


Smart Nation
S I N G A P O R E
Many Smart Ideas · One Smart Nation

Smart Diamond to Define Smart City
Smart Governance




Source: Frost & Sullivan

- Singapore is building the World's first Smart Nation by harnessing technology and gathering insights from data to the fullest with the aim of
 - improving the lives of citizens,
 - creating more opportunities, and
 - building stronger communities.

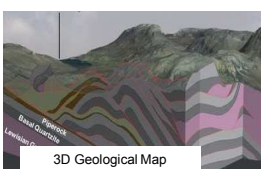
Measurement + Prediction = Performance




Resilient and Sustainable Growth - Growing Needs for 3D Information



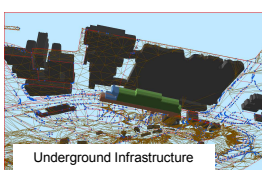
Development Planning



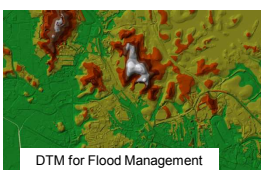
3D Geological Map



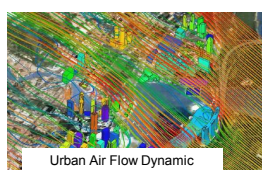
Underground Utilities



Underground Infrastructure



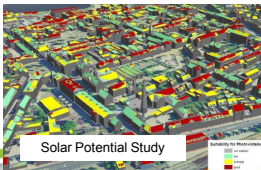
DTM for Flood Management



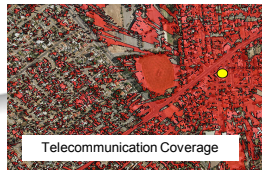
Urban Air Flow Dynamic




Urban Heat Island



Solar Potential Study





Telecommunication Coverage

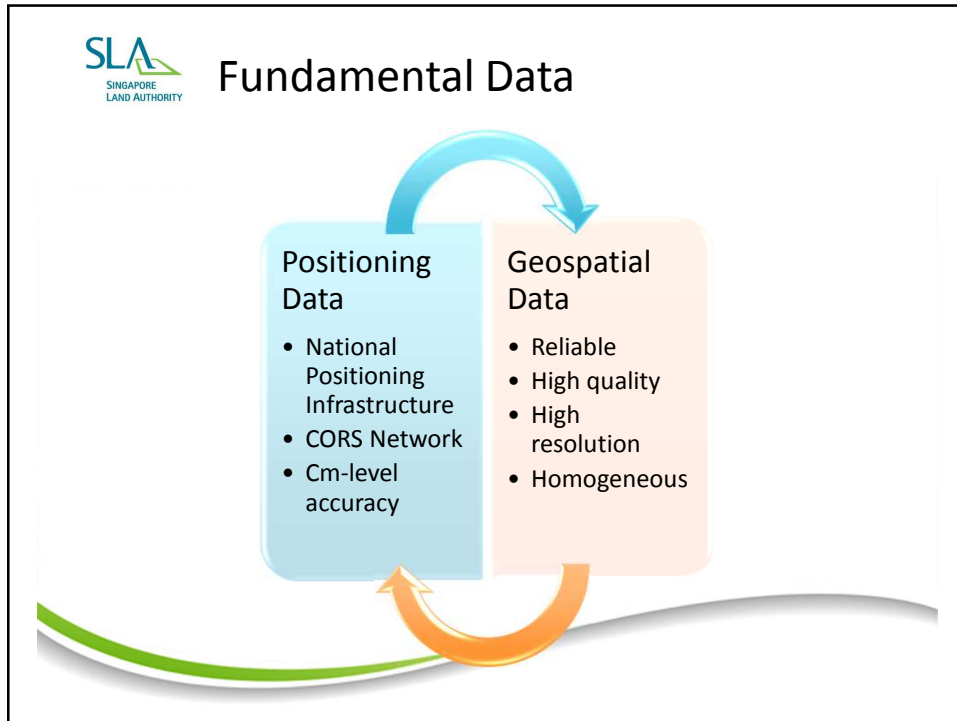
 **Singapore Land Authority (SLA)**

Limited Land • Unlimited Space

-  **Optimise and Manage Land Resource**
-  **Administer Property Transaction System**
-  **Manage Geospatial Information**

 **What is the Problem?**





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SiReNT - Precise GNSS Infrastructure in Singapore

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

Map of Singapore showing the locations of SiReNT GNSS Reference Stations: SSTS, SNYU, SING, SNPT, SLYG, SNUS, and SNMK.

Collage of satellite imagery and ground infrastructure components, including a satellite in orbit, a ground station antenna, and a solar panel array.

0 5 10 Kilometers

SiReNT GNSS Reference Stations

A row of eight photographs showing different types of GNSS reference stations, including ground-based antennas, solar panels, and monitoring equipment.

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Smart Applications Need Precise Positioning

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New Upgraded SiReNT based on GNSS


Enhanced satellite availability
Enhanced positioning efficiency


Time Interval	Number of Satellites
00:00 - 03:00	3
03:00 - 06:00	4
06:00 - 09:00	4
09:00 - 12:00	4
12:00 - 15:00	5
15:00 - 18:00	5
18:00 - 21:00	7
21:00 - 24:00	6





GNSS Assisted Piling System












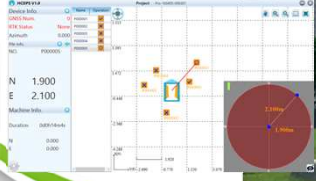


- Incorporated SiReNT into the development of GNSS assisted piling system.












Smart Crane for Precast Building







- Development of a satellite assisted Smart Crane system
- Made possible by introducing the RTK technique







Intelligent Transport Systems

Junction Safety System:
The development of an in-vehicle and roadside units positioning solution for crash detection and early warning.



Development of Driverless Vehicles

- SiReNT provides precise navigation capability for Self-Driving vehicle implementations in Gardens-by-the-Bay and LTA's Driverless Vehicle trials in One-North.



Delphi - Audi SQ5 prototype



Gardens By The Bay - Auto Riders

ST PHOTO: KIA CHEE SIONG



A*Star - iiRAV Autonomous Vehicle

SLA SINGAPORE LAND AUTHORITY **Drones Navigation (POC projects)**

- Real-time autonomous navigation
- Post processing of flight path
- Post processing of data acquired from flight

ST Engineering ST Aerospace H³ Dynamics

Reference Station

UAV

Ground Control Station (GCS)

Receive DGPS error correction data

Send error correction data to UAV as well as uplink commands to control UAV

UAV receives error correction data and corrects its position to be more accurate

↑ GPS Accuracy <1m

Connected to Internet to collect DGPS error correction data from SLA

SLA SINGAPORE LAND AUTHORITY **Solar Irradiance Study**

- To collect ZTD and IPWV data from GNSS measurements and incorporate this information in a numerical weather prediction model to improve the solar irradiance forecasting

A Super Smart Grid

SERIS Solar Energy Research Institute of Singapore



Fundamental Geospatial Data

- Survey Control Information
- Cadastral Survey Information
- Mapping Data
 - Terrain
 - Building
 - Road




National Coordinate System



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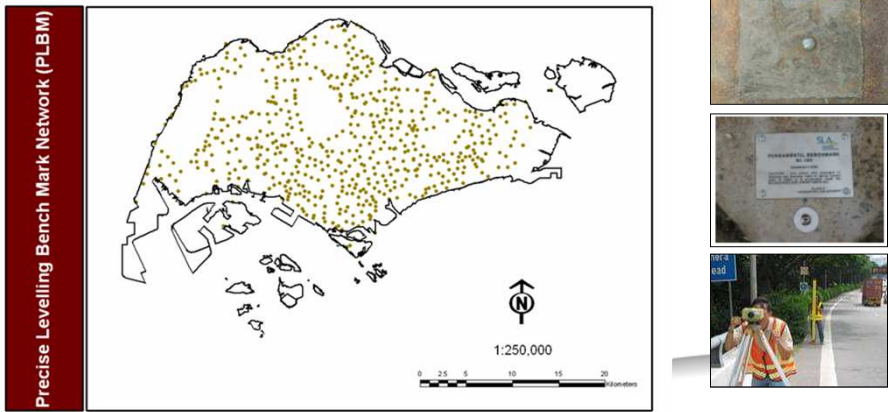
Fundamental Bench Mark (FBM)



The map displays the locations of Fundamental Bench Marks (FBM) across Singapore, marked with red triangles. Specific markers labeled include FBM107, FBM108, FBM109, FBM110, FBM111, FBM104, FBM106, and STD BM6. A photograph on the right shows a physical FBM marker, a metal plate with the SLA logo and text: "FUNDAMENTAL BENCHMARK NO. 110", "Established in 2005", and a cautionary note: "CAUTION - Any person who disturbs or removes this benchmark, or any other benchmark, established under the SURVEY AND MAPPING ACT, shall be liable to prosecution under the SURVEY AND MAPPING ACT." Below the map is a green decorative wave graphic.

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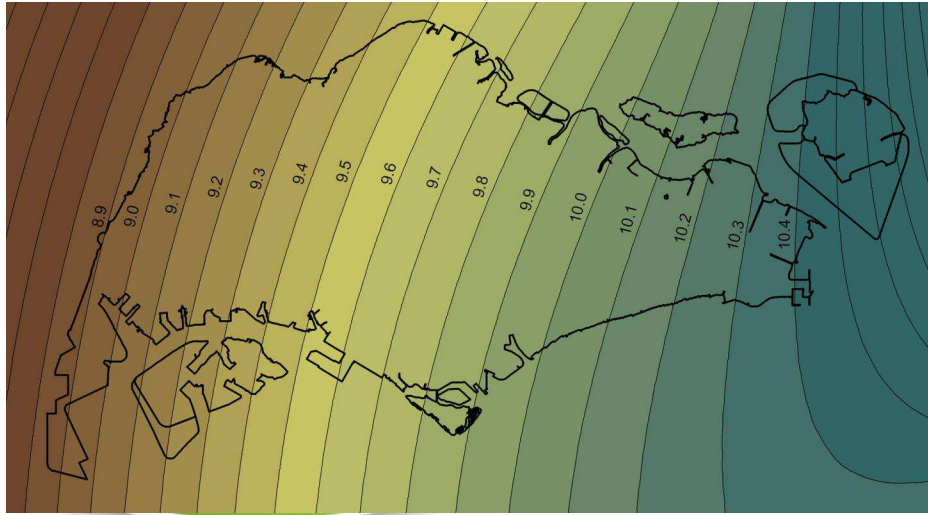
Precise Levelling Bench Mark Network (PLBM)



The map shows the extensive network of Precise Levelling Bench Marks (PLBM) across Singapore, indicated by numerous small yellow dots. A vertical red bar on the left side of the map contains the text "Precise Levelling Bench Mark Network (PLBM)". Below the map is a scale bar (0 to 20 meters) and a north arrow. A scale of 1:250,000 is also provided. On the right, three photographs illustrate PLBM markers: a weathered stone marker, a metal plate marker with the number "3", and a surveyor using a tripod-mounted instrument.



Using GNSS for heights measurement - Geoid Model



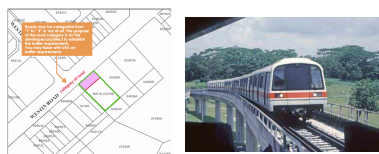
“The Map” - Cadastral Survey Information

The image is a composite illustrating cadastral survey information. On the left, a 'Certified Plan (CP)' shows a technical drawing of a land parcel with dimensions and a north arrow. On the right, a 'Cadastral Map (GIS)' is displayed within a software interface, showing a grid of land parcels with various attributes listed in a legend. The bottom portion of the image is an aerial photograph of a city area, with two specific land parcels highlighted by orange dashed-line polygons and labeled 'Lot ID Area'.



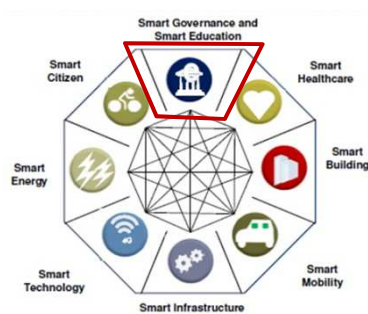
Cadastre Information is Important

- Property Title Registration
 - Property Ownership
 - Property Transaction
 - Property Tax
- Sustainable Development
 - Road Reserved Line
 - Reserved zone
 - Compulsory Acquisition
 - Government Land Sales
- Planning
 - Master Planning
 - Infrastructure Planning



Smart Cadastre System

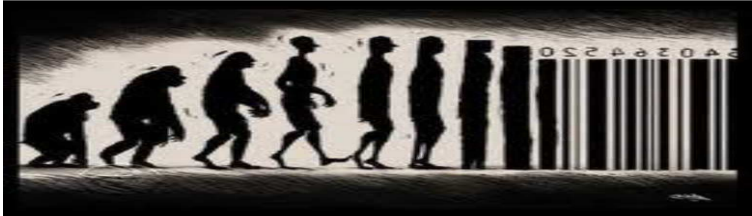
- What is Smart Cadastre?
 - Fully Digital Data Management
 - Automated and Intelligent Processing
 - Adopt Open Source Standard
 - Expanded into 3D and 4D
 - Data Analytics
- Key Components
 - Smart Data Model
 - Standard (LandXML)
 - IT system - CSMS



Source: Frost & Sullivan

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Data - Electronic to Digital

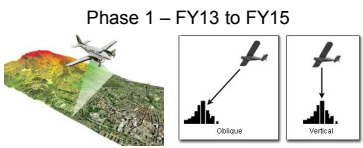


<u>Hardcopy</u>	<u>Electronic</u>	<u>Digital</u>
<ul style="list-style-type: none"> •Manual Submission 	<ul style="list-style-type: none"> •Electronic Submission •Scanned raster images 	<ul style="list-style-type: none"> •Digital Submission •LandXML •Online cadastre information and policy •Pre-submission check •Semi-Automatic Processing of Jobs

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Data Capturing using Rapid 3D Mapping Technology

Phase 1 – FY13 to FY15

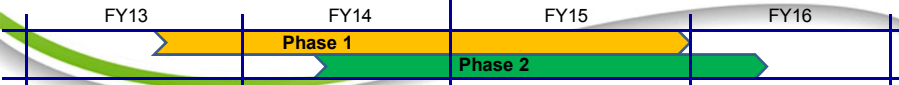



Airborne Laser Scanning & Imaging

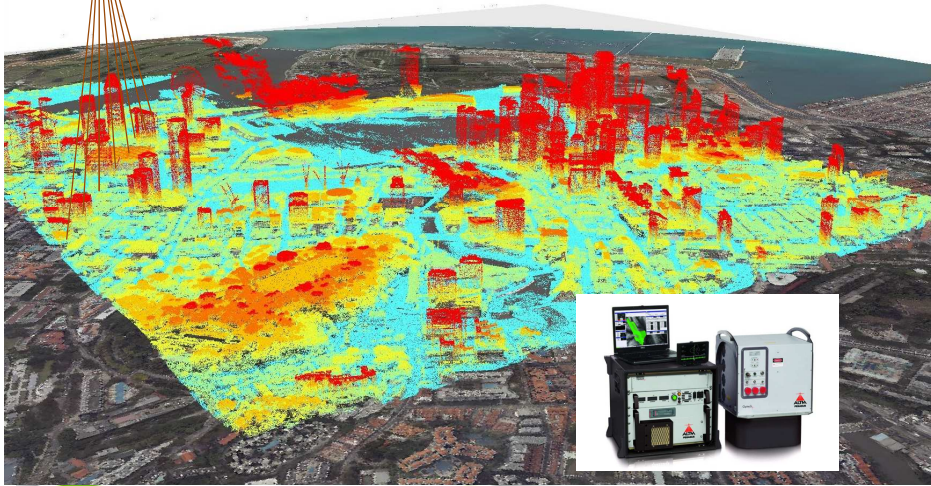
Phase 2 – FY14 to FY16




Mobile Laser Scanning & Imaging

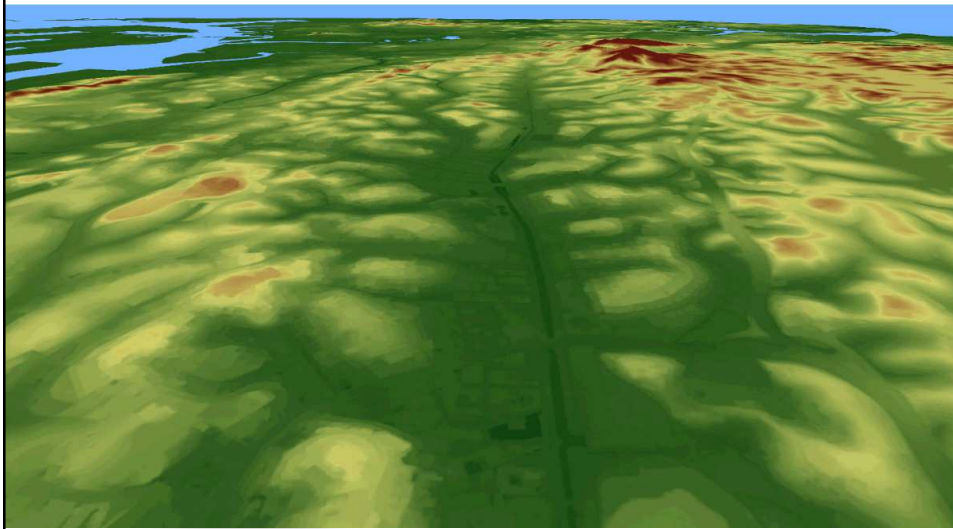


 Airborne Laser Scanning



Optech Pegasus ALTM

 Digital Surface Model (DSM) /
Digital Terrain Model (DTM)



The image shows an aerial view of Singapore with a flight path indicated by orange lines from an aircraft labeled 'SLA'. A green hatched rectangular area represents the camera's coverage. Below the main image are four icons: two for 'Oblique' and 'Vertical' photography, two images of the 'Leica RCD 30 Oblique Camera' hardware, and a diagram showing a 50mm lens with a 35-degree field of view.

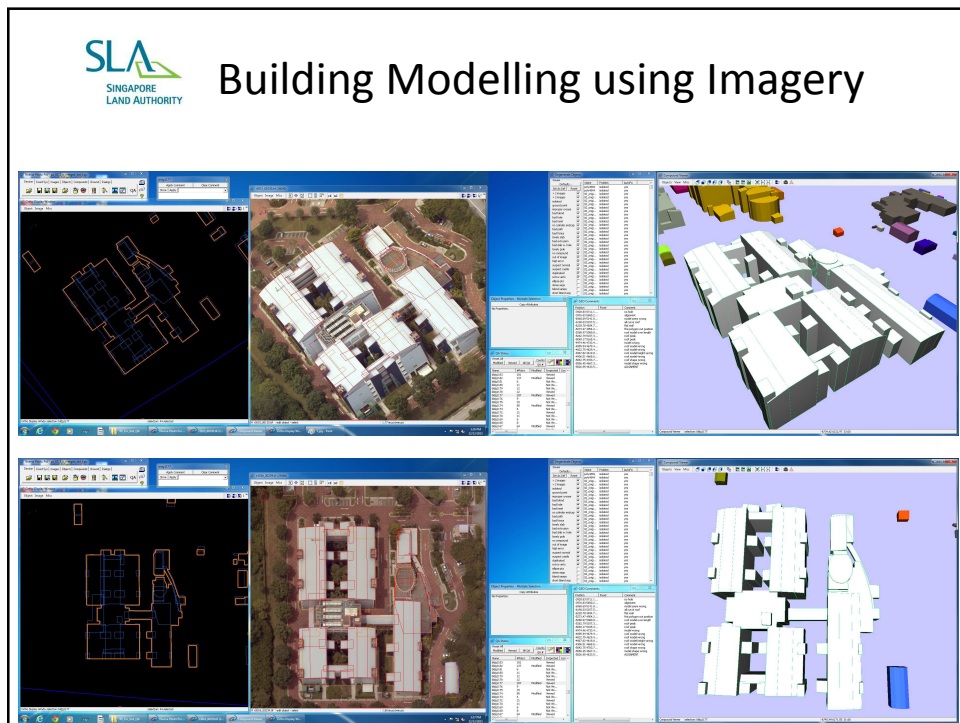
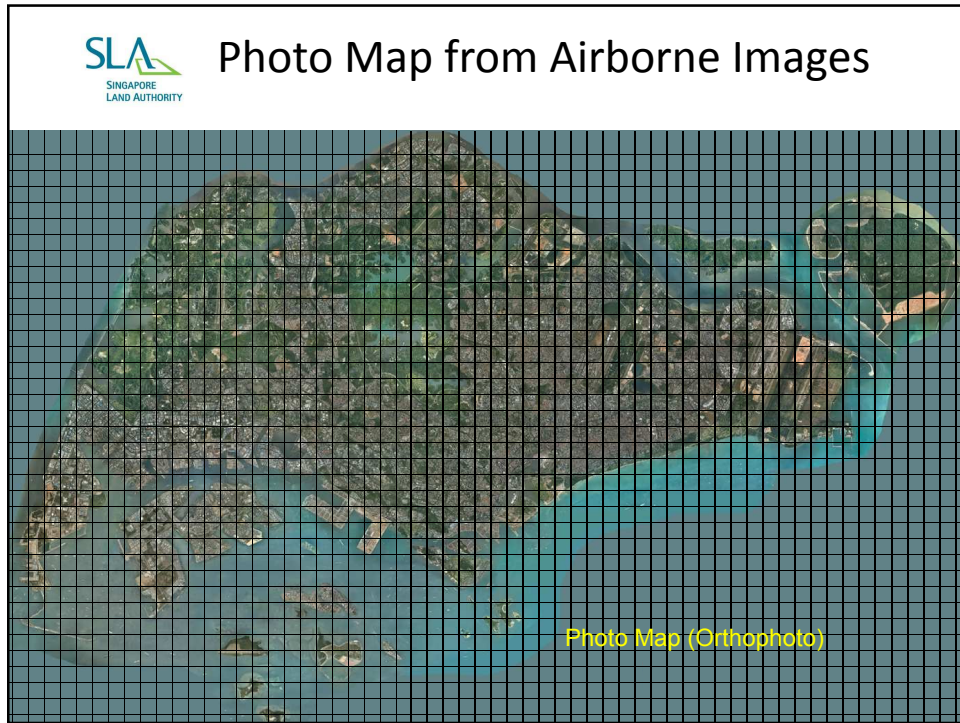
Leica RCD 30 Oblique Camera

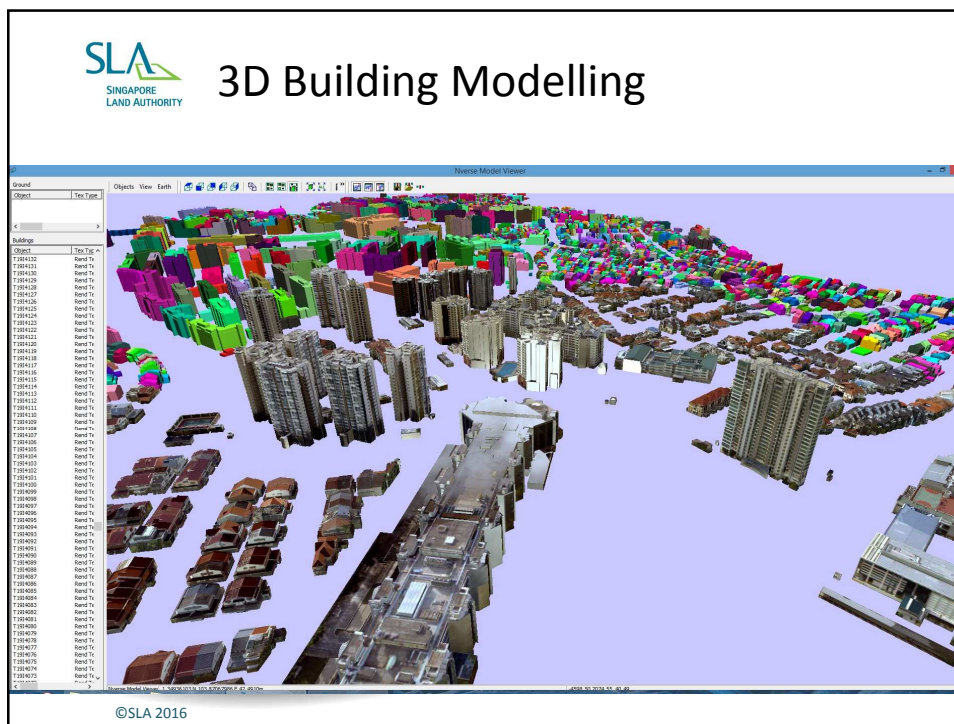
The image displays a central aerial view of Singapore with four inset windows showing oblique and vertical views of the same area. The top-left inset shows an oblique view, the top-right shows a vertical view, the bottom-left shows another oblique view, and the bottom-right shows another vertical view. The SLA logo and the text 'Vertical and Oblique Images' are at the top. A copyright notice 'Copyright © Singapore Land Authority' is visible at the bottom of the main image.

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Vertical and Oblique Images

Copyright © Singapore Land Authority



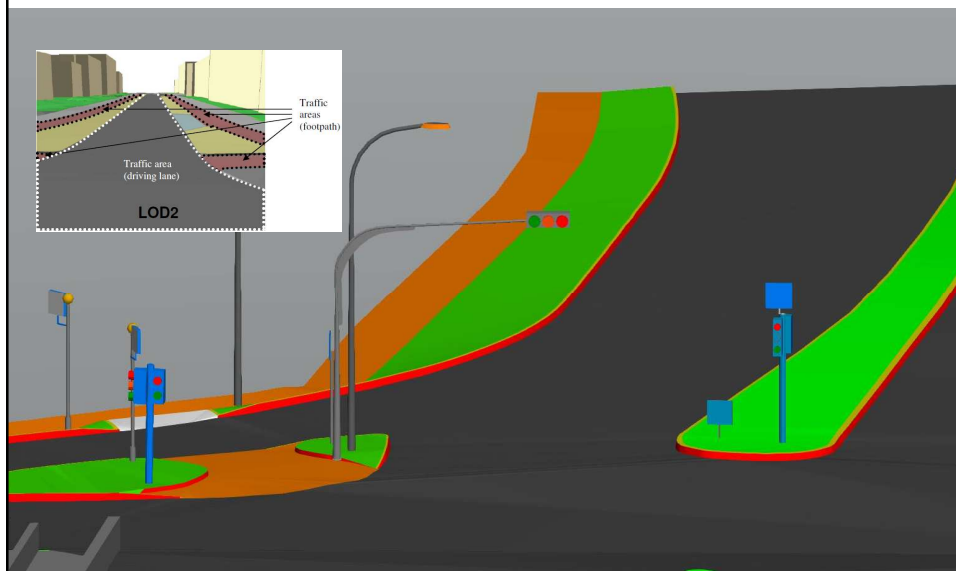





Mobile Laser Scanning Point Cloud



3D Modelling – Transportation and Street Furniture






Data Management Strategies

Collect once, use by many

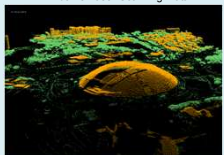
1. Single point of truth (SPOT) is managed and maintained in Open Source Data Format and Data Schema
 - Embrace international open standard (e.g Open Geospatial Consortium (OGC) standard, ISO standards)
 - Ensure government data is technology-independent
2. Data standard
 - Establish 3D data standard to ensure interoperability and support inter-agency data sharing
 - Actively contribute and influence international 3D standard
3. Multiple source / technology




Benefits for Whole-of-Government

3D Data

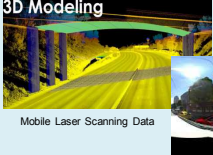
Arbore Laser Scanning Data




Airborne Vertical / Oblique Images



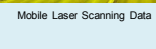
3D Modeling



360 Camera Imagery



Mobile Laser Scanning Data



3D Products

Digital Terrain Model & Digital Surface Model

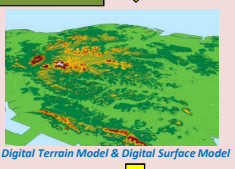

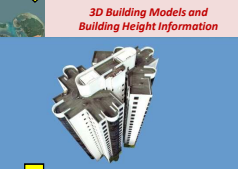



Photo Map



3D Building Models and Building Height Information




Road Surface and 3D Road Models




Applications


Flood Risk Map




Coastal Protection Map



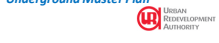
Flight Safety Planning




Tree Mapping




Underground Master Plan




Planning




Urban Heat Island Study




Driverless Vehicle Development




National Geological Map




Virtual Singapore



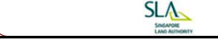
SolarNova Project



3D Cadastre



Slope Risk Analysis Map



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Data Model - CityGML Modelling Theme

OGC
Open Geospatial Consortium, Inc.

CityGML

© KIT - Karlsruhe Institute of Technology

Themes to describe the City

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CityGML 3D Building (LoD2)

3D Geometry + Topology + Semantics + Appearance



Where is the Data?

- Government play an important role
 - Providing fundamental data
 - Ensuring standards
 - Build and sustain ecosystem
- Fundamental Data
 - Collect Once – Use by Many
 - Open Standard
 - Future-proof

