Semantic 3D Model based Solution for Smart Cities in China

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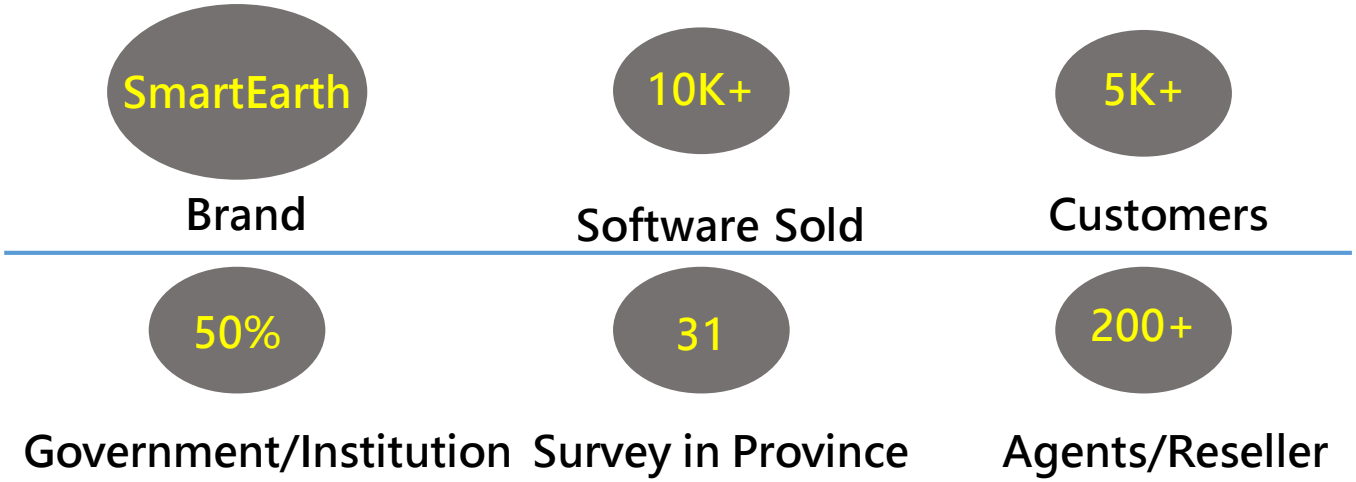
Dr. Huang Dong, CTO

Graduated from University of Karlsruhe. Main interest: mobile Internet, location-based service applications, SCADA and smart factories, GIS systems and Smart City Application. Current work and research focus on real-world 3D data processing and applications, computer vision and artificial intelligence technologies in the GIS and other fields.

Terra InfoTech (Beijing) Co., Ltd.

leading 3D digital earth and location service technology provider in China, dedicated to provide one-stop 3D software products services, solutions and data services.



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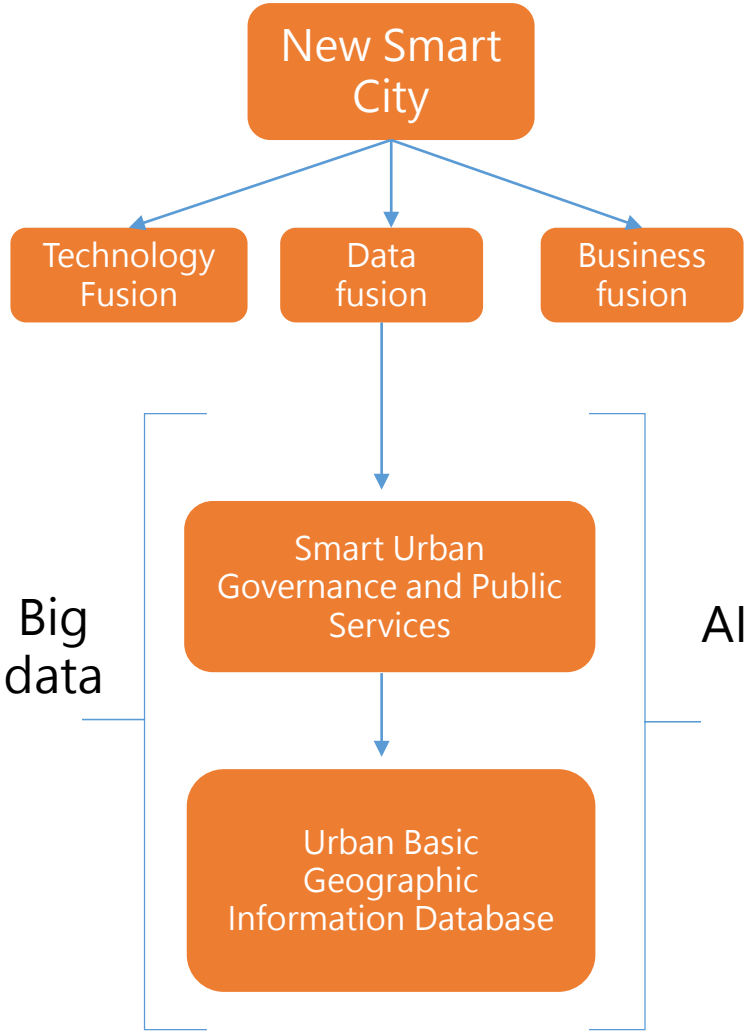
Background



Tencent 腾讯

Baidu 百度

Alibaba.com 阿里巴巴

Based on Big Data,

index a city

powered by AI

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Current Situation

1st Tier Cities

Beijing, Shanghai and Guangzhou has completed the data collection and modeling process of the oblique photogrammetry. Some cities have already started the classification of each building and floor. And the data semantization would be of the focus and the key technology to fuel various applications.

Quasi 1st Tier Cities

Hangzhou has initiated the Urban Intelligent Semantic Modelling Planning.

2nd Tier Cities

Zhengzhou has accomplished the semantic modelling polit project of the key areas based on the oblique photogrammetry data.

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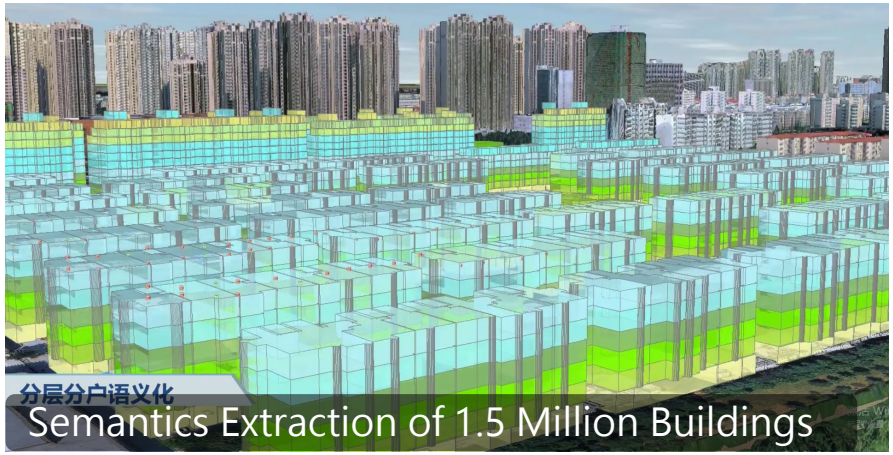
Shanghai

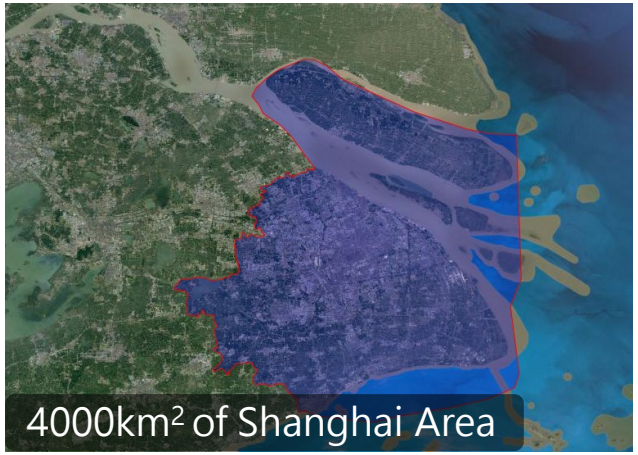
Shanghai is one of the leading cities in China in terms of urban management. And the “Smart Police Project” is a representative project under “Shanghai ET City Brain”, which is conducted by Shanghai Police and Alibaba Group. It requires:

- 4000 km^2 Mesh modelling
- 1.5 million classified buildings
- 30+ million floor and household classification and 3D semantic model extraction
- Links to 100+ million sensors

- As required by Shanghai Police, we also integrate the multi-source data.



Semantics Extraction of 1.5 Million Buildings


4000km^2 of Shanghai Area

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Beijing

In 2017, Beijing Municipal Commission for City Planning and Land Resources Management has started the data generation in Beijing built-up area, covering 3600 km^2 in total.

Current situation:

Complete the flight in October 2017, yet the data processing remain unfinished

Next Plan:

Mesh model itself could not meet the need of emerging business and operations from various departments. Therefore, Beijing has been experimenting based on the structural semantic 3D model, such as classification.

Problems:

1. Slow data processing: It decreases the data timeliness
2. Applications bottleneck: There are few data-related applications except the visualization of real world

Solution

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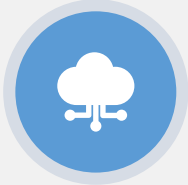
Data Fragmentation

How to handle multitude data source?

Multi-data Source Integration



Business Fragmentation

How to manage full lifecycle of business?

Multi-business Integration

Knowledge Fragmentation

How to apply cross-domain industrial knowledge?

Multi-knowledge Integration

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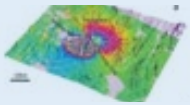
Overwhelming Urban Spatial information

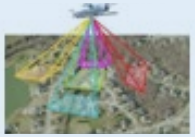
City operation produces enormous information

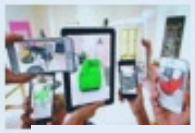

Indoor navigation


Indoor model

BIM


InSAR


Oblique photogrammetry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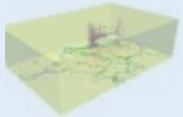
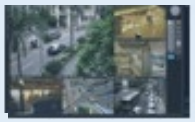
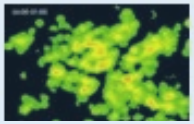
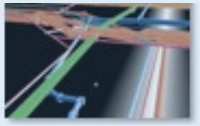
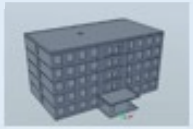

Spatio-tempora trajectory


Video Surveillance


Population activities


Cellular signal


Underground pipeline


...

80% of urban information is related to spatial geography

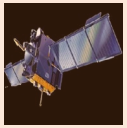
Transportation

Tax

Legal Person

Cellular signal

Positioning




Property rights


Citizenship

Social Security

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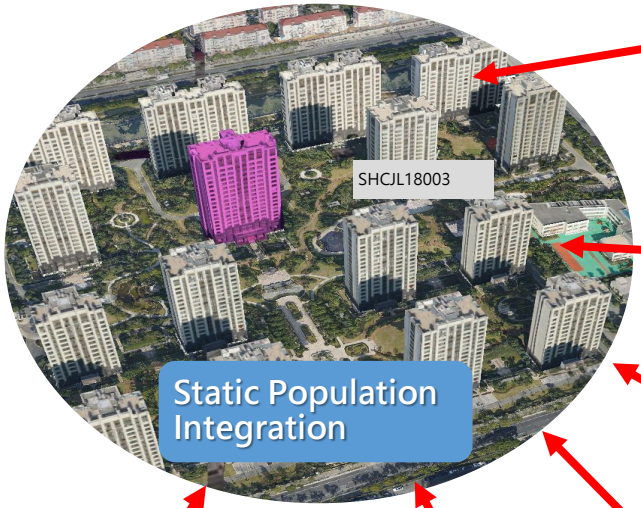
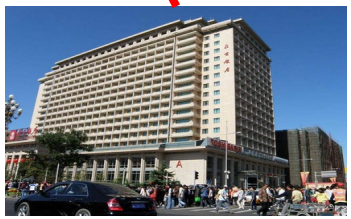
Example: Multi-data Source Integration-Semantics Integration



3D model



Photos showing reality

"1S and 6A"

Standard Address Database, Actual Population, Actual Legal Person, Actual Real Estate, Actually Police, Actual Police Equipment, Actual Police Force

"4S and 4A"

Standard Plot, Standard Address Database, Standard Building Encoding, Standard Basic Grid

Actual Population, Actual Real Estate, Actual Employer, Actual Facility

Multitude Population Attributes

Gender, Age, Occupation, Employer, Social Security…

Construction Attributes (50+)

Encoding, Name, Address, Base Area,、Gross Area, Classification and Use of Buildings, Structure, Floor Numbers, Construction date, Owner information, Examine and Approve information

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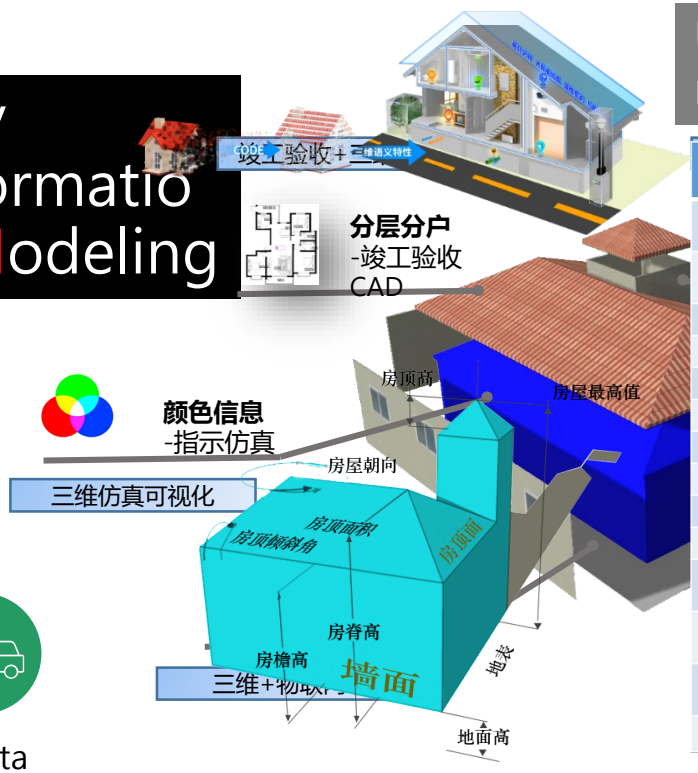
Urban Information Model Trinity

Entity Model
Urban multi-element structural 3D in real scene

3D Model
Metadata Model
Industrial Data Index

Cloud Data Description Model
Semantization of spatial structure logic standard

City Information Modeling



Big Data Integration Tool
Indexing each industry data via spatial data, creating a urban information organism

Using graph structure to record spatial relations

序号	内容	序号	内容
1	建筑最高房顶	15	建筑面类型
2	建筑最低房顶	16	建筑表面积
3	估算误差	17	面最低点高程
4	地面高	18	面最高点高程
5	建筑高	19	以DTM为参考的最低高程
6	建筑高参考	20	以DTM为参考的最高高程
7	建模方法	21	屋顶方向
8	房顶类型	22	屋顶角
9	房顶名称	23	建筑ID
10	房顶参考值	24	建筑面积ID
11	模型创建日期	25	建筑与建筑面组合ID
12	输入数据类型	26	建筑ID、面ID、面类型ID的组合ID
13	主要房顶类型码	27	建筑的最大建筑构件屋顶类型
14	建筑面序号		

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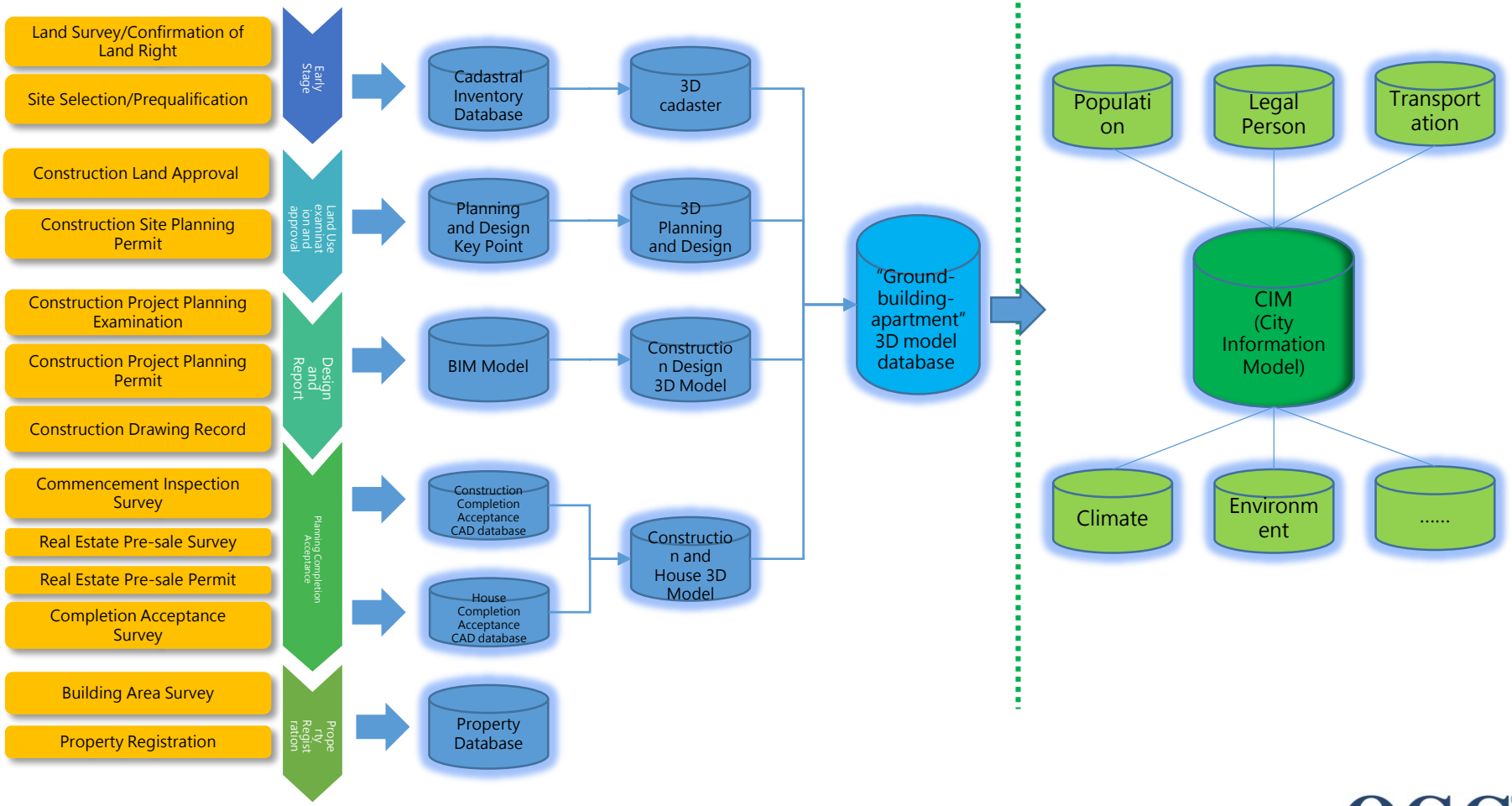
“Ground-building-apartment” Full Lifecycle Business Integration



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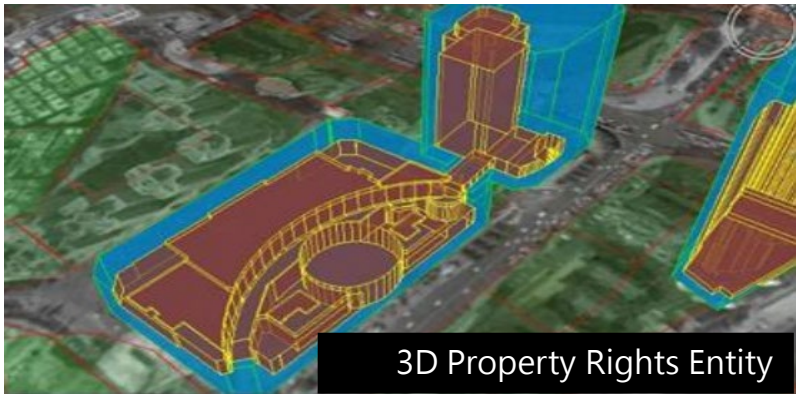
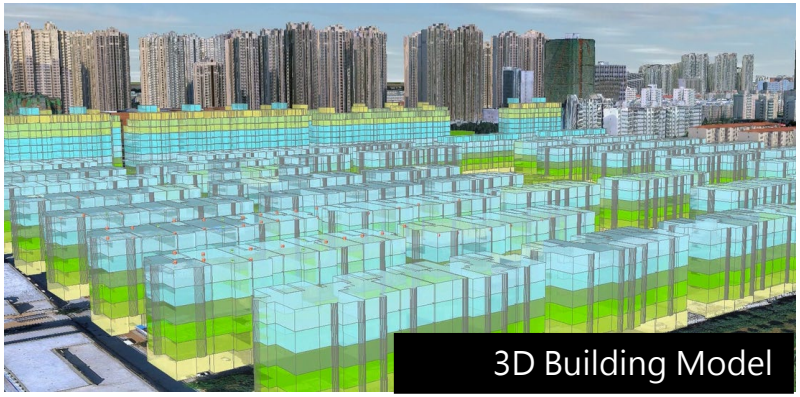
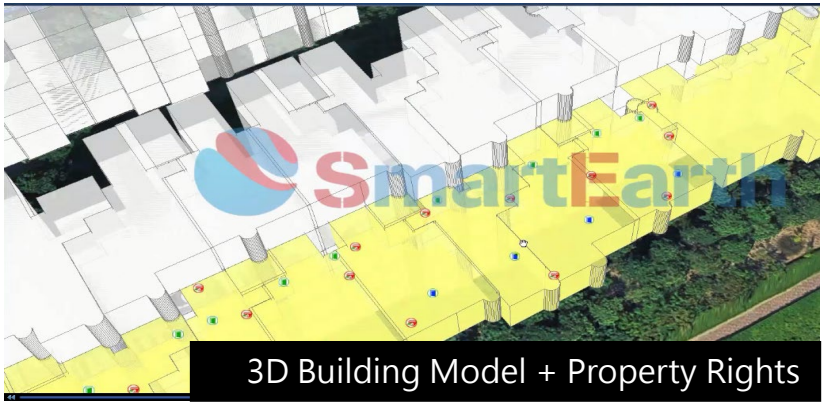
Multi-business Integration


3D Property Rights Entity


3D Planning and Control Entity


3D Building Model



3D Building Model + Property Rights

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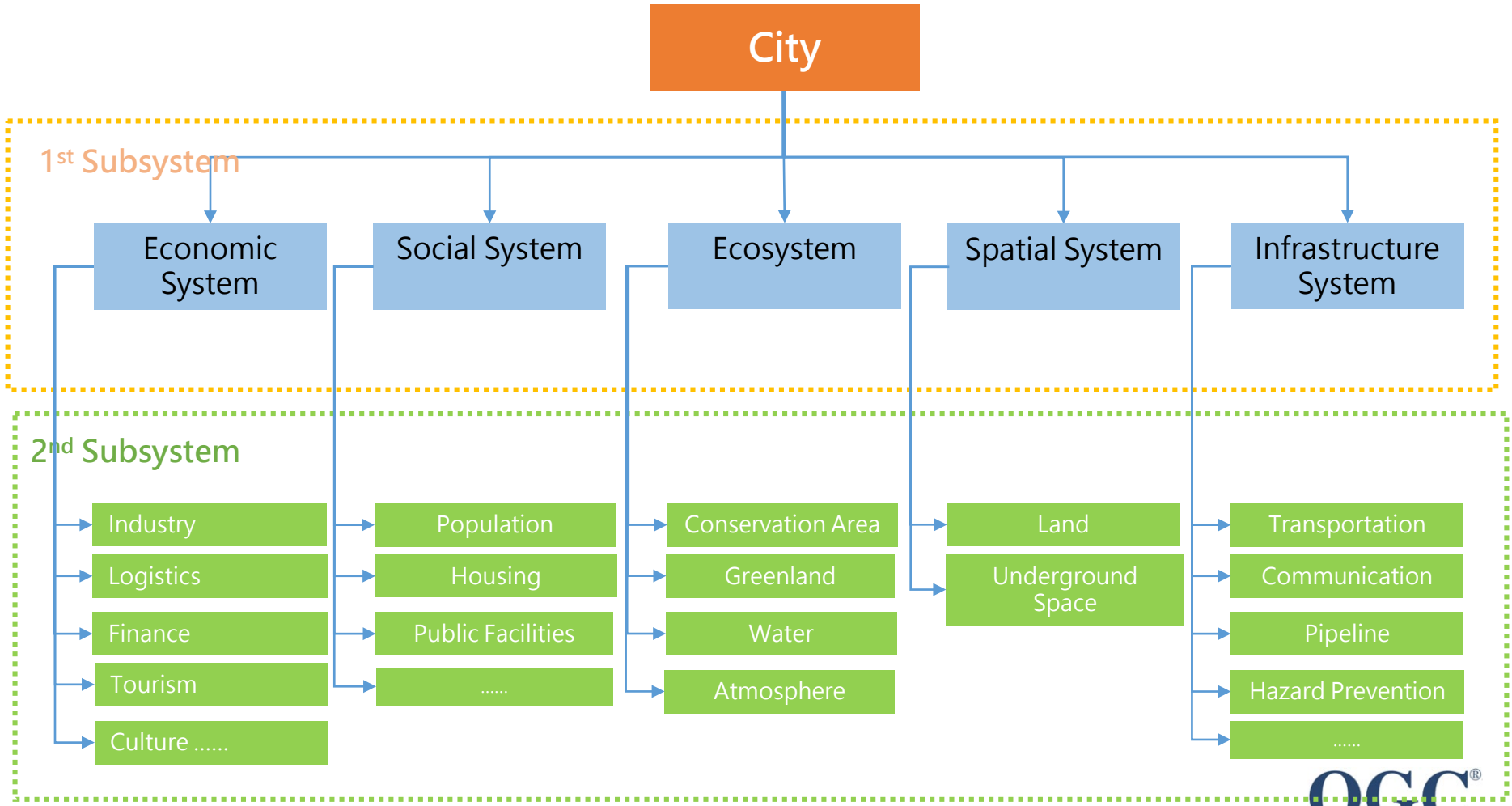
Theory, Methodology and Application Model of Urban Construction



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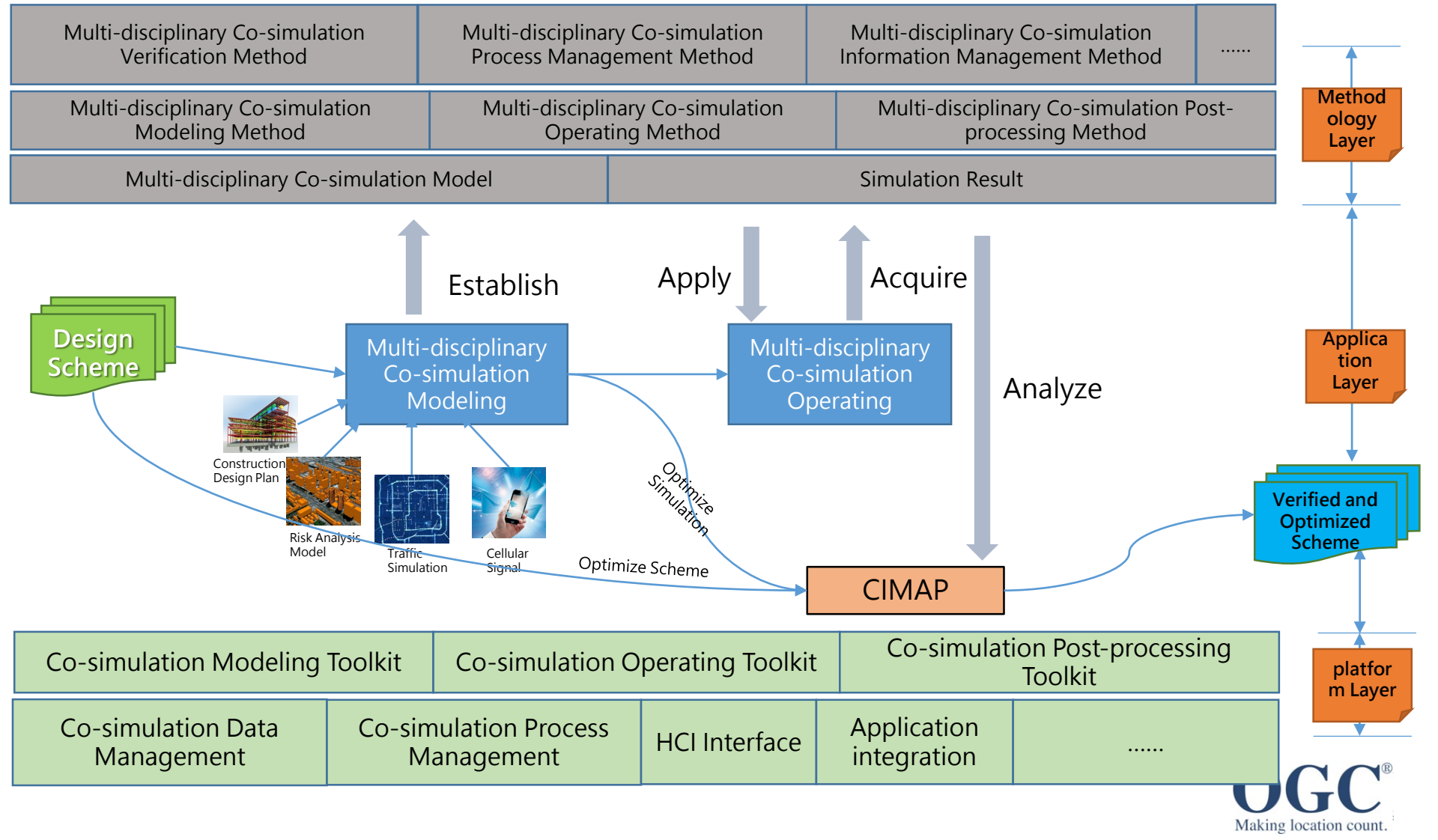
Theory, Methodology and Application Model of Urban Construction



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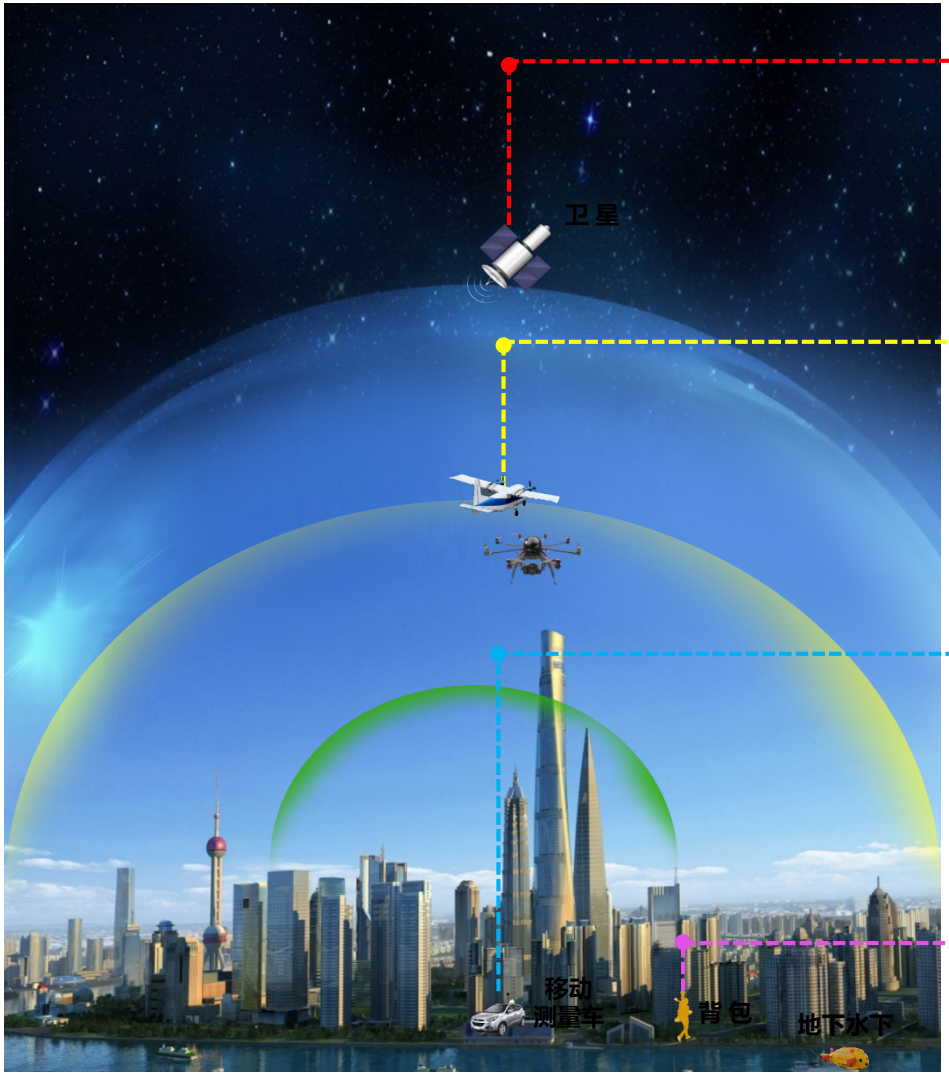
How to get Semantic Data?



Oblique Cameras

LIDAR

Computer Vision

3D Reconstruction

PhotoMesh

Robotics

3D SLAM

Semantics (Features information)

CityGML

CIMGenerator

AI

Feature Extraction

Block

Cell

4D

Mesh

CIM

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How to get Semantic Data?

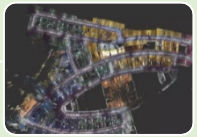
Computer Vision

3D Reconstruction

PhotoMesh™

Robotics

3D SLAM



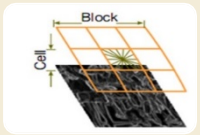
Semantics (Features information)

CityGML

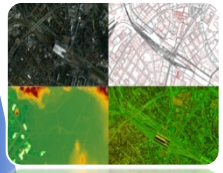
CIMGenerator

AI

Feature Extraction

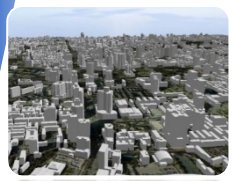


4D



Mesh

CIM



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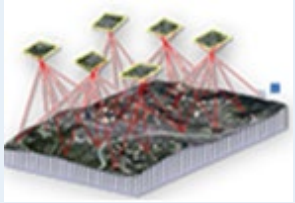
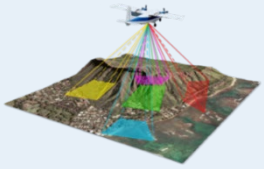
Pipeline

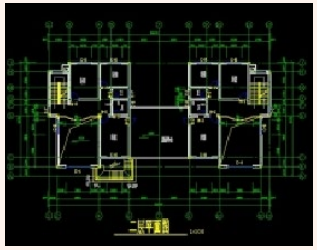
Aerial images



Point Cloud



CAD Blueprint



- Automatic generation of urban information model base on the data from laser scanning and oblique photogrammetry
- Creation classified fine models via texture mapping
- Generation of indoor and outdoor models using existing BIM data and CAD blueprint

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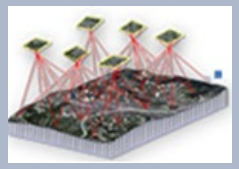
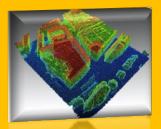
Workflow of CIM Generator

Data Acquisition	Data Input	Data Processing	Untextured Model	Data Processing	Result
Aerial Images  Point Cloud 	DSM  Point Cloud  DEM/DTM  **DLG/Building Contour**  DOM/TDOM 	 Extraction and Editing of Untextured Model	 Untextured Model with Semantic information	 Image Retrieval and Texture Mapping	 Semantic model with extensible analysis

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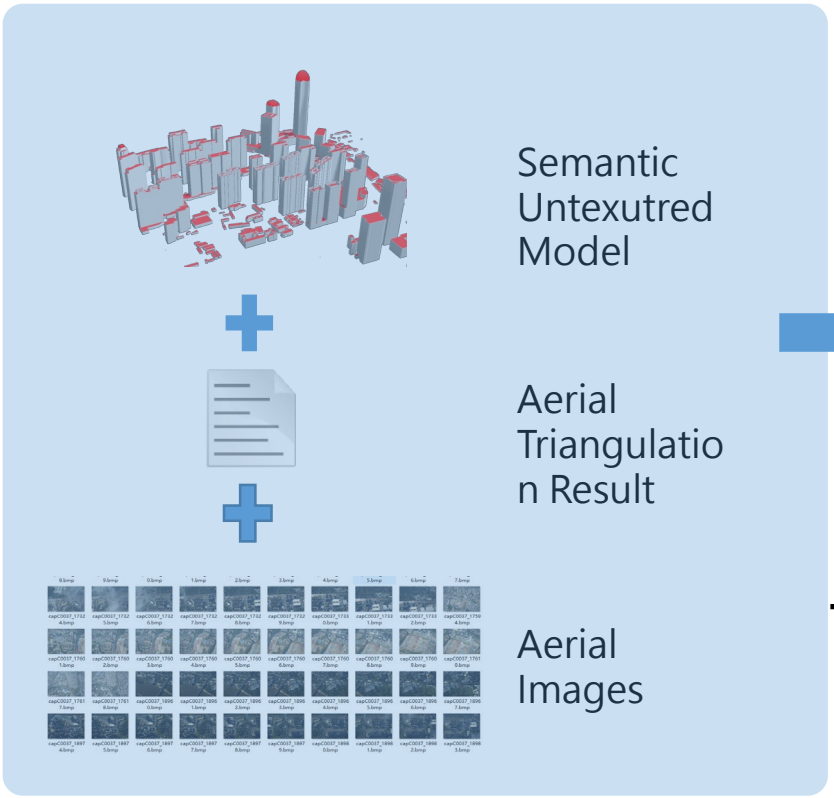
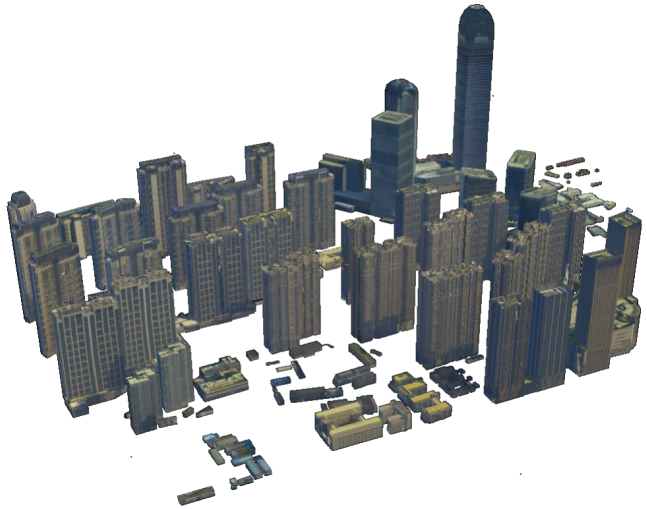
Texture Module

3DSHP, aerial triangulation result and aerial images as input, Texture Module enables fully automatic texture mapping.





Texture Module – Fine Texture Mapping

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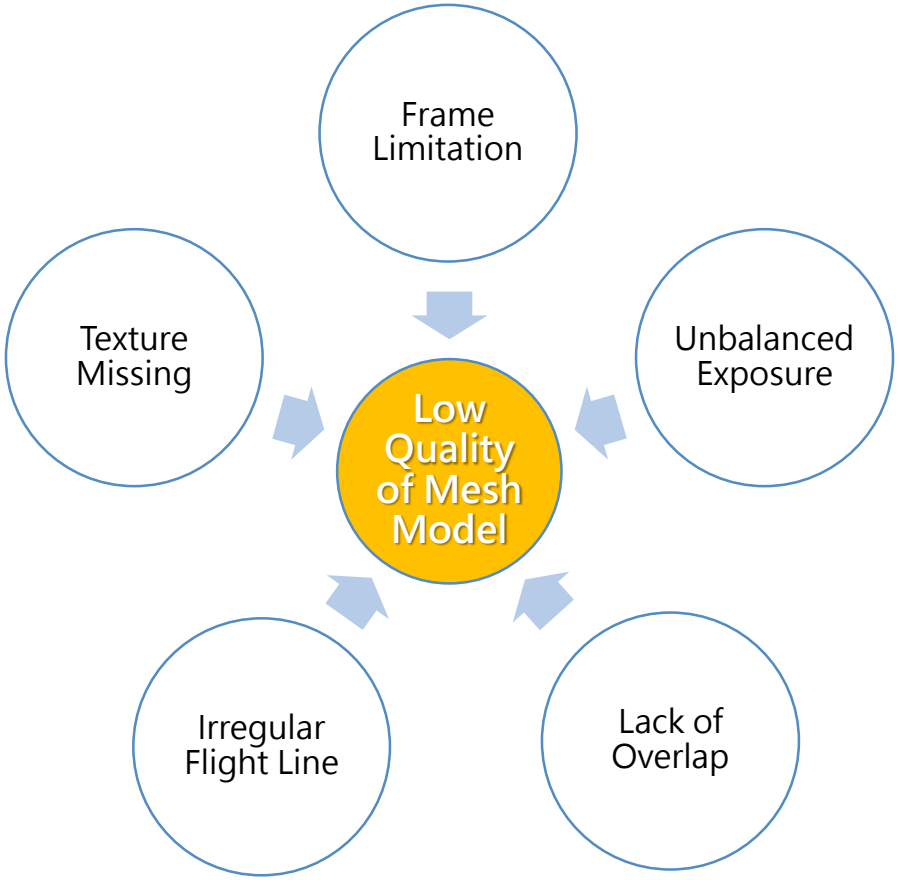
Texture - Support fine modeling base on the oblique photogrammetry data



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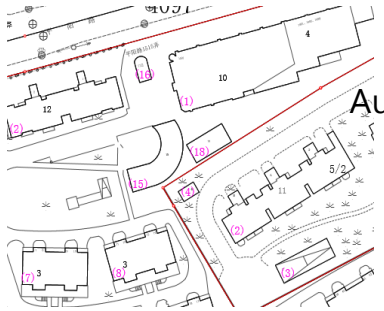
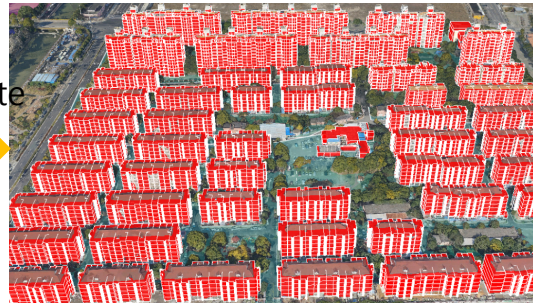
CIM Indoor Module

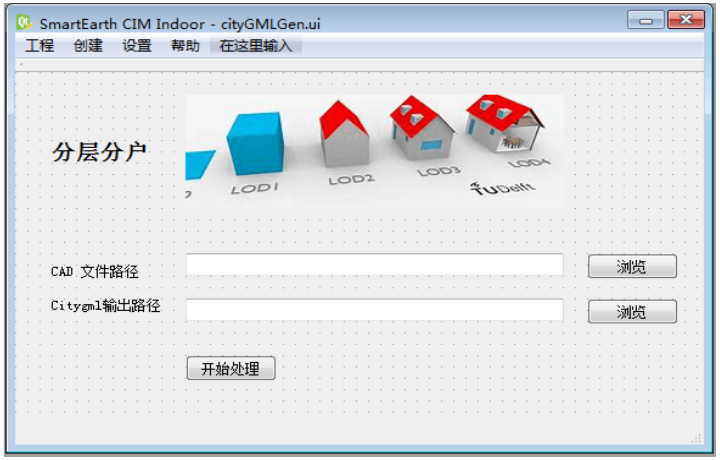
Based on the widely used CAD floor plans, we can generate the urban building models with LoD 4, and save them in semantic model format.



Auto-generate



CAD Blue Print



Indoor Module – Automatic Building Model Generation And Classification

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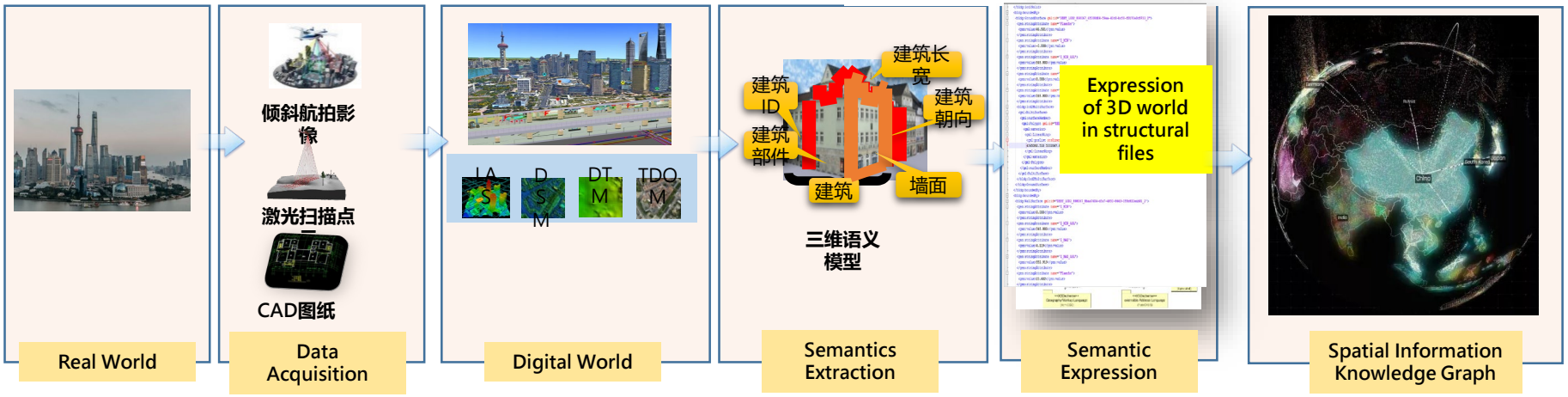
Intelligent Data and Spatio-temporal Knowledge Graph

Semantization

- Machine-Understandable
- Multi-source/Heterogeneity/Multi-modal Integration
- Spatial Information Knowledge Graph



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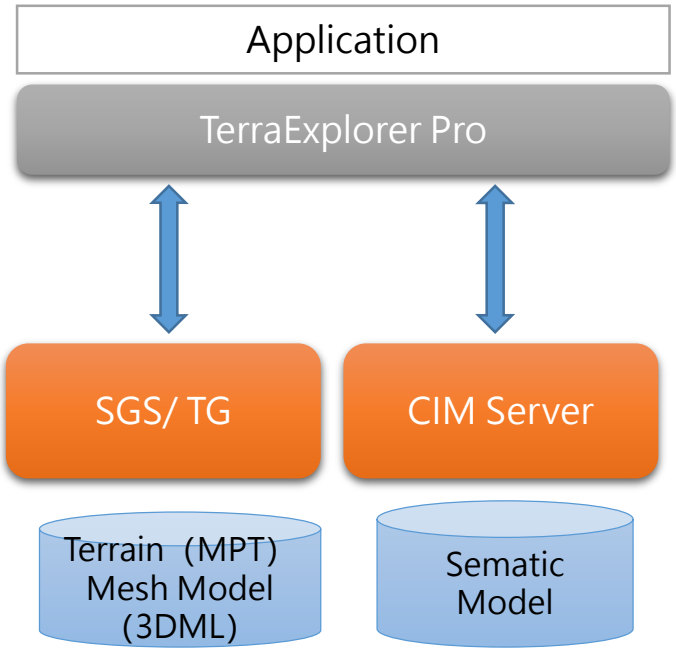
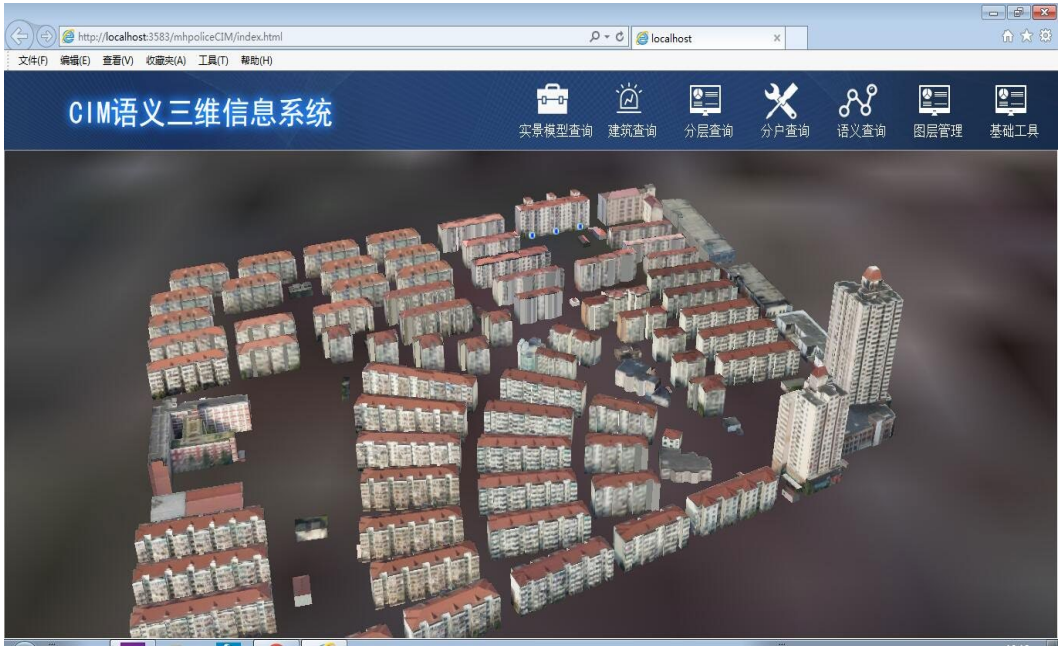
CIM Server Data Publish

Professional Application Development:

SGS + TE Pro+ CIM Server





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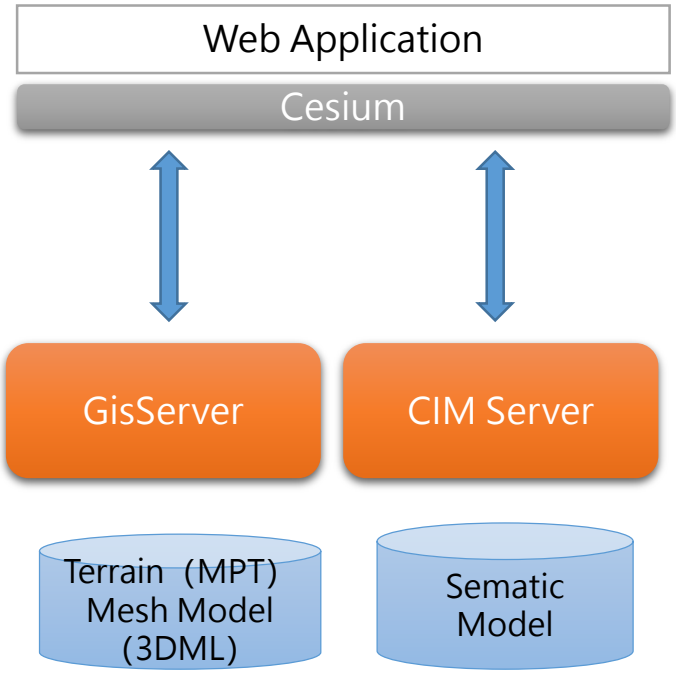
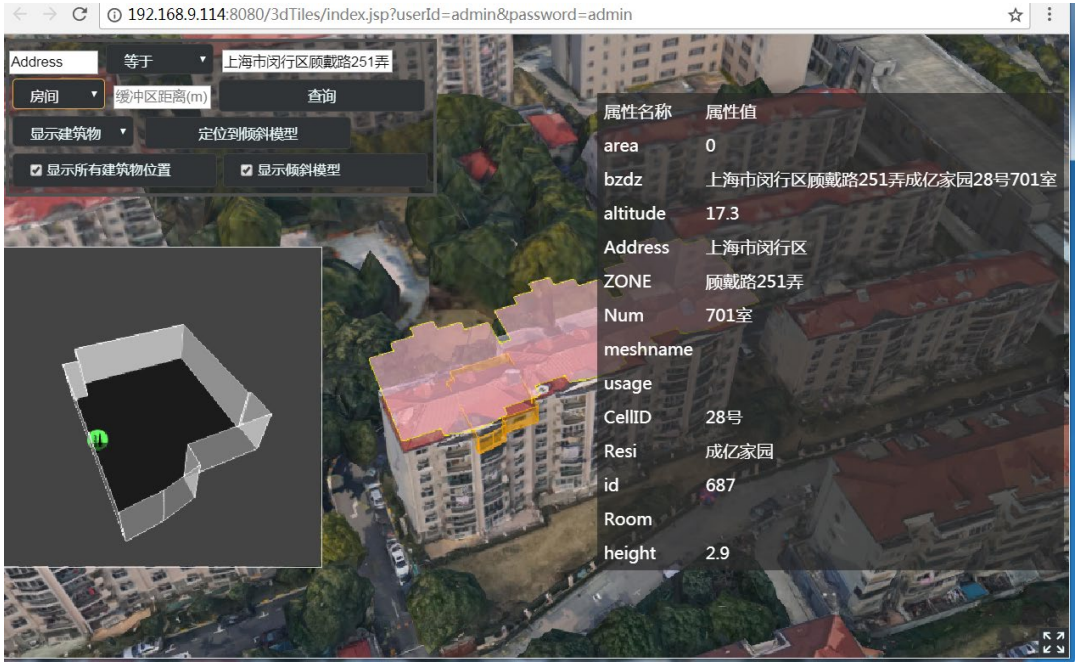
CIM Server Data Publish

Light-weighted Application Development:

SE GISServer + CIM Server





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SmartEarth

Issues

- The most asked question from customer:
- What is the point to add Semantics to Data?
- What is ROI of adding Semantic information to geospatial data?
- How can we link Semantic Model to Knowledge Graph or AI technology? Is there reference design or implementation?
- Can we have a use case collection of adopting Semantic in Smart City Application?