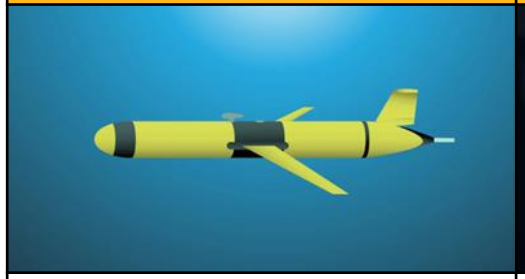
Powering Innovation That Drives Human Advancement

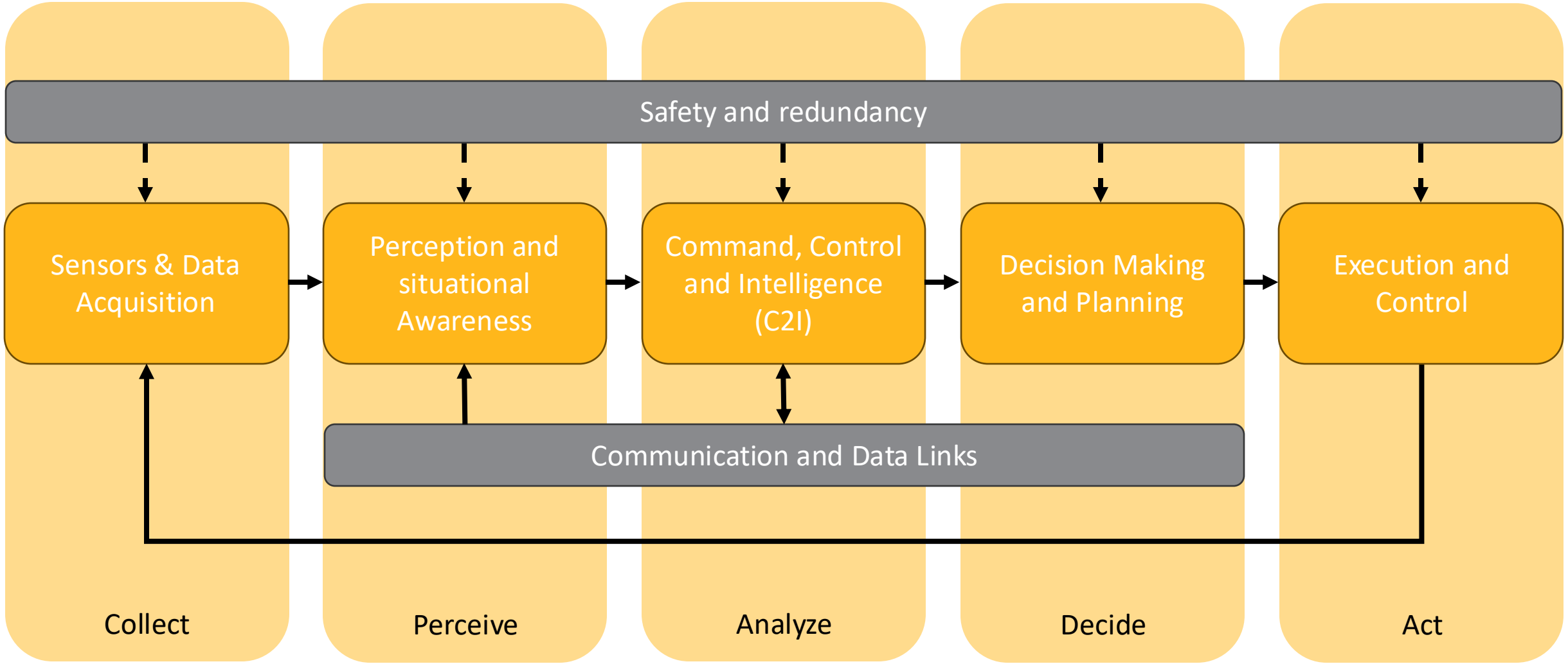
Autonomous Solution

Validation and Testing

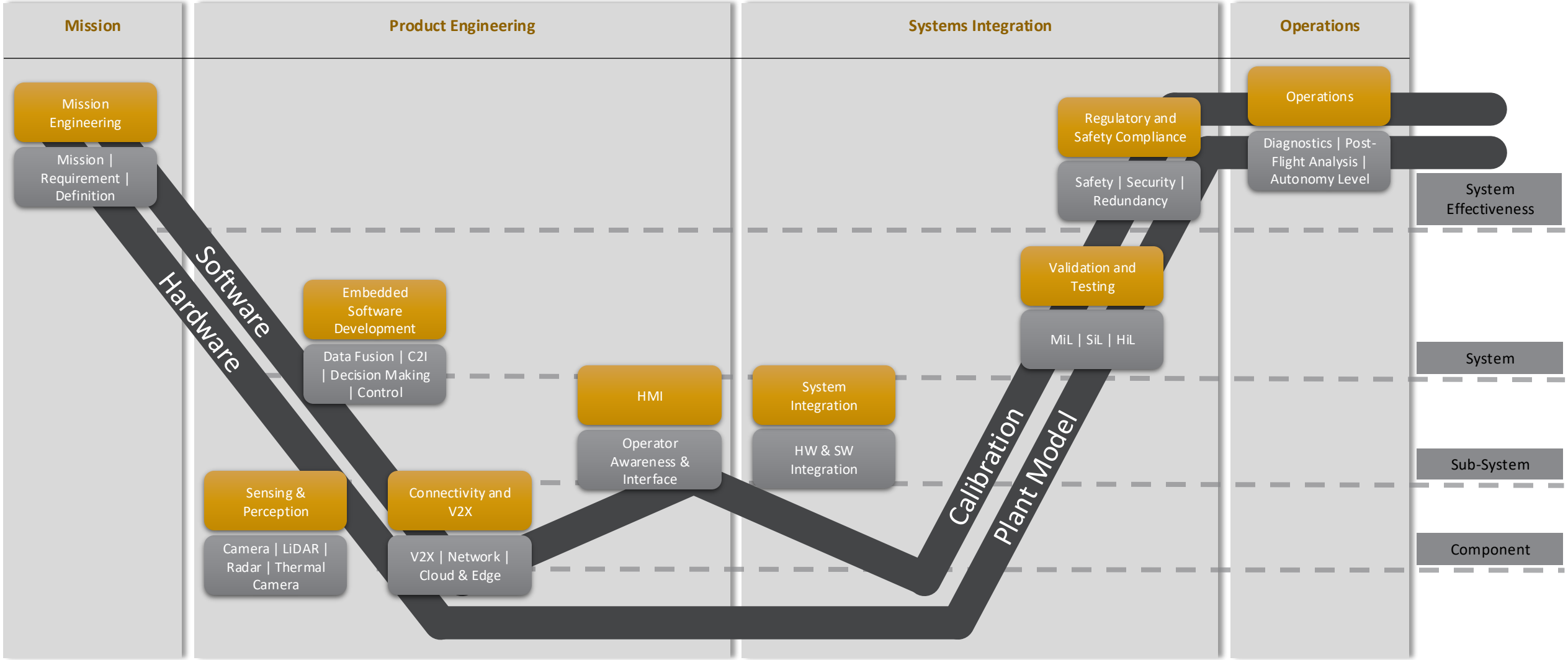
Autonomy in Aerospace and Defense

Aircraft	Ground Vehicles	Commercial & Consumer	Delivery & Logistics
			
• Unmanned Air Mobility • Unmanned Aerial Vehicle • Air-to-Air Refueling • Next-Gen Fighters	• Unmanned Combat Vehicles • Ordinance Disposal • Route Clearing • Donkey	• Urban Air Mobility • Bad Weather • In-Flight Emergencies • Regional Aircraft	• Cargo Carrying • Last-Mile Delivery
Underwater Vehicles	**Space Operations**	**Industrial & Agriculture**	**Emergency Services**
			
• Uncrewed Underwater Vehicles • Remote Operated Research Vehicles	• Rendezvous Proximity Ops • Rovers/Miners • Navigation, Entry, Descent	• Imaging Payloads • Aerial Applications	• First Responder • Search and Rescue

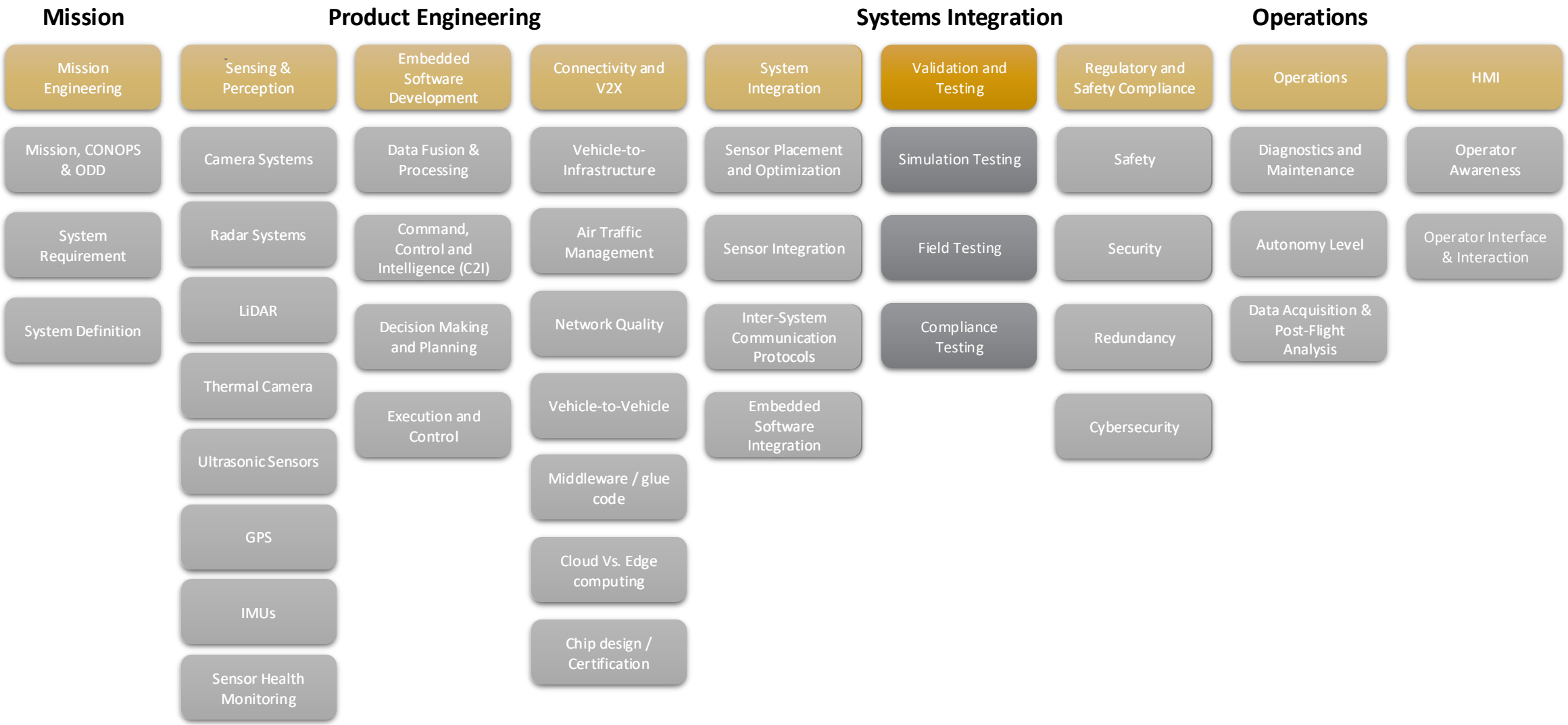
Functional Architectural Viewpoint



Product Development process for Autonomous systems



Ansys Autonomous Solution – Overarching View



Comprehensive System Test & Validation: MiL, SiL, & HiL Strategies

Introduction to System Test & Validation

- **Unified Approach:** Integrates Model-in-the-Loop (MiL), Software-in-the-Loop (SiL), and Hardware-in-the-Loop (HiL) to ensure thorough testing at every development stage.
- **Purpose:** Streamline validation processes to maximize system reliability and performance in actual operational environments.

Objectives

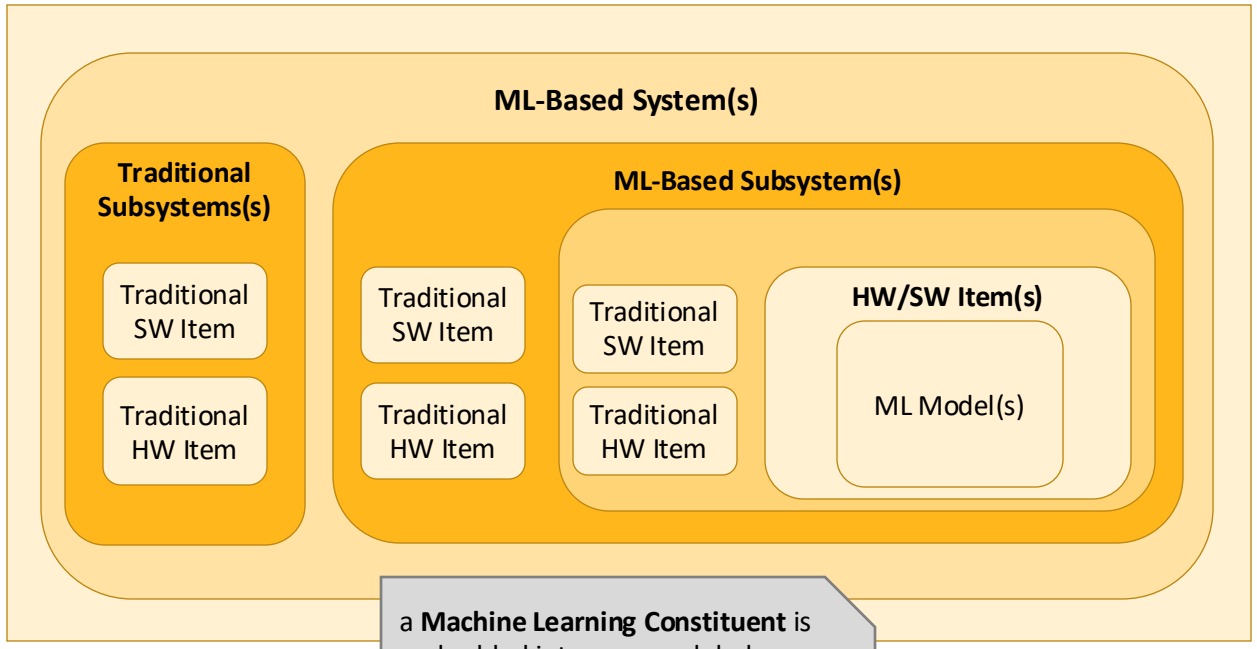
- **Early Detection and Correction:** Identify potential system failures and performance issues across development phases to reduce risks and costs.
- **Enhanced System Integrity:** Ensure that all system components function seamlessly together, adhering to stringent industry standards.

Challenges & Opportunities in Validation and Testing

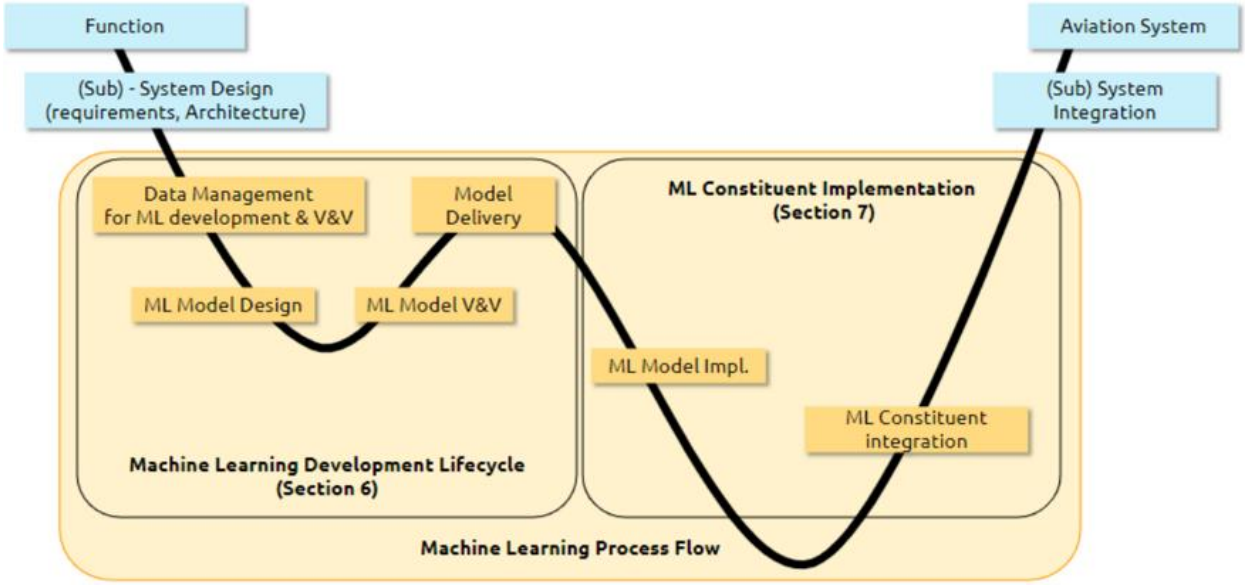
Challenges		Opportunities
• Early validation challenges without real-world data. • Difficulty in predicting system performance accurately.	**Model-in-the-Loop (MiL)**	• Facilitates rapid exploration and innovation in early design. • Allows theoretical model validation and iteration.
• Overlooking physical constraints' impact on software behavior. • Isolation from hardware can miss integration issues.	**Software-in-the-Loop (SiL)**	• Improves software reliability through thorough virtual testing. • Enables early detection and correction of software issues.
• Resource-intensive setup for accurate real-world simulation. • Complexity in integrating and testing with actual hardware.	**Hardware-in-the-Loop (HiL)**	• Ensures system performance under real-world operational conditions. • Validates integration of software and hardware effectively.

AI/ML-based Systems Architecture & W-shaped Process Flow in SAE ARP6983

(WIP) New process standard for validation of requirements and verification of the design implementation for certification and product assurance and guidelines with the assessment of safety



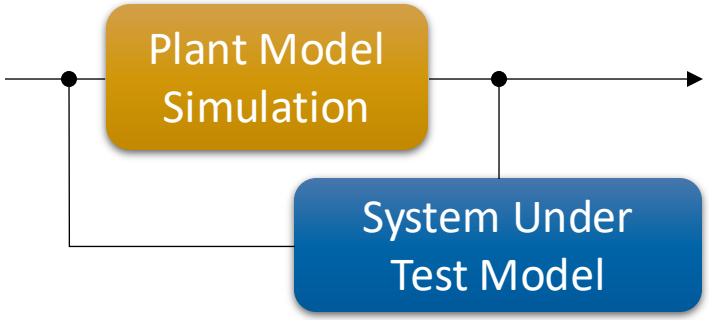
a **Machine Learning Constituent** is embedded into a more global Subsystem that is developed in a traditional manner with the usual certification rules (DO-178C for Software, and DO-254 for complex electronics hardware)



Development and validation of ML/AI components is based on **statistical simulated scenario-based exploration** in **continuous development and integration (CI/CD)**

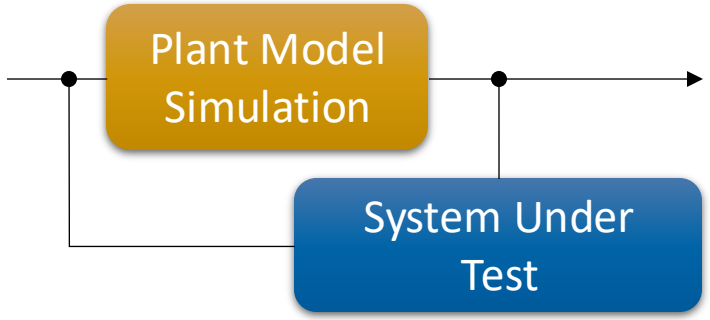
System Test & Validation with Ansys: MiL, SiL, & HiL

Model-in-the-Loop



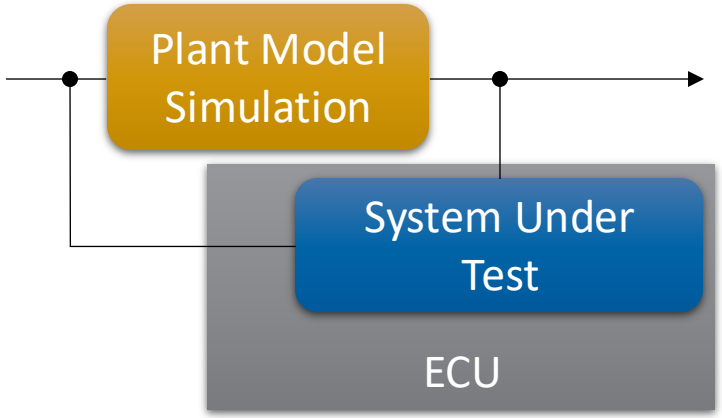
- Early Validation of System Design
- Rapid Prototyping
- Comprehensive Modeling Capabilities
- Integrated Development Environment

Software-in-the-Loop



- Software Validation
- System Performances Optimization
- Real-Time Simulation Support
- Flexible Integration

Hardware-in-the-Loop



- Hardware Testing under Realistic Conditions
- Risk Mitigation
- High-Fidelity Simulation
- Scalability and Customizability

MiL Test & Validation: Bridging Theory to Practical Aerospace Solutions

Challenge

Demonstrating and explaining the ideation of autonomous systems in required scenarios poses significant challenges.

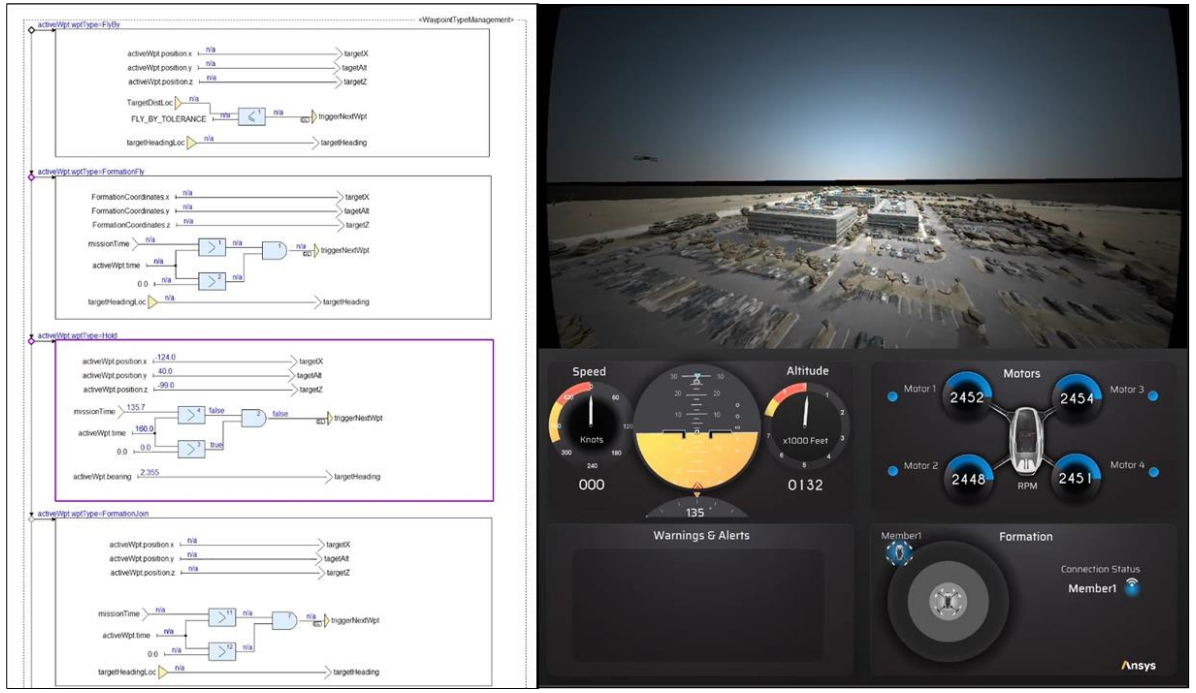
- Rigorous testing in environments that mirror real-world conditions.
- Explainability: Ability to demonstrate and clarify the behavior of autonomous systems.
- Rapid transition from theoretical designs to practical applications.

Solution

- MiL Test & Validation Tools.
- Advanced tools for thorough scrutiny of aerospace designs.
- Specialized validation for autonomy sub-systems and AI/ML integration.

Benefits

- Streamlined design validation and refinement process.
- Early identification and rectification of potential issues.
- Confidence in the integration and validation of AI/ML components.
- Accelerated innovation with AI/ML, reducing reliance on traditional methods.



Applicable Products: Ansys ModelCenter®, Ansys SCADE®, Ansys Twin Builder®

SiL Test & Validation: Integrating AI/ML into Aerospace Systems

Challenge

Testing environments are limited and don't adequately represent real-world conditions.

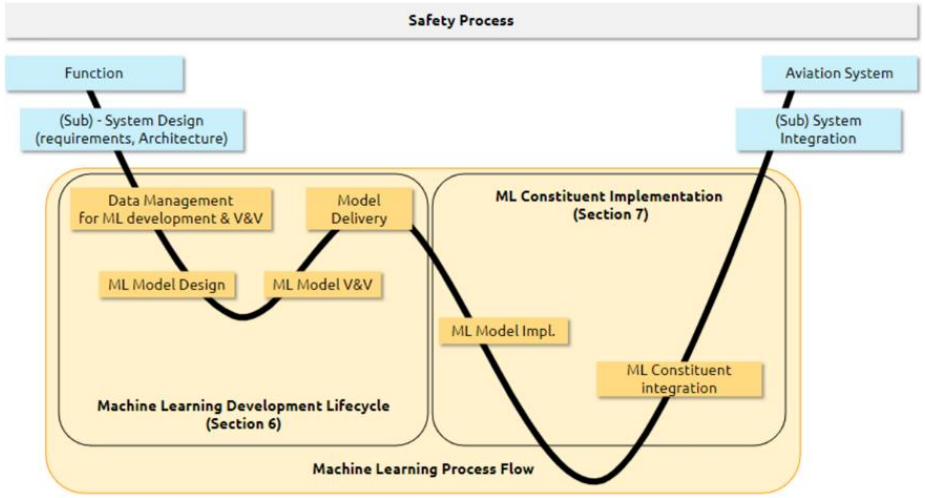
- Seamless integration of sub-systems and AI/ML within aerospace environments.
- Adherence to industry guidelines and regulations.
- Efficient validation of sensor-driven data and AI/ML training.
- Overcome the limitations of traditional non-AI methods.

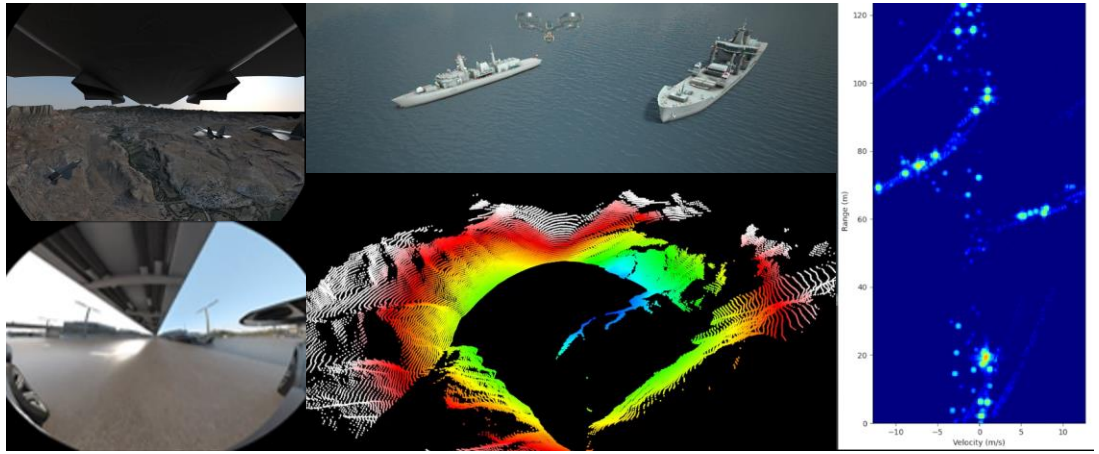
Solution

- SiL Test & Validation Tools.
- Integrated platforms for merging sub-systems.
- Proficient tools for AI/ML training, especially for sensors.

Benefits

- Reduction in the number of necessary test flights.
- Enhanced confidence in AI/ML components.
- Robust integration of AI and ML components.
- Comprehensive security with cybersecurity tools such as Ansys medini.





Applicable Products: Ansys medini® analyze™, Ansys SCADE Suite™, Ansys AVxcelerate Sensors™, Ansys optiSLang®, Ansys Systems Tool Kit (STK®), Ansys Test and Evaluation Tool Kit (TETK)™

HiL Test and Validation: Real-Time Simulations for Aerospace Systems

Challenge

Conducting the necessary number of test flights to achieve compliance proves daunting.

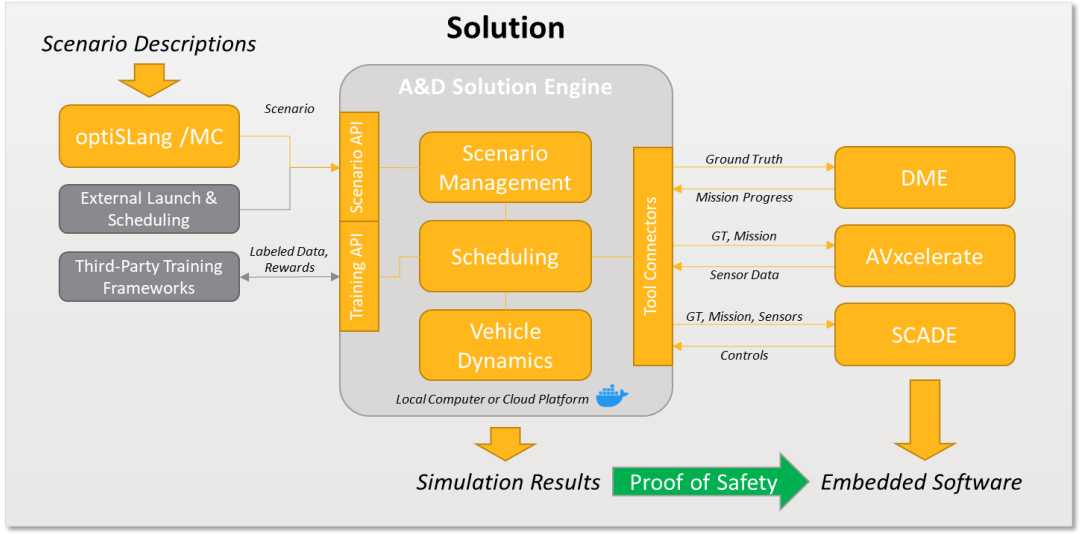
- Real-time simulations that reflect actual mission scenarios.
- Specialized validation systems for sensors, hardware, and AI/ML algorithms.
- Close the loop between theory, software, and hardware.
- Cybersecurity measures that ensure resilience.

Solution

- HiL Test & Validation Tools.
- Comprehensive closed-loop testing tools for real-world feedback.
- Robust cybersecurity tools, ensuring system resilience against potential threats.

Benefits

- Systems are not just functional but also secure from external threats.
- Unparalleled insight into how systems perform in real-world conditions.
- Confidence in real-world deployment readiness.
- Assurance in the integration and validation of hardware components.



Applicable Products: Ansys SCADE Suite™, Ansys Systems Tool Kit (STK®), Ansys AVxcelerate Sensors™, Ansys optiSLang®, Ansys Test and Evaluation Tool Kit (TETK)™

Mission Engineering with Ansys – Solution-Product Matrix

Learn more about Ansys products at: https://www.ansys.com/products

Applications	Ansys ModelCenter®	Ansys SCADE Suite™	Ansys Twin Builder®	Ansys optiSLang®	Ansys medini® analyze™	Ansys AVxcelerate Sensors™	Ansys Systems Tool Kit (STK®)	Ansys Test and Evaluation Tool Kit (TETK)™
MiL Test & Validation: Bridging Theory to Practical Aerospace Solutions	●	●	●					
SiL Test & Validation: Integrating AI/ML into Aerospace Systems		●		●	●	●	●	●
HiL Test & Validation: Real-Time Simulations for Aerospace Systems		●		●		●	●	●

/ Increased Collaboration; Faster Innovation; Customized Workflows; Optimization; Cloud & HPC


Ansys