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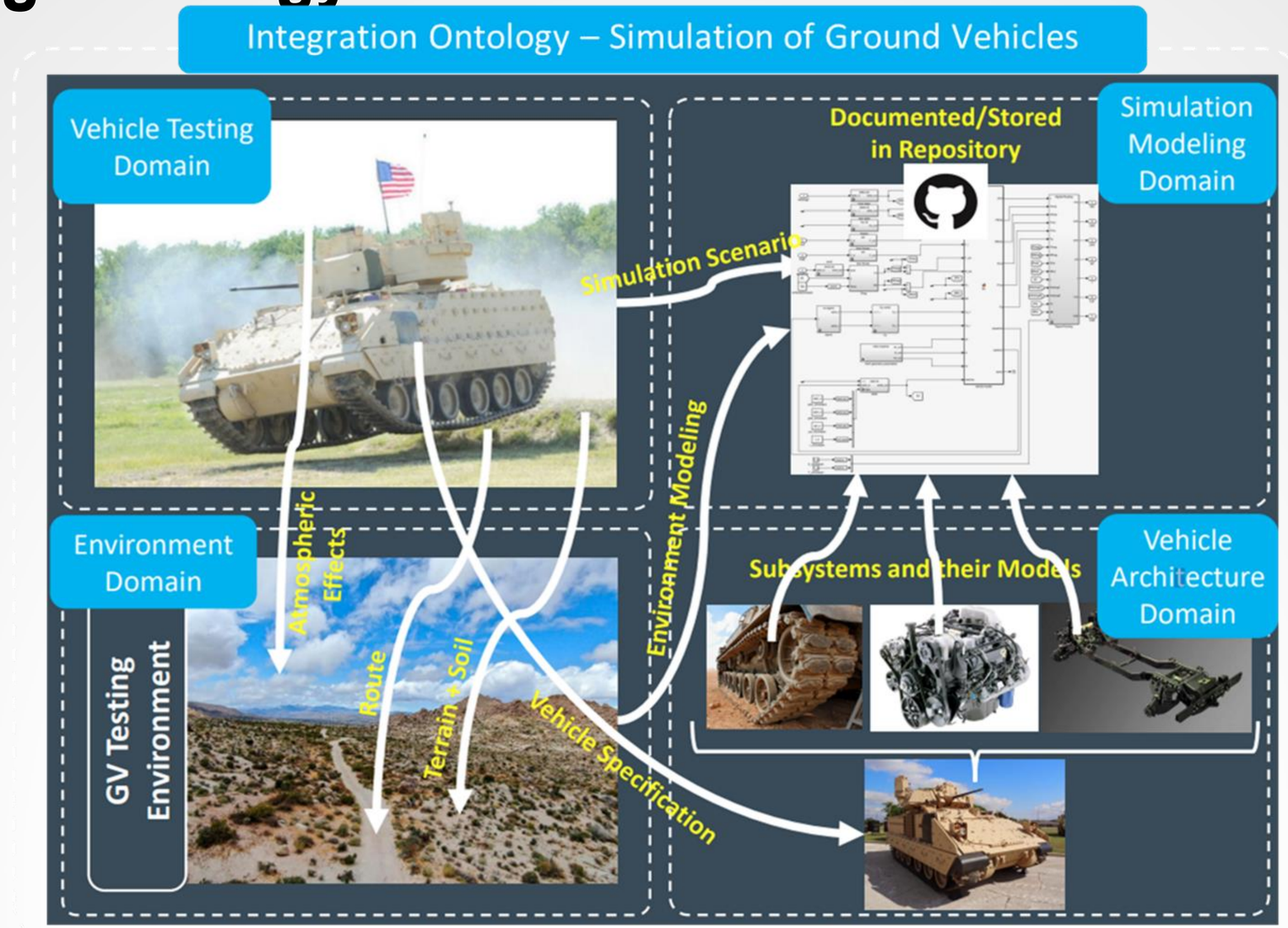
GVSMO: An Ontology for the Simulation Modeling of Ground Vehicles

Ed Louis, Evan Taylor, Greg Mocko, and Evan Hybl

Summary

- Click to Motivation and approach
- Discussion of domain ontologies
- Integration of ontology and example
- Future Work and Accessing GVSMO

The Ground Vehicle Simulation Modeling Ontology

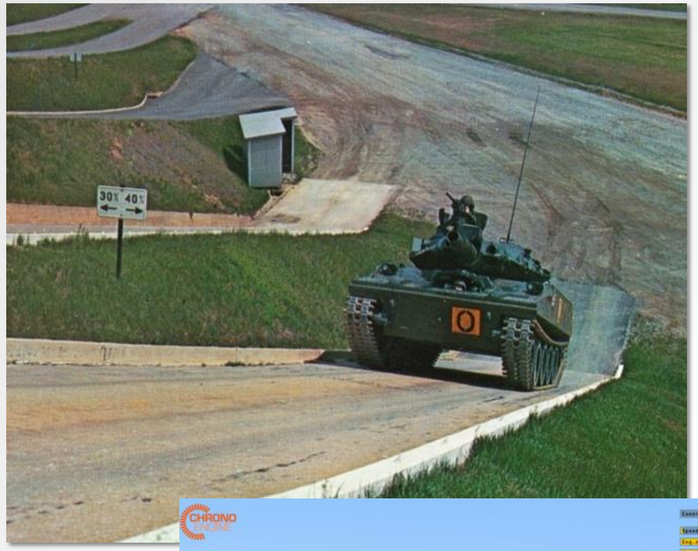


Motivation

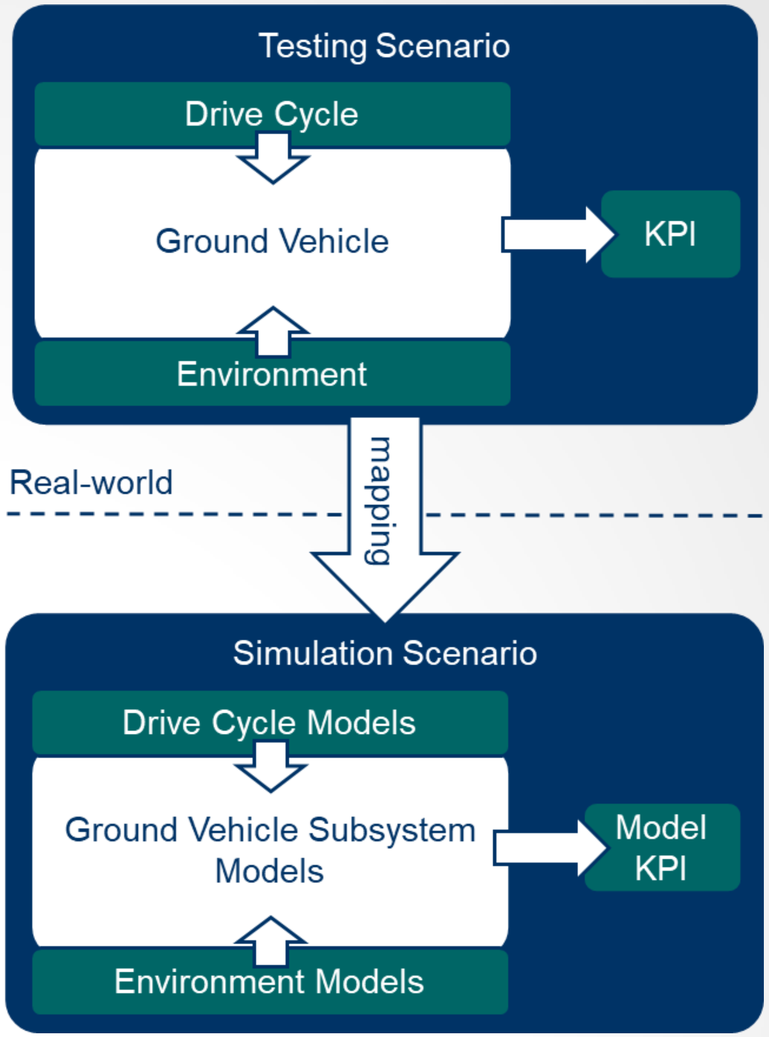
- US Army goals for next-gen ground vehicle technology and capability [1, 2, 3]
  - Advanced powertrains
  - Autonomy
  - Off-road mobility
- Goals for design [4, 5, 6]
  - Lower reliance on physical prototyping
  - Shorter design timelines

https://gbp.com.sg/stories/elta-systems-demonstrates-advanced-autonomous-ground-combat-vehicle/

Simulation-Based Design

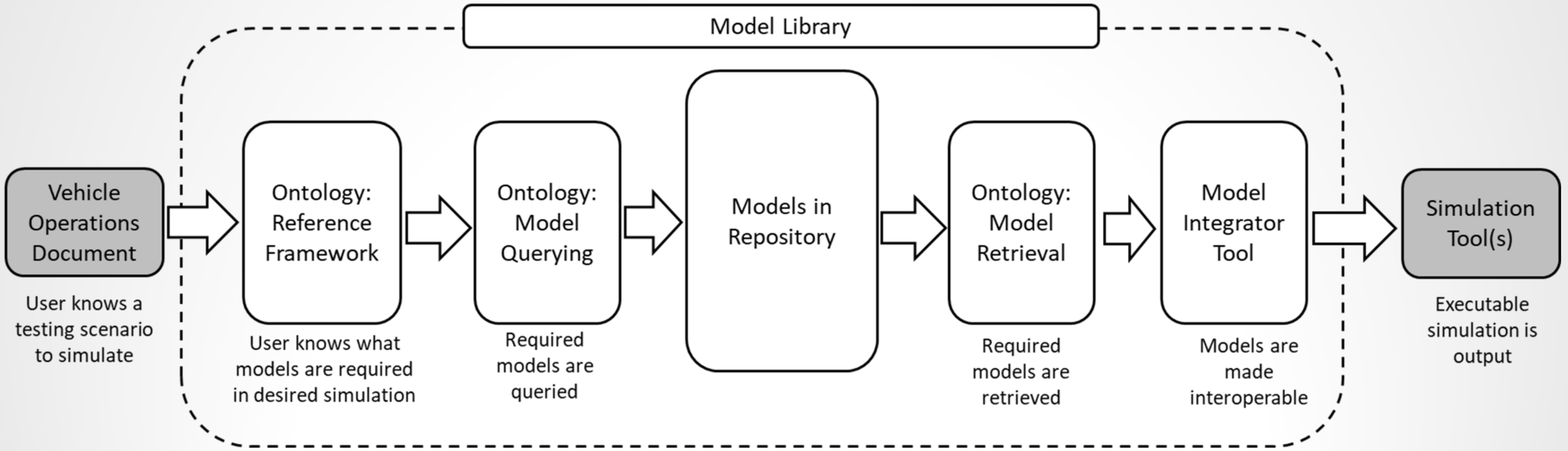


[https://www.hippostcard.com/listing/aberdeen-proving-ground-tank-at-munson-test-area-postcard-1960s/8470936]



Model Library

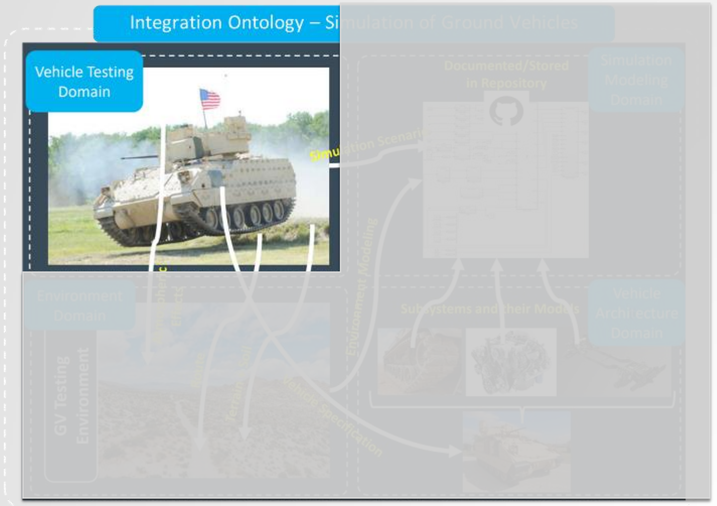
- Assists user to write/find simulations from testing documents
- Adds functionality beyond a simple file server and keyword-based querying

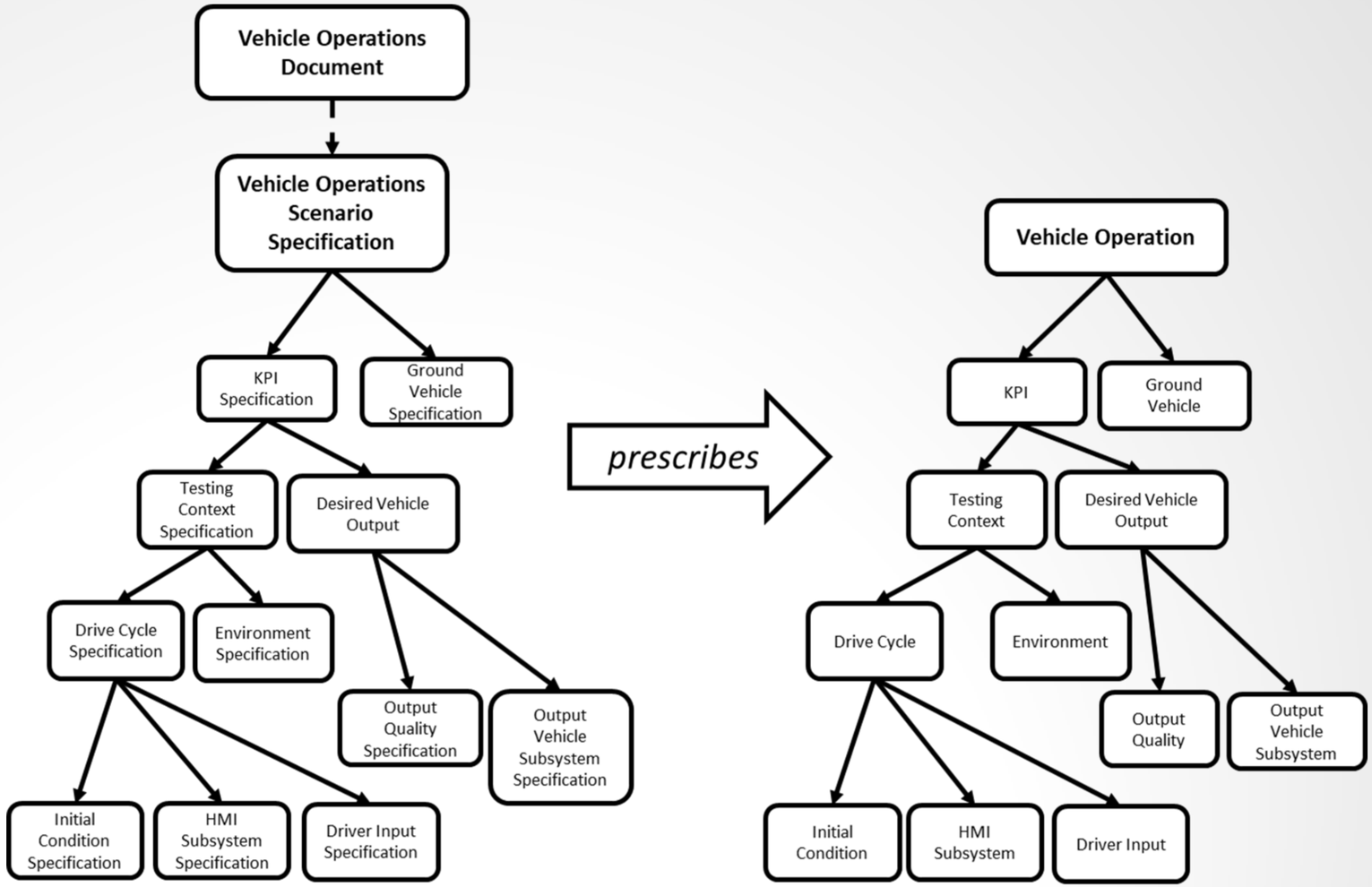


Development Approach

- Divided into high-level domain into 4 sub-domain ontologies and an integration ontology
  - Integration ontology establishes cross-domain mappings
- Leverage Basic Formal Ontology (BFO) and Common Core Ontologies (CCO) [7]
- Sub-domain class hierarchies developed using combined approach [8]
  - Top-down approach struggles to bound granularity
  - Bottom-up approach struggles to bound scope

Vehicle Operations Ontology (VehOps)





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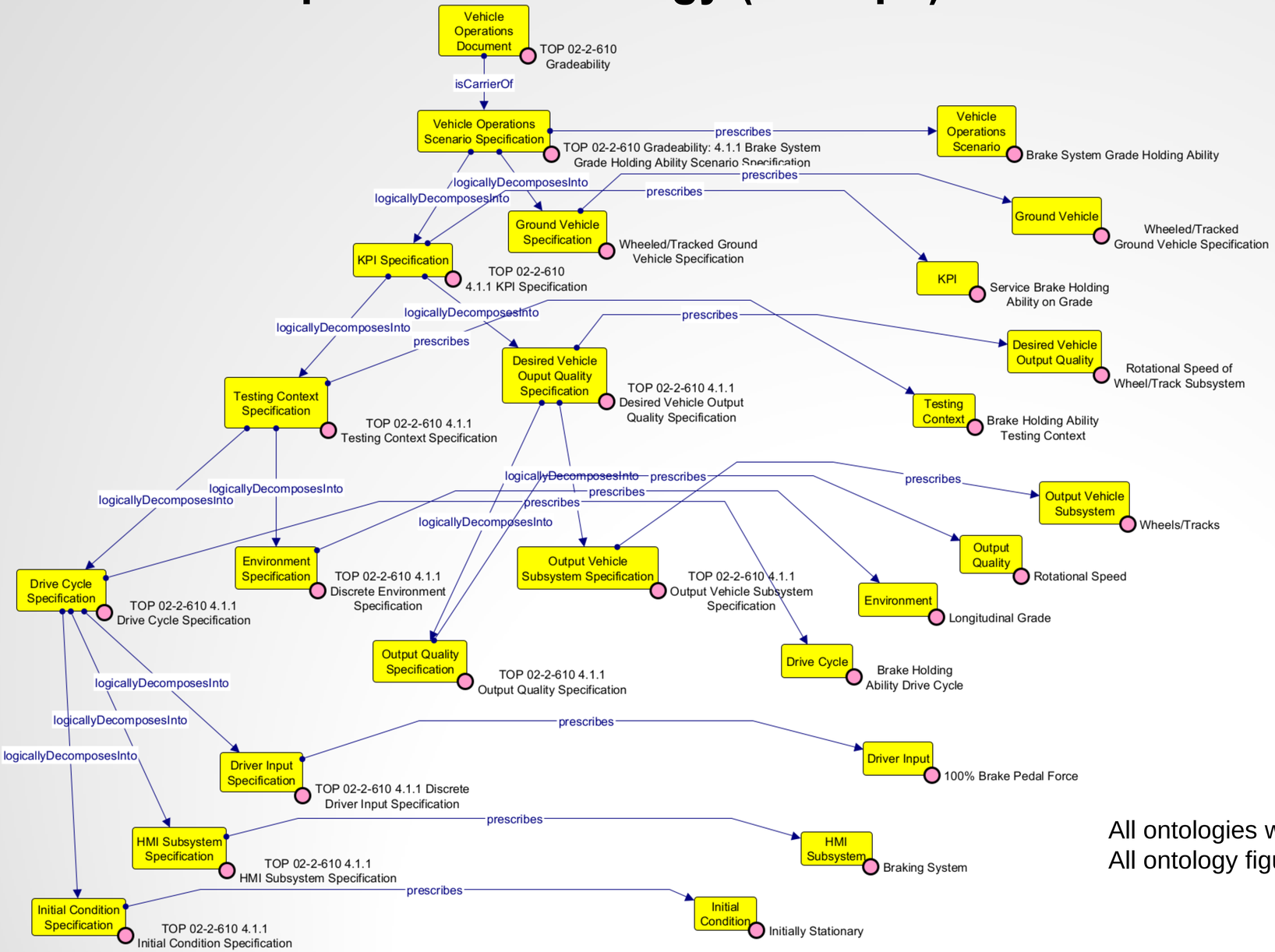
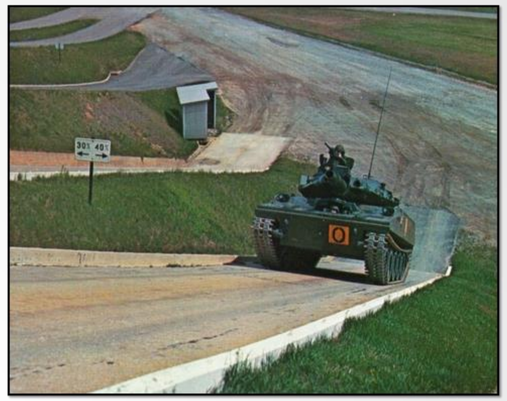


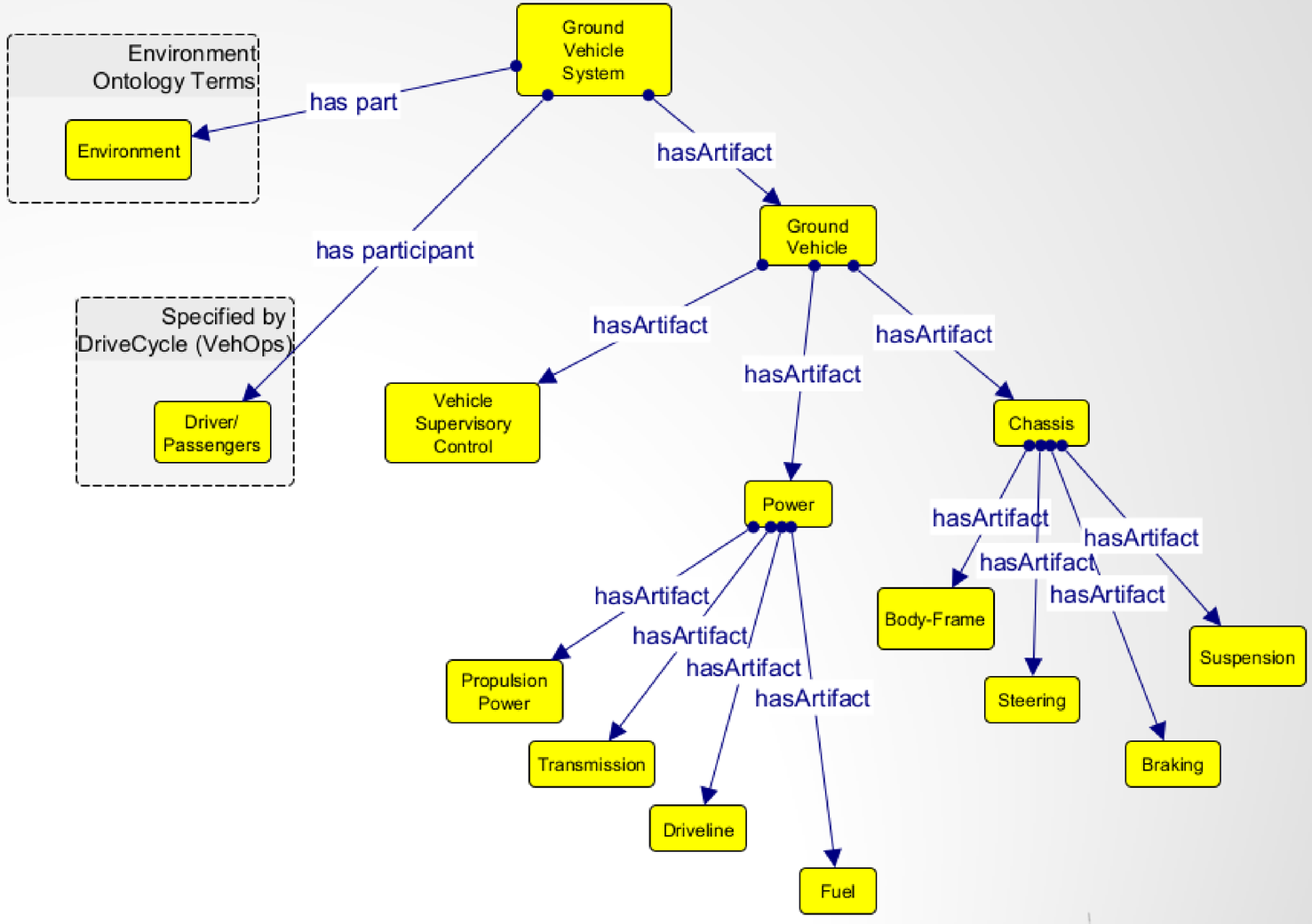


TOP 02-2-610 Gradeability [9]

All ontologies written in OWL language using Protégé
All ontology figures made using yEd Graffoo

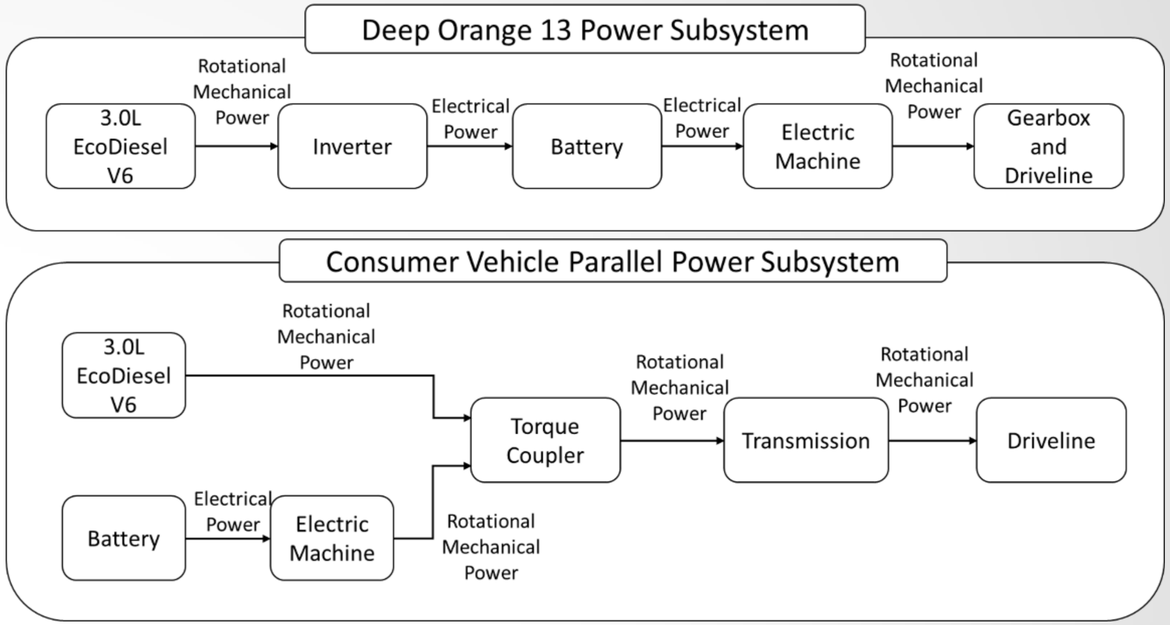
Vehicle Architecture Ontology (VehArch)

- Decomposition of GV systems and function
  - SAE J3049 [10]
  - Connection port types are non-directed connections of physical quantities or signals



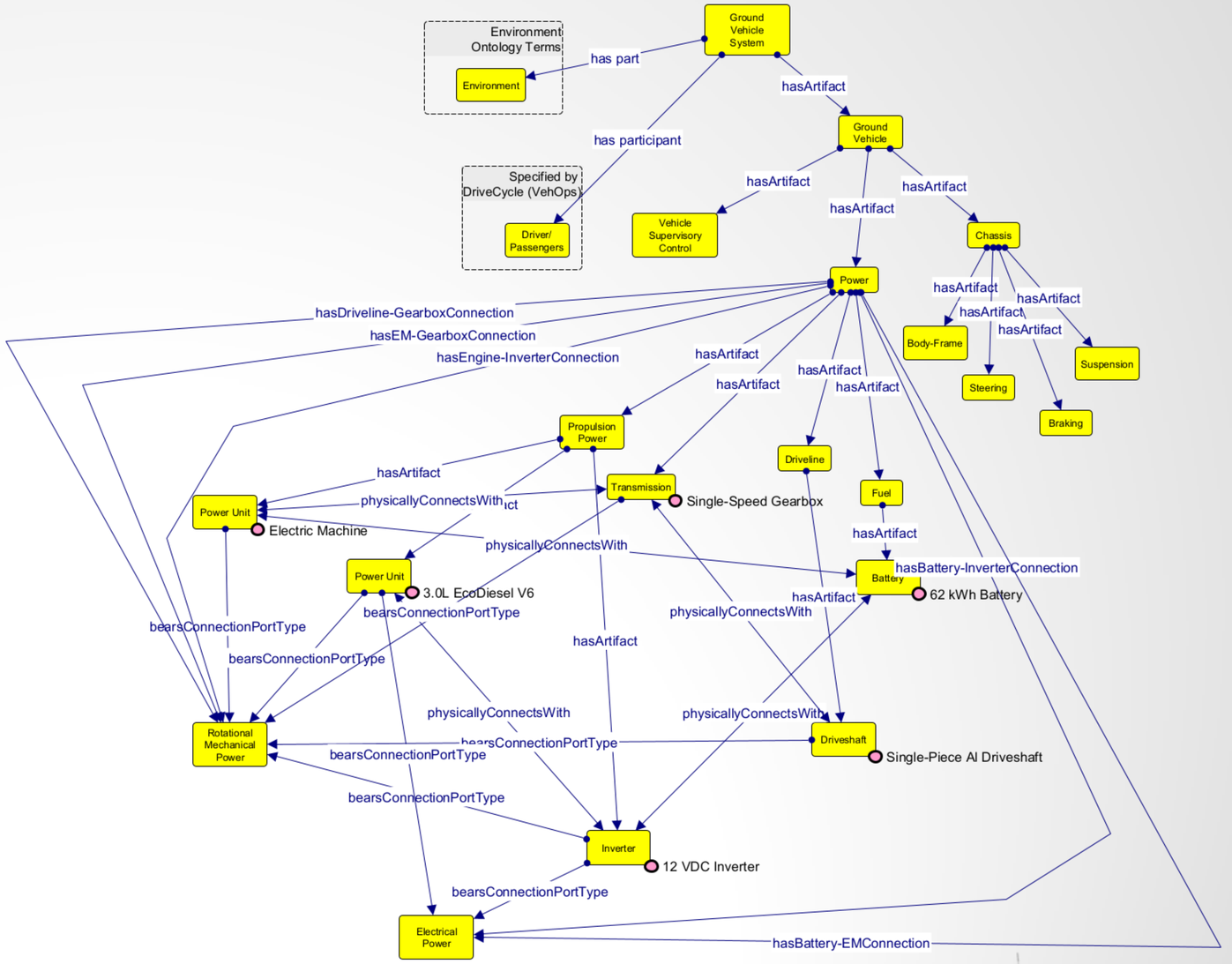
Vehicle Architecture Ontology (VehArch)

- VehArch seeks to support variant architectures
  - Same systems/components reconfigured into several architectures
  - Example: Series hybrid and parallel hybrid powertrains



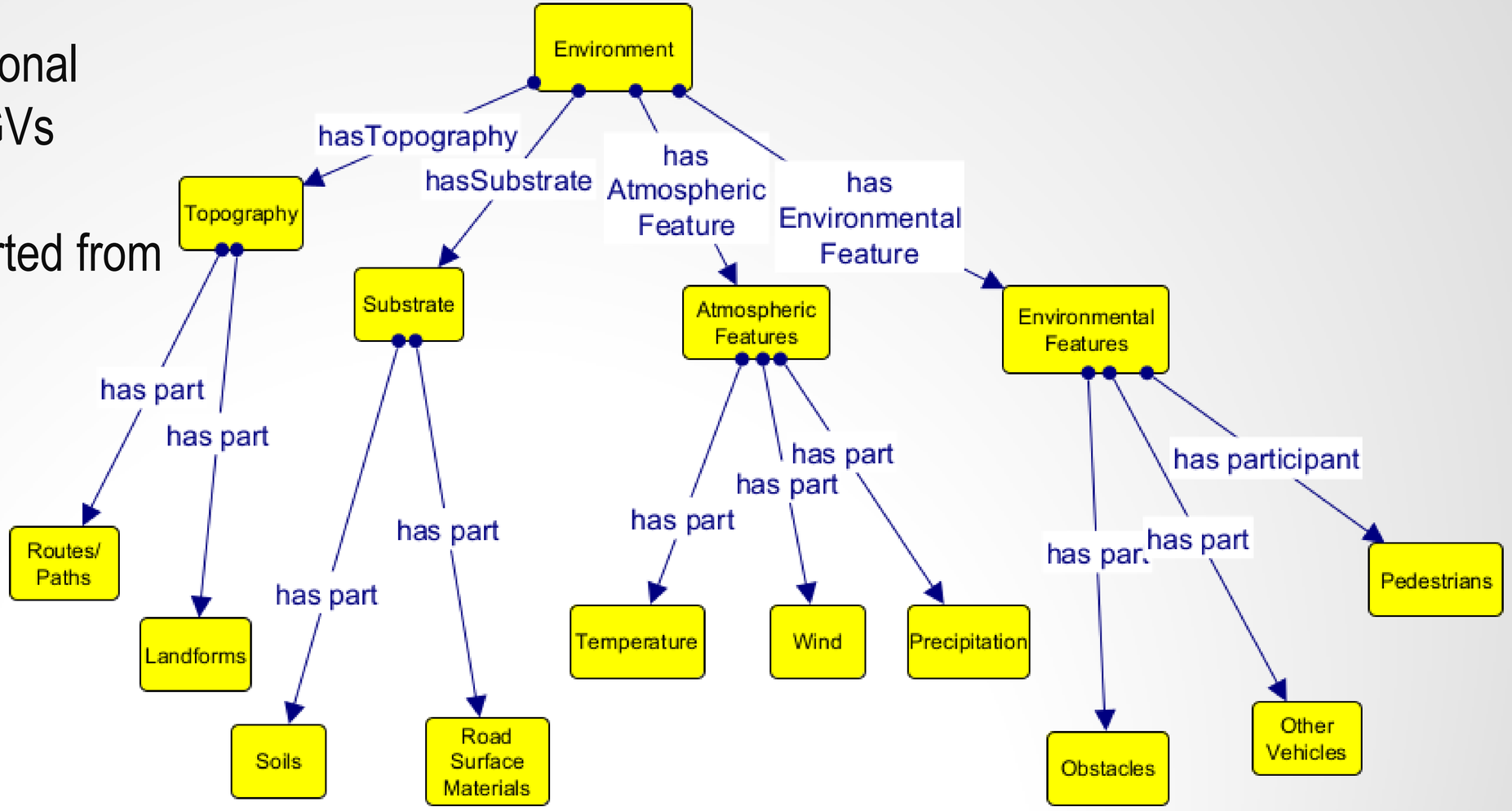
Series Hybrid Representation

- Series hybrid example
- Object properties established in VehArch:
  - ‘physicallyConnectsWith’
  - ‘bearsConnectionPortType’
  - ‘hasSubsystem-SubsystemConnection



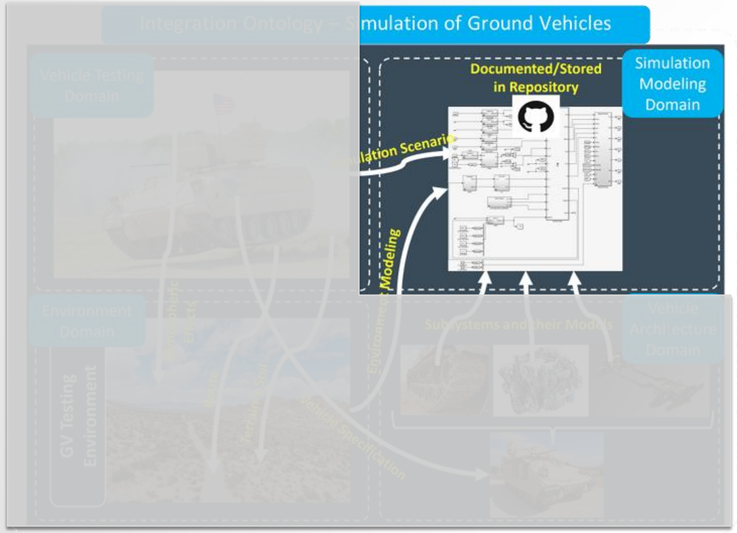
Environment Ontology (Env)

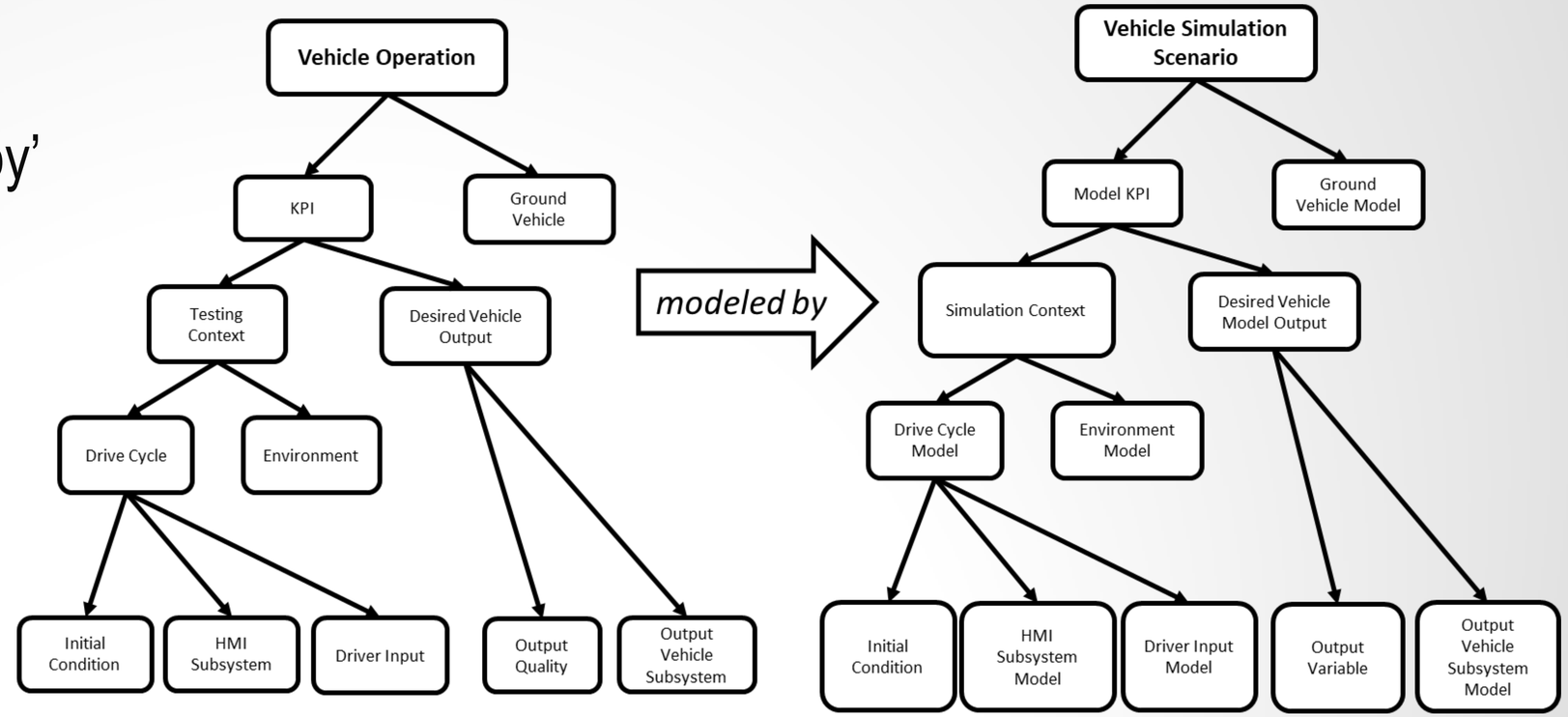
- Expresses operational environments of GVs
- J3049[10]
- Some terms imported from EnvO [11]



Simulation Modeling Ontology (SimMod)

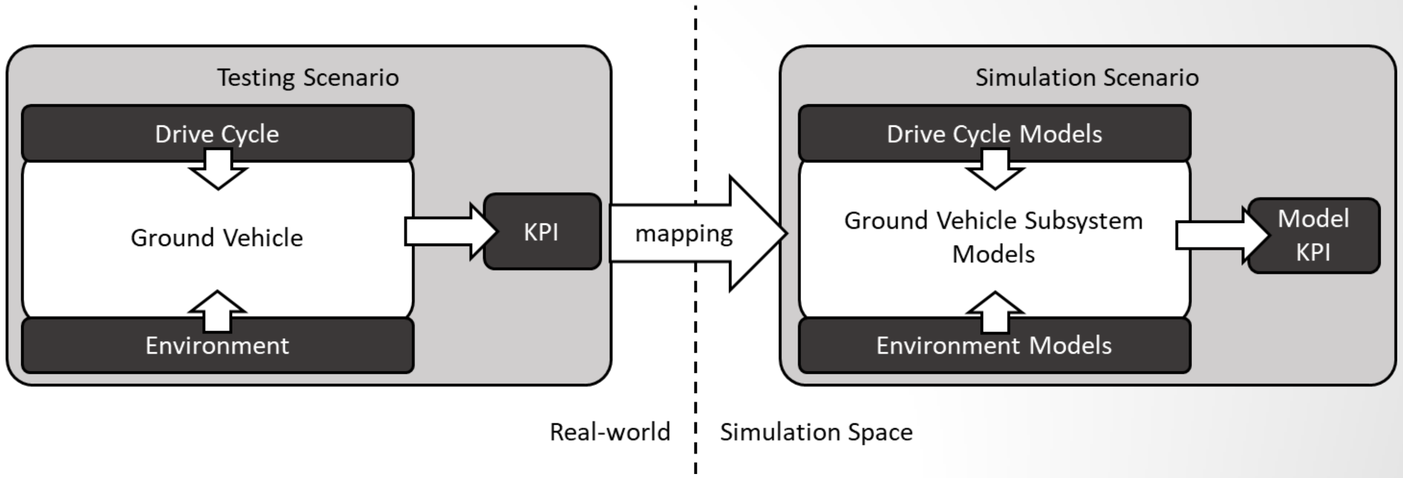
- VehOps scenario decomposition maps to the simulation scenario decomposition
  - ‘models’ and ‘modeled by’ object properties





Integration Ontology (Int)

- Brokers connections between the domain ontologies
- Workspace for documenting instances and examples
- Single file for merging and deploying the ontology in the Model Library



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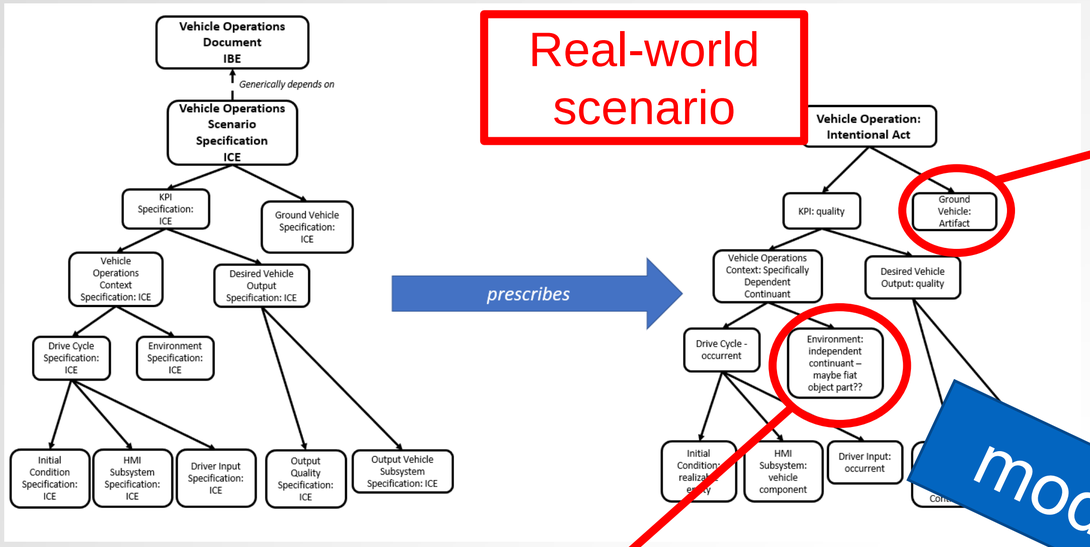
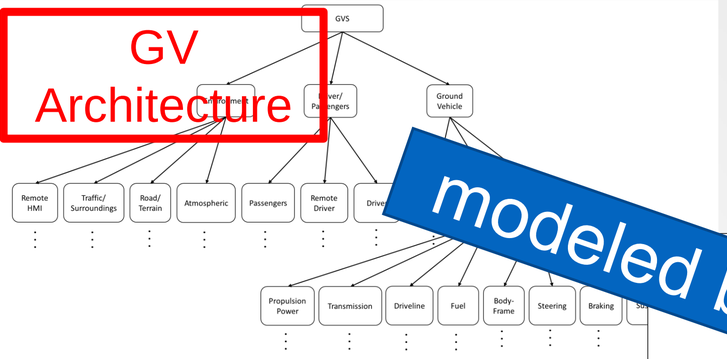


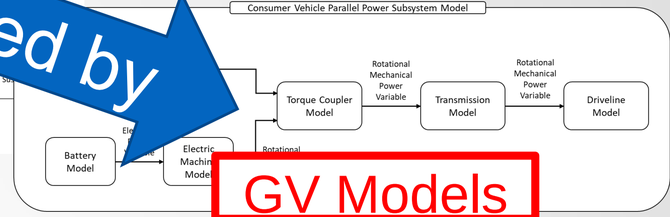
Real-world scenario

prescribes

GV Architecture



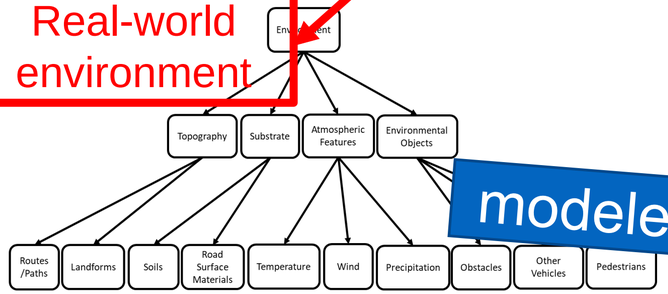
modeled by



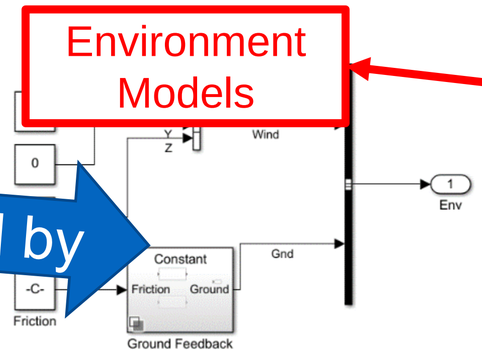
GV Models

modeled by

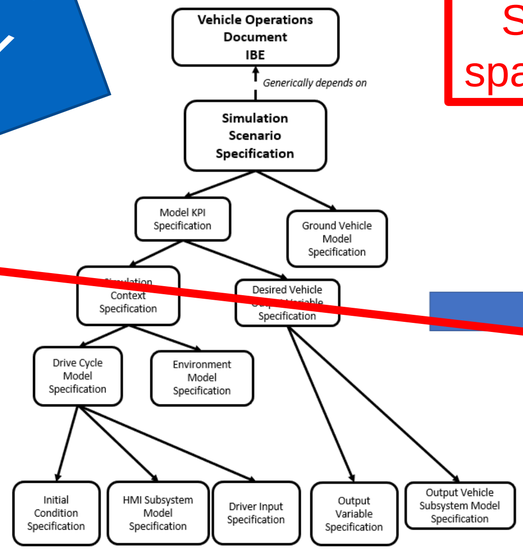
Real-world environment



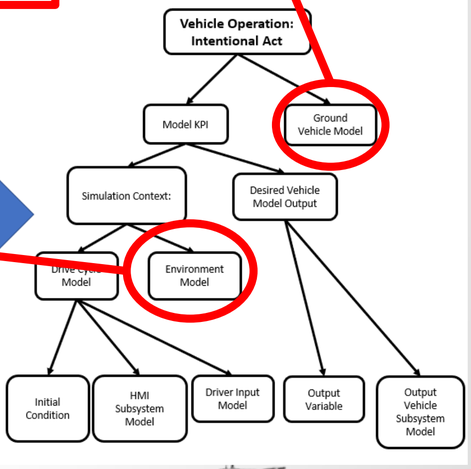
Environment Models



Simulation-space scenario

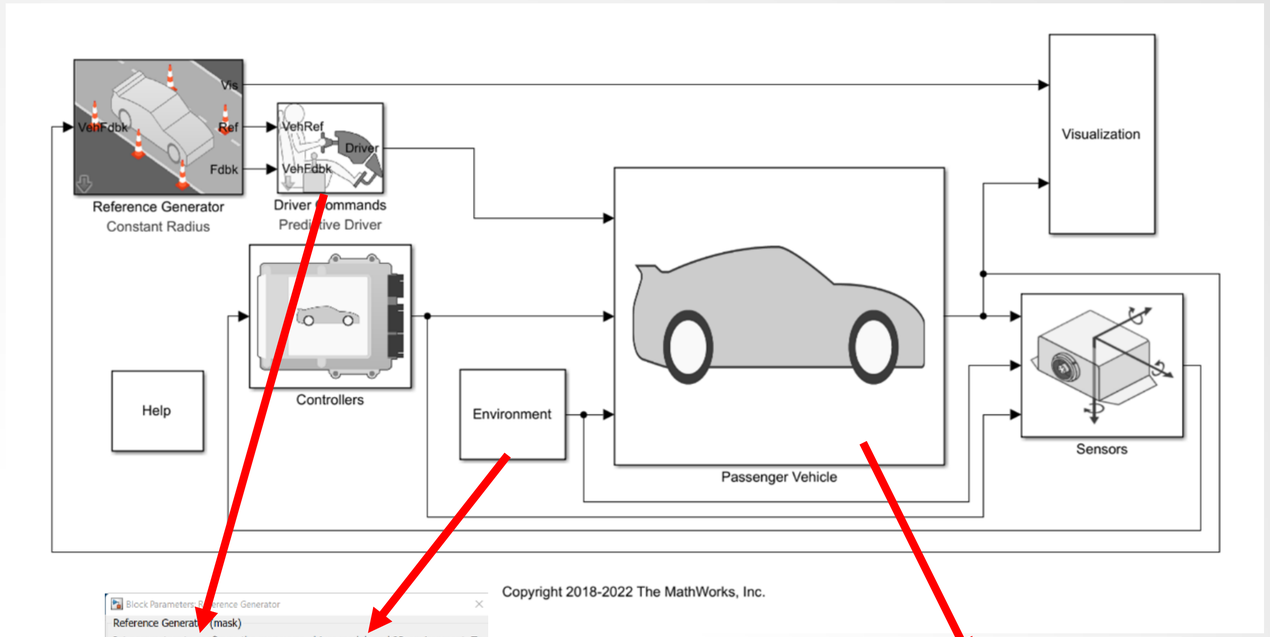


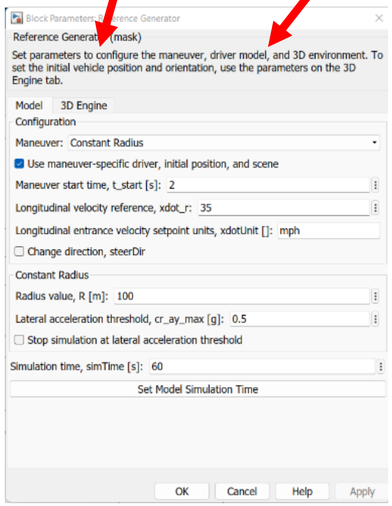
prescribes

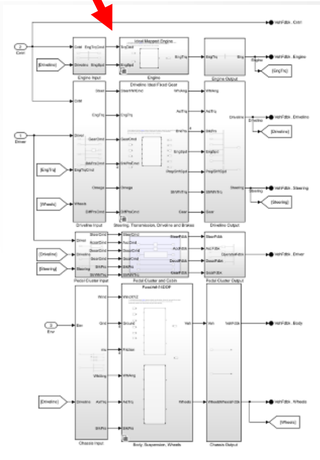


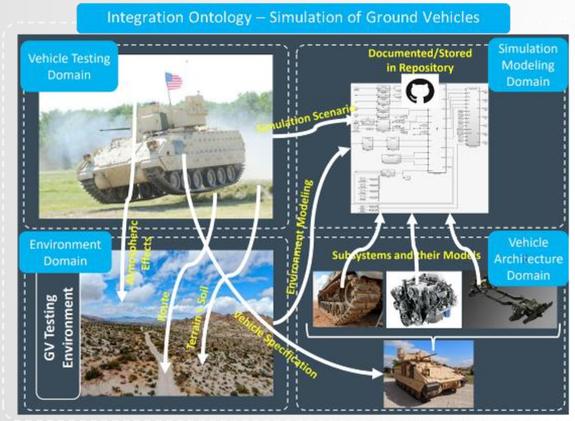
Example (Model and Scenario)

- SAE J266 [12]
- Simulink Vehicle Dynamics Toolbox [13]









Example – Ontology Representation

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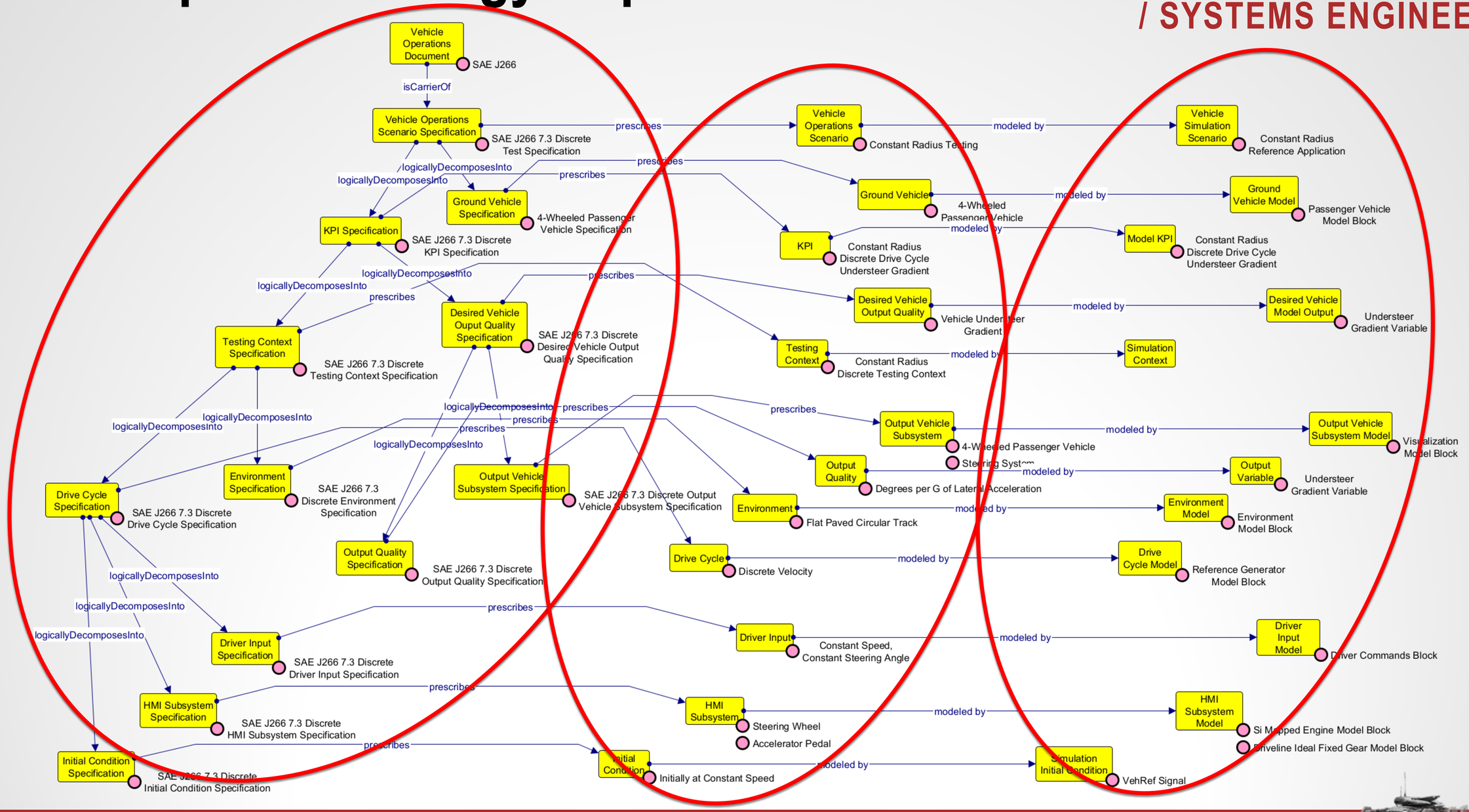

Future Work

- Semantic, set-based querying with SQWRL
- Integration within a model repository
- Deployable application

Accessing GVSMO

- Author contacts
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- GVSMO GitHub (github.com/gregmocko/GVSModelOntology)
  - Merged Ontology
  - Individual Domain Ontologies
  - Queries
  - Documentation

Acknowledgement

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