneft

Singapore is the birthplace of Asia's first pair of icebreakers, designed for operations in one of the harshest and coldest frontiers on Earth, the Arctic Sea. In 2008, Keppel Singmarine became the first shipyard in Asia to engineer and deliver the first two icebreakers for operations in the Arctic region - a very challenging environment for vessel operations. The two icebreakers, Varandey and Toboy, are designed to cut through solid ice of over 1.7 metres thick, equivalent to the height of a grown man and operating in extreme temperatures as low as -45 degrees Celsius. The vessels adhere to the "Clean Design" and "Zero Discharge" standards to help mitigate the impact of icebreaking operations on the Arctic ecosystem. To date, Keppel Singmarine has completed 10 ice-class vessels and is currently building another one, mainly for the Arctic and Caspian regions.



Project Name:
Constructing New MRT Tunnels Crossing Existing Live MRT Lines

Project Owner:
Land Transport Authority

The Downtown Line (DTL) stage 3 connects the eastern part of Singapore to the city centre. These tunnels are vertically aligned to allow them to dive at maximum gradient from the Fort Canning Station, scrapping just above the existing North East Line (NEL) with a 1m gap. From here, they continue to dive aggressively to avoid the piles of the National Museum before going deeper to 8m below NSL and to 3m below Circle Line, before docking at the Bencoolen Station. Constructing at such close proximity to 'live' tunnels posed high risks of service disruption which could potentially cripple the public transport system for prolonged periods. Despite all the challenges, the construction of these tunnels have since been successfully completed. The connection provided by DTL stage 3 will save commuters both time and costs, adding convenience to their daily journeys and promoting greater use of public transport. With greater accessibility, this will also make the surrounding estates more vibrant.



Project Name:
Cross-Island and Jurong Island-Pioneer Cable Tunnels

Project Owner:
SP PowerAssets Ltd

Singapore Power's Transmission Cable Tunnel Project is a sustainable solution for the long-term future of Singapore's power supply, ensuring the continued reliability, quality and security of the network, while anticipating future demand. The project will facilitate the efficient installation, maintenance and replacement of transmission cables. The project implemented several industry-first initiatives including:

- Constructing Singapore's longest, deepest and tightest radii tunnels – spanning 40km in length, deepest depth at 80m, and tightest curvature of 75m;
- Successfully completed horizontal directional drilling for 1.25km and under Jurong Channel, yielding valuable geological information;
- Implementing real-time Integrated Data Management System to capture and correlate construction activities to ground response;
- Raising construction safety standards by capturing construction activity using video recording to spot and educate workers on unsafe acts

Scheduled for completion in 2018, this project will enhance Singapore's economy and improve quality of life by maintaining the country's electricity grid as one of the best performing networks in the world.



Project Name:
Construction of connecting MRT Tunnels to DTL1 (Chinatown) Undercrossing Singapore River

Project Owner:
Land Transport Authority

The Singapore rail network will be further expanded with the addition of the Downtown Line stage 3 when it is completed. Unknown to most people, the construction of the tunnels of Downtown Line stage 3 crossing the Singapore River was a herculean task. It involved construction of tunnels underneath a water body, in the midst of popular tourist spots at Clarke Quay and at just arm's length to the underground CTE tunnel. This had to be done while maintaining the waterway for river cruise boats, to ensure adequate hydraulic flows to prevent flooding upstream and to keep water clean as it is connected to Marina Reservoir. Adding to the slew of challenges, the project had to be completed within an aggressive timeline. Despite all the difficulties, the construction was successfully completed on time.



Project Name:
Deep Tunnel Sewerage System (DTSS)

Project Owner:
PUB, the National Water Agency

In the mid-1990s, PUB embarked on the unprecedented Deep Tunnel Sewerage System (DTSS) Project to serve Singapore's used water needs for the next 100 years. DTSS comprises deep tunnels to intercept flows in existing sewers and channelling by gravity to advanced treatment plants, where used water can be reclaimed for re-use. Adopting a highly compact design, the DTSS Project allows existing conventional plants and pumping stations, which occupy large areas in prime locations, to be phased out and the land released for other higher value development. Phase 1 of DTSS serving the eastern and northern part of Singapore was completed in 2008 and PUB is now implementing Phase 2 to extend it to serve the western and southern part by 2025. In Phase 2, the new used water treatment plant at Tuas will be co-located with NEA's incineration facility with process interfaces to harness the synergies of the water-energy-waste nexus.



Project Name:
Conversion of Overhead Pole to Underground Plant for Telecommunication Cables

Project Owner:
Singtel

Before 1980, telecommunication cables were provided using overhead poles or the Overhead Plant method to reach individual households or buildings. Over the years, however, overhead poles have posed public safety, aesthetics and reliability problems. Despite higher cost of constructing and operating underground telecommunications plants, Singtel initiated a programme in 1980 to convert overhead plants to underground ones. Today, Singtel cable plants in Singapore are all underground except for a few areas. Singtel's foresight to proceed with the conversion programme has proven beneficial as it facilitated fibre cable roll-out for the New Generation National Broadband Network (NGNBN) over 20 years later. Singtel's conversion programme was an enormous undertaking that helped enhance Singapore's aesthetics and contributed to the Government's plans to beautify Singapore into the "Garden City" at that time. In addition, the underground plants method has boosted the reliability and resiliency of Singapore's telecommunication network against the natural elements.



Project Name:
District Cooling System (DCS) for Marina Bay: Creating the World's Largest Underground District Cooling System in The Little Red Dot

Project Owner:
Singapore District Cooling Pte Ltd

Unknown to Singaporeans, Marina Bay houses the world's largest underground District Cooling System (DCS) with the highest distribution network utilisation, based on GFA serviced. This "chilled water cloud" provides air conditioning 24/7, 365 days, for 2 million sqm or 23 iconic buildings. Innovating engineering makes DCS unique, allowing this huge industrial facility to be "invisible" despite installing 20 giant chillers, 8 km of huge pipes, 25 cooling towers in a confined underground space. This innovative system reduces equipment capacity, space, cost and energy. For buildings, there are cost savings of more than 40%. Annually, 34,500 tonnes of CO2 emission is reduced. The ice thermal storage system is one of the world's largest with a capacity of seven Olympic-size swimming pools, saving 24MW of electrical network. The system is highly reliable with no supply interruption since service started in 2005. The network is maintained and operated by an optimised workforce of a small group of well-trained staff.



Project Name:
Downtown Line Bugis Station

Project Owner:
Land Transport Authority

The Downtown Line (DTL) is the longest underground rail project in Singapore to date and will run through high-traffic and built-up corridors. Built in three stages, it started with the 4.3km-long Downtown Line Stage 1 (DTL1), which consists of six stations. DTL1's most challenging aspect was requiring the new interchange DTL1 Bugis Station to be interfaced with the current, fully operational EWL Bugis Station. Arup developed an optimised design that is 20m shallower than the initial design, shortening the walking distance between the commuter networks and reducing excavation and construction costs. To safeguard the structural integrity of aged buildings within the dense urban area and in consideration of limited underground space, the top-down construction method with cross walls had to be used to minimise wall deflection and ground settlement. DTL1 Bugis Station's engineering excellence has set a precedence for sustainability and innovation in future rail developments and significantly enhanced the efficient public transport network.



Project Name:
Driverless Mass Rapid System (North East Line)

Project Owner:
Land Transport Authority

The North East Line (NEL) is the world's first fully automated underground driverless heavy rail rapid transit line, stretching 20 km from Punggol to HarbourFront. NEL was conceptualised as a fully automated railway with high level of system integration. At that time, new cutting-edge technologies for the signalling, communication, rolling stock and integrated supervisory control systems were employed. The main advantage of a driverless MRT system is the flexibility of service deployment. Driverless trains are also able to follow more closely to the planned schedule. The introduction of the driverless NEL trains in 2003 increased accessibility to the North-east region which promoted commercial, industrial and residential development. With the continuous growth and development along NEL, ridership has increased tremendously over the years.



Project Name:
Floating Platform and Seating Gallery

Project Owner:
Defence Science and Technology Agency

The Floating Platform marked Singapore's first application of Very Large Floating Structure technology, and the unique concept of creating space has charted new possibilities for land-scarce Singapore. It was built by SembCorp Marine Shipyard. The Floating Platform and Seating Gallery were originally planned to provide an interim venue for five National Day Parades, but they have hosted many more events. With Singapore's city skyline as the backdrop, the Floating Platform and Seating Gallery have been the choice venue for the Singapore F1 Grand Prix, the opening and closing ceremonies of the inaugural Youth Olympics Games, and the annual SAF Passing Out Parades for recruits. The engineering team's innovative solution for the Seating Gallery's lightning protection system has also received the Workplace Safety and Health Innovation Award (Gold) in 2008.



Project Name:
Gardens by the Bay, Singapore

Project Owner:
Gardens by the Bay

Gardens by the Bay, with its iconic dome-shaped conservatories and Supertrees, represents Singapore's vision of transforming the country into a "City in a Garden". Breaking the mould of traditional gardens, it is designed to be a horticultural-themed leisure destination – an oasis in the city where people can relax and reconnect with nature despite living in an

urbanised environment. This sustainable garden leverages on innovative green technology and engineering practices. The energy-efficient cooling system of the conservatories allow for plants from around the world to be brought into tropical Singapore, while the Supertrees harvest solar energy for night lighting. Few places in the world showcase such a novel combination of nature, architecture and technology – which has placed the Gardens squarely in international consciousness. Since its opening in June 2012, over 20 million people have visited it to date. In bringing the world of plants to Singapore, Gardens by the Bay presents Singapore to the world.



Project Name:
Infrared Fever Scanning System (IFs)

Project Owner:
Defence Science and Technology Agency,
ST Electronics

During the Severe Acute Respiratory Syndrome (SARS) outbreak in March 2003, DSTA and ST Electronics engineers worked together quickly to adapt a military thermal imager and develop the IFs to detect persons with suspected fever non-intrusively. Developing IFs involved the application of systems engineering and the innovative integration of multidisciplinary knowledge in the areas of radar, electro-optics, IT, applied statistics, physics and human physiology. Deployed across all Singapore immigration checkpoints, the IFs screened tens of thousands of travellers, identified many febrile cases, and restored confidence in the community. The scanners remain in use in many countries to help screen travellers possibly exposed to infectious diseases such as H1N1 and the Middle East Respiratory Syndrome.



Project Name:
Invention of the ThumbDrive™

Project Owner:
Trek 2000 International Ltd

The ThumbDrive™, first conceptualised in 1999 by home-grown company Trek 2000, revolutionised the way digital data, once synonymous with the floppy disk, was transferred from one device to another. The success of the ThumbDrive™ propelled Trek 2000 onto the global stage and grew the company from a five-man team to a global enterprise. This paved the way for the emergence of other innovative products such as the Flucard®, a Wi-Fi enabled SD card, as well as the Ai-ball, the world's smallest Wi-Fi camera that is currently being used by higher learning institutes such as the Singapore University of Technology and Design (SUTD). Development of the ThumbDrive™ is never-ending and even presently, new features are being introduced to further improve the product. The invention of the ThumbDrive™ could be said to greatly improve all our lives in areas such as functionality and convenience.



Project Name:
Jurong Island

Project Owner:
JTC Corporation

The completion of the Jurong Island was an engineering feat of its time for JTC and Singapore. Reclamation works began in 1995 and were completed in 2009 – 20 years ahead of schedule. Today, as the largest specialised industrial estate in Singapore, it has attracted more than \$47 billion global investments. Its integrated ecosystem remains as one of its key competitive strengths. Companies with strong linkages are located side by side to allow them to obtain their products or supply their feedstock from their neighbours, facilitated by a network of interlinked pipelines. The resulting production synergies enable companies to reduce their capital outlay and transportation costs. Singapore's position as a global chemicals hub has grown in tandem with the extensive development of the Jurong Island, now home to more than 100 companies, including top international names and local companies and continues to provide the nation a competitive edge in the global industry.



Project Name:
Jurong Rock Caverns (JRC)

Project Owner:
JTC Corporation

Located 150 metres below ground and 130 metres beneath the seabed of the Jurong Island, the Jurong Rock Caverns is the deepest underground public works endeavoured in Singapore. It is South East Asia's first commercial underground rock caverns facility designated for liquid hydrocarbons storage of up to 1.47 million cubic metres, the equivalent of 600 Olympic-sized swimming pools. The team employed cutting-edge construction methods to build five nine-storey high caverns, nine kilometres of tunnels, and piping networks with supporting utilities. The project is testament to Singapore's ability to overcome land resource constraints. Culminating six years of conceptual planning and design, and nine years of construction, JTC had spearheaded a new paradigm of innovative land use. With the construction of the caverns, 60 hectares of land above ground was freed up to enable the growth of higher value-added industries. This project has opened further possibilities for development, with the expertise and confidence gained from building these caverns.



Project Name:
Kallang-Paya Lebar Expressway

Project Owner:
Land Transport Authority

The Kallang-Paya Lebar Expressway (KPE) provides seamless connectivity among three major expressways in Singapore and is a high speed road link for the north-east corridor, including Sengkang and Punggol new towns, to the city centre. The dual three-lane KPE tunnel is equipped with state-of-the-art technology providing a safe, comfortable and pleasant driving experience through South East Asia's longest underground road tunnel. It was constructed up to 25m deep and 35m wide, in very challenging ground conditions, with soft clays up to 50m deep and as close as 3m to existing high-rise buildings. It also involved construction under the Geylang River, under 2km of Pelton Canal, under the live East-West MRT viaduct, beneath an aircraft taxiway, under two expressways and major arterial roads. The Geylang River had to be moved over two stages to permit construction of the KPE. Construction started in 2001 and in September 2008, the Prime Minister of Singapore officially opened the KPE.



Project Name:
Keppel Bay

Project Owner:
Keppel Bay Pte Ltd

Located on the former Keppel Shipyard, the Keppel Bay is part of the vibrant waterfront city in southern Singapore. The precinct offers premier homes including Caribbean, Reflections and Corals at Keppel Bay and Marina at Keppel Bay. Combining rich heritage and modern architecture, each development in Keppel Bay is innovatively designed to maximise view, space and functionality. Some of the unique features include preservation of the historical Queen's Dock and Dock 1, construction of a 750-metre shoreline which paved the way for a 10-metre wide public promenade that converges with Keppel Bay Bridge to provide easy access to the scenic waterfront promenade, amenities and MRT stations; and stunning architecture such as Reflections at Keppel Bay with six distinctive and double curvature glass towers. The Keppel Bay has placed Singapore on the world's prime real estate map. Its transformation runs parallel to Singapore's growth story, projecting the city's aspirations of being a progressive and forward-thinking society.



Project Name:
Keppel Mega Drilling Semi-Submersible - DSS Series

Project Owner:
Keppel Fels Limited (A division of Keppel O&M)

Keppel FELS' drilling semisubmersible (semi) DSSTM design is among the world's most technically advanced deepwater drilling rigs. The state-of-the-art drilling semisubmersible (semi) DSSTM 20 Keppel FELS developed and

designed for Maersk Drilling in 2003 is a significant milestone for Singapore's offshore industry. Keppel Offshore & Marine is the first shipyard in Singapore to develop its own proprietary semisubmersible designs. The DSSTM designs are recognised for its high efficiency, maximum operation uptime, enhanced safety considerations and unique design features such as superior motion characteristics. Rigs built to the DSSTM series have operated successfully around the world and received accolades. The DSSTM 51 rig, Maersk Developer, won the Rig of the Year Award in 2011. Keppel also won the Singapore Structural Award in 2014 from the world renowned Institution of Structural Engineers for its successful Mega semisubmersible design.



Project Name:
KFELS N Class

Project Owner:
Keppel FELS Ltd

The KFELS N Class was the largest and most advanced jack-up rig to be constructed in Singapore in 2006. The design was developed as an innovative and cost-effective jackup solution for the Norwegian Sector of the North Sea. The high specification rig design for Ultra Harsh Environments challenged the design norms of its time. It was conceptualised using an innovative approach to extend the capability of the jackup rig to operate in production and drilling mode simultaneously, thereby maximising functionality while complying with the demanding requirements of rigs operating in the North Sea region. Three KFELS N Class jackups rigs have been operating successfully in the North Sea. It is an engineering feat that fortifies Singapore's leadership position as the world leader in jackup design and construction.



Project Name:
Lift Upgrading Programme (LUP)

Project Owner:
Housing & Development Board

The 15-year, \$5-billion Lift Upgrading Programme (LUP) has benefitted over 500,000 households. Besides enhancing residents' physical and social well-being, LUP has increased the value of their flats. LUP has also helped to preserve existing community bonds as residents who faced mobility issues no longer had to move away. Many residents have expressed that the LUP process had given them more opportunities to interact with one another and strengthened their sense of belonging. In striving to maximise benefits while minimising disturbance and costs, HDB has developed innovative solutions and consultative strategies which have enriched its technical and public relations expertise. Executing major Addition & Alteration works of adding more than 10,000 lifts in close proximity to homes, while complying with various authorities' requirements was challenging. Nevertheless, survey results affirm that over 95% of residents supported LUP while 80% found the temporary inconveniences minimal or tolerable.



Project Name:
LTA Contactless Smart Card Reader Top Cover Design for MRT Stations

Project Owner:
Land Transport Authority

In 1999, LTA started to design a new interface for the gantries of MRT stations with the adoption of state-of-the-art contactless smart card readers. The new system was designed to fit existing stainless steel gates. The simple streamline shape of the outer shell belies the construction of a complex system where very advanced design tools and processes, especially 3D printing, were used to create fast iteration of prototypes with a short development time and significant cost saving. The design was an immediate success from its trial run that started in 2000 and by the end of 2002 to its retirement in 2014, it became part of everybody's daily life. In its fourteen years of operation, it has performed more than five billion transactions resulting in over four million hours of cumulated time saving for commuters.



Project Name:
Marina Barrage

Project Owner:
PUB, the National Water Agency

Built across the mouth of the Marina Channel, the Marina Barrage (MB) creates Singapore's first reservoir in the heart of the city, Marina Reservoir. The unique 3-in-1 concept of MB is an innovative and cost-effective engineering solution to meet Singapore's water supply needs, and at the same time, provide flood control and recreational opportunities. These benefits are achieved through the construction of a low-level barrage across the Marina Channel, creating a freshwater reservoir in the city that supplements Singapore's water supply. The MB also alleviates flooding in low-lying areas in the city such as Chinatown, Boat Quay and Geylang. The MB is architecturally designed with a spacious green roof and landscaping that blends well into the adjacent "Gardens by the Bay", providing an attractive and welcoming public space for visitors to enjoy. Free from tidal influence, the Marina Reservoir has become an ideal venue for recreational water activities.



Project Name:
Marina Coastal Expressway
– Singapore's First Undersea Expressway

Project Owner:
Land Transport Authority

The 5km dual five-lane Marina Coastal Expressway (MCE) is the toughest and the most massive road project in Singapore's 50-year history. Constructed in extremely difficult ground conditions with deep layers of soft marine clay, MCE is Singapore's first undersea and widest road tunnel, with 3.6km tunnel, two facility buildings and involving 13.1ha of land reclamation. Despite massive engineering challenges, MCE was safely completed on schedule and opened on 29 December 2013. MCE is a strategic underground east-west transport link between KPE and ECP in the east and AYE in the west, which enhances the capacity of the road network, supports the strategic land use plan and improves accessibility in Marina Downtown. MCE also permits the downgrading of a section of ECP to an arterial road to enable the valuable undeveloped land in Marina Bay to be unleashed and seamlessly developed into a quality live-work-play precinct in the city centre.



Project Name:
Marina Bay Sands

Project Owner:
Marina Bay Sands

Designed by renowned architect Moshe Safdie and constructed by lead engineering firm Arup, the 2,561-room Marina Bay Sands is Singapore's largest and Asia's sixth largest hotel. The Marina Bay Sands' three hotel towers are among the most complex buildings ever built. Sitting atop the three towers is an architectural masterpiece, the Sands SkyPark, which has one of the world's longest public cantilevers and is large enough to park 4½ A380 jumbo jets. It is also home to a 150-metre infinity swimming pool, the world's largest outdoor pool at the height of 200 metres. Marina Bay Sands integrates sustainability into its design through an extensive glass façade which allows natural daylight to illuminate indoor areas. Part art piece, part functional, Wind Arbor's stainless steel net at the Hotel Atrium's facade comprises 260,000 aluminium metal flappers which reflect light, shielding the interior from sunlight and preventing the building's temperature from rising too rapidly. This reduces energy consumption to cool the building.



Project Name:
My Waterway@Punggol

Project Owner:
Housing & Development Board

My Waterway@Punggol is the centrepiece of the Punggol 21 Masterplan to rejuvenate and transform the former agricultural and farm wasteland into a bustling eco-town of the 21st century. It is a first-of-its-kind in Singapore, bringing about new and affordable waterfront living to the doorstep of heart-landers. HDB engineers introduced novel engineering techniques to maximise resources and contribute to sustainable construction practices. A three-pronged approach was adopted - utilising innovative technologies to improve soil condition, green construction practices to overcome massive earthworks and promoting environmental sustainability. Earth excavated during construction was used to fill the low-lying areas around the waterway to prepare the sites for future developments. This cut-and-fill approach has resulted in cost savings of approximately SGD 40 million. The waterway's park and communal spaces have presented opportunities to integrate shopping, dining, entertainment, sports, recreation and community events, to enhance the living environment for all.



Project Name:
Marina Bay- Engineers Bringing Plans to Reality

Project Owner:
Urban Redevelopment Authority

The Marina Bay district is an internationally-renowned business and financial hub. This successful transformation of Marina Bay was the result of a forward-looking planning approach, where land was reclaimed in the 1970s to cater for future growth of our Central Business District. To support the planning vision, engineers in URA had to comprehensively plan, coordinate and implement the necessary supporting infrastructure and services in place ahead of time to serve the developments. The CST network in Marina Bay is the first in South-East Asia, comprising a wholly connected network of purpose-built underground tunnels that will house and distribute various utility services. These tunnels allow for the easy maintenance of utilities and eliminates the need for road opening, which causes traffic disruption and pollution. The waterfront promenade, Helix Bridge and Jubilee Bridge also provide access and vantage points for pedestrians to enjoy the Bay.



Project Name:
National Library Building

Project Owner:
National Library Board Singapore

The National Library Building is a knowledge icon located in the heart of the arts, cultural, entertainment and civic district of Singapore. The building houses the corporate office of the National Library Board (NLB), the Lee Kong Chian Reference Library and the Central Public Library. Since its opening in 2005, the National Library Building receives around 4 million visits yearly. Dignitaries who have visited the building include Queen Elizabeth II of the United Kingdom, the Imperial Emperor and Empress of Japan and the King Jigme Khesar Namgyel Wangchuck of Bhutan. The building is one of the first structures in Singapore to have its composite steel structure designed using innovative performance-based fire engineering. Design features such as the bare steel structure and steel floor beams are expressed while ensuring structural stability and fire resistance. It incorporates a system that integrates business, management and building functions to create a highly efficient and 'intelligent' environment.



Project Name:
New Singapore Cable Car Line on Sentosa

Project Owner:
Sentosa Development Corporation

The Singapore Cable Car has been one of the key transport modes into Sentosa for more than 40 years. In July 2015, the new intra-island cableway on Sentosa was launched in conjunction with SG50 celebrations. Built as an efficient and environmentally-friendly mode of transport, the new Sentosa Cable Car Line enhances access to western Sentosa and spans across three stations – Siloso Point, Imbiah Lookout and Merlion. It complements existing transportation systems and contributes to a more seamless transportation network within the island. The ride in the sky en-route to various attractions not only takes guests up and away from the road traffic, but increases their overall enjoyment as a unique commute. This addition forms a significant part of Sentosa’s transport infrastructure, which has evolved along with the island’s transformation into the dynamic leisure destination it is today, where close to 20 million locals and tourists visit annually.



Project Name:
Pasir Panjang Port Terminal Phases 3&4 Development

Project Owner:
Maritime & Port Authority of Singapore

Between 2007 and 2015, 198 hectares of land were reclaimed to add 15 million TEUs to enhance Singapore as a leading transshipment hub. A more sustainable construction where 45% of 50 million m3 reclamation fill were replaced with dredged materials and excavated earth instead of traditional marine sand, had reduced the reliance on marine sand and disposal grounds, leading to substantial savings of \$470 million. The innovative use of Cement-Mixed-Soils in geo-containment bunds had saved 4 million m3 of sand. 150 reinforced-concrete box-caissons, the world’s largest in size, were precast using Double-Gantry-Slipform-Method and Individual-Pushing-Caisson-Carrier-Vehicle. Less manpower/foreign workers and high quality of product were achieved. Translocation of affected corals at Labrador Nature Reserve, EIA and EMMP were implemented to protect the surrounding environment. The growth of our port generated demand for maritime ancillary services. The maritime sector is a significant engine of growth, contributing 7% of Singapore’s GDP and providing employment to over 170,000 people.



Project Name:
NEWater

Project Owner:
PUB, the National Water Agency

With advancement in membrane technology, it is now feasible to produce water of drinking standards, called NEWater, from treated used water reliably and at reasonable cost. The NEWater processes use a multiple-barrier approach: dual membrane technology of microfiltration/ultrafiltration and reverse osmosis, followed by ultra-violet disinfection. NEWater is a major breakthrough in strengthening the resilience of Singapore’s water supply system. NEWater currently can meet up to 30% of Singapore’s water needs, and up to 55% of our water demand by 2060. NEWater is mainly used in manufacturing and cooling purposes at the industries. NEWater is also added to our reservoirs to blend with raw water during dry periods, which is called indirect potable use. NEWater recycling has amazing multiplying effect as it recycles every drop of water to produce half a drop of NEWater and through many cycles, we can practically produce one additional drop of water from every drop of water.



Project Name:

Samwoh Eco-Green Building – First building in the region constructed using up to 100% recycled construction and demolition waste

Project Owner:
Samwoh Corporation Pte Ltd

Singapore generates about 1.5 million tonnes of construction and demolition (C&D) waste annually and its disposal posed a major environmental problem due to land scarcity. Moreover, Singapore has a strong dependency on imported natural aggregates for development. These trigger the exigency for the recycling of C&D waste for beneficial applications. Prior to our joint-study with BCA and NTU, the use of processed C&D waste i.e. recycled concrete aggregate (RCA)] in structural concrete has always been met with skepticism and limited to non-structural applications. Our research has successfully overcome technological limitations to incorporate RCA in structural concrete with the construction of Samwoh Eco-Green Building, the first in the region to be constructed using up to 100% RCA. The building has received many distinguished accolades for its green innovation while our findings have also been published in two world-renowned journals in UK and US. The use of RCA in structural concrete provides a significant contribution to Singapore’s sustainable development, marking a giant step towards a truly zero-waste nation.



Project Name:
Next Generation Nationwide Broadband Network

Project Owner:
Infocomm Development Authority of Singapore

As telecommunications operators typically own and operate their networks in an end-to-end manner, new operators interested to join the market would face high market entry barriers as such infrastructure requires significant investments. To increase competition and industry vibrancy to benefit consumers and businesses, IDA embarked on the Next Generation Nationwide Broadband Network (NGNBN) project with a unique Open Access model that transformed a vertically integrated telecoms market into one with three horizontally separated layers. The NGNBN was fully deployed in four years, putting in place a nationwide ultra high-speed optical fibre network that created an Open Access environment enabling a growth of 30 retail operators and 12 operation companies that helped deliver a wide range of high speed applications and services to consumers. The restructuring of the industry enabled the use of info-communications that boost productivity and competitiveness, reinforcing Singapore as an info-communications hub and enabling the development of new economic opportunities, business growth and social vibrancy.



Project Name:
Singapore Assault Rifle 21 (SAR 21)

Project Owner:
ST Kinetics, Defence Science and Technology Agency

The SAR 21 is a highly accurate and easy-to-use assault rifle made in Singapore that has been in service for over 15 years. Ergonomically designed to suit the build of the average Singapore soldier, the SAR 21 features a full-length barrel but with a shorter overall length, making it advantageous in close combat situations without compromising its effective range. The SAR 21 also adopts a constant recoil principle for low recoil and good control, and its patented vent-hole system in the barrel extension and protective shield in the upper receiver enhances the user’s safety. Integrated with factory-set optical sight, the SAR 21 enables soldiers to achieve shooting accuracy without the need for individual zeroing in the field. This reduces the time to train a soldier and significantly enhances the SAF’s operational readiness and responsiveness.



Project Name:
Semakau Landfill (SL)

Project Owner:
National Environment Agency (NEA)

In the 1990s, Singapore was running out of land space for a new landfill. This spurred Singapore to create Semakau Landfill (SL), through enclosing the sea-space bounded by Pulau Semakau and Pulau Sakeng located eight kilometres south of Singapore with a seven-kilometre perimeter sand bund. Phase 1 was completed in April 1999 with 11 landfill cells being created using internal sand bunds. The engineering feat included deep-sea piling and open sea construction. Phase 2 was completed in July 2015 using an innovative single-cell design. Besides reaping significant savings in construction and sand costs, the design also maximised the landfill capacity and extended SL's life-span to 2035. The engineering feat included a 200-metre floating platform to facilitate the safe discharging of ash and a floating wastewater treatment plant. With its rich and teeming biodiversity, SL is a prime example of balancing infrastructural development with environmental conservation in an environmentally sustainable way.



Project Name:
Singapore Sports Hub

Project Owner:
SportsHub Pte Ltd

The Singapore Sports Hub is one of the world's first fully integrated sports, entertainment and lifestyle destinations. The 35-hectare Sports Hub, housing multiple facilities including the 55,000-seat capacity National Stadium, is an apex of architectural and engineering design. The stadium features the world's largest free-spanning dome structure of over 310m, a comfort cooling system and an 8,000-metric tonne retractable roof that enables it to host a wide range of events in any weather. With a flexible seat configuration, the stadium is also the only one in the world capable of flexible configurations to host a wide range of football, rugby, cricket and athletic activities to federation standards, plus entertainment events. The largest global Public-Private-Partnership sports infrastructure project, the development is a key project in the government's urban redevelopment and sports facilities masterplan to provide venues for world-class sporting events and promote a national sporting lifestyle.



Project Name:
Singapore Flyer

Project Owner:
Straco Leisure Pte Ltd

A national icon, the Singapore Flyer has transformed the city-state's visual landscape. At 165m, it is Asia's largest giant observation wheel. Arup developed a revolutionary rim design and cable arrangement that improved the stability of the structure. The innovative two-dimensional ladder-truss structure is both larger and more efficient than its predecessors and represents the pinnacle of design in Giant Observation Wheels. It also gives the Flyer its lightweight, almost-transparent appearance. To overcome the support structure limitations and space constraints on site, Arup adopted an advanced vertical erection method where the wheel was erected in a 'pie slice' fashion, with each segment being rotated until all segments had been installed. An engineering feat, architectural icon and monumental structure, the Singapore Flyer has enraptured the world's attention, propelled Singapore to the forefront of global tourism and established it as a compelling, cosmopolitan destination to visit.



Project Name:
Singapore's First Mass Rapid Transit System

Project Owner:
Land Transport Authority

The North-South and East-West Lines of the Mass Rapid Transit (MRT) System, with 42 stations and costing S\$5 billion, was fully completed in July 1990, within budget and schedule. The engineering work was massive and complex. Over the course of the project, Singapore engineers acquired the necessary skills and knowledge to develop other MRT lines. It was reknown as the world's first metro system with energy-saving Platform Screen Doors. Today, the MRT system carries about two million passengers per day. It serves densely populated towns and brings the commuters directly into high employment centres and the CBD. It also serves the three regional centres. By providing good accessibility, it supports Singapore's economic growth and enhances the social well-being of its residents. It has enabled dense urban development in land-scarce Singapore. The MRT was a major milestone in the transformation of Singapore into a modern metropolis.



Project Name:
Singapore River Clean-Up

Project Owner:
National Environment Agency (NEA) and PUB,
The National Water Agency (PUB)

The Singapore River clean-up from 1977 to 1987 is the most extensive river clean-up effort in Singapore's history. The large-scale project took 10 years to complete and involved the close co-operation of many agencies, such as the then Ministry of the Environment, HDB, JTC and URA. The success of this engineering feat required a Whole-Of-Government approach, and a systemic and holistic solution that included the removal of pollution sources along the river and an engineering solution to clear the river of debris and polluting matter. As a result of the clean-up and continual efforts to prevent re-introduction of pollution, the Singapore River was given a new lease of life and economic importance as a significant tourism site. The project also played a pivotal role in Singapore's history in raising awareness of the adverse effects of polluting our waterways, and in reminding people of the importance of keeping our waterways clean.



Project Name:
Symphony for ePayment - CEPAS Card for All

Project Owner:
Land Transport Authority

Symphony for e-Payment (SeP), a unique Public Transport ticketing system developed in-house, serves the entire population, including about 1.7 million concession beneficiaries. Development for a card standard commenced in 2004 and culminated in publication of the Singapore Standard SS518:2006 Contactless E-Payment Application Specification (CEPAS). It is the building block of SeP comprising 30,000 touch points and a back-office system serving all Public Transport Operators and Card Managers, processing 20 million transactions exceeding \$6 million daily. It clears and settles transactions within three hours daily, comparable to best banking practices. Missing transactions were reduced to less than \$250 daily out of a total of \$6 million. A common card platform was established with Electronic Road Pricing, making Singapore the first in the world with a common card for private and public transport. Implemented in Jun 2010, the world's first distance-based fare charging feature is the fairest method of charging the commuter who is not penalised when making transfers.



Project Name:
The Esplanade Bridge – a memorable, inspirational and iconic bridge across the mouth of Singapore River

Project Owner:
Land Transport Authority

The Esplanade Bridge is a 280m-long and 44.4m-wide dual-carriageway arched bridge with pedestrian footpath on both sides spanning across the Singapore River at Marina Bay. Completed in 1997, its distinctive design complements the city skyline from the waterfront and other old bridges across the Singapore River. The Esplanade Bridge has created a significant impact to the Marina Bay area. It provides faster connectivity between Marina Centre and Marina Bay Financial District. With its completion, the historically significant areas around the Padang are freed from heavy traffic flow, making it more enjoyable for everyone to use the amenities in and around the Padang and the Marina Bay area. The Esplanade Bridge has added another milestone to the rich history of the Singapore River. Today, it remains to be an iconic structure at the mouth of the Singapore River and Marina Bay waterfront with the Merlion beaming beside it.



Project Name:
The Pinnacle@Duxton

Project Owner:
Housing & Development Board

The Pinnacle@Duxton is Singapore's first 50-storey public housing. The seven towers were constructed with high strength concrete and prefabricated components. The unique façade is made up of 528 pieces of precast components, comprising five types of precast facades, innovatively arranged in seven distinct configurations. This façade successfully generated visual interest and reduced the perceived building mass. The 12 skybridges allowed public spaces to be literally "reclaimed" from the sky, enabling creative play areas and facilities for community interaction. The development has rejuvenated Tanjong Pagar by bringing in younger residents. The site's historic significance is also well preserved in an outdoor gallery museum. The ingenious landscaping strategy that seamlessly extended the adjacent Duxton Plain Park horizontally and vertically into the high-level sky gardens, has created a pleasant living environment, not just for the residents but all Singaporeans. The project has also conserved mature trees by consciously integrating them into the landscaped areas.



Project Name:
Underground Ammunition Facility (UAF)

Project Owner:
Defence Science and Technology Agency, Singapore Armed Forces

The UAF is the world's first large-scale underground ammunition facility built within a densely populated urban area. Its development demonstrated the viability of using rock cavern space, opening up a new frontier in space creation in land-scarce Singapore. The UAF achieved land savings of more than 300ha, equivalent to half of Pasir Ris New Town. In developing the UAF, DSTA developed new safety standards in ground shock for underground ammunition storage, which have been adopted by NATO. Competency in cavern construction developed through the UAF has been put to use for MINDEF and major national underground initiatives. The Geology of Singapore (2nd edition) published by DSTA filled a major gap in the knowledge of Singapore's geology and represented a major contribution to the local construction industry and geo-science community.



Project Name:
World Class Electricity Grid Reliability

Project Owner:
Singapore Power Limited

Singapore enjoys one of the world's most reliable electricity networks. Our electricity grid reliability benchmark, the System Average Interruption Duration Index (SAIDI), improved from over 100 minutes of electricity interruption in the 1980s to just 0.34 minute today. Cutting-edge condition monitoring technologies and innovative network design are continuously adopted to ensure an efficient and reliable network. Since the late 1980s, the Supervisory Control and Data Acquisition (SCADA) system implemented at various distribution networks has enabled 24/7 remote control and monitoring of circuit breakers. In the 1990s, a flower configuration network design for the 22kV network was adopted. Combined with SCADA, this allowed us to promptly react to incidents while improving grid reliability. Since 2001, our equipment condition monitoring programme has averted more than 900 potential failures. SP PowerGrid continues to enhance the reliability and capacity of our network to meet the growing needs of customers. This is critical for the continued growth of the Singapore economy.



Project Name:
World's First Electronic Road Pricing (ERP)

Project Owner:
Land Transport Authority

Singapore's ERP System is not only one of the world's most innovative infrastructure development but also the world's first integrated pay-as-you-use scheme which maximises the capacity of the road network with variable price levels updated regularly, based on traffic flows. Unlike the road toll plazas in many other countries where motorists queue up to pay toll charges, this state-of-the-art multi-lane free flow system provides convenience to motorists with seamless payment of ERP charges. The success of this system is further exemplified by Singapore being labelled as one of the least congested major cities in the world despite the growing urban population and limited land space, according to 'Infrastructure 100: World Markets Report 2014' by KPMG. The ERP system has also led to the development of Electronic Parking System (EPS) that allows automatic deduction of parking fees based on the same technologies which further enhances motorists' driving experience.



Project Name:
Zero Energy Building @ BCA Academy, South East Asia's First Retrofitted Zero Energy Building

Project Owner:
Building and Construction Authority

The Zero Energy Building (ZEB) at the BCA Academy is the first in South East Asia that was retrofitted from an existing building. A joint effort by the government, industry and academia, the ZEB marks a milestone in Singapore's journey towards becoming a global leader in Green Building Technologies in the tropics and subtropics. The ZEB adopts the best passive design practices including day-lighting and passive displacement ventilation and uses many state-of-the-art technologies such as innovative air-conditioning systems, smart LED lighting and intelligent building management system. It is 50% more energy efficient compared to a typical office building. Since commencing operations in 2009, the ZEB has achieved net zero energy usage for six continuous years with the solar panels on the roof producing more energy than is consumed by ZEB. This has inspired the building industry to develop energy efficient buildings locally and overseas, deploying many of the technologies successfully test-bedded in ZEB.