URBAN REDEVELOPMENT AUTHORITY

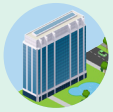
ARUP

UNDERGROUND DEVELOPMENTS

A benchmarking study to explore international best practices in underground space management

MORE SPACE TO LIVE, WORK AND PLAY

Under the Land Use Plan 2030, the Ministry of National Development has allocated and safeguarded Singapore's surface land space for a number of uses – industrial, infrastructure and utilities, which take up substantial land as follows:



17% Industry and commerce

13% Transport infrastructure

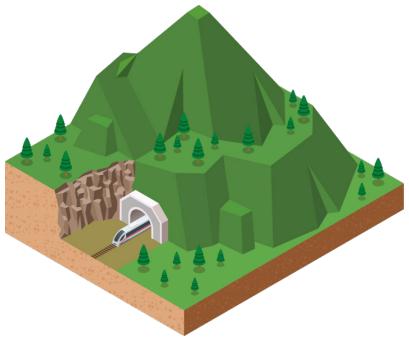
3% Utilities

To meet the many and growing needs of our urban environment, some of these uses could be moved below ground. The idea is not to put homes or offices underground, but to use the underground space for infrastructure such as rail lines, utilities, warehousing and storage facilities. At the ground level, the land that is freed up would then be used for housing, community uses and greenery. By tapping on this valuable resource, we can improve the quality and vibrancy of everyday life in Singapore.

UNDERGROUND DEVELOPMENTS AROUND THE WORLD

Globally, underground spaces have been widely used to house industry, utility and transport infrastructure in the heart of urban areas, to reduce their negative impact on city living. Good planning and implementation approaches have been instrumental to the success of these underground developments. We have looked at ten locations around the world to see what we can learn and apply to underground development in Singapore.

WHY CITIES GO UNDERGROUND



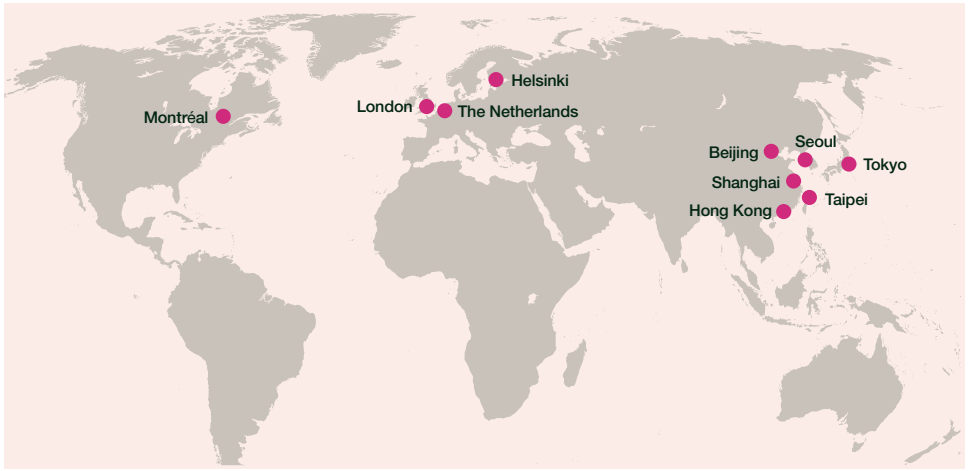
Topography and geology

The hilly and mountainous terrain in Hong Kong lends itself naturally to underground development, particularly of rail and road tunnels. With these physical conditions it can be more economical to go through steep terrain, rather than over or around it. Favourable geology such as the availability of high quality rock at or near the ground surface in both Helsinki and Hong Kong lowers the cost of creating underground cavern facilities.

Climate

For cities like Helsinki and Montréal, climatic conditions are the main drivers for underground space development. Extremely cold winters in these cities make travelling outdoors inconvenient and uncomfortable. This has driven the creation of extensive Underground Pedestrian Networks (UPNs), allowing people to commute comfortably despite the harsh winters. The same can be applied to tropical climates like Singapore's, where underground space can be a refuge from heavy rainfall or hot and humid conditions.

TEN BENCHMARKED LOCATIONS



Land shortage

Driven by land shortage and rapid urbanisation, underground space is valued as additional developable space to meet urban needs. High land prices resulting in higher development costs have driven Asian cities such as Tokyo, Hong Kong, Seoul, Shanghai, Beijing and Taipei to explore expanding the use of their underground spaces.

WHAT GOES UNDERGROUND

The benchmarked locations present learning points for ways to plan, build and make use of underground space.

UNDERGROUND INFRASTRUCTURE

Rail

Many cities put rail infrastructure underground. **Seoul** has the greatest extent of underground urban rail with over 400km of rail below ground.

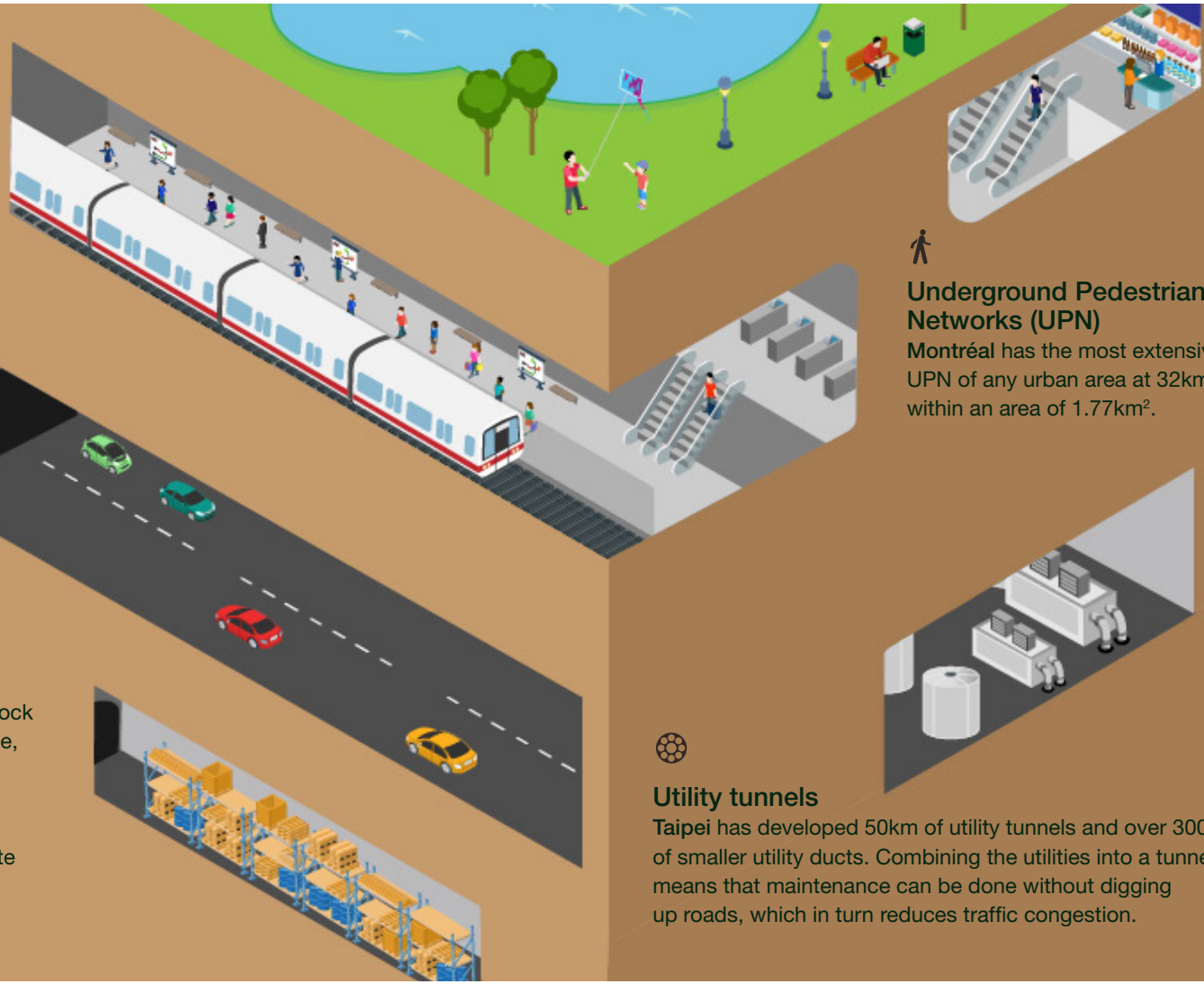
Roads

By locating 15% of its urban expressways below ground, noise and air pollution effects in **Tokyo** are reduced. In addition, the expressway no longer creates a physical barrier between neighbourhoods.

Caverns

Helsinki has the most extensive use of underground rock caverns globally. Usage cuts across commercial space, car parking, transport infrastructure and utility plants.

Hong Kong has developed several successful cavern projects, including a waste transfer station and a waste water treatment facility.



Underground Pedestrian Networks (UPN)

Montréal has the most extensive UPN of any urban area at 32km within an area of 1.77km^2.

Utility tunnels

Taipei has developed 50km of utility tunnels and over 300km of smaller utility ducts. Combining the utilities into a tunnel means that maintenance can be done without digging up roads, which in turn reduces traffic congestion.

UNDERGROUND DEVELOPMENTS IN SINGAPORE

Over the years, underground spaces in Singapore have been developed to house shopping malls, carparks, transport infrastructure, pedestrian links and utility infrastructure. This benchmarking study provides a platform to learn from global best practices so that we can better utilise Singapore's underground space.

UNDERGROUND INFRASTRUCTURE AND KEY MILESTONES

Rail

Singapore has one of the world's densest rail networks, coming behind Tokyo. Out of 180km of urban rail, 82km are located below ground. Singapore continues to invest heavily to extend its rail network across the island.

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1987
North-South Line and East-West Line
Singapore's first MRT tunnels

2003
North East Line
Singapore's first fully underground MRT line

2010
Circle Line
Bras Basah Station features the longest escalator in the whole MRT system

Kim Chuan Depot
World's first underground train depot

Roads

Nearly 10% of Singapore's expressway network is located below ground, including the KPE, CTE, MCE and the future North-South Corridor.

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1989
Central Expressway
Chin Swee Tunnel and Kampong Java Tunnel are Singapore's first road tunnels

1996
Woodlands Bus Interchange
Singapore's first underground bus interchange

2008
Kallang-Paya Lebar Expressway
Southeast Asia's longest underground road tunnel

2013
Marina Coastal Expressway
Singapore's widest road tunnel

Caverns

Singapore has two major cavern developments, the Underground Ammunition Facility and the Jurong Rock Caverns which can hold about 1.47 million cubic metres of crude oil and petroleum. There is currently no comprehensive plan to identify potential cavern sites.

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2008
Underground Ammunition Facility
Singapore's first cavern development

2014
Jurong Rock Caverns Phase 1
Singapore's deepest underground development

Underground Pedestrian Networks (UPN)

Singapore's UPN are mostly concentrated in the Central Business District and Orchard Road shopping district. Further plans to extend the networks within the core city areas have already been drawn up.

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2000
CityLink Mall
Singapore's first underground shopping mall

2013
Marina Bay Link Mall
Expanding Singapore's underground pedestrian network in the Marina Bay area

Utility tunnels

Singapore has developed the Common Services Tunnel in the Marina Bay area and will study the use of such tunnels for other green field development areas.

Utility plants

Around the world, utility plants have been located underground. Singapore has successfully implemented underground district cooling plants in Marina Bay, with scope to locate more plants underground.

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2008
Labrador-Harbour Cable Tunnel

Deep Tunnel Sewerage System Phase 1

2008 - 2014
Marina Bay Common Services Tunnel
Southeast Asia's first multi-utility tunnel

UNDERGROUND PLANNING AND MANAGEMENT

Some cities have developed and implemented ways to better manage the use of underground space. These are compared with current practices in Singapore to identify ways that we can improve.

PLANNING AND MANAGEMENT ACROSS BENCHMARKED CITIES AND SINGAPORE

Data

Hong Kong provides and maintains a publicly accessible online database of building records, geological data and a geotechnical library for underground planning.

Helsinki has developed a centralised data and information support system focused on underground data that dates back to 1956. Updated data is accessible to all interested parties online.

Across cities in the Netherlands a single, independent public agency was appointed to be responsible for the land registry, land boundaries and mapping of utility lines. Standard data formats developed, resulted in readily available utility data to developers.

In **Singapore**, information on underground spaces is not readily available. As with a number of other cities, a common challenge in obtaining accurate underground data makes it difficult to plan and construction uncertain.

Public Private Partnership (PPP)

Montréal has successfully implemented its UPN in partnership with the private sector. Incentives and planning requirements are used to encourage developers to connect to the network and ensure its success.

Tokyo has developed ways to partner the private sector in underground development. In the Marunouchi District, town management committees including local stakeholders are formed to promote underground development and ensure the space is attractive to users.

Due to higher costs and risks in **Singapore**, the private sector is often not keen on developing underground spaces. Cash grants, gross floor area discounts or waivers and planning conditions are incentives created to encourage underground developments. Currently, the perception of higher costs and development risks still remains.

Planning

Hong Kong has undertaken extensive studies of potential underground space use. This has culminated in the Strategic Cavern Suitability Maps guiding the development of rock resources for cavern uses.

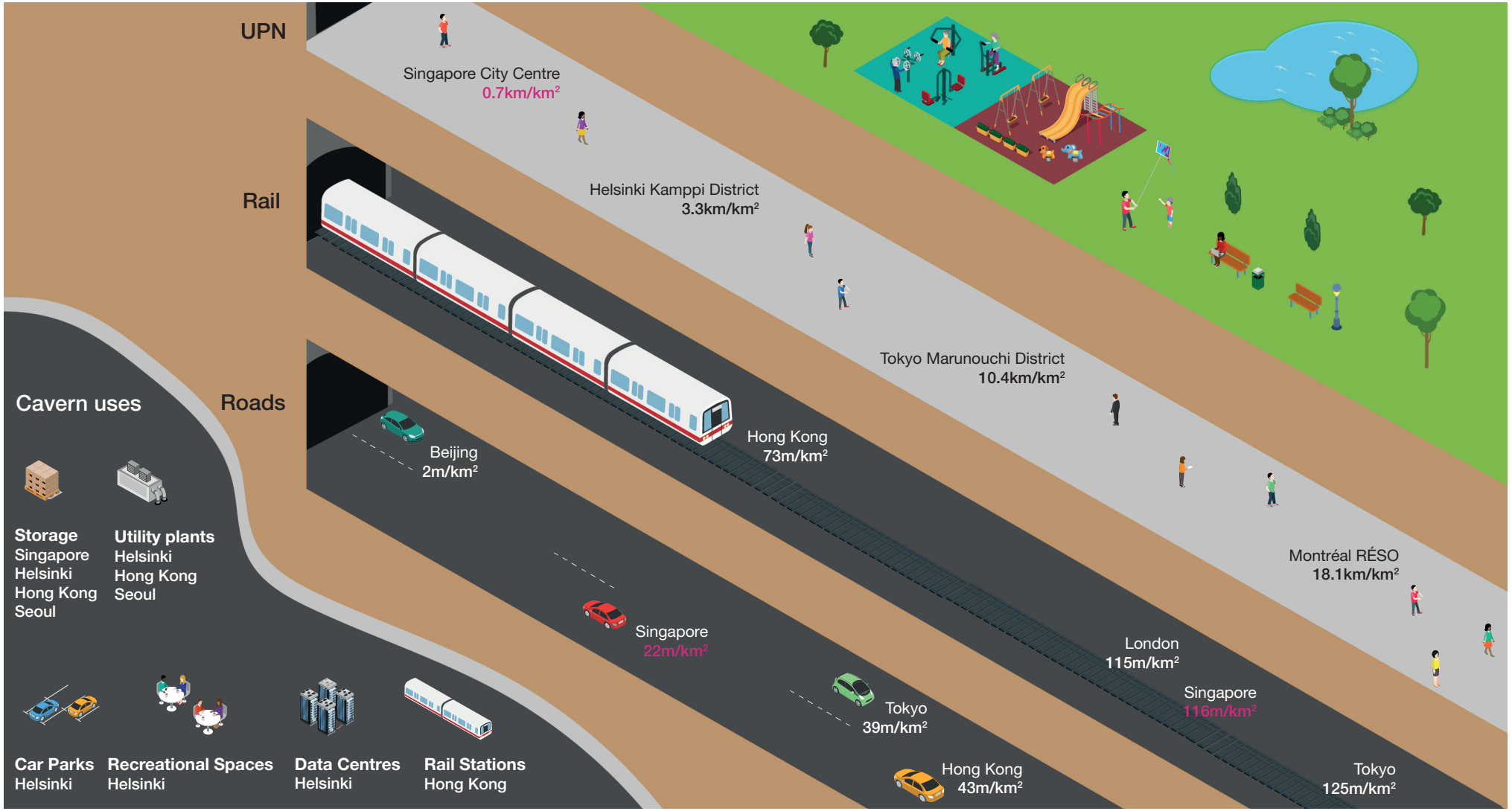
Helsinki has developed the world's first underground master plan guiding and shaping how underground space could be developed and used.

Singapore has a well-developed above ground master plan and UPN plan. However, other underground developments are generally planned on a more ad-hoc, first-come first-served basis.

WHERE SINGAPORE STANDS

In comparison to top benchmarked cities, we look at the extent of underground development in Singapore and where we stand in each category.

UNDERGROUND INFRASTRUCTURE

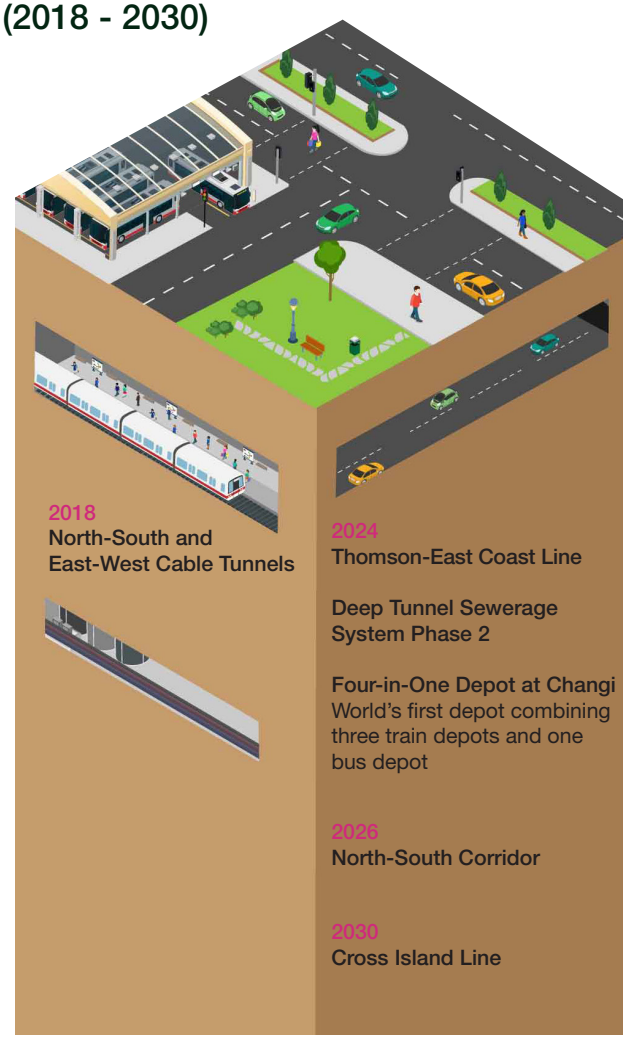


Based on 2014 data

WHAT'S NEXT FOR SINGAPORE

Singapore is exploring greater use of its underground space to further optimise land use and provide capacity for future needs. Where it is feasible and meaningful, going underground would be the approach to optimise land use and improve the quality of our living environment. In general, the shallow levels of the underground would be used for people-centric activities that require connectivity to above-ground; while the deeper levels would be used for utilities, infrastructure, storage and logistics uses.

UPCOMING DEVELOPMENTS (2018 - 2030)



Rail, Roads, Underground Pedestrian Networks (UPN), Utilities and Caverns

Prioritise underground space use for support infrastructure

On top of expanding its underground transport infrastructure and utility networks, Singapore is actively studying new and innovative ways to develop the underground space. These include:

- Planning for infrastructure and industrial uses in rock caverns to create more space
- Creating an underground goods mover system to reduce the number of heavy vehicles on roads
- Placing utility plants underground to optimise the living environment.

International best practices

Data

More accurate and accessible underground data

Underground development is associated with higher uncertainties and risks due to the lack of information on what lies beneath the surface.

Across cities in the Netherlands and in Helsinki and Hong Kong centralised platforms have been established, each with a feedback system in place to collate and share building, geological and utility data.

Singapore's Building and Construction Authority is developing a 3D geological model that will be collated into a central database for underground space planning. There are plans to collect accurate data of underground structures and utilities as well.

PPP

Public and Private Partnership to realise underground development

While developing underground can be costly, we can achieve successful and meaningful underground projects through PPP and innovative development models.

In Montréal and Tokyo, an incentive framework for the private sector has been adopted to encourage the creation of pleasant underground space.

In Singapore, new project implementation models and incentive structures can be explored to provide avenues for meaningful underground development to be realised. There is also potential to tap on R&D and new technology to make underground development more cost-effective.

Planning

Organise and reserve underground space for future development

Early planning of well-integrated above and underground developments – such as Helsinki's underground master plan – is critical to ensure maximised use of spaces available. Hong Kong has also developed cavern map and guidelines to safeguard and implement cavern development.

Singapore has an extensive UPN plan for the city area. The Urban Redevelopment Authority is taking steps to enhance planning by developing a 3D underground master plan. Some other steps include:

- Organising underground space into shallow, deep and cavern layers, with people-centric activities in the shallow layers, and infrastructure and utilities in the deeper layers
- Identifying and safeguarding areas with potential for cavern development

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