3D MAPPING DEVELOPMENT

Ben CHAN
Assistant Director / Survey & Mapping
Lands Department
Roles of the Survey and Mapping Office (SMO) of Lands Department

- establishment and maintenance of a geodetic network;
- provision of land boundary (cadastral) surveys, photogrammetric survey as well as cartographic and reprographic services;
- maintenance of a computerised land information system for mapping data and land boundary records;
- production and revision of maps and plans at different scales for different purposes; and
- administration of the Land Survey Ordinance (Cap. 473).
2D Topographic Map

Has been used for decades and it is a very effective topographical map for various applications

Applications:

- For topographical map applications
- For planning and works applications by architects, engineers, planners, developers, etc.
- For general and social applications
- For GIS developments / applications

235 features in 1:1000 Basic Map
2D map is insufficient

Our Real World

Conventional Map

Change of Land Use
3D Spatial Data of LandsD

Started in 2007

Launched in 2012
3D Spatial Data of LandsD

Building Height (>10m)
~53000 models

~210,000 models (L1)
~9,000 models (L2&L3)

~2000 models
~90 major roads

 Territory-wide
3 Aspects of 3D Mapping Development - Now and Future
3 Aspects of 3D Mapping Development
- Now and Future

1. 3D Data Capture / Data Collection
2. 3D Data Standards and Modelling
3. 3D Data Sharing
(1) 3D Data Capture/ Data Collection
(1) 3D Data Capture / Data Collection

Advanced survey technologies replace conventional survey methods

- Unmanned Aerial Vehicle (UAV)
- Backpack Mobile Mapping System, MMS
- Large Format Digital Camera
- Vehicle Mobile Mapping System

2008: Laser Scanner
2013: Unmanned Aerial Vehicle (UAV)
2016: Large Format Digital Camera
2017: Vehicle Mobile Mapping System
(1) 3D Data Capture / Data Collection

Outsourcing Mesh Model Projects

Phase I
- Fixed-wing Aircraft / Helicopter
- Captured at 6,000 and 7,000 Ft Altitude
- 10cm GSD
- 174 sq.km

Phase II
- Helicopter
- Captured at 1,000 and 2,000 Ft Altitude
- 8cm GSD
- 165 sq.km
(1) 3D Data Capture / Data Collection

Photorealistic Mesh Model

Project Areas

Mesh Models
Provision of 3D Textured Mesh Model

To enrich the 3D Spatial Data of LandsD

3D Textured Mesh Model

Limitations of 3D Textured Mesh Model
(1) 3D Data Capture / Data Collection

Image and laser points captured by Vehicle-based Mobile Mapping System (VMMS)
Enhancement of Mesh Model Street Level

Apply Vehicle-based Mobile Mapping System Data

Limitations of 3D Textured Mesh Model

With Vehicle-based Mobile Mapping System (VMMS) Data
Enhancement of Mesh Model Street Level

<table>
<thead>
<tr>
<th>Survey</th>
<th>Context Capture</th>
<th>DP-Modeler</th>
<th>3dsMax</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Aerial photos &amp; MMS photos etc.</td>
<td>• Generate mesh in .osgb format</td>
<td>• Create .obj model</td>
<td>• Export to other format such as .3ds and .dae</td>
</tr>
</tbody>
</table>

Based on the 2D building outline, add textures and structures that are greater than 4 meters.
Individualized Building Model from Mesh Model
(1) 3D Data Capture / Data Collection

Use Artificial Intelligence (A.I.) for mapping

Conventional Feature Extraction by Coding

Automatic Feature Extraction by A.I.
(1) 3D Data Capture / Data Collection

Use Artificial Intelligence (A.I.) for mapping

Video courtesy of Data-Enabled Scalable Research (DESR) Laboratory, HKUST
(1) 3D Data Capture / Data Collection

Video courtesy of Data-Enabled Scalable Research (DESR) Laboratory, HKUST
(1) 3D Data Capture / Data Collection

**BIM data as a source of 3D map data**

BIM Data and 3DSD Integration
(1) 3D Data Capture / Data Collection

Crowdsourced bathymetry

NOAA announces launch of crowdsourced bathymetry database

By Lt. Cmrd. Adam Reed, Integrated Oceans and Coastal Mapping (IOC/M) assistant coordinator

Today NOAA announces the end of a testing phase in the development of a new crowdsourced bathymetry database. Bathymetric observations and measurements from participants in citizen science and crowdsourced programs are now archived and made available to the public through the International Hydrographic Organization (IHO) Data Centre for Digital Bathymetry (DCDB) Data Viewer. The operationalized database allows free access to millions of ocean depth data points, and serves as a powerful source of information to improve navigational products.

Source: https://www.nauticalcharts.noaa.gov
3D Digital Map Development

Exploration of 3D Digital Map updating by crowdsourcing
(2) 3D Data Standards and Modelling
(2) 3D Data Standards and Modelling

Define 3D Data Standards and Modelling Specifications, including **3D Geometry** and **3D Map Information**

3-step approach:

1. Find out any international standards, adopt the standards and modified to fit HK situation
2. Proof of concept with prototype development
3. Full implementation
(2) 3D Data Standards and Modelling

3 Stages of 3D Digital Map Development

Stage 1: 3D maps for visualization

Stage 2: 3D maps for floor/unit-based applications

Stage 3: 3D maps for city modelling
(2) 3D Data Standards and Modelling

3 Stages of 3D Digital Map Development

Stage 1
- 3D maps for visualization

Territory-wide Photorealistic 3D Models by Aerial and Street View Images
(2) 3D Data Standards and Modelling

3 Stages of 3D Digital Map Development

Stage 1
- 3D maps for visualization

Stage 2
- 3D maps for floor/unit-based indoor applications

Enhanced Models with Floor and Unit Information (Major Government Buildings and Estates)
(2) 3D Data Standards and Modelling

3 Stages of 3D Digital Map Development

Indexed 3D Scene Layers (i3s)

1) Overview
2) Downloads
3) Related News

1) Overview
A single i3S data set, referred to as a Scene Layer, is a container for arbitrarily large amounts of heterogeneously distributed 3D geographic data. Scene Layers are designed to be used in mobile, desktop, and server-based workflows and can be accessed over the web or as local files.

The delivery format and persistence model for Scene Layers, referred to as Indexed 3D Scene Layer (i3S) and Scene Layer Package (SLPK) respectively, are specified in detail in this OGC Community Standard. Both formats are encoded using JSON and binary ArrayBuffers (ECMAScript 2015). i3S is designed to be cloud, web and mobile friendly. i3S is based on JSON, REST and
(2) 3D Data Standards and Modelling

3 Stages of 3D Digital Map Development

OGC CityGML LOD specification for 3D city models / need improved specification (CityGML 3.0) ?

Source: http://filip.biljecki.com/phd.html
(2) 3D Data Standards and Modelling

3 Stages of 3D Digital Map Development

- Urban Planning / Operations
- Emergency Mgt / Response
- Transportation / Routing / Logistics
- Indoor navigation
- Retail Site analysis
- Sustainable / Green Communities
- City Services Management
- Noise abatement
- Telecommunications placement
- Many other uses...

Source:
http://www1.nyc.gov/site/doitt/initiatives/3d-building.page
(2) 3D Data Standards and Modelling

3 Stages of 3D Digital Map Development

3D Geometry with Information

Stage 2

Existing Topographic Dataset

Building

Site

1

FloorPolyID

BuildingID

EnglishDisplayName

ChineseDisplayName

Headroom

DataSource

LevelSource

BaseLevel

RoofLevel

Notes

FloorPolyName

UnitPoly

1

FloorPolyID

UnitPolyID

FloorPolyID

EnglishUnitDescription

ChineseUnitDescription

UnitUsage

BaseLevel

RoofLevel

Notes

FloorPolyName
## 3D Data Standards and Modelling

### 3 Stages of 3D Digital Map Development

#### 3D Geometry with Information

<table>
<thead>
<tr>
<th>FloorPoly Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FloorPolyID</td>
<td>Unique ID</td>
</tr>
<tr>
<td>BuildingID</td>
<td>Building which the floor situated at</td>
</tr>
<tr>
<td>EnglishDisplayName</td>
<td>English Description (e.g. G/F, 1/F)</td>
</tr>
<tr>
<td>ChineseDisplayName</td>
<td>Chinese Description (currently unused)</td>
</tr>
<tr>
<td>Headroom</td>
<td>Headroom of the floor</td>
</tr>
<tr>
<td>DataSource</td>
<td>Data Source of the information (e.g. building plan, BIM)</td>
</tr>
<tr>
<td>LevelSource</td>
<td>Data Source of Floor Elevation</td>
</tr>
<tr>
<td>BaseLevel</td>
<td>Base Level of the Floor</td>
</tr>
<tr>
<td>RoofLevel</td>
<td>Roof Level of the Floor</td>
</tr>
<tr>
<td>Notes</td>
<td>Notes and Remarks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UnitPoly Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UnitPolyID</td>
<td>Unique ID</td>
</tr>
<tr>
<td>FloorPolyID</td>
<td>Indicate the floor polygon it belongs to</td>
</tr>
<tr>
<td>EnglishUnitDescription</td>
<td>Description of the unit as stated on plan</td>
</tr>
<tr>
<td>ChineseUnitDescription</td>
<td>Description of the unit as stated on plan</td>
</tr>
<tr>
<td>UnitUsage</td>
<td>Usage of the unit</td>
</tr>
<tr>
<td>BaseLevel</td>
<td>Base Level of the unit</td>
</tr>
<tr>
<td>RoofLevel</td>
<td>Roof level of the unit</td>
</tr>
<tr>
<td>Notes</td>
<td>Notes and remarks</td>
</tr>
<tr>
<td>FloorPolyName</td>
<td>State the floor name where the unit situated</td>
</tr>
</tbody>
</table>
(1) 3D Data Standards and Modelling

CIC (Task Force on BIM Standards Phase 2)

1. Standards for common BIM procedures such as project coordinates, project units model management and file naming convention

2. LOD Responsibility Matrix that sets out potential modelled elements by discipline and attaches a CAT Code to those elements.

DevB

1. BxP Execution Plan Template to advise the modelling methodology for discipline by providing examples of different elements typical for each discipline’s model and associated an object type to that specific element.

2. Update the DevB TC No.16/2000 for as-built and design BIM data
(2) 3D Data Standards and Modelling

3 Stages of 3D Digital Map Development

Address Data Infrastructure

2D GeoAddress (2019)

- an identifier to linking services and address related information maintained in B/Ds

3D GeoAddress Code (under planning)

- matching the proposed 2D GeoAddress
- unique identifier in floor and unit levels
- facilitate the development of more innovative applications
(2) 3D Data Standards and Modelling

3 Stages of 3D Digital Map Development

**Stage 1**
- 3D maps for visualization

**Stage 2**
- 3D maps for unit-based indoor applications

**Stage 3**
- 3D maps for city modelling

Comprehensive 3D Map Objects
(2) 3D Data Standards and Modelling

Study on 3D Digital Map Development

- International / national mapping standards
- Technology edge on 3D mapping
- Interview stakeholders

1:1000 Digital 2D Topographic Map (235 Features)
(3) 3D Data Sharing
(3) 3D Data Sharing

Provision of Services for the Study on Integration of BIM data and 3D Spatial Data

Purpose
To create a BIM-friendly data environment to facilitate works and land development processes

Provision of Service Contract
LandsD started a project for the study on Integration of BIM Data and 3D Spatial Data in March 2017 and completed in March 2018
(3) 3D Data Sharing

**Provision of Services for the Study on Integration of BIM data and 3D Spatial Data**

**Interviewees**

- Development Bureau
- Construction Industry Council
- Government Departments

**Project Steering Committee**

**Contractor Project Team**

- Project Manager
- BIM Specialist
- GIS Specialist
- System Analyst
BIM data sharing for 3D map updating
Simplification Result

▲ Source BIM Data

▲ Simplified BIM Data

▲ Simplified FBX

▲ ArcGIS & Skyline 3DSD
As-built/Simplified BIM Data Repository
(3) 3D Data Sharing

Release new BIM compliant data formats for 3D Spatial Data

2019

FBX format

IFC, CityGML or other formats (Proposing)

Source: Autodesk
(3) 3D Data Sharing

Establish Building Information Modelling (BIM) Data Repository

- Define simplified BIM Standard
- Establish BIM Data Repository for map updating and proptech

2018

- As-built/Simplified BIM Data Repository Prototype
- Revise Works Bureau Technical Circular No. 16/2000 – Provision and Collation of Land Survey and Mapping Data

2019

Start Design and As-built Data Management System
Announce 3D Spatial Data updating schedule in 2019 to avoid duplication of work on 3D model creation and encourage data sharing.
### Number of Existing Buildings (whole territory of HK)

<table>
<thead>
<tr>
<th>Types</th>
<th>Buildings (Height &gt;= 10m)</th>
<th>Buildings (Height &lt; 10m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>210,000 (about)</td>
<td>157,000 (about)</td>
</tr>
<tr>
<td></td>
<td>53,000 (about) (25%)</td>
<td>157,000 (about) (75%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Available in 2019</th>
<th>After 2019</th>
<th>Available in 2019</th>
<th>After 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3D Mesh Models</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(LandsD &amp; PlanD)</td>
<td>45,000 (21%)</td>
<td>8,000 (4%)</td>
<td>87,000 (42%)</td>
<td>70,000 (33%)</td>
</tr>
<tr>
<td><strong>Individualized 3D Building Models</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(LandsD)</td>
<td>28,000 (13%)</td>
<td>25,000 (12%)</td>
<td>18,000 (9%)</td>
<td>139,000 (66%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Individualized 3D Building Models (Enhanced with Street-level Imagery)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(LandsD)</td>
<td>800 (0.5%)</td>
<td>52,200 (24.5%)</td>
<td>nil</td>
<td>157,000 (75%)</td>
</tr>
</tbody>
</table>
(3) 3D Data Sharing

Release new type of 3D map product, i.e. 3D Mesh Model

**Target 01**
About one-third of Hong Kong area covered

**Target 02**
Whole territory of Hong Kong area covered
(3) 3D Data Sharing

3D Spatial Data publishing / updating schedule

Target 03
50% of about 210,000 individualized building models updated in Level 2 / Level 3

Target 04
All individualized building models updated in Level 2 / Level 3
3D Data Sharing for Government Departments

3D Spatial Data Viewer for LandsD

3DXplorer in GIH for Government Departments
(3) 3D Data Sharing

3D Digital Map forms the basis of essential spatial data and supports Common Spatial Data Infrastructure, CSDI
(3) 3D Data Sharing

Technology Convergence

Supported by 3D Digital Map

Collaboration with BIM

Property Technology
(PropTech)

ICMS, IPMS, ILMS Standards

Construction 2.0

CSDI Consultancy Study
Institutional Framework
CSDI – Digital Infrastructure for Smart City
A Bridge between Digital and Real World - Digital Twin

With the support of three building blocks

- CSDI Portal
- 3D Digital Map
- Positioning infrastructure

Overseas example
- National SDI (NSDI) for the United States
- INSPIRE (NSDI) for the European Union
- Abu Dhabi SDI
- National SDI for Singapore
What is the future 3D Map?

Example: Helsinki’s 3D City Models

The models are available as open data

Source: https://www.hel.fi/helscinki/en/administration/information/general/3d/3d

2 Types of 3D Model
- 3D Reality Mesh Model
- CityGML 3D Information Model
  - includes a terrain model and individualized building models
  - buildings are presented in two formats: LoD1 - flat-roofed
  - LoD2 - with differentiated roof structures and textured
What is the future 3D Map?

Example: Berlin’s 3D City Models

- Fully textured
- Individualized building models created by aerial photogrammetry and their roofs were measured with lasers
- Various 3D formats including CityGML format

The models are free of charge, available for download in the Berlin 3D download portal.

Source: https://www.businesslocationcenter.de/en/WA/B/seite0.jsp
What is the future 3D Map?

**Example: Virtual Singapore**

- Dynamic 3D city model built of national 3D map developed with the use of LiDAR as well as real-time dynamic data
- Integrates data from government agencies, information from the internet, from IoT devices and sensors
- Various 3D formats including CityGML format

Source: https://www.geospatialworld.net/blogs/singapores-smart-nation/
What is the future 3D Map?

Example: Rotterdam 3D

- 3D representation of the municipality based on a number of key registers, height data, data management and photographs
- Includes buildings, trees, lampposts and cables and pipes
- Various 3D formats including CityGML format

The models are available as free open data

Source: https://www.rotterdam.nl/werken-leren/3d/
Collaborations among the Government, Industry, Academia and the Research Sector
3D Mapping Standards
MMS
3D Data Collection
A.I.
3D Modelling
BIM
UAV
Data Formats
3D Indoor Map
Mesh Model
3D GeoAddress
3D Data Sharing
3D Geometry
CSDI
3D Data Capture
PropTech
Summary

• The Survey and Mapping Office (SMO) of the Lands Department is serving the community by providing quality mapping services and products.

• We will consider the requirements for geospatial information (2D/3D) by:
  - Continuing to play a key role in providing a reliable, trusted and maintained geospatial information base; and
  - Providing data that is accessible, interoperable and standardised.

• The 3D Digital Map development in Hong Kong requires collaboration of the Government, Industry, Academia and Research sectors.

• Together, we can support the Hong Kong Smart City Blueprint and various smart city applications and developments.
"Coming together is a *beginning*, staying together is *progress*, and working together is *success.*"

- Henry Ford

*Henry Ford*
*(the founder of the Ford Motor Company)*

Source: