The rolling over of the year is a time for reflecting and taking stock of the year past—have we managed to live up to our ethos of shaping a better world? We hope that some of the stories presented in this edition show you that we have.

A part of Singapore that we have had a big hand in shaping is one-north. As our cities become increasingly space and resource constrained, our new projects need to be efficient and have a low impact on the environment. Our projects there (pages 6 to 7) are guided by these principles and should stand the test of time.

Every year we seem to have the pleasure of being involved in a creative project, and this year we enjoyed a delightful collaboration with SUTD to create a simple but innovative pavilion. Although a temporary structure, the design approach is a forerunner of future techniques that brings life to an otherwise barren corner of the campus (pages 10 to 11).

In the New Year, I will be embarking on a new adventure by moving back to the UK. Peter Hoad, a Principal with Arup will be taking over the leadership in Singapore (page 14). Peter has been with the firm for 35 years and is no stranger to Singapore. I am confident that there will be a seamless transition.

While I would miss the warmth (both people and climate) and the dynamism of the ‘little red dot’, I am also excited to take on a new challenge in our London office. It’s hardly a forlorn goodbye – I’d say farewell for now and see you soon.

Wishing you a prosperous year of the Horse!
The future of inter-city travel

Gone are long and slow journeys as high speed trains serving cities such as Beijing, Tokyo, Taipei, Seoul, London, Paris and more, provide direct intercity connectivity as quickly as airplanes, and at a lower cost.

Not only does High Speed Rail (HSR) present a better quality of life for passengers, but it also cuts down on traffic congestion. Fuel-efficient HSR trains are significantly more environmentally-friendly than other modes of transport, such as car and short-haul flights, in terms of passengers per kilometer travelled. To top it off, HSR systems create jobs, increase productivity and provide better access to transportation of goods and people for local businesses.

The successful implementation of HSR requires detailed study and planning to maximise the benefits and bring real value for money.

With more than three decades of experience in engineering design and consulting for global infrastructure projects, Arup’s director and global rail leader, Colin Stewart, says HSR is far from one-size-fits-all.

“HSR requires customisation to meet a particular country’s culture, city spacing, complimentary modes, connectivity, and for ease of the journey,” says Stewart, who has been involved in rail projects such as High Speed 1 in the UK, Express Rail Link in China, and more.

In Asia, the spotlight has recently been cast on the proposed HSR link between Singapore and Kuala Lumpur, expected to shrink the journey from city centre to city centre from over four hours to less than two hours.

The Winding Track

Given the sheer scale of HSR construction, many challenges of perception, engineering and politics arise over the course of a project.

Stewart says the successful completion and adoption of HSR is reliant on the public’s willingness to accept it as their preferred mode of transport.

“Future generations will wish to minimise their time travelling and use it wisely,” says Stewart. “HSR provides speedy journeys and comfortable environments where passengers can stay connected on their smart devices, socialise and have refreshments.”

HSR faces several engineering challenges. Stewart shares that HSR systems are complex safety critical systems and many factors have to be considered, such as incorporating major tunnels, viaducts, and high stability tracks to provide high capacity and ensure safety at high speeds.

“Certain HSR systems also face political challenges, such as routes that run across borders, which require fast immigration systems to be installed,” says Stewart. “Passengers will expect fast service for their total journey and not merely a fast train ride.”

Linking Cities

Arup has been involved in HSR projects across North America, Europe, Australia and Asia for the past two decades.

High Speed 1, which carries passengers between London and Paris in just two hours and 15 minutes, is one of Arup’s most iconic HSR projects. The £5.8 billion line opened in 2007 as the first new railway in England in more than 100 years, and the first built to operate at a high speed of 300km/h.

A HSR station and transportation interchange with 17 full-length platforms was designed by Arup in Beijing in 2008. One of the largest stations in the country, the Beijing South Railway Station connects China’s capital with Shanghai and Tianjin, eventually accommodating 100 million passengers every year.

Making HSR a success

With several HSR projects under his belt, Stewart shares the following attributes that make HSR a success.

100km-wide stops

HSR trains use significantly more energy accelerating and braking than running at a constant speed. 100km between major stops is optimal for superior energy-efficiency of HSR travel.

Easy transfers

HSR lines should stop at locations with speedy and convenient ways for passengers to transfer to other modes. HSR trains can carry close to 1,300 passengers and take a major load off existing transport systems. City centres and airports are prime locations.

Efficient customs and immigration systems

Cross-border HSR systems require efficient customs and immigration systems to reduce time lost waiting. Government authorities need to balance high checkpoint standards with tried and tested processes for seamless journeys.

Risk analysis

The level of security required has to be determined with a risk analysis – breaches or intrusions are that much more dangerous on trains traveling at 350km/h. Streamlined security checks must be in place to ensure safe cross-border journeys, without compromising the speed of the journey.

Future-proofing

Technological advances should be catered for when HSR infrastructure is designed and built. Train speeds have doubled in the last 50 years and will continue to increase in the future. Infrastructure should be designed with an eye on the future – what we design today will be there for generations.

Contact: Colin Stewart / Michael McGowan

Colin Stewart
Global Rail Leader

Colin Stewart is experienced in the creation, procurement, design and implementation of infrastructure projects around the world. In the past 33 years, Colin has been involved at the highest levels of engineering design and advice across a huge spectrum of infrastructure projects. One of the biggest and most successful UK Infrastructure projects he has worked on in recent years is the Channel Tunnel Rail Link (HS1).

Having delivered many successful projects, Colin has become an expert in high speed rail and oversees the Arup work on such projects in many countries, including UK, Hong Kong, China, Portugal and America.

Colin also has first-hand experience of private finance projects through his roles as project manager, designer, technical and strategic advisor.
Smart spaces

Housing a cluster of high-tech research institutions, Arup was first involved in the masterplanning of the one-north precinct. Our work on the projects here showcase the kind of innovative engineering solutions that is crucial in a demanding future. From natural ventilation systems to energy-efficient façades, they are milestones on the road to a smarter and more inspiring way to work, live and play.

The Star

A refreshing change from Singapore’s many air-conditioned shopping centres, The Star is the country’s first open-air, naturally cooled entertainment, lifestyle and retail mall rolled into one. To achieve an environment-friendly complex, we used Building Physics to optimise air and wind movement, keeping the temperature comfortably cool without the need for energy-draining artificial systems. The use of CFD simulations revealed critical areas where mechanical fan-assisted ventilation helped augment the natural ventilation, ensuring comfort on warm days. Carefully placed canopies also let in a maximum amount of daylight without compromising rain protection. With the integration of so many sustainable practices, it is little wonder that the Building and Construction Authority has awarded the building a Green Mark Gold award.

Scope: Environmentally sustainable design (ESD), acoustic*, fire and facade engineering

*Consulted by Artec (now merged with Arup)

Fusionopolis 1 (Connexis & Symbiosis)

Designed to create a dynamic and collaborative environment, Fusionopolis 1 is a purpose-built work-live-play-learn environment. Housing scientific facilities and media studios, it consists of five levels of retail space, 50 units of serviced apartments and an Experimental Theatre. The refinement of the steel work by our structural team enabled the building to be erected on time and with cost savings. Our acousticians overcame the hurdle of designing within such an unusual spatial constrain to deliver an award-winning theatre space. We created an interactive decorative lighting programmed to light up in-sync with the number of theatre occupants. Above all, the safety of occupants is ensured through the use of performance-based fire engineering solutions and evacuation strategies.

Scope: Structural and fire engineering, acoustics and lighting design

Fusionopolis 2A

Set to house Singapore’s largest R&D clean room facility when completed, Fusionopolis 2A is a sensitive zone where high research activity takes place. This means that minimising micro-vibrations is crucial for the smooth operation of demanding laboratory equipment on the site. Arup’s structural engineers introduced vibration-limiting controls to the floor plates and designed an outer façade for the main building that shields it from wind disturbances and ground-borne vibrations. Vibration controls that were introduced into the core structure prevents internal disturbances caused by footfalls and process equipment operations. These innovative features would allow for new technologies to be test-bedded on a massive scale in a safe environment.

Scope: Civil, structural and façade engineering, geotechnics

Fusionopolis 2B (Solaris)

Consisting of two tower blocks, a two-level basement and a shared mezzanine car park, Solaris was a challenging, time-constrained construction project. Skillfully applying our structural and geotechnical experience in commercial buildings, Arup was able to deliver the project with speed and economy. By utilising an efficient top-down construction approach, we made it possible for the top levels and basement to be built concurrently. An excellent understanding of the site’s geology also enabled us to use a shallower basement wall design that is cheaper to build, but serves its function just as well as a thicker wall. An eye-pleasing 1.3km-long continuous landscape planter that wraps itself around the building’s façade is the cherry on the cake for this smartly constructed project.

Scope: Civil and structural engineering, geotechnics

Lucas Real Estate

Singapore ‘Sandcrawler Building’, Fusionopolis 4

Named after the Sandcrawlers from the first Star Wars film, LucasFilm’s regional headquarters is not only designed to be visually striking, but also built to be a high-performing, energy-efficient building. The demanding geometry required our structural engineers to employ a full palette of solutions to create the spaces, allowing the eight storey building to almost hover over a lush jungle-garden. Making use of state-of-the-art technology and clever landscaping, this building to almost hover over a lush jungle-garden. Making use of state-of-the-art technology and clever landscaping, the building is able to maintain a cool environment in the tropical climate. Aluminium louvers on the roof minimise heat gain while a smart glass façade lets in natural light without soaking up the solar heat. A 100-seat theatre, a highlight of this futuristic building, is designed to provide viewers with an exceptional acoustic and visual experience.

Scope: Civil and structural engineering, acoustics, audiovisual and multimedia, theatre consulting

The Metropolis

The Metropolis consists of two office towers that are unified by a lush landscape deck ideal for both the hosting of social events and a quiet solitary stroll. Arup was tasked to create a high performance unitised curtain wall façade system that would serve as a non-structural, weather-proofing outer skin for the buildings. Keeping the interiors of the buildings cool by reducing solar heat gain through passive designs, this curtain wall design allows the shading component of the curtain wall to be attached prior to installation and also removed externally. The flexibility in its design allows easier maintenance of the façade during its service life. The cost and time-efficient design allows installation to be done from within the buildings, negating the need for scaffolding and freeing up working space for other works.

Scope: Facade engineering

The Ministry of Education Headquarters

When we were commissioned to work on the Ministry of Education (MOE) Headquarters in 2001, Arup provided full façade consultancy for the 25-storey-high building. It broke new ground when it was the first project in Singapore to use computer stimulations to analyse how sunlight would enter the office spaces. An optimal amount of daylight penetration can make a building both comfortable and energy efficient. To manage direct sunlight, Arup also equipped the headquarters with light shelves. These would also serve to reduce solar heat gain and the amount of energy required to cool the building.

Our façade specialists are currently working on second MOE Headquarters situated just adjacent to the current one.

Scope: Façade engineering
Monitoring underground construction projects can be costly, time-consuming and incredibly complex, given the large volume of data collected. But the introduction of a new data analytics system – a partnership between Arup, Atkins and data science company QuantumBlack – is now enabling more efficient interpretation of ground and structural movement by monitoring data from underground construction projects.

The data analytics system improves risk management and cost efficiency, and can be implemented as part of planning or interpreting data from instrumentation and monitoring systems. In 2013, the system was successfully piloted on the new underground and surface railway project in London called Crossrail, the largest civil engineering project in Europe. To manage risks, engineers needed to improve the visibility of the data, understand any issues and respond immediately. Making sense of all the data drawn from 250,000 sensors, however, proved to be a difficult task. Crossrail is investing significantly in instrumentation and monitoring. Engineers must respond to monitoring results appropriately and quickly enough to manage any risks to ongoing construction work. By implementing data analysis techniques during their review, the team enjoyed better visibility of trends and anomalies, and was able to identify opportunities to optimise the instrumentation and monitoring system.

Data Science at work
The data analytics system uses mathematical algorithms to review spatial and time-dependent correlations in the data. The following aspects are examined:

Sampling
The development of settlement at monitoring points is assessed and analytics help determine whether the monitoring program can be optimised, either by altering the reading frequency of monitoring instruments, or changing the number of instrument points visited. The analytics are also used to predict settlement at instrument points removed from the historical data set. If error between the measured value removed from the data set and predicted settlement is small, the monitoring regime can be optimised in the future. Such optimisation can significantly save costs but engineering judgment has to be applied to ensure reductions in monitoring intensity does not significantly increase risk.

Forecasting
Potential breaches of trigger values are more quickly identified by reviewing the development of settlement against construction progress – this also helps the team forecast the end of construction, or final settlement for a given construction phase. Engineers can then plan the introduction of mitigation measures in a shorter time frame if final settlements are projected to exceed trigger values.

Visual Results
For ease of reference, construction progress and monitoring results are presented through Adaptive Instrumentation and Monitoring (AIM), a web-based application that can be viewed on a PC or iPad.

Anomaly detection
The tool analyses "spikes" or anomalies in the data and alerts engineers. The analytics distinguish between a range of different anomalies, helping engineers identify those that require further investigation.

Potential for Growth
There is great potential to use data analytics beyond underground construction. Analytic techniques can be readily adapted to other civil engineering purposes, and are particularly suited for better understanding correlations within large data sets. Better risk and cost management as well as programme opportunities that were not clear from conventional methods of data analysis can be identified from the findings. Examples include reviewing asset condition data for maintenance strategy, and reviewing financial performance and communications within organisations to alert stakeholders when projects go awry.

Analytics offered by Arup, Atkins and QuantumBlack can be deployed by acquiring consulting services for specific projects or technology licenses. The recommended phased introduction of analytics includes carrying out an initial diagnostic, followed by pilot deployment testing, and finally rolling out for full-scale usage. This allows clients to understand potential benefits at an early stage of their project.

Contact: Michael McGowan / Charles Im
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A steel jigsaw structure stands on a sloping lawn within the campus of Singapore University of Technology and Design (SUTD). Beneath the successful and collaborative engineering feat is a shaded open-air workspace for students and staff to enjoy.

The SUTD Library Pavilion was created for anyone in the school to relax, work and interact. Amenities such as work desks, mobile bookshelves and wireless internet can be found in the structure, which serves as a meeting place, outside dormitories and classrooms, for students to socialise and collaborate on projects in a casual setting.

The canopy uses no columns, beams or vertical walls – it is instead made of a lightweight timber shell overlain with galvanised steel sheets. Unlike usual steel gridshell structures requiring complex three-dimensional structural joints, all elements of the pavilion were prefabricated from more than 3000 pieces of plywood and close to 600 pieces of galvanised steel sheets, helping to keep costs low at $200,000.

True to the school’s hands-on approach to education, the 3000-piece jigsaw was assembled by the students and faculty in collaboration with project sponsors Arup, Autodesk and Ariana International Hogan.

For their blueprint, students only had to refer to a numeric map of a three-dimensional puzzle during construction, indicating which pieces fitted next to one another as opposed to complicated assembly charts.

Arup was instrumental from design through to construction by assisting SUTD academics in the development of the structural system, forming the connection details with SUTD architects and providing guidance on the gridshell geometry. The Arup team also finalised the structural design and testing methodology.

Arup’s Project Director, Mike King, said the biggest challenge was designing an innovative and unique structural system using unusual materials and components. These included plywood members, galvanised sheeting and stainless steel hinges within the connections. The materials and components had to form an efficient structure where no two nodal connections were the same.

The eight-month project wrapped up in May 2013, with construction completed in just over two months.

“*We really enjoyed using hi-tech design tools such as parametric computer modeling and computer-aided manufacturing techniques, together with the low-tech approach of hand assembly by the students. To develop multiple unique low-cost joints, we even sourced hundreds of stainless steel hinges from a hardware store in Little India.*”

Mike King

Contact: Mike King
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Client: SUTD
Key collaborators: T r Hamzah & Yeang Sdn Bhd
City Form Lab
Arina International Hogan

Arup scope: Structural and façade engineering, geotechnics
Project completion: 2013
**Project wins**

**Puteri Harbour Conference Centre**
Modelled after the French Riviera, Puteri Harbour is a luxurious integrated waterfront and marine development that features world-class residential, business, retail and entertainment projects. The jewel of Asia’s newest regional city Nusajaya and the key driver of the Iskandar Malaysia programme, this premiere precinct would soon welcome a new Waterfront Convention Centre. Located at a prime position on the harbour, it is set to become a star business venue, catering to all the needs of any conference, convention, meeting or exhibition.

In collaboration with Cox Architects, Arup is providing design and consulting services for this premier project. This includes structural, façade, lighting, fire, acoustic and audio-visual aspects of the building. Consisting of four exhibition halls totalling 6,500m², two ballrooms and a 500-seat auditorium, the convention centre’s striking panelised façade is set to become a key attraction and iconic landmark at Puteri Harbour.

**Feasibility Study of Indonesian Food Manufacturing Plant**
Arup was commissioned to look at the existing Wet and Dry food manufacturing plants at an industrial site of approximately 20,000m² at Cikarang. In line with the client’s wish to meet both local and international regulations and increase production capacity to meet growing sales demand, Arup will conduct an extensive review of the site to identify GMP (Good Manufacturing Practice) compliance gaps. We will recommend improvements to material and personnel flow and to processes and equipment that will increase production capacity. These will include upgrades and additions to buildings, engineering systems and utilities The scope of the review includes both facility, process and operations related areas, including architectural layout, structure and foundation, material handling flow, manufacturing system and packaging line layouts, engineering services and site utilities.

**LGT Towers, Kuala Lumpur**
Consisting of commercial offices, residential apartments and hotels, the LGT Towers would serve to add a generous dose of vibrancy to the heart of Kuala Lumpur. This integrated landmark destination is located within an existing green area in the Malaysian capital city, and would feature three tower buildings. Inter-connected with skywalks at high levels and sharing a common basement space, they would form a micro-environment, where each tower is divided into a familiar face but also allows us to expand our social circle with talented members of the industry. Our guests were able to unwind after a long day at the festival and strike up inspiring conversations over welcomed drinks. The laughter-filled atmosphere was made even more joyous by the Singapore’s Sports Hub’s win in the Best Future Project (Leisure-Led Development) category. We are already looking forward to the next glass-clinking get-together with our honored guests and cherished friends, when we would hopefully have more reasons to celebrate and make merry.

**Award wins and events**

**Singapore Sports Hub recognised at World Architecture Festival**
The World Architecture Festival is the largest festival and awards competition that celebrates architectural excellence on the globe. Held at Singapore’s Marina Bay Sands on 2-4 October, the 2013 edition of this esteemed festival was particularly exciting and joyous for Arup. The Singapore Sports Hub, a landmark project of Arup won the award for Best Future Project in the leisure-led development category. The architecture for the Sports Hub was designed by Arup’s architectural team in London (Arup Associates) & DP Architects with AECOM as landscape designers.

According to the judges, this sustainable, fully integrated sports, entertainment and lifestyle hub was outstanding due to its “its exemplary master-planning vision, engineering, solutions and handling of diverse programme scales”. Scheduled to open this year, people from all walks of life would be able to enjoy its world-class sports and recreational facilities, including an innovative 55,000-seat national stadium that features the world’s largest free-spanning steel dome roof. We are extremely proud to have played a key role in the sports venue design and engineering of the Singapore Sports Hub, which will no doubt become a major icon within the city’s beautiful landscape.

**Is Change For The Better?**
In commemoration of Arup’s Green Engineer of the Year win, Office leader Russell Cole hosted a get-together that aimed to spark conversation about change, nostalgia, progress and memory. To bring together old friends and to meet some like-minded new ones, we organised a cozy soiree at the Italy Bar Ristorante. In addition to good food, great drinks and fabulous company, our honored guests were also treated to an Arup-produced short film* that focuses on the ever-evolving landscape of Singapore and the emotions these changes evoke in the city’s residents. We hope that our guests left the event thinking about how they can, as designers, engineers and makers of the built environment, help to preserve or reinvent the idea of home in a continuously changing world.

* Film available at: http://www.youtube.com/watch?v=YAN4OlBb944

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**Feasibility Study of Indonesian Food Manufacturing Plant**
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**LGT Towers, Kuala Lumpur**
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**Singapore Sports Hub**
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**Happier 2013**
For the second year in a row, we hosted a light-hearted party during the World Architecture Festival that not only gave us an opportunity to chat up a storm with familiar faces but also allowed us to expand our social circle with talented members of the industry. Our guests were able to unwind after a long day at the festival and strike up inspiring conversations over welcomed drinks. The laughter-filled atmosphere was made even more joyous by the Singapore’s Sports Hub’s win in the Best Future Project (Leisure-Led Development) category. We are already looking forward to the next glass-clinking get-together with our honored guests and cherished friends, when we would hopefully have more reasons to celebrate and make merry.
In the past 35 years, Peter has worked across markets on international projects from Australia, the Pacific, Asia and the UK. A strong background in structural engineering provided Peter with a solid platform to develop his specialist knowledge in blast engineering design and security consulting.

Peter is well-acquainted with Singapore having lived here at various times. He was first involved in the North East Line project and more recently, he established the Risk and Security consulting business in Singapore. His other projects include providing security consultancy on the iconic Marina Bay Sands and blast resilience consultancy on the Singapore Sports Hub and Thomson Line.

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Lau Ching Luan
Infrastructure Group

Lau is an Associate with Arup and has more than 14 years of structural engineering experience. Lau’s successful delivery of projects all over the world has led him to work in the UK, Korea, India, Brazil and the US; and across markets – from rail, aviation, commercial buildings to residential.

Now based in Singapore, Lau is currently leading a number of multidisciplinary teams on the high profile MRT and infrastructure projects in the city. Bringing his experience on underground structure and deep excavation design to his present projects on the MRT, he is responsible for the concept, design and construction of both stations and tunnels.

In addition to working on the Thomson Line and Downtown Line, Lau is also currently the Deputy Project Manager for the extensive Eastern Region Line.

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