



**Dr. Sameer Saran**

Head, Geoinformatics Department, RSGG  
Indian Institute of Remote Sensing (ISRO)  
Dehradun, [sameer@iirs.gov.in](mailto:sameer@iirs.gov.in)



#### Background

- Need & Motivation of 3D City Models
- 3D Data Models and Data Types
- General Taxonomy

#### CityGML

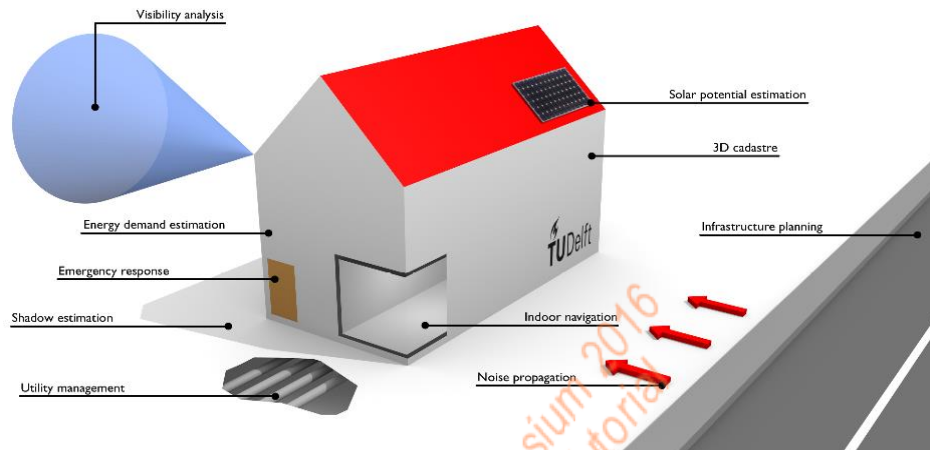
- Overview
- Multi-scale modeling
- Spatial-Semantic Coherence

#### IIRS Initiatives using 3D City Models

- Estimation of Solar Irradiation
- Traffic Noise Modeling
- Interoperability Model
- Indoor Logistics: Mapping, Navigation, Positioning & pattern analytics

## Need and Motivation behind 3D City Models *iirs*

- A 3D city model is a representation of an urban environment with a three-dimensional geometry of common urban objects and structures, with buildings as the most prominent feature.
- 3D City Models may be applied in a multitude of application domains for environmental simulation and decision support



## 3D Data Models *iirs*

### **3D Data Models are of 2 types:**

- **Geometrical Models** : defines the geometric objects and elements types. They consist of different spatial objects (points, linestrings, etc.) with the representation of their properties.

**e.g.** COLLADA, VRML, X3D, etc.

- **Semantic Models** : defines entities and their non-spatial characteristics and relationships among the entities.

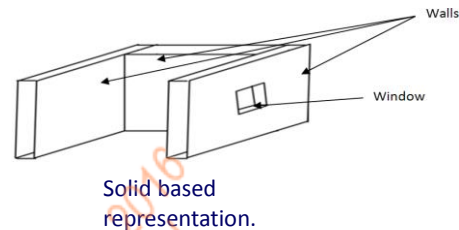
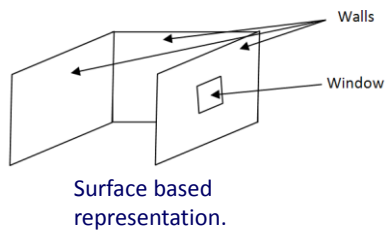
**e.g.** CityGML, IFC, gbXML, etc.

## 3D Data Types



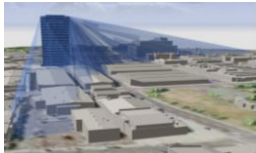

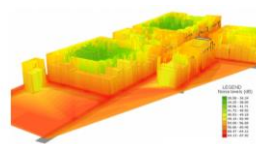
**Main 3D data types to used in 3D data models:**

- 3D objects are represented by its **boundaries (B-Rep)**,
- 3D objects are represented by **voxel elements**,
- 3D objects are represented by a combination of **the 3D basic block (CSG)**.



## General Taxonomy of 3D Use Case



Category	3D Analysis	Application	Representation
1.	Applications based on Geometry	Estimation of the shadow	
2.	Analysis based only on geometry and semantic information	Estimation of the solar potential	
3.	Analysis based on domain specific extension and external data	Noise emission calculation	

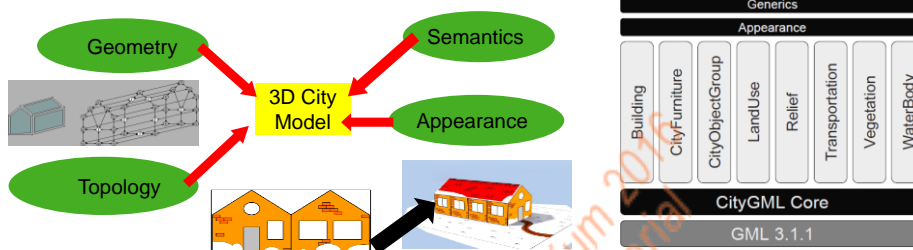
***But categories are not mutually exclusive in all cases***

# CityGML



## Features:

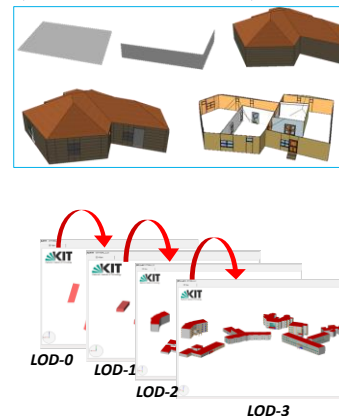
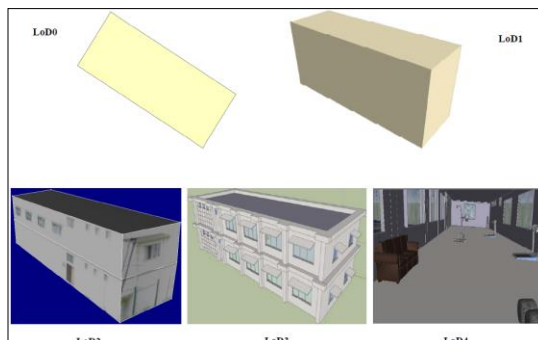
- Open data model.
- XML-based format.
- Used for storing and exchanging virtual 3D objects and city models among applications.
- Has both Geometrical & Semantic model of information.
- Implemented as an application schema for the Geography Markup Language 3 (GML3).
- Supports Multi-Scale Modeling according to the details level required in different applications.



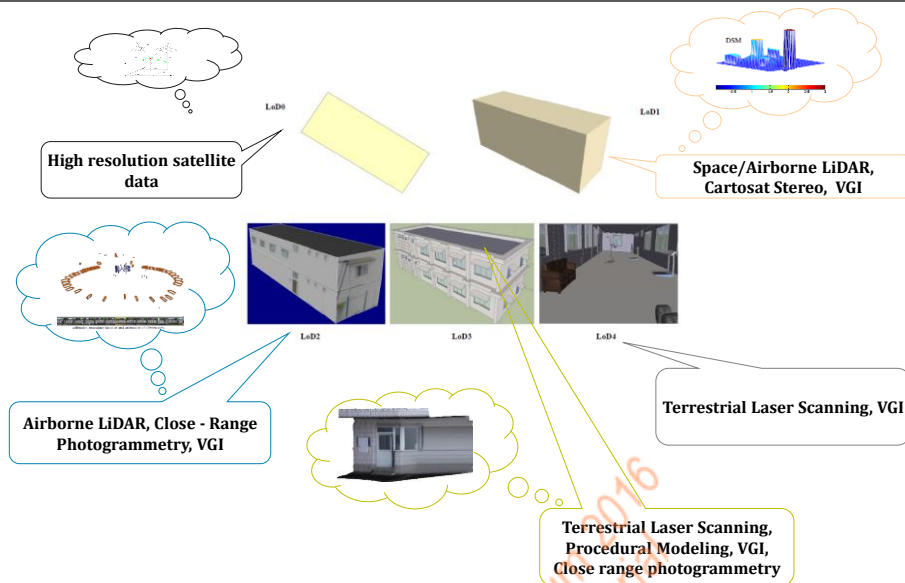
## Multi scale modeling of IIRS Campus & Gymnasium



- LOD-0 : A 2D footprint.
- LOD-1 : Block Model of Building.
- LOD-2 : Adds differentiated roof structure and thematically differentiated surfaces.
- LOD-3 : Architectural model with detailed wall and roof structure.
- LOD-4 : Adds interior structures for 3D objects like rooms, interior doors & stairs, etc.



# 3D Acquisition Techniques



## CityGML : Building Module (LoD3) Illustration

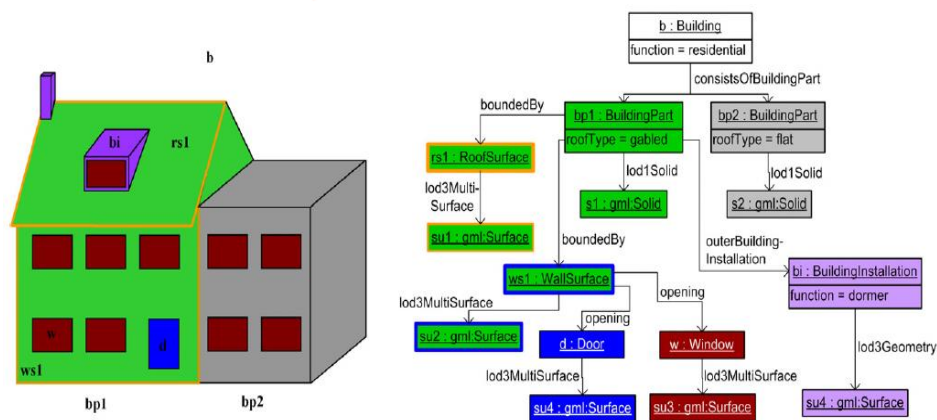
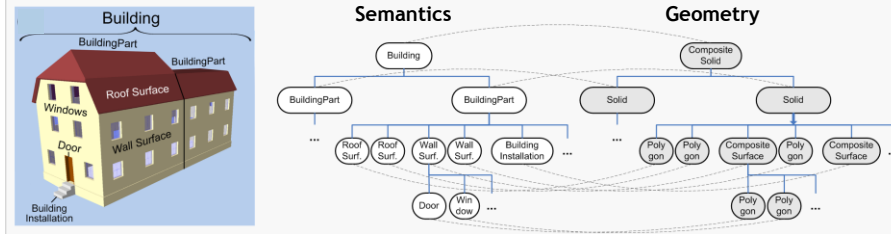


Illustration of LoD3 building : spatial representation (left) and CityGML feature structure as UML instance diagram (right)

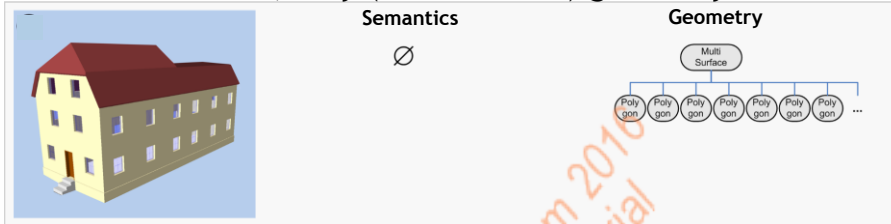
# CityGML (Spatial-Semantic Coherence) vs KML



## CityGML: (Up to) Complex objects with structured geometry



## KML: No semantics, only (unstructured) geometry



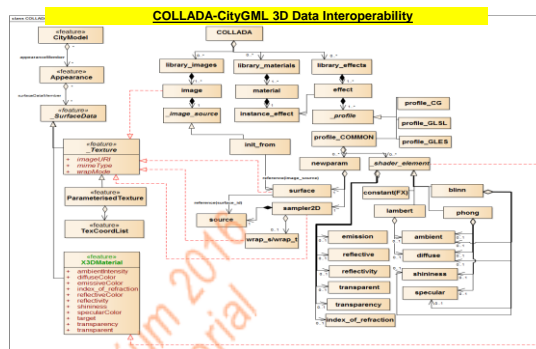
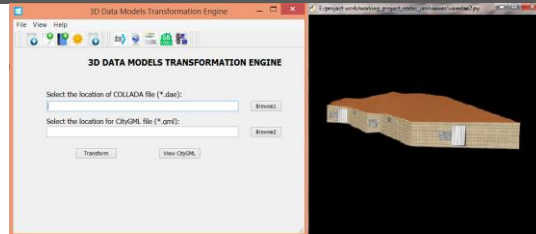
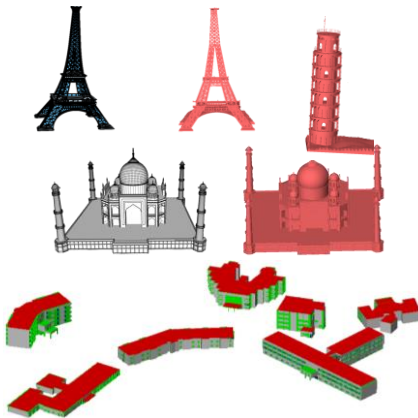
IIRS Initiatives



## 3D GIS - CityGML based Interoperability



- Study of 3D data models viz. Collada (\*.dae), gbXML, IFC and OGC based CityGML
- Mapping of base elements for storage and exchange of virtual 3D City models
- Improving 3D models with Geometry & Semantics in a single model considering all Level of Detail Modelling (LOD-0 to LOD-4)
- Surface model (BRep) for 3D representations.



Kumar K., Sameer Saran and A. Senthil Kumar, 2015. "CityGML based Interoperability for the transformation of 3D Data Models" *Transaction in GIS* (in Press).

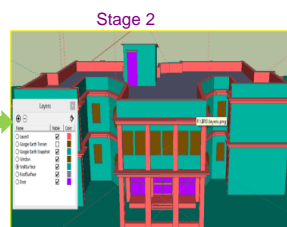
## 3D City Modeling for harnessing solar energy to develop solar cities



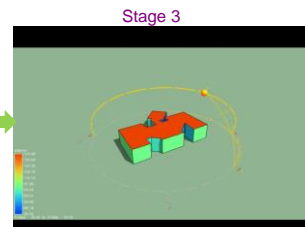
- To estimate effective percentage of roof/wall/window of a building contribute to harness solar energy
- To simulate solar heat potentials of buildings on monthly/daily or hourly basis considering sun-earth geometry



3D Building Model Generation



Semantic Dissection of 3D Model



Simulating Sun Illumination for Solar Energy Estimation

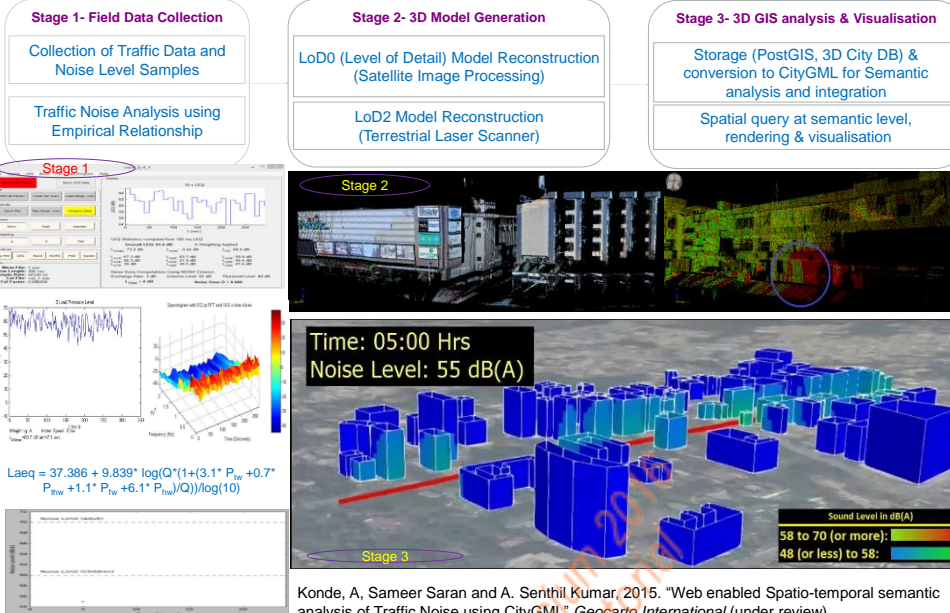
- Building footprints captured from Cartosat-1
- 3D model of LoD 3 created using sketch-up/ CityEngine
- Conversion of sketch-up to Collada model (\*.dae)
- Transformation of Collada model to CityGML using Feature Manipulation Engine (FME)
- Loading CityGML to PostgreSQL/ PostGIS and storing semantic information into RDBMS for semantic queries
- Conversion of CityGML to (green building) gbXML
- Enrichment of semantic information with additional energy simulation class attributes
- Simulation of building information model (BIM) into solar energy estimation using Sun-Earth geometry

Saran, S., P. Wate, S.K. Srivastav and Y.V.N Krishnamurthy, 2015 "CityGML at semantic level for energy conservation strategies" *Annals of GIS*, Vol. 21, No. 1, 27-41. (doi:10.1080/19475683.2014.992370)

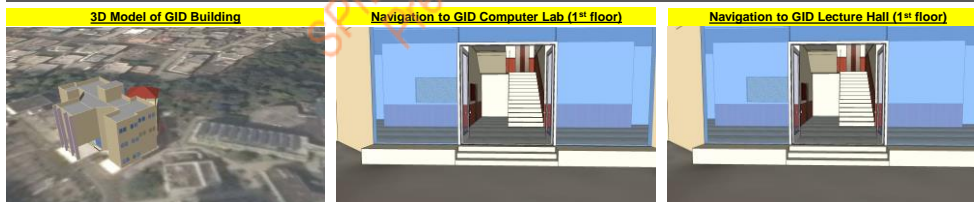
Wate, P. and Sameer Saran, 2015 "Design of CityGML Energy ADE for integration of Urban Solar potential Indicators using UML" *Geocarto International*. <http://dx.doi.org/10.1080/10106049.2015.1034192>.



## Traffic Noise Modelling using 3D GIS for Smart City Planning



## 3D GIS - Indoor Logistics



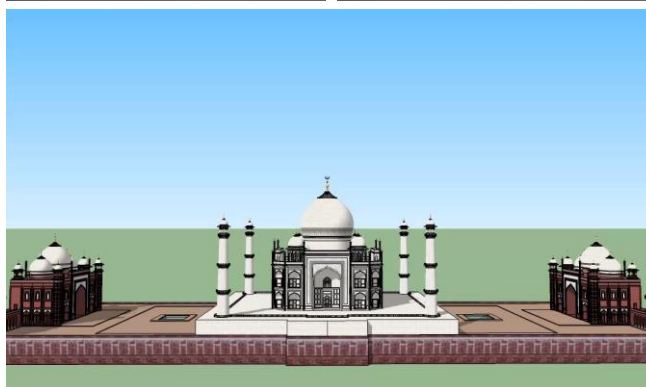
**Indoor mapping:** This includes accurate floor plan mapping and 3D visualization.

**Indoor positioning:** This includes mapping points of interest and static content.

**Indoor locating:** This includes locating mobile devices and other dynamic content.

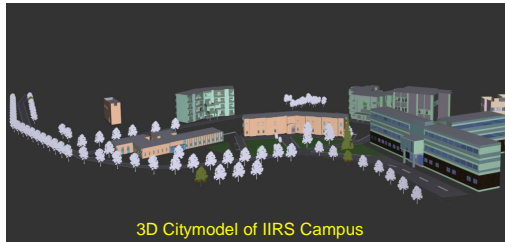
**Indoor routing & analysis:** This includes indoor routing and the management of business processes with GIS analysis tools.

**Indoor asset tracking:** This includes tracking mobile assets for dispatching and other operational efficiency purposes.

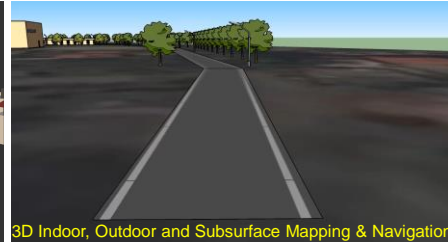




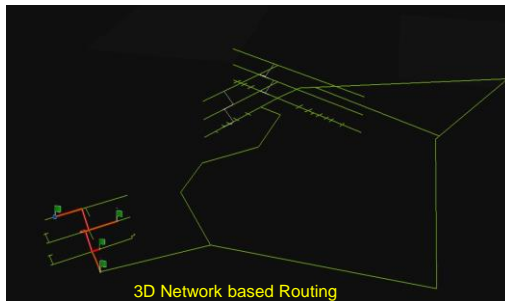
## 3D GIS - Indoor Mapping, Routing & Navigation



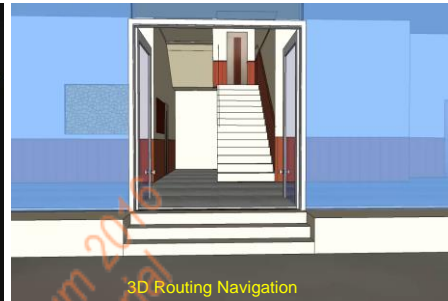
3D Citymodel of IIRS Campus



3D Indoor, Outdoor and Subsurface Mapping & Navigation

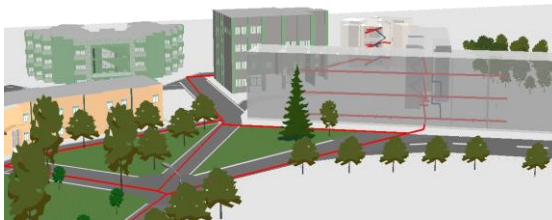


3D Network based Routing



3D Routing Navigation

## 3D Indoor Routing of IIRS Campus



3D Network Dataset

□ 3D Models of buildings created in SketchUp and imported as Collada Model into ArcScene.

□ 3D Network dataset created in ArcScene, including pathways and staircases, inside and outside the buildings.

- Pathways
- Staircases

- Points Chosen as starting and end points.
- Routing model designed in Model Builder of ArcScene.
- Optimal Route shown by the Network Analyst.

— Optimal Route

— Start Point

— End Point



Route between two rooms in two buildings



THANK YOU

[sameer@iirs.gov.in](mailto:sameer@iirs.gov.in), [saran.iirs@gmail.com](mailto:saran.iirs@gmail.com)

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