"Demonstration of Using a Geo-Ontology for Simulated Image Generation in Support of GEOBIA"

Paul Pope, Ph.D., ASPRS CMS-RS
Lakshman Prasad, Ph.D.

ASPRS 2019
January 28-31, 2019
Denver, CO

LAUR 19-20311

Backstory

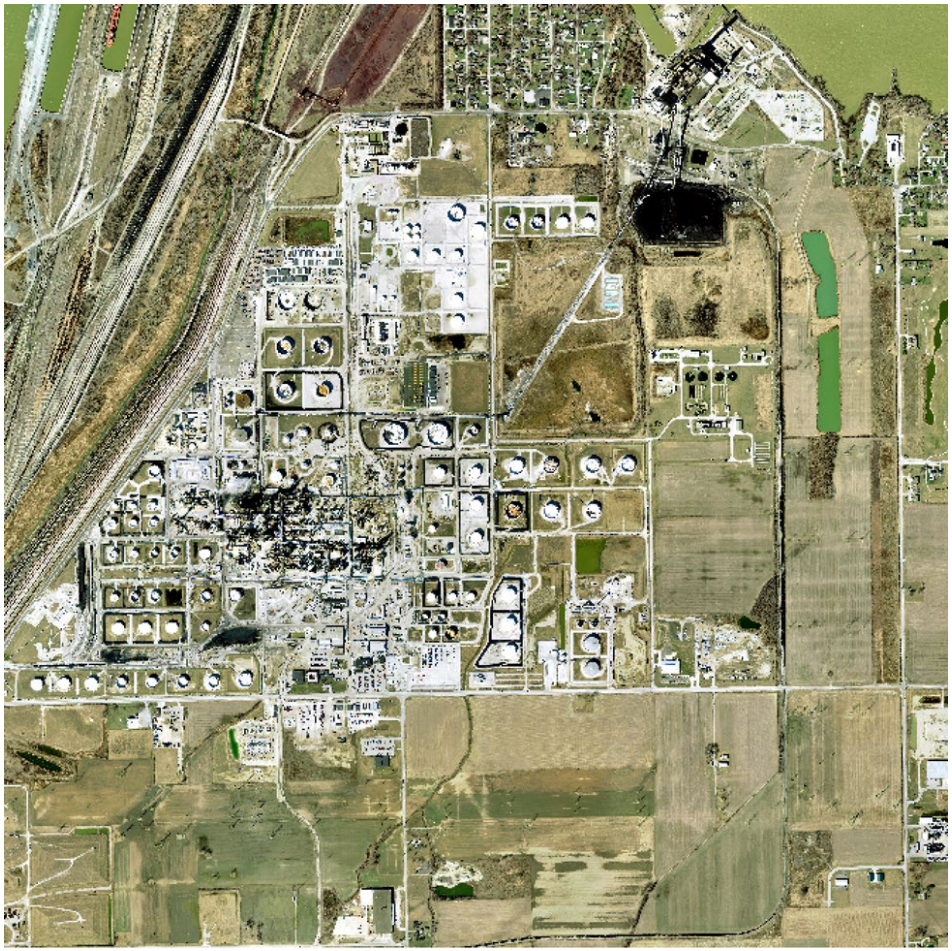
- Continuation of ASPRS2018 presentation
  - Geo-ontology to Synthetic Imagery (O2Synth) for GEOBIA
- This ASPRS2019 presentation
  - Demo of using Synthetic Imagery & Geo-ontology for GEOBIA
- Funded by DOE/NNSA DNN R&D

Outline

- Background & Motivation: GEOBIA
- Objective
- Ontology
- Ontology to Synthetic imagery (O2Synth)
- Examples
- Useage
- Conclusion

Background & Motivation: GEOBIA

- Geographic Object-Based Image Analysis (GEOBIA)



Example

Industrial facility, et al.
Lucas county, OH
Multimodal data
(R, G, B, NIR, & LiDAR)
3 km x 3 km
0.3 m GSD

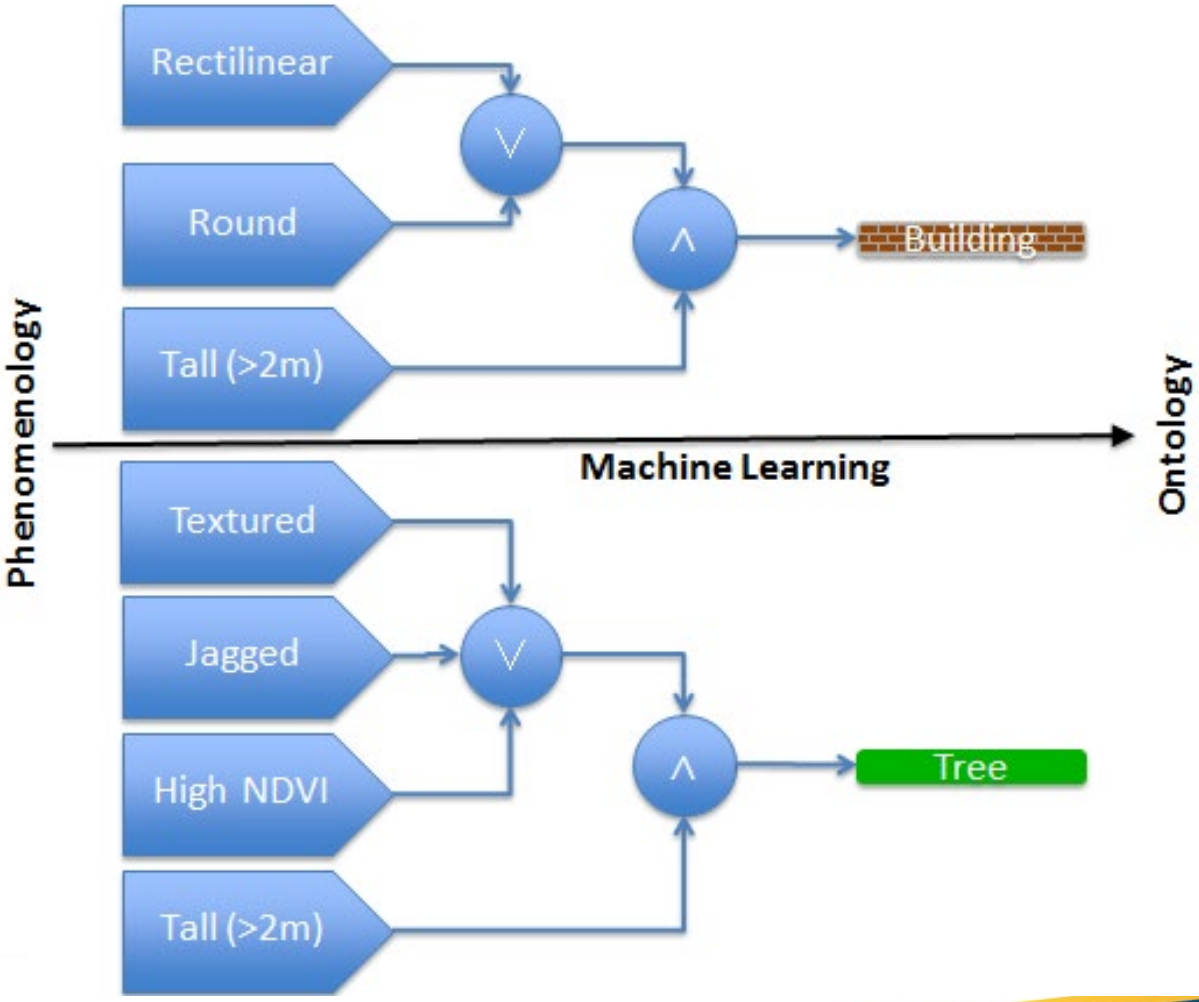
L. Prasad, P.A. Pope, and Kari Sentz, (2016), "Semantic Segmentation of Multispectral Overhead Imagery"
SPIE Commercial + Scientific Sensing & Imaging Symposium, Baltimore, Maryland, April 17-21, 2016.

Background & Motivation: GEOBIA

Example

Digital Surface Model (DSM)
derived from Lidar

Background & Motivation: GEOBIA



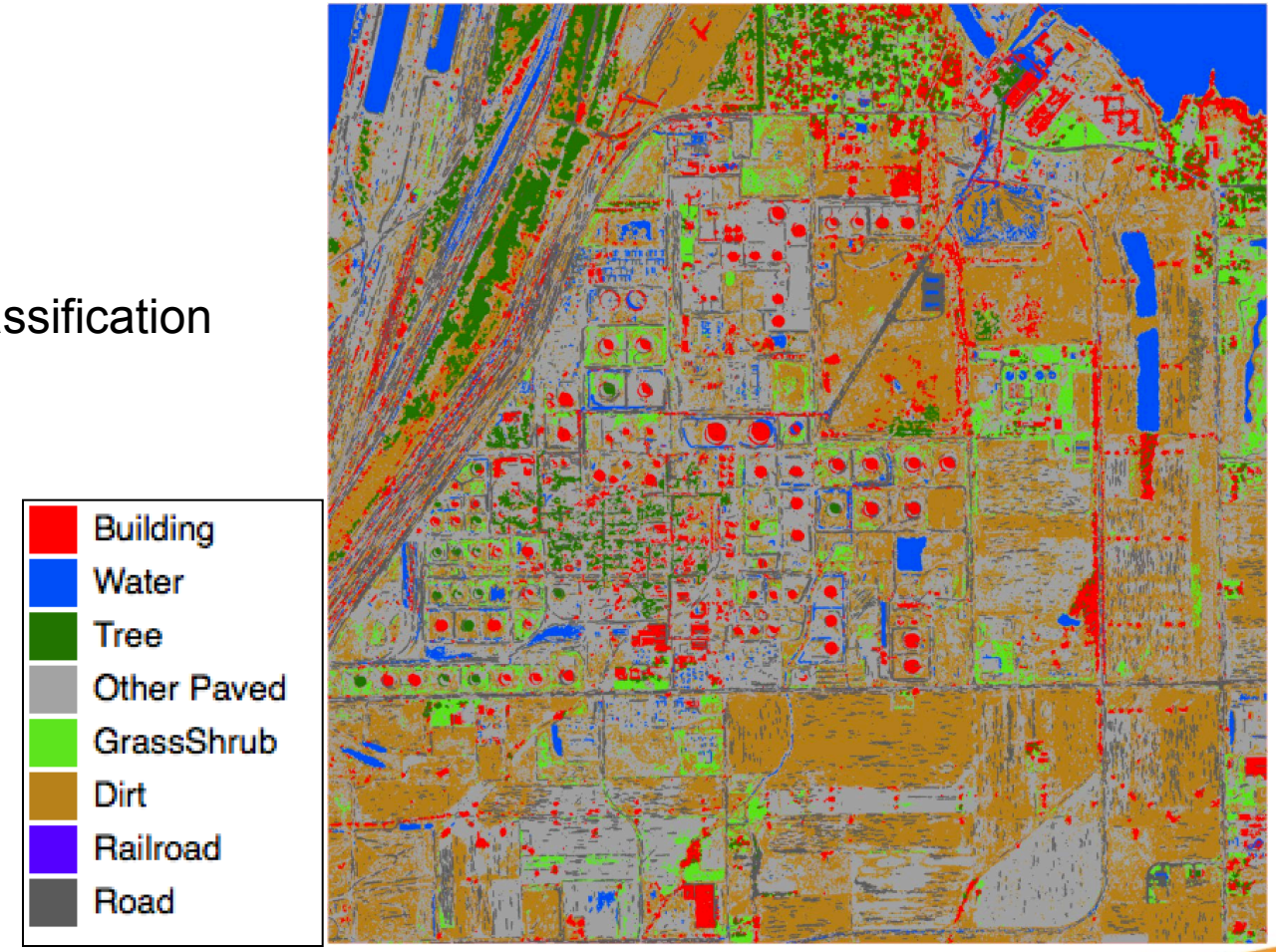
Example

Semantically guided, rules-based, land cover classification

Background & Motivation: GEOBIA

Example

Land cover classification

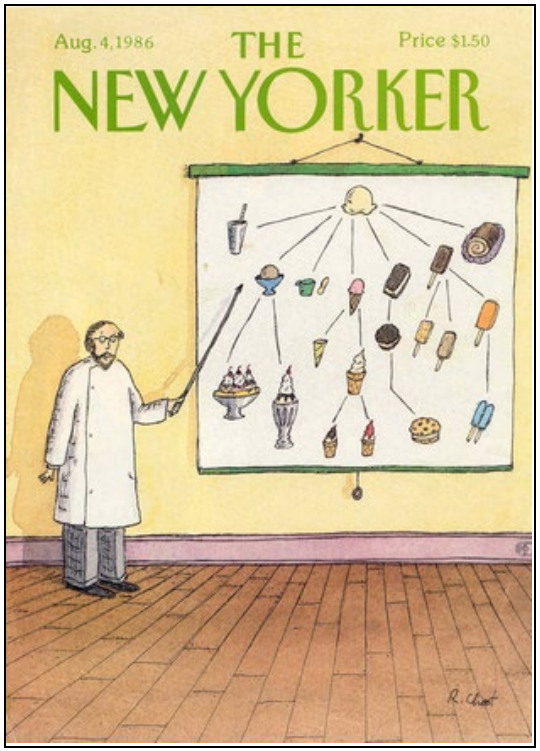


Objective

- Provide support for:
  - Training&Testing imagery for GEOBIA and ML
  - Factors analysis
    - constants? variables? (background, clutter)
    - spectral, spatial, temporal resolutions
- Need **Photographic** & **Process** realism
- Semantics -> **Ontology** (domain knowledge)
  - Geographic characteristics, ergo geo-ontology
- Example: Industrial facilities,
  e.g., Nuclear Power Plant (NPP)

Ontology

- An ontology is a formal, explicit specification of a shared conceptualization.
- Formal -> machine-readable
- Explicit -> concepts and useage constraints are explicitly defined
- Shared -> consensual knowledge
- Conceptualization -> an abstract model of some phenomenon



(Gómez-Pérez, A., M. Fernández-López, and O. Corcho, 2003, "Ontology Engineering," pg. 6)

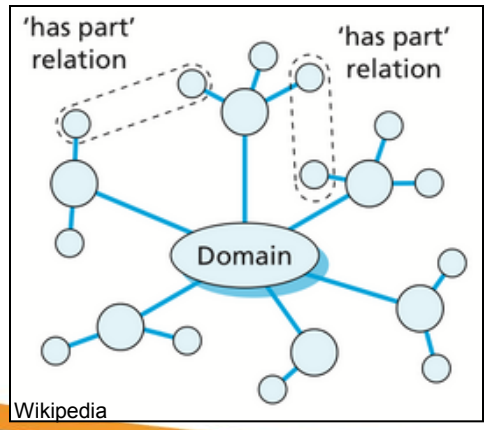
Geo-ontology: nuclear power plant

Callaway nuclear power plant, Reform, MO (**CRMO**)

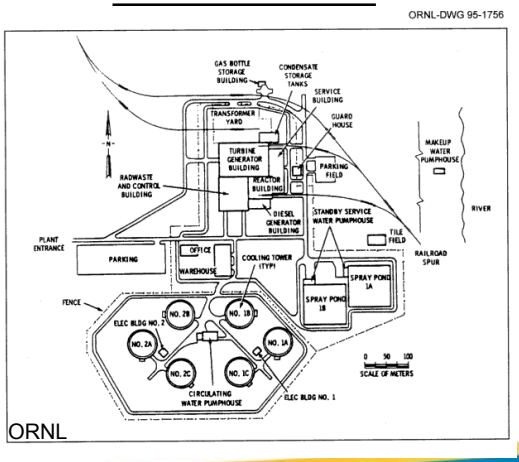
Objects ("things")

- ReactorContainmentBldg
- HyperboloidCoolingTower
- TurbineBuilding
- ElectricalSwitchYard
- CoolingWaterPond
- DieselGeneratorBldg
- DieselFuelTank

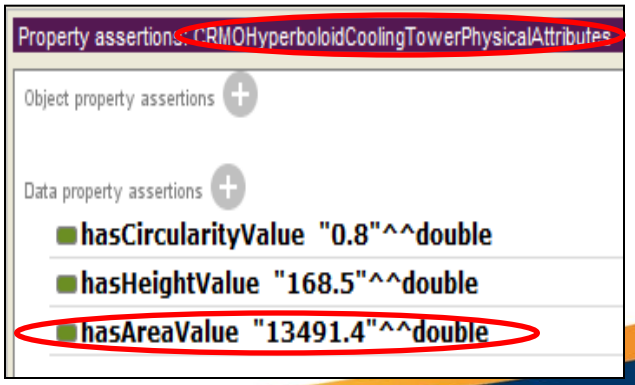
Geo-ontology (graph)



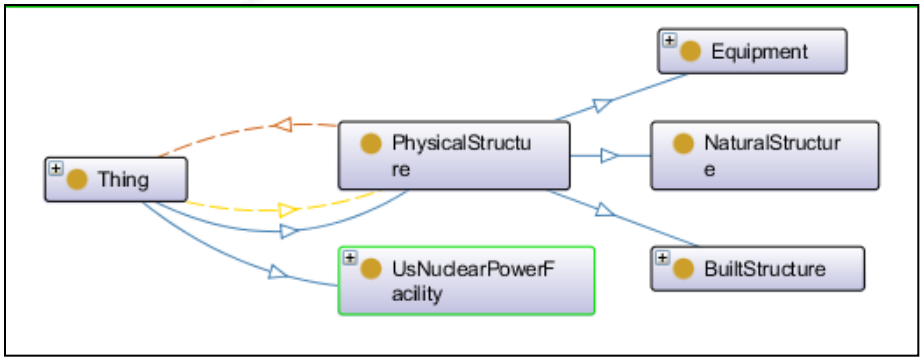
Mensuration

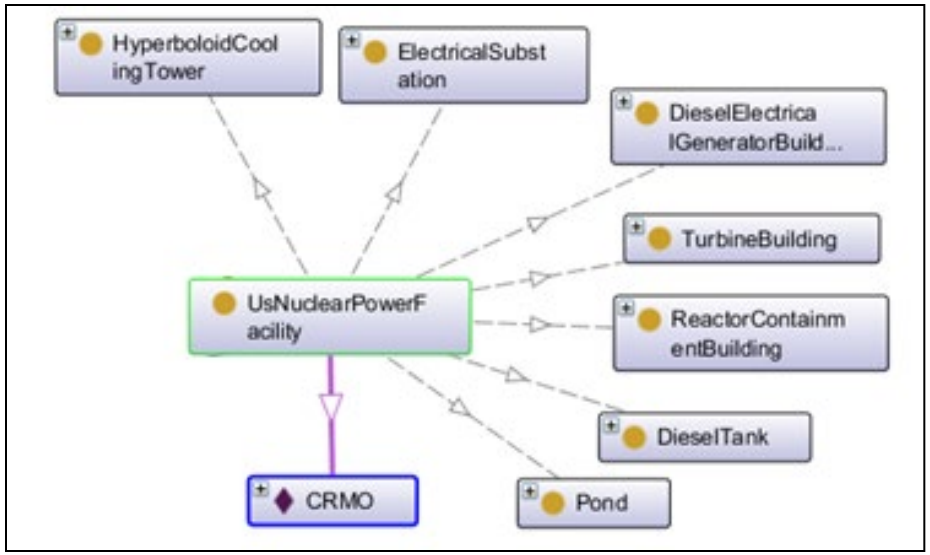


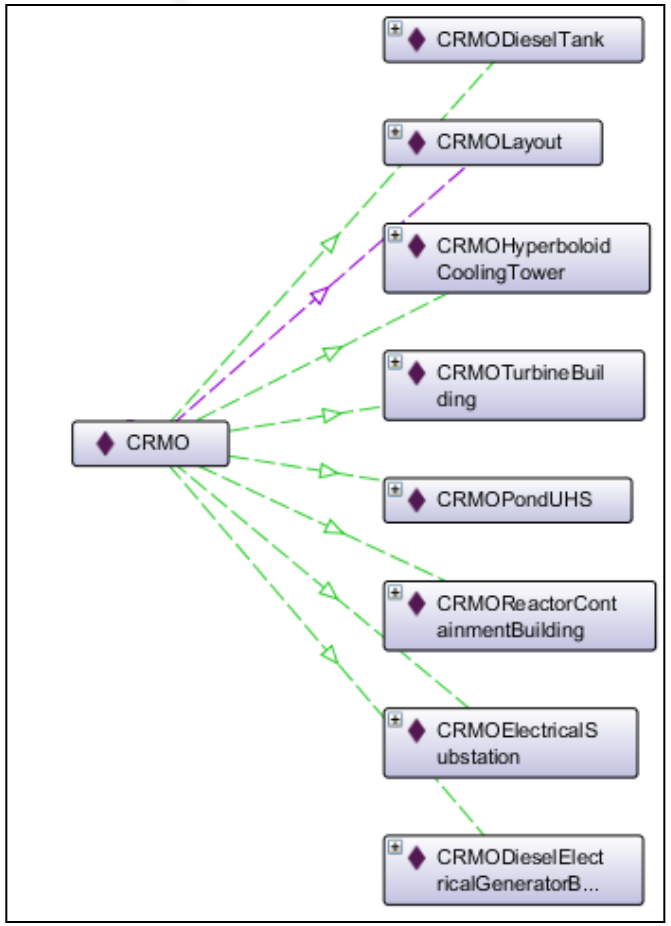
Instantiation



Geo-ontology: nuclear power plant

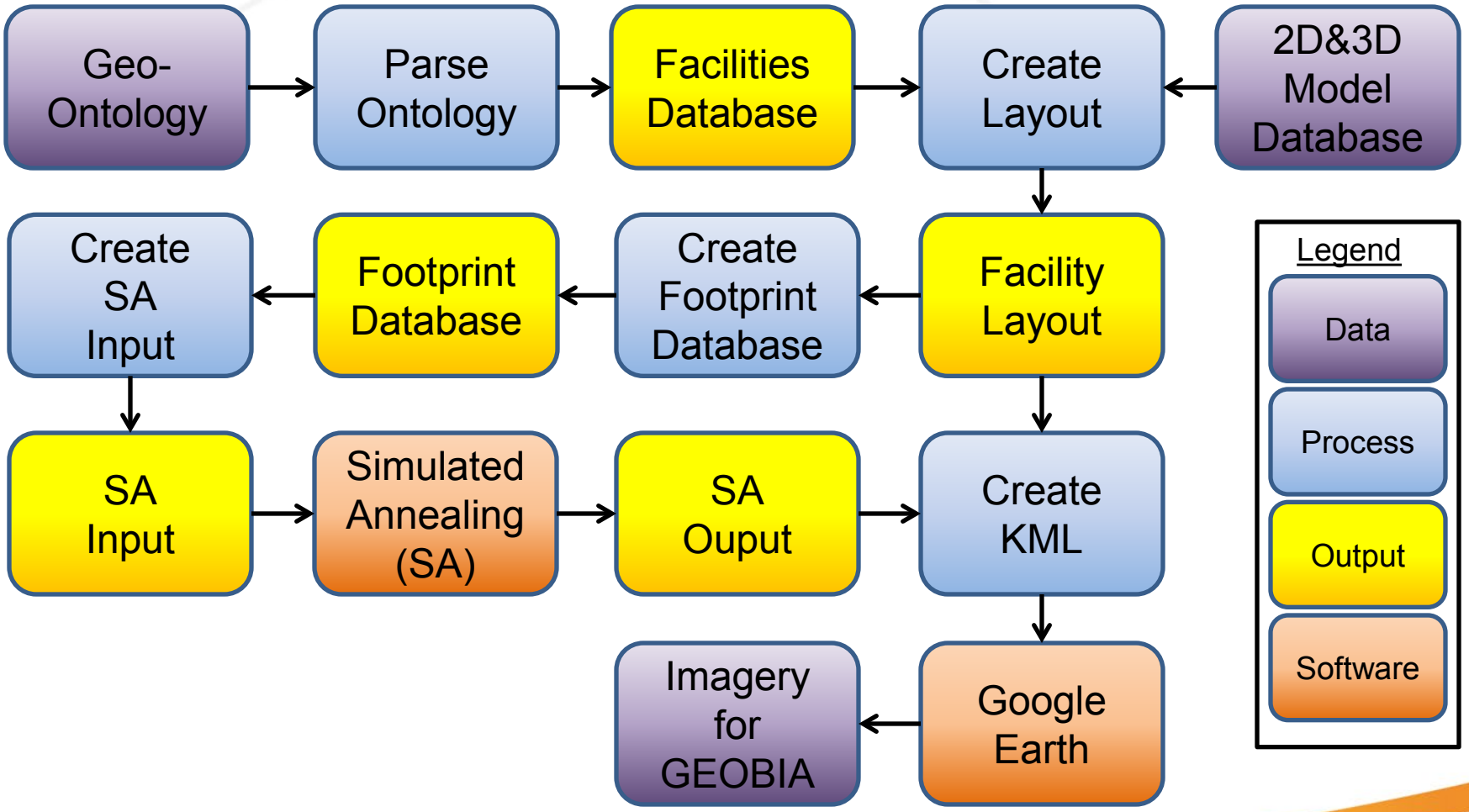






Geo-ontology engineering tools: Protége and OntoGraf

Ontology-to-Synthetic imagery (O2Synth)



Examples

- Geo-ontology w/ instantiatons drives:
  - Object types
  - Sizes
  - Arrangement

The synopic layouts/imagery output by O2Synth are *semantically consistent*

with subject matter expertise and reality

as encapsulated by the geo-ontology

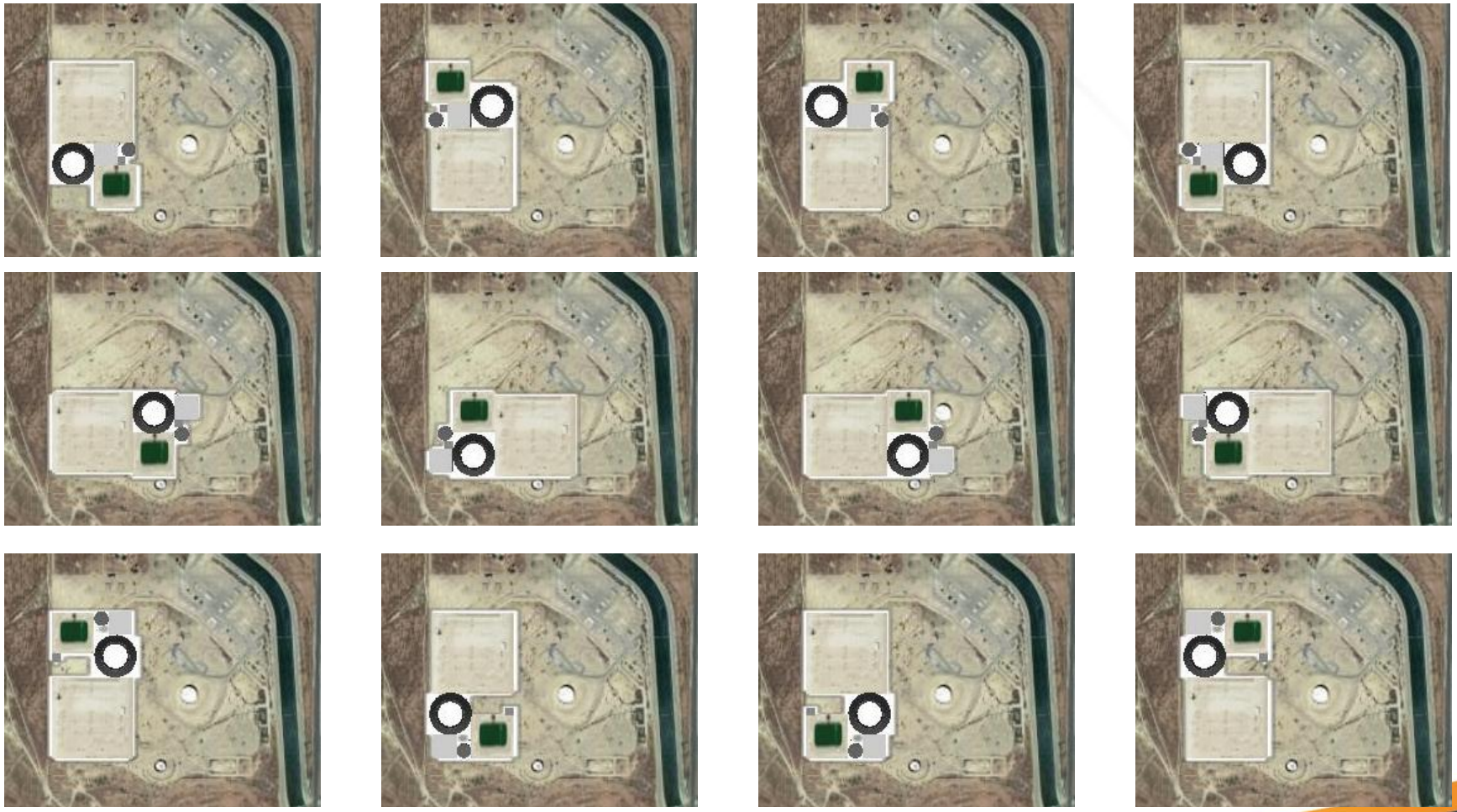
and the instantiations (e.g., CRMO)

contained within it.

Tabula Rasa

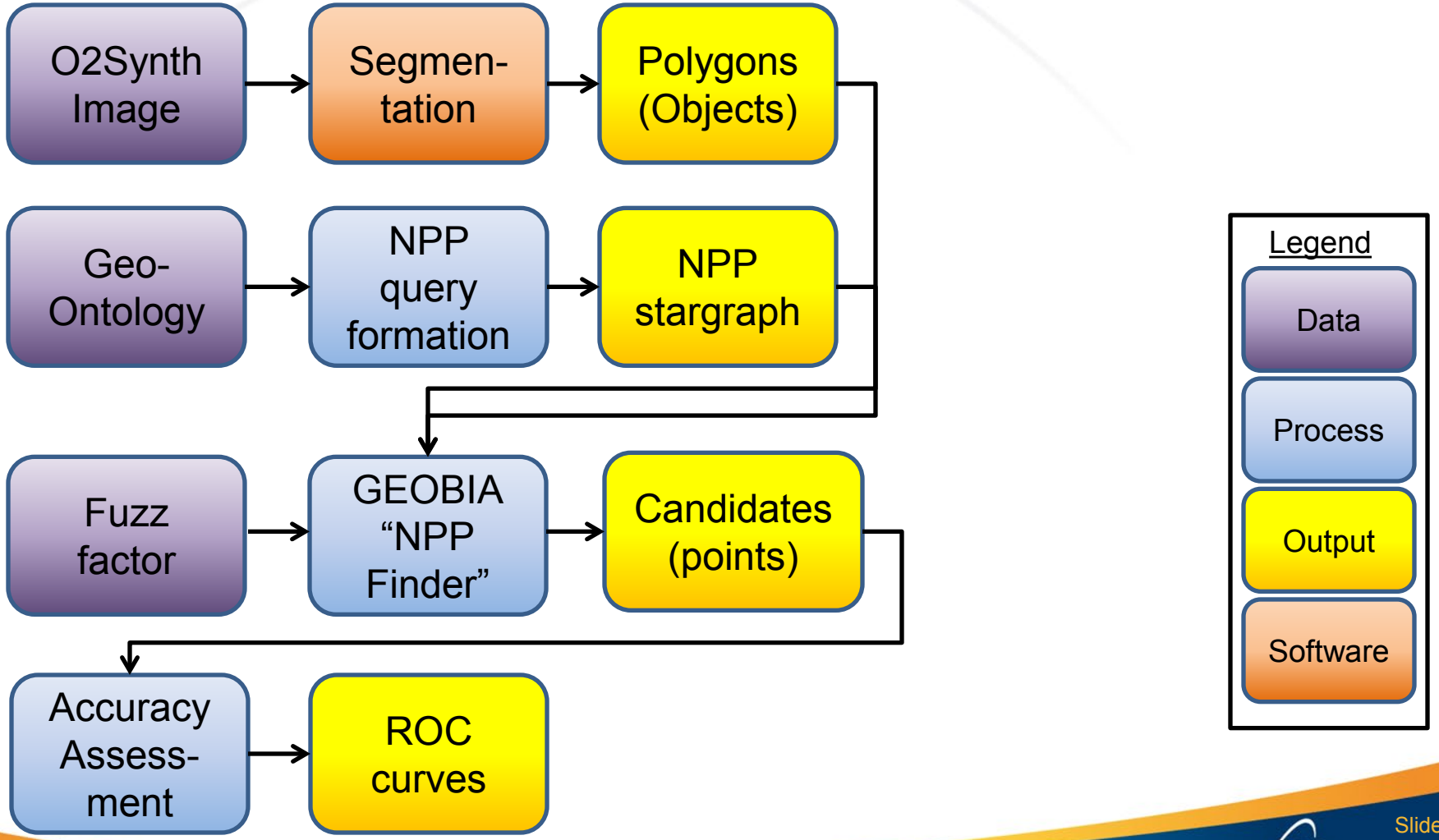
Tabula Rasa + NPP

Twelve Examples from O2Synth

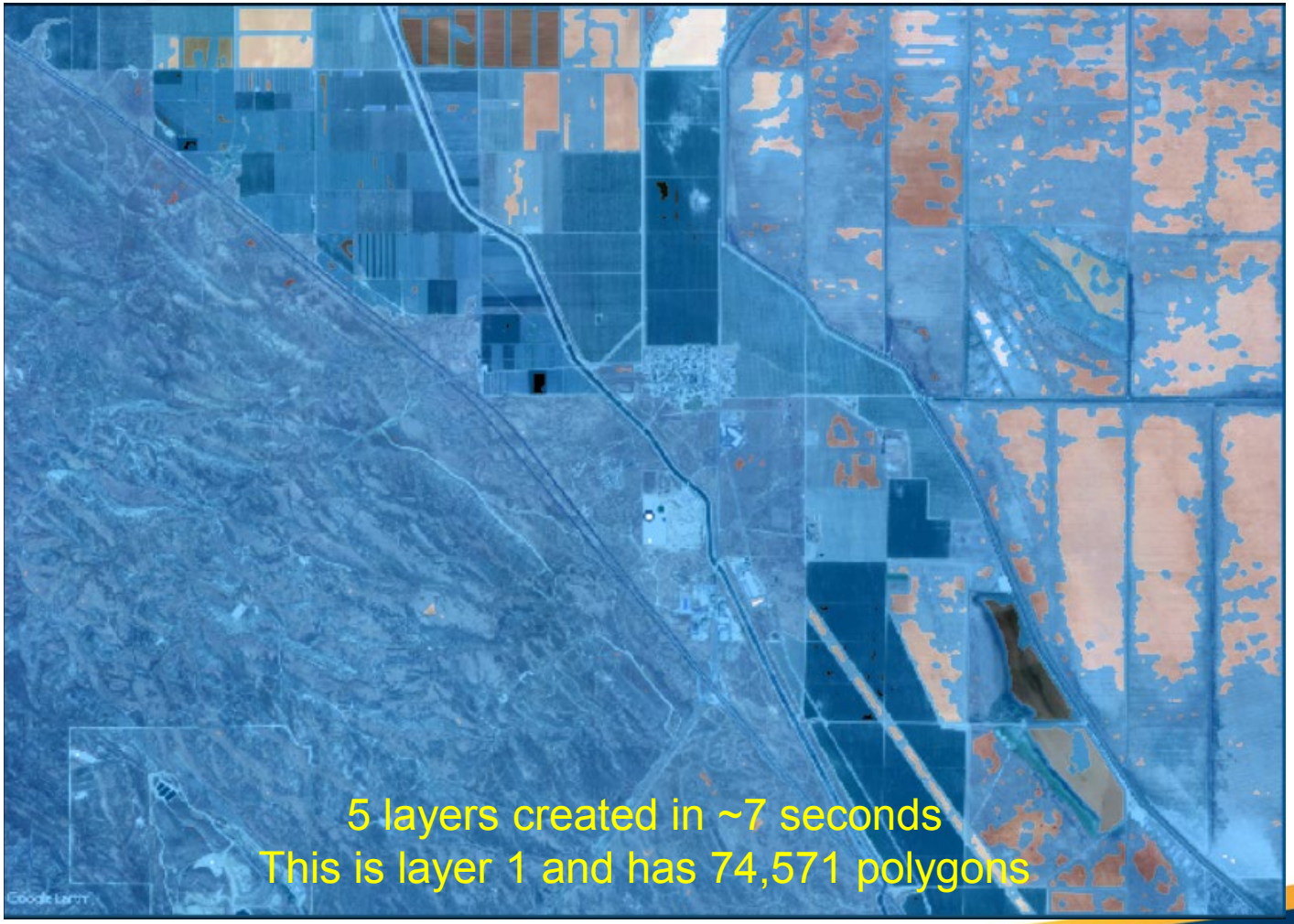


Note: *different* imagery, but same *thing*.

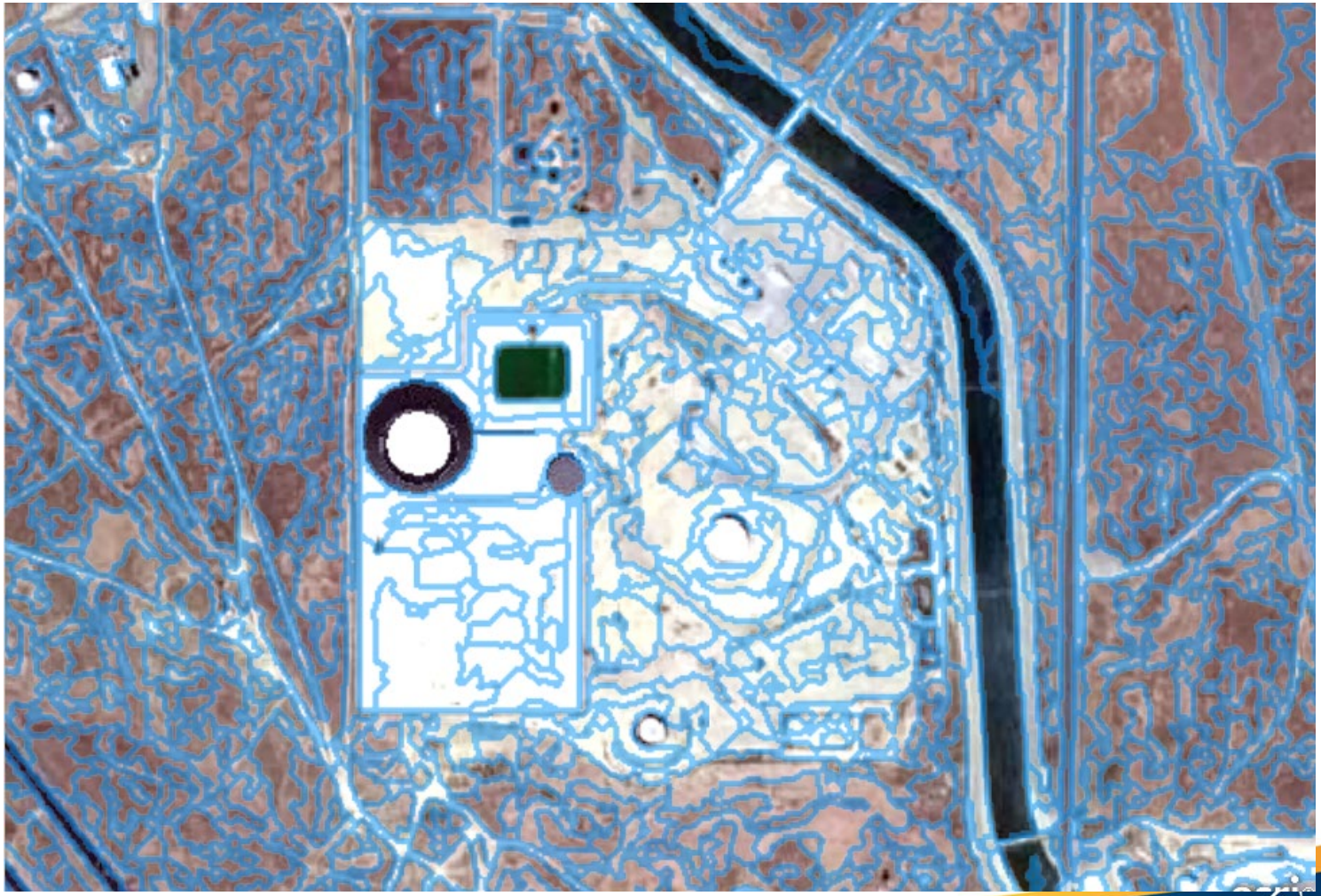
Nuclear Power Plant (NPP) finder



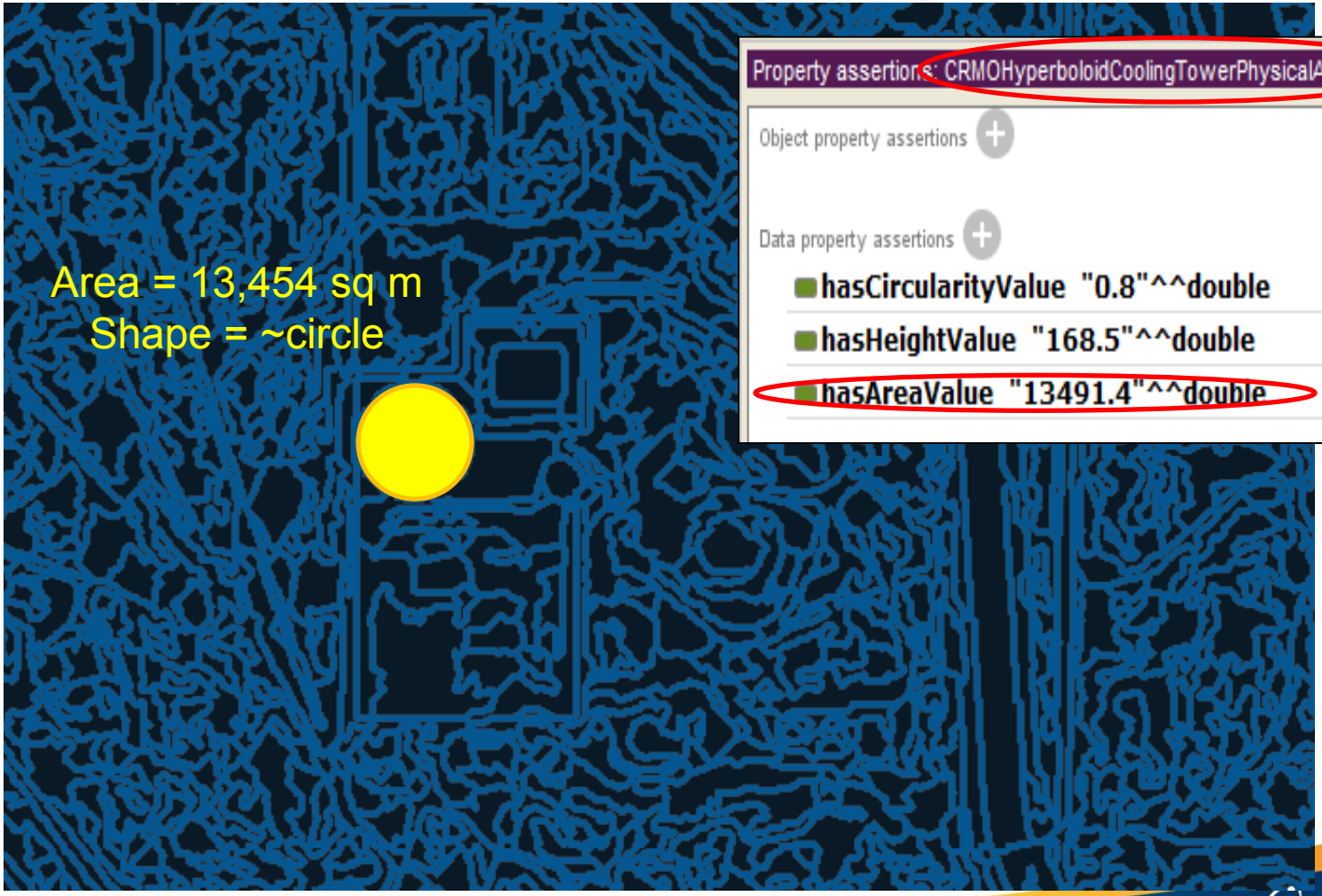
Hierarchical segmentation into *objects*



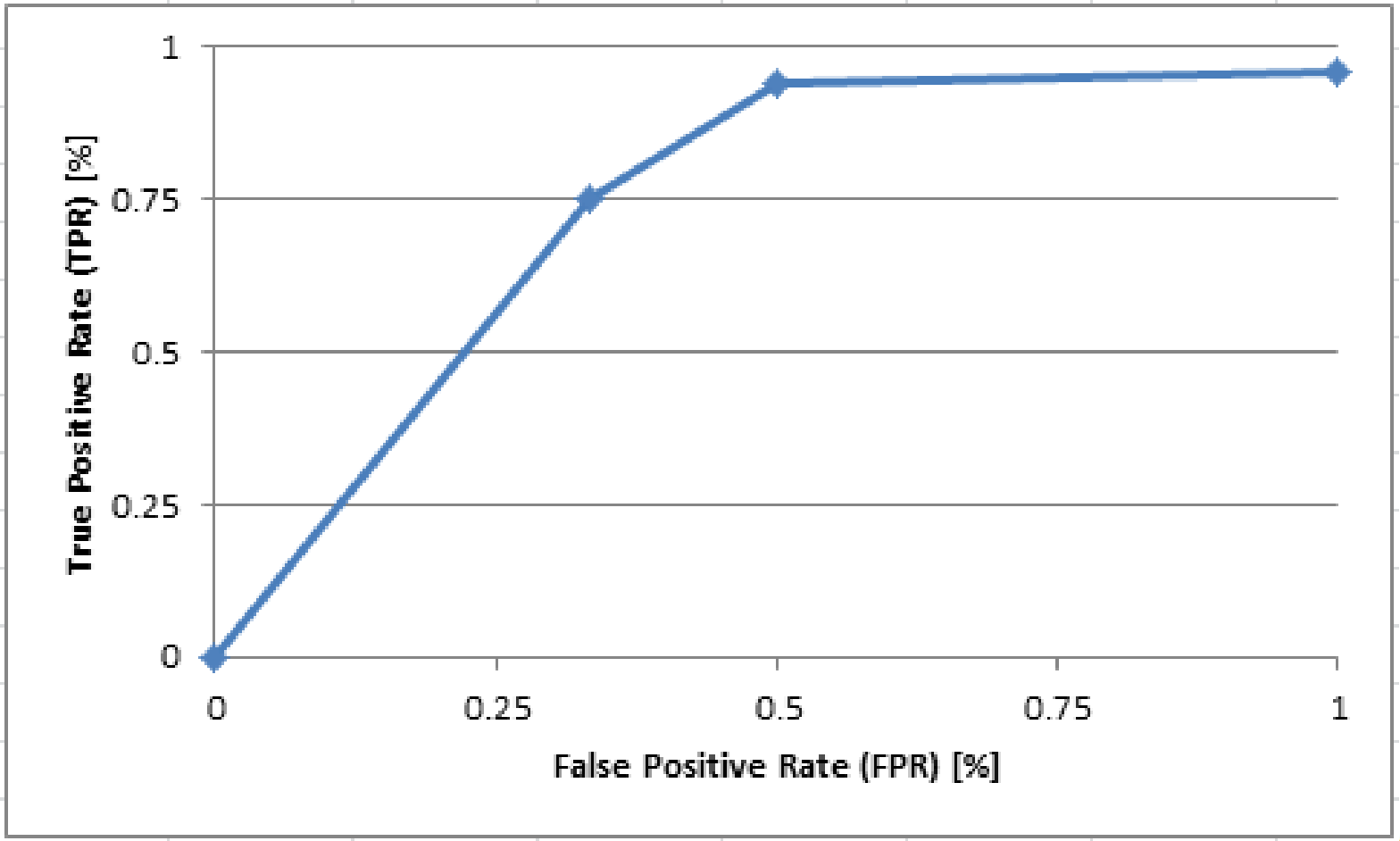
Hierarchical segmentation into *objects*



GEOBIA



Accuracy Assessment: “NPP Finder”



Conclusion & possible Future Work

- Demonstrated: geo-ontology guided synthetic image creation & use
- Increase conceptual fidelity (e.g., more objects, clouds, shadows, textures, projections, etc.)
- More instantiations (1,000s)
- Demonstrate use to train&test
  Deep Learning (DL) algo.

Q&A

Thank you!