SAND2019-11391PE

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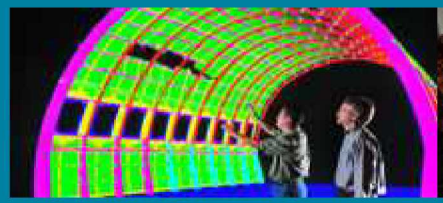
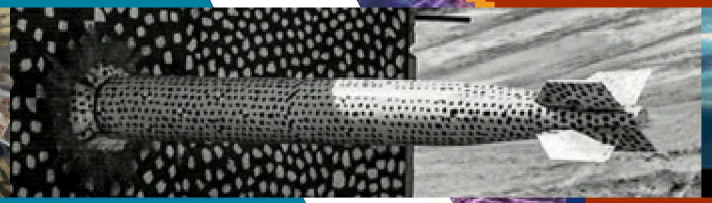
# Stockpile Responsiveness Program: Model Interoperability/Credibility








SANDIA NATIONAL LABORATORIES

Ed Carroll (PI), John McCloud, Carlos Tafoya, Pete Chandler, Jonathan Compton, Cengiz Akinli(GT), Alicia Sudol(GT), Jason Jarosz, Sebastian Quimbay, Will McLendon

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# Model Credibility

## 1) Accelerating Development and Insertion: Enable Engineering Models to Interoperate
## 2) Accelerating Qualification: Assess Engineering Models as Credible Source of Truth

### Problem To Solve

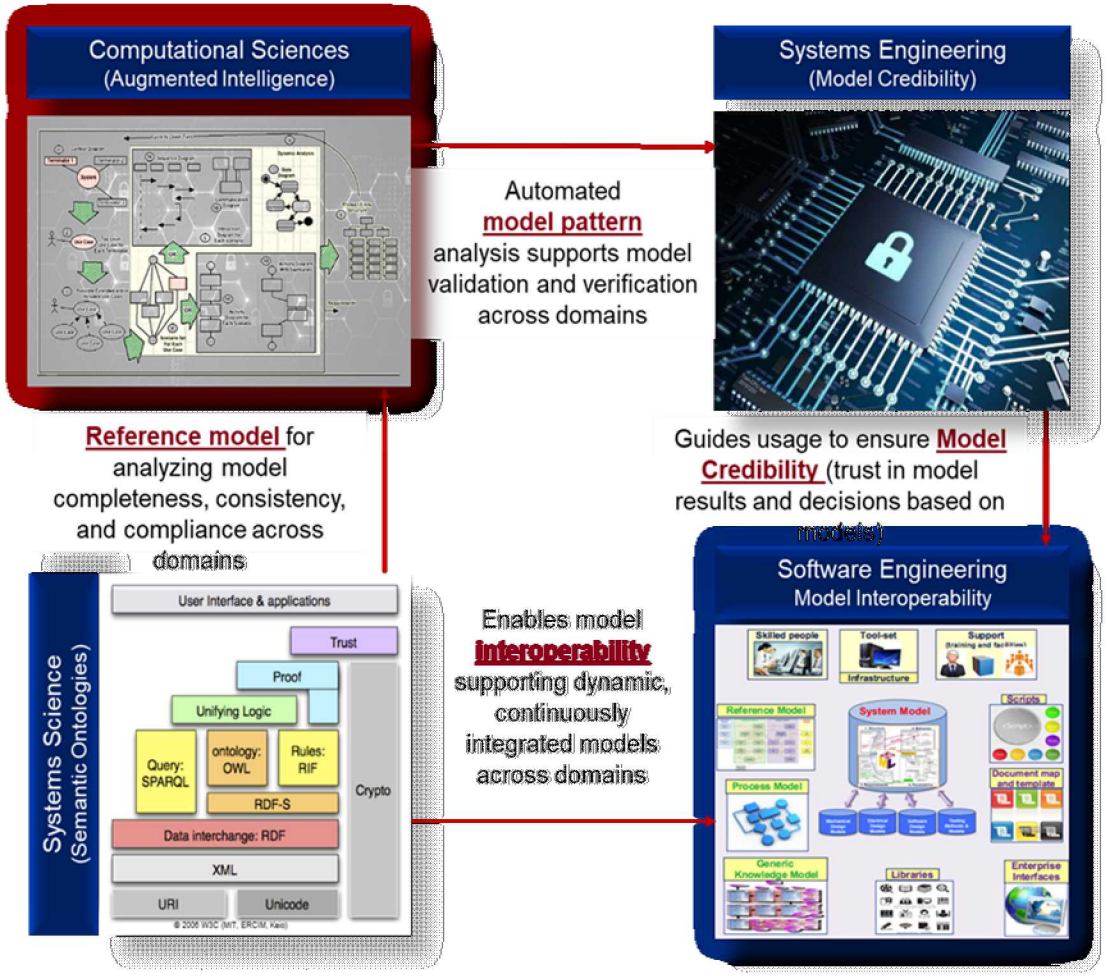
- Engineering designs are developed in stove-piped separation from other designs and design issues. Little to no design reuse.
- To shorten development time, we need to reuse designs, collaborate and integrate between design domains
- Addressing an agile and adaptable weapon configuration


### Approach

1. Extract/Discover the model ontology
2. Transform models between tools
3. Leverage NLP and graph theory
4. Apply AI to assess models as credible

### Solution

*Interoperable models assessed as credible*

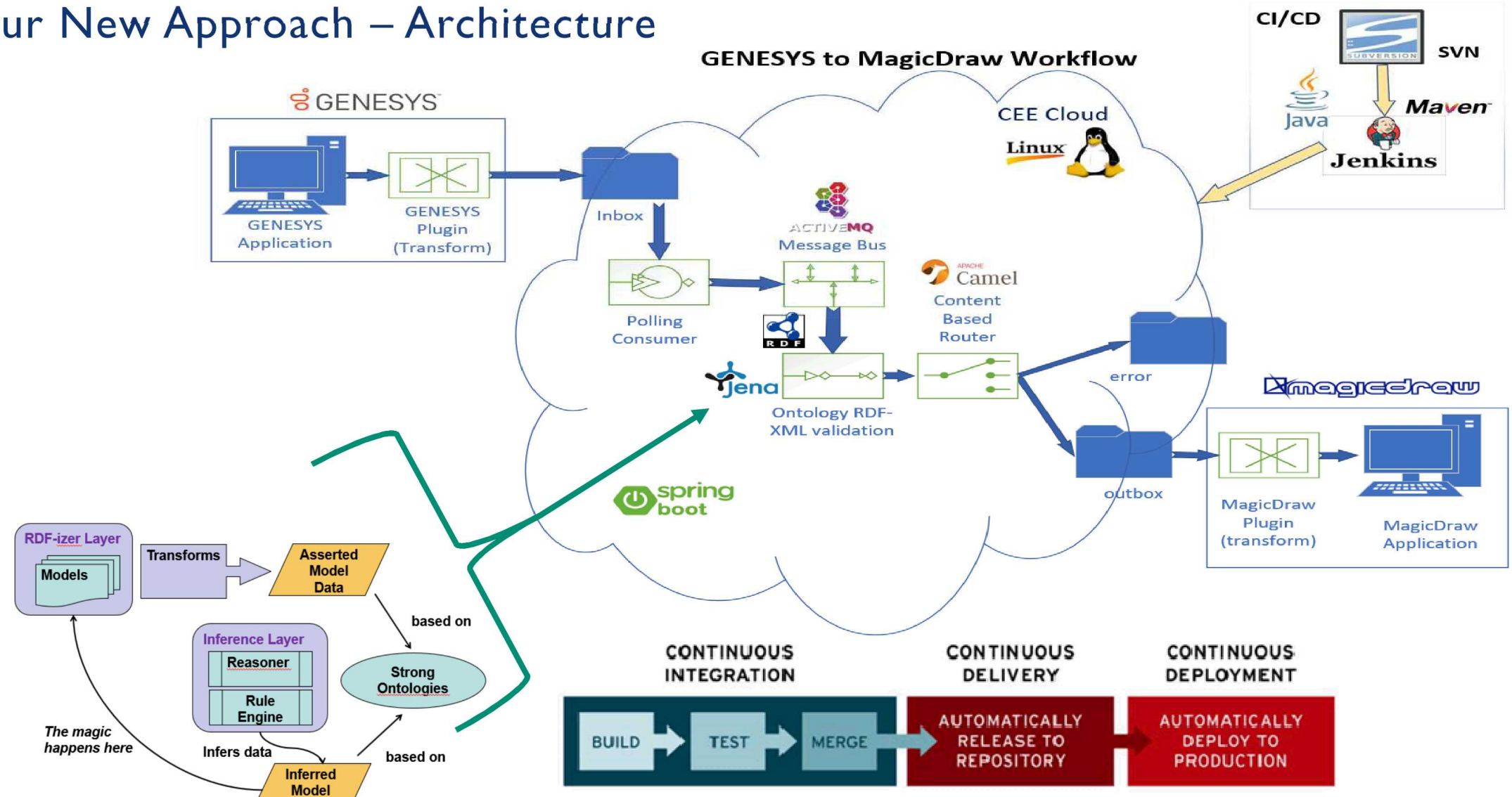



*FY19: Demonstrate SE and Sim model interoperability approach; Lay initial model credibility VVUQ*
*FY20: Leverage to complex SE/SIM/MCAD model interoperability; Demonstrate AI model assessment*

# Model Credibility



## Our New Approach – Architecture








Not your typical science project. When it is time to scale up the development team, we are ready with standards, patterns, and best of breed tooling

# Model Credibility

## Our DEMO

☺Happy path (ontology reasoning passed)

- Export the models, from GENESYS (in RDF) to file system.
- Bus picks it up and sends it to the reasoner for analysis.
- **Reasoner gives the thumbs-up**
- The Bus sends the results to the file system's import directory.
- MagicDraw imports the RDF (preserving instances and relationships).

☹Negative path (ontology reasoning failed)

- Modify the models, to an invalid state (counter intuitive case)
- Export the modified models from GENESYS to file system.
- Bus picks it up and sends it to the reasoner for analysis.
- **Reasoner gives the thumbs-down**
- The Bus sends the results to the file system's error directory.

On 9/16 we demonstrated

- The transformation of two GENESYS models into RDF format
  - Fast Food
  - Hot Shot
- The application of reasoning rules against the RDF version of the GENESYS models
  - Disjoint reasoning rules
  - Incorrect data –
    - We will change a data entry in the GENESYS model itself – resend – then reasoned for the expected error
- Using two reasoners:
  - Pellet – established – implements tableau algorithm to make logical conclusions in subset of FOL (towards logical consistency)
  - SHACL – Applies reasoning rules to the content of the model, assessing model-specific and programmatic constraints
- Inducted the GENESYS RDF output file into MagicDraw
  - And confirmed that 100% of the model was inducted

# Research direction in FY20 – Model Credibility

In a tangential FY19 study (Toward a Corporate SE Ontology) that project:

- Compared the ontology objects from JPL, NASA and DoDAF
- Assembled a list of questions that a Systems Engineer should ask to assess whether a model is credible.
- Analyzed ISO 15288 to identify the objects and relationships of tasks and activities.
- Conducted preliminary research on the use of graph theory against an ontology. This is fundamentally obvious, but we are searching for ways to expand our reasoning
  - Is the model well formed (OWL 2.0 compliant)?
  - Does the model map to the reference model?
  - Does the model conform to the ontology?
  - Are certain required model objects present?
  - Does the model contain required patterns?

In FY20+ we hope to leverage work from this study to:

- Develop and apply reasoning rules to assess credibility
  - Transform the questions into reasoning rules (using graph theory)
  - Build a library of reasoning rules - does the model:
    - Follow good practice,
    - Fulfill intended use,
    - Describe the real world,
    - …
    - Incorporate VVUQ concepts

**SUMMARY OF MBSE MODEL CREDIBILITY EVALUATION CRITERIA**

| | | |
|---|---|---|
| A | **Compliance (with MBSE good practices and domain standard ontology)** | |
| | CRITERION DESCRIPTION: the model properly and fully conforms to the good practices and established guidelines for implementing MBSE models. There are no errors and/or omissions relative to implementing MBSE guidelines, to include properly applied configuration management of the model. The MBSE model should properly employ the standard ontology for the domain of interest and all external data should be entered into the proper ontology elements. | |
| B | **Accuracy (ability to accurately and effectively fulfill the intended use of the model)** | |
| | CRITERION DESCRIPTION: the model must be able to answer the questions that are put to it; note that these questions should be defined up front and should drive the design and development of the MBSE model. The model must be properly structured to answer the questions and should contain sufficient information to produce the answers. | |
| C | **Correctness (how well the model describes the real world system)** | |
| | CRITERION DESCRIPTION: the model must properly and fully represent the real world system of interest, including the composition of the system, the behaviors of the system, and the critical characteristics for employment of the system. A correct model can be used in lieu of the real system to answer questions of interest, to include questions of the appropriateness of the system design for the real world system's real world mission. | |
| D | **Completeness (maturity of the model in the context of the program developing the model)** | |
| | CRITERION DESCRIPTION: Is the model's maturity sufficient for the current stage of the system lifecycle (including content reviews and configuration management)? Are the contents of the model sufficient to accomplish the intended use of the model and the intended use of the system being modeled? | |
| E | **Testability (ability of the model to participate in testing the design)** | |
| | CRITERION DESCRIPTION: the architecture model should serve as a key element of design for testability and test first/test exploration. One aspect of this is that the model itself should be part of "testing" by providing behavior representations that are executable. Another aspect is that the model shall provide useful guidance to other test first/test exploration of design options (such as identifying test exploration of unknown aspects of the architecture/design) | |
| F | **Reusability (reuse of previous models in the current model + ability to reuse current models elements)** | |
| | CRITERION DESCRIPTION: the model should be built from elements reused from previous models and should provide elements to a library for reuse. The model should display the patterns appropriate to the domain of the system. | |

# *Collaboration Questions:*

- ***How might we collaborate:***
  - How do we affect a cultural transformation to MBE?
  - What are your ideas on how to turn human-based assessment questions into AI reasoning rules?
- ***For complex engineering models of national security systems***
- ***So that models can be assessed as the "credible" source of truth***

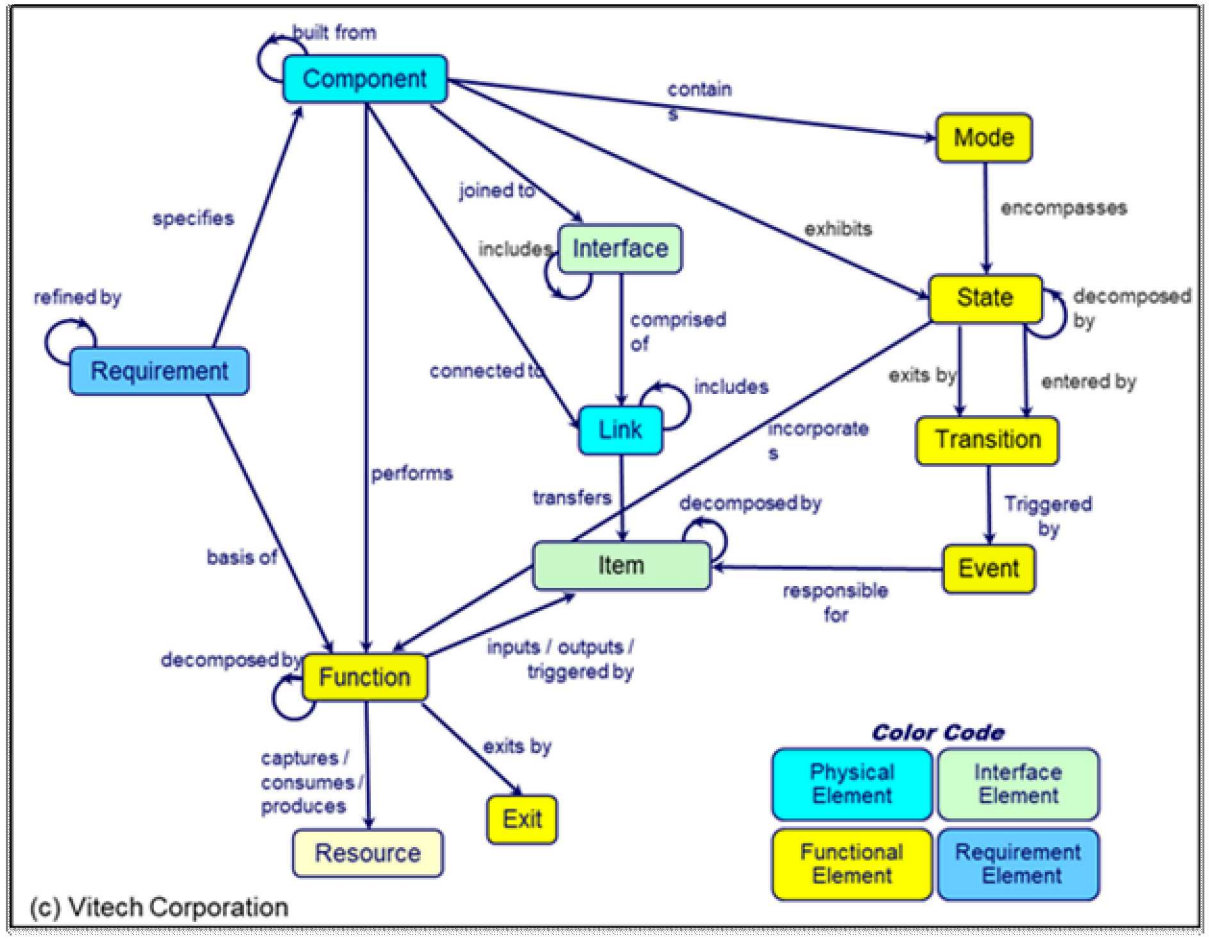
# Model Credibility/Why Ontologies?



## Our approach retains the ontological structure of the model

Traditional databases do not retain the integrity of an ontological structure

- So, first we output the model to a Resource Description Framework (RDF) format




Then we use canonical rules to validate that the model output (now in RDF format) is well formed

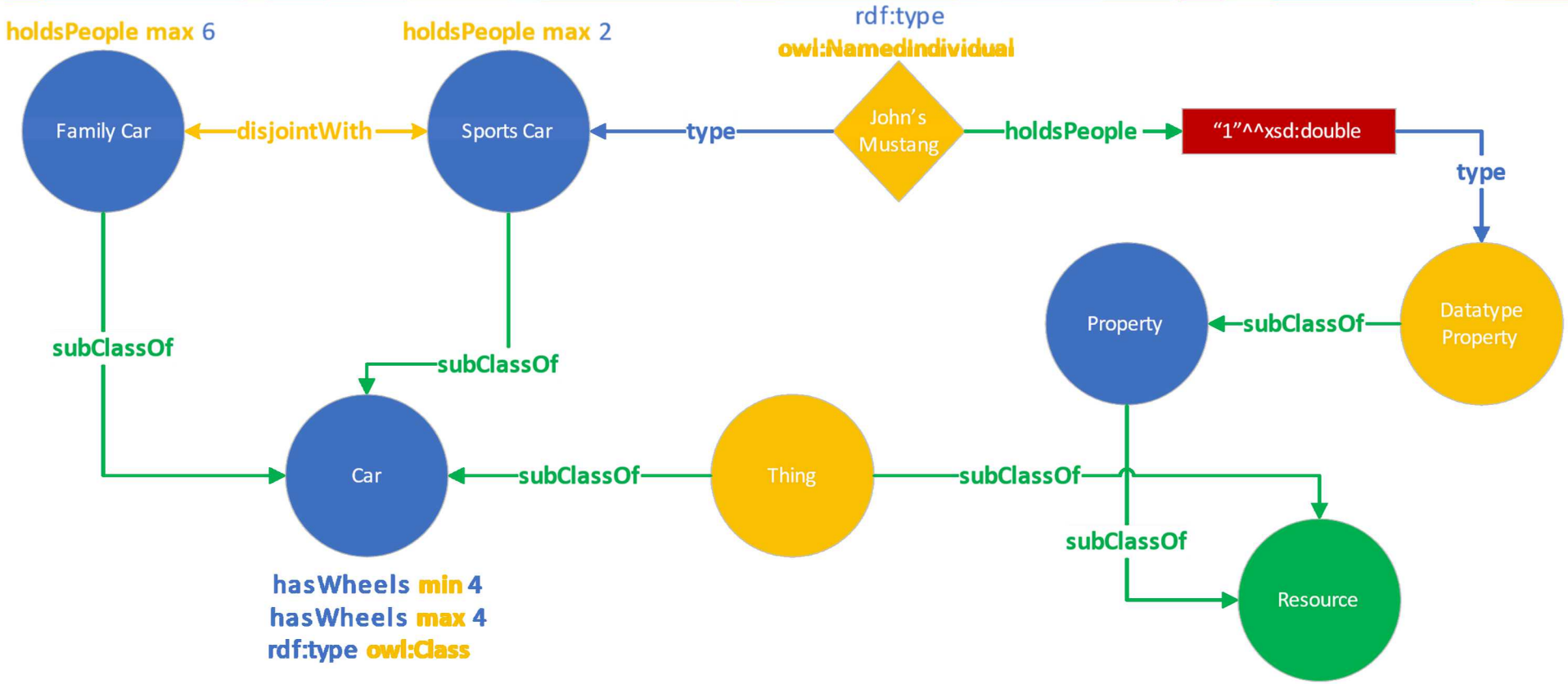
- For our demonstration, we are taking advantage of the already well formed ontology in GENESYS
- We apply reasoning rules to ensure logical consistency, as well as to ensure our programmatic and systems modeling requirements are met.

Component - built_from - Component
Component - connected_to - Link
Component - documented_by - Document
Component - joined_to - Interface
Component - performs - Function
Component - provided_by - Organization
Environment - experienced_during - Phase
Function - ouputs - Item
Function - triggered_by - Item
Link - connects_to - Component
Product - triggers - Program Activity

A standard ontologically well formed canonical reference model provides the foundational structure for object mapping and comparison

# Model Credibility/Why Ontologies?





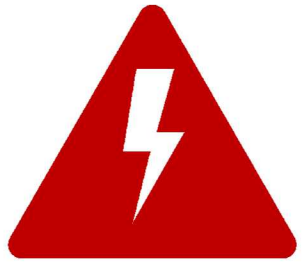


Creates set-theoretic constructions and equivalency relationships. Allows for logical reasoning under subset of First Order Logic

Establishes parent-child relationships, valid domains and ranges for predicates, datatypes, and a base type for classes.

Organizes data as a relational graph consisting of subject-predicate-object triples. Also establishes "types" of things.

# Model Credibility/Why Ontologies?

**Semantic Disconnect**

Same words; same data types.
Meaning different things.


**An Ontology recognizes this semantic disconnect.**
**An Ontology knows that these two separate meanings are not equivalent.**

**What he said!**

**Low-Traffic Roads** Any road with < 5,000 cars a day
**Safety Harness:** Any suspension system with belts having 5-points or more

**What he Understood!**

**Low-Traffic Road:** Any road that is not a highway
**Safety Harness:** Any harness with 3-points or more