



International Council on Systems Engineering
A better world through a systems approach

A Framework for Seamless Interoperability

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Drivers Behind the DoD's Shift Toward Digital Engineering

Evolving Mission Complexity



- Joint operations increasingly involve coordination across multiple domains (space, land, air, etc)
- Mission scenarios shift rapidly, requiring the ability to reconfigure and re-evaluate system capabilities on short timelines

System-of-Systems Integration Challenges



- Modern platforms (e.g., sensors, comms, etc) must function as part of a dynamic system-of-systems
- Siloed tools and inconsistent data standards prevent clear traceability between mission needs and technical implementation

Need for Data-Driven Decision Making



- Operational environments are unpredictable; decisions must be grounded in objective data
- Accelerated acquisition timelines require early insight into how design choices impact mission effectiveness

Digital Engineering enables the speed, insight and integration that today's missions demand

The Vision: Integrated Digital Engineering Environment

Mission Engineering



Reusable MBSE Model Libraries



Collaborative Cross Domain Modeling And Simulation



Digital Twins



AI/ML Capabilities



Integrated Digital Engineering Environment

A connected digital environment linking mission requirements, system models, and simulation enables continuous verification and comprehensive assessment of mission effectiveness

Challenges of Linking Mission to System to Simulation Models

Toolchain Fragmentation



- Mission and System models often reside in Cameo, while high-fidelity simulations are often built in MATLAB/Simulink, creating disconnected workflows
- While the two tools can natively be integrated, passing more complicated parameters between the two is challenging

Limited Interoperability and Data Exchange



- Current SysML v1 standards lack dynamic data linking needed for seamless traceability
- Simulation outputs have limited integration back into system or mission models, requiring manual data handling and custom coding

Managing Model Variations and Traceability

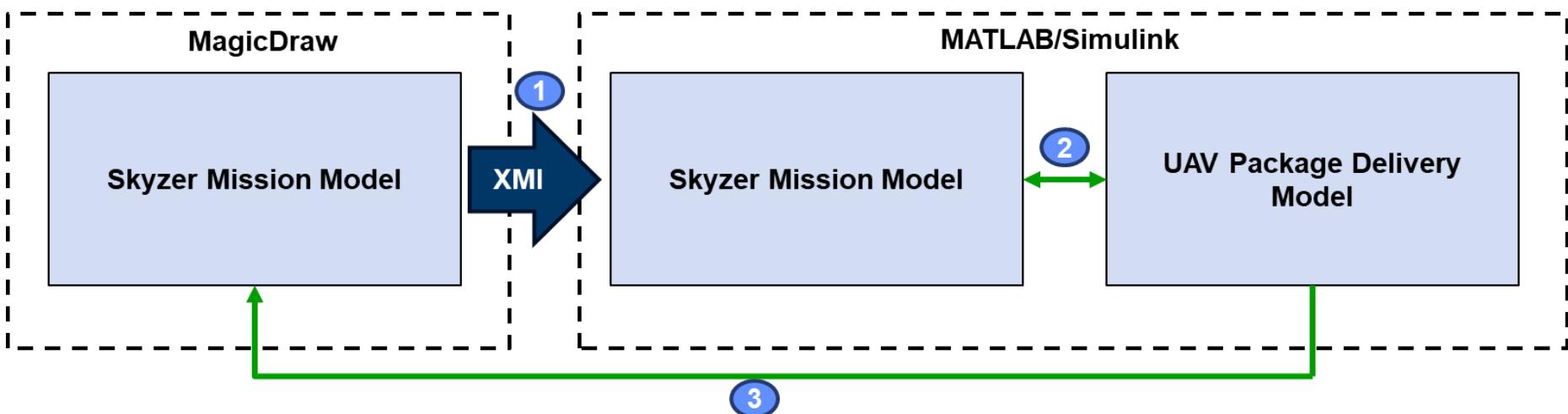


- Multiple system design variants exist, but linking each variant's simulation results back to mission requirements is difficult
- Lack of bidirectional traceability impedes automated verification and slows decision making processes

We developed a framework that automates mission requirement flow through system models to simulations, enabling continuous verification and comprehensive mission assessment

Integrated Framework Overview

User Story: As the mission planner, I need to understand which variant of the Skyzer system will best satisfy mission constraints (e.g. speed, weight, safety). By linking the mission model, system variants, and simulation data, I can perform rapid, automated assessments of which configuration is most effective for a given mission



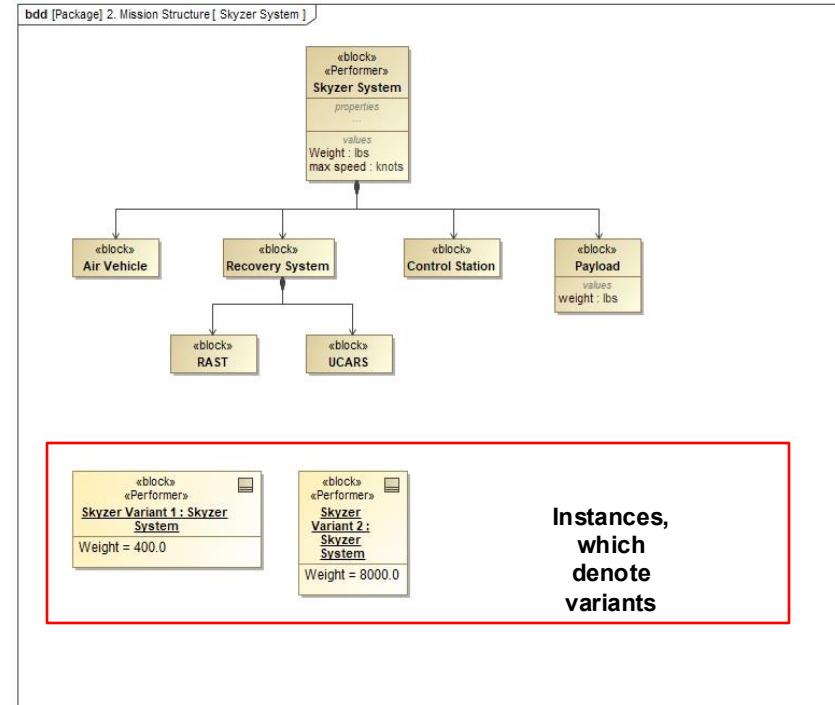
1. Import to System Composer:
 - System Requirements
 - System Diagrams
 - Interface Definitions
 - System Parameters
 - System Variants

2. Link to High-Fidelity Models:
 - Relevant environmental parameters
 - Relevant system Parameters
 - Relevant variants

3. Report to MBSE model in MagicDraw:
 - Recorded simulation results

Model Overview: Skyzer Mission Model

- Serves as the foundation for linking mission-level objectives to system-level architecture and behavior
- Leverage open-source model used by OMG for SysMLv1 to SysMLv2 transition efforts
- Original open-source model was modified to include:
 - Variant options for key system parameters
 - Additional mission requirements to align with simulation model
 - Test cases for verification of mission requirements



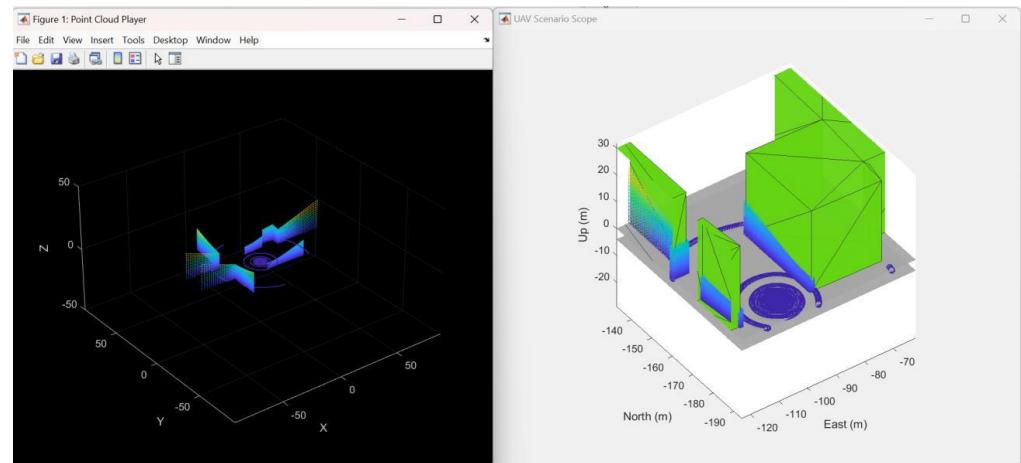
Model Overview: Skyzer Mission Model

#	△ Name	Text	Satisfied By	Verified By
1	<input type="checkbox"/> 1.2.1.7 UAV High Sea States Operation	The Skyzer system shall be able to execute the in-flight portion of its mission in Sea State 7 conditions with wind aloft not less than 80 knots	<input checked="" type="checkbox"/> Wind Speed : Skyzer Mission Model	<input checked="" type="checkbox"/> Sea State During Mission
2	<input type="checkbox"/> 1.2.2.1 Fly Autonomous	The Skyzer UAV shall be able to fly Autonomous		<input checked="" type="checkbox"/> Successful Takeoff and Landing
3	<input type="checkbox"/> 1.2.2.2 Autonomous navigate to search area	The Skyzer UAV shall Autonomous navigate to search area specified in mission plan		<input checked="" type="checkbox"/> Successful Takeoff and Landing
4	<input type="checkbox"/> 1.2.2.8 UAV Fly Patterns	The system shall autonomously fly a search pattern specified in the mission plan		<input checked="" type="checkbox"/> Successful Takeoff and Landing
5	<input type="checkbox"/> 1.3.1 Max Speed	The UAV shall have a max speed of 200 knots	<input checked="" type="checkbox"/> max speed : Skyzer Mission Model	<input checked="" type="checkbox"/> Speed During Mission
6	<input type="checkbox"/> 1.4.3 Weight	The Skyzer UAV shall weigh no more than 5,000 lb.	<input checked="" type="checkbox"/> Weight : Skyzer Mission Model	<input checked="" type="checkbox"/> Weight During Mission

Skyzer Mission Requirements added for demonstration

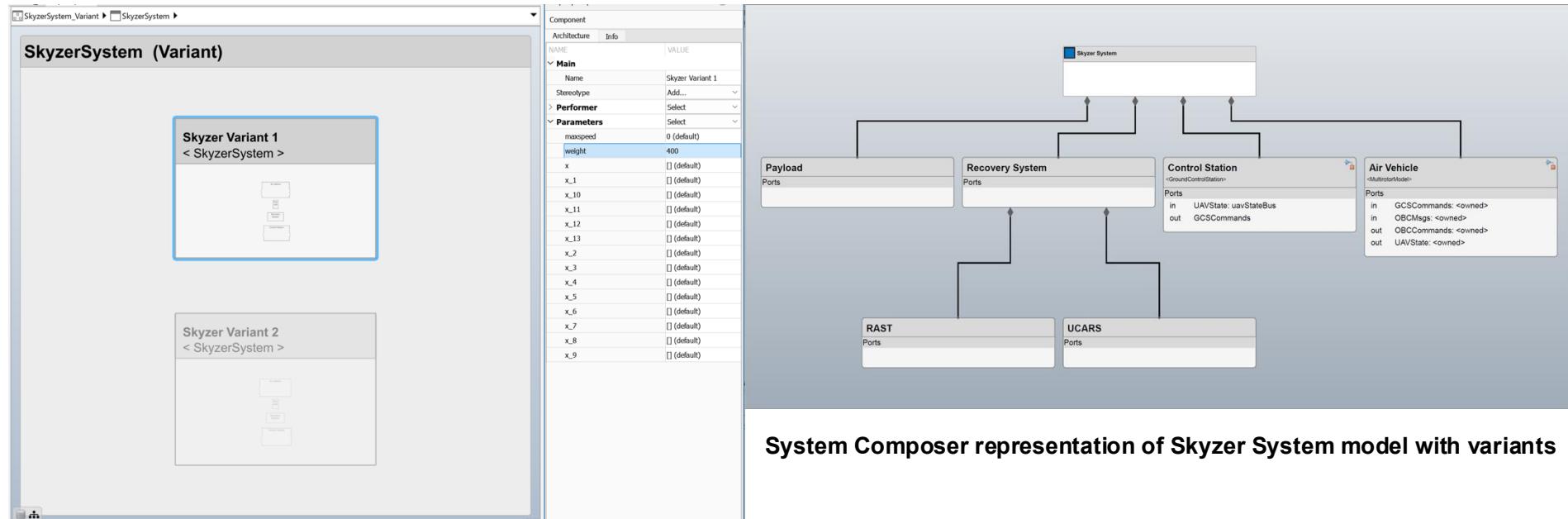
Model Overview: UAV Package Delivery Model

- The UAV Package Delivery model provides a representation of high-fidelity models likely to be used for analysis and verification.
- Originally developed by MathWorks, it serves as an example for users interested in implementing a small multicopter simulation.
- The model includes realistic flight dynamics, control systems, and test cases for performance evaluation.
- Selected due to its mission profile aligning closely with that of the Skyzer Mission Model, minimizing the need for extensive modifications.



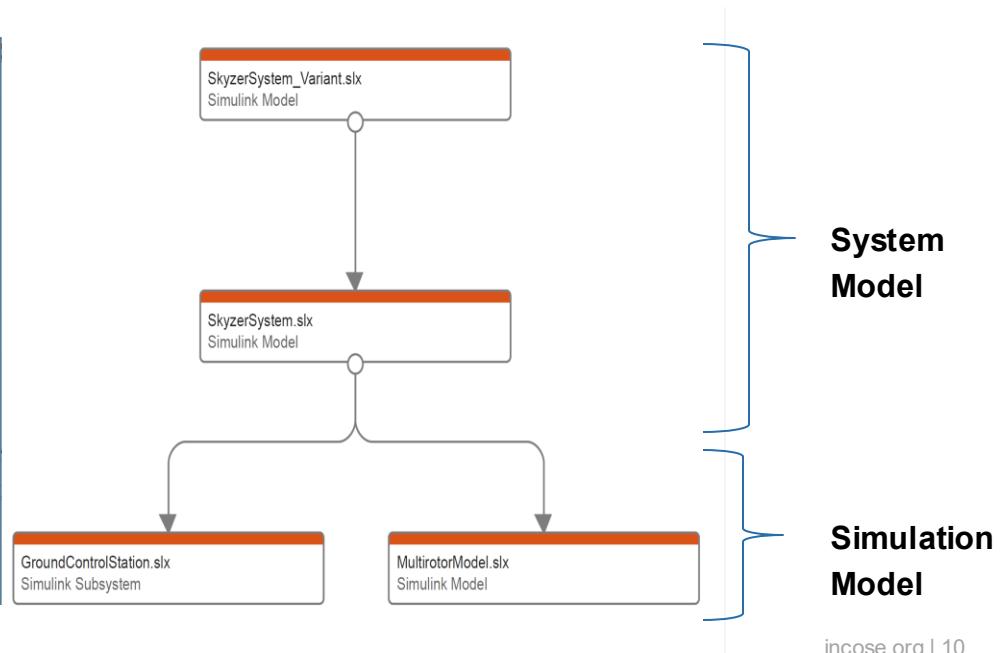
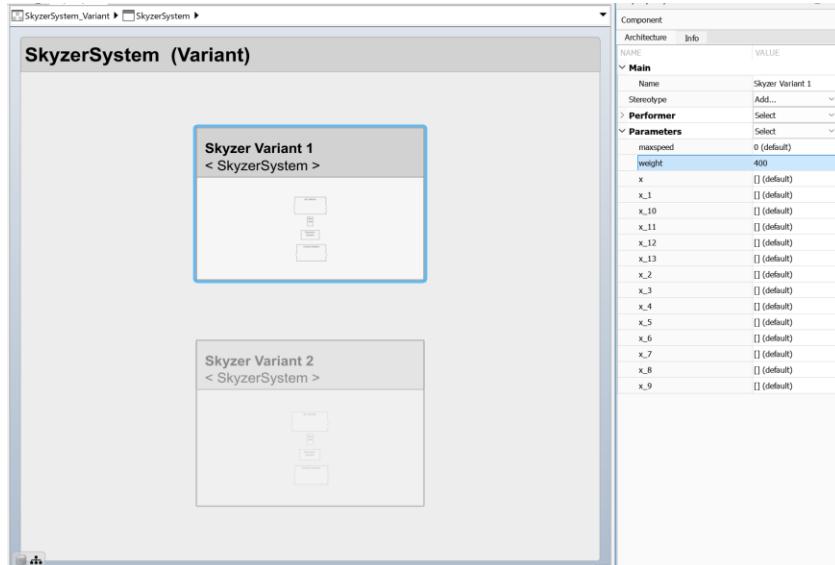
Linking Models to Simulation

- Initial step is to bring in system model into System Composer via XML
- This creates a representation for establishing digital thread



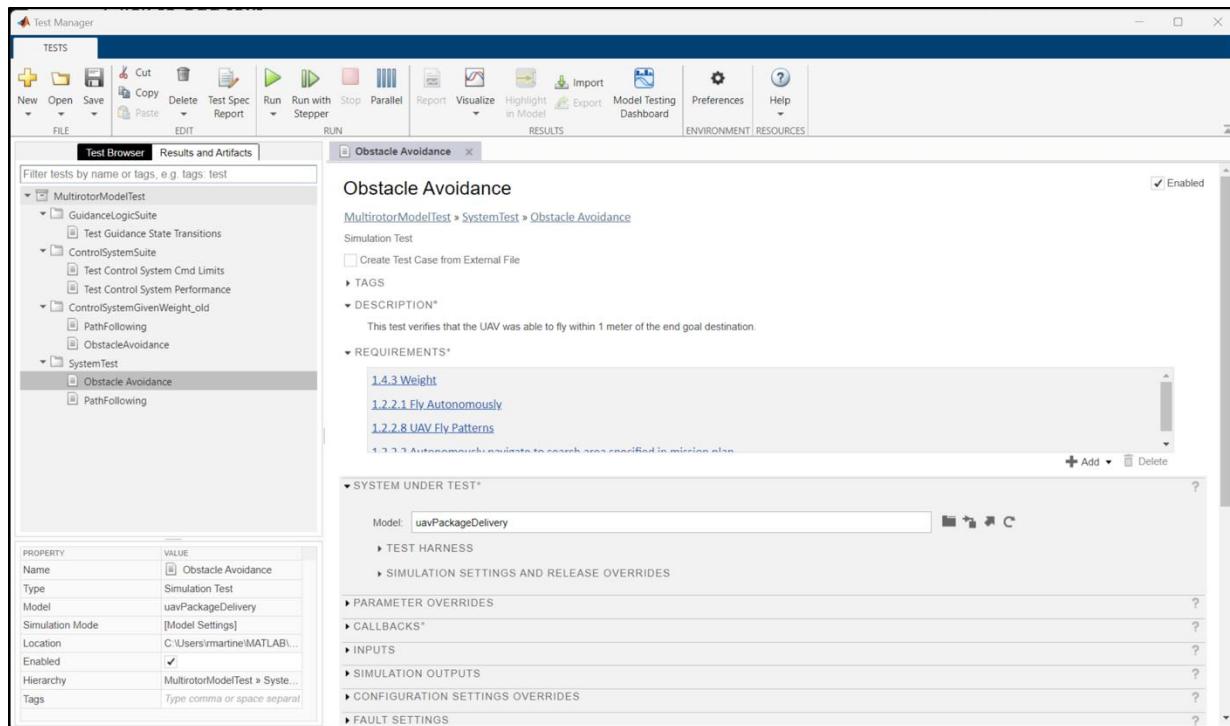
Linking Models to Simulation

- Next is to link system model (Skyzer) to simulation model (UAV Package Delivery)
- This is done by link the system model elements directly to their respective Simulink components



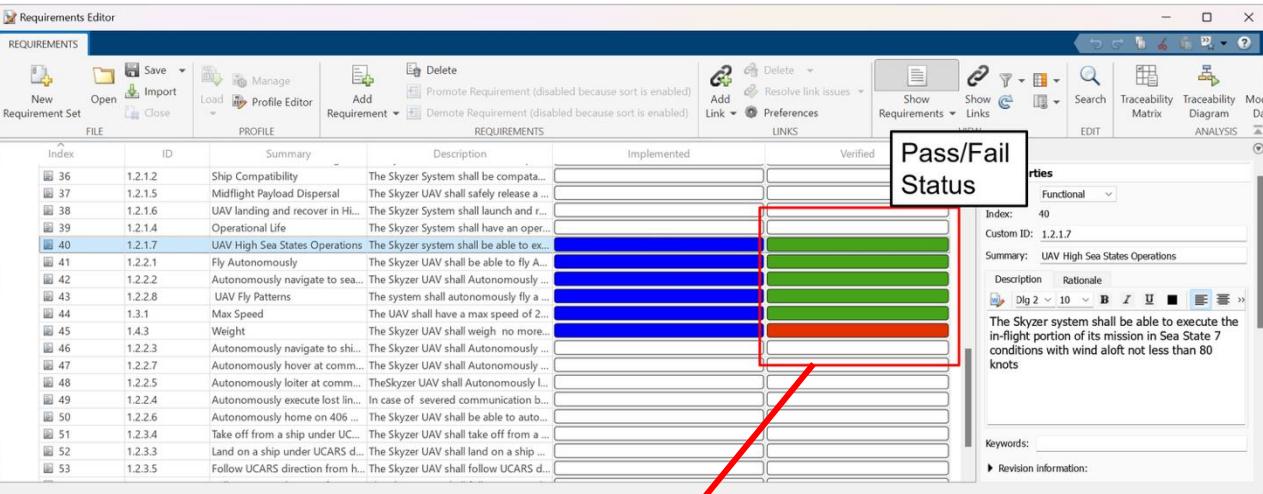
Verification and Capturing Results

- The UAV Package Delivery Model includes test cases that assess performance against predefined criteria.
- These test cases were mapped to system requirements from Skyzer Mission model
- Tests can be executed for each system variant configuration



Test Case Definition Example

Verification and Capturing Results



Requirements Editor

FILE PROFILE REQUIREMENTS EDIT ANALYSIS

Index	ID	Summary	Description	Implemented	Verified
36	1.2.1.2	Ship Compatibility	The Skyzer System shall be compata...		
37	1.2.1.5	Midflight Payload Dispersal	The Skyzer UAV shall safely release a ...		
38	1.2.1.6	UAV landing and recover in Hi...	The Skyzer System shall launch and r...		
39	1.2.1.4	Operational Life	The Skyzer System shall have an oper...		
40	1.2.1.7	UAV High Sea States Operations	The Skyzer system shall be able to ex...		
41	1.2.2.1	Fly Autonomously	The Skyzer UAV shall be able to fly A...		
42	1.2.2.2	Autonomously navigate to sea...	The Skyer UAV shall Autonomously ...		
43	1.2.2.8	UAV Fly Patterns	The system shall autonomously fly a ...		
44	1.3.1	Max Speed	The UAV shall have a max speed of 2...		
45	1.4.3	Weight	The Skyzer UAV shall weigh no more...		
46	1.2.2.3	Autonomously navigate to shi...	The Skyzer UAV shall Autonomously ...		
47	1.2.2.7	Autonomously hover at comm...	The Skyzer UAV shall Autonomously ...		
48	1.2.2.5	Autonomously loiter at comm...	TheSkyzer UAV shall Autonomously ...		
49	1.2.2.4	Autonomously execute lost lin...	In case of severed communication b...		
50	1.2.2.6	Autonomously home on 406 ...	The Skyzer UAV shall be able to auto...		
51	1.2.3.4	Take off from a ship under UC...	The Skyzer UAV shall take off from a ...		
52	1.2.3.3	Land on a ship under UCARS d...	The Skyzer UAV shall land on a ship ...		
53	1.2.3.5	Follow UCARS direction from h...	The Skyzer UAV shall follow UCARS d...		

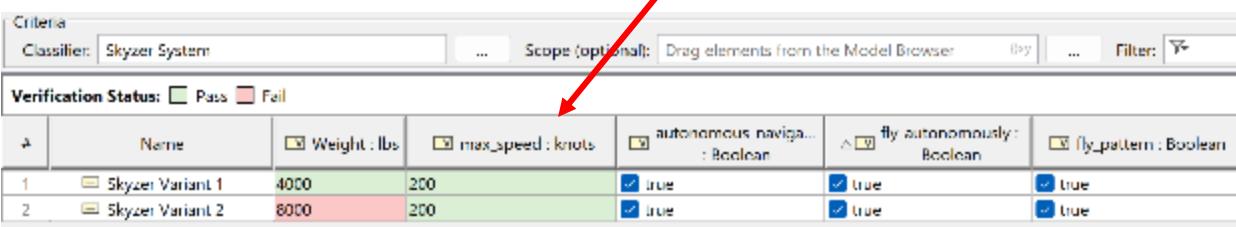
Pass/Fail Status

Properties

Functional

Index: 40
Custom ID: 1.2.1.7
Summary: UAV High Sea States Operations
Description: Rationale
Keywords:
Revision information:

- Results from test cases now passed back into MagicDraw for traceability
- A custom utility uses XMI identifiers to update the Skyzer model with pass/fail status, maintaining synchronization with.



Criteria

Classifier: Skyzer System

Scope (optional): Drag elements from the Model Browser

Verification Status: Pass Fail

	Name	Weight, lbs	max_speed, knots	autonomous_navigation : Boolean	fly_autonomously : Boolean	fly_pattern : Boolean
1	Skyzer Variant 1	4000	200	<input checked="" type="checkbox"/> true	<input checked="" type="checkbox"/> true	<input checked="" type="checkbox"/> true
2	Skyzer Variant 2	8000	200	<input checked="" type="checkbox"/> true	<input checked="" type="checkbox"/> true	<input checked="" type="checkbox"/> true

Conclusion

- Developed a framework that links mission models, system architectures, and simulations to enable seamless end-to-end traceability
- Demonstrated how this integration supports continuous verification of mission requirements across system variants
- Enables faster, data-driven decision making by connecting operational intent to technical performance