Time	Greater Sustainability (I)	Resilient Infrastructure	New Spaces
2.00pm	*Shaping Sustainable Cities of Tomorrow through Research & Innovation* **Dr Cheong Koon Hean** CEO, HDB	*Opening Remarks: Enhancing Resilience in the Built Environment* **Er. Tay Ah Ching** Deputy Director, Enforcement & Structural Inspection Department	*Opening Remarks on New Spaces* **Er. Loh Yan Hui** CEO and Global Lead, Aviation, Surbana Jurong Private Limited
	A: Building a Quality Living Environment	*A: Autonomous and Advanced Monitoring Systems*	*A: Underground Spaces*
	Urban Ecosystem Services: Roles & Relevance in High density Cities **Assoc. Prof. Tan Puay Yok** Department of Architecture, NUS School of Design & Environment	*Digitalization of Infrastructure with Smart Materials and Sensorial Networks* **Prof. Nemkumar Banthia** Civil and Mechanical Engineering, University of British Columbia	*Visualising Underground GeoData in 3D* **Prof Chu Jian** Civil and Environmental Engineering, NTU
	Effects of landscapes on the brain **Dr. Olszewska Guizzo, Agnieszka** Research Fellow, Yong Loo Lin School of Medicine, NUS	*Monitoring urban trees using high-resolution airborne and satellite remote sensing imagery* **Dr. Yin Tiangang** Joint researcher, NASA Goddard Space Flight Centre and Earth System Science Interdisciplinary Center, University of Maryland	*GIS based Lifecycle Durability Assessment of Underground Infrastructures* **Dr Zhang Yao** Division of Structures and Mechanics, NTU
		UAV (drones) Application for DTSS Inspection **Mr Wang Fei** CEO, AeroLion	*Life Safety and Structural Fire Safety of Mega Underground Caverns in Singapore* **Prof Tan Kang Hai** Civil and Environmental Engineering, NTU
			Human-Centric Underground Workspaces: Results of a multidisciplinary, multi-year study **Dr. Adam Roberts**

			Senior Research Fellow, School of Mechanical and Aerospace Engineering, NTU
3.30pm	**Networking Break** Participants are invited to visit the exhibition		
4.00pm	*B: Enhancing Urban Greenery and Ecology*	*B: Enhanced Resiliency for Infrastructure*	*B: Land Reclamation*
	Creating Biophilic Towns: Effective Implementation of Biophilic Design Principles & Strategies **Mr Leonard Cai** Deputy Director (Landscape Design Office), Building & Research Institute, HDB	*Smart Urban Habitat – Enhancing Resiliency in the Heartlands* **Dr Johnny Wong** Chief Technology Officer / Senior Director (Research & Development), MND Group Director (Building & Research Institute), HDB	*Creating port land with re-cycled dredged and excavated materials* **Dr. Darren Chian** Asst. Professor, Civil and Environmental Engineering Department, NUS
	From Celestial to Cellular: A Multi-Modal Approach for Monitoring Singapore's Coastal and Marine Environment **Dr Karenne Tun** Director, Coastal and Marine Branch, National Biodiversity Centre, NParks	*Understanding some of the key issues that affect the durability of structures* **Dr Aravind Dasari** Associate Professor, Schools of Materials Science & Engineering	*Geosynthetics in coastal structures: Applications in Singapore* **Dr. Chris R. Lawson** Managing Director, Ten Cate Geosynthetics Group Asia **Dr. Chew Soon Hoe** Asst. Professor, Civil and Environmental Engineering Department, NUS
	Digital Tools and Modelling: Sustainable Greening of Urban Cities Mr Foong Chee Leong Director, IT, NParks	*Infrastructure resilience in an age of modern terrorism threat* **Er. Dr. Ang Choon Keat** Principal Consultant, Prostruct Consulting Pte Ltd	*Advanced geotechnical instrumentation and monitoring for land reclamation* **Dr. Zhandos Y. Orazalin** Post-Doctorate Associate, SMART
	Moderated Q&A **Moderator: Dr Nigel Goh** Director (CUGE Research), NParks		*Moderated Q&A: Sustainable Land Creation* **Moderator: Mr Chua Kok Eng** Director (Infrastructure and Reclamation), HDB

DETAILED BREAKOUT TOPICS

GREATER SUSTAINABILITY

Dr Cheong Koon Hean
CEO, HDB

Dr Cheong Koon Hean is the CEO of the Housing and Development Board (HDB) overseeing the development and management of some 1 million public housing flats in 26 towns/estates. Dr Cheong was also the CEO of the Urban Redevelopment Authority from 2004 to 2010.

Dr Cheong is currently on the Boards of the HDB, the National University of Singapore and is a Council Member and former Deputy President of the International Federation for Housing and Planning. In addition to being a fellow of the Singapore Institute of Architects and the Institute of Planners, Dr Cheong serves on various expert panels and advisory committees including the World Economic Forum's Real Estate and Urbanisation Global Agenda Council, the National University of Singapore and is the Chairman of the Nominating Committee of the Lee Kuan Yew World City Prize. She is also the Tan Swan Beng Endowed Professor in Nanyang Technological University. Amongst others, she was awarded the Meritorious Service Medal for outstanding public service and the University of Newcastle's 2010 Convocation Medal for professional excellence. In 2016, she became the first Asian to be conferred the JC Nichols Prize for Urban Visionaries by the Urban Land Institute and the Lynn S Beedle Lifetime Achievement Award by the Council for Tall Buildings and Urban Habitat. She was also appointed the 2018 SR Nathan Fellow by the Institute of Policy Studies, NUS.

Topic: Shaping Sustainable Cities of Tomorrow through Research & Innovation

Tengah, HDB's latest new town, is envisioned to be a "Biophilic, Sustainable & Smart Forest Town of Tomorrow". Guided by HDB's Roadmap to Better Living, Sustainable Development and Smart Town framework, Tengah is also positioned as a Flagship Living Laboratory to test bed new ideas and cutting-edge innovations. The presentation will illustrate how new research ideas will help to achieve and stretch Tengah's sustainability goals. In addition, Tengah will introduce new initiatives in the areas of biophilic and human-centric design, as well as achieve greater energy optimisation. The research community will be invited to collaborate with HDB in new areas of research to realise the vision for Tengah.

Assoc. Prof Tan Puay Yok
Department of Architecture, School of Design and Environment, NUS

Dr. Tan Puay Yok is an Associate Professor in the Department of Architecture in the School of Design and Environment of the National University of Singapore. He is the Programme Director for the Master of Landscape Architecture programme and the leader of the research and teaching group for landscape studies. His research, teaching and professional activities focus on the science, policies, and practices of urban greening and ecology of the built environment. He combines his background in the sciences, experience in urban governance from the public sector, and interactions with practitioners to apply knowledge for urban greening to improve environmental quality and societal well-being. He also serves as the Associate Editor for Landscape and Urban Planning and Journal of Urban Ecology. He is active in international collaborations and grant reviews, and also advises on landscape design and planning projects in the region as means of transferring knowledge from the academia to practice.

Topic: Urban Ecosystem Services: Roles & Relevance in High density Cities

Singapore is an unusually green city—it stands out as an outlier for having a high population density and being green at the same time. What is more remarkable is that an active urban greening programme started more than five decades ago, long before modern concepts of "urban ecosystem services", "nature-based solution", "green infrastructure", etc., are used to advocate for urban greening to be a critical component of urban development in numerous cities worldwide. The systematic and comprehensive approach towards greening Singapore, one that could even be said to be over-zealous, makes Singapore the world's leader in urban greening, as it is often argued by local and overseas observers. One must therefore ask this question: if Singapore is already so green, is a concept like "urban ecosystem system services" still useful to guide urban greening of the city? Aren't the urban greening activities of Singapore already delivering ecosystem services? Therefore, is the urban ecosystem service concept and others only useful in the academic realm, and have little practical value? In this presentation, I share my perspectives on these questions, focusing on the following propositions: being green is not necessarily being ecological, being ecological requires deliberate design, and practice research involving design should be more widely adopted to marry theory and practice.

Dr. Agnieszka A. Olszewska-Guizzo
Post-doctoral Research Fellow, Yong Loo Lin School of Medicine

Dr. Agnieszka A. Olszewska-Guizzo is a post-doctoral research fellow at the collaborative research project between NUS and NParks, titled "Effects of Landscapes on the Brain". She received her Ph.D. in Landscape Architecture and Urban Ecology from University of Porto, Portugal in 2016. She is interested in exploring the relationship between the different features of the natural and built environments influence on human health and wellbeing though the methods of neuroscience. In several experiments she has conducted, she has successfully incorporated EEG tools to investigate the changes in brainwave oscillations in participants exposed to different types of built environment. She has introduced and operationalized the term contemplative landscape and proposed a quantitative assessment scale to distinguish landscape views according to which are most beneficial for mental health in terms of passive exposure.

Topic: Effects of landscapes on the brain

The presentation will discuss the first preliminary outcomes of the larger study titled "Effects of Landscapes on the Brain". This interdisciplinary project on the intersection of psychology and landscape architecture will fill the gap in knowledge about the environmental moderators of delivery of mental health and well-being outcomes from the design of green spaces in cities.

Through this study, we observe the brainwaves and haemodynamic oscillations of 50 healthy and 50 depressed individuals in response to passive exposure to different types of landscapes, including the landscapes considered therapeutic. The experiment takes place in a controlled laboratory setting as well as in the real environment of preselected sites around Singapore. To collect the data we use the combination of two neuroscience tools: electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS) along with a set of self-reported psychological questionnaires.

This approach can help unveil the causal relationship between exposure to specific types of urban landscapes and the brain response of healthy and depressed individuals, including effect size. In this presentation, only preliminary data from 10 healthy individuals will be discussed, as the project is still ongoing.

SESSION A: BUILDING A QUALITY LIVING ENVIRONMENT

Mr Leonard Cai
Deputy Director (Landscape Design Office), Building & Research Institute, HDB

Mr Leonard Cai is currently the Head of the Landscape Design Office in the Building & Research Institute of the Housing & Development Board (HDB). He leads an in-house Landscape Architecture research & design consultancy team that spearheads innovation and sets new benchmarks in landscape architecture design.

Since joining HDB, Mr Cai has established the HDB Biophilic Town Framework, which aims to create greater sense of place, well-being and quality of life for residents, through the optimization of ecosystem services in urban landscapes. Complementary to the framework, Mr Cai has also developed the Biodiversity Index for Residential Towns, an assessment and decision-making tool that allows the ecological integrity and biodiversity levels of any residential town to be measured and enhanced.

As a Landscape Architect, Mr Cai planned and designed multiple award winning residential landscapes and parks including The Verandah @ Matilda, Northshore Residences I & II, Waterfront I & II @ Northshore, Woodleigh Glen, and Woodleigh Hillview. He has also garnered accolades in landscape planning projects, such as the Punggol Northshore District Landscape Masterplan, which won the Outstanding Award under the NParks Landscape Excellence Assessment Framework (LEAF).

Topic: Creating Biophilic Towns: Effective Implementation of Biophilic Design Principles & Strategies

HDB has developed the Biophilic Town Framework which is a calibrated and holistic approach to the incorporation of nature and the optimisation of urban ecosystem services within our towns and neighbourhoods for greater environmental health and human well-being. Since the progressive roll-out of the framework in 2018, several developments have incorporated biophilic design principles & strategies into their design, as outlined under the framework. Through illustrative examples, this talk will share ideas on the effective implementation in residential developments.

Dr Karenne Tun
Director, Coastal and Marine Branch, National Biodiversity Centre, NParks

Dr Karenne Tun is the Director of the Coastal and Marine Branch at the National Biodiversity Centre, National Parks Board (NParks). She joined NParks in 2013, after an 18-year circuit within academia, non-profit organisation and private environmental consultancy, during which time she obtained her PhD from the National University of Singapore where she focussed on developing tools for coral reef monitoring and management. Karenne's interest in the marine environment was ignited as an undergraduate, where, over the years, her fascination turned to concern at their rapid decline, particularly within the region. Karenne subsequent work at NUS focussed on studying the impacts of anthropogenic activities on coral reefs, before moving onto coordinating coral reef monitoring efforts in the Southeast Asian region. Karenne's current work at NParks covers issues related to the management and conservation of Singapore's coastal and marine environment and the biodiversity they support. Her team is also responsible for managing Singapore's first Marine Park - the Sisters' Islands Marine Park, and works closely with the wider community to encourage responsible stewardship and sustainable use of the Marine Park to achieve the overarching objectives of conservation, outreach, education and research.

Topic: From Celestial to Cellular: A Multi-Modal Approach for Monitoring Singapore's Coastal and Marine Environment

Singapore's spatially limited coastal and marine areas are densely populated and heavily utilized by various industries including shipping, transport, petroleum, petrochemical manufacturing, aquaculture as well as non-industrial uses such as residential development and recreation. Combined, they place great demands on our natural coastal and marine areas. To ensure sustainable and long-term co-existence between various beneficial uses and nature conservation, Singapore has adopted the Integrated Urban Coastal Management (IUCM) framework; a holistic whole-of-government approach to planning and management of Singapore's coastal and marine spaces that is guided by evidence-based scientific research. With the development of new and advanced tools to help us understand and make sense of our environment, we are now moving towards the application of multi-modal approaches for monitoring Singapore's coastal and marine environment. From celestial to cellular, we are looking at integrating satellite tracking, visual and non-visual monitoring (acoustic and sonar), numerical modelling and molecular approaches to better monitor and manage Singapore coastal and marine environment, and this presentation will highlight some of our new initiatives.

Dr Nigel Goh
Director, Research, Centre for Urban Greenery and Ecology, NParks

Dr Nigel Goh has been Director of Research at the Centre for Urban Greenery and Ecology at the National Parks Board in Singapore since Apr 2018. He leads research on urban ecosystems, tree management, and greenery-related aspects of recreation and well-being.

For 4 years prior to this, he was Senior Advisor at the United Nations Development Programme's Global Centre for Public Service Excellence. While there, he wrote the booklet Detours, Dead-ends and Diversions: Singapore's Road to Development Reconsidered. His other international development policy focus was intrinsic motivation of public officials, an often-ignored aspect of performance effectiveness in developing countries; successfully launching in Jul 2017 a global study of intrinsic motivation in developing country public officials.

Nigel was also previously Director of Corporate Development and Director of Parks at the National Parks Board. In 2011, he led a major revision of the organisation's planning cycle, aligning divisional work plan formulation with budget and appraisal cycles. In 2008, as Assistant Director of the Coastal & Marine Environment Programme Office, he established a multi-agency initiative that strengthened Singapore's national/international capacity to address coastal and marine environment issues from policy and technical perspectives. During this time, Singapore established an internationally-recognised Integrated Urban Coastal Management approach to coastal management.

Nigel's professional experience started with academic research (more than 20 internationally peer-reviewed scientific papers) at the National University of Singapore (NUS). This was followed by work on commercial R&D in the pharmaceutical industry; following that, he headed collaboration and technology marketing around intellectual property created from research at NUS. He obtained his Ph.D. in marine ecology from NUS in 1996 and an MBA from the Nanyang Business School (Nanyang Technological University) in 2013.

RESILIENT INFRASTRUCTURE

Prof. Nemkumar Banthia
Civil and Mechanical Engineering, University of British Columbia

Nemkumar (Nemy) Banthia is a Professor and Senior Canada Research Chair at the University of British Columbia. He also leads the India-Canada Centre for Innovative Multidisciplinary Partnerships to Accelerate Community Transformation and Sustainability (IC-IMPACTS)—a Research Center of Excellence—as its Scientific Director and CEO.

One of the most cited researchers in the field of concrete materials and structures, Dr. Banthia has worked tirelessly to understand the performance of concrete structures under various conditions of loading and environment, developed numerous advanced ultra-high performance concrete materials with fiber reinforcement, devised innovative methods of laboratory and field testing, and developed novel sensors for structural health monitoring.Fellow researchers have cited Dr. Banthia's work over 10,000 times, he holds 8 patents, has published over 400 refereed papers, and edited 20 volumes. He serves on the editorial boards of seven international journals and is the Editor-in-Chief of Cement and Concrete Composites—a journal with the highest Impact Factor in the field. He is a fellow of the American Concrete Institute, Canadian Society for Civil Engineering, Indian Concrete Institute, Canadian Academy of Engineering, and the Royal Society of Canada.

Dr. Banthia's awards include: the Wason Medal of the American Concrete Institute; the Solutions Through Research Award of the BC Innovation Council; the Wolfson Merit Award of the Royal Society of the UK; the Killam Research Prize from the Killam Foundation; the Horst Leipholz Medal of the Canadian Society for Civil Engineering; the Mufti Medal of Excellence of the International Society for Health Monitoring of Infrastructure (ISHMII); and the Leadership in Science and Technology Award of the Drishti Foundation. Most recently, Dr. Banthia was awarded the Global Citizenship Award at the alumni UBC 2018 Achievement Awards in recognition of his work in improving the lives of marginalized, remote communities in rural Canada and India through the implementation of sustainable infrastructure innovations.

Topic: Digitalization of Infrastructure with Smart Materials and Sensorial Networks

The presentation will focus on smart materials and sensors as applied to infrastructure. Numerous sensors will be described along with results from some real life bridge structures where sensors are currently placed.

The presentation will further focus on the development of smart concrete with carbon fibers and carbon nano-tubes that possess both piezo-resistive and chemo-resistive properties, and can not only measure strains and detect cracking, but also pinpoint the location of a moving deleterious chemical front (such as chlorides and sulfates) such that the life cycle performance of the structure can be assessed. Finally, the presentation will describe the research challenges in the domain of Smart Infrastructure.

Dr. Yin Tiangang

Joint researcher, NASA Goddard Space Flight Centre and Earth System Science Interdisciplinary Center, University of Maryland

Tiangang Yin has been a joint researcher at NASA Goddard Space Flight Center (GSFC) and the Earth System Science Interdisciplinary Center at the University of Maryland since 2018. Prior to joining GSFC, he was a SMART SCHOLAR Postdoctoral Fellow at the Singapore-MIT Alliance for Research and Technology (SMART). He obtained his Ph.D. in Remote Sensing and Geoscience from the Centre d'Etudes Spatiales de la BIOsphère (CESBIO), University of Toulouse, France. Tiangang's research interests include 3-D reconstruction of vegetation and biophysical parameter estimation from airborne and terrestrial LiDAR, retrieval of solar induced chlorophyll fluorescence from remote sensing data, and 3-D radiative transfer modeling and energy balance of the Earth's surfaces coupling with atmosphere. Since July 2017, he has been a co-Investigator for Singapore NParks project "Remote sensing for urban tree management: species classification and health monitoring".

Topic: Monitoring urban trees using high-resolution airborne and satellite remote sensing imagery

Monitoring health and functioning status of urban trees are of great importance to Singapore in terms of understanding the inter-influences among urban vegetation ecosystem, anthropogenic activities, and regional climate change. The National Parks Board (NParks) has responsibility for the management of the urban green canopy in Singapore comprising more than 2 million planted trees. The current management practice involves inspections by arborists to maintain information on species diversity, tree health and ecosystem services. Our research objective is to investigate the alternative monitoring approaches by using quantitative remote sensing technology in parameterizing urban individual trees in terms of biophysical (e.g. leaf area), biochemical (e.g. chlorophyll content) and physiological (e.g. photosynthetic active radiation) variables. Nowadays, cutting-edge commercial satellite data (e.g. Worldview of Digital Globe) can cover city scale with sub-half-meter spatial resolution to isolate individual urban trees, but this advantage is accompanied by low spectral and temporal resolution and strong cloud coverage in Singapore. To overcome these challenges in interpreting satellite data, we are conducting an upscaling study. This study will be using ground-based terrestrial LiDAR scans (TLS), Unmanned Aerial Vehicle (UAV) coupled with hyperspectral imagery, combined with existing airborne LiDAR point cloud from the Singapore Land Authority. These higher resolution data will be used to investigate temporal changes in a broader set of parameters and vegetation indices that have been proposed as more accurate indicators of tree status. All retrieved parameters are linked using advanced 3-D physical radiation models to investigate the capability of various satellite data in monitoring urban individual trees located alongside roads and in parks. We are currently developing scientific software applications from remotely sensed data that can be used by NParks to monitor the health of the urban forest in Singapore. This project is led by Singapore-MIT Alliance for Research and Technology (SMART) and NParks in collaboration with CNES (France), NASA (USA), and Singapore-ETH Centre.
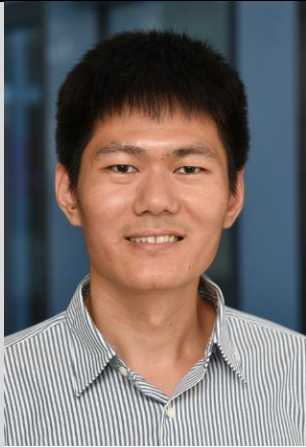
Dr Wang Fei
CEO, AeroLion Technologies Pte. Ltd.

Dr. Wang Fei is the CEO of AeroLion Technologies Pte. Ltd. (ALT), a high-tech spin-off company from the National University of Singapore (NUS). ALT's technical capabilities are built around its unique UAV GPS-less navigation technology, and the company's business activities focus on providing industrial UAV solutions for challenging GPS-less environments. Dr. Wang once also worked as research scientist in Temasek Laboratories @ NUS, being project manager of several UAV related projects. Dr. Wang received his B.Eng. degree with First Class Honors in the Department of Electrical and Computer Engineering, National University of Singapore in 2009 and Ph.D. degree in the NUS Graduate School for Integrative Science and Engineering. He has joined the NUS Unmanned Systems Research Group (NUSUAV) from his 4th year undergraduate study for his Final Year Project. Since then he had been actively working on UAV indoor navigation systems, and lead the NUSUAV team to participate in various international UAV competitions such as UAVForge hosted by Defense Advanced Research Projects Agency (DARPA) US, AVIC Cup - International UAV Innovation Grand Prix, hosted by the Aviation Industry Coporation of China, and The International Micro Air Vehicle Competitions (IMAV). NUSUAV had obtained several championships for these international competitions. He was also the recipient of the Guan Zhao-Zhi Award of the 33rd Chinese Control Conference.

Topic: UAV Application for Deep Tunnel Sewerage System Inspection Synopsis

Singapore's Deep Tunnel Sewerage System (DTSS) is a superhighway for the management of used water. Regular inspections and maintenance of the protection lining inside the deep tunnel sewers are key to prevent disruptions to its operations. However, the depth of the tunnel and its harsh environment makes it challenging for human entry to conduct manual inspections. AeroLion Technologies (ALT) has proposed a novel way to carry out this inspection. They have successfully automated a miniature unmanned aerial vehicle (UAV) to capture high-resolution images of the tunnel's internal wall. The UAV system, which can enter and exit the tunnel via manholes and drop shafts, can also precisely keep track of its position with respect to the shaft entrance and avoid contact with the flowing used water and its drag force. This development has solved challenging problems like GPS-less navigation in dark and geometrically singular environment, UAV miniaturization and reliability in harsh sewerage tunnel environment, etc. In addition, the same technology can also be used for many other industrial inspection problems in inaccessible environments.

Er. Dr. Johnny Wong
Chief Technology Officer/Senior Director (Research & Development)
Ministry of National Development

Group Director (Building & Research Institute)
Housing & Development Board

As the Group Director of Building & Research Institute (BRI), a research set-up under the Housing & Development Board (HDB) of Singapore, Dr Wong is responsible for leading HDB's efforts in spearheading innovative, cost effective solutions to create a better living environment and achieve greater sustainability.

Some of the initiatives which he spearheaded includes the development of a green roof tray system, HDB Smart Town framework, deployment of solar energy systems in public housing and connection systems for precast applications. Dr Wong was also instrumental to the development of a comprehensive development framework to guide the development of Punggol Eco-Town. In driving Singapore's Smart Nation agenda, Dr Wong co-chairs an inter-agency working committee to spearhead Smart town efforts, which aims to leverage smart technologies to make towns and estates more liveable, efficient, and sustainable.

Dr Wong graduated with a first class honours degree in Bachelor of Engineering in 1993 from the University of Sheffield, United Kingdom and obtained a Ph.D in Civil & Structural Engineering from the same University in 1997. With notable contributions to his field of work as a Professional Engineer, Dr Wong has been conferred several awards including the Henry-Boot Award, Laverick-Webster-Hewitt Award, the Institute of Civil Engineers Award and Public Administration Medal (Silver) for his contributions to the Public Sector. Dr Wong is a Board member of the Professional Engineers Board. He also serves as the Chief Technology Officer/Senior Director (R&D) in the Ministry of National Development, where he works to fulfil the Ministry's broader goals in driving technology R&D for the Built Environment.

Topic: Smart Urban Habitat – Enhancing Resiliency in the Heartlands

As Singapore's public housing authority, the Housing & Development Board has built over 1 million flats in about 10,000 residential blocks since 1960. These flats house more than 80% of Singapore's 5.3 million population within 24 towns. As Singapore matures as a nation, many challenges have also emerged – including climate change, ageing infrastructure, manpower constraints and changes in the social fabric.

To overcome these challenges, HDB actively researches and deploys new smart technologies and urban solutions across the entire development process – from planning all the way to operations & maintenance. By collaborating with government agencies, research institutes and the private sector, HDB is creating a Smart Urban Habitat in order to transform towns into a more liveable environment for residents. One of the key projects is the Smart Hub, an estate management system and a central data hub for the built environment. Through the capabilities of the Smart Hub – monitoring of estate services, application of AI and comprehensive urban analytics – HDB towns would be more efficient, resilient, sustainable and safe.

Dr Ang Choon Keat
Founder and Managing Director, Prostruct Consulting Pte Ltd

Er. Dr. Ang Choon Keat is the Founder and Managing Director of Prostruct Consulting Pte Ltd, a Singapore based professional engineering consultancy in civil and structural engineering, and specialised in the design and analysis of buildings and infrastructure to resist blast and other effects of weapons and explosions and safe storage of explosives. He is a registered Professional Engineer (Civil) in Singapore with two decades of experience in design consultancy and project management for building and infrastructure projects in the public and private sectors. He is also a registered Specialist Professional Engineer (Protective Security) in Singapore and provides blast consultancy for protective structures in both private and public sectors. He has a strong track record in analysing and designing of buildings and infrastructure to resist blast and weapons effects, including safe storage of explosives. Choon Keat is highly experienced in performing Security by Design (SBD) studies. His portfolio includes blast consultancy for transportation, social and community, data centres, military and police, healthcare, and industrial and infrastructure projects, in Singapore as well as overseas.

Choon Keat is also active in the Research and Development and Testing for protective structures. He was a member of international committees for experts in explosive safety and has collaborated with local and international partners from other technical agencies, universities and research centres on research into protective structures and explosive safety. He frequently shares his work in publications and speaking at conferences and seminars. Prostruct Consulting Pte Ltd is the only Testing Laboratory in Singapore accredited for the testing of building elements under blast loading.

Topic: Infrastructure resilience in an age of modern terrorism threat

The threat from terrorism to our society is at its highest level in recent years. Terrorist attacks frequently involved explosive devices or ballistic attacks. Vehicle bombs and homicide bombers with improvised explosive devices (IED), vehicle ramming, shooting and other physical attacks have become common mechanisms for terrorist attacks. Defending society against such rapidly evolving threats will remain a challenge throughout the 21st century. Any successful response to protect society from such incidents will require a well-planned, multi-layered approach that strikes a fine balance between assuring a nation's security and maintaining the freedoms that modern societies enjoy. Technology has and will continue to play a major role in these efforts, and innovative and comprehensive protective technologies must be developed to achieve this objective.

NEW SPACES

Er. Loh Yan Hui,
CEO and Global Lead, Aviation, Surbana Jurong Private Limited

Er. Loh Yan Hui is the CEO and Global Lead, Aviation at Surbana Jurong. He is responsible for developing the aviation business globally, including delivering on Surbana Jurong's Changi Airport Terminal 5 related projects. He is the Consortium Lead Representative of the Changi T5 Master Building Consultancy Engineering project and the Changi T5 Master Civil Consultancy project. He was also appointed to the SMEC Holdings Board since 2016 following the acquisition of SMEC by Surbana Jurong.

Previously as Surbana Jurong's Deputy CEO, Infrastructure, he directed and managed the operational activities of the Infrastructure business within Singapore and provides technical resources to the Group's overseas divisions to support infrastructure project procurement and deliveries. Er. Loh has more than 39 years' experience in the infrastructure industry and has been a registered Professional Engineer (Singapore) since 1990. He led a multi-disciplinary team of more than 600 staff in Surbana Jurong. Some of his key projects were the Waterway@Punggol, Singapore's first man-made major waterway that runs through the Punggol Eco-Town, the Pulau Tekong reclamation project, the North-Eastern Coast Phase 4 reclamation project, the Pasir Panjang Terminal Phases 3 & 4 reclamation project, Tuas Terminal Phases 1 & 2 reclamation projects, Jurong Region Line Package 3, etc. He has contributed in R&D projects and published technical papers in international conferences and journals.

Er. Loh currently serves as the Deputy Chairman of the Department Consultative Committee of the National University of Singapore's Department of Civil & Environmental Engineering. Er. Loh served as a member of the Singapore Team which played an important role in the resolution of the Pulau Tekong reclamation bilateral dispute with Malaysia, and the Technical Evaluation Panel for the 1st Sustainable Urban Living call for proposals under Singapore's Ministry of National Development (MND) Research Fund. Er. Loh was also a Reviewer for research proposals for the Marine Science Research & Development Programme (MSRDP).

Er. Loh was awarded the inaugural MND Minister's (Team) Award in 2006 for contribution as a member of the Singapore's "Settlement Agreement" team. He was also awarded the Ministry of Transport Minister's Innovation Award (Distinguished Award) in 2008 and 2011, and Ministry of Transport Minister's Innovation Award (Merit Award) in 2010 and 2011. He was a member of Surbana Jurong's teams that won the Top 50 Engineering Feats @ IES-SG50 Award 2016 for My Waterway @ Punggol and Pasir Panjang Terminal Phases 3 & 4 Development.

Prof Chu Jian
Civil and Environmental Engineering, NTU

Prof Chu Jian is the Director of the Centre for Usable Space and the Interim Co-Director of the NTU-JTC Industrial Infrastructure Innovation Centre, NTU. He is the Vice Chair for Technical Committee TC217 on Land Reclamation and a Committee Member for TC211 on Ground Improvement in the International Society for Soil Mechanics and Geotechnical Engineering. Prof Chu is a recipient of R. M. Quigley Award (2004) from the Canadian Geotechnical Society and the Outstanding Geotechnical Engineer Award (2018) from the Geotechnical Society of Singapore among other honours. He has delivered more than 60 keynote and invited lectures at international conferences. He is also an editor, associate editor, and editorial board member for nine international journals.

Topic: Visualising Underground GeoData in 3D

The Geotechnical Data Modelling and Management System (GeM2S) is a planning tool which planners and engineers can use to aid the conduct of site investigation works to better reduce ground conditions uncertainty, especially for deep underground projects. As huge amount of geological and geotechnical data has been collected from past development projects and this R&D project involved in developing a system to better utilise these data for future underground construction. The deliverable includes creating a 3D subsurface geology model of Singapore based on the borehole data collected. The user can use the GeM2S system and geology model to create virtual borehole and produce cross-section profiles at their interest site. In this way, the uncertainties involved in the design parameters for the ground conditions can be better managed and thus the design can be more reliable without being too conservative. A method will also be provided to allow the data to be transferred to a platform compatible with Building Information Modelling, so that the borehole data can be easily be used for construction projects. This will help further in reducing construction cost and increasing productivity. Making full use of these resources will save considerable amount of money and time for future project planning and construction.

Dr Zhang Yao
Division of Structures and Mechanics, NTU

Dr. Zhang Yao is currently a Research Fellow working in the Transport Research Center (TRC) at Nanyang Technological University (NTU), Singapore. He obtained his PhD from NTU in 2015. His BSc. and MSc. Degrees were both awarded by Tsinghua University, China. His research focuses on the structural health monitoring and condition assessment. He has worked on several research projects with LTA, SMI and other government agencies.

Topic: GIS based Lifecycle Durability Assessment of Underground Infrastructures

One of the challenges in maintaining the durability of underground infrastructure in large cities is the capturing, storing, retrieving and manipulation of relevant monitoring information regarding the underground structures. In the project "GIS-based Lifecycle Durability Assessment of Underground Infrastructures", various forms of data including crack, spalling and delamination, exposed rebar, efflorescence and leakage and chloride ingress, etc. are graded according to a proposed scoring system and combined using a weighting system in order to produce a relevant durability index. The durability index and time to action are then implemented graphically into a GIS map.

Prof Tan Kang Hai
Civil and Environmental Engineering, NTU

Prof Tan Kang Hai chaired technical sub-committees on development of National Application Documents on fire and accidental action effects on structures during the period of transition from the British Standards to Structural Eurocodes. His research work formed the technical basis of the circular from Singapore Civil Defence Force on "Fire Safety Design of Multi-storey steel-framed buildings with composite slabs" in 2017. He secured an MND fund to develop a safe and cost-effective design for Singapore's mega underground cavern developments in 2014. The research results in innovative design concepts for underground life safety and two technical disclosures for fire protection materials. He is one of the four steering committee members for the bi-annual Structures-in-Fire international conference series. He won a "Certificate for Highly Cited Research" in Engineering Structures in 2017. A registered Professional Engineer (PE) since 1996, he is on the HDB Civil & Structural Engineering Advisory Panel. He is also a registered PE with a specialisation on Protective Security (PE-PS). Currently, he is Deputy-Chair of IES for Technical Committee of Infrastructure Cluster. He represents NTU as a member of the National Standard Council, Singapore. He also represents IES in the FSSD Selection Panel for certifying Fire Safety Engineers. Prof Tan has given about 60 keynotes, seminars and invited talks, and delivered 90 professional short courses on reinforced concrete, steel and composite steel structures under both ambient and fire conditions.

Topic: Life Safety and Structural Fire Safety of Mega Underground Caverns in Singapore

The use of underground space frees up valuable surface land for housing and creation of green space for human centric activities. Nonetheless, there are some challenges for underground developments and one of which is to mitigate the effect of fire on safety of users and underground structures.

Prof Tan and his colleagues along with JTC, DSTA and SCDF, have undertaken a multi-faceted research programme to tackle challenges on fire safety for underground space, jointly supervised by Prof Aravind Dasari from NTU. The project encompasses two aspects – the design of active systems to combat propagation of smoke and the provision of adequate passive fire resistance for the underground structure to sustain post-flashover fire. The active systems comprise of early detection system, suppression systems, and engineered smoke control system. Suitable early-detection systems that are more sensitive to soot produced during burning are identified through numerical simulations that account for smoke movement and geometry of an underground cavern. Efficient fire suppression systems were proposed for specific occupancy to control fire development. An innovative zonal extraction strategy was proposed through numerical simulations to control the movement of smoke. This strategy does not rely on the extraction within the entire cavity and can even achieve perpetual tenability. The passive system consists of most advanced construction materials that have excellent fire resistance, such as fire-resistant ultra-high-performance-concrete (UHPC), geopolymer concrete, structural lightweight concrete with micro air-bubbles and carbon nano-fibers and engineered cementitious concrete (ECC). A noteworthy development is the research on fire-resistant coating.

Dr Adam Roberts

Senior Research Fellow, School of Mechanical and Aerospace Engineering, NTU

Dr Adam Roberts is a Human Factors psychologist with specialisation in neuro-ergonomics. For the past four years, he has been examining how environmental factors affect work performance. In the School of Civil and Environmental Engineering at NTU, he studied how underground spaces could affect workers. Prior to NTU, Adam was a postdoctoral research fellow at the Faculty of Linguistics, Philology & Phonetics, University of Oxford and worked in the Babylab in the Department of Experimental Psychology, University of Oxford. Adam received his PhD in Cognitive Psychology from the University of Sheffield in 2009, and his Masters in Neuroscience and Artificial Intelligence from the University of Manchester Institute of Science and Technology in 2004.

Adam has worked on projects relating to environmental effects on the brain and behaviour, speech and language perception, and brain-controlled adaptive automation. He has over 10 years of experience with psycho-physiological recording, including eye-tracking, EEG brain responses, and cardiovascular measures.

Topic: Human-Centric Underground Workspaces: Results of a multidisciplinary, multi-year study

With increasing population density in cities, underground space use in these cities is also on the rise. This can come in the form of more traditional underground facilities, such as water treatment plants and MRT stations, but also more diversified uses such as underground offices and data centres. As these novel underground workplaces are proposed, designed, and constructed, we need to take a human centric approach to ensure that workers are happy and healthy.

This talk will present an overview of the results of the latest and largest systematic interdisciplinary research examining psychological, social and health parameters of workers in underground spaces (UGS). Beginning with the general public's perceptions of and attitudes towards UGS, it will move on to discuss case studies of existing UGS around the world, a large scale Singapore workplace study comparing aboveground and underground spaces, and laboratory tests in simulated work environments. This research has wide-reaching implications beyond UGS into general indoor space design, where minor cost-effective solutions could dramatically improve worker performance.

Asst. Prof Darren Chian Siau Chen
Civil and Environmental Engineering Department, NUS

Dr. Darren SC Chian is an Assistant Professor at the Department of Civil and Environmental Engineering, National University of Singapore (NUS). He obtained his Ph.D. and B.Eng. (1st Class with Gold Medal) from Cambridge University and Nanyang Technological University respectively. His core research interests include ground improvement and field investigation.

In ground improvement, Dr. Chian is an enthusiast of recycling waste material to good use. He is actively involved in collaborative research projects with local government agencies to adopt unwanted soils from underground construction projects and dredging operations as land reclamation and construction fill materials. His experience and flair in physical modelling knowledge has also led him to excel in cement treated clay technology, where he has developed a state-of-art predictive strength development model considering a multitude of variables such as soil and cement types, mix proportions, curing duration and temperature and particle size of granular impurities. Machine learning adopting support vector machines, gradient boosted trees and random forest techniques has also been implemented which offers promising improvement in strength prediction robustness and efficiency. The model has now been adopted in the geotechnical ground improvement industry.

Dr. Chian's interest in field investigation stems from the post event reconnaissance training acquired under the UK's Earthquake Engineering Field Investigation Team (EEFIT) prior to joining NUS. Since then, he was fielded in the UK's Earthquake Engineering Field Investigation Team (EEFIT) and funded by the UK Engineering and Physical Sciences Research Council (EPSRC) to carry out disaster reconnaissance missions following the Mw7.6 Padang Earthquake in Indonesia 2009, Mw9.0 Great East Japan Earthquake in Japan 2011, and the Mw7.8 Musine Earthquake in Ecuador 2016, as a geotechnical specialist. In order to create greater impact to society, he performed feasibility studies with the use of remote sensing using satellite imagery for multihazard analysis of landslides following his reconnaissance mission to Sumatra, Indonesia shortly after the 2009 Padang earthquake. His interest continued at NUS where he developed remote sensing capabilities and conducted extensive field deployments at NUS campus and LTA construction sites, validating millimetre accuracy of his technique with measurements from precise-cut plates, deflection planks and land surveying.

Topic: Creating port land with re-cycled dredged and excavated materials

At the Next Generation Port at Tuas, millions of tons of clay and silt generated from dredging of seabed and excavation of land are filled into the reclamation of Tuas Terminal Phases 1 and 2. Re-cycling these dredged and excavated materials will ease our demand for offshore disposal spaces and reduce our dependence on sand imports. However, unlike sand, land reclaimed with these materials may creep more over time leading to ground deformation that appears only decades following the completion of the land reclamation. Moreover, the sensitivity of precision electronics in automated guided vehicles and automated cranes limits the settlement of

terminal pavements. The challenges of the heterogeneous nature of the reclamation fill originating from various parts of Singapore and stringent ground settlement requirements for automated terminal operations have not been studied elsewhere in such detail.

In this talk, Asst. Prof Chian Siau Chen Darren will be sharing the team's experiences on the MPA-NUS collaborative project and how future reclamation practices can adopt similar dredged and excavated materials as valuable resources for reclamation filling.

Dr. Chris R. Lawson
Managing Director, Ten Cate Geosynthetics Group Asia

Asst. Prof Chew Soon Hoe
Civil and Environmental Engineering Department, NUS

Chris Lawson is the Managing Director of Ten Cate Geosynthetics Group Asia. Chris received his Engineering Degrees from The University of New South Wales, Sydney, Australia. He has worked in the field of geosynthetics for 40 years in Australia, Europe, North America and Asia. During this period, he has served on a number of international organizations developing Standards and Codes of Practices for geosynthetics and geosynthetics structures. Chris has acted as technical advisor on many large scale geosynthetics projects in the field of embankments, reinforced soil techniques, coastal, hydraulic and environmental engineering structures in many countries, including Singapore. He is the author of over 50 technical papers on geosynthetics, geotechnical engineering, mining and hydraulic and coastal engineering.

Dr. Chew Soon Hoe, is currently an Assistant Professor with the Department of Civil Engineering, National University of Singapore. He was the Deputy Director of the Centre for Protective Technology (CPT), a research and development centre jointly formed by the Ministry of Defence, Singapore, and NUS.

His research interests include geosynthetics, slope engineering, land reclamation, soil improvement, deep excavation in soft soils, numerical modeling in geotechnical engineering, geo-environmental engineering and geological engineering. He is actively involved in research and consultancy relating to various applications of geosynthetics in Singapore and this region. Specifically, he was involved in the use of geotubes in Pasir Panjang Port Extension Project, use of geobags in east coast beach restoration project, use of geotubes and geobags in Kuching, Malaysia, waterfront restoration project, as well as the larger scale trial study including geotubes in Tekong reclamation project.

Dr Chew published very extensively on soft clay and ground improvement related topics. He was awarded "Defence Technology Prize", from Chief Defence Scientist, Ministry of Defence, Singapore in 2006. He was also the recipient of the "Minister Innovative Awards" from Ministry of Transportation, 2011, on his "innovative use of geotube filled with cement mixed soft clay". He was also awarded with "Friends of Waters" by PUB, the water agency in 2013. He latest awards is "2015 Minister's Awards (Team)" by the Ministry of National Development on the project supporting the HDB team of engineers on "Reuse of soft clay for infilling works at Pulau Tekong".

He was a council member of the Institution of Engineers, Singapore, IES 2006-2018. He is also currently the President of Southeast Asia chapter of International

Geosynthetics Society (IGS), and the president of Singapore Chapter of American Society of Civil Engineers (ASCE). Dr Chew was appointed to be member of HDB's Civil & Structural Engineering (CSE) Advisory Panel for Mar 2016 to Feb 2018, and re-appointed for Mar 2018 to 2020 Feb.

Topic: Geosynthetics in coastal structures: Applications in Singapore

Geosynthetics have been used in Singapore for many years. For example, the construction of Changi Airport in the early 1980's used geosynthetics. Since that time geosynthetics in conjunction with sand and rock have been used in all of Singapore's reclamation projects. While sand and rock fill are ideal construction materials, of recent times, they have become a scarce and expensive resource for reclamation projects in Singapore. So much so that alternative fill types are actively pursued. Examples include the use of construction and tunnelling spoil and locally available dredged fills. However, these fill types can suffer from poor gradation, low and variable shear strength, poor drainage and high compressibility. Innovative geosynthetics structures have been used in conjunction with these fill types to construct stable land reclamation fills and edge dykes. The presentation reviews the development of these innovative solutions in Singapore.

Dr. Zhandos Y. Orazalin
Post-Doctorate Associate, Singapore-MIT Alliance for Research and Technology (SMART), Singapore

Dr. Zhandos Orazalin received the Bachelor's degree in Civil Engineering from Karaganda State Technical University, Kazakhstan and the Master of Science (SM) and Doctor of Philosophy (PhD) degrees in Civil and Environmental (Geotechnical) Engineering from the Massachusetts Institute of Technology (MIT), USA. He is currently a postdoctoral associate at the Singapore-MIT Alliance for Research and Technology (SMART). Dr. Orazalin's research is focused on a comprehensive cloud-powered construction analytics platform that integrates the real-time monitoring data (from wireless sensors, in-situ testing devices and unmanned aerial vehicles) with advanced geotechnical models to design, control and monitor the urban underground construction in a smart way.

Topic: Advanced geotechnical instrumentation and monitoring for land reclamation

This presentation will cover the background on modern geotechnical instrumentation and monitoring for land reclamation using advanced wireless sensors integrated with the state-of-the-art geotechnical models of ground performance via the cloud-powered construction analytics algorithms.

The main challenges of urban construction in reclaimed land relate to construction safety and the impacts of construction on neighbouring infrastructure (buildings, utilities, and others), as well as expensive ground improvement to control ground movements. Even though most construction sites are equipped with traditional geotechnical instrumentation, the collected data is delivered in a piecemeal fashion such that it is difficult to interpret the overall performance of the constructed system. The measured data is also decoupled from the offline computational model predictions of expected performance. In short, there is a lack of information for supporting construction management decisions. The main idea of the proposed solution is the reduction of risks and costs during urban construction through a comprehensive cloud-based analytics platform that integrates the instrumentation data with advanced numerical models of ground performance in near real-time. The automated input data sources include the conventional geotechnical instrumentation and the novel hardware solutions such as wireless sensors, in-situ testing devices and unmanned aerial vehicles. The online platform enables designing, controlling and monitoring of underground construction in a smart way through a user-friendly web-interface. The presentation will summarize the system design, the development process and the lessons learned during the proof-of-concept application of this platform on a real construction project in Singapore that included a complex excavation with temporary earth support systems.

Mr Chua Kok Eng
Director (Infrastructure and Reclamation), HDB

Mr. Chua Kok Eng is the Director of Infrastructure and Reclamation Department, Building & Infrastructure Group of Housing & Development Board (HDB). He oversees the department in its work to lead the planning and implementation of infrastructure projects to support the HDB building programme and land reclamation projects to meet national strategic objectives to create new land for development. Since 1980, he has dedicated his service to HDB—first in Civil Engineering Department and then to Research and Planning Department before his current position. Throughout his years of experience in managing infrastructure and land reclamation projects, Mr. Chua has been leading the Pulau Tekong land reclamation, Changi East land reclamation and the Polder Development, which have contributed to an increase in Singapore's land stock today. Mr. Chua's leadership has led his teams to clinch esteemed accolades for levering on innovation to overcome engineering challenges. Two such awards are "Top 50 Engineering Feats @ IES-SG50" for My Waterway @ Punggol and "Energy Globe National Award 2018" for Reuse of Excavated Earth for Infilling Works through Smart Staging Grounds. Given his commitment to develop engineering competency and productivity within land reclamation, Mr. Chua currently participates actively in various Agency Committees.

Moderator for Panel Discussion (Session B: Land Reclamation)