An Ontology-based Standard for City Data

ISO/JTC 1 WG 11 Smart Cities

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Who we are

- Enterprise Integration Laboratory investigates the use of Information Technology to create business infrastructures that enable:
  - dissemination of information
  - coordination of decisions
  - management of actions
- Our basic research has explored topics such as:
  - Ontologies for Enterprise Modelling,
  - Agent Architectures and Coordindation and
  - Constraint-Directed Scheduling,

  and applied them to problems such as Smart Cities, Transportation, Supply Chain Management, Knowledge-Based Design and Enterprise Engineering.

Toronto Virtual Enterprise (TOVE) Ontologies (1991-2010)

Ontology Engineering Process

Competency Questions

Activity-Based Costing

Online Retail

Quality Traceability

Organization (Structure, Behaviour, Control)

Skills & Competency (Human Resources)

Requirements (version, traceability)

Activity/State Process

Resources

Product (Parts, Features, Function, Version)

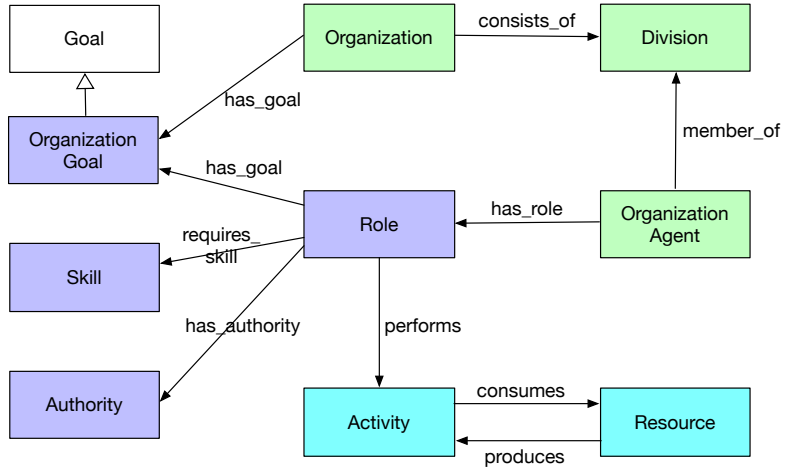
Constrained Time

Geospatial

Provenance

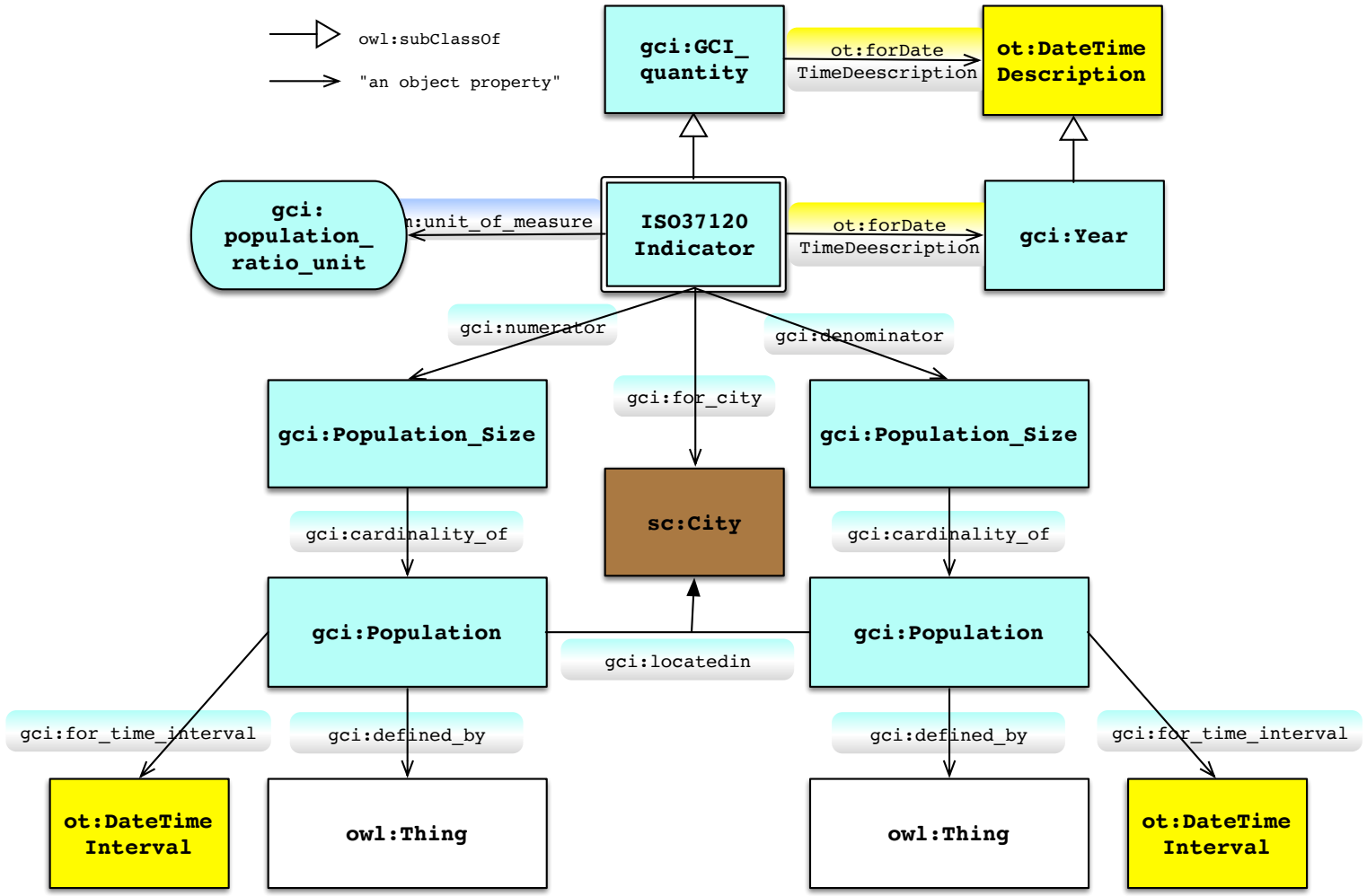
Validity

Trust

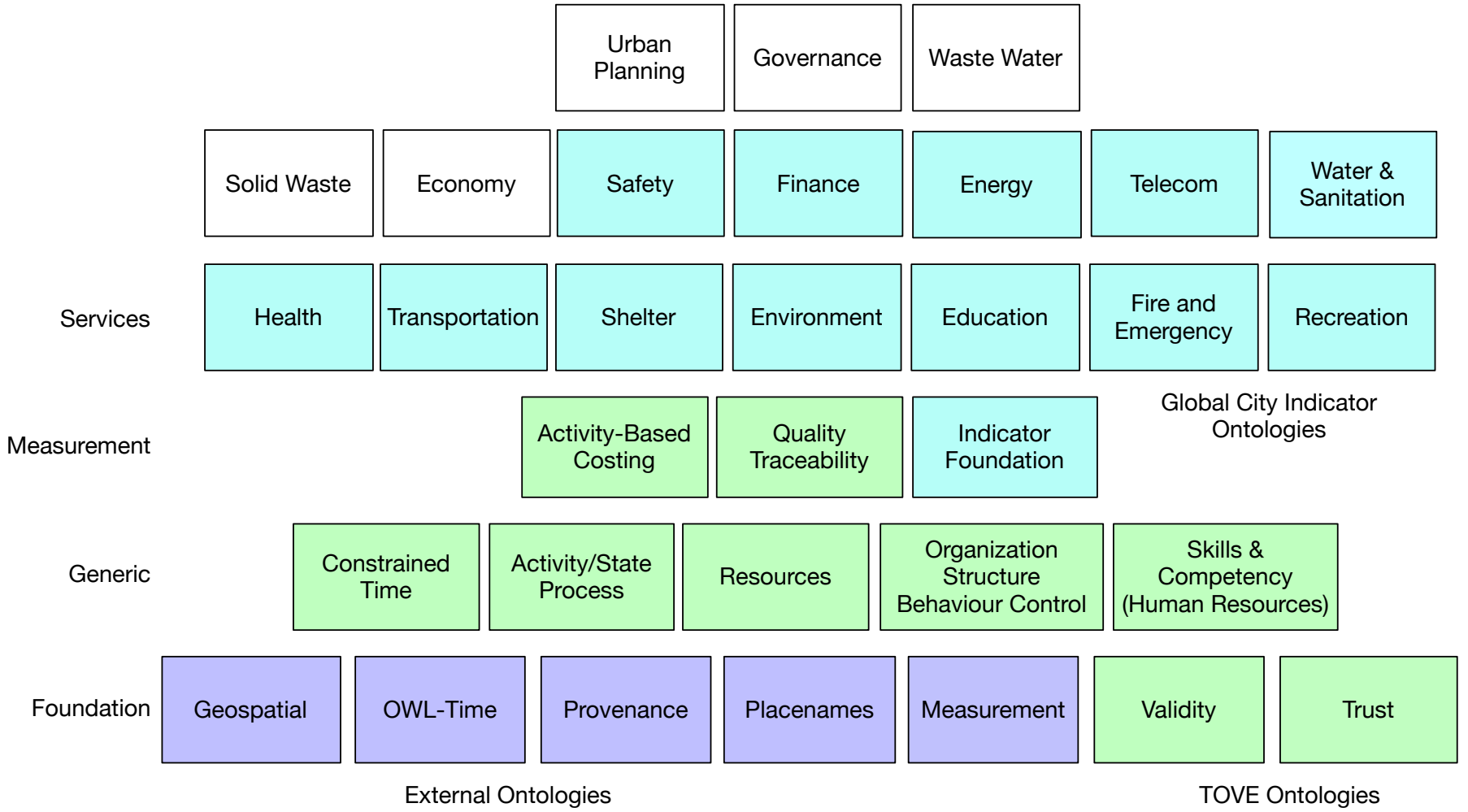


ISO 21972
Upper Level Ontology for City Indicators

- Defines an ontology for the representation of indicator definitions
  - For use in automating the measurement of systems and cities
  - Applied to ISO 37120 Sustainable Cities and Communities
- Based on our GCI Indicator Ontology



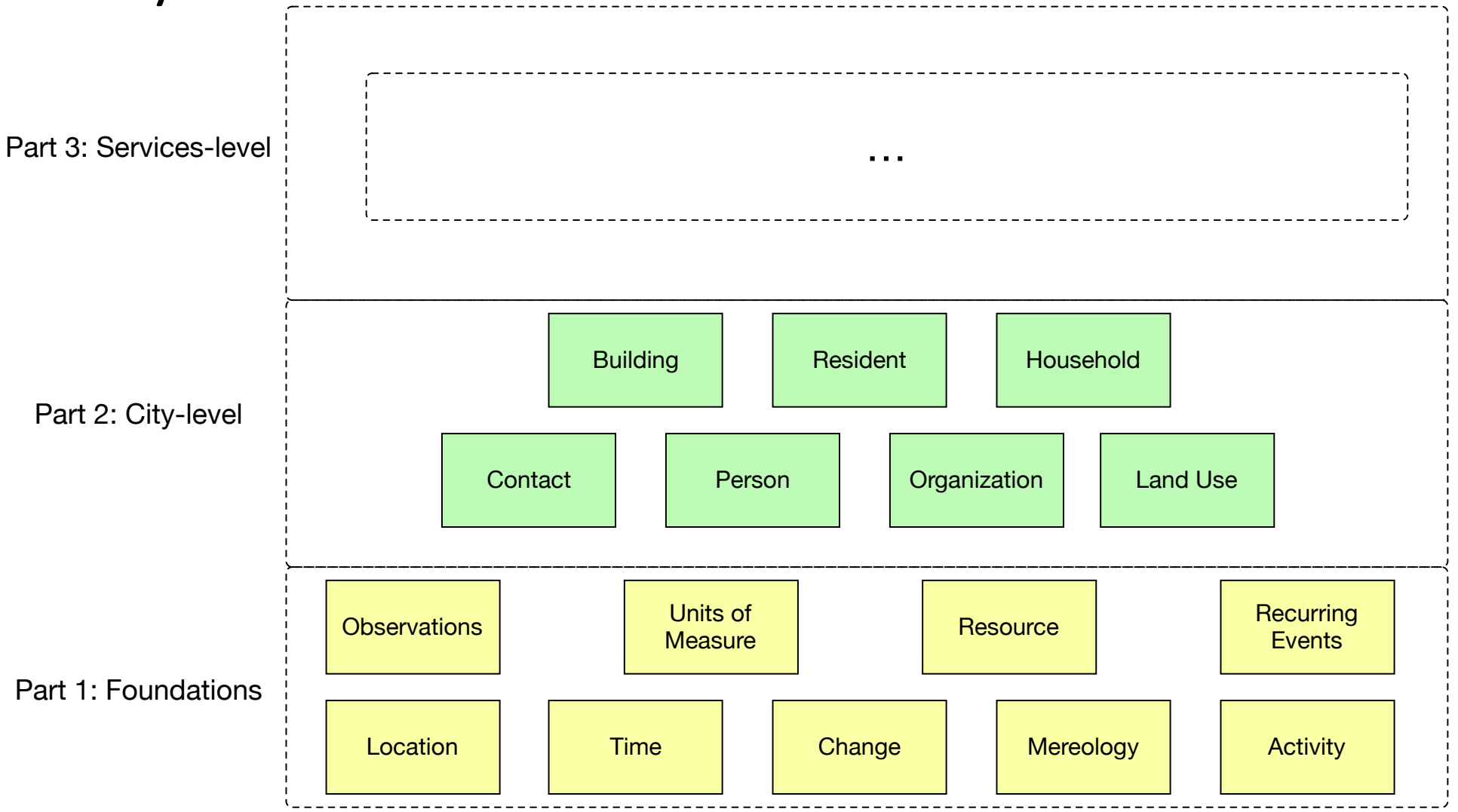
Global City Indicator (GCI) Ontologies (2011-)



The City Data Model

- New work item proposal in ISO WG11 Smart Cities
- **Goal**: specify a standard to enable semantic interoperability across city services
  - City services: both physical and social
- **How?**
  - Provide an ontology-based model of the common concepts required to represent city services' data
  - 3-part standard, divided by level of abstraction

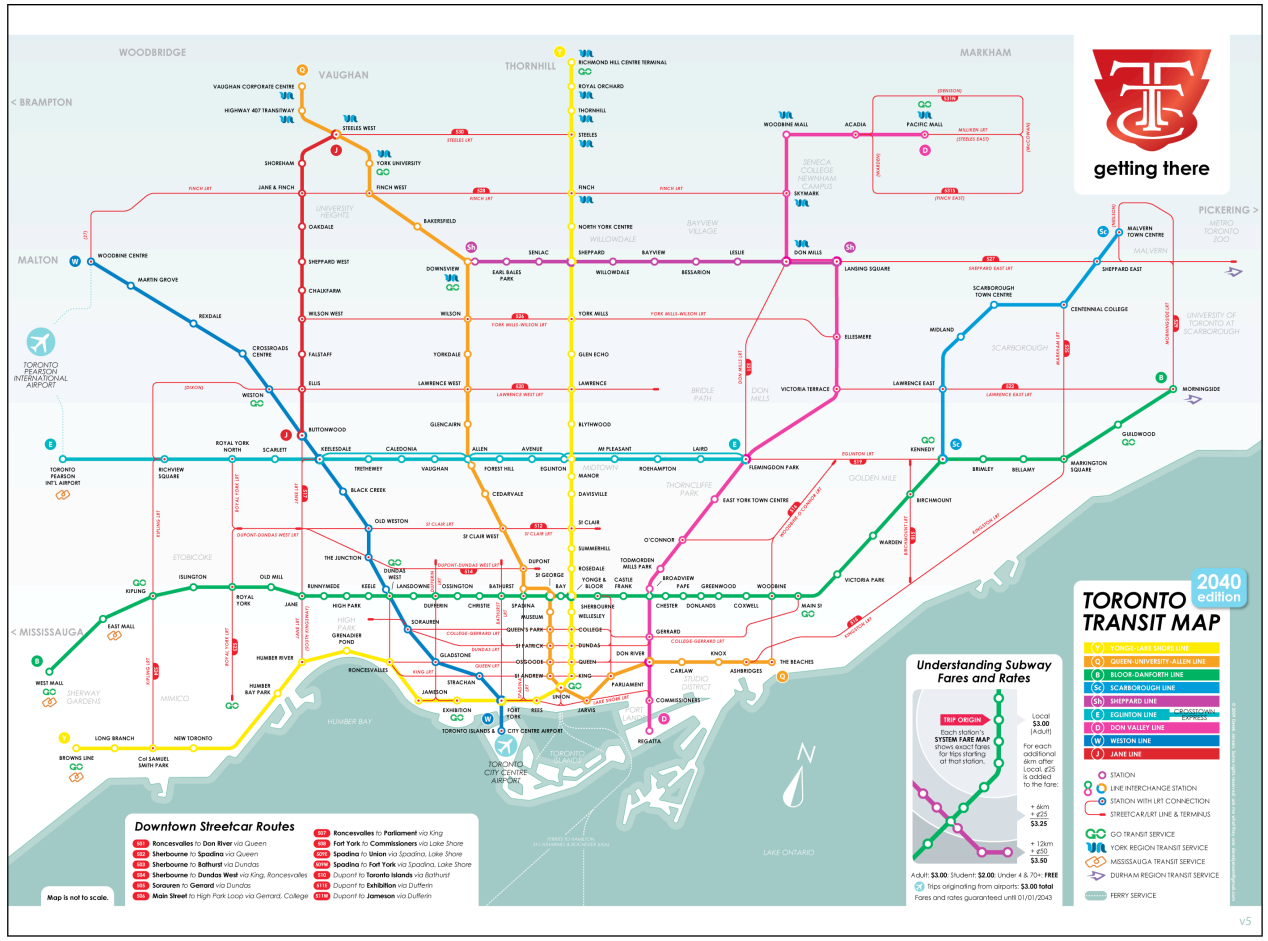
City Data Model Overview: 3 Parts



Initial City Services

- **2019 - Transportation Planning:**
  - Starting point is the iCity Transportation Planning Suite of Ontologies
  - Liason with TC204
  - Collaboration with Esri Canada to create a knowledge graph that adopts the ontology to merge Esri data with transportation planning data
- **2020 - Water and Sanitation:** Asset Management

Transportation Planning



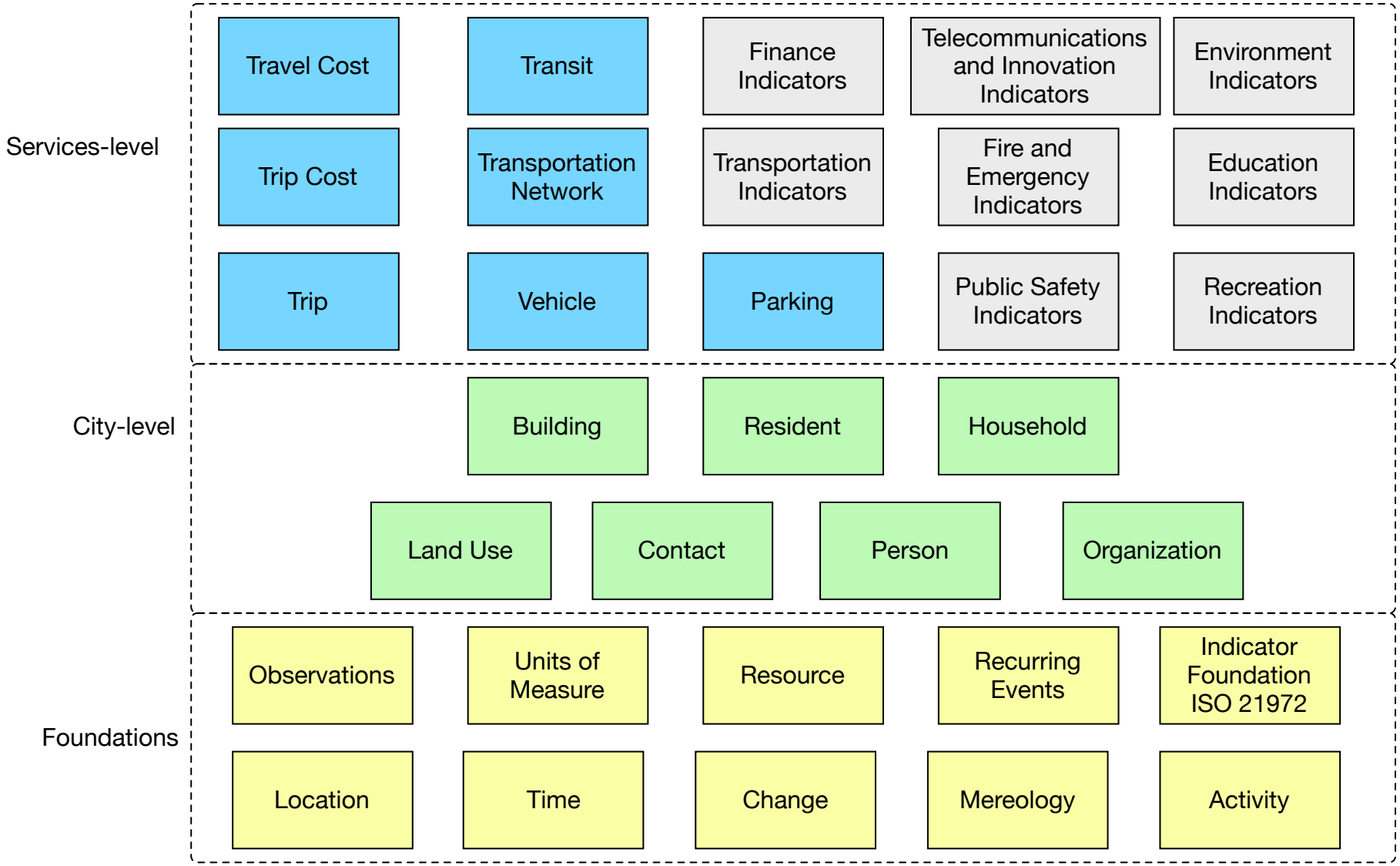
Goal: Planning transportation infrastructure over a long horizon

- What will demand for public transportation and roads be over the next 30 years?
- How do changes in transportation infrastructure affect travelers?
- What are the environmental impacts of growth?
- …

Transportation Planning

- Problem: data silos
  - Multitude of transportation planning tools are in use by researchers and cities
  - No easy way to compare results as each has their own unique data models
  - Collected data is often “single use”, even within research groups
- Requirements for integration: a standard data model
  - Must work with different tools, representations
  - Must have a **unique** interpretation; incorrect and correct interpretations should be clearly identifiable
  - Must be easily extensible: tools and approaches are always changing
- Proposed Solution: an ontology for transportation planning

City Data Model for Transportation Planning



Summary

- Foundation and city-level concepts are common across many applications in transportation and beyond
- The City Data Model will be used and extended to capture city services data, but may not be suitable for all types of transportation data
- Some key questions:
  - What concepts are shared with other areas of transportation?
  - How can we work together to converge on these definitions?

iCity TPSO Ontologies

Accessible as OWL (RDF/XML) files in Protégé Editor or raw text
Basic HTML documentation via web browser

- Activity: http://ontology.eil.utoronto.ca/icity/Activity/
- Building: http://ontology.eil.utoronto.ca/icity/Building/
- Change: http://ontology.eil.utoronto.ca/icity/Change/
- Household: http://ontology.eil.utoronto.ca/icity/Household/
- Land use: http://ontology.eil.utoronto.ca/icity/LandUse/
- Mereology: http://ontology.eil.utoronto.ca/icity/Mereology/
- OM: http://ontology.eil.utoronto.ca/icity/OM/
- Organization: http://ontology.eil.utoronto.ca/icity/Organization/
- Parking: http://ontology.eil.utoronto.ca/icity/Parking/
- Person: http://ontology.eil.utoronto.ca/icity/Person/
- Public Transit: http://ontology.eil.utoronto.ca/icity/PublicTransit/
- Resource: http://ontology.eil.utoronto.ca/icity/Resource/
- Spatial Location: http://ontology.eil.utoronto.ca/icity/SpatialLoc/
- Time: http://ontology.eil.utoronto.ca/icity/Time/
- Transportation System: http://ontology.eil.utoronto.ca/icity/TransportationSystem/
- Travel Cost: http://ontology.eil.utoronto.ca/icity/TravelCost/
- Trip: http://ontology.eil.utoronto.ca/icity/Trip/
- Trip Cost: http://ontology.eil.utoronto.ca/icity/TripCost/
- Vehicle: http://ontology.eil.utoronto.ca/icity/Vehicle/

Report working draft: http://ontology.eil.utoronto.ca/icity/iCityOntologyReport_1.2.pdf