ANNEX

Highlights of "Underground: Singapore's Next Frontier" exhibition

A) Why we go underground

Going underground expands our space resources by **making better use of our land** and freeing up valuable surface land for more liveable uses. This **improves the quality of our living environment** with more land for greenery, homes and community spaces.

Underground pedestrian links and MRT lines **enhance connectivity and accessibility** for commuters, allowing them to travel in safe, all-weather comfort regardless of external conditions.

Besides these, dedicated underground tunnels for utilities and infrastructure can **increase resilience** for these networks by providing a safe, secured and controlled environment for the installation, operation, maintenance and replacement of the networks.

B) Underground benchmark study

URA commissioned Arup Singapore to do a study that took stock of Singapore's journey in using underground space, and benchmarked how 10 cities, including Hong Kong, Helsinki, Tokyo, London, and Seoul compare with Singapore based on 2014 data.

Singapore was found to be at the forefront for underground rail development, with rail density[1] slightly ahead of London and behind Tokyo. However, Singapore had the lowest density for underground pedestrian links among the leading cities developing underground pedestrian networks, and was behind Hong Kong and Tokyo for underground road density.

As Singapore currently only uses underground cavern space for storage, the study suggested that Singapore consider learning from other cities which had made use of cavern space for other uses such as utility plants, and data centres.

A fuller summary of the benchmark study can be found online at https://ura.sg/underground.

[1] Density is defined as route length per unit of metropolitan area.

C) Upfront planning of underground space

As with many other cities, underground space in Singapore has been developed largely on a first-come-first-served basis. An integrated, upfront planning approach will improve the efficient and effective use of underground space.

Upfront planning of above ground and underground space ensures compatibility of uses, integrates supporting structures with their surroundings, and safeguards underground space for the future.

For example, upfront planning for basement connections to complement street-level activities can create a seamless pedestrian experience and enhance connectivity.

Planning in 3D

Unlike conventional land use planning, underground space cannot be seen from the surface. 3D technology is used to visualise the underground space. This is particularly important in areas with extensive and complex underground infrastructure.

Accurate 3D information can also be used to facilitate the industry's design and planning work, such as ensuring the proposed design complies with underground planning controls and requirements.

Several types of technology are used to integrate spatial and engineering information to generate and analyse the 3D underground information.

<u>Building Information Modelling (BIM)</u>
BIM is a digital representation of the digital and functional features of a facility, and is used in the entire life-cycle of a facility, from the design and construction to facilities management.

<u>Geospatial Information System (GIS)</u>
GIS specialises in capturing, managing and analysing multiple layers of spatial and geographic data, and is widely used in land use planning.

D) What lies beneath

Singapore is made up of five major types of rock and soil formations as well as reclaimed land. These formations have varying levels of hardness and strength, which affect the amount of structural support required and the suitable uses for underground developments.

The Building and Construction Authority (BCA) is developing a 3D geological model that will show these geological formations in more detail.

Ground investigation works

Different construction methods and structural designs are used for underground developments depending on existing ground conditions. As these affect the cost and time required, detailed ground investigation is needed before any design or construction work for underground spaces is carried out.

Various types of ground investigation works are used to investigate our underground space. Borehole drilling is the most common method used, but the industry is also making use of more innovative methods to overcome the shortfalls of borehole drilling.

Identifying suitable areas for caverns

Singapore is using underground cavern space for storage of ammunition and oil. Caverns are preferably situated within strong rocks.

URA is developing a Cavern Suitability Map to show the preferred types of cavern uses in suitable areas, based on the above ground uses.

E) Improve management of shallow utility lines

Many cities have an extensive and complex network of utility lines in their shallow underground space, especially under roads. Proper management and organisation of these lines will ensure that services to homes and businesses are not disrupted and that the laying and maintenance of these lines can be carried out safely, with minimal disruptions to the environment.

In some instances, utility lines can be better organised by housing them within a Common Services Tunnel, such as the one in Marina Bay, or a Common Services Duct, for smaller-sized cables.

While processes can be improved to better manage newly-laid utility lines, there is also a need to ensure consistency with existing utility lines and establish a complete picture of our underground utility space. This can be done by exploring new non-invasive technologies to survey existing utility lines and progressively mapping out existing utility lines during road opening works.

F) Implementing underground projects

The exhibition showcases underground projects that use innovative methods and technologies to minimise disruptions to the public and boost productivity during construction.

Minimise disruptions

The use of a Tunnel Boring Machine instead of the cut-and-cover method reduces disruption to surface activities while tunnelling works are carried out. Examples of such projects include Stamford Diversion Canal, and the underpasses at the Thomson-East Coast Line's (TEL) Havelock and Stevens stations.

A new construction technology known as ground freezing will also be used for the first time for the construction of the TEL's Marina Bay station. As part of the process, ice walls will be used to stabilise the soil and prevent water seepage to protect existing MRT tunnels above while tunnelling works are in progress below.

Boost productivity

Automation and mechanisation can result in higher productivity growth and reduced human errors during construction and maintenance of underground developments.

Jurong Island-Pioneer Cable Tunnel
SP Group devised a Railed Gantry Crane and Hydraulic Lifting System to erect the centre partition wall for a section of the tunnel. This resulted in significant time savings compared to the usual forklift method. The cable tunnel also uses Automatic Inspection Vehicles to capture images of the tunnel which are then processed by video analytics to detect any abnormalities.

An efficient information sharing system also improves overall work process and facilitates coordination.

East Coast Integrated Depot
The use of Building Information Modelling (BIM) technology helps to identify and communicate potential risks through a virtual environment before physical construction. The project team used BIM as a design and management tool to collect, store and optimise the use of information throughout the project life cycle.

Deep Tunnel Sewerage System (Phase 2)
To ensure a safe construction environment, the Shaft and Tunnel Excavation Monitoring System is used to manage the data collected from excavation works for monitoring, analysing and planning uses. The system monitors key parameters which provide early notification to the engineer, allowing timely decisions to be made to

ensure construction safety. Compared to conventional methods, the system will save more than half the manpower needed to monitor and analyse the construction data.