GEOSPATIAL WORLD FORUM

TRANSFORMING ECONOMIES IN 5G ERA
The Geospatial Way!

7-9 April 2020 /// Amsterdam

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3D National Map for Smart Nation

Dr. Victor Khoo
Singapore Land Authority
Singapore Land Authority (SLA)

- SLA is a statutory board formed in Jun 2001
- Vision - Limited Land • Unlimited Space
Mission – To optimise land resources for the economic and social development of Singapore

**Optimise Land Resource**
ensure the best use of State land and buildings

**Administer Land Management System**
provide an effective and reliable land management system, including the issuance and guarantee of land titles and geo-spatial demarcation of land, and

**Manage Geospatial Information System**
enable the full use of land information for better land management and creation of new business opportunities
Limited Land • Unlimited Space
Creating Space Above and Below

Underground Science City

Industry Space Above Roads

Jurong Rock Caverns
2D Maps Not Adequate

- Not able to fully represent the real world
• 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
3D Map Data – Needs are Growing

- 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
Considerations for 3D Map Data

• What are the objectives and applications of the 3D datasets?
• Who are the users of the 3D datasets?
• Factors to consider
  – Accuracy / Precision
  – Level of Detail / Scale
  – Reliability / Currency
  – Coverage / Completeness
  – Data model / Format
  – Appearance / Reality
3D Mapping

3D Cadastre

Small Scale (low detail)
Large Scale (high detail)

Building information

Building Information Model

Source: NBIMS
3D National Mapping Initiative

- SLA leads a WOG initiative to create and maintain an accurate national 3D map

- Develop once; use by many
  - High resolution in order to meet the requirements of most agencies
  - Open standard exchange format for interoperability and sharing in SG-SPACE
  - Common authoritative 3D base map to support collaboration among agencies
  - Workflow for continuous maintenance to ensure currency of data
3D Mapping Project Scope

Capture 3D Data
- Airborne Imagery and Laser Scanning
- Mobile Imagery and Laser Scanning

Create 3D Models
- CityGML exchange format
- Terrain Models, 3D Buildings, 3D Roads (LOD0, LOD1, LOD2)

Establish Standards & Database
- CityGML Schema (OGC open standard)
- Relational Database

Update Changes
- Ground-based Laser Scanning/ Topographic Survey
- Satellite Imagery
- Building Information Model (BIM)
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

FY13       FY14       FY15       FY16
Phase 1     Phase 2
3D Map - Data and Products

3D Data
- Airborne 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
- 3D Road Models
Airborne Data Capturing Platform

- Two (2) twin engine aircrafts will be mobilised
- One sensor on each aircraft
- 40 days of data capturing
Laser Scanning Data – Point Cloud

Altitude of 3600ft
Minimum 5 points/sq m
Vertical accuracy +/- 15cm
Digital Surface Model (DSM) / Digital Terrain Model (DTM)
Leica RCD 30 Oblique Camera
Vertical and Oblique Images
Photo Map from Airborne Images

Photo Map (Orthophoto)
3D Building Modelling
Mobile Mapping System

- 360 Spherical Camera - Ladybug 5
- Mobile Laser Scanner – Riegl VMX-450
- IMU – Inertial Measurement Unit (inside)
- GNSS Receiver
- DMI – Distance Measuring Instrument
Mobile Laser Scanning Point Cloud
MMS 360 Images and Point Cloud
3D Modelling – Transportation and Street Furniture
3D Modelling and Data Management

• CityGML represents
  – 3D geometry, 3D topology, semantics, and appearance
  – in 5 discrete scales (Levels of Detail, LoD)

• Oracle Spatial Database

Source: Thomas Kolbe
CityGML - Level of Detail (LoD)

LOD 0 – only FootPrint and/or RoofEdge

LOD 1 – Block model w/o roof structures
LOD 2 – Differentiated roof structures, building installations
LOD 3 – Detailed architecture model
LOD 4 – LOD 3 + model of the interior space

(Source: TUDelft)

(Source: OGC)
Airborne Images to create 3D Building (LOD1, LOD2)

3D Geometry + Topology + Semantics + Appearance
Working with Partners

Terrain model for flood management

Building height information for flight safety
Slope Map and Aspect Map
3D Convergence - Ubiquitous Cadastre

Owner: John
Location: 30 Black Pepper Prawn Street
Lease expiry: 31 Dec 2099

Owner: Alan
Location: 78 Good Food Avenue
Lease expiry: 1 Jan 2199

Owner: Steven
Location: 62 Chilli Crab Road #15-01
Lease expiry: 15 June 2050
3D view: 

.....
3D Cadastre – Building Subdivision
Laser Scanning Data – Tree Mapping
### Tree Database

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**Municipal Services Office**

Estimate number of trees to support MSO’s effort in Centralisation of Public Greenery Maintenance

**National Parks**

Provide high resolution 3D tree information to support carbon accounting

**SLA**

Identify location and estimate number of trees on State Land
Urban Heat Island Effect Assessment

- How will the development of a new town affect the wind flow and comfort (thermal) in adjacent towns? Wind corridors; good ventilation; parks, open spaces and greenery?
Urban Planning

Proposed New Development

Building Height Control
Inter-visibility / Lines of Sight
Solar Potential Study
Development of Driverless Vehicle (DV)

- Produce 3D laser scanning data for the DV testing
- Collaborate with research institutes to understand the requirement of 3D map to support DV
Spin-off

- 3D indoor mapping to support Location Based Services (LBS)
- Underground mapping in 3D
- Augmented Reality and Virtual Reality
- Research
  - Future city / smart city
  - Clean energy
  - Transport and mobility
  - Simulation
Thank You