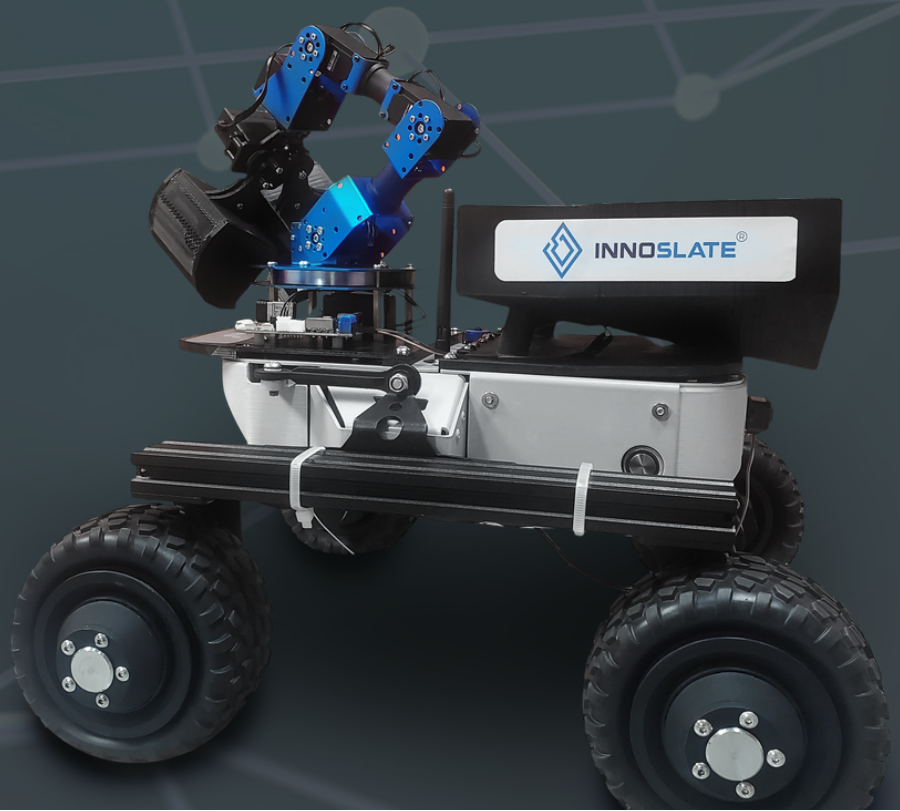
SPEC INNOVATIONS

THE INNOSLATE APPROACH TO DIGITAL ENGINEERING



WHO WE ARE

Systems and Proposal Engineering Company, dba SPEC Innovations was founded in 1993. The company has worked on significant architecture and systems engineering projects for the DoD, DOE, and other government and commercial organizations. Learn more at www.specinnovations.com. We began the development of Innoslate in 2010 when we found it challenging to do the work we needed to do with the limited tools available at the time. Innoslate was first released in 2012 and is currently in version 4.0 as a full lifecycle tool, with integrated Systems Engineering and Program Management capabilities. It uses the open standard, Lifecycle Modeling Language (LML), as its open ontology. It currently supports users around the world. Innoslate is also available on NIPRNET, SIPRNET, and C2S, as well as behind your own firewalls. You can learn more about Innoslate by going to our website, www.innoslate.com.

OUR APPROACH TO DIGITAL ENGINEERING

SPEC Innovations takes a unique approach to digital engineering (DE). We began by developing a seamless product, Innoslate, that spans all aspects of systems engineering and program management. We call that "horizontal integration." This approach has provided a domain-independent way to optimize cost, schedule, and performance, while mitigating risk throughout the product lifecycle for systems of systems.

Our next step in digital engineering provides interoperability from the systems engineering domain to the design engineering domains throughout the lifecycle. We call this "vertical integration." To accurately perform this vertical integration we need to identify the information needed by each design engineering modeling tool and the output from each of these tools.

We should be able to provide the specific inputs required using Innoslate/LML's ontology with limited extensions. Most of the values for these inputs can be captured as Characteristics or Measures and then provided directly to the tool. We have done this as an example with LabView for a hardware-in-the-loop (HWIL) demonstration using a hardware mockup of a CubeSAT.

We should also identify the specific outputs from each tool to identify how they affect the decision making process at the higher levels. This output from the design engineering tools may take the form of a curve or distribution that affect the overall mission/system level simulation developed in Innoslate. An example of that would be to use a high fidelity simulation, such as Riverbed (formerly OPNET), to characterize the latency and capacity of a

network. These limitations would then be used in the Innoslate simulator to assess the impact of these potential delays on the overall mission or system performance using Innoslate's simulators.

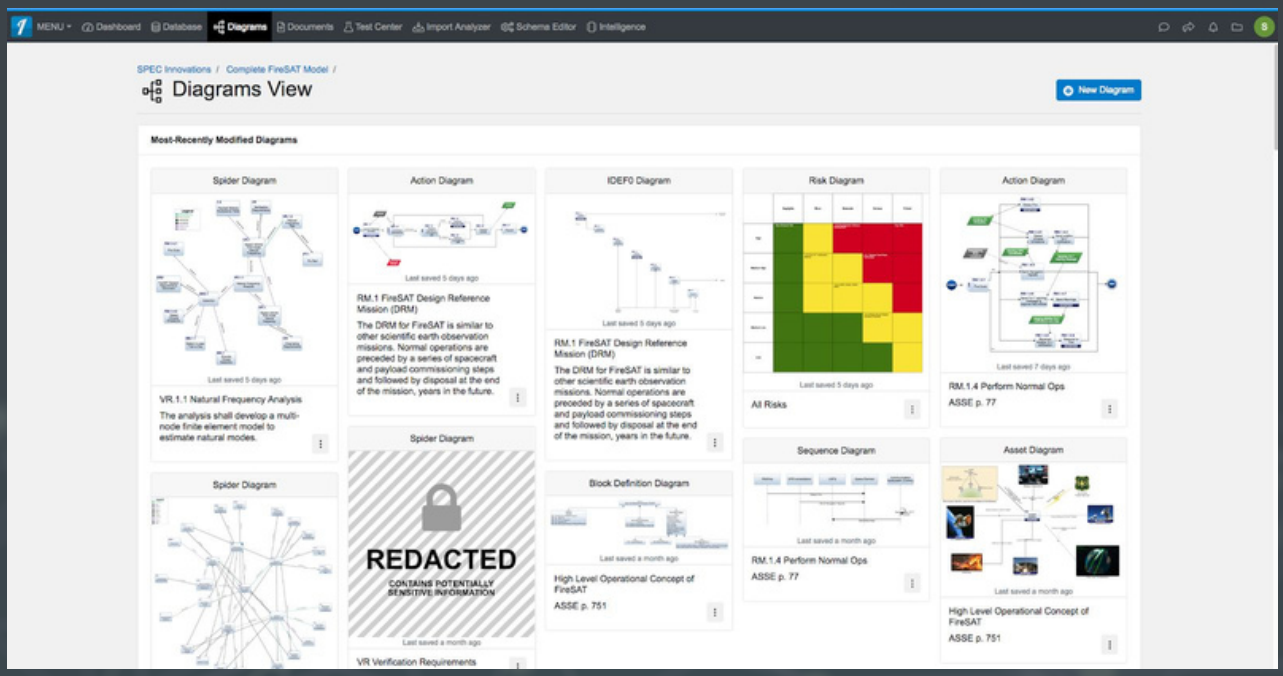
Note that in the cases above, there was no reason to directly interface through file transfers or APIs the information. In fact having an "air gap" allows for a more complete analysis of the detailed models before "feeding" the mission/system simulation. We need to make sure any digital engineering solution we develop avoids the famous, "garbage in - garbage out" problem.

INNOSLATE'S DE FEATURES

SPEC Innovations has been following the Digital Thread/Digital Twin initiative by DASD(SE) since its inception. Below shows the Digital Thread Posters presented at the AIAA SciTech Conference in January 2018. These posters has previously been shown at the 2017 NDIA SE Division Conference. We will use the questions from these posters to show the Innoslate approach to Digital Engineering.

INNOSLATE SUPPORTS THE DEVELOPMENT, INTEGRATION, AND/OR CURATION OF MODELS

Innoslate provides modeling capabilities across many languages/frameworks, including SysML, LML, some UML, and some IDEF. It also provides the capability to create documents, with diagrams from the tool embedded in the document and updated as those diagrams are updated.



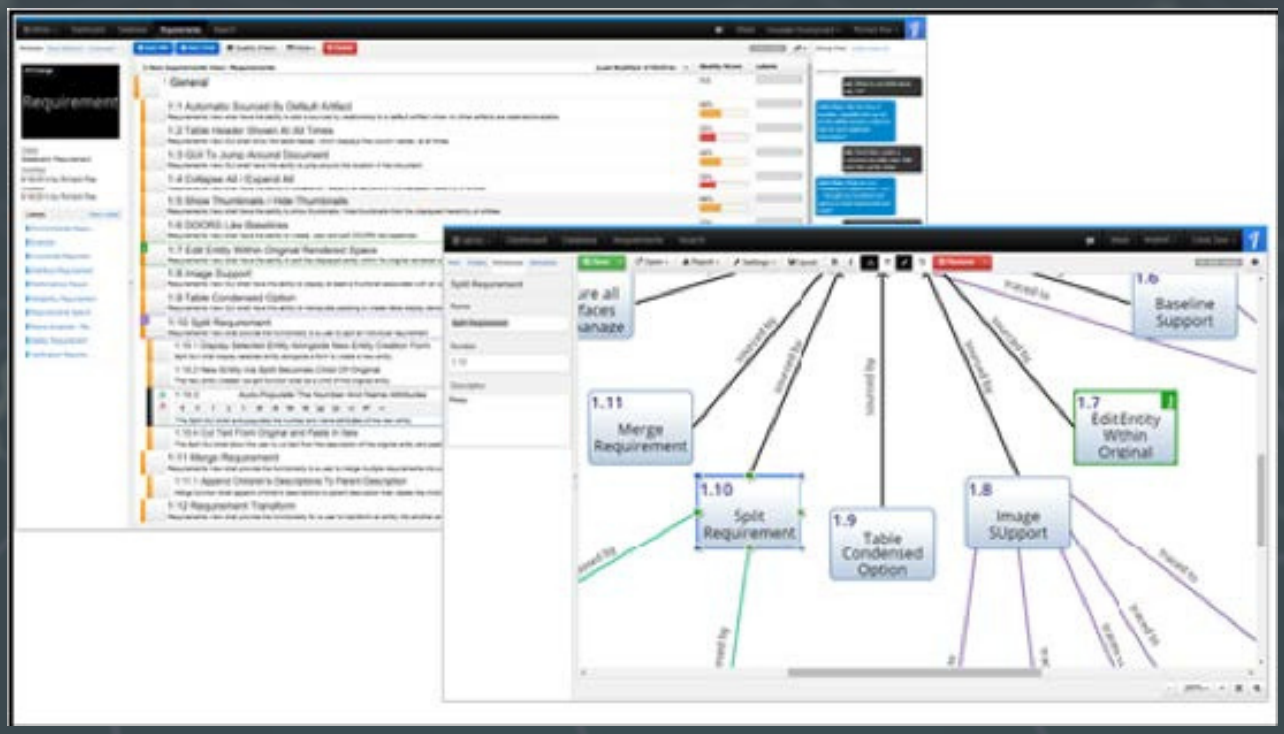
The modeling is done in one or many projects. Models between projects can be shared using the cross-project relationships available within the tool. Import/export of XML is also available.

Curation can be accomplished using Artifacts, Baselining documents, and export of models via XML (which can in turn be uploaded as Artifacts within the database). The information can be tagged using labels and searched for using the complex search capability.

INNOSLATE SUPPORTS THE USE OF MODELS TO COMMUNICATE, COLLABORATE, AND PERFORM MODEL-DRIVEN LIFECYCLE ACTIVITIES

Innoslate® provides a means to author models in one language, such as SysML, and then display the information in other forms (e.g., LML, IDEF, etc.). The use of a common ontology (LML) that has been mapped to other languages (SysML) and Frameworks (DoDAF/DM2, IDEF0), enables this capability. Thus information can be communicated in a form that any stakeholder can understand and assimilate.

Innoslate® was designed as a collaboration tool. All users of a project see the same database at the same time. Real-time indicators show who is looking at what information independent of their view of that information. If an item is changed, a refresh indicator will appear. A built-in Chat (private and group) capability is also available to enable communications between users.



Innoslate's real-time indicators and chat enable collaboration around the world

LML and Innoslate® support the entire lifecycle from concept development through disposal. It contains the capability to conduct program and test planning, CONOPS development, requirements analysis and management, modeling and simulation (discrete event and Monte Carlo), and verification through the Test Center. It also supports program management functions, such as Risk and Issue tracking, WBS development, capturing of decisions, and cost and schedule generation from business processes. Resource modeling and other constraints are also available via the tool. It has been used in every phase of the lifecycle.

INNOSLATE IMPLEMENTS THE AUTHORITATIVE SOURCE OF TRUTH CONCEPT

Since the tool generates the diagrams and other views of the information from the database, it acts as a single source of "truth." Since this database can be virtualized, it can grow as large as the hardware and SQL Server will allow. With cross project relationships and permissions, we can also compartment information as needed.

INNOSLATE SUPPORTS THE USE OF THE AUTHORITATIVE SOURCE OF TRUTH TO PRODUCE DIGITAL ARTIFACTS, SUPPORT REVIEWS, AND INFORM DECISIONS

All artifacts (diagrams, reports, exports) come from the single database, thus all artifacts produced from the tool will represent the state of the information at their time of production.

Model-Based Reviews (MBRs) can be accomplished using the tool's commenting feature (available at the object level and accessible from any diagram or view). MBRs have been performed using the tool for all the NASA milestone reviews. This capability was demonstrated to the NDIA M&S Committee in February 2014.

A Decision entity class is available within the tool to facilitate the decision process, but all facets of the tool help inform decisions, particularly the Requirements Quality Checker and Intelligence Views, which use NLP technology to evaluate the quality of the modeling. The simulators also aid in verifying the processes.

INNOSLATE SUPPORTS THE INFUSION OF TECHNOLOGICAL INNOVATIONS TO ENABLE THE END-TO-END DIGITAL ENTERPRISE

Innoslate® was designed for the application of new technologies and innovations for the digital enterprise. It Innoslate® was designed for the application of new

technologies and innovations for the digital enterprise. It was one of the first systems engineering tools to use cloud computing and a web front-end. Currently, Innoslate® has applied Natural Language Processing (NLP) technology to check the quality of requirements, identify modeling issues (Intelligence View), and assist in the traceability of entities (Traceability Assist and Suspect Assist). With the use of the JavaScript interface, the simulator can use API calls to other web services and bring that information into the simulation. Also the Java SDK and REST APIs enable greater integration of new technologies into Innoslate® by third parties.

INNOSLATE SUPPORTS THE USE OF THE AUTHORITATIVE SOURCE OF TRUTH TO PRODUCE DIGITAL ARTIFACTS, SUPPORT REVIEWS, AND INFORM DECISIONS

Using a web interface, makes the human-machine interface easier and more intuitive, plus it takes advantage of built-in browser tools, such as spelling and grammar checking. The underlying language (LML) provides explicit decision points that can be allocated to either the human or the machine, thus making the modeling of these HAI processes more clear and complete. The Java SDK and REST APIs also offer third parties the capability to design and experiment with different user interfaces. We call this "Architecture to Operations," a paper which was presented at the 2017 NDIA conference.

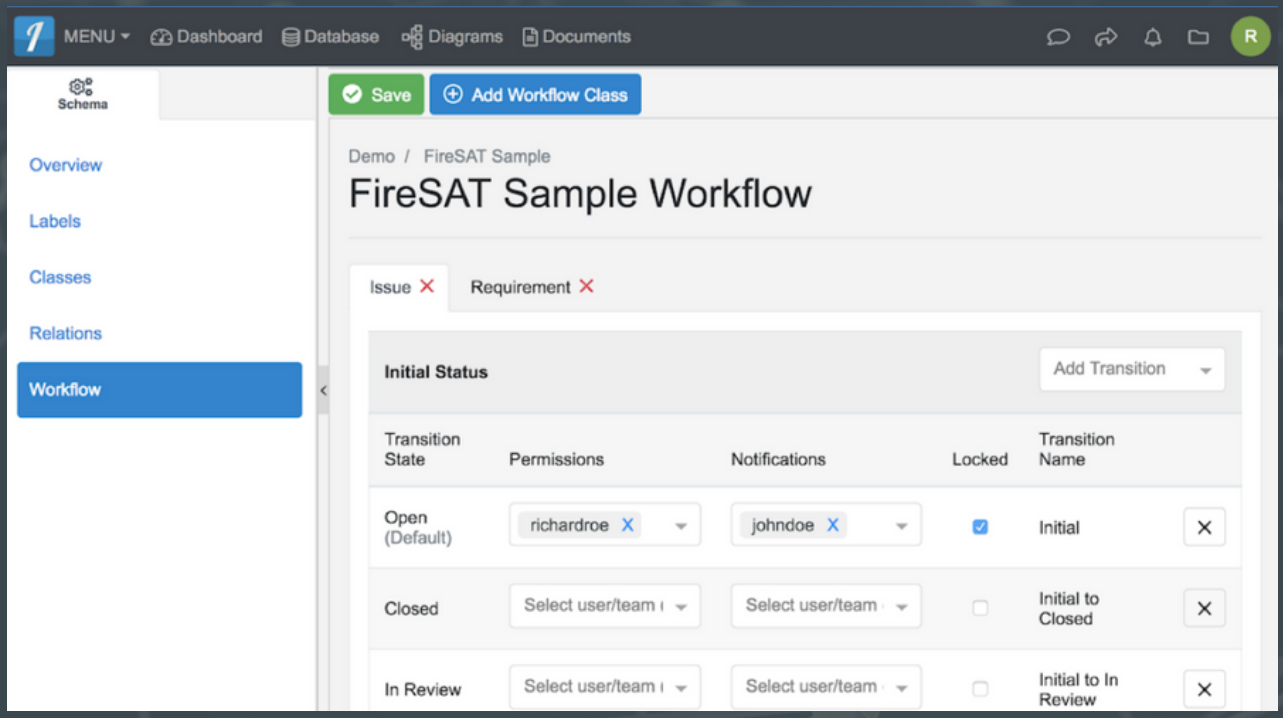
INNOSLATE SUPPORTS THE DEVELOPMENT, MATURATION, AND/OR USE OF DIGITAL ENGINEERING IT INFRASTRUCTURES

Being cloud based and on all the major commercial cloud environments (Amazon AWS, Google AppEngine, and Microsoft Azure), as well as classified clouds, such as NSERC and C2S, enables Innoslate® to fit into the modern IT infrastructures that will have to be used for digital engineering. Innoslate® was also designed with scalability

in mind. Digital engineering will require the capturing and management of Exobytes of data. Scalability will become critical to that environment.

INNOSLATE SUPPORTS THE DEVELOPMENT, MATURATION, AND/OR USE OF DIGITAL ENGINEERING METHODOLOGIES

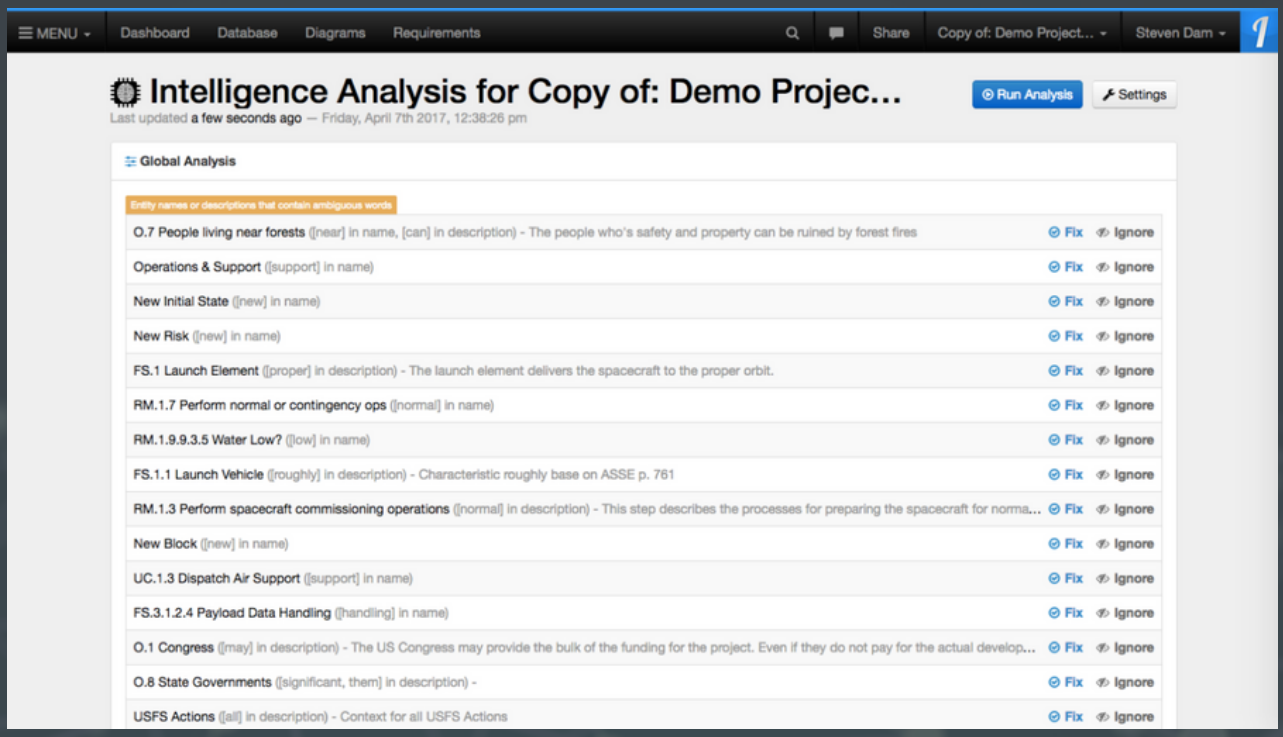
Innoslate® can support any methodology and be used to model processes and other aspects of those methodologies. Workflow can also be used to enforce processes.



Innoslate's real-time indicators and chat enable collaboration around the world

INNOSLATE CAPTURES AND SHARES BEST PRACTICES WITHIN THE TOOL

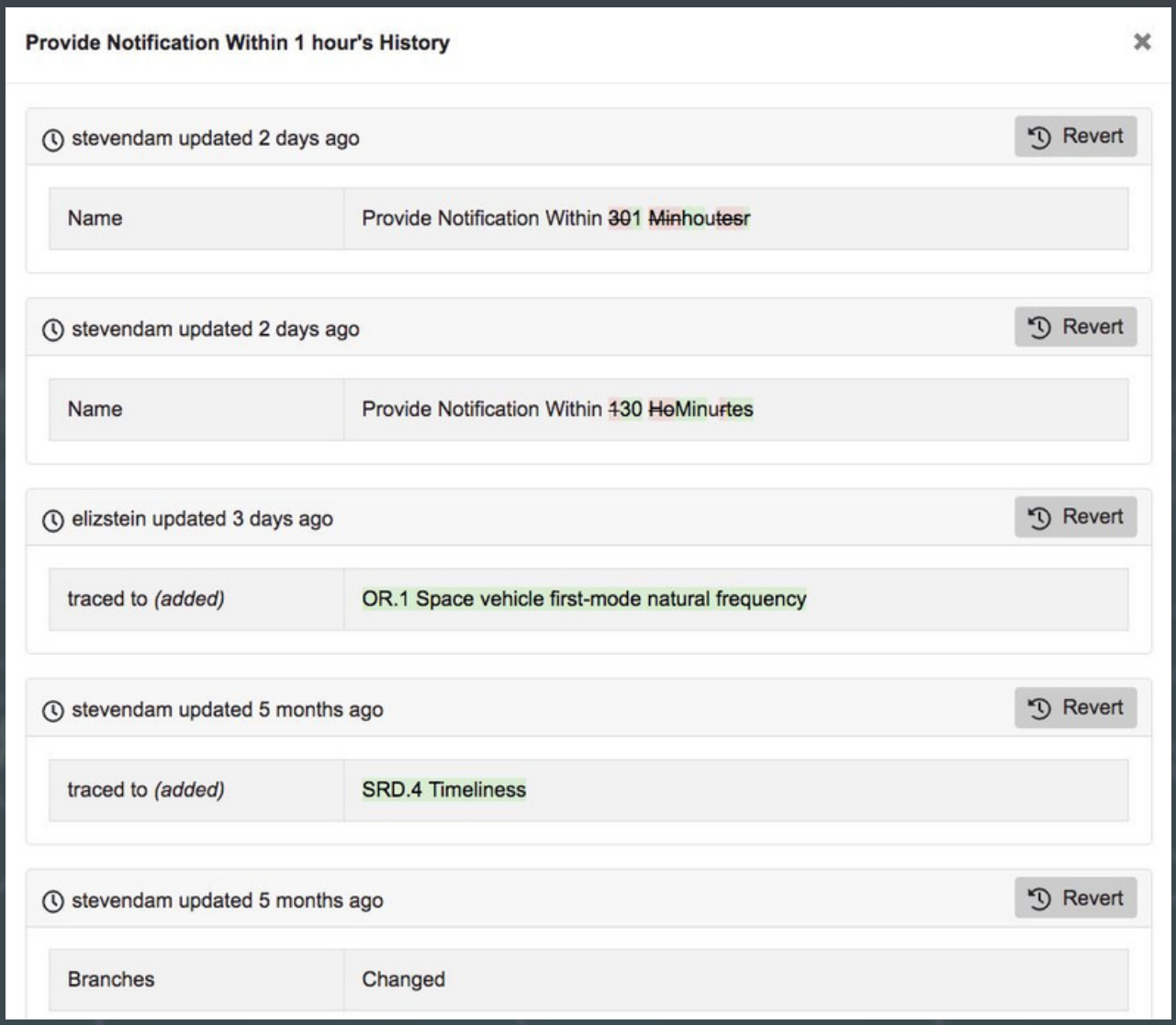
Innoslate® currently uses best practices identified by work done though the Naval Postgraduate School and Stevens Institute of Technology as the basis for the heuristics used in Intelligence View. Additional best practices can be captured as a document in Documents View for sharing with other projects in the organization.



Intelligence View enforces best practices in digital engineering modeling

INNOSLATE SUPPORTS ACCOUNTABILITY TO MEASURE AND FACILITATE IMPROVEMENT OF TANGIBLE RESULTS

Since Innoslate® automatically captures all change information, these History files can be mined to identify ways to improve the digital engineering practices. The Activity Feed on the dashboard also allows managers to see who is change what. Workflow provides a means to control the changes in status of requirements, issues, and any other entity class in the tool.



Innoslate tracks the change history of every entity

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INNOSLATE VISUALIZES MODULARITY OF THE SYSTEM

Figure 1. shows a SysML Internal Block Diagram (IBD) for the the Innoslate modular architecture. Plugins are viewpoints of the Innoslate database. Plugin features include:

- Not a standalone application (requires Innoslate Core)
- All authentication is through Innoslate Core with the options for:
  - Single-Sign-On CAC (Default)
  - Native Email/Password (Optional)
  - LDAP (Optional)
- All data is stored in the U.S. Government or commercial managed MSSQL database using Innoslate Core
- Innoslate REST API facilitates plugin data exchange

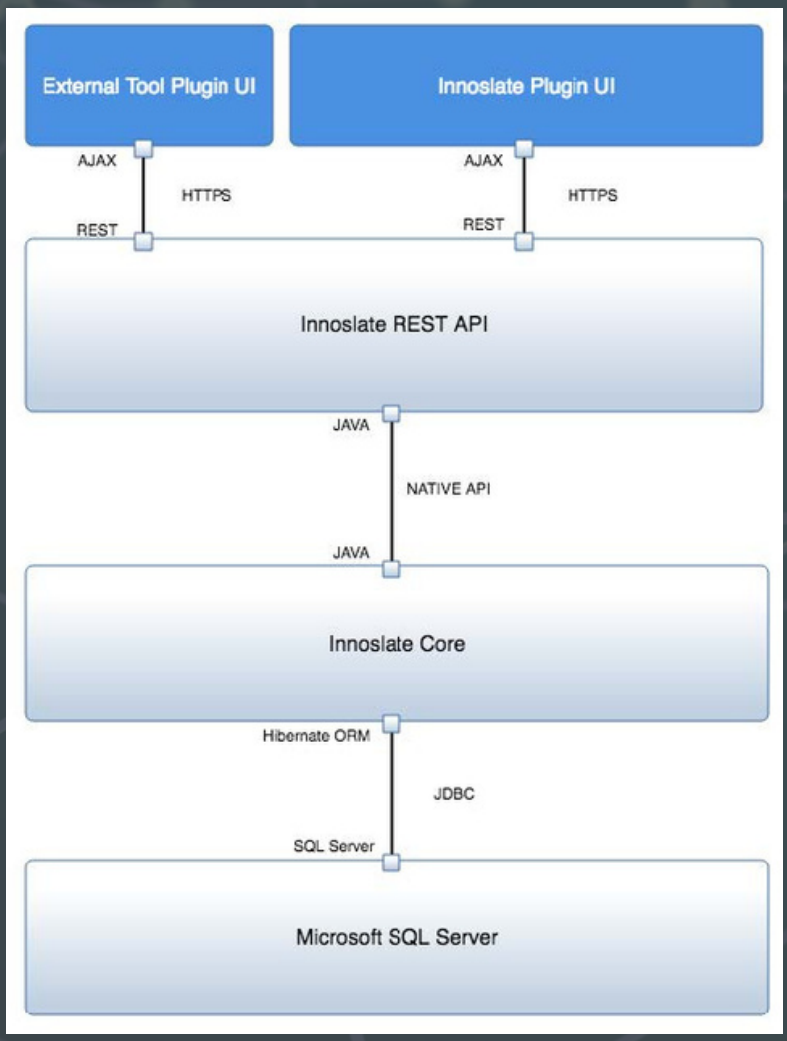
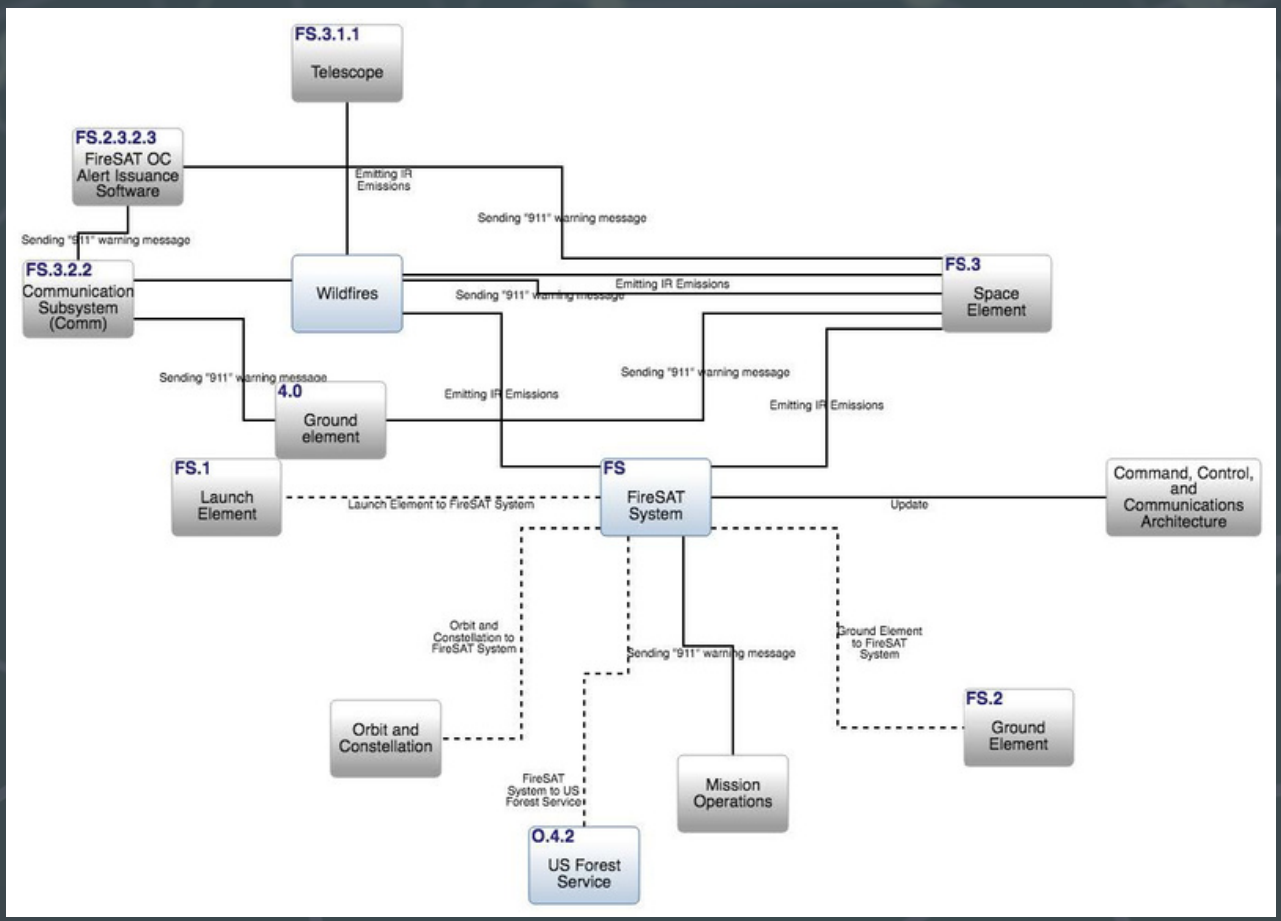


Figure 1. Innoslate Modularity

INNOSLATE IDENTIFIES AND VISUALIZES SYSTEM COMPONENTS AND INTERFACES

Innoslate® provides many different diagrams to visualize the systems components and interfaces, including the Asset Diagram (LML), Internal Block Diagram (SysML), and N2 Chart. All these diagrams use the same ontological elements: Assets for the components and Conduits for the interfaces. Data flows (Input/Output entities) can be allocated to the Conduits. These data flows have "size" (which can be a distribution) and the Conduits have "capacity" and "latency" attributes as well. These attributes are used in the simulators to constrain the functional model, thus affecting the overall system performance.



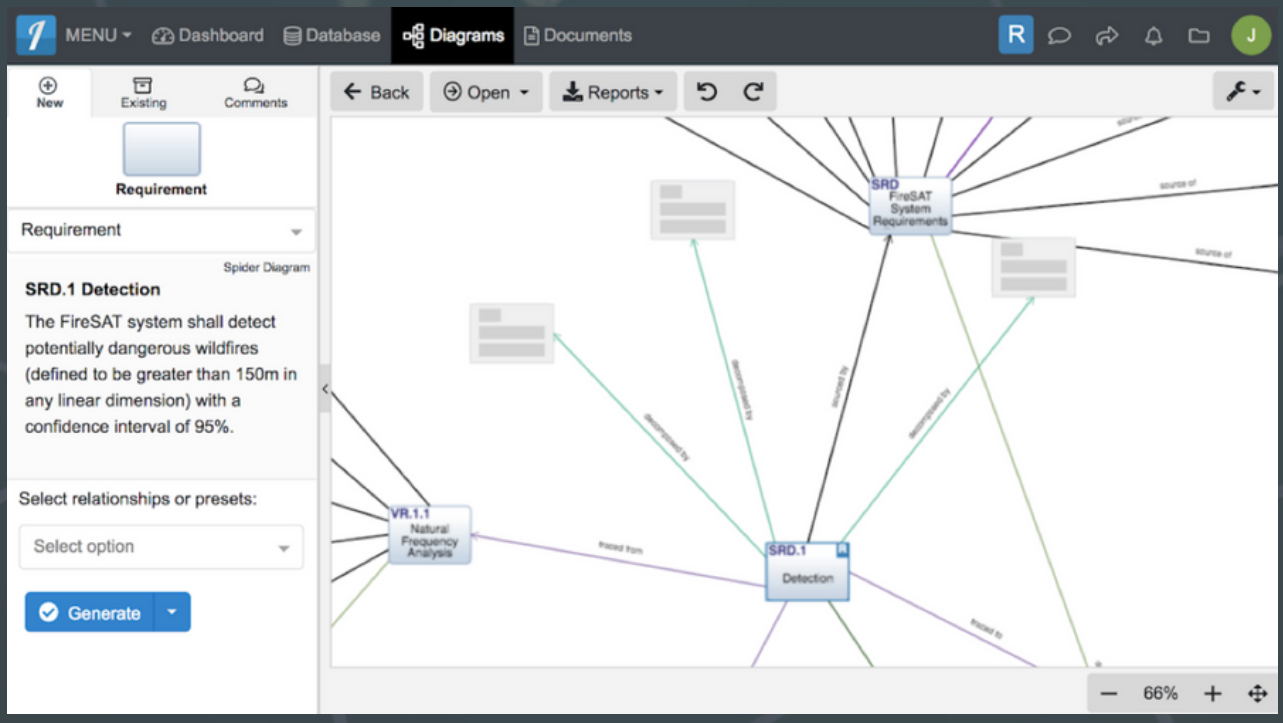
Innoslate's unique Physical I/O Diagram shows Assets, Conduits, and I/Os in one chart

In addition, Innoslate® provides a CAD Viewer to view .stl or .obj files, which are standard output formats from CAD

tools. If the ,obj file is used, the objects in the file can be translated into Innoslate Asset entities and linked back to the drawing.

INNOSLATE VISUALIZES MODULARITY AT DIFFERENT LEVELS IN THE SYSTEM

The underlying language (LML) provides an ontology where all classes of information are decomposable. This capability enables the modeling to be performed at any and all levels necessary. Innoslate® also supports cross-project relationships, so that each level can be modeled separately, if desired, and then shared with other models. This modularity will become critical when concerned with the sharing of proprietary information. Users who do not have permission to see information from a particular project will not see that information if it is included in another project using the cross-project relationships. A redaction bar shows up in its place.



Innoslate permissions and cross project relationships enable using information from other projects while protecting that information

INNOSLATE VISUALIZES THE IMPACTS OF INTERFACES WITH OTHER SYSTEMS

This visualization occurs with any of the physical diagrams. Again, if cross-project relationships are used, you can see those specific interfaces. Another visualization tool is the Spider Diagram. Since Innoslate® uses relationships to capture the interfaces, the Spider Diagram shows those related elements as well.

INNOSLATE DETERMINES INTEROPERABILITY

Since interoperability requires interfaces at many levels, Innoslate® provides the means to identify those interfaces at every level. The fact that all the drawings are generated from the data will allow the analyst to see how the information connects. Further research in this area is also feasible and may be yet another place where graph theory and NLP technologies can be used to provide more automated heuristics.

INNOSLATE CAPTURES LINKAGES BETWEEN HARDWARE AND SOFTWARE

Innoslate® provides the means to identify any interfaces between hardware and software as well. They are both (along with people) considered “Assets” in the ontology. Assets can have Conduits or Logical Connections between each other. So, if the modeler does not want to use the Conduit, they could use the Logical connection for this purpose. And, of course, other relationships can be provided using the Schema Editor.

INNOSLATE PROVIDES APPLICATION PROGRAMMING INTERFACES TO USE CUSTOM APPLICATIONS

Innoslate® comes with a complete set of APIs, including Java, REST, and for Enterprise users, JavaScript. These APIs are used by Innoslate® developers as well, so they are

rarely deprecated. We have developed completely new user interfaces for Innoslate® to mimic legacy tools using these APIs.

INNOSLATE ENABLES TRANSFER OF DATA FROM ONE MODEL CONSTRUCT TO ANOTHER

The APIs provide a means to “put” or “get” information and can provide this function. Other data transfer mechanisms of models include the XML and XMI importers, along with Word, CSV, and Plain Text import capabilities.

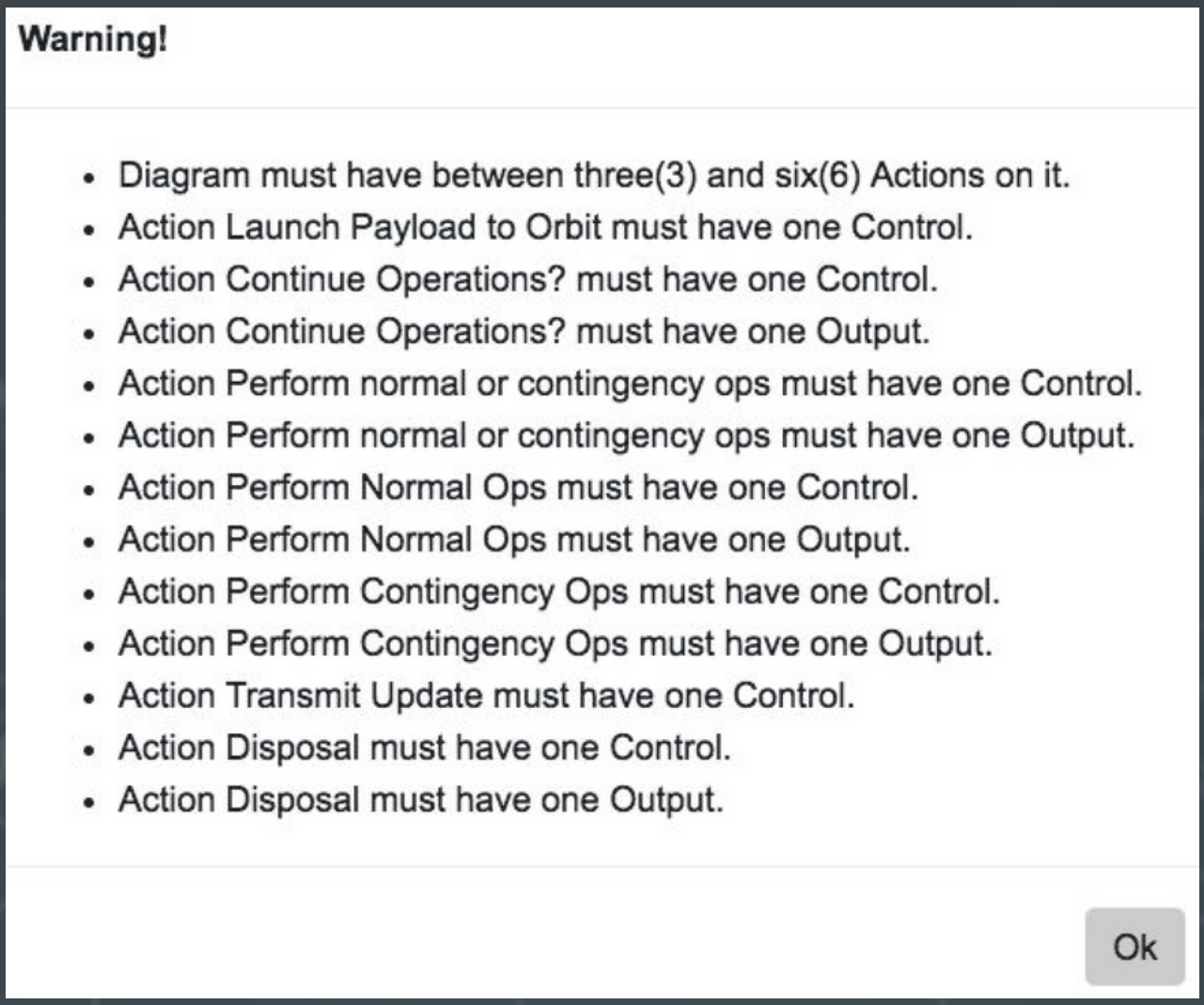
INNOSLATE CAPTURES STANDARDS INFO FOR SYSTEM INTERFACES & COMPONENTS

Standards can be captured as Artifacts and decomposed into Statements and Requirements. Those standards can then be easily related to any other information in the database, including interfaces (Conduits) and components (Assets).

INNOSLATE TESTS FOR STANDARDS COMPLIANCE

Innoslate® provides the Traceability Assistant as part of the Traceability Matrix. This matrix and assistant can be used with the standards trace to interfaces and components to help identify that the standards are being met.

In addition, when rules are available, Innoslate diagrams, such as the IDEF0, and has the tools to indicate when errors occur. For example, when the number of boxes exceed six on the diagram, this violates one of the IDEF0 rules (must have between 3 and 6 functions on a graph).

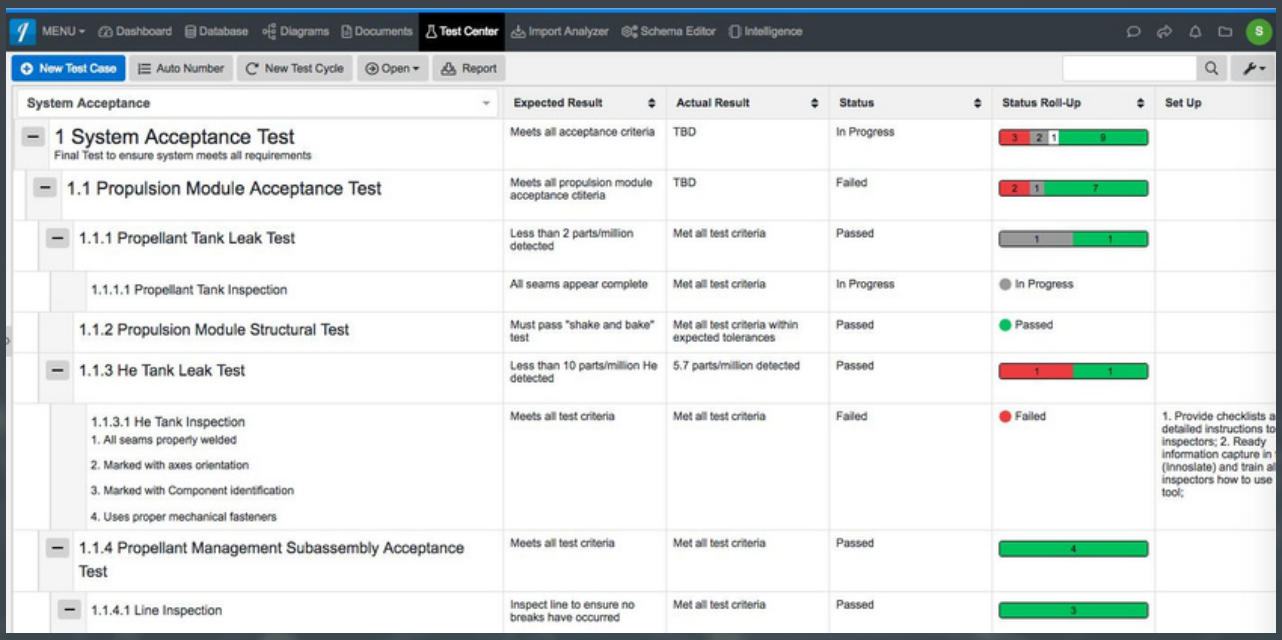


Innoslate rule checking aids the modeler in meeting requirements

Intelligence View checks the entire model for best practices, using 68 tailorable heuristics, developed from work by US Naval Postgraduate School.

INNOSLATE TESTS FOR VERIFIES MODULARITY AND OPENNESS

These criteria can be captured as part of the Test Center's Test Cases and results. If criteria can be developed for these, SPEC would be interested in using those criteria as part of its Intelligence View, as well.



System Acceptance	Expected Result	Actual Result	Status	Status Roll-Up	Set Up
1 System Acceptance Test Final Test to ensure system meets all requirements	Meets all acceptance criteria	TBD	In Progress	3 2 1 9	
1.1 Propulsion Module Acceptance Test	Meets all propulsion module acceptance ctiteria	TBD	Failed	2 1 7	
1.1.1 Propellant Tank Leak Test	Less than 2 parts/million detected	Met all test criteria	Passed	1 1	
1.1.1.1 Propellant Tank Inspection	All seams appear complete	Met all test criteria	In Progress	In Progress	
1.1.2 Propulsion Module Structural Test	Must pass "shake and bake" test	Met all test criteria within expected tolerances	Passed	Passed	
1.1.3 He Tank Leak Test	Less than 10 parts/million He detected	5.7 parts/million detected	Passed	1 1	
1.1.3.1 He Tank Inspection 1. All seams properly welded 2. Marked with axes orientation 3. Marked with Component identification 4. Uses proper mechanical fasteners	Meets all test criteria	Met all test criteria	Failed	Failed	1. Provide checklists a detailed instructions to inspectors; 2. Ready information capture in (Innoslate) and train al inspectors how to use tool;
1.1.4 Propellant Management Subassembly Acceptance Test	Meets all test criteria	Met all test criteria	Passed	4	
1.1.4.1 Line Inspection	Inspect line to ensure no breaks have occurred	Met all test criteria	Passed	3	