

Spatially Enabled Future Cities

Victor Khoo

Senior Deputy Director

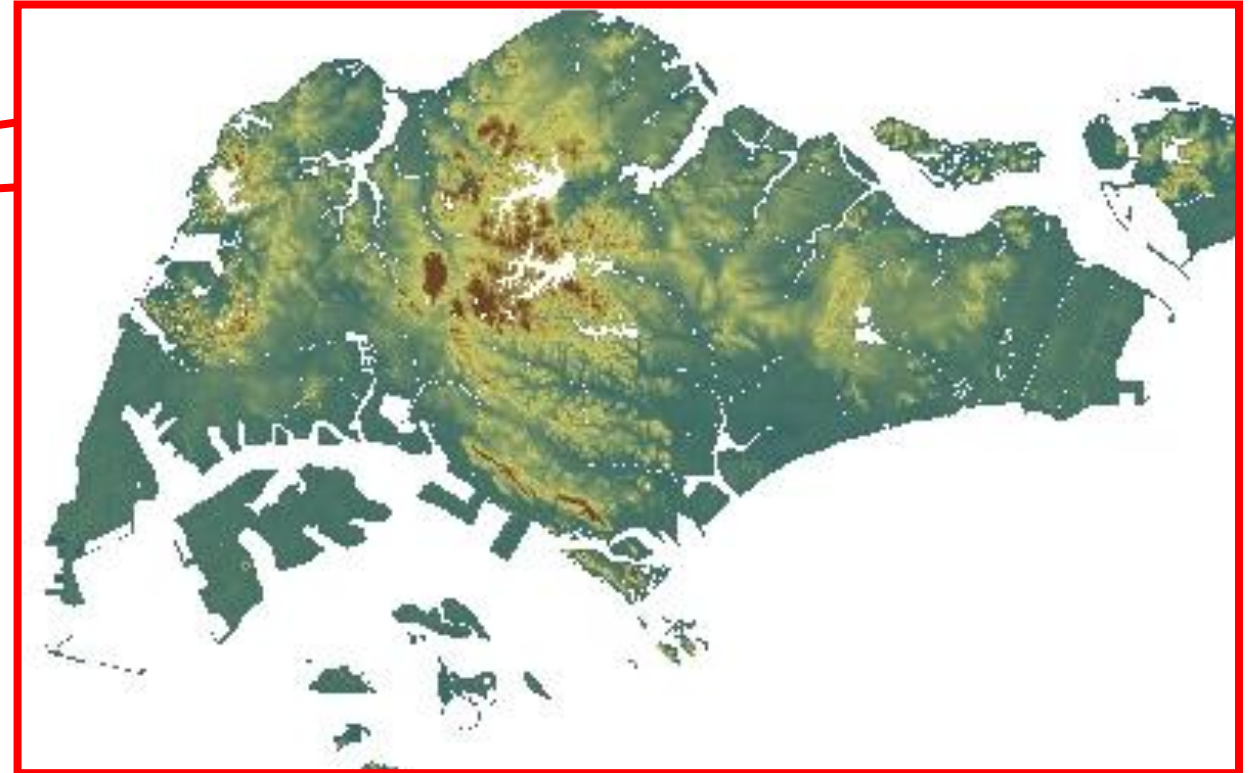


United Nations World Geospatial Information Congress

The Geospatial Way to a Better World



Singapore



Source: Google

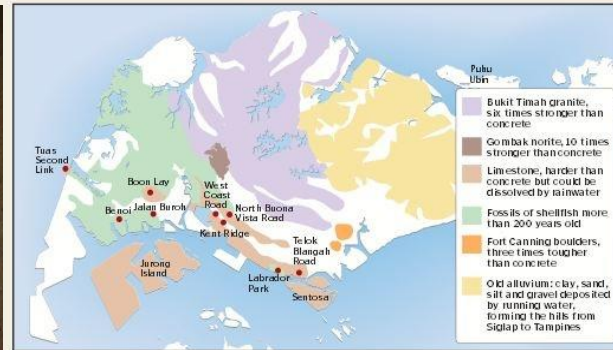
Creating Space Above and Below



Industry Space Above Roads



Underground Mall



GOING UNDERGROUND

Singapore has many different types of rocks under its surface, from granite and norite, which are much harder than concrete, to limestone, which could be dissolved by rainwater. Here are some of the rock formations and a snapshot of Singapore's underground projects.



Jurong Rock Caverns

Singapore's Underground Initiatives

Legislative Change to Facilitate Future Planning and Development of Underground Space

Subterranean development guidelines to be drafted

URA tender seeks consultants to craft framework on underground space use

By ROYSTON SIM

THE Urban Redevelopment Authority (URA) plans to develop a set of guidelines on subterranean development here, in a step towards creating an underground master plan.

It has called a tender seeking consultants to "develop a comprehensive and holistic framework to enable more extensive use of underground space in Singapore".

The URA said this will help steer future decisions on land use and safeguard areas for potential underground developments.

It said the recommendations and guidelines will also guide the preparation of an underground master plan to "dovetail" with the current land use master plan.

The latter sets out how much needs to be built to efficiently spread the population across the island.

Development Minister Khaw Boon Wan wrote in his blog that there is scope to do much more in terms of using underground spaces here.

He mooted the possibility of an underground equivalent to the master plan to complement developments above ground.

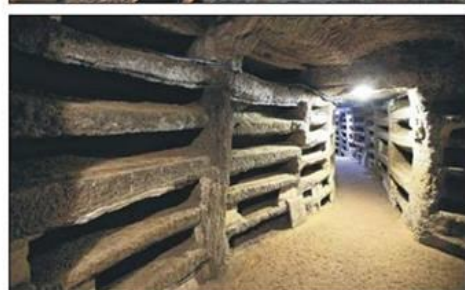
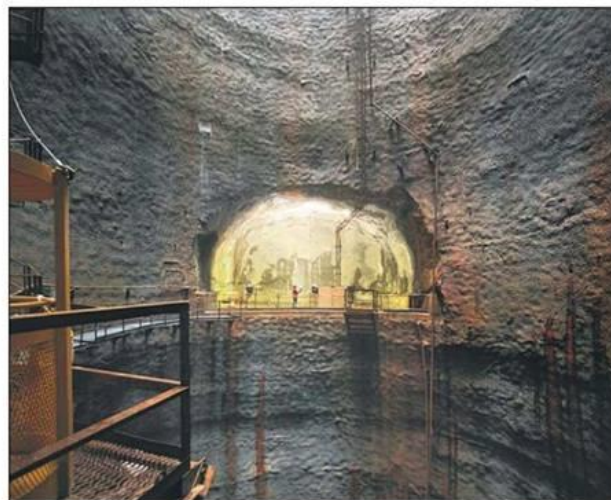
Before developing guidelines for the URA, the consultants will have to research case studies and the best practices of underground developments around the world.

They will also review all the past studies on the subject done in Singapore and benchmark the Republic's use of subterranean spaces against other cities.

Mr Khaw had cited underground city Reso in Montreal, which is used by 500,000 people daily and boasts offices, hotels, cinemas and even universities.

In Scandinavia, swimming complexes, concert halls and churches have also been built below the surface.

The study should also look at



Jurong Rock Caverns (above), which is used to store petrochemicals and oil, and the catacomb of Priscilla (left) in Rome, which was used by Christians as a cemetery from the second to the fourth century, are two examples of the use of underground spaces.

PHOTOS: JTC, REUTERS

the extent to which basement structures are currently used for carparks and malls and how much key infrastructure such as the MRT is housed beneath the earth.

Using examples from overseas, consultants should provide recommendations and set guidelines on using underground spaces.

- How to identify locations to build underground;
- Integrating developments above and below ground; and
- Legislation mandating developers to go underground.

The URA also highlighted several challenges in implementing underground projects here, such as high costs and a lack of proven uses of deep cavern space.

In terms of underground pedestrian links, there is a lack of incentive to build these connections and building owners are reluctant to do so, it noted.

Experts here have also cited the varied nature of Singapore's rock and soil formations as another challenge.

Existing subterranean developments here include the Jurong Rock Caverns, which store petrochemicals and oil.

There are also plans for an underground science city beneath Kent Ridge Park.

Mr Lim Peng Hong, who owns engineering firm PH Consulting, said studies on underground use have been done before.

However, this latest one mooted by the URA is more comprehensive.

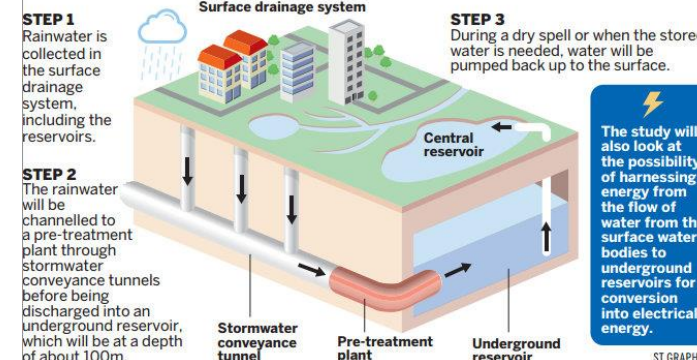
The higher cost of going underground must be weighed against the benefits, he said.

He added that the psychological impact of working or doing activities underground must also be considered.

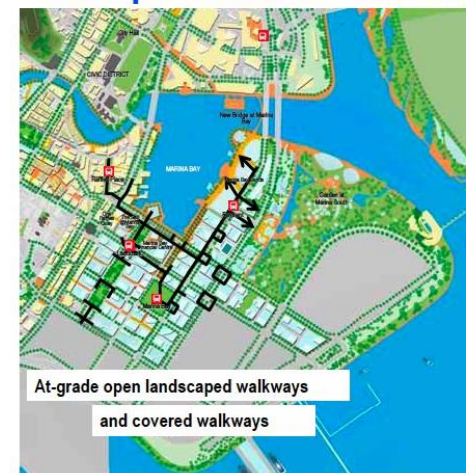
"That's probably why the URA wants to look at best practices, at how other countries are using the space and how they make it more acceptable to people."

Going underground

PUB is exploring the possibility of using underground space for drainage and water storage to help Singapore overcome the effects of climate change, such as more intense rain and prolonged dry spells. A tender for a feasibility study will be called in the coming months.



Comprehensive Pedestrian Network



Above-grade & underground pedestrian links



Singapore Land Authority (SLA)

VISION

Limited Land • Unlimited Space

MISSION

To optimise land resources for the economic and social development of Singapore



Developmental:

- Optimisation of State Land and Properties (generation of revenue for government)
- “Gatekeeper” for land use in Singapore



Regulatory:

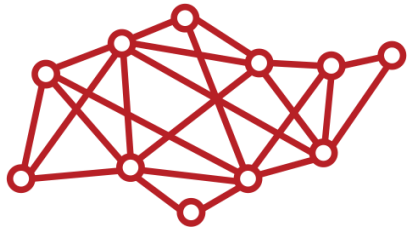
- Registration of land and property transactions – guarantee of all property rights in Singapore
- Management of national land survey system
- Administration of Residential Property Act



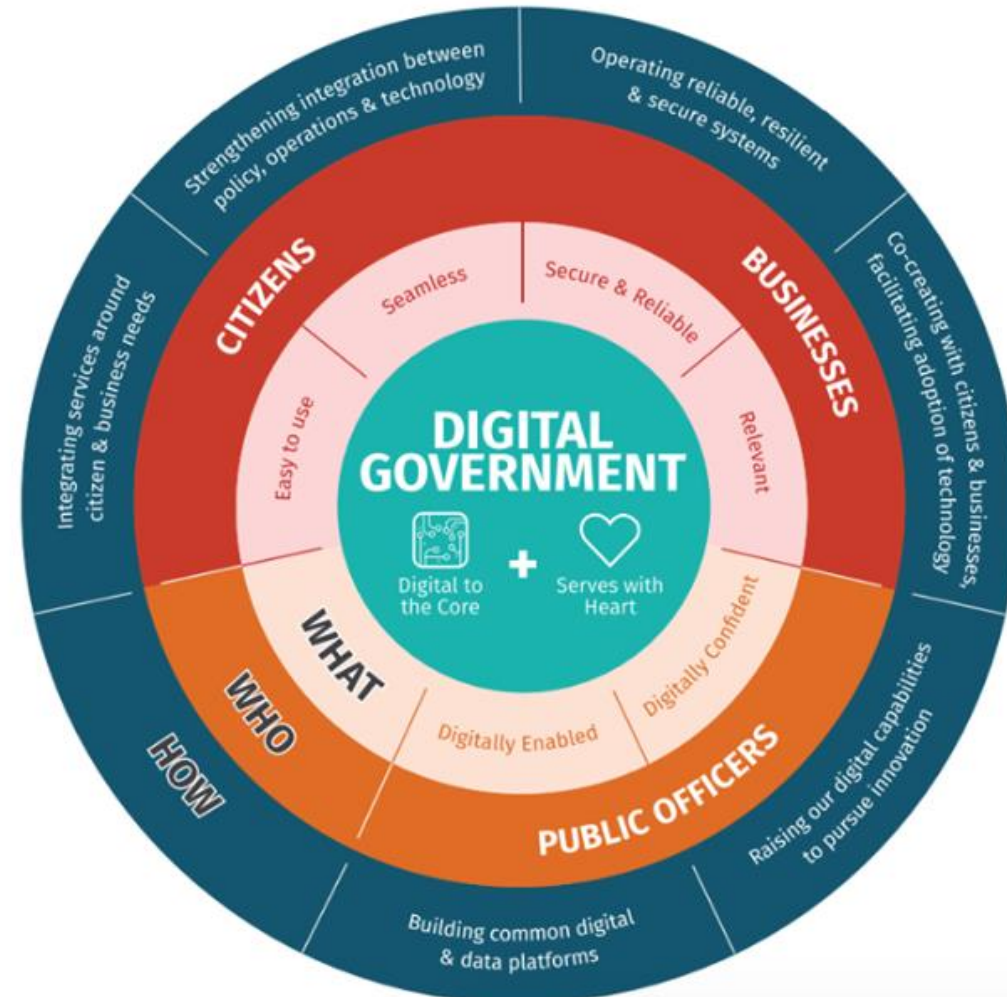
Mapping & Geospatial :

- Development of geospatial and technologies in support of Smart Nation
- Operation of geospatial platforms within government
- Building up geospatial capabilities within the public service

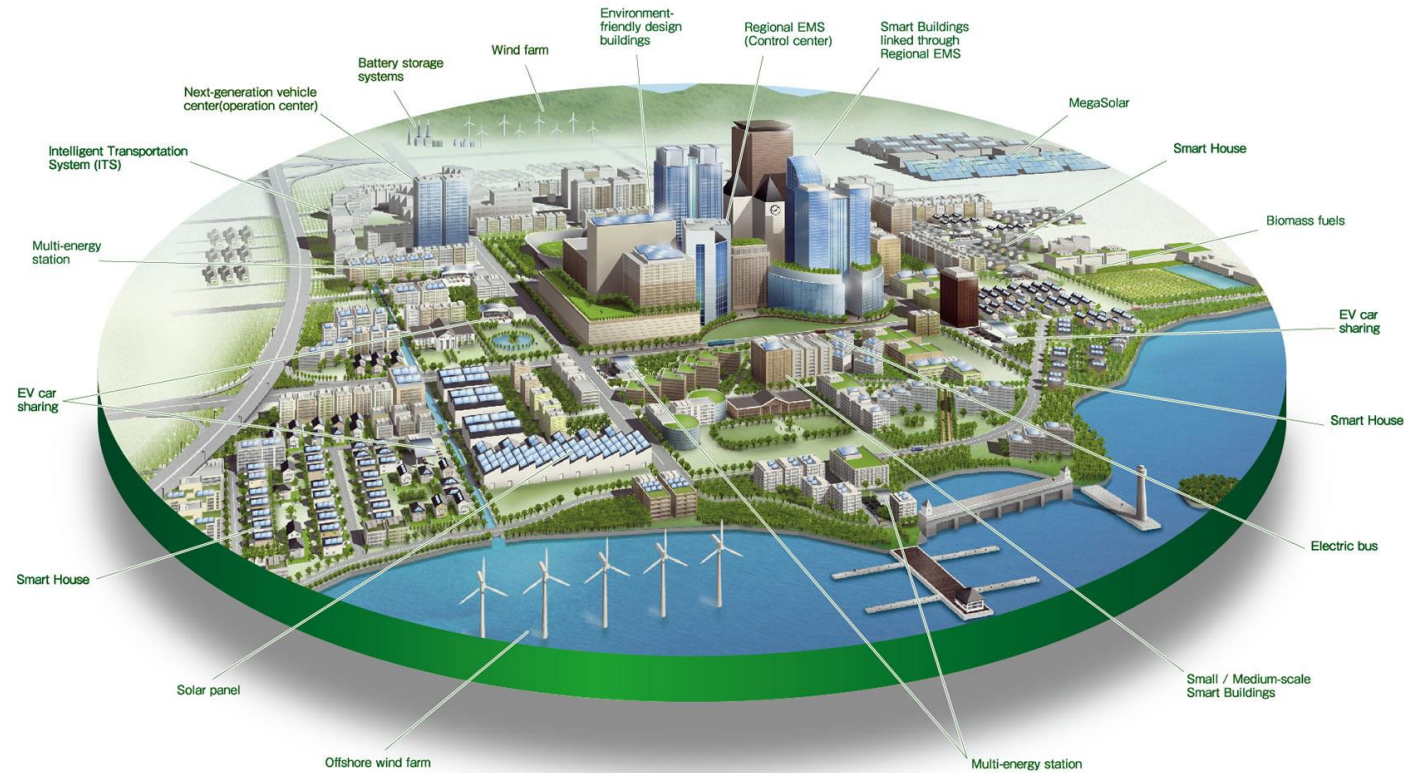
Digital Government



SMART NATION
&
DIGITAL GOVERNMENT OFFICE



Cities of the Future



Sustainable

Resilient

Smart

What does Goespatial
Enablement means?

Fundamental Geoinformation



Geoinformation
Your Surrounding

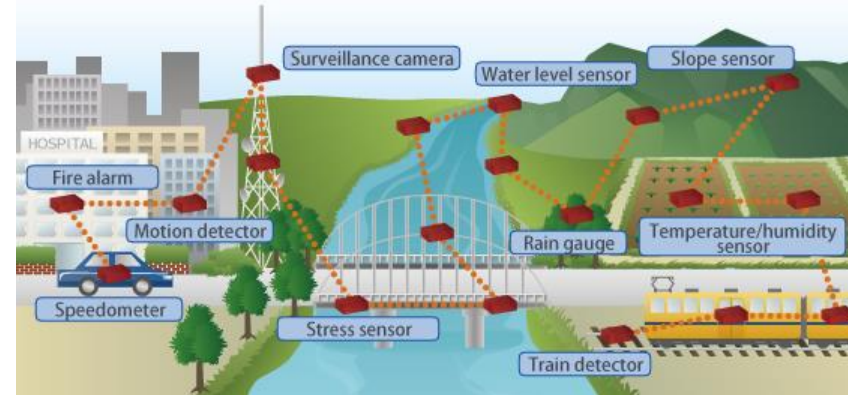


Geo-Infrastructure
Your Location

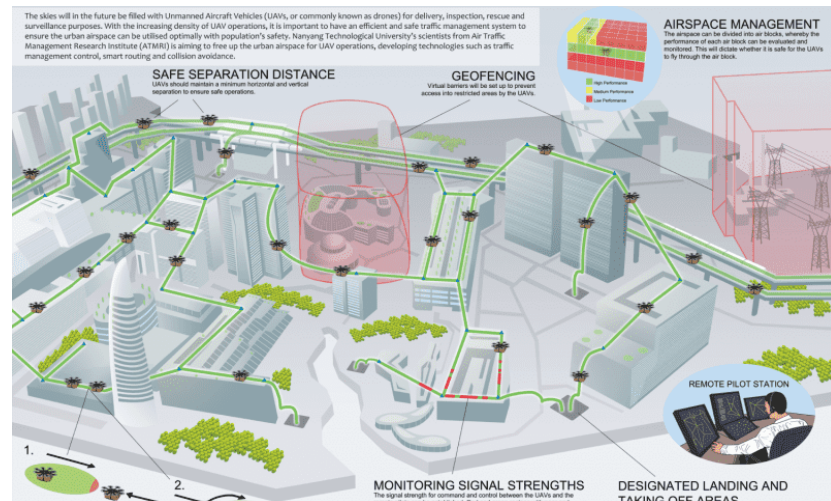
Precise Position and High Resolution Maps for Smart Applications



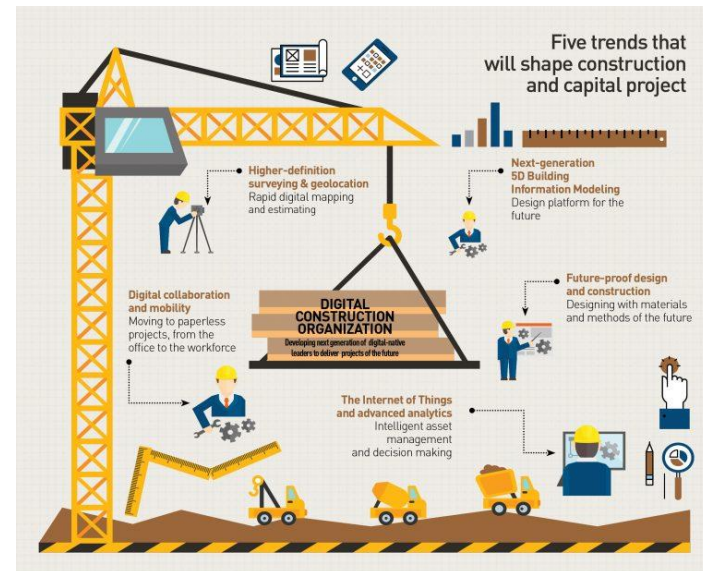
Smart Mobility 2030



Sensors Network

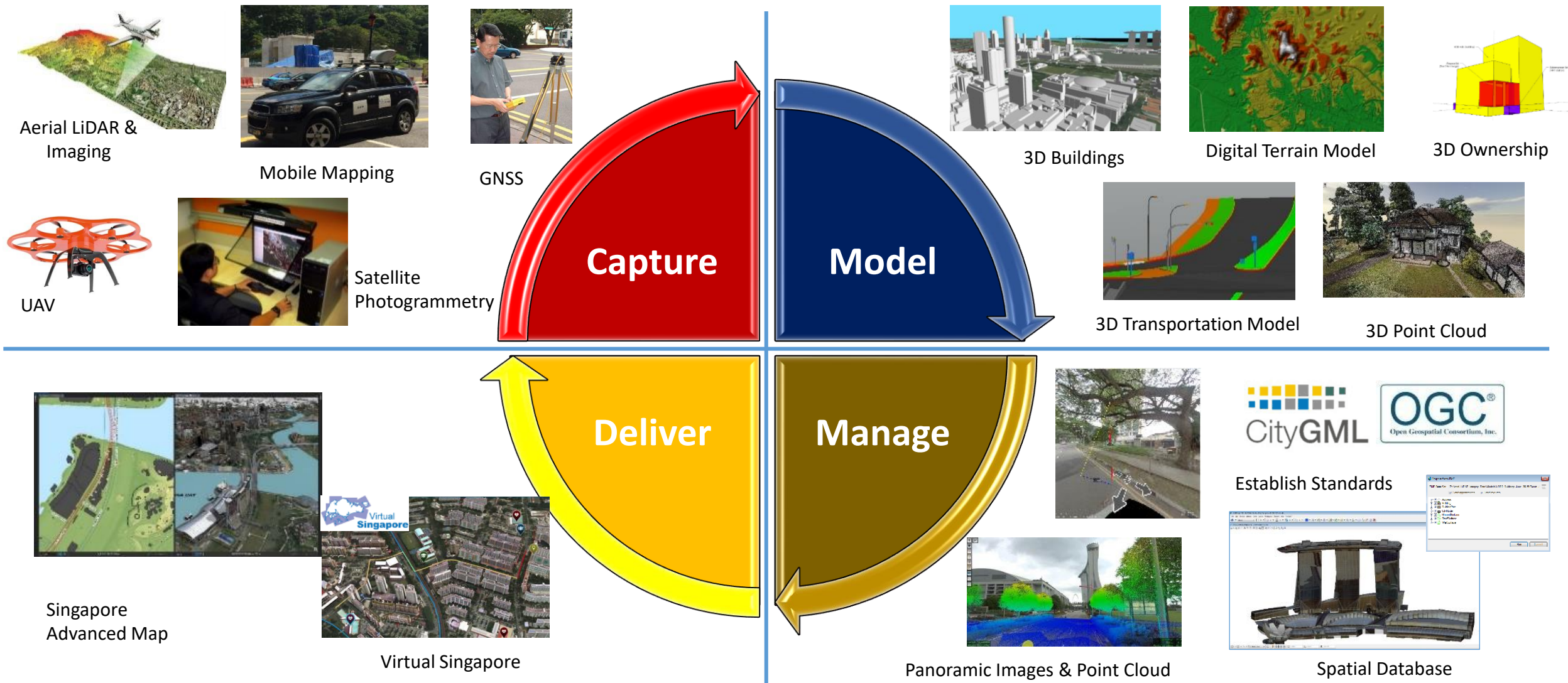


NTU Proposed concept for UAV air traffic management



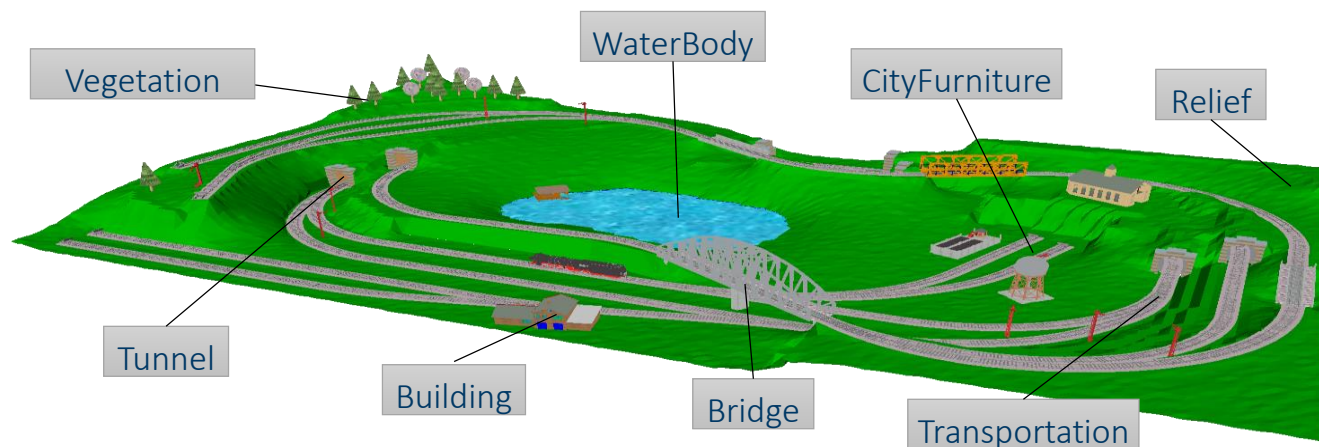
Smart Construction
Source: Geospatial World

National Mapping Framework

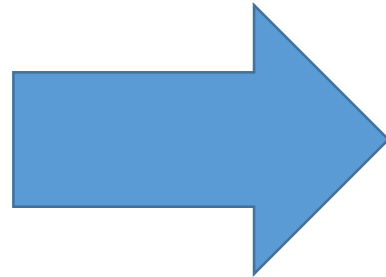


Supporting Sustainable, Resilient & Smart City

- Digital transformation
- Ensure interoperability
- Evolve from 2D to 3D and beyond
- Enhance geospatial capabilities



Digital Transformation

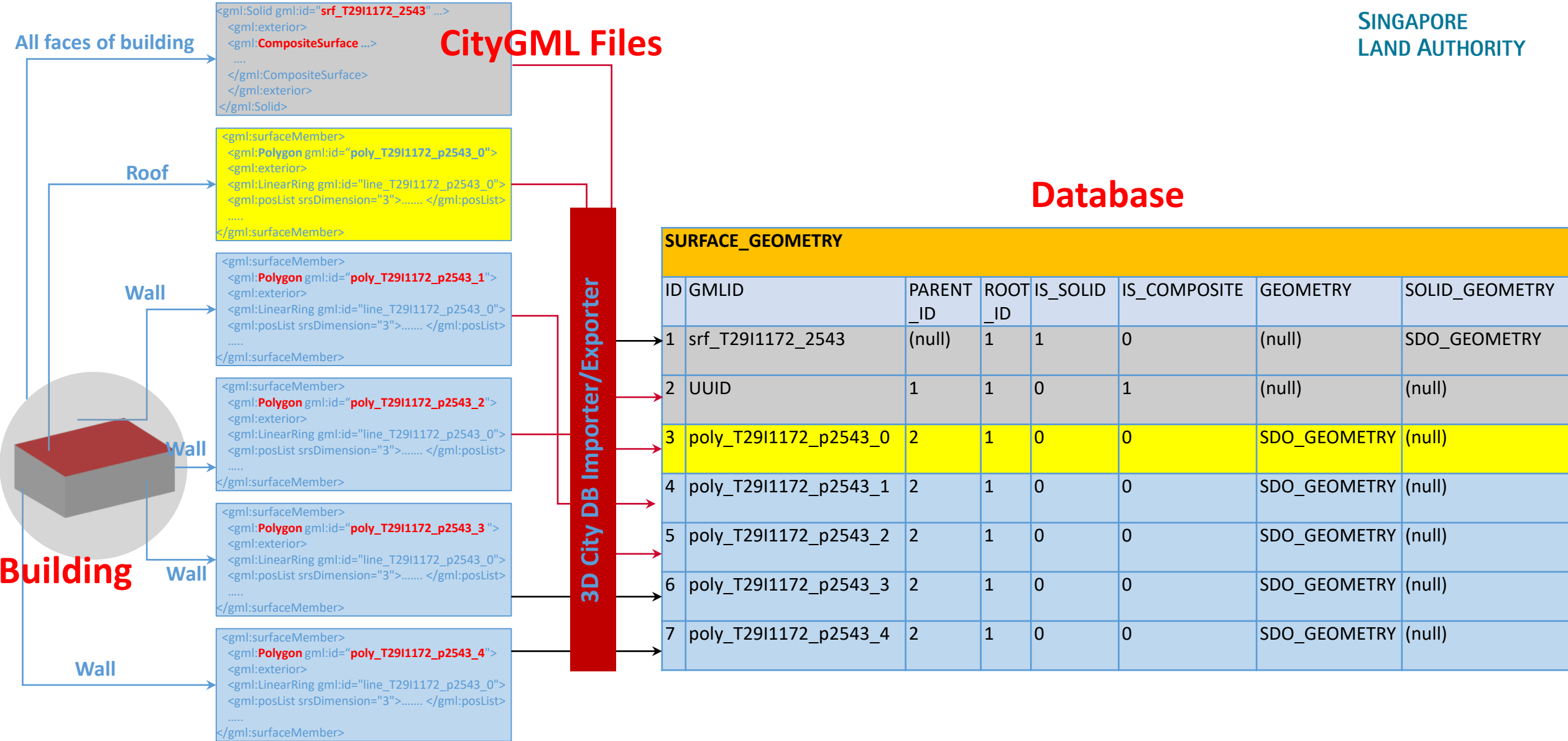


```
<End>309810.31992060284 370316.99547977943</End>
</Spiral>
- <Line dir="336.262803296404" length="419.512560716454">
  <Start>309810.31992060284 370316.99547977943</Start>
  <End>309641.44843472657 370701.01788779336</End>
</Line>
</CoordGeom>
</Alignment>
- <Alignment name="Alignment - 2" length="1211.255997059351" staStart="0." des
  <CoordGeom>
  - <Line dir="336.26280329641" length="419.512560716561">
    <Start>309641.44843472657 370701.01788779336</Start>
    <End>309472.5769488503 371085.04029580741</End>
  </Line>
  - <Line dir="15.097888445971" length="791.743436342791">
    <Start>309472.5769488503 371085.04029580741</Start>
    <End>309678.80151245283 371849.45451490517</End>
  </Line>
  </CoordGeom>
  </Alignment>
</Alignments>
</LandXML>
```

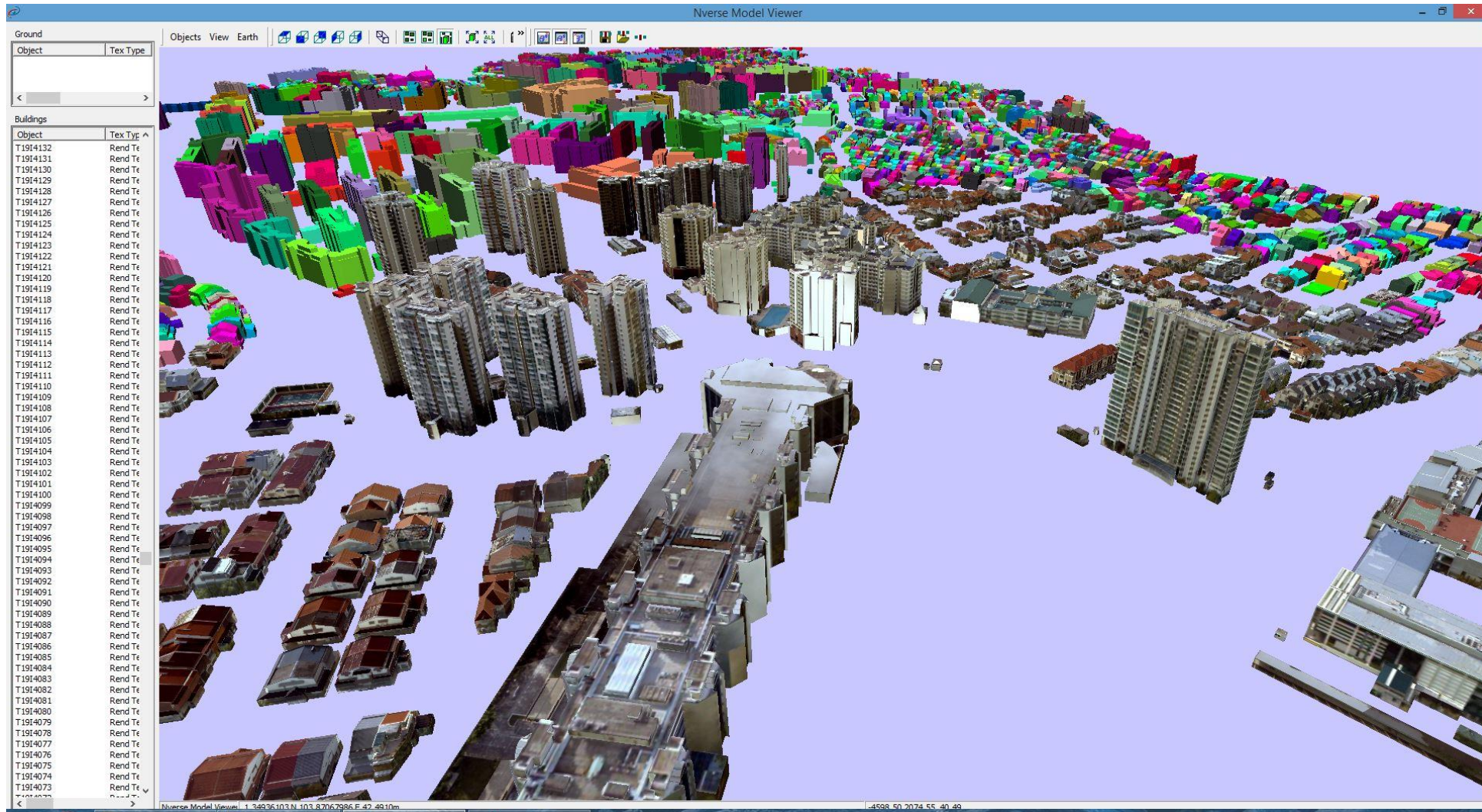


Point ID	X coordinate	Y coordinate	Height (m)
24356	13245.23	61524.98	2.34
71626	13225.89	61524.38	3.15
17263	13524.98	23452.09	1.25
17625	13276.55	61454.25	1.36
74635	13672.28	61174.72	1.35
74653	13095.00	61466.72	1.98
.....

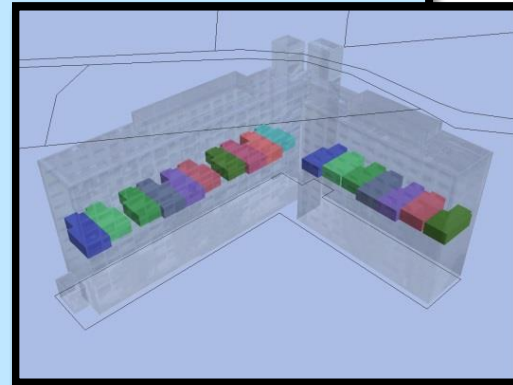
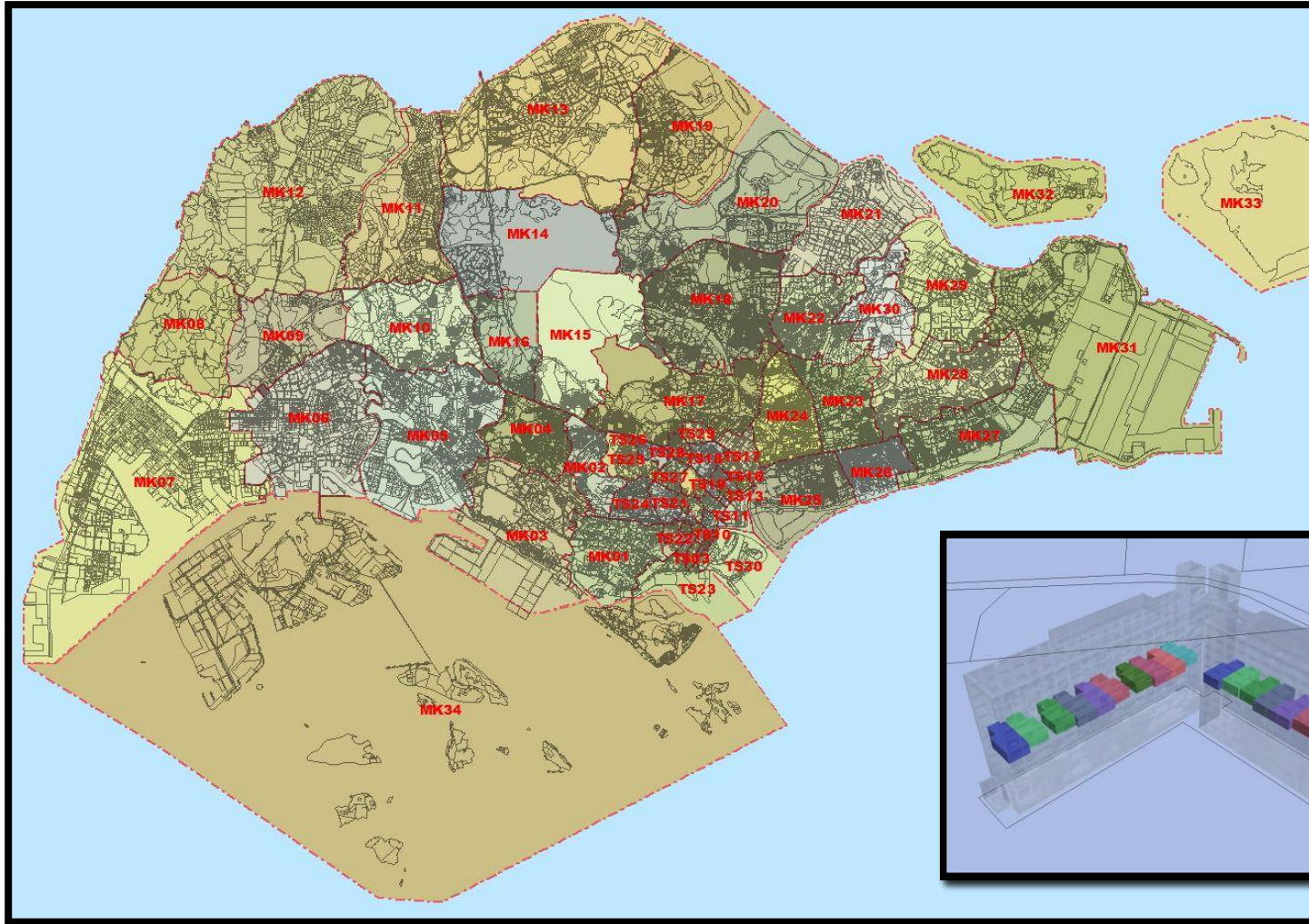
Ensure Interoperability



Evolving from 2D to 3D

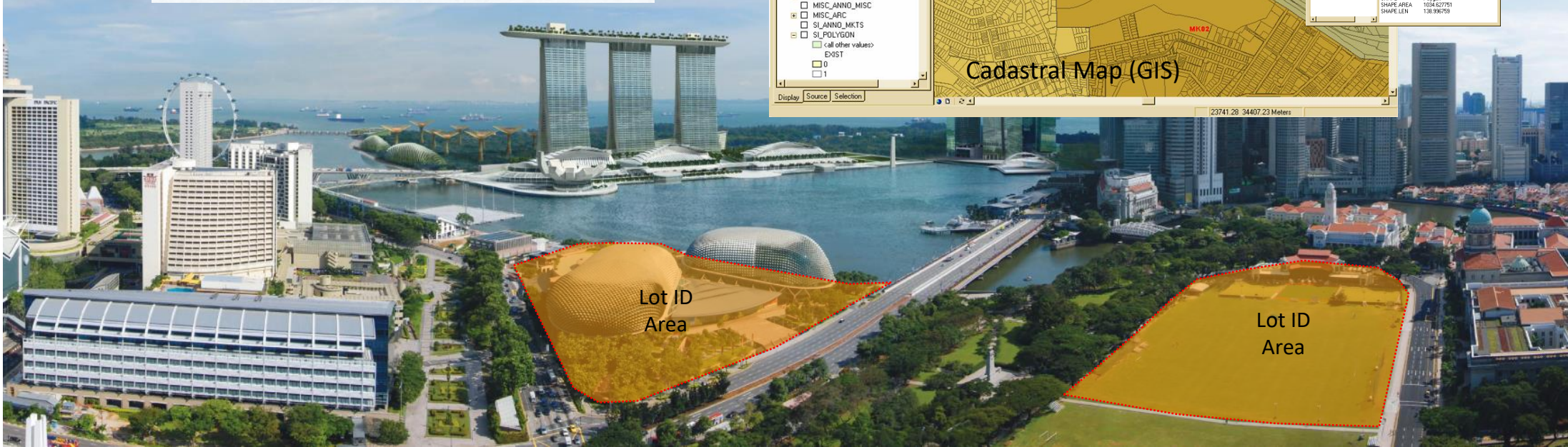
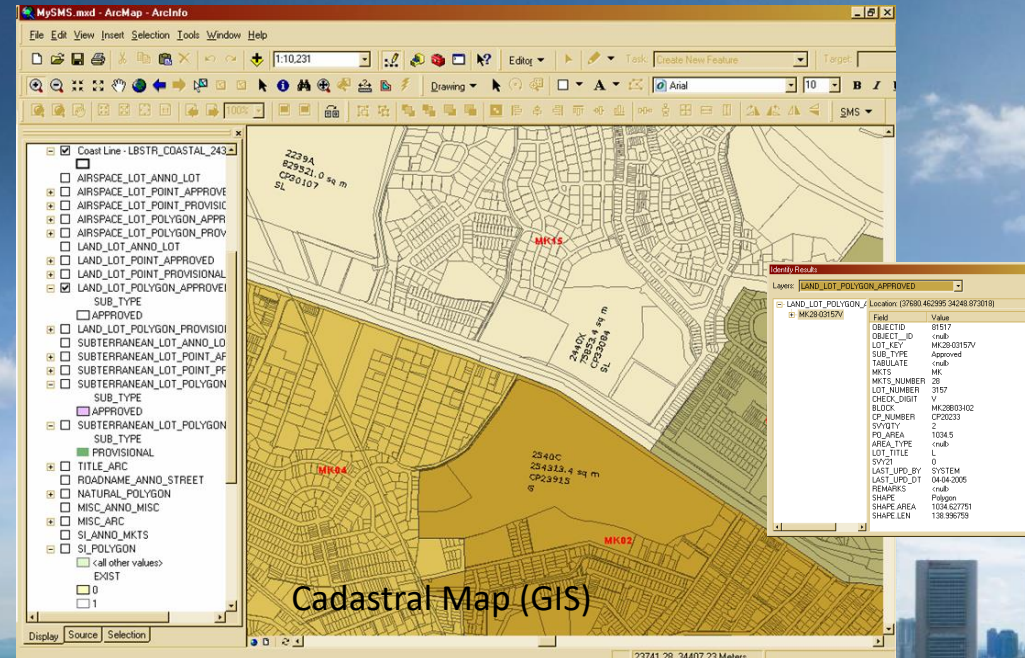
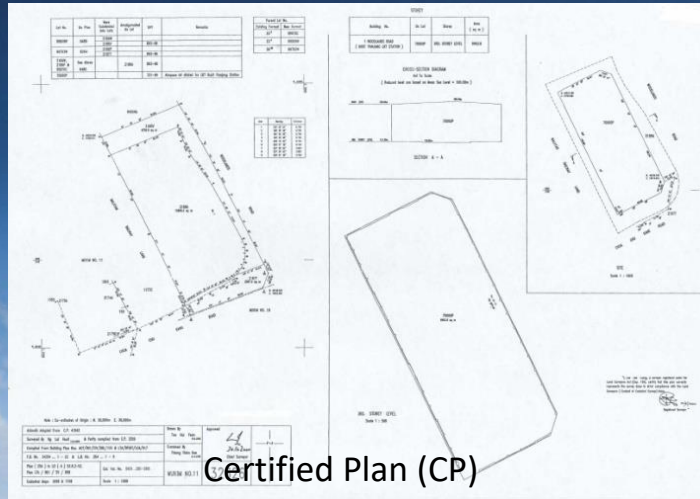


Land and Property Ownership Framework



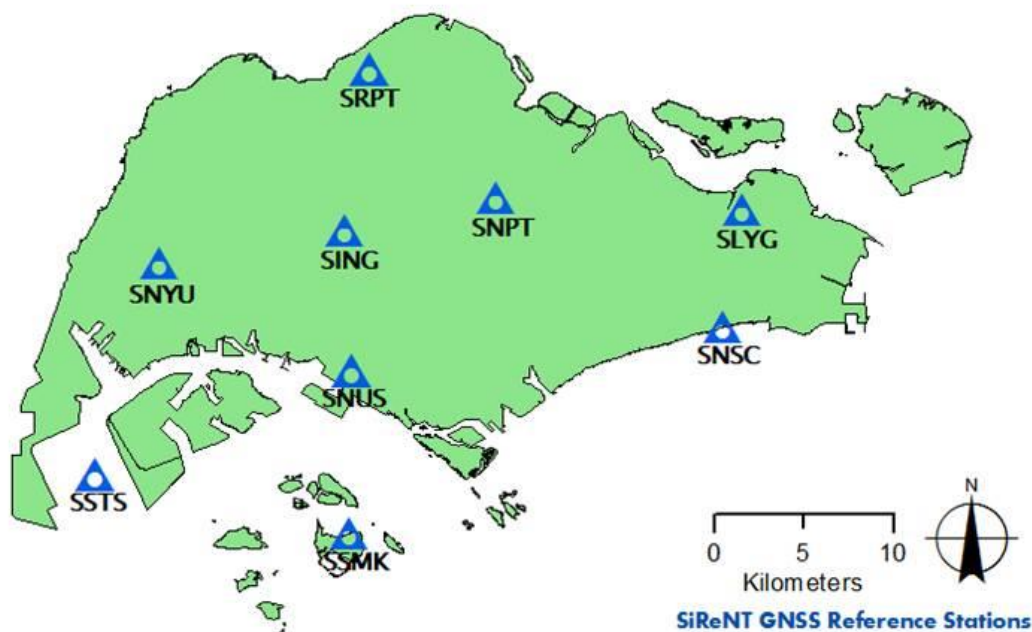
- Approximately 144,000 land parcels
- Approximately 1.2 million strata parcels
- 99.97% of the ownership are under Land Titles system

Development of Smart Cadastre



Precise GNSS Infrastructure in Singapore

- National Reference System for Surveying, Mapping and GIS
- Support real-time precise navigation and monitoring



SiReNT as a National Positioning Infrastructure

Focus on enabling government agencies



Positioning

- Surveying & Mapping
- Engineering
- GIS Data Collection
- Asset Management



Navigation

- Intelligent Transport Systems
- Self-Driving Vehicles
- Public Transportation
- Emergency Services
- Fleet Management



Monitoring

- Tectonic Movement
- Subsidence Monitoring
- Structural Movements
- Deformation Monitoring
- Atmospheric Conditions

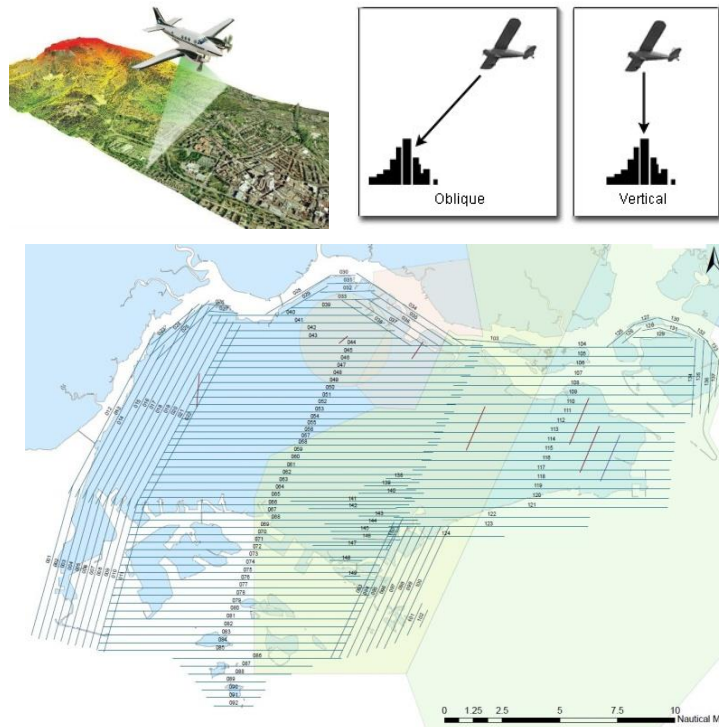


3D National Mapping



Phase 1

Airborne Laser Scanning and Imaging
(FY13 to FY15)



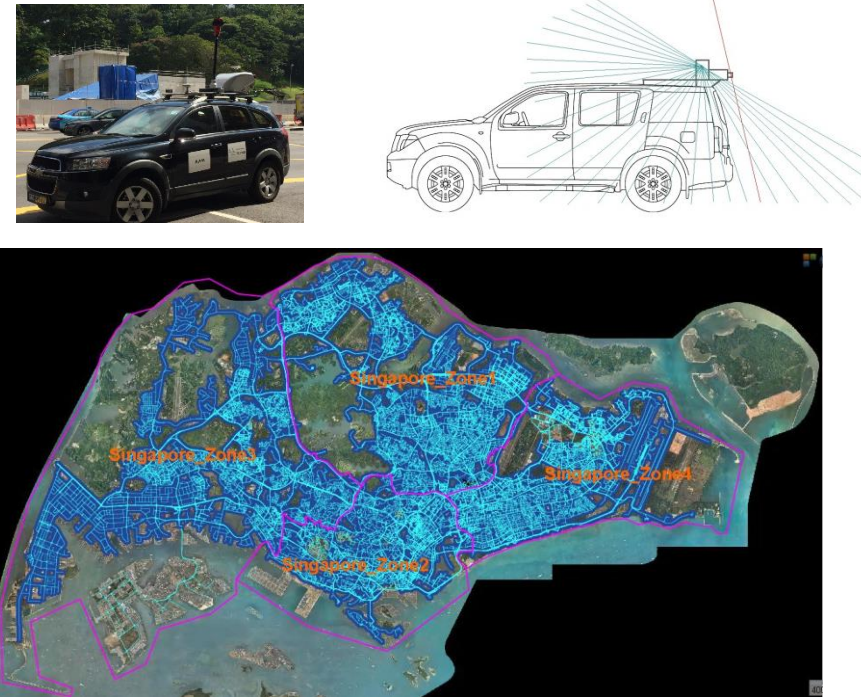
FY14

FY15

Phase 1

Phase 2

Mobile Laser Scanning and Imaging
(completed: Jun 17)

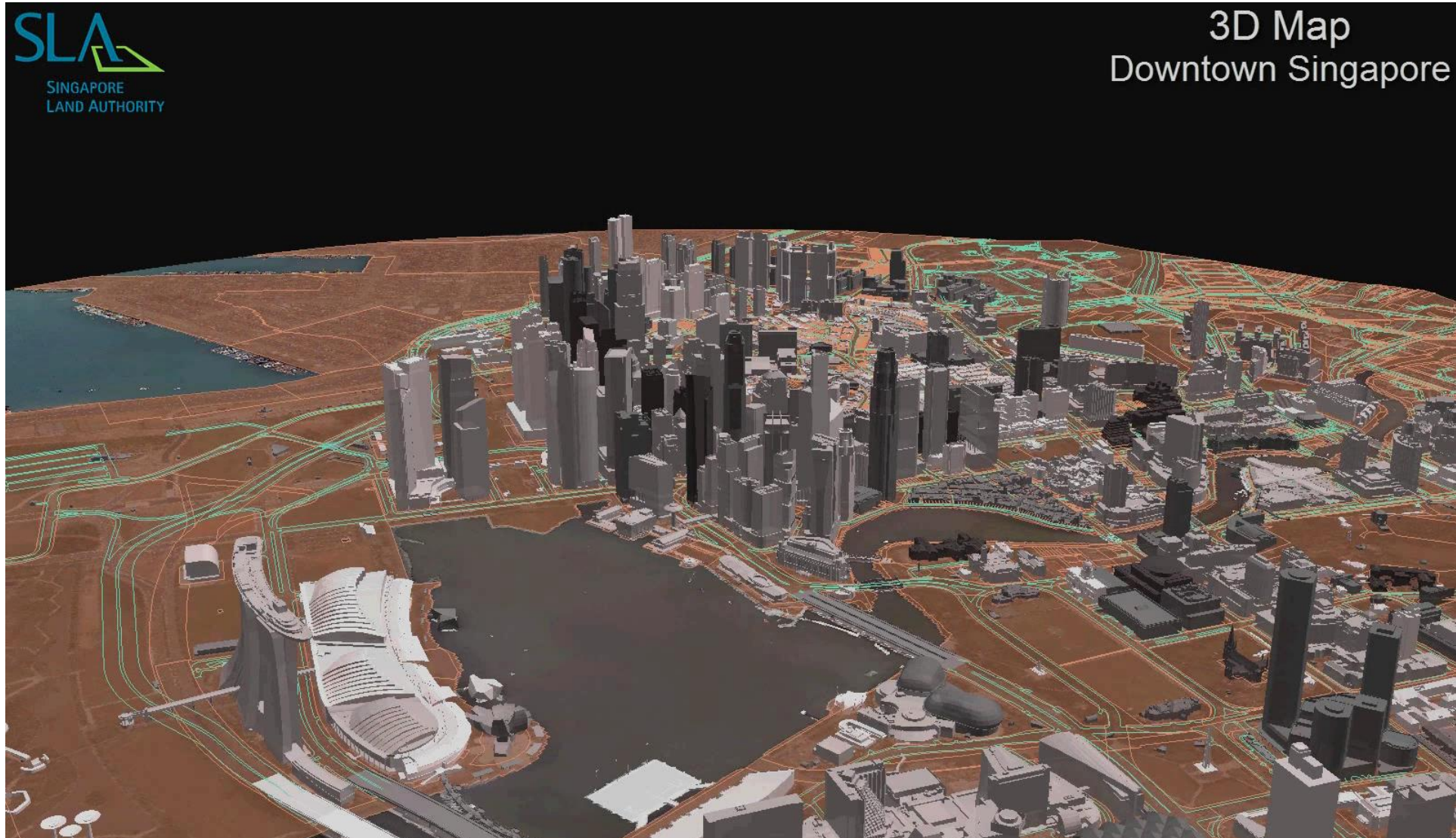


FY16




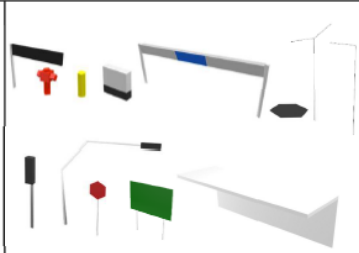
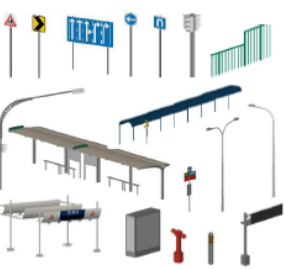


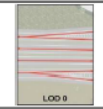
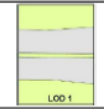
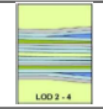
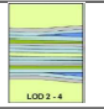
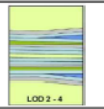







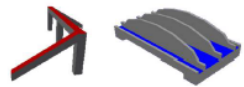
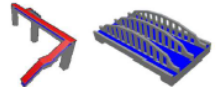
FY17

Phase 2

3D City Model for Virtual Singapore



3D City Model Standard

	LoD0	LoD1						
Building			CityFurniture				NA	NA
	Floorplan of the building	Single block represented						
Relief								
	Propose to have a single representation for ease of maintenance			Point, line or polygon/foot print representations for various objects	Simplistic representation	Models to capture shape and appearance of objects	Not meaningful to have more detailed representations for a city level	
SolitaryVegetation			Transportation					
	2D position of the tree	Simplistic shape (c		Represented as transport network lines	To capture actual shape of the transport object	To capture transport features such as auxiliary transport, pavements, carparks, etc	To capture multiple lanes information	To capture kerb information
PlantCover			WaterBody				NA	NA
	Footprint of an area filled with specific vegetation	Block representation		Line or polygon representations for various water bodies	Represented as blocks with fixed depth of 5 meters	Modelling of actual varying depths of water bodies	Not meaningful to have more detailed representations for a city level	
Bridge								NA
				Footprint of bridge	Detailed representation of the space under a bridge without semantics.	Detailed representation of the space under a bridge. Surfaces and features to be captured	More detailed bridge features, able to perform walk through for overhead bridges	Not meaningful to have more detailed representations for a city level

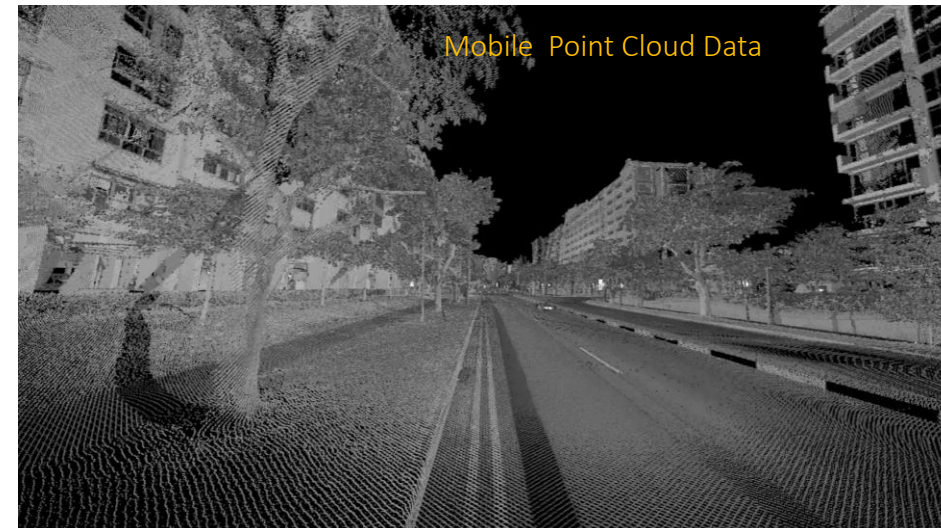
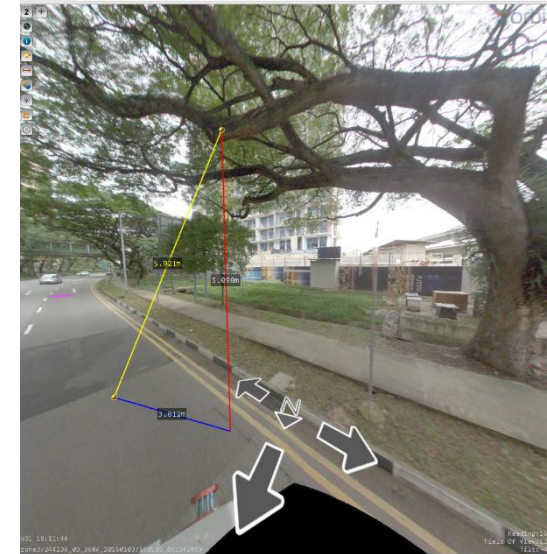
Mobile Mapping



Mobile Laser Scanner – Riegl
VMX-450



360 Spherical Camera -
Ladybug 5



Data-Driven Decision Making

Solar Potential Study



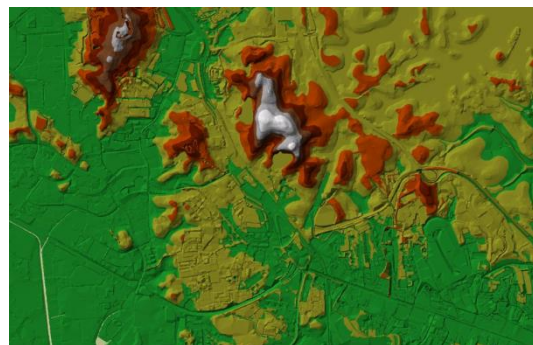
Development Planning



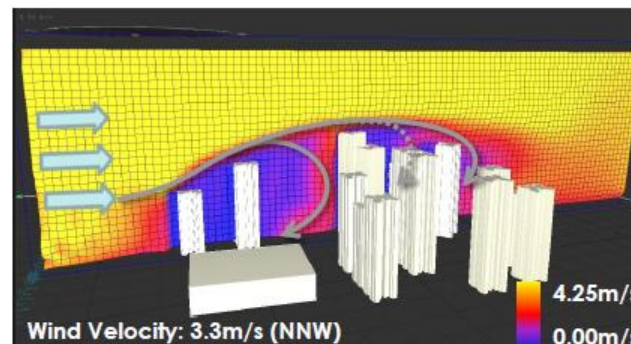
Underground Infrastructure



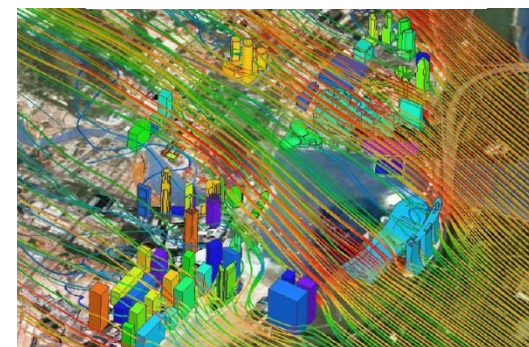
DTM for Flood Management



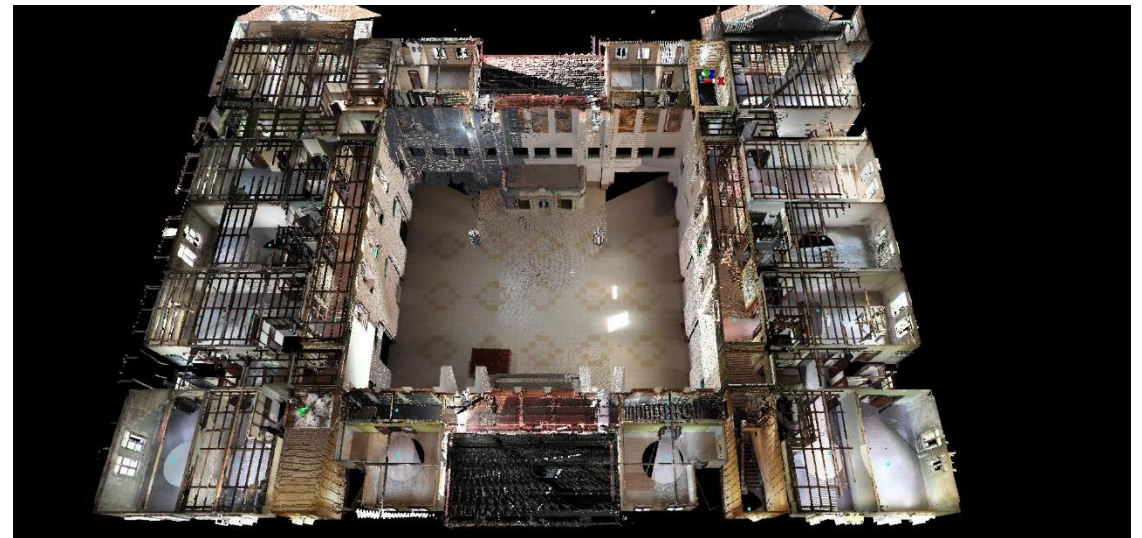
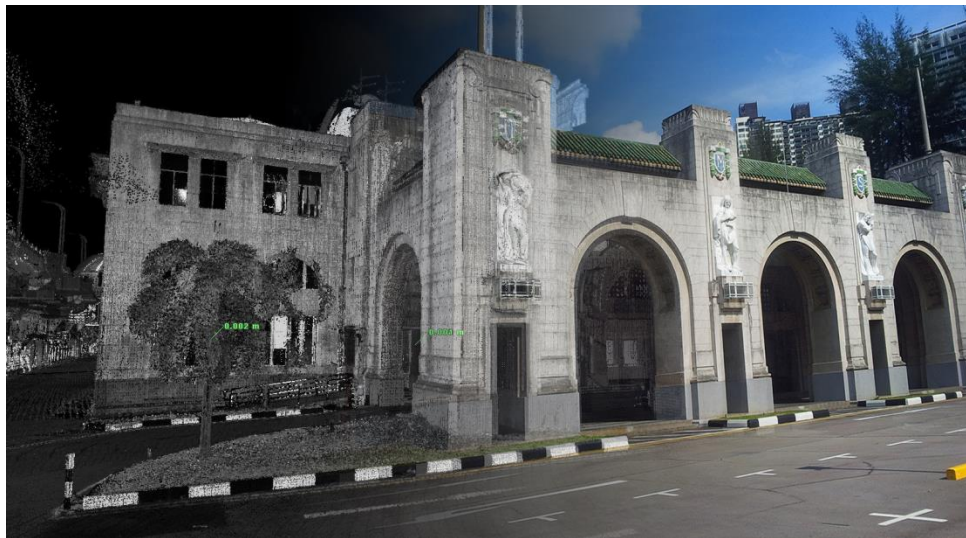
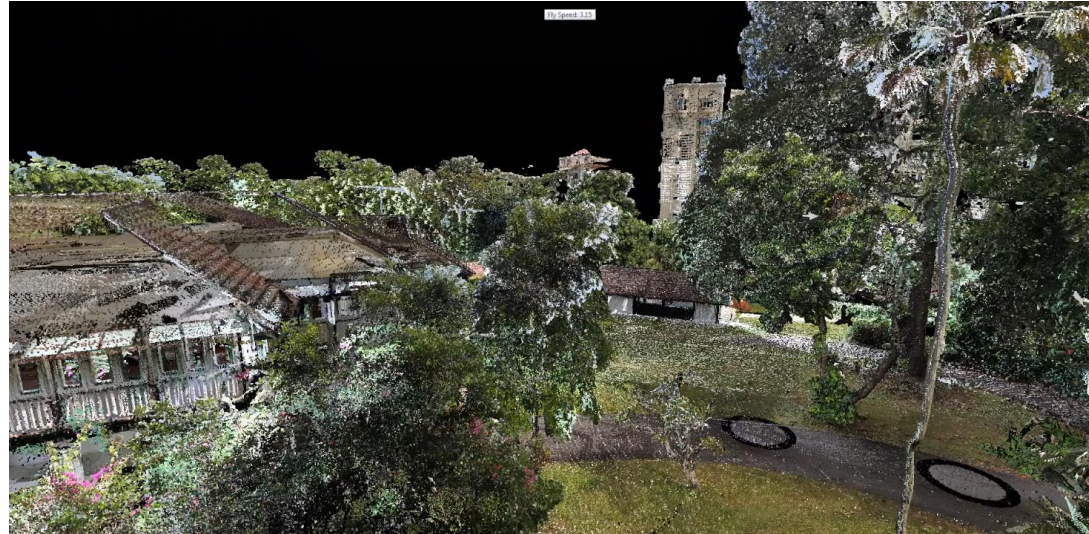
Urban Heat Island



Urban Air Flow Dynamic



Laser Scanning



Self-driving Vehicle Development

- SiReNT provides precise navigation capability for Self-Driving vehicle implementations in Gardens-by-the-Bay and LTA's Driverless Vehicle trials in One-North.
- Mobile Laser Scanning data contributes towards the development of self-driving Vehicle



ST PHOTO: KUA CHEE SIONG



Delphi - Audi SQ5 prototype

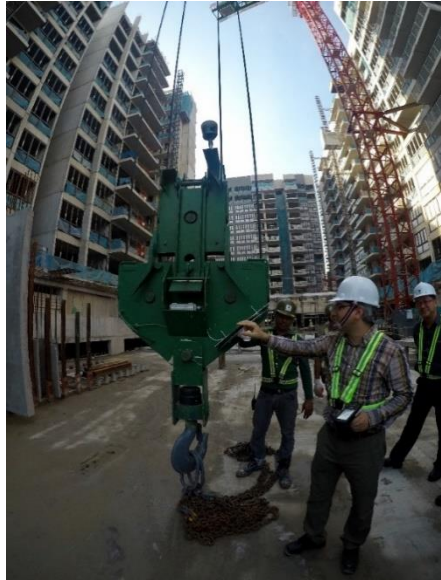


A*Star - iiRAV Autonomous Vehicle

Smart Construction

GNSS Assisted Piling System

Smart Crane



Smart Construction - Height Monitoring

- Enforcement of height restrictions on a construction site
- Other methods mainly require line of sight to work
- Using RTK allows accurate machine height monitoring and enforcement



Integrated Above and Underground 3D Map

