

Insight to Diverse Information using Graphs and Ontologies

steve.vestal@galois.com

ed.sandberg@galois.com



Customer: NASA Ames & JPL

Budget: \$750K

PoP: May 2022 – May 2024

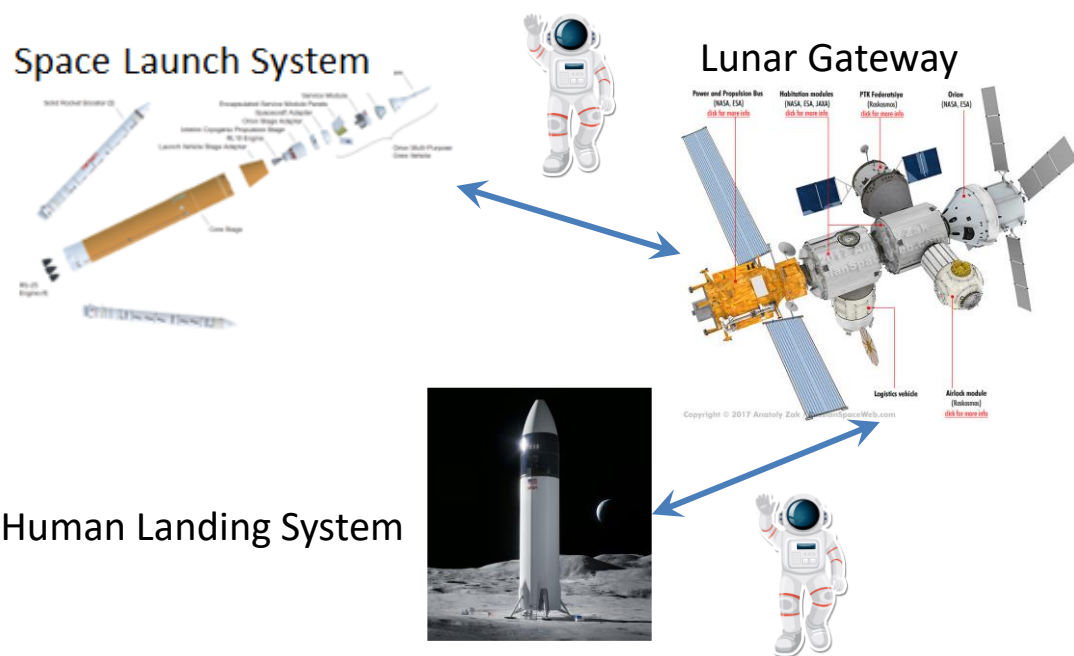
Teammate: Kansas State University

Purpose

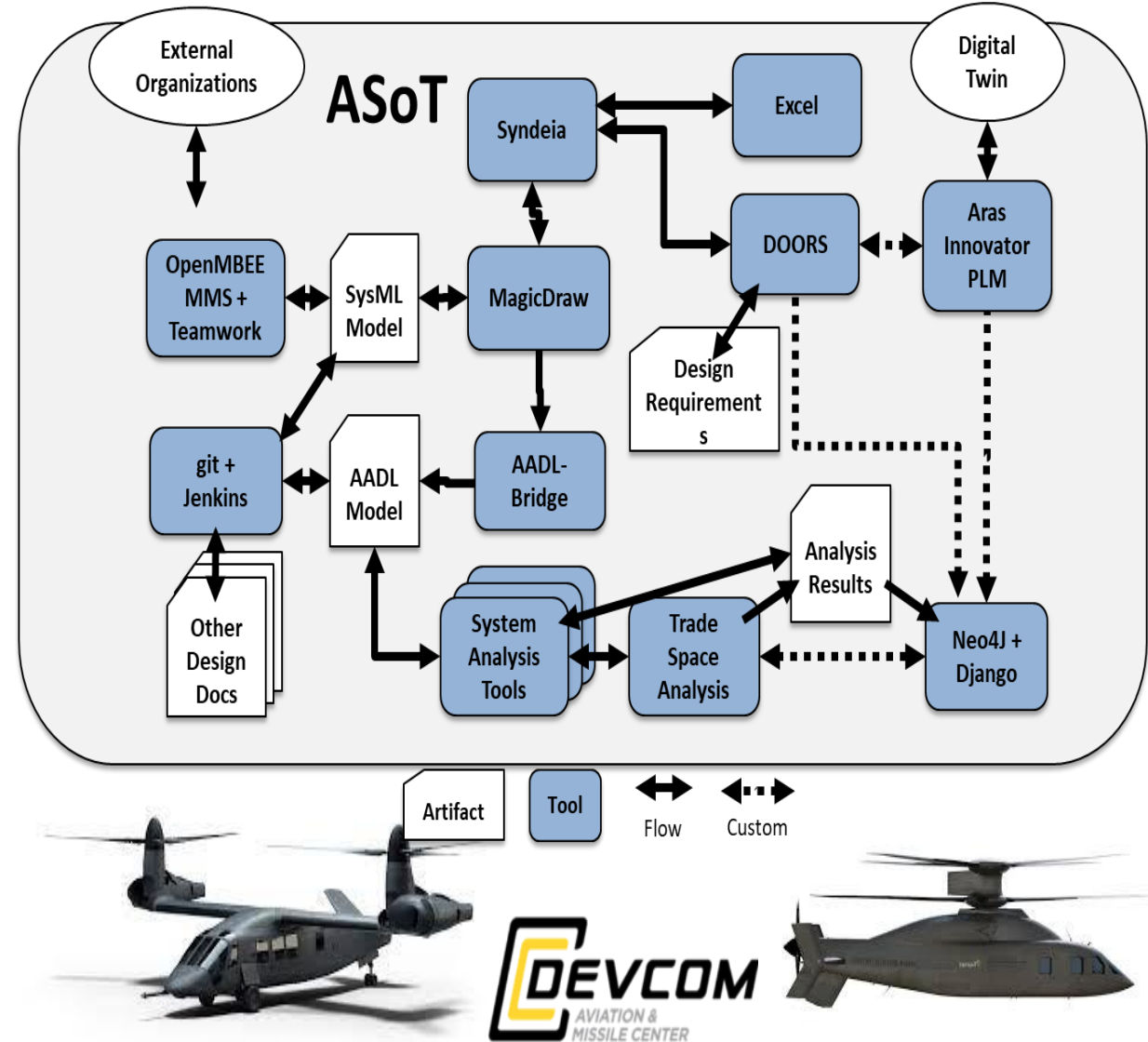
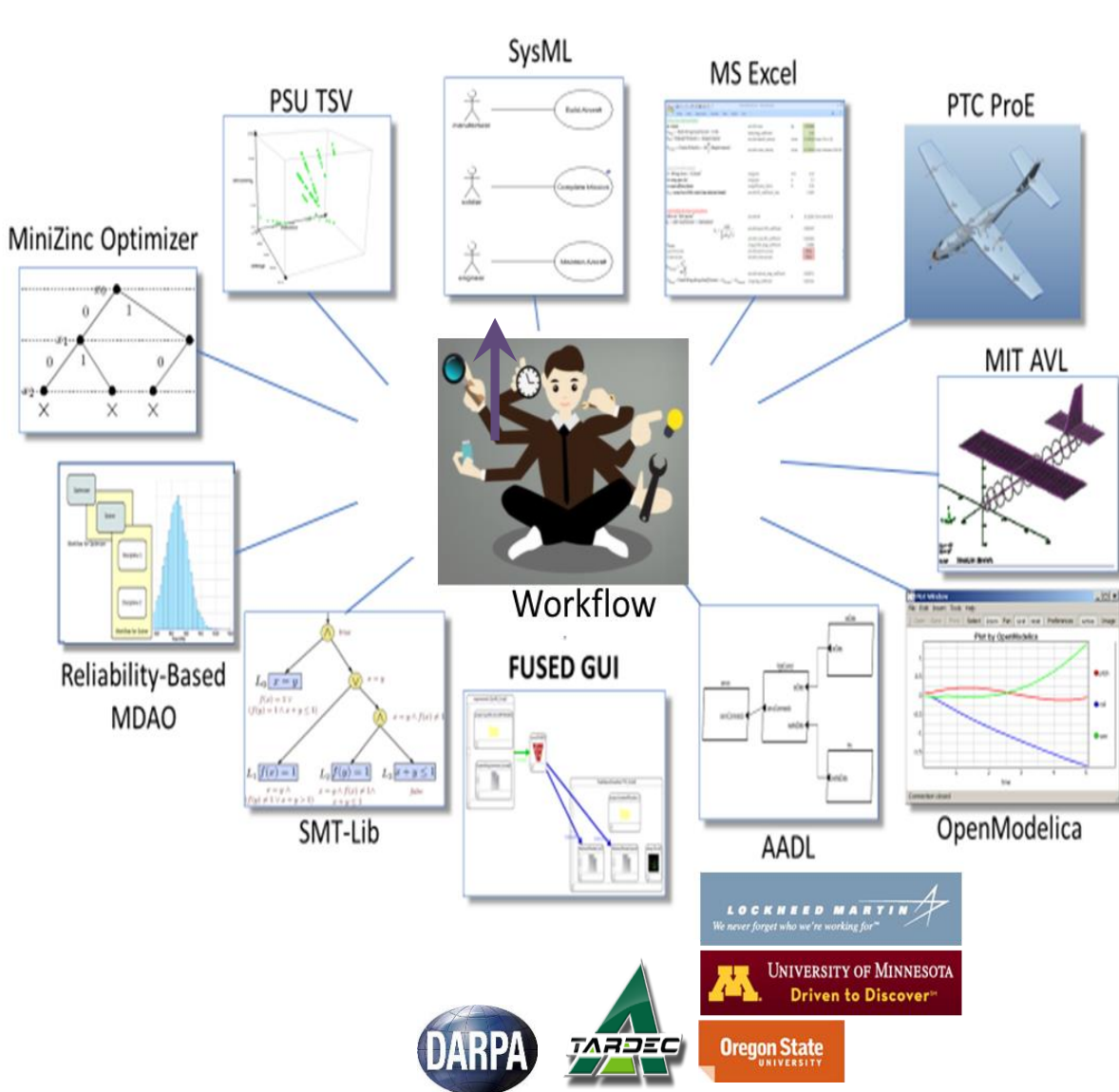
Improve design process for complex systems that satisfy requirements from multiple stakeholders. Help different stakeholders find and understand the information they need to accomplish their task from a distributed set of diverse models.

Challenges

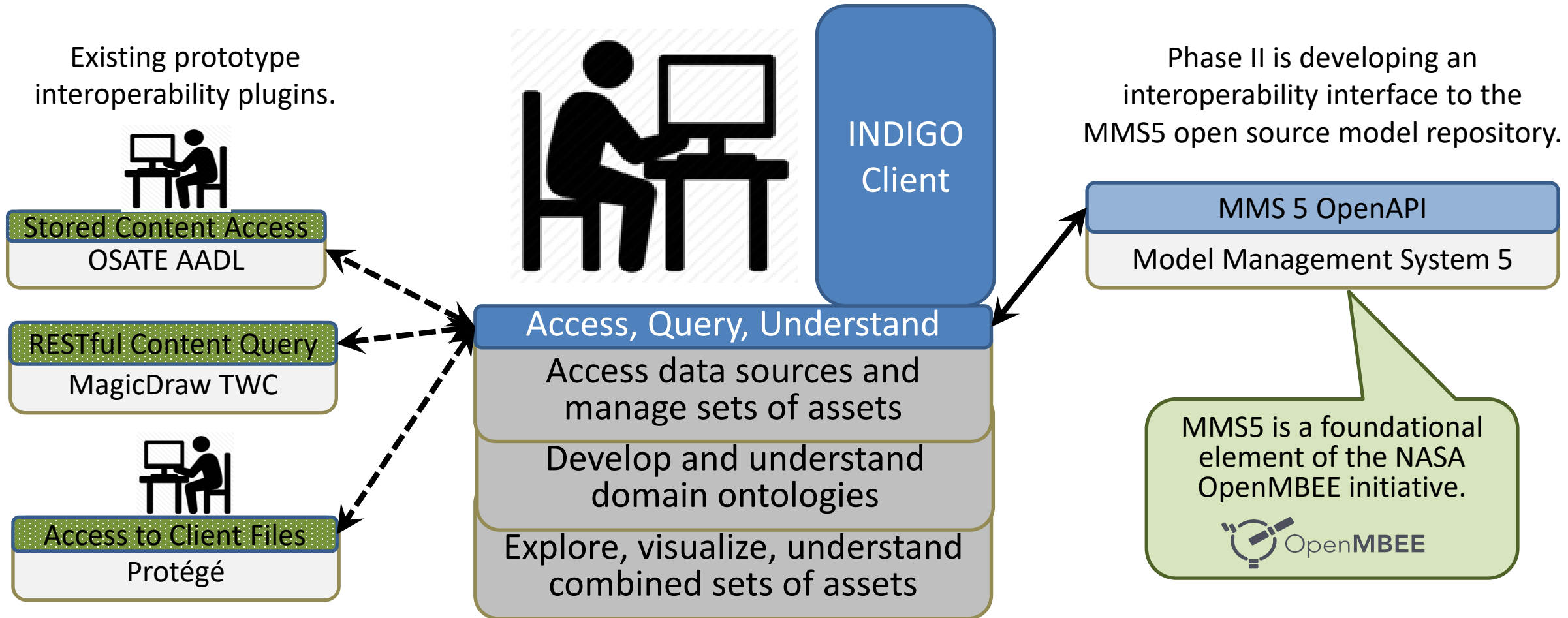
- Stakeholders have different fields of expertise
- Multiple, diverse modeling languages and tools
- Multiple viewpoints and workflows
- Overlapping information in multiple models
- Multiple remote sources of models
- Distributed information ownership & control
- Read-only access to models that use supplier guidelines



Challenges that Motivated & Informed INDIGO



INDIGO Searches and Visualizes Information from Multiple Sources and Viewpoints



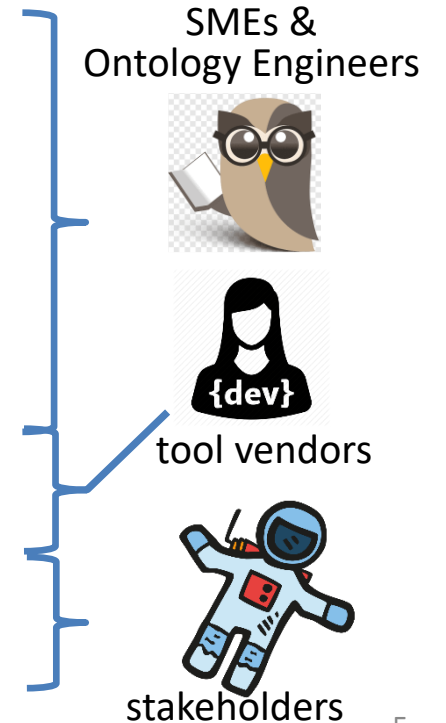
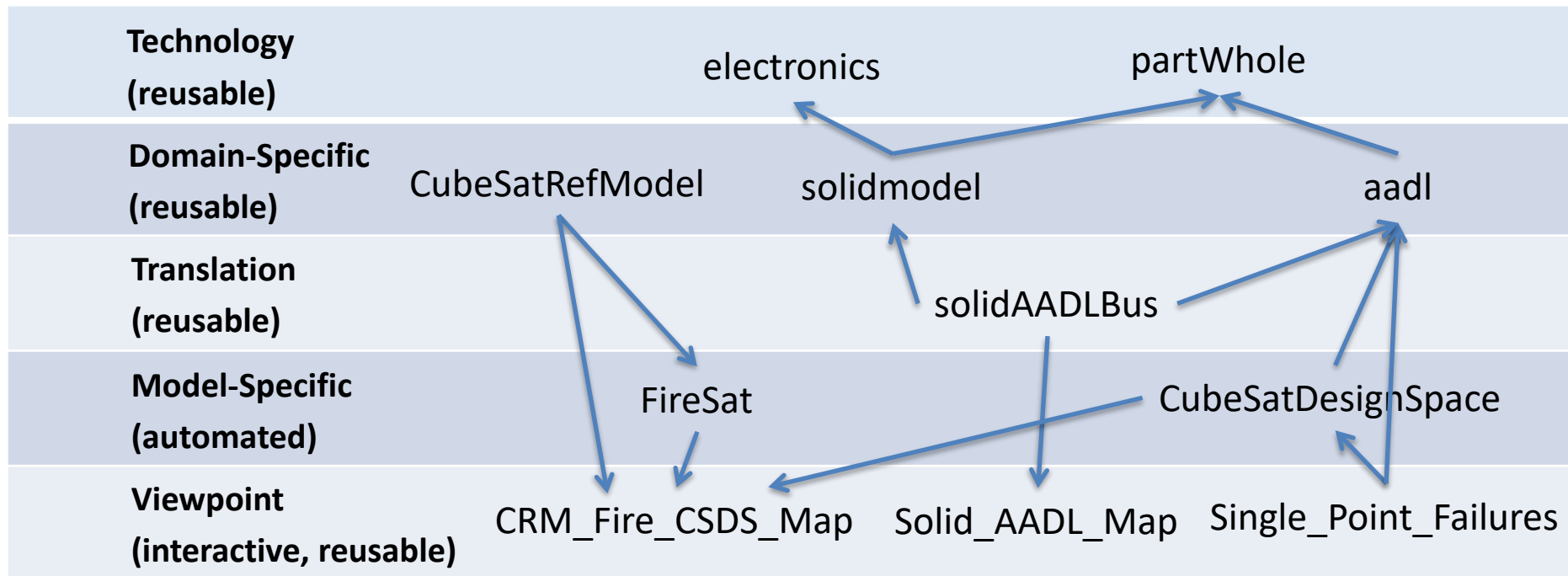
INDIGO Technical Innovations

- **Formal ontologies based on description logic** provide greater flexibility and enable automated reasoning, e.g., infer relationships between models, find data using familiar stakeholder terminology. *Conventional type systems have limited power for multiple viewpoints for multiple stakeholders and engineering domains.*
- **Integration of description logic and graph patterns**, an extension of OWL2 called FHOWL. *Conventional description logics have limited power to definitively specify complex structures (the tree model property), e.g., cannot specify equations whose value properties come from multiple elements.*
- **Modular ontology capabilities** allow users to combine ontologies and knowledge bases in unplanned ways. *Standard OWL import does not fully support automated closure of complex import patterns or planned bridging between semantic worlds.*

Ontologies for Multiple Domains and Sources

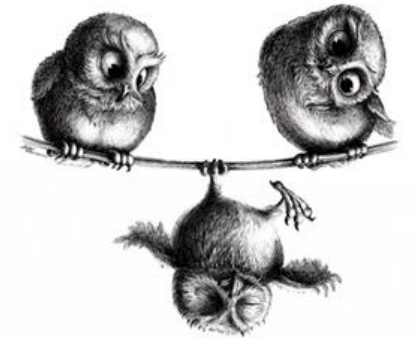
INDIGO describes and requests information using terms defined in formal ontologies.

- structured natural language definitions and queries
- literate ontology format that interleaves formal definitions with HTML
- user selection of ontologies that define familiar terms
- query with automated reasoning and pattern matching
- automated translations between domain terminologies
- interactive, automated generation of diagrams



Demonstrations

- INDIGO views for phases of use
 - Locating, accessing, and organizing models and domain ontologies
 - *Ontology Browser, Ontology Manager, Project Explorer*
 - Exploring and viewing sets of models from multiple viewpoints
 - *Model Explorers, interactive query/selection viewpoints*
 - Developing and using domain ontologies in literate formats
 - *FHOWL Editor*
- Scenarios
 - Access models from Model Management System 5
 - Understand relations between three models from three vendors
 - *CubeSat Reference Model (SysML), FireSat (SysML), CubeSat tradespace (AADL)*
 - Develop & apply a library of validation (bug-finder) patterns
 - *Redundant Network model (AADL)*
 - Translate & map between different engineering domains
 - *Air Vehicle Enclosure (AADL) <-> Air Vehicle (mock solid)*



OpenMDK Concept and Community Benefits

Transition from folders of files of text to graphs with semantics is a game-changer.

- Can't effectively manage Excel, mdzip, etc., models using git, svn, etc.

Domain ontologies are used in many fields, e.g., MBE, bioinformatics, cheminformatics

- Schema ontologies based on language specifications significantly improve interoperability & digital threads

Configuration management standards build on the foundational RDF, e.g.,

- Identify copies of evolving models (OWL ontology IRI/XML namespace, version IRIs)
- Dependencies of a model on other models (OWL import)
- Datatypes (XML)

Proposed OpenMDK project

- OpenMDK specification to be used by modeling apps; includes MMS 5 OpenAPI
- Open source framework to easily create OpenMDKs for legacy tools (build on xml2owl, ecore2rdf, reqIF2owl, ...)
- Initial critical-mass set of high-priority OpenMDKs