Introduction to MUDDI: Model for Underground Data Definition and Integration

MUDDI ETL-Plugfest

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24 July 2018

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Making location count.

Underground Infrastructure Data

- UGI data challenges
  - Special spatial
  - Built and un-built
  - As-designed / As-built / As-maintained / As-sensed
  - Optimum models
  - Data sharing
- Use cases and roles for UGI data
  - Excavation
  - Design
  - Operation
  - Smart and resilient
- Technical landscape for UGI data
  - Analysis and visualization
  - Design and architectural trade-offs
  - Ownership and responsibility

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What is a Standard?

- "*An agreed way of doing something*"
- **Standards are distilled wisdom** of people with expertise in their subject matter and who know the needs of the organizations they represent – people such as manufacturers, sellers, buyers, customers, trade associations, users or regulators.
- **Standards are knowledge**. They are powerful tools that can help drive innovation and increase productivity. They can make organizations more successful and people's everyday lives easier, safer and healthier.

EC: Practical standards guide for researchers - en

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Why Open Standards?

- Prevents a single, self-interested party from controlling a standard
- Lower life cycle costs
  - Increased expectation of procurement success
- Encourage market competition
  - Choose based on functionality desired
  - Avoid "lock in" to a proprietary architecture
- Stimulates innovation beyond the standard by companies that seek to differentiate themselves.

"What OGC brings to the table is…everyone has confidence we won't take advantage of the format or change it in a way that will harm anyone"

Michael Weiss-Malik, Google KML product manager

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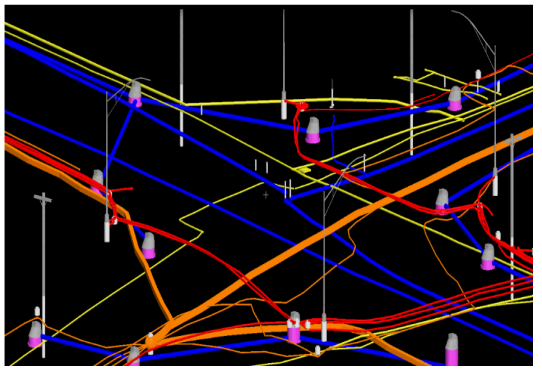
Source: Open Standards, Open Source, and Open Innovation: Harnessing the Benefits of Openness, April 2006. Committee For Economic Development. www.ced.org

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
- 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



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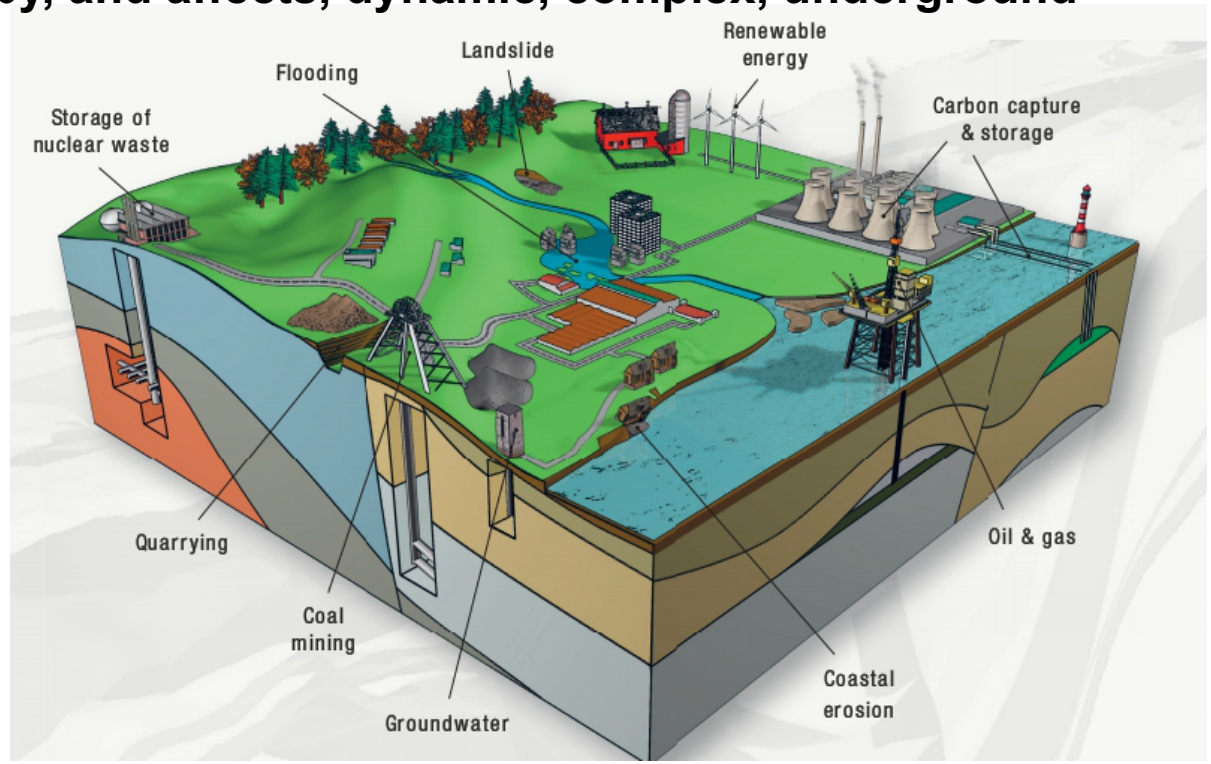
OGC Underground Concept Development Study Report
http://docs.opengeospatial.org/per/17-048.html

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



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Use cases and perspectives

- **Routine street excavations**
- Emergency response
- Utility maintenance programs
- **Large scale construction projects**
- **Disaster planning and response**
- Smart cities programs.

- Perspectives
  - Data integration
  - Visualization – 2D, 3D, 4D, AR
  - Data quality and consistency
  - Dependency analysis
  - Digital twinning and simulation

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Model Requirements

Table 2. Use case derived model requirements

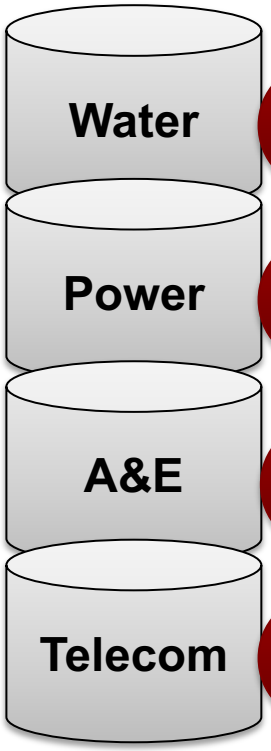
ID	Requirement	Capability Example
EX1	Horizontal UGI cross-section of all entities with high horizontal, medium vertical accuracy	2.5D feature geometries
AE1	Detailed 3D UGI geometry	3D feature geometries
AE2	Detailed 3D underground environment information	Voxel indexing
AE3	Survey, sample, and measurement information	Linked survey measurements
DP1	Physical and operational dependency relationships	Topological, structural, functional dependencies
DP2	Vulnerabilities - inundation, fire, frost, environmental hazards, terrorism / vandalism	Vulnerability assessments
DP3	Simulations and predictions (thencast / nowcast / forecast)	Simulation model parameters
ER1	Spatial and functional relationships between all UGI elements	Network topology
OM1	Within-network topology and functional relationships above-below ground	Network roles
OM2	UGI asset status and lifecycle information for cross-utility planning	Feature-as-asset lifecycle
SC1	Instrumentation, property, and feature-of-interest relationships	Related sensor observations and inspections
SC2	Sensing data streams	Time-series properties
SC3	Contributed observations	Data quality / provenance indicators

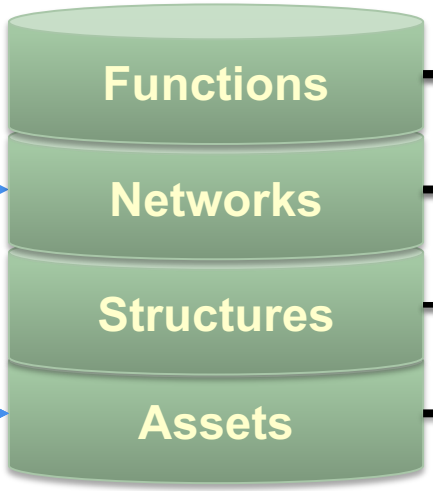
Data Integration Architecture

Diverse Data Sources, Systems, Formats

Unified Model with Multiple Perspectives

Distinct Data-driven Applications

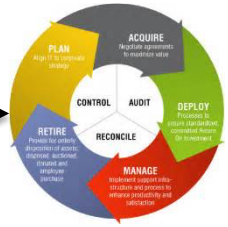




Disaster Planning

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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Reference models for built / utility infrastructure

- 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
- Power Utilities
- Enterprise Systems for Utilities –
- Wastewater Pipeline & Manhole Condition Assessment Gas Distribution
- Water/Wastewater Modeling
- GEOfeature

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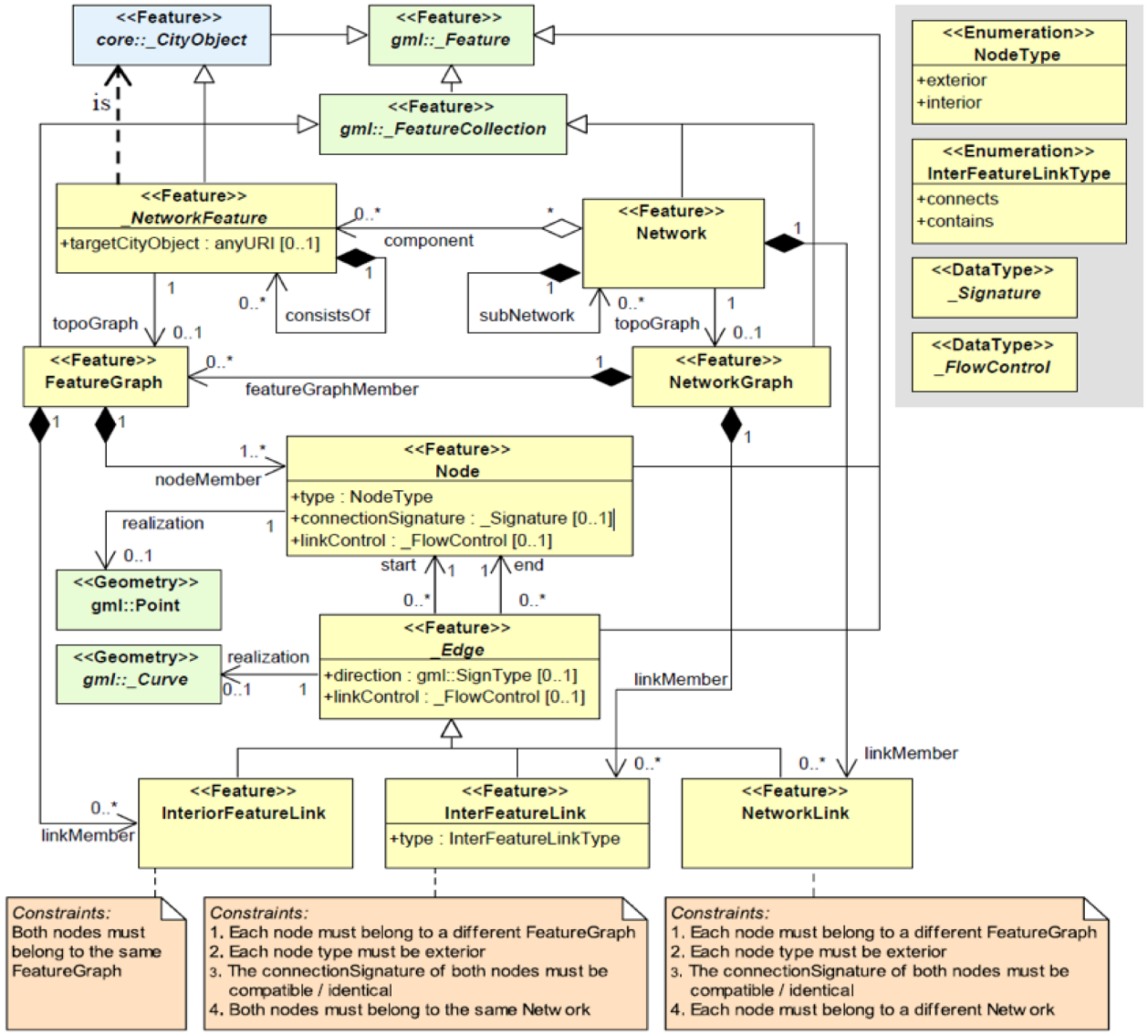
Ordnance Survey

City GML UN ADE



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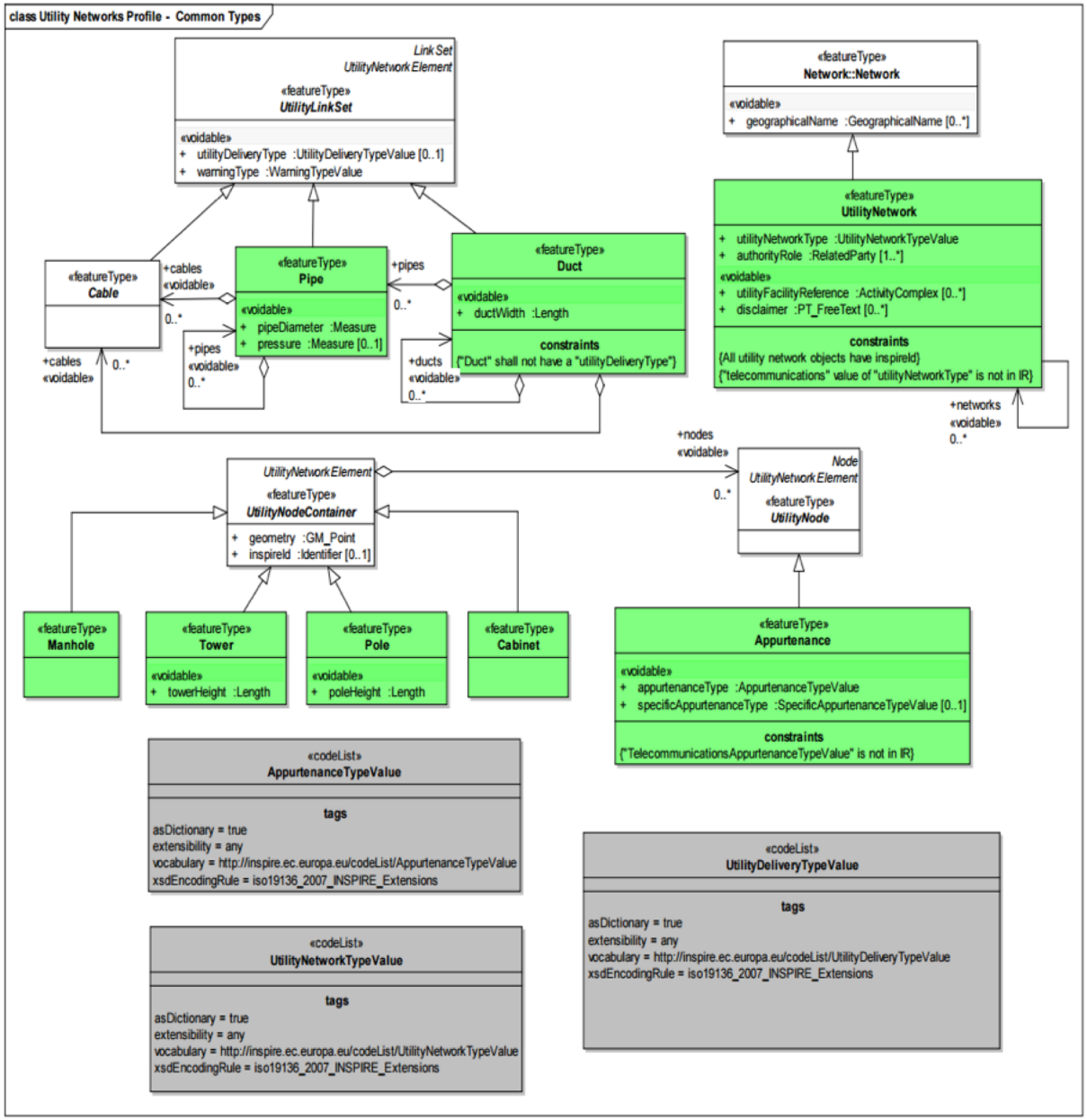
INSPIRE Utilities Model



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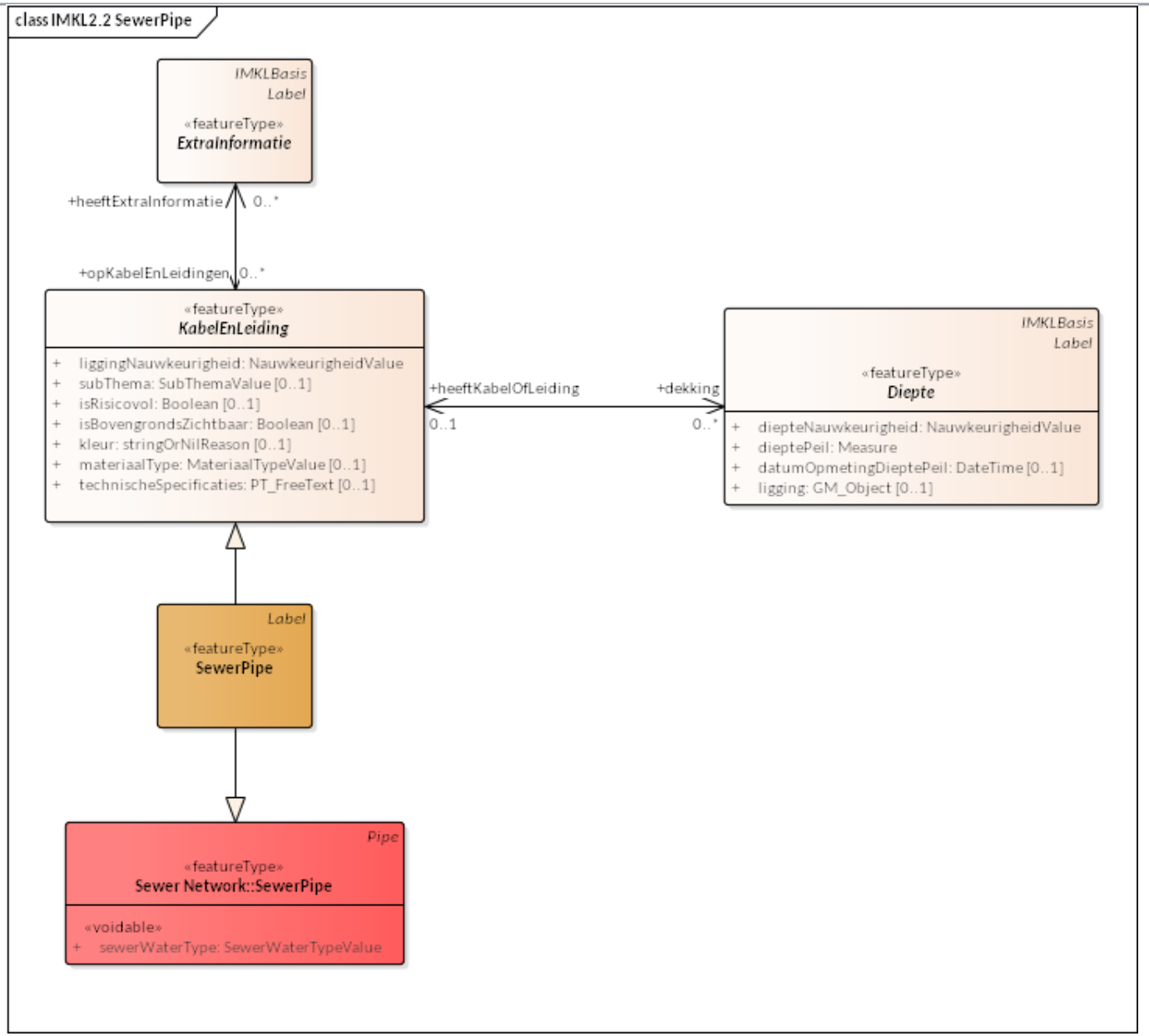
IMKL


class IMKL2.2 SewerPipe
IMKLBasis
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+ subThema: SubThemaValue [0..1]
+ isRisicovol: Boolean [0..1]
+ isBovengrondsZichtbaar: Boolean [0..1]
+ kleur: stringOrNilReason [0..1]
+ materiaalType: MateriaalTypeValue [0..1]
+ technischeSpecificaties: PT_FreeText [0..1]
+heeftKabelOfLeiding
0..1
+dekking
0..*
IMKLBasis
Label
«featureType»
Diepte
+ diepteNauwkeurigheid: NauwkeurigheidValue
+ dieptePeil: Measure
+ datumOpmetingDieptePeil: DateTime [0..1]
+ ligging: GM_Object [0..1]
Label
«featureType»
SewerPipe
Pipe
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Sewer Network::SewerPipe
«voidable»
+ sewerWaterType: SewerWaterTypeValue

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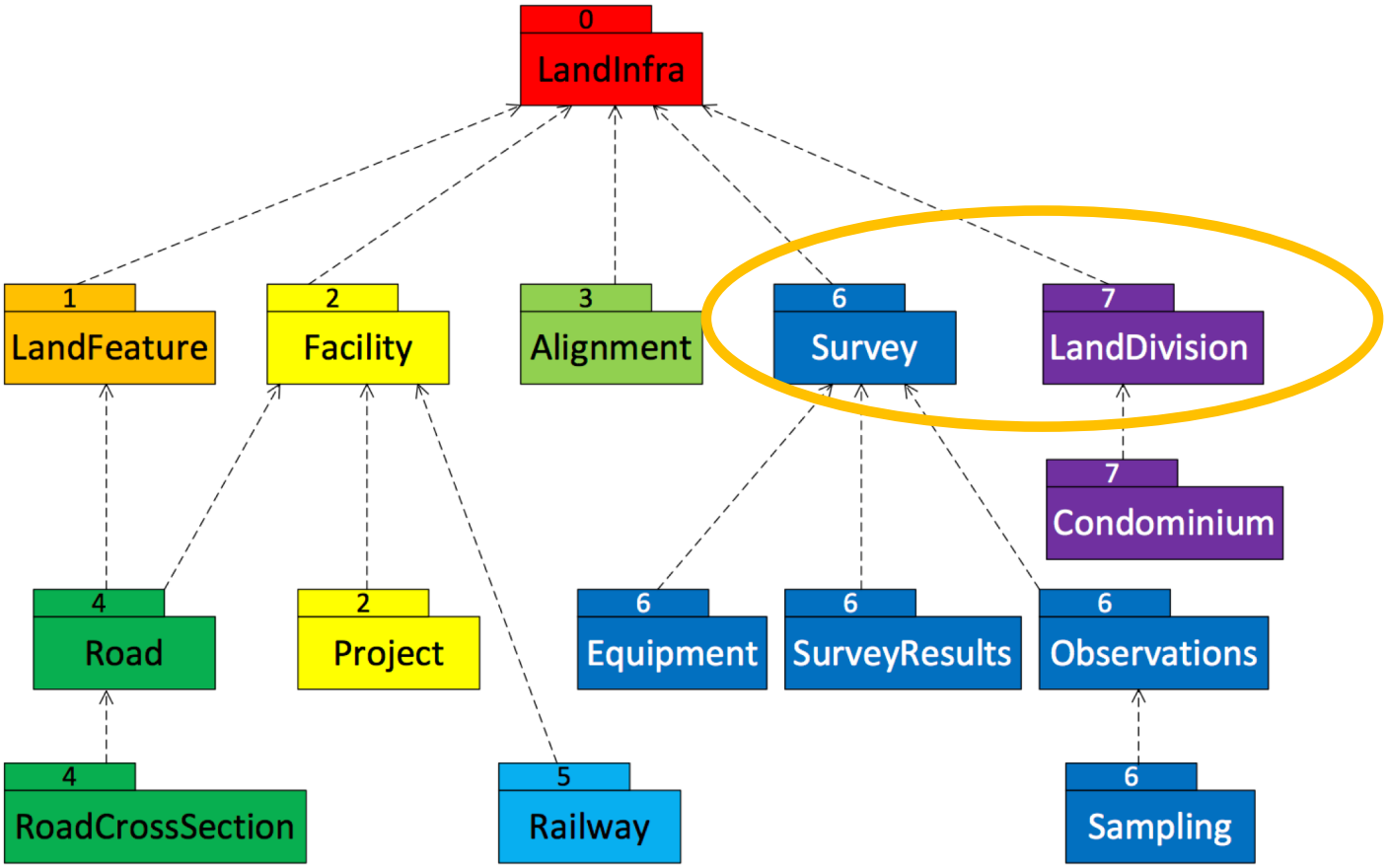
LandInfra



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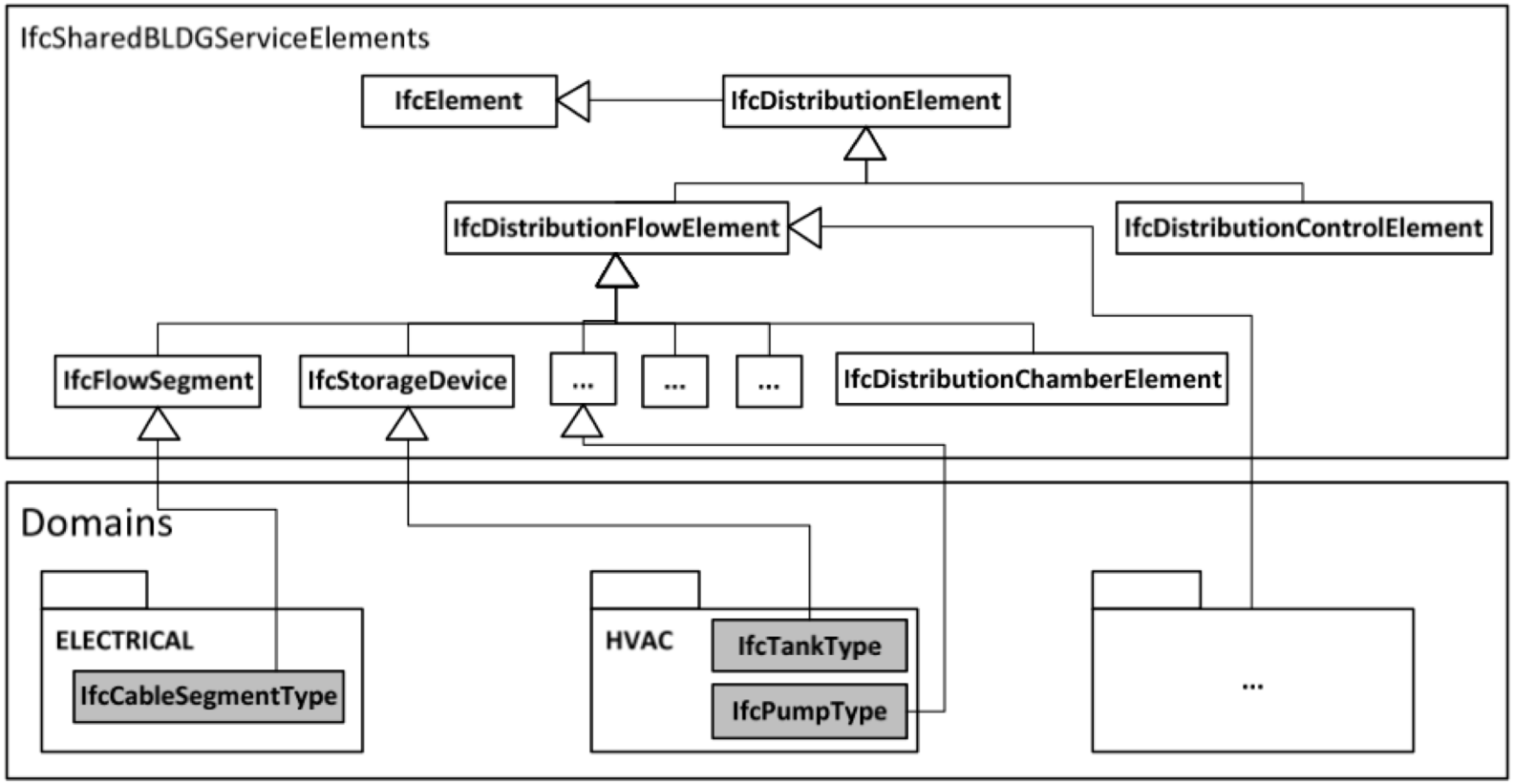
IFC



Reference underground environment models

- BGS National Geological Model
- BRGM SCUDD
- GeoSciML
- EarthResourceML
- INSPIRE
- GeoTOP
- GroundwaterML
- SoilIEML

Models are designed for different purposes (engineering, water management, hazard assessment). The model intents need to be understood to allow for meaningful translation and combination between them.

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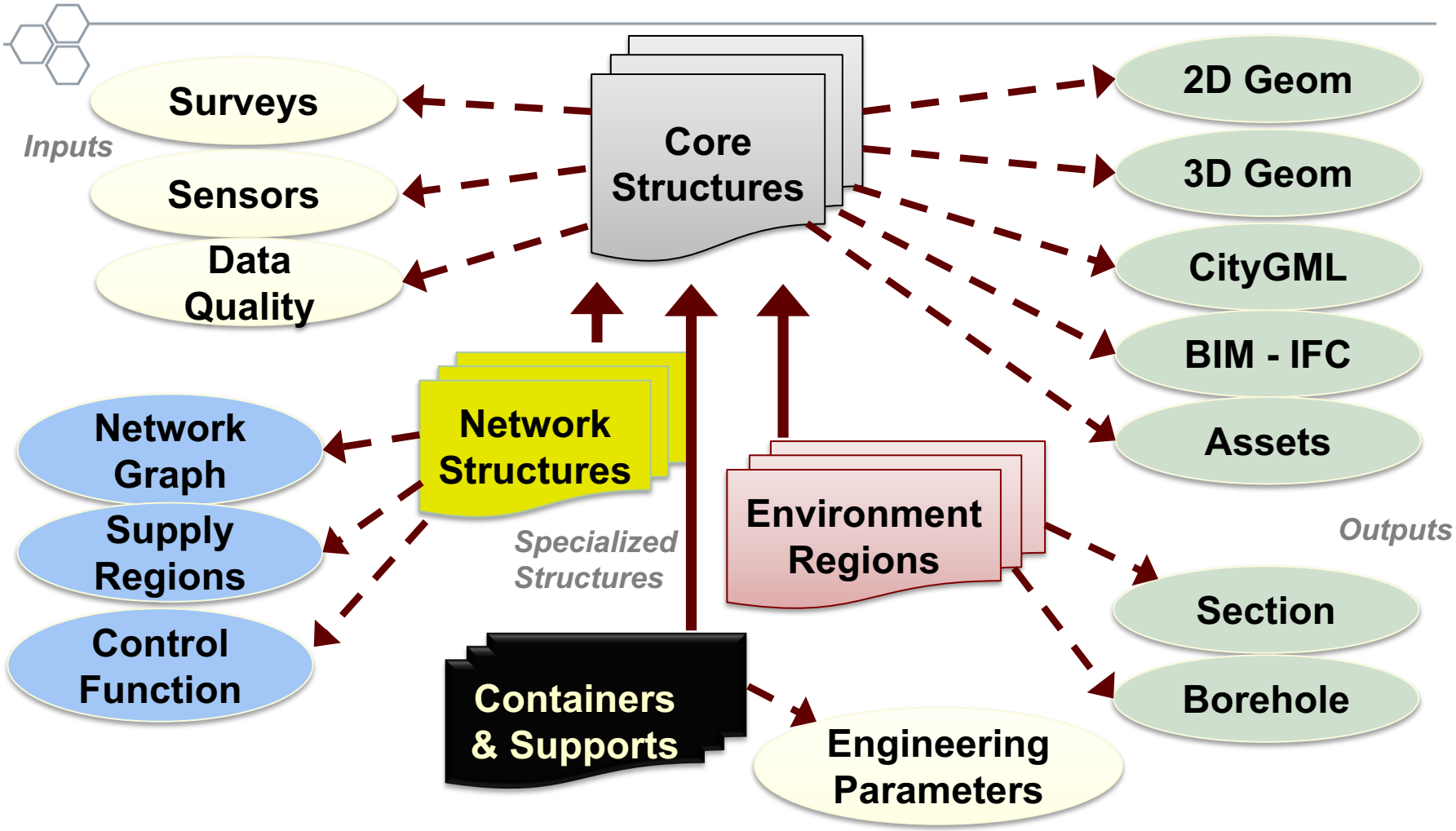
Ordnance Survey

UGI3M Model Structure



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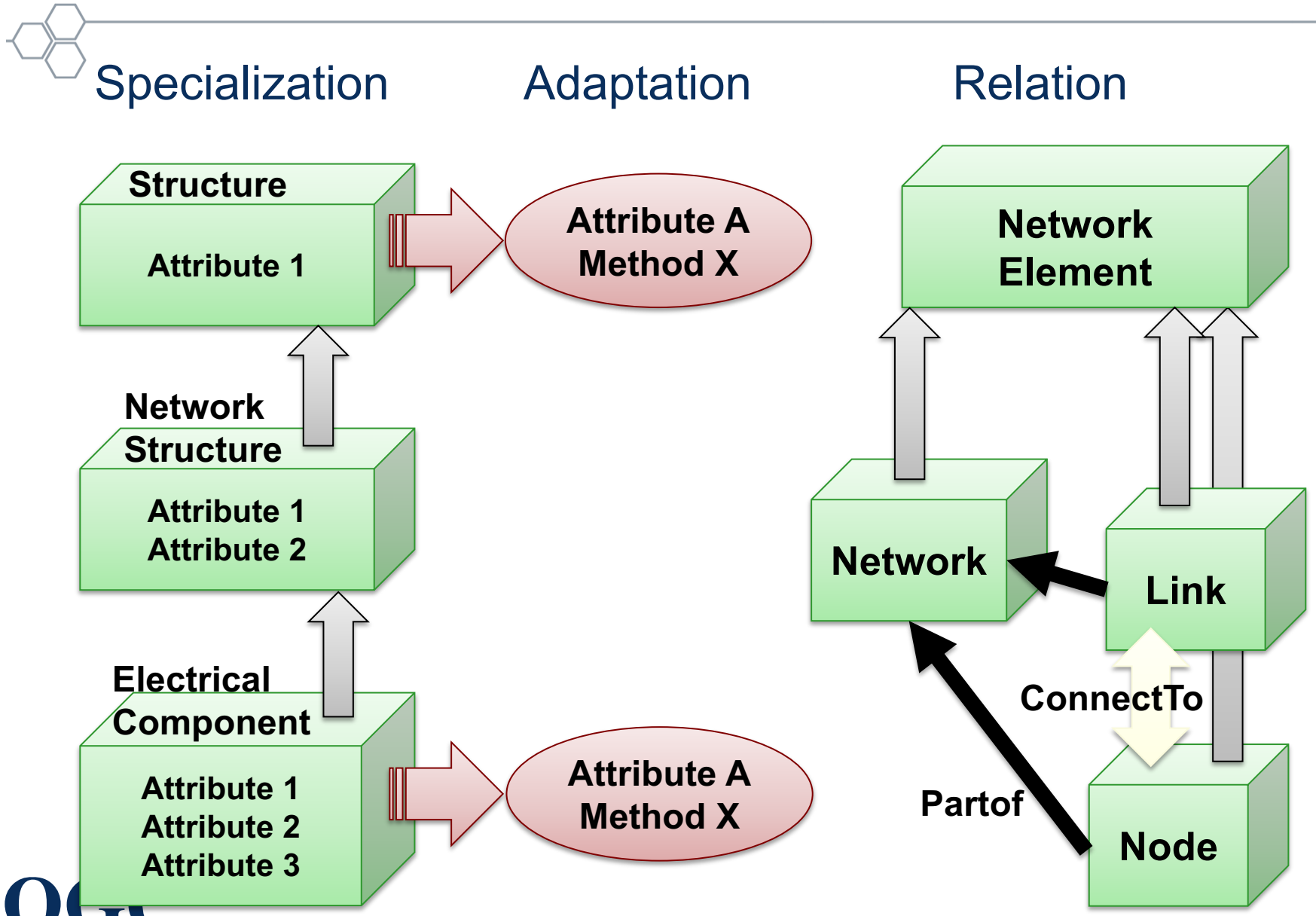
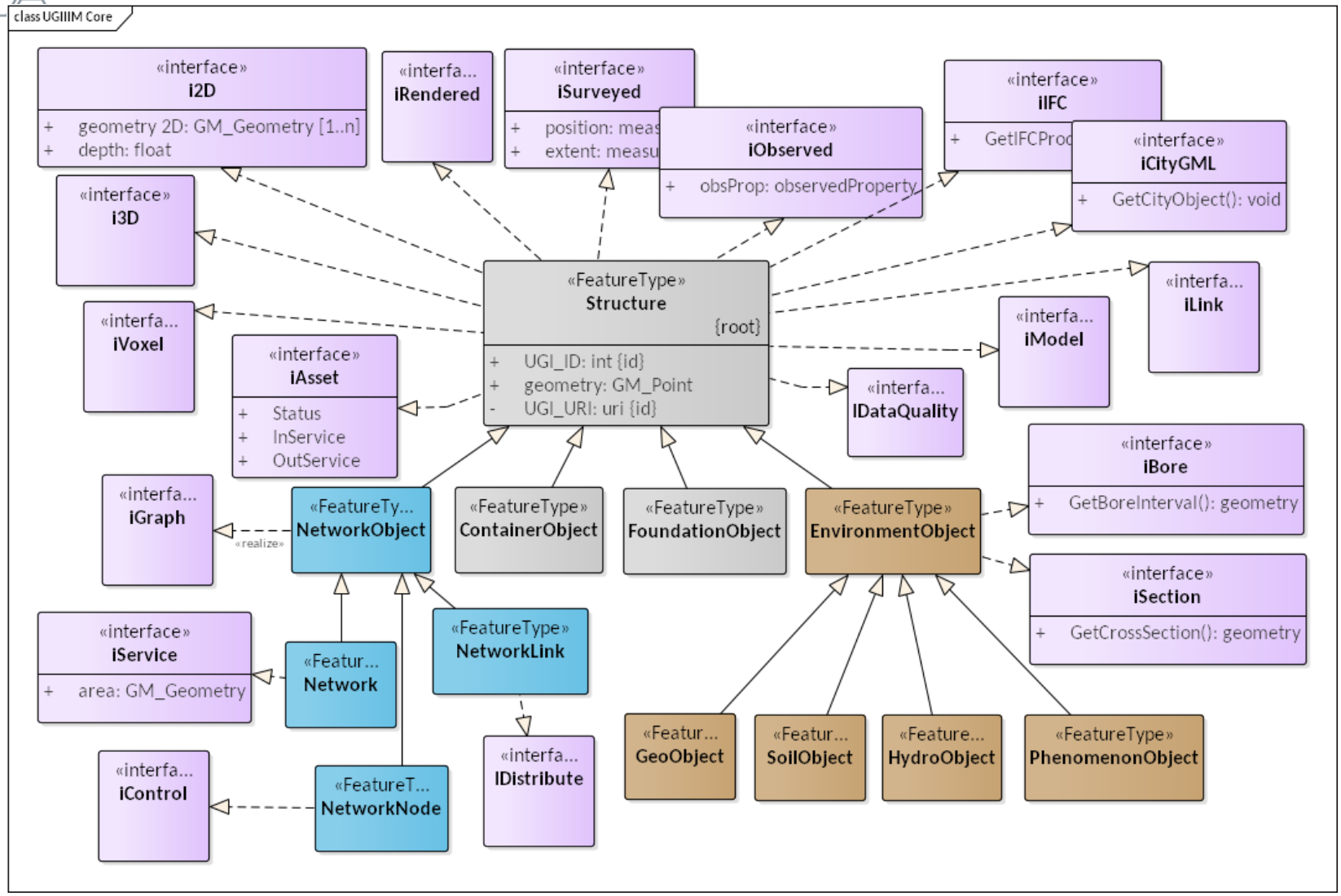
Model Patterns



Core MUDDI Model



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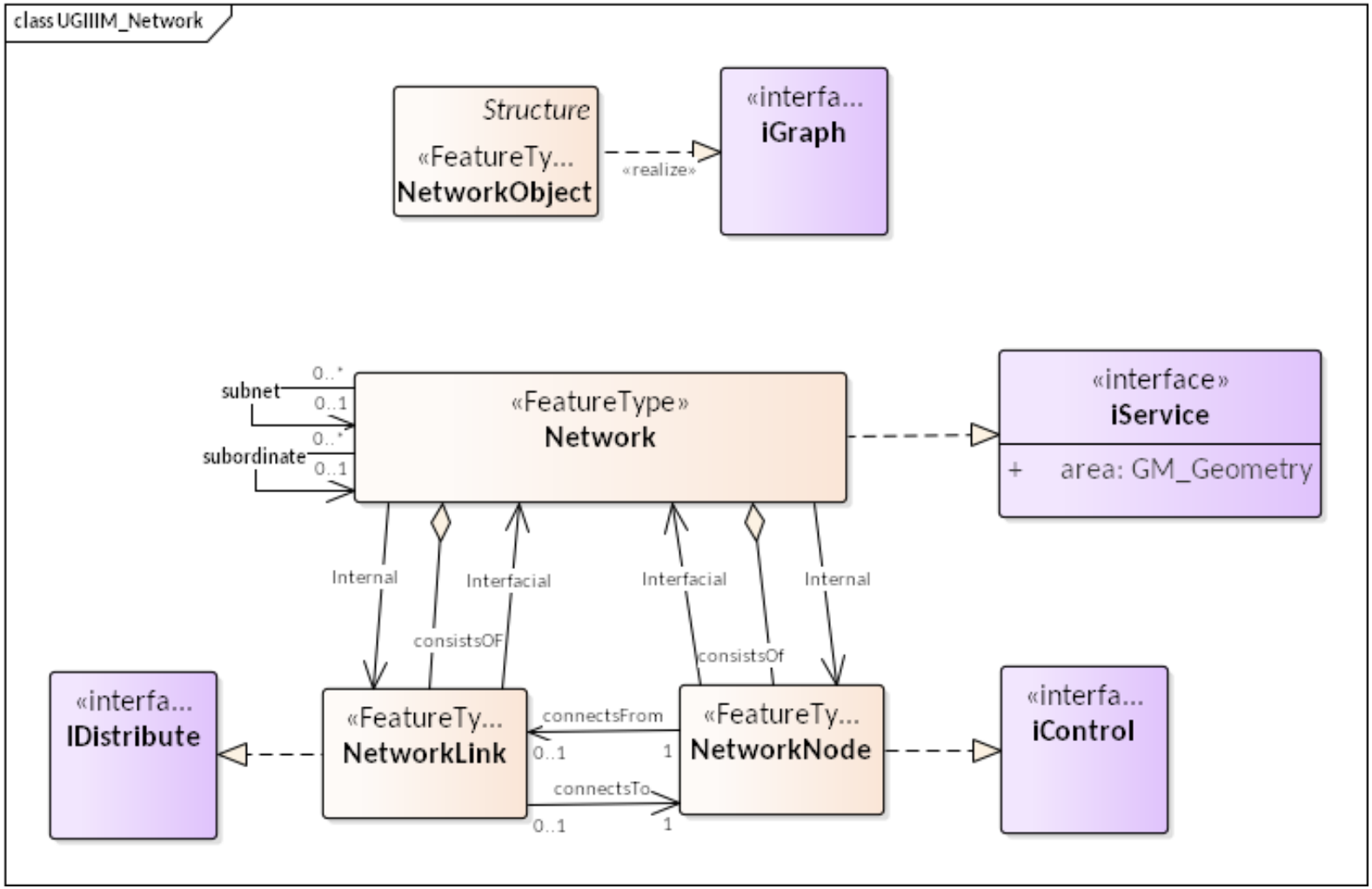
Network Relations



Questions to Ask (of the Data)

Queries	Interfaces
3D image of all the UGI elements within 15' of planned excavation	2D geometry 3D geometry
Minimum distance between 2 underground utility networks	3D geometry Network graph
Major transmission lines as distinguished from distribution elements	2D geometry Network control
Important control components in a neighborhood	Network control Network supply
Age, material composition, thickness of the UGI elements	Asset Surveys
Likely composition, moisture, chemistry of soils surrounding particular UGI elements	2D geometry Section
Likely extent of corrosion of these elements, potential vulnerability to vibration and accidental strikes, spatial extent of network vulnerability	Asset Sensor Network graph

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Implementation

- Encodings
  - CityGML
  - Simple Features SQL
  - FME interchange format
  - JSON-LD
- Datastores
  - Separate tables for object subtypes, interfaces
  - Separate column selection for each object
  - Key-value graph
- Strategies
  - Start with core structure data, add interfaces and specializations as applications require
  - Start with full complexity, create simplified views where data exists

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Your Turn

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