# Location Powers; Our Urban Environment

## Modeling the Subterranean City

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- Josh Lieberman develops, leads, and manages OGC Innovation Program initiatives.
- He has been involved in OGC both as a member and as an initiative architect for almost two decades.
- Also a part-time senior researcher at the Harvard Center for Geographic Analysis and teaches graduate classes at UMBC.
- Currently leads the OGC SCIRA project, Underground Infrastructure Pilot activity, and Maritime Boundaries and Limits Pilot.

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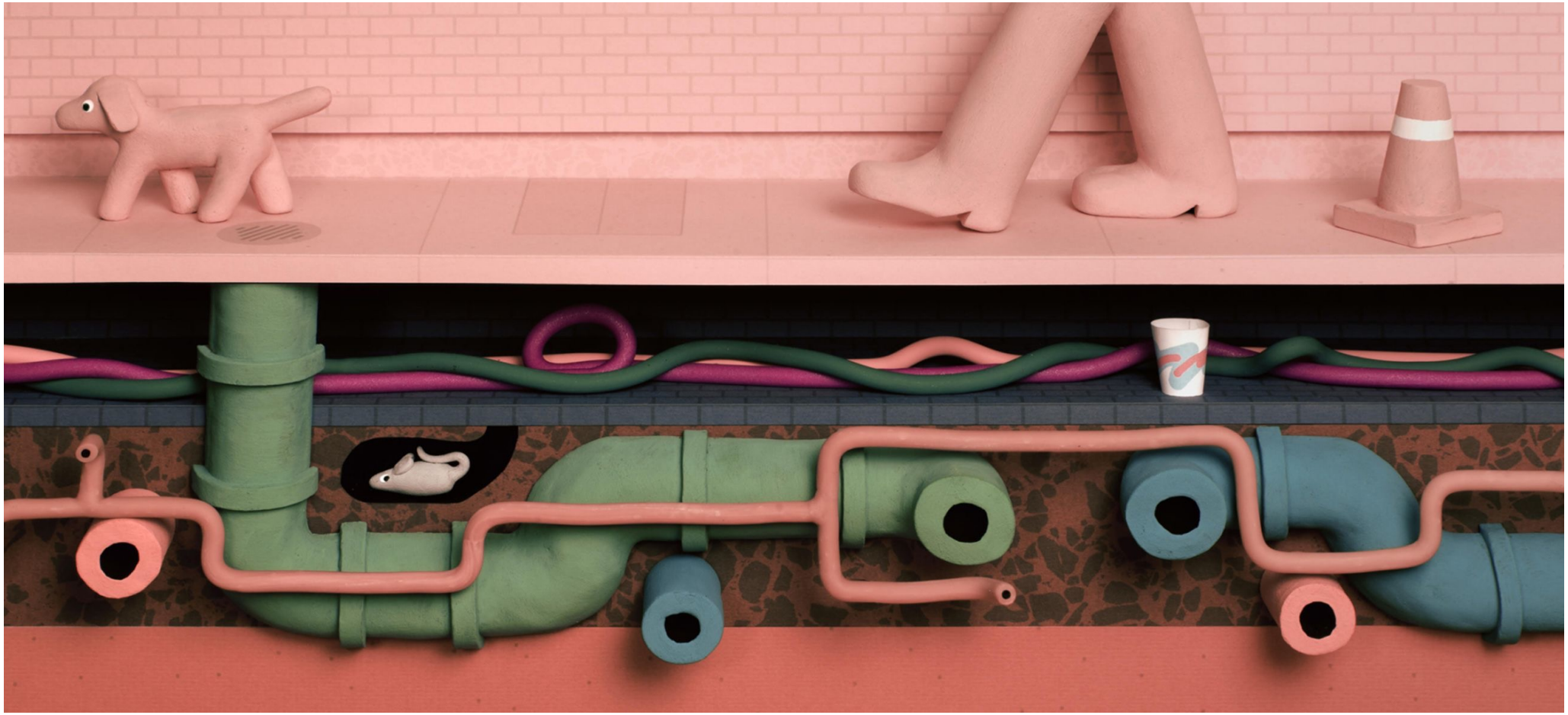
# Who Knows the Subterranean City



- The answer to “Who knows?” is often “No one”
- Source: *Nobody Knows What Lies Beneath New York City* – https://www.bloomberg.com/news/features/2017-08-10/nobody-knows-what-lies-beneath-new-york-city

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# Who Owns the Underground

Disconnects between rights to the underground space and rights to information about the space

- Who owns the space under cities? The attempt to map the earth beneath us - https://www.theguardian.com/cities/2018/jul/10/who-owns-the-space-under-cities-the-attempt-to-map-the-ground-beneath-our-feet

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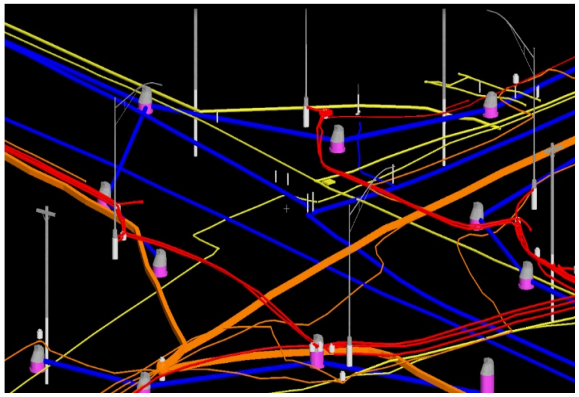
# Underground Infrastructure Information (UGII) – Current State of Affairs –



- Present UGII data quality is poor
  - Different data models
  - Stored in different ways
  - Different geometry and semantics
  - Indifferent connect to aboveground data
- Inability to exchange UGI data
  - Maintainers have different purposes
  - Ownership, governance challenges
  - Interoperability issues
- Costs of UGII failures are recognized
  - Routine excavations can be disastrous
  - Inefficiencies in construction
  - Unable to predict cascading failures

OGC Underground Concept Development Study Report
http://docs.opengeospatial.org/per/17-048.html



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# Underground Information (UGI) Projects

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   - Findings and Recommendations
   - http://www.opengeospatial.org/projects/initiatives/undergroundcds
2. Data Model – conceived
   - Necessary foundation for the Pilot
   - To support multiple, interoperable implementations
3. Plugfests and Experiments
   - NYC activities, others planned
   - Alignments and harmonization
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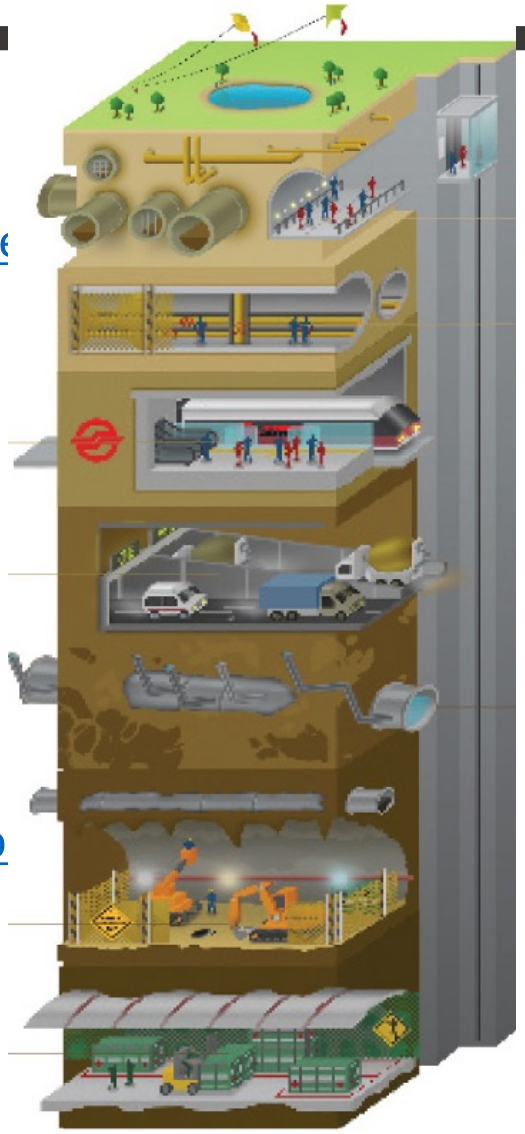
4. Pilot Implementation - planned
   - Develop, Test and Demo technology advancements
   - Provide basis for city procurements



*Source: Singapore Land Authority*



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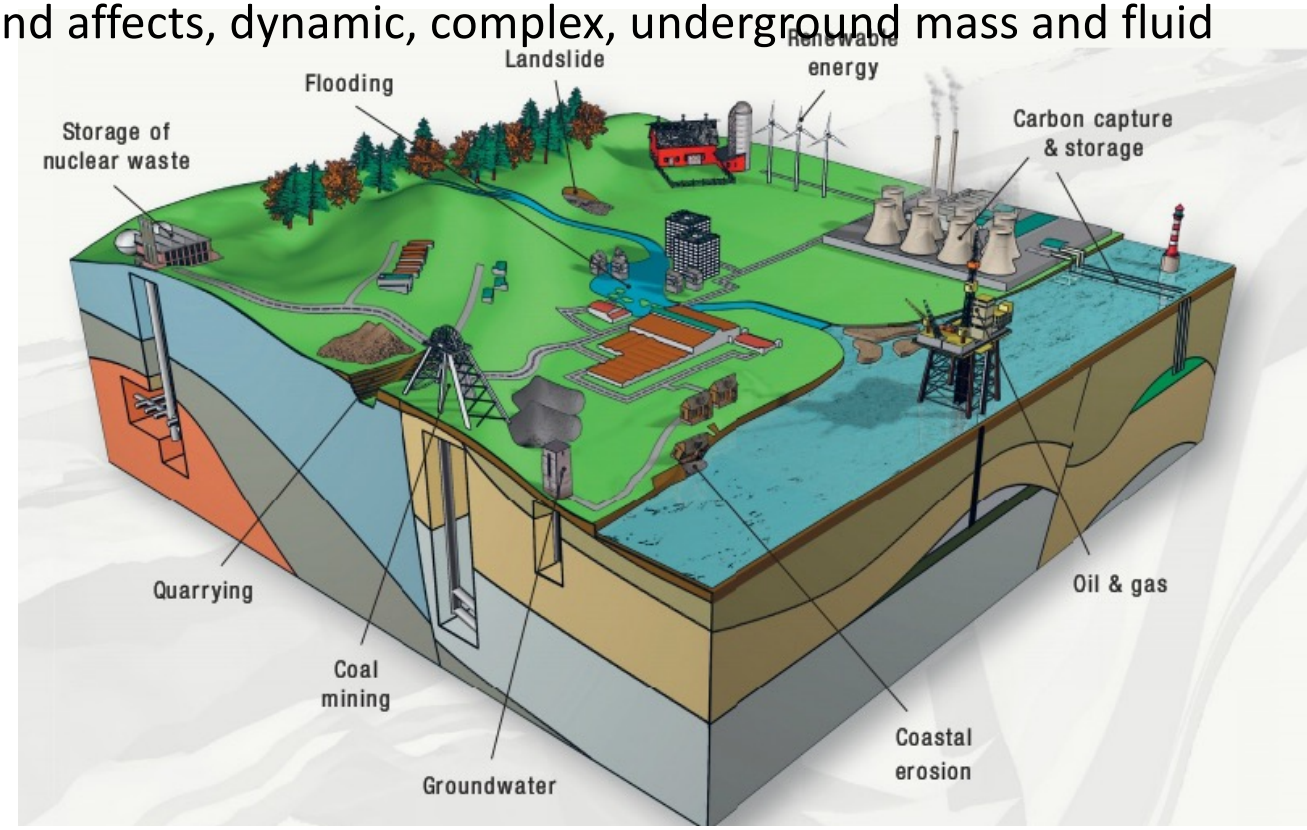
# Geological properties & processes matter

- Underground structures, properties and hazards affect where, and how, to build most effectively
  - The Institution of Civil Engineers estimate that about **50%** of cost and time over-runs on civil engineering projects are caused by 'unforeseen ground conditions.'

- Dense urban environments = conflicting demands on the subsurface
  - Holistic approach needed to avoid developments being considered in isolation

- Infrastructure is affected by, and affects, dynamic, complex, underground mass and fluid processes
  - Groundwater
  - Contamination
  - Heat
  - Shrink / swell
  - Sink holes
  - Weathering and corrosion



# Use cases and perspectives

- **Use Cases**
  - **Routine street excavations**
  - Emergency response
  - Utility O & M
  - **Large scale construction projects**
  - **Disaster planning and response**
  - Smart cities services.
  - …Impacts on (unknown) drinking water recharge zones
- **Perspectives**
  - Data integration
  - Visualization – 2D, 3D, 4D, AR
  - Data quality and consistency
  - Dependency analysis
  - Connectivity and provision
  - Digital twinning and simulation

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# …So Many to Choose From

- CityGML Utility Network ADE (Application Domain Extension)
- INSPIRE Utility Networks
- IMKL (Information model for cable and pipes)
- Land and Infrastructure Conceptual Model (LandInfra)
- Underground Pipeline Information Management System
- CIM for Power Utilities
- Enterprise Systems for Utilities –
- Wastewater Pipeline & Manhole Condition Assessment
- Gas Distribution
- Water/Wastewater Modeling
- GEOfeature
- ASCE “As-Built”

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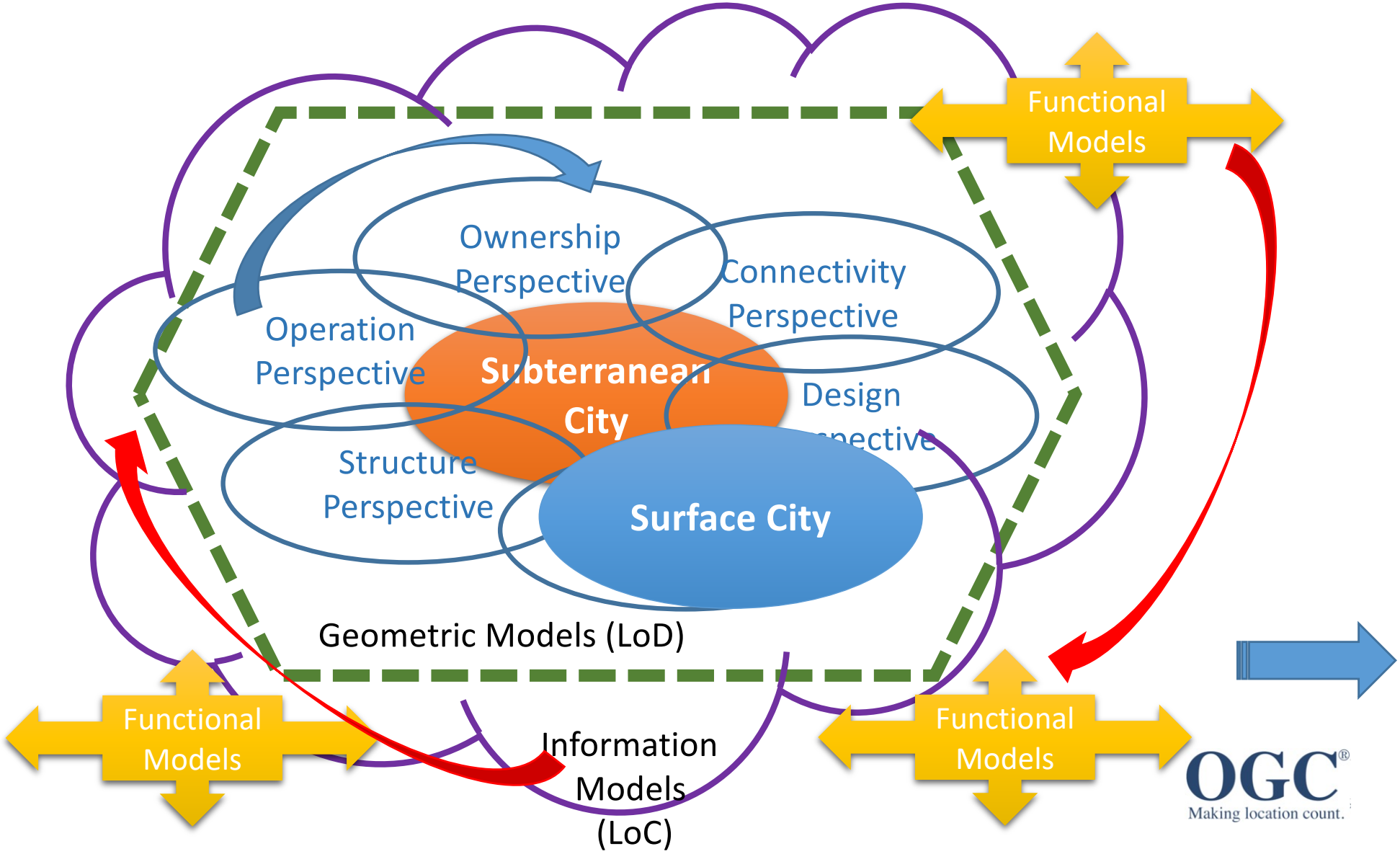
# Models within Models



# Data Integration Architecture

Diverse Data Sources, Systems, Formats

Unified Model with Multiple Perspectives

Distinct Data-driven Applications

Water

Power

A&E

Telecom

Functions

Networks

Structures

Assets


Disaster Planning

Large-scale Construction

Safe Excavation


Planning, Investment, Lifecycle

Standard Model Interfaces

- On-demand Query
- Proxy / Cache
- Authoritative Repository

Unified / Harmonized Data Access



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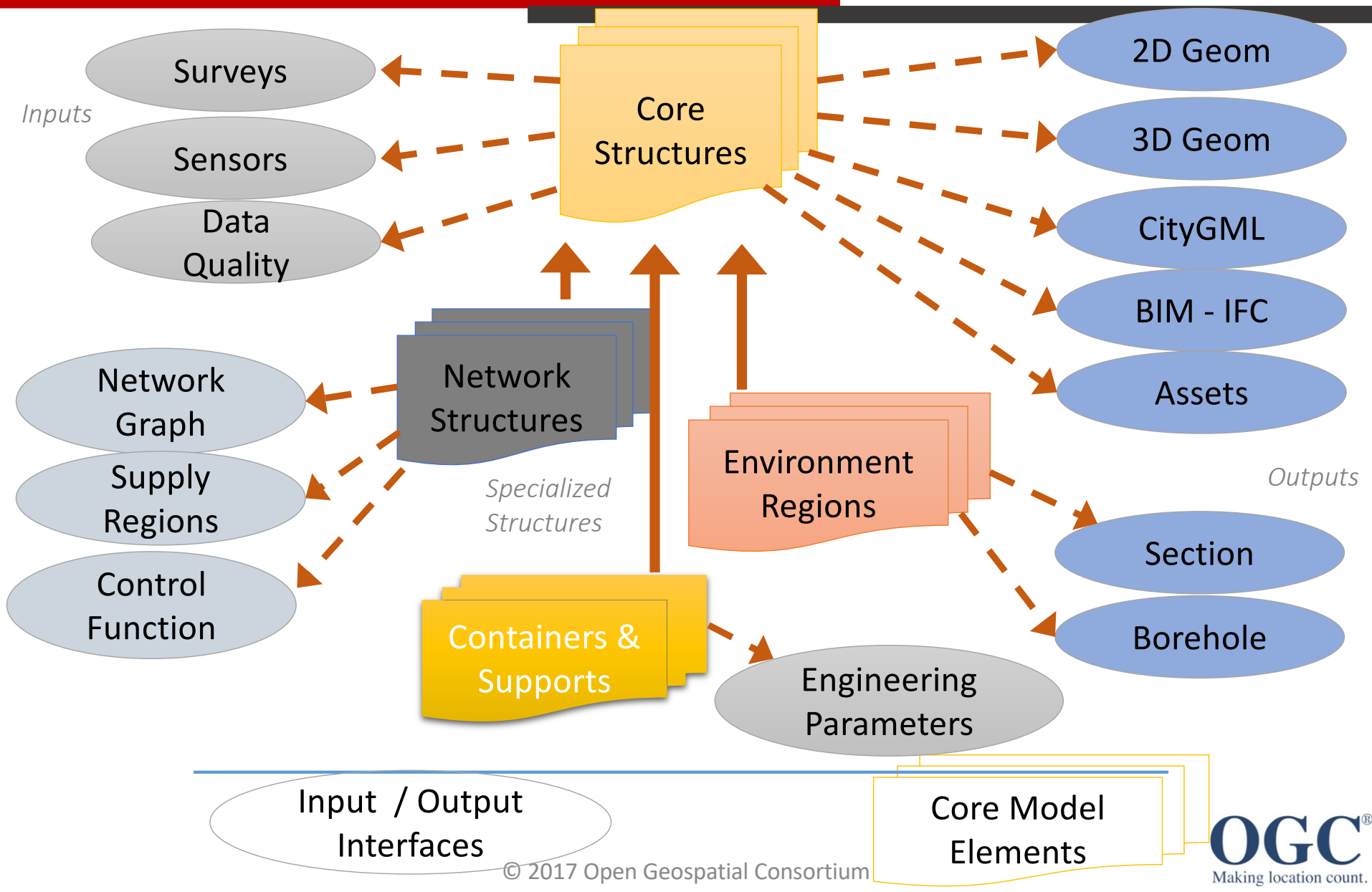
# MUDDI Model Structure



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# Trial Balloons and Mad Science

- Expanded DOITT prototype, evolved positioning and connecting of structures, addition of environment
- “Rolling shovel” pilot:
  - Identify a street with proceeding excavation
  - Synthesize underground data synthesis from existing and **above-ground evidence**.
  - Refine data with GPR and other geophysics
  - Validate new dataset with excavation evidence
- OEM demo data
  - Combination of data sharing and synthesis to create integrated / federated dataset ready for emergency response (e.g. steam explosion)
  - Develop portrayal model for ready-to-use products in emergencies
  - Test of federation strategies (map image to central repository) to balance security and readiness.

# MUDDI Profiles, Modules, Extensions

- Use case validation requires creating and implementing profiles of MUDDI that include just the elements, realizations, attributes, and visualization rules needed to address use case requirements and align with other models used in relevant domains, e.g.
  - Asset profile with rough locations and structure identity / ownership
  - Excavation profile with 2D position, 2.5D extent, material, condition
  - Emergency response profile with 3D position & extent, connections, controls
  - Construction design profile with 3D accuracy and proximity / mobility affordances
  - Disaster planning profile with functional network and environment representations for modeling and prediction

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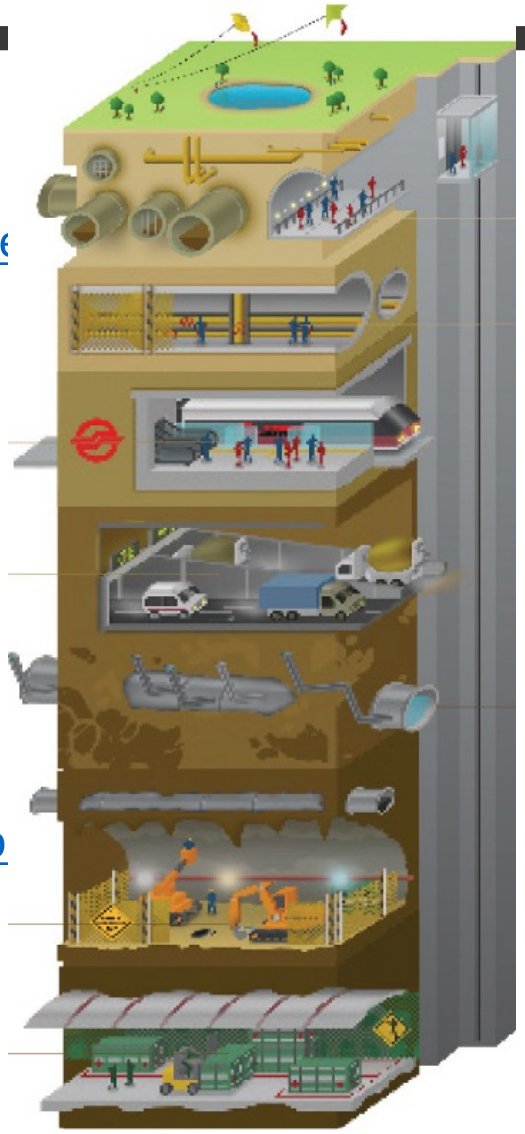

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# Questions for the Audience

- Is there really common ground for the underground?
- Does the benefit of good underground data justify the cost?
- What real security issues does (good) underground data raise?
- Are digital twins for the subterranean city feasible, desirable?

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