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The Language of Complexity: Ontology in Systems Design and Engineering

Raytheon Missile Systems

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Oct 24, 2017

The Problem

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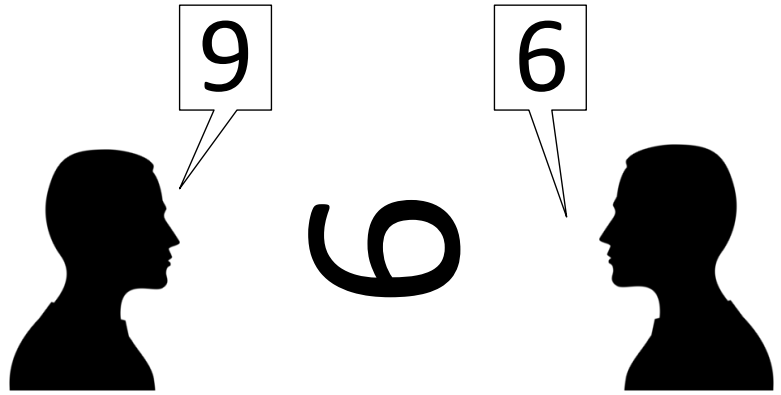
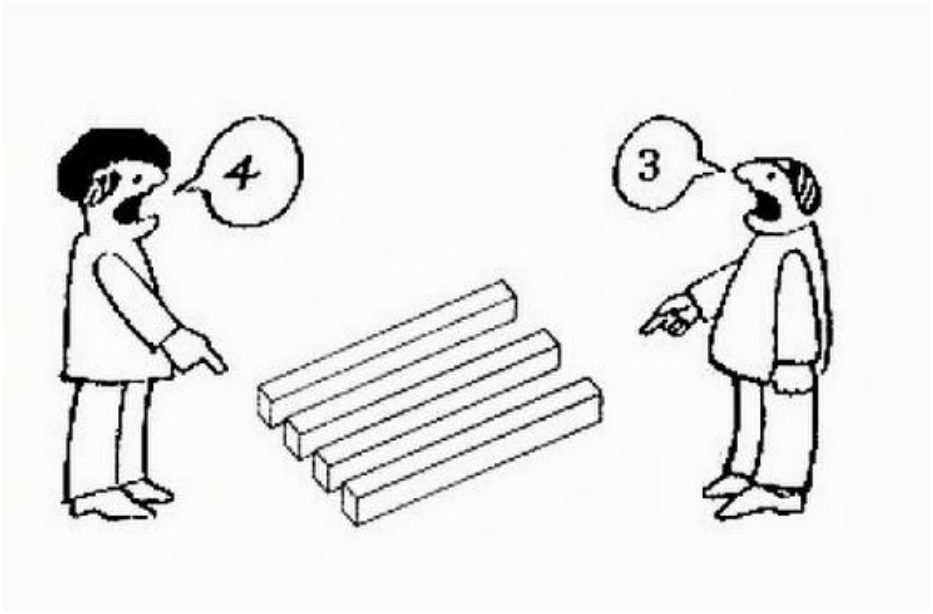
Toilet Out of Order

Use Floor Below





The Problem (cont'd)

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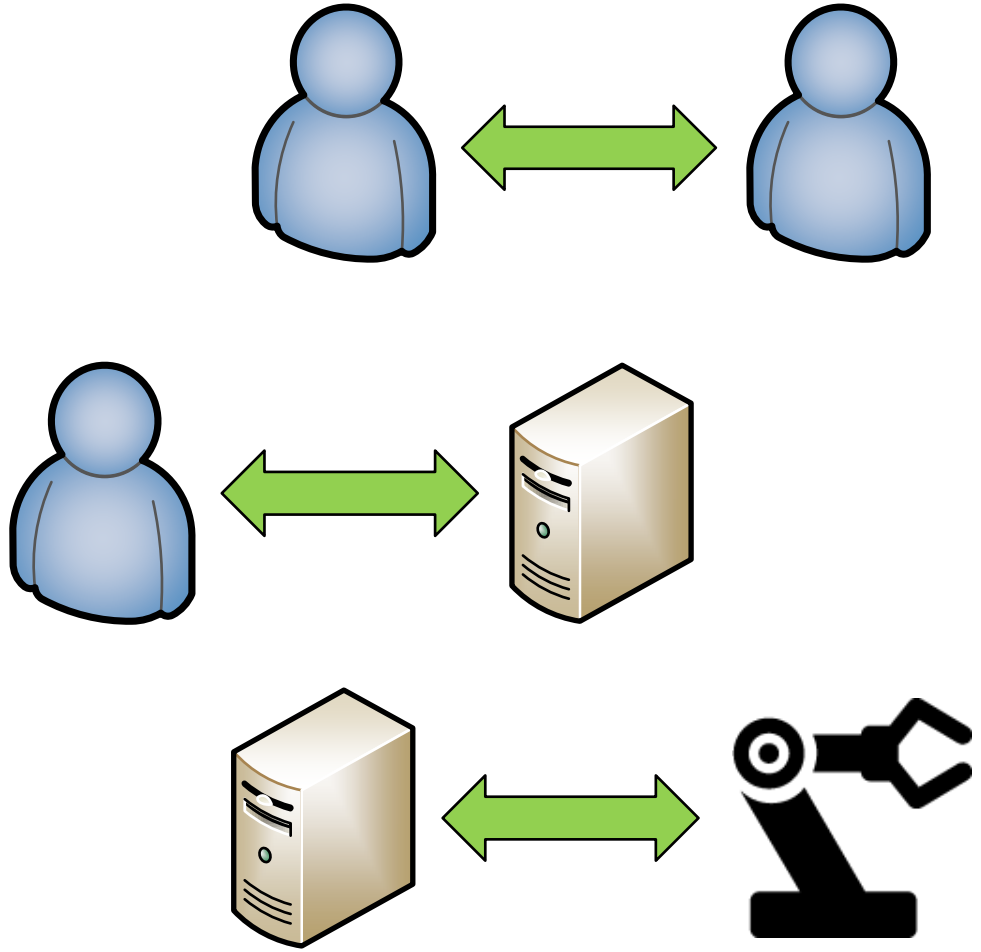
During Systems Development, how do we ensure we **consistently communicate** the **correct meaning** in language used between:

- humans & humans
  - across domains / disciplines
- humans & machines
- machines & machines



Without clear communication, we get cost overruns, delays, and rework.

What is an Ontology?

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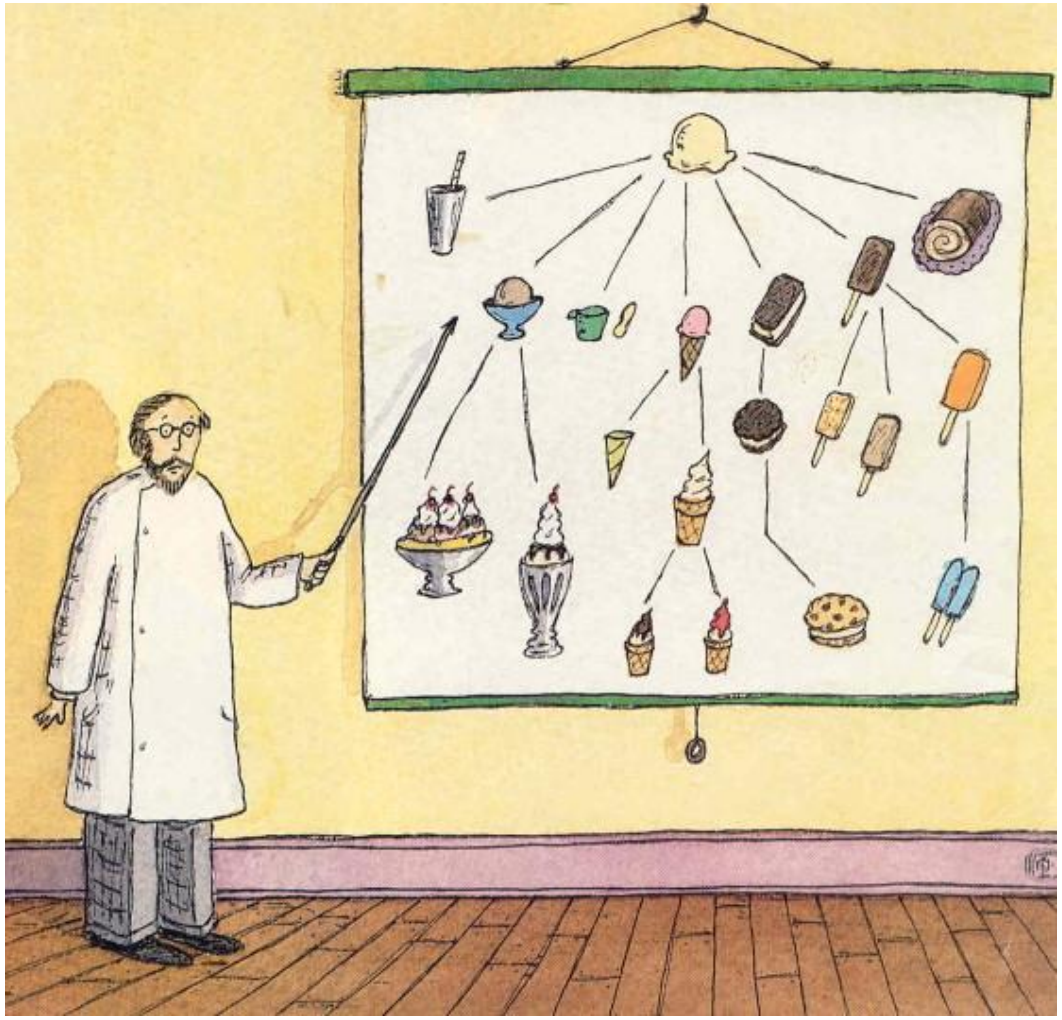

A formal specification of things, concepts, and the relationships between them, within some knowledge domain.

Describes:

- classes: abstractions of things
- individuals: the actual things themselves
- properties: relationships between individuals
  - includes constraints / restrictions on relationships

Written Works Ontology

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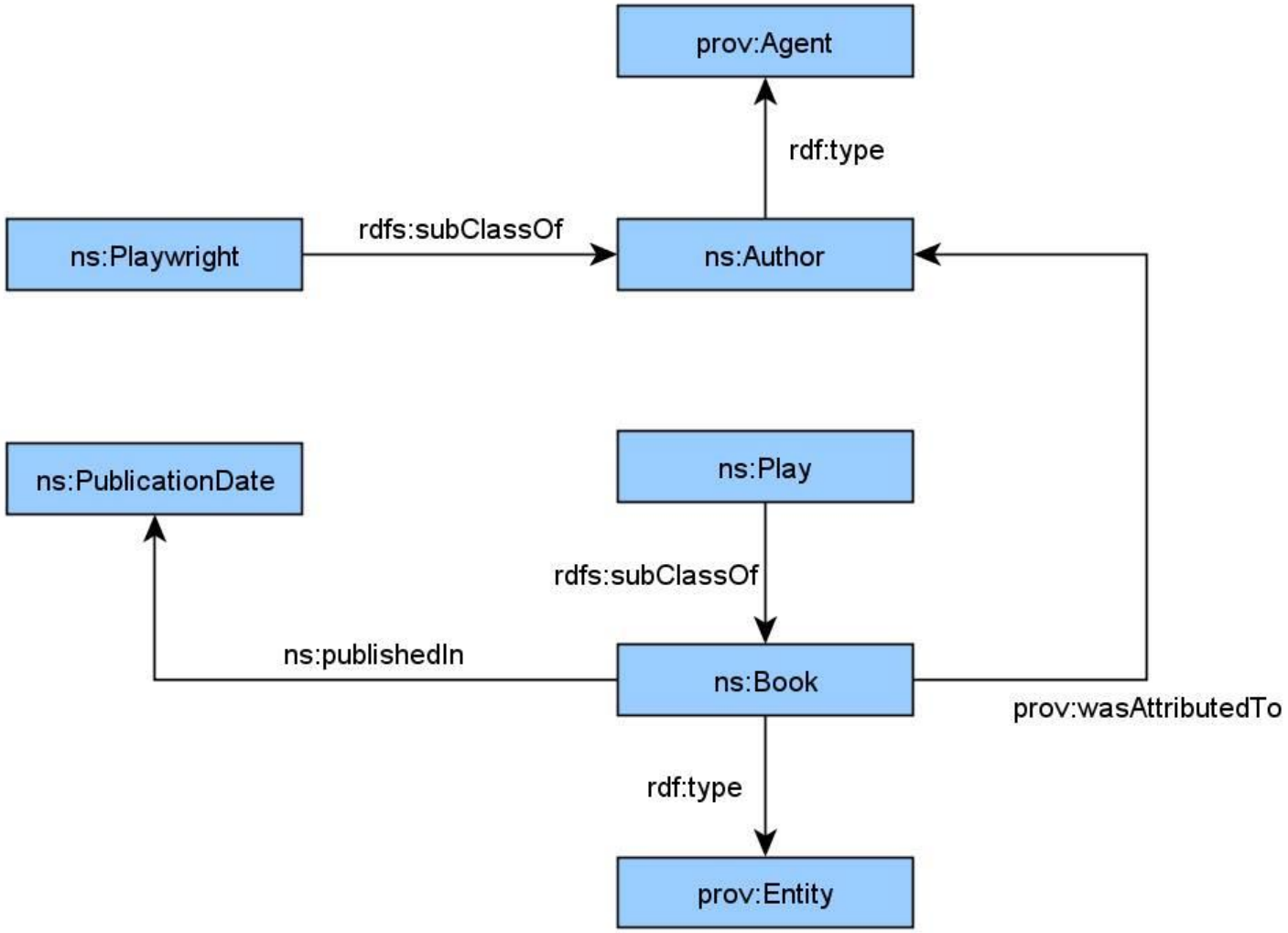

Why Ontologies?

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- Language disambiguation
- Well established technology
- Can model any system
- Formal relationships between objects
- Machine and human readable
- Reasoning / Inferencing engines
- Complex queries
- Information model to complement physics-based models

US Army Corps of Engineers®

Industry Application

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- Ford
  - Started developing ontologies to capture their manufacturing process in 1989 (Rychtyckyj, 1999)[3]
  - Digitized and standardized “process sheets”: vehicle assembly work instructions
  - Improved labor time estimation accuracy
  - Invested effort to rewrite ontology in a newer language, even with impact to production (Rychtyckyj, 2016)[4]

Design Process with Ontologies

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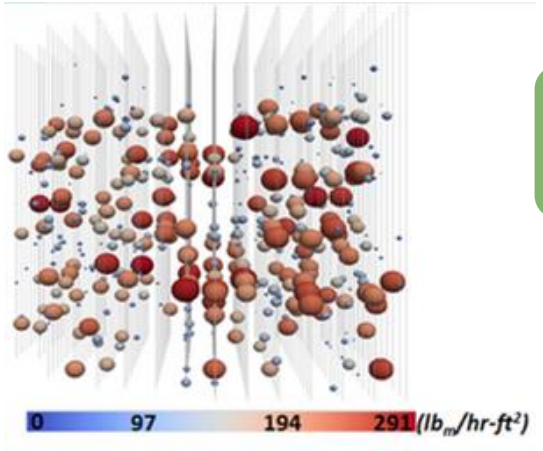

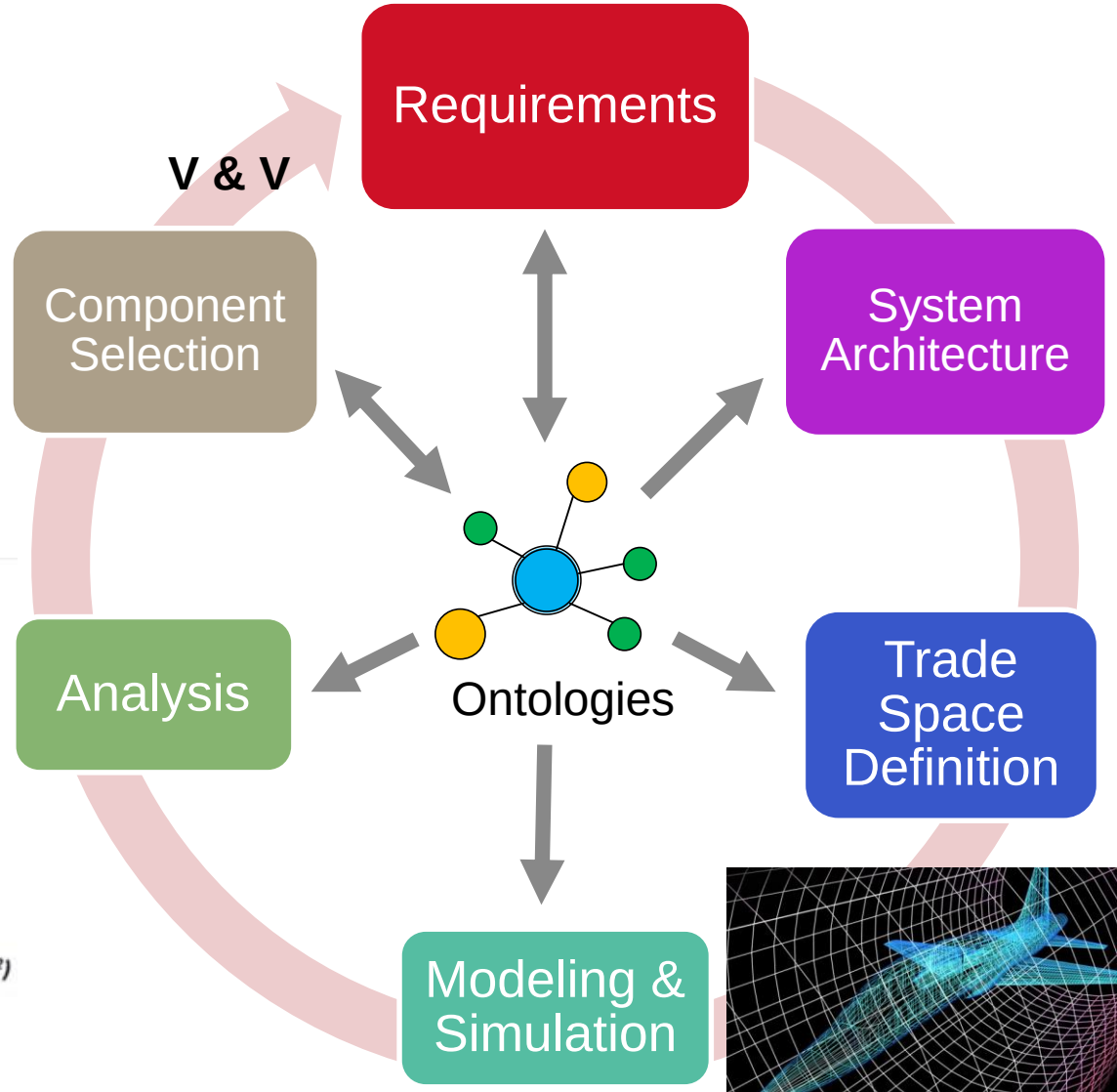

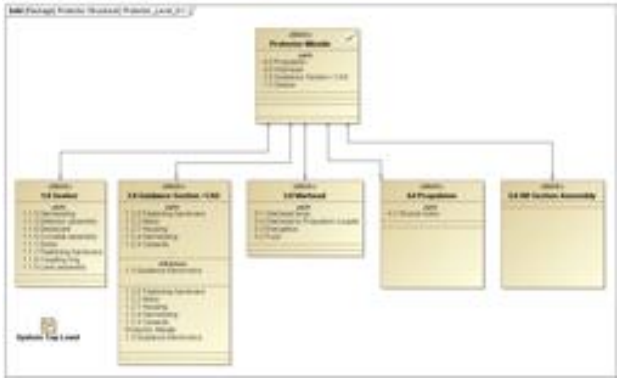

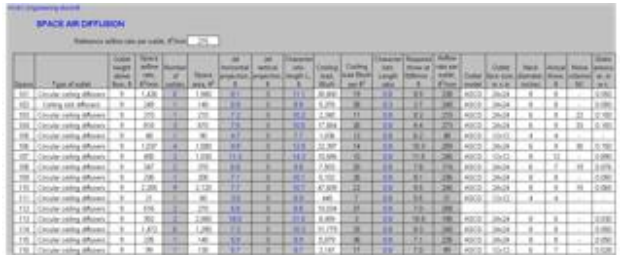

Domain Ontology

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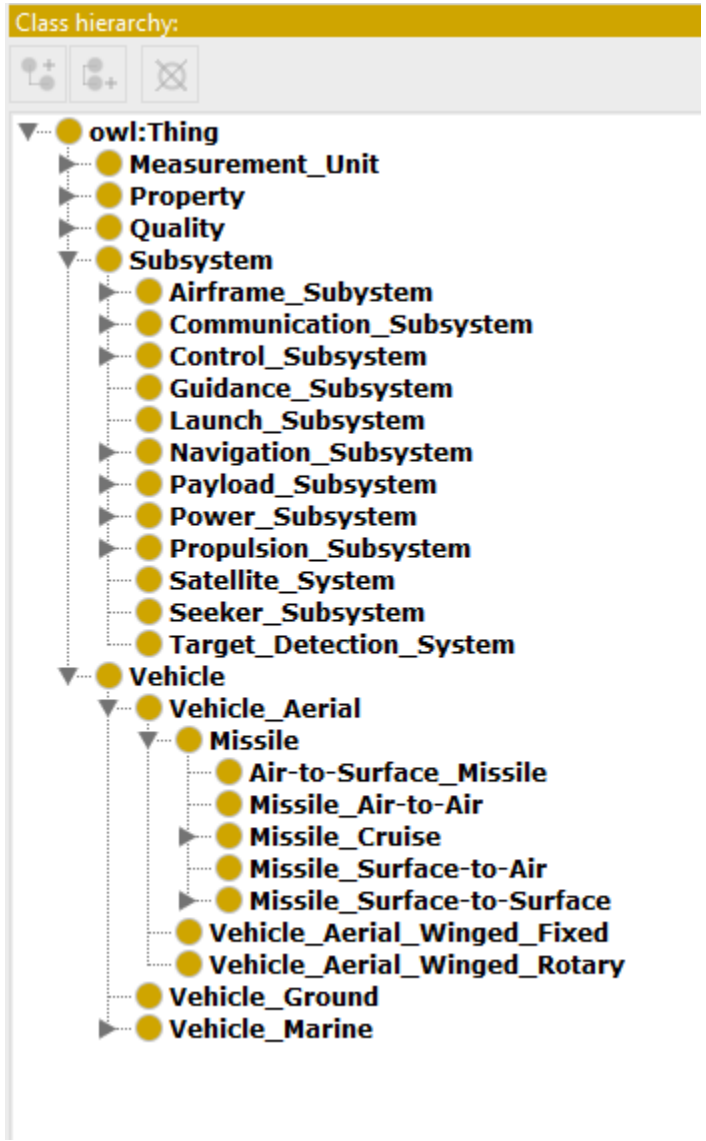

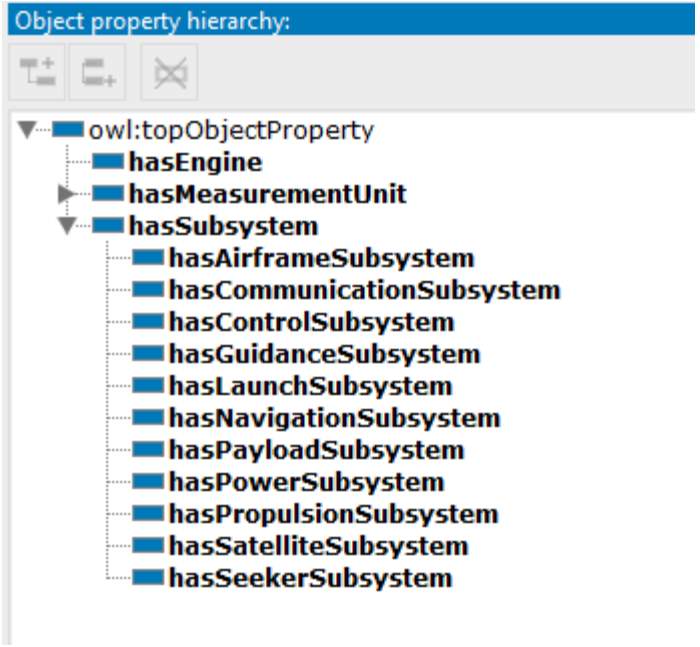

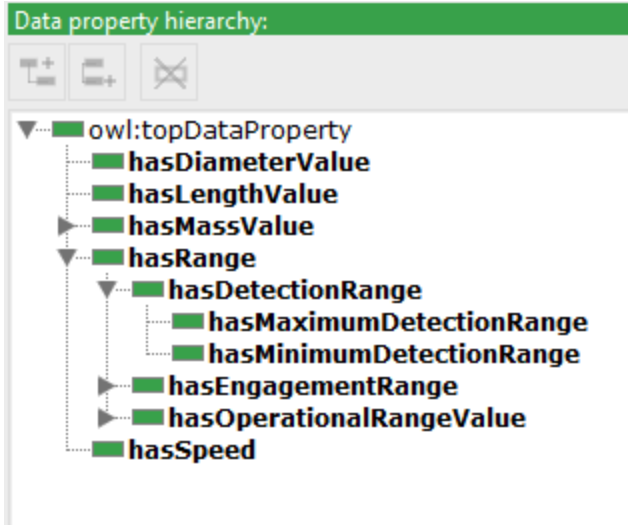

Value Proposition to the DoD

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- Improve acquisition process
  - Design products faster (Better Buying Power[5]).
  - Improve ability to compare competitive product proposals.
  - Evaluate a broader assessment of alternatives.
- Consistency among stakeholders
  - Ensure that the DoD's interpretation of requirements equals manufacturer's interpretation.
- Traceability
  - Allow for traceability of design decisions back to the requirements

Questions?

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References

1. Roz Chast, http://rozchast.com/cartoons_newyorker.shtml.
2. IBM developerWorks, 2012, Reification and Trust: Ontology-driven NLP.
3. Rychtyckyj, N. 1999. DLMS: Ten Years of AI for Vehicle, Assembly Process Planning. In *Proc. of AAAI'99/IAAI'99*, 821–828.
4. Rychtyckyj, N. 2016. Ontology Re-Engineering: A Case Study from the Automotive Industry. In *Proc. of AAAI'16/IAAI'16*, 3974-3981.
5. Better Buying Power

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