EMERSON

NI connect

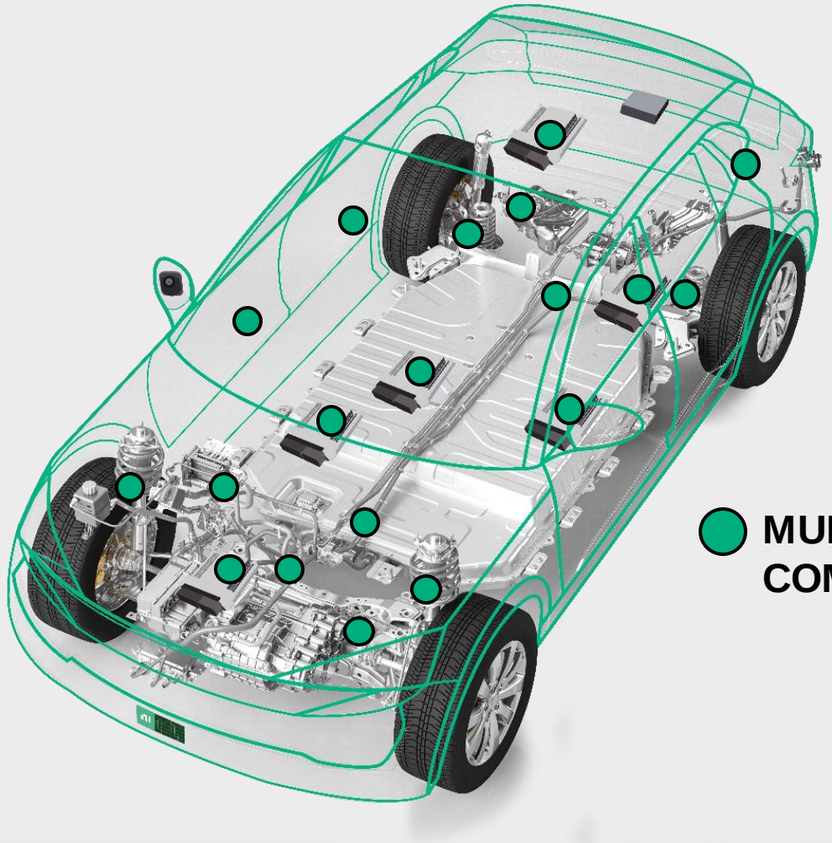
2024 AUSTIN

HIL Testing Fundamentals

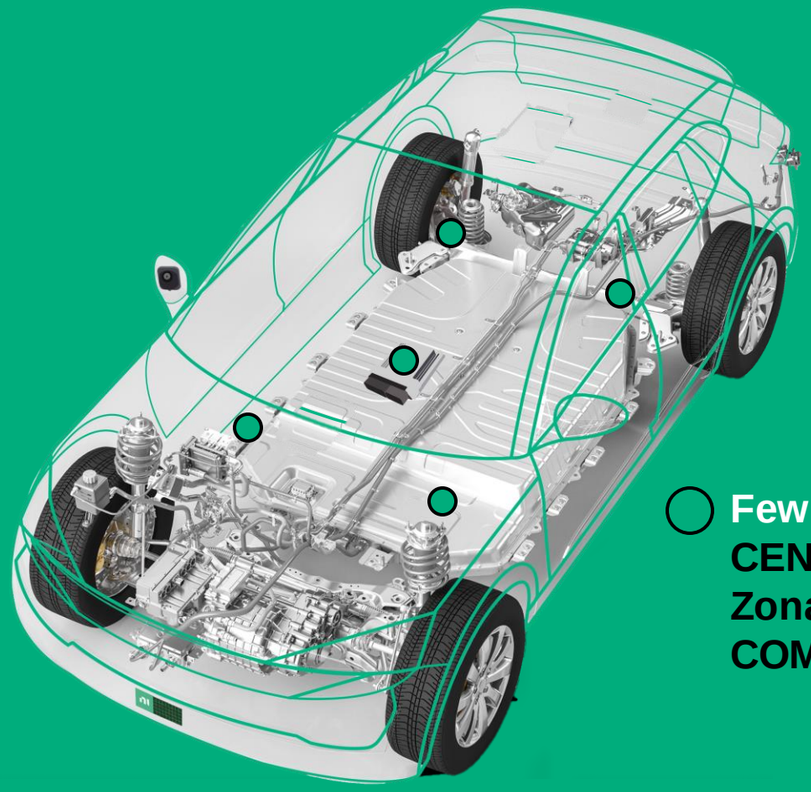
Ritesh Sharma
Offering Manager, NI

E/E Architecture Transformation

Moving Towards a Centralized E/E Architecture



MULTIPLE COMPUTE ECUs



Few CENTRILIZED/ Zonal COMPUTE ECU

What is a Software Defined Vehicle? (SDV)

Introduction to SDVs
SDVs are revolutionizing automobile design and function with software as the key driver of vehicle capabilities

Increased Flexibility
SDVs unprecedented adaptability through software updates introducing new features, enhancing efficiency, security, and vehicle life spam

Accelerated Innovation
SDV technology accelerates the rate of innovation and software development allowing for faster development

Ecosystem Integration
SDVs seamlessly integration providing opportunities for enhanced connectivity, safety, and user experience

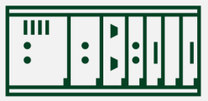
Customer Experience
SDVs personalized and adaptive user experience with software allowing immersive infotainment systems, and autonomous driving capabilities

What Can NI Do in HIL?

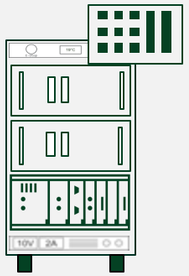
Body & Interior	Chassis	EV / HEV	Combustion	Active Safety	Passive Safety	Connectivity	Infotainment
Body Control	Chassis Control	Hybrid Power	Engine	Radar injection	Seat Belt	Navigation	Instrument Panel
HVAC	Steering	Inverter	Fuel Injection	Camera injection	Airbags	Bluetooth	Radio Interface
Lighting	Brakes	Thermal	Throttle	AEB,	Warning Sounds	Wireless Charge	Heads-Up
PEPS	Traction	Transmission	Ignition	ACC	Sensing	Wi-Fi	Voice
Theft Deterrent	Suspension	Throttle	Transmission	Lane Keep	Air Suspension	V2X	Display
etc…	etc…	etc…	etc…	etc…	etc…	etc…	etc…

Scale Across ECUs and Test Systems

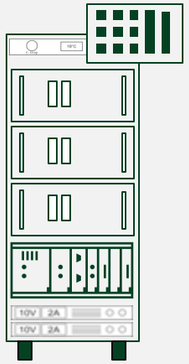
Configurable | Scalable | Customizable | Hardware & Software



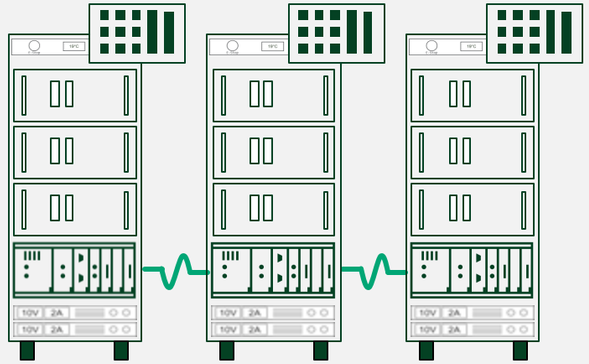
Desktop HIL



Component HIL



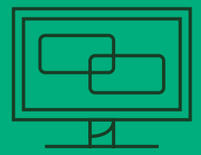
Sub-System HIL



System Integration HIL

The NI HIL Advantage

Software



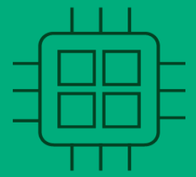
MODEL INTEGRATION

Execute power electronics, motor, and vehicle dynamics models across desktop, real-time, and FPGA compute paradigms in a single platform

VeriStand

MathWorks Collaboration

Technology



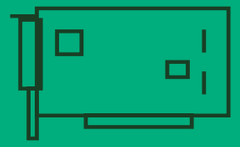
ADVANCED COMPUTING

Test with higher fidelity through high-speed deterministic execution of parameterized and configurable models in I/O connected FPGAs

LV FPGA

OPAL-RT Partnership

Equipment



I/O BREADTH

A broad range of I/O ensures you can meet the test requirements of advancing technology

PXI

SLSC

Operations

CUSTOMIZABILITY

A customizable, open platform lets you adapt to changing requirements and lowers the risk of purchasing a system

Modular I/O

Flexible Software

Integration

INTEGRATION

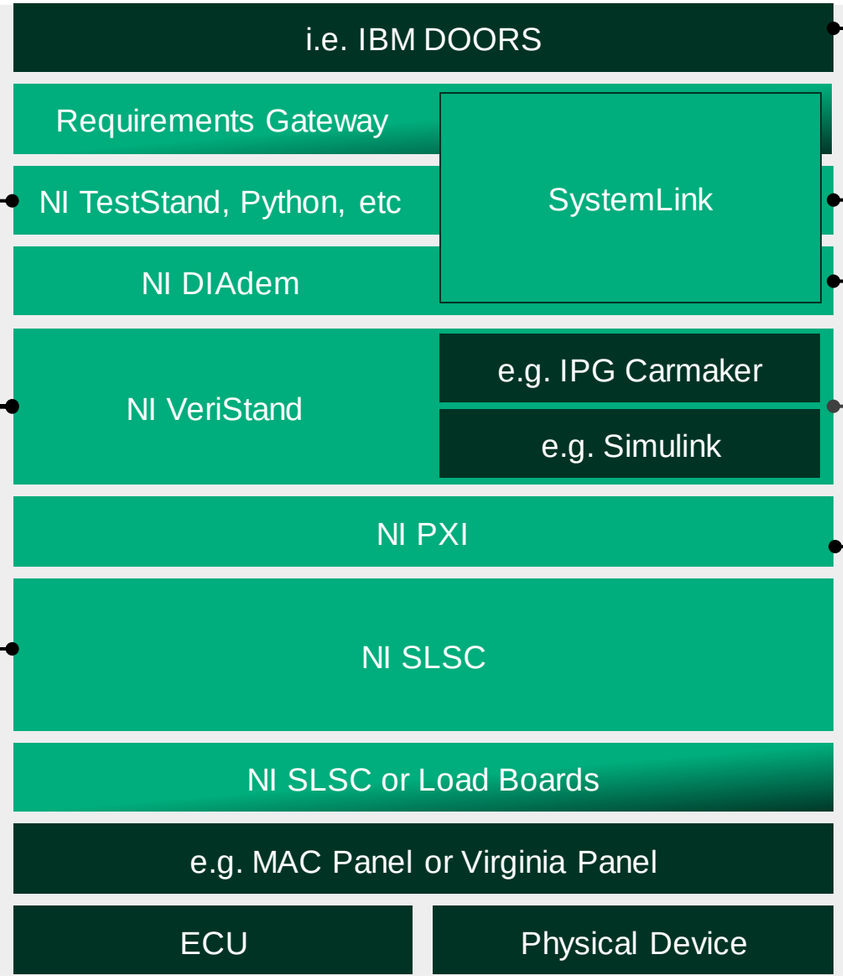
Integration with standards like ASAM XIL, FMI/FMU, OSI and 3rd party systems helps you adapt to changing requirements and lowers the investment risk

Standards

Open Ecosystem

EMERSON | NI

Built Around Openness & Interoperability Standards



ASAM XIL

Interface with HIL Simulators from any vendor through industry standard ASAM XIL test steps

VeriStand Extensibility

Interface with any model, I/O type, or HIL Simulator that has an API

SLSC Open Design

SLSC was designed to be extensible by partners and customers to support unique signal conditioning and load requirements

Public APIs

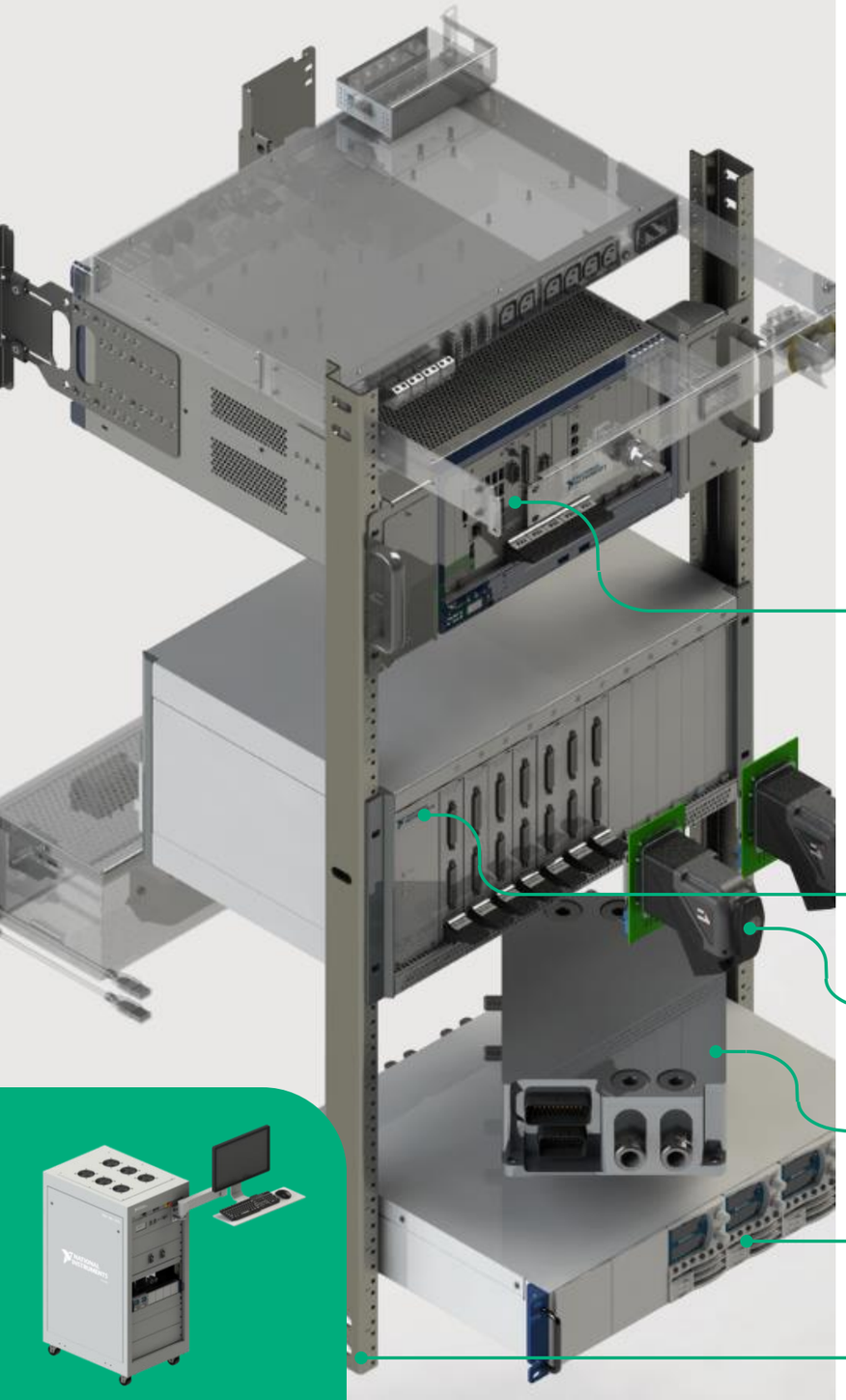
APIs allow integration and automation with a variety of tools you already use

Functional Mockup Interface

Support for the FMI standard to integrate with your existing toolchain

PXI Open Standard

NI I/O hardware is built on the modular PXI open standard to integrate the latest I/O types and processors



NI HIL Test Solution

Customer defined

Flexible and scalable

High performance

Open for integration

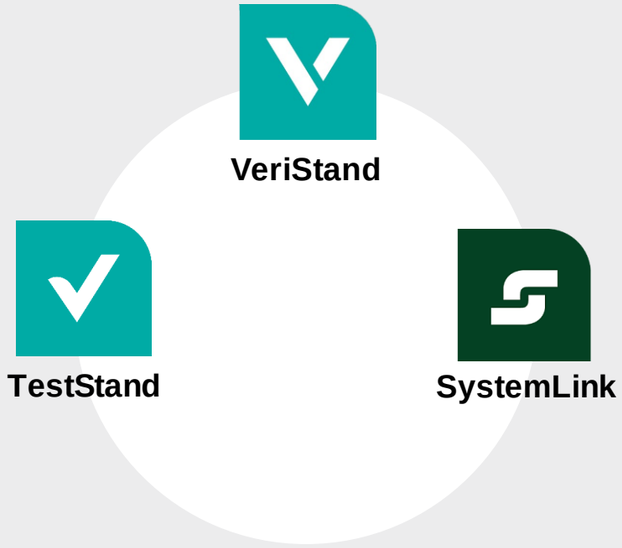
Software	SystemLink – data and system management TestStand – test executive VeriStand – real-time test and model integration LabVIEW – programming and customization
PXI	Measurements and I/O Communications Models in FPGA
SLSC	Switch, Load, Signal Conditioning for fault insertion and routing signal paths.
Connectivity	Cabling references for flexible connections to DUTs
DUT	ECU
RMX	Programmable loads and DUT power
ATE Core Configurations	Test Systems Delivered

EMERSON | NI

SOFTWARE

Key Software for HIL Testing

Enable Automated Test & Measurement Professionals



1	**VeriStand**	Validates hardware and performs embedded software test for HIL with model integration, real-time stimulus generation, and an extensible software environment.
2	**TestStand**	A test executive software that accelerates system development and deployment for engineers in validation and production.
3	**SystemLink**	Streamline lab operations and amplify engineering insights in an integrated, scalable, enterprise solution.

EMERSON | NI

NI HIL Software

VeriStand™

NI's primary HIL tool and core for the HIL platform
Ready to Run Software for HIL
Quickly Configure Systems

Model Integration
Customizability
Test Automation

- vECU Addon
- ADAS Addon
- VCOM Addon
- Power Electronics Addon
- GNSS Addon

Real-Time Modeling Environment Support

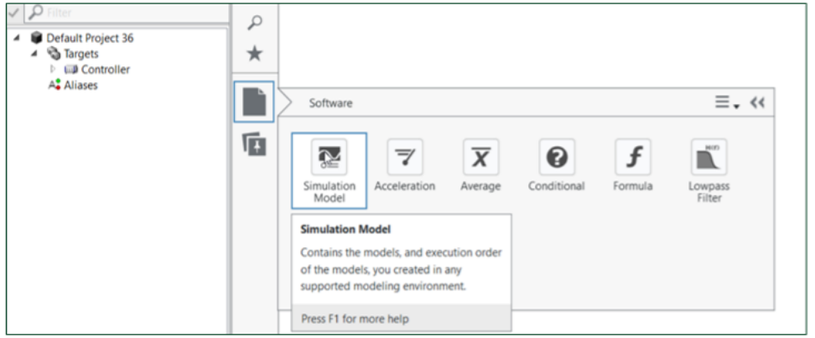
MathWorks Simulink® Software

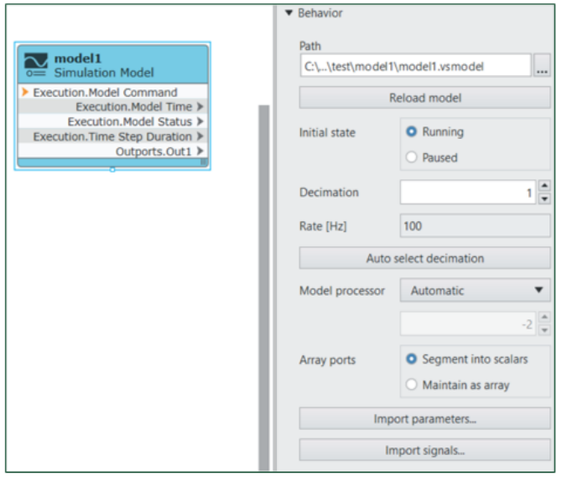
LabVIEW

C/C++

FMI 2.0/3.0 Co-Simulation Support

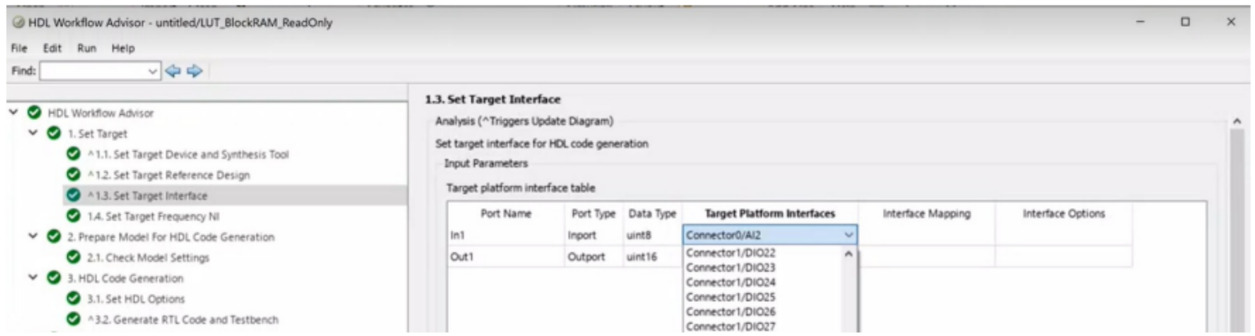
- AVL Boost
- FMU SDK
- Wolfram SystemModeler
- MapleSim
- Altair Activate
- And Can Support More Here



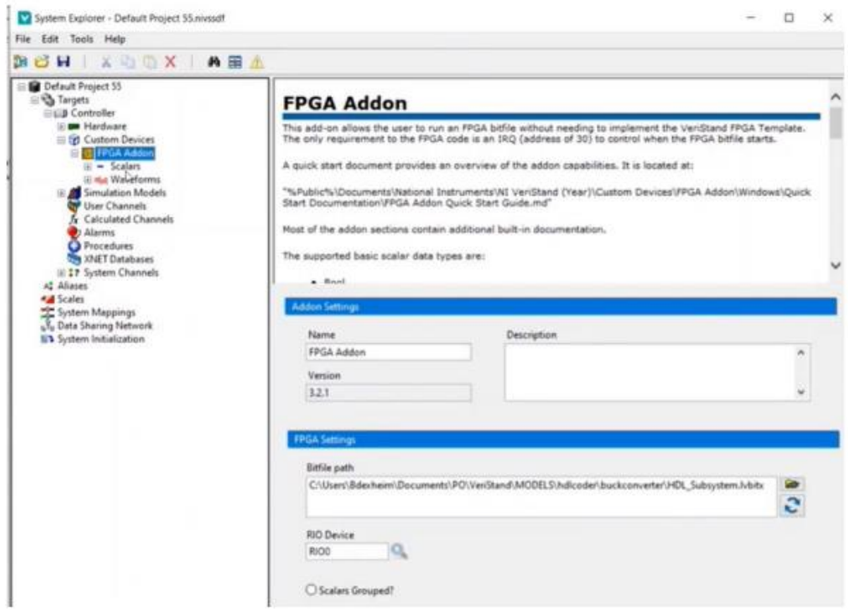


HDL Coder Support Package for NI Hardware

MathWorks HDL Coder



VeriStand™



EMERSON

VeriStand™

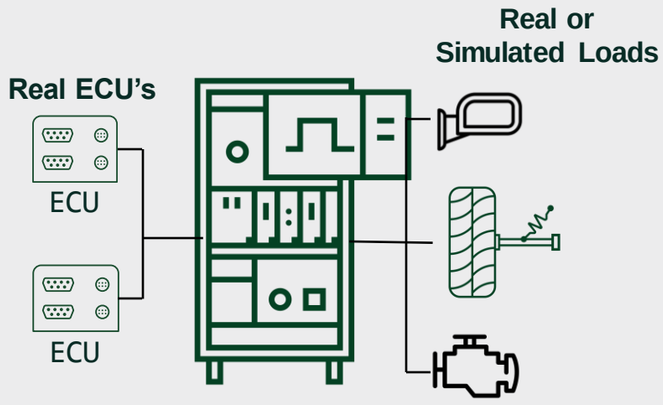
Left Shifting Software Validation

Increase Software Quality, Iterate Faster, Decouple Hardware and Software Validation Workflows

A new software validation approach is necessary for OEM's to succeed in deploying software-define vehicle (SDV) platforms with new electrical architectures and technologies.

Traditional Approach

- **Locks software ECU hardware cycle**
- **Time consuming integration and configuration**
- **Slow response to requirement change**



Seamlessly separate hardware and software workflows

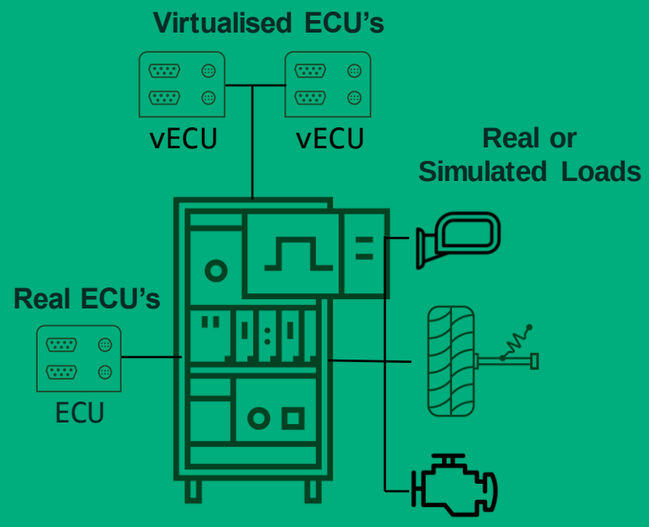
Enable rapid software validation without hardware

Access new talent familiar with modern toolchains

Faster development iteration cycles

Future Approach

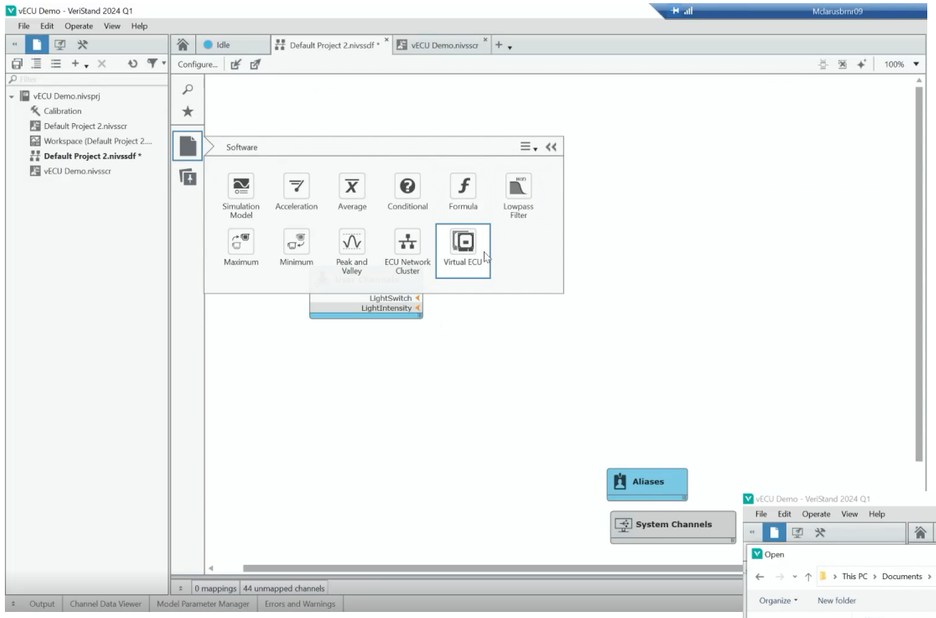
- **Flexible and scalable system for agile software development**
- **Scales via cloud for max availability & efficiency**



EMERSON | NI

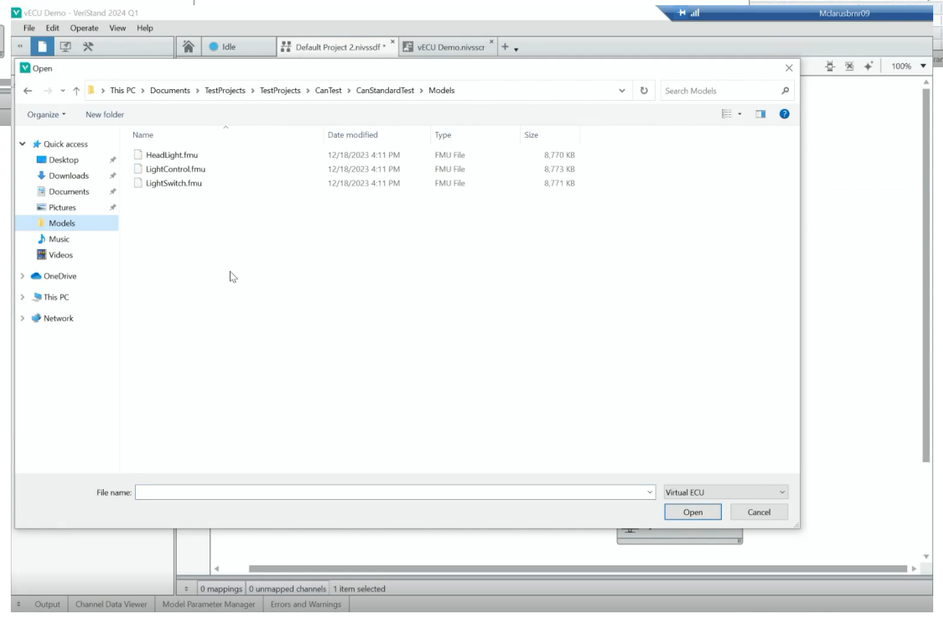
VeriStand™

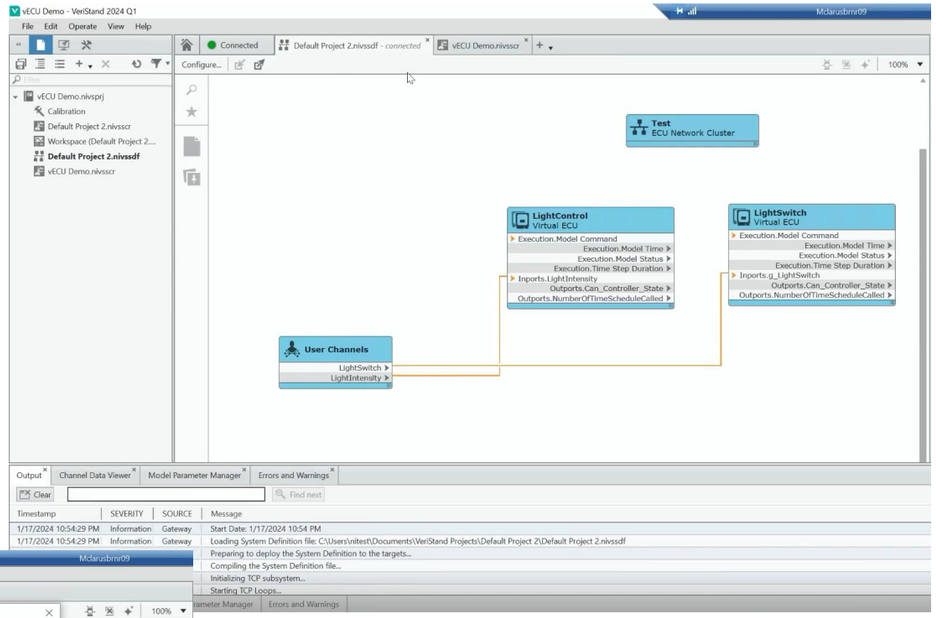
NEW VeriStand Virtual ECU Toolkit



1 **Drop Virtual ECU**

2 **Select Virtual ECU**



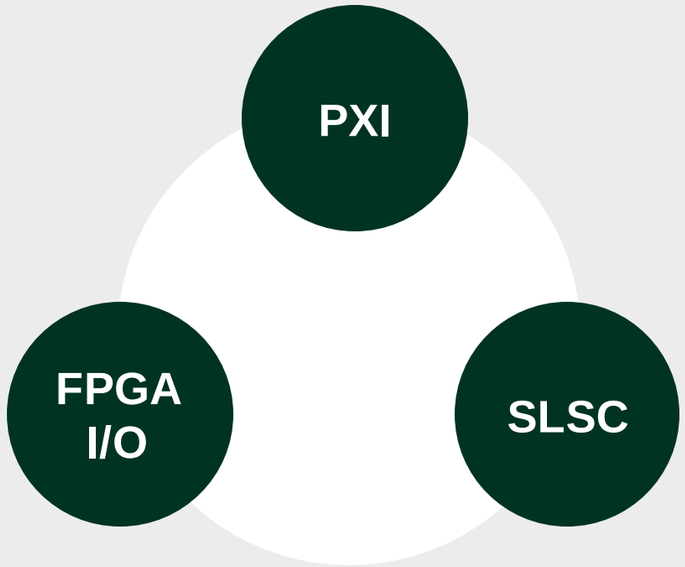


3 **Wire & Deploy Virtual ECU**

EMERSON | NI

HARDWARE

NI HIL System Hardware Architecture



1	PXI	Embedded Controller		Chassis
2	FPGA			
3	SLSC	Chassis		Modules

Advantages of PXI Instrumentation

Flexibility

Modular, Programmable Hardware

Future-proof systems with reconfigurable hardware that can support various measurements and test techniques

Measurement IP

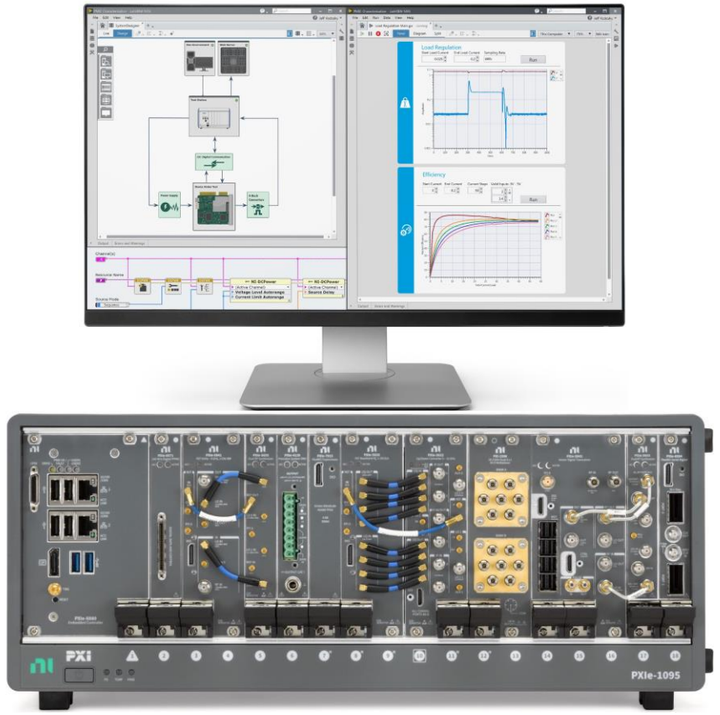
Out-of-the-box Solution

Pre-built IP for advanced battery test techniques, including OCV, ACIR, EIS, HPCD and others

Production Ready

Rugged and Reduced Footprint

Integrate multiple instruments and channel expansion into a single chassis



Software

Systems and Data Management

Integrates with solutions for managing system configuration, remote monitoring, and data aggregation and analysis

Measurement Quality

Accuracy and Repeatability

Industry-leader in repeatable and accurate measurements with a wide portfolio enables the right mix of cost and performance

Timing and Synchronization

PXI Chassis

PCI Express Gen 3 throughput up to 24 GB/s, sub nanosecond latency, P2P streaming, integrated triggering

EMERSON

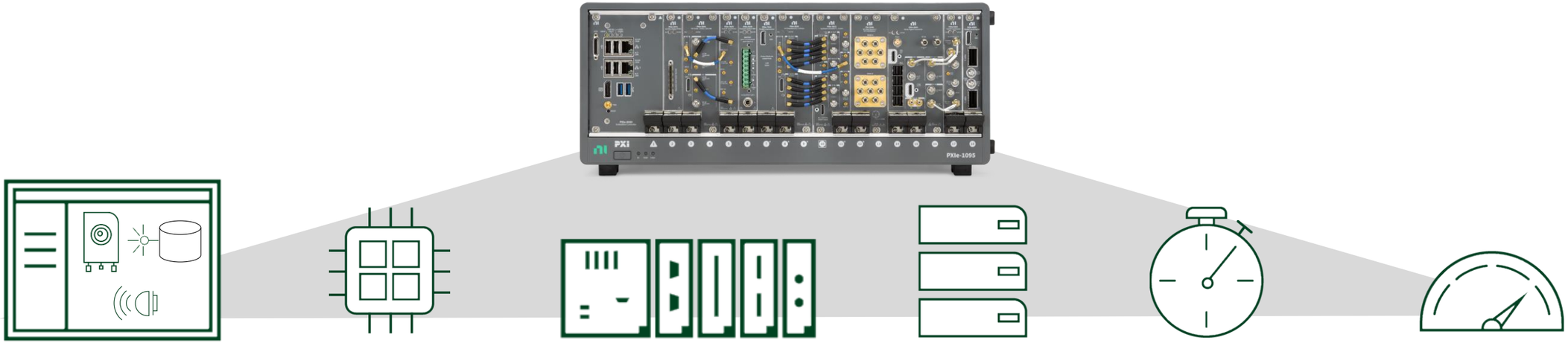
Broad Modular Instrumentation Portfolio

DAQ and Control	Instrumentation	Interfaces
Multifunction I/O	Oscilloscopes	GPIB, USB, LAN
Counter/Timer/Clock	High-Speed Digital I/O	RS232/RS485
Digital I/O	DMM and SMU	CAN, LIN, DeviceNet
Analog Input/Output	Signal Generators	SCSI, Ethernet
Vision and Motion	Switching	VXI/VME
FPGA/Reconfigurable I/O	RF Analyzers and Generators	Boundary Scan/JTAG

EMERSON

Scalability of PXI Platform for Any Application

Scaling to Your Needs – Today and Tomorrow



Component Level — Tester Complexity — Vehicle Level

Modular PXI instrumentation fits in a variety of chassis sizes and can be racked into multi-chassis systems for reuse and flexibility

Switch, Load, & Signal Conditioning (SLSC) for HIL

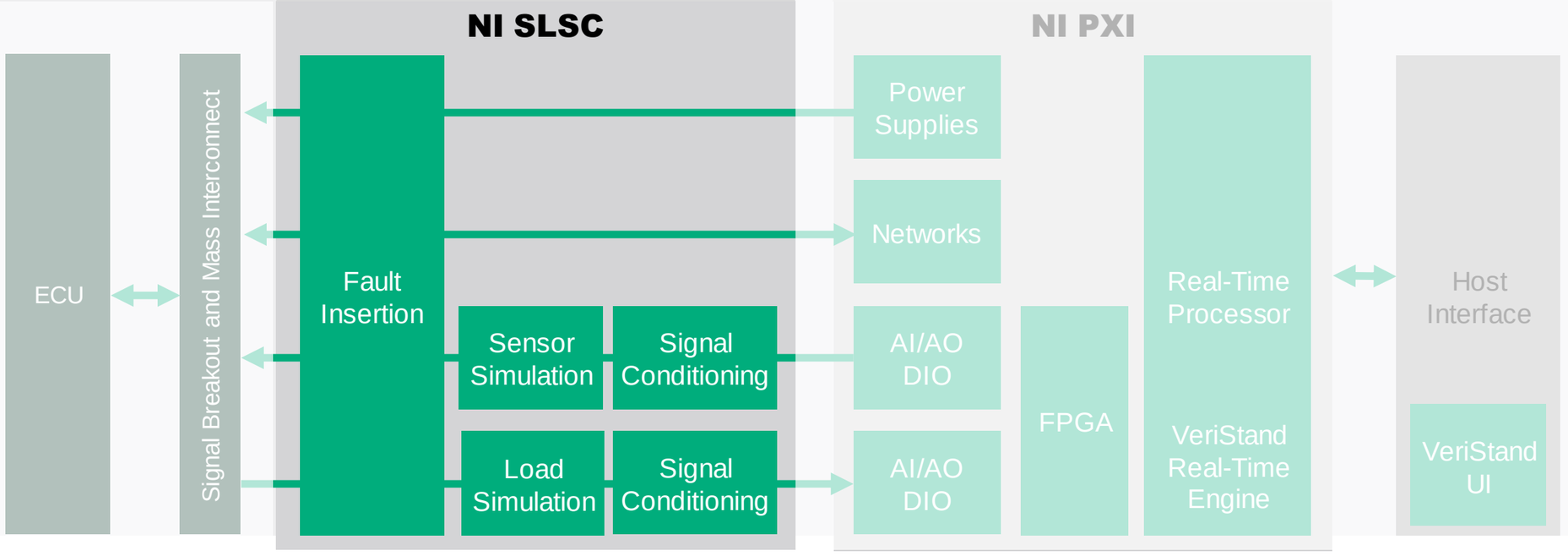
An open architecture for extending NI hardware with **switches, loads, and signal conditioning** targeted at HIL applications.

Enables larger switches for fault insertion

Handles small to medium loads on a simple circuit card

Adds custom signal conditioning

Reduces signal routing complexity



NI HIL System Architecture

EXAMPLES OF COMPONENTS

Communication

PXIe-8510/6
6-ch CAN/LIN
Interface

PXIe-8523
4-Port AETH
1000BASE-T1

PXIe-8517
2-Port FlexRay
Interface

PXIe-8430/8
8-Port RS-232
Interface

PXIe-828x
RDMA over ETH
25 to 50 Gbit
Up to 2 Ports

PXIe-8861/81
Embedded Controller
Windows IoT LTSC
USB, GibE, GPIB, Thunderbolt

Instrumentation

PXIe-78xx FPGA
Kintex 7, Vertix 5,
AI: up to 16ch & 1MS/s
AO: up to 24 ch & 1MS/s

PXIe-148x Camera
GMSL2/3,
FPD-LINK III/IV
up to 4in/4out, 8in, 8out

PXIe-41xx SMU
1 to 24-ch,
6 to 200V,
up to 3A

PXIe-4322 AO
8-ch, Analog Output
Ch-Ch Isolated,
16V, 250kS/s/ch

RMX-4102
400W (20V, 20A)
Power Supply

RMX-4104
800W (36V, 24A)
Power Supply

Load/ Pin Switch/ Fault Insertion

SLSC-12251/52 FIU
16-ch, 8A / 8-ch, 30A
Load Switch, FET with
Current Measurement

SLSC-12201/02 FIU
32-ch DIO, 33V
32-ch DIO, 60V

AL-3010/11 Resistor
16-ch, 60V, 110mA
10 to 8 MOhm

AL-4010 Batt Cell Sim
6-ch (6 battery cells)
Cell Vol Range: 0-7V,
Curr Load Range: ±2A

OP-8935
8-ch AI, 8-ch AO, ±20V
with Fault Insertion

Desktop HIL

Component / Sub-System HIL

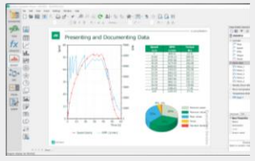
System Integration HIL

Software

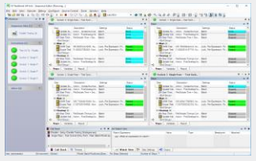
NI Software Toolchain for Software Validation

VeriStand

DIAdem



TestStand



SystemLink

EMERSON

xMOVE

I/O Flexibility and Reconfigurability

xMove-based HIL approach provides flexibility based on standard components

Modularity at both I/O board and sub-system (I/O Box) levels

Flexibility as operational advantage to evolving requirements

Scalability maximizes test coverage from component to system level validation

Reconfigurability of signal type on pin level through software

Can be packed (custom-design) into a small cabinet

EMERSON

COTS Test System

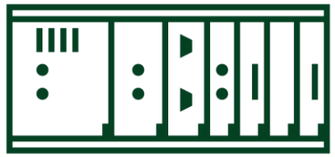
Re-Configurable
Scalable
Customizable
Hardware & Software

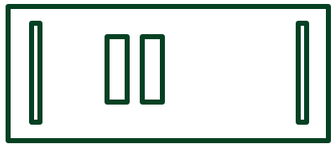
COTS xMOVE Sub-System

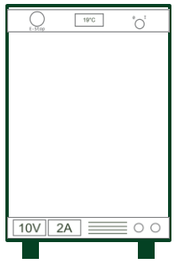
Re-Configurable
Scalable
Customizable
Mass Interconnect

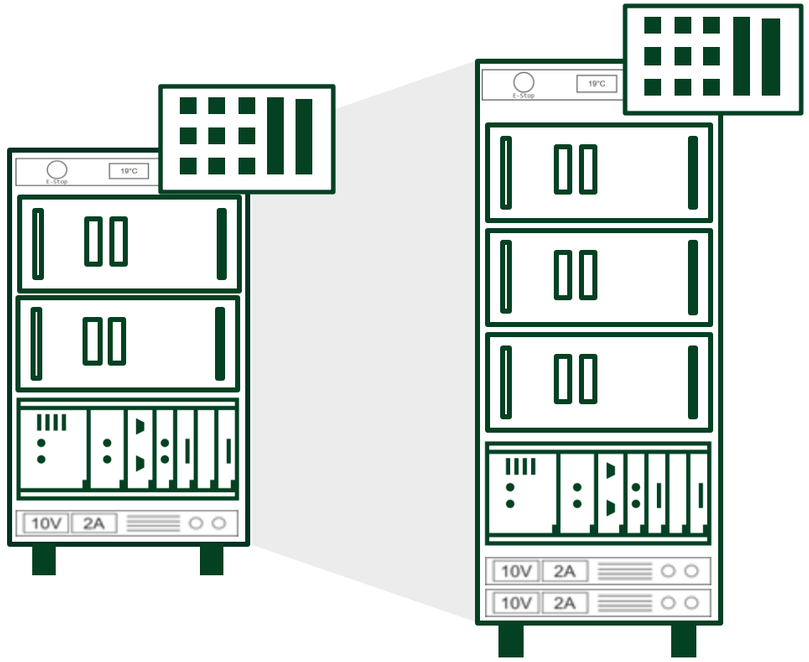
COTS Test Infrastructure

19” Rack 24U, 40U
Power Supplies
E-Stop
Power Distribution





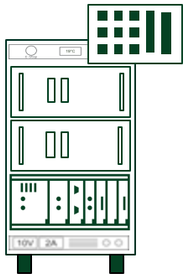




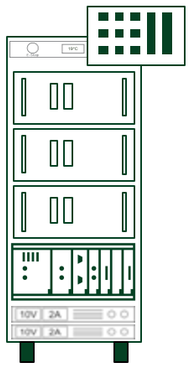
COTS Test (Rack) Solutions

Configurable | Scalable | Customizable | Hardware & Software

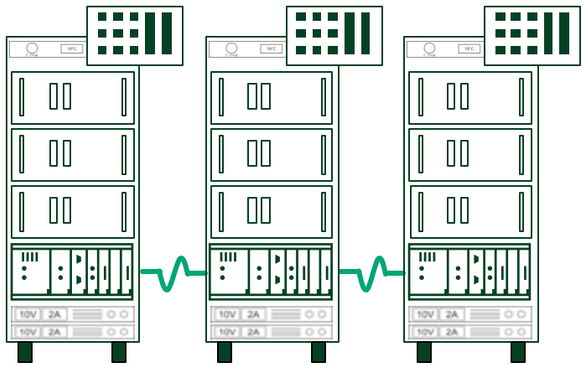
Desktop HIL



Component HIL



Sub-System HIL

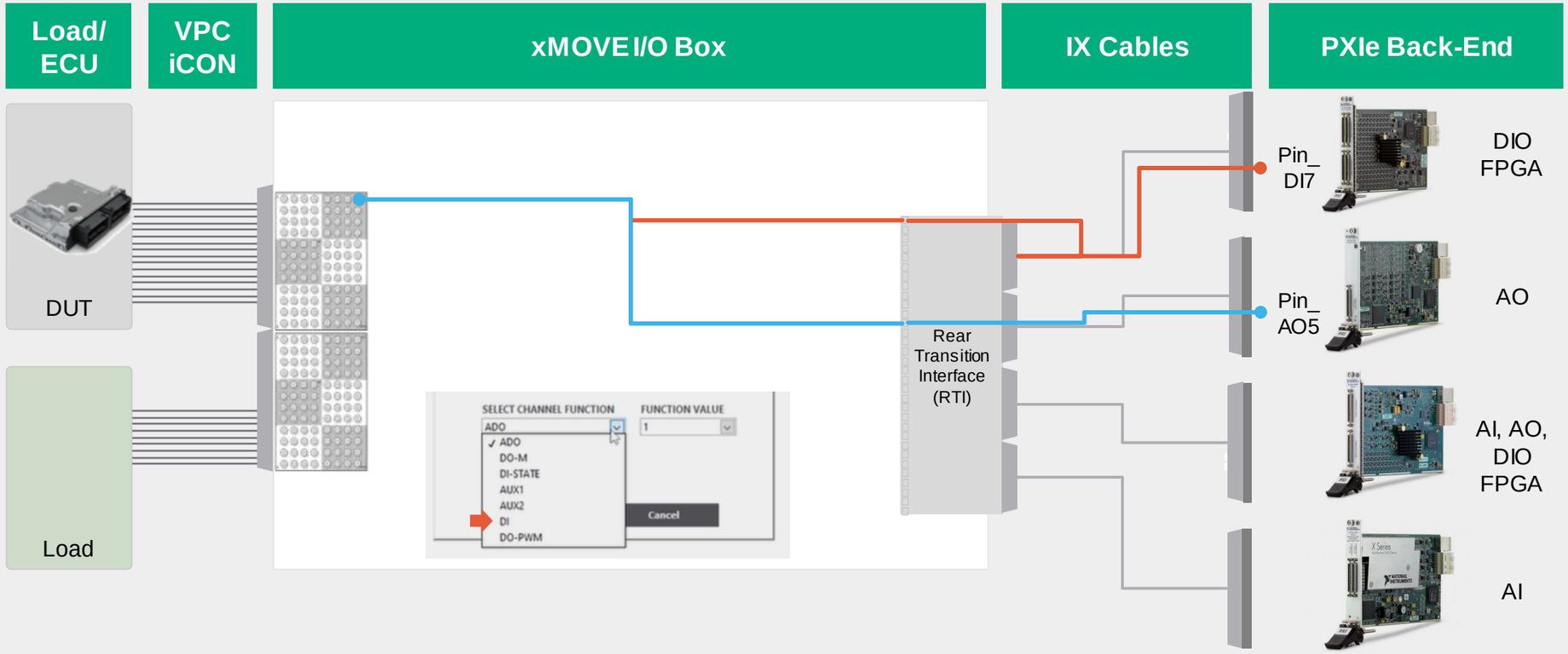


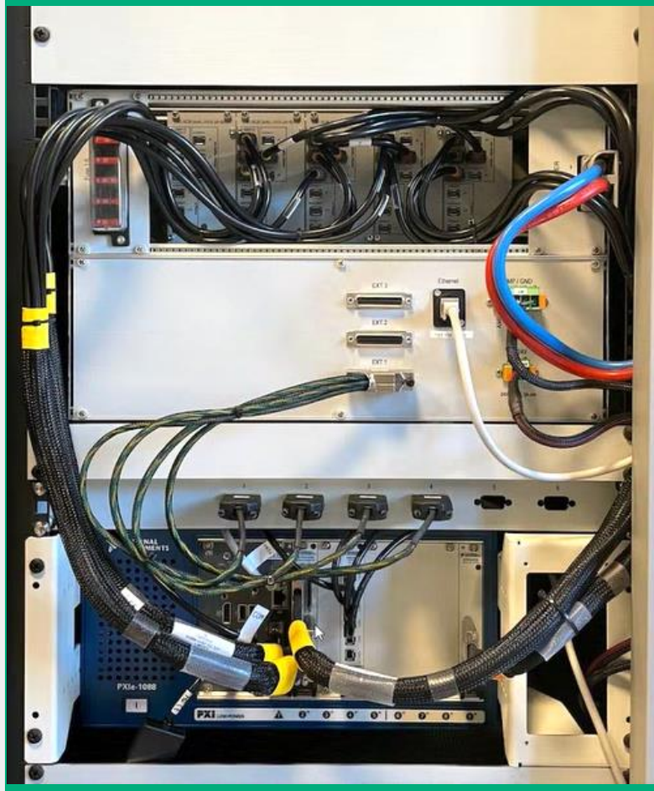
System Integration HIL

xMove is registered trademark of ALIARO Group

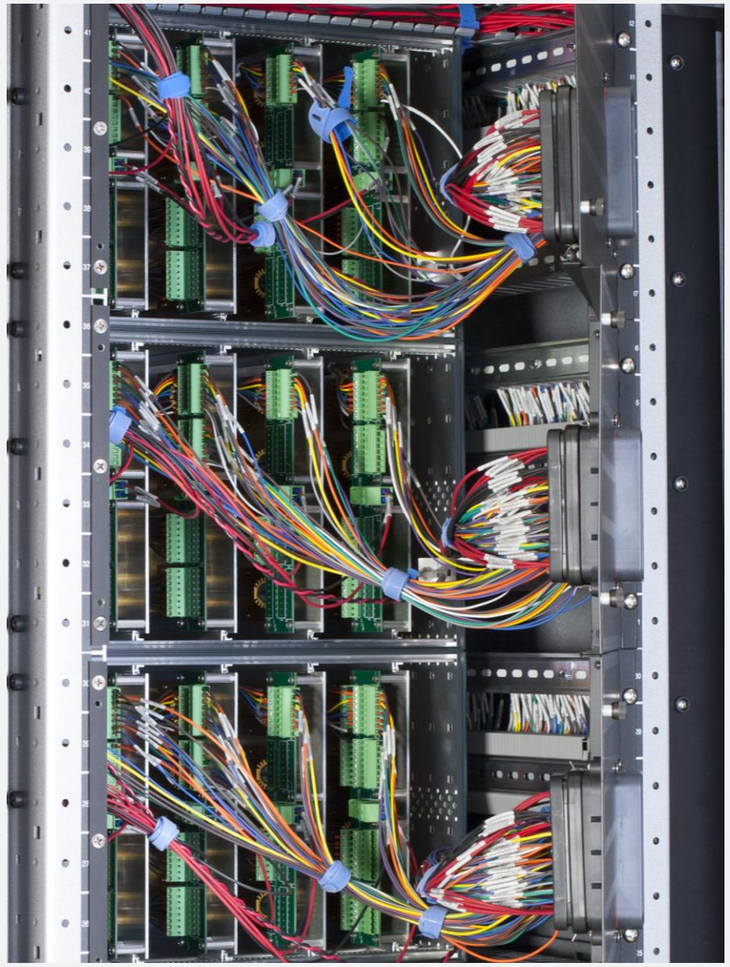
Signal Path Flexibility without the Need for Rewiring

Defined in smart Software and executed in flexible Hardware

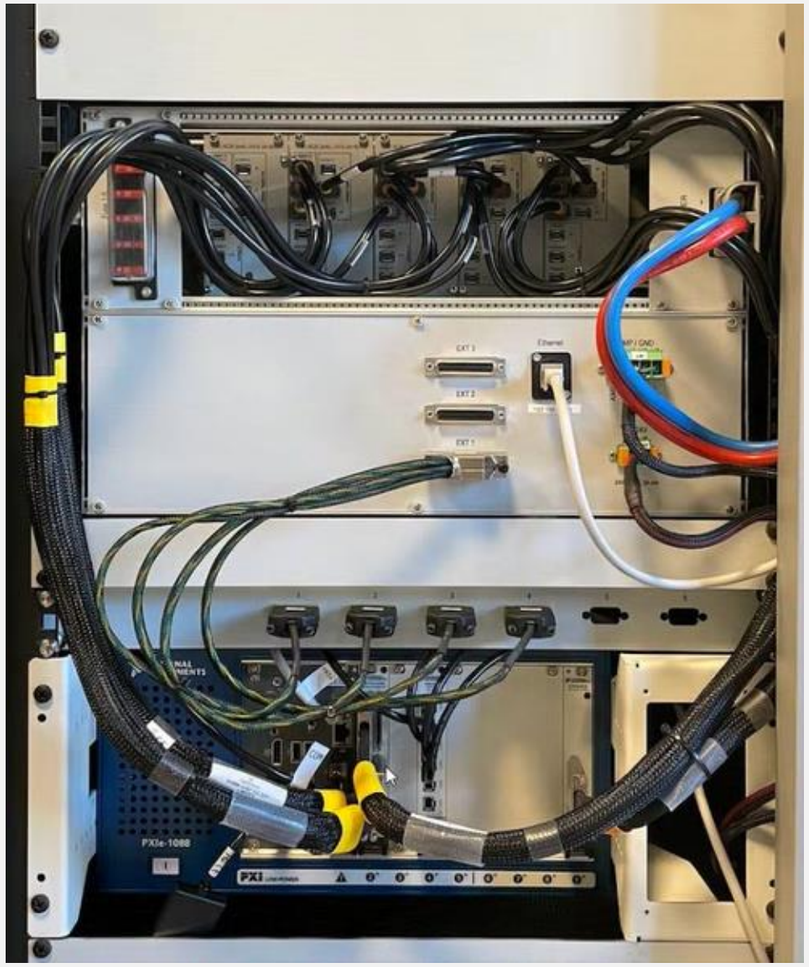




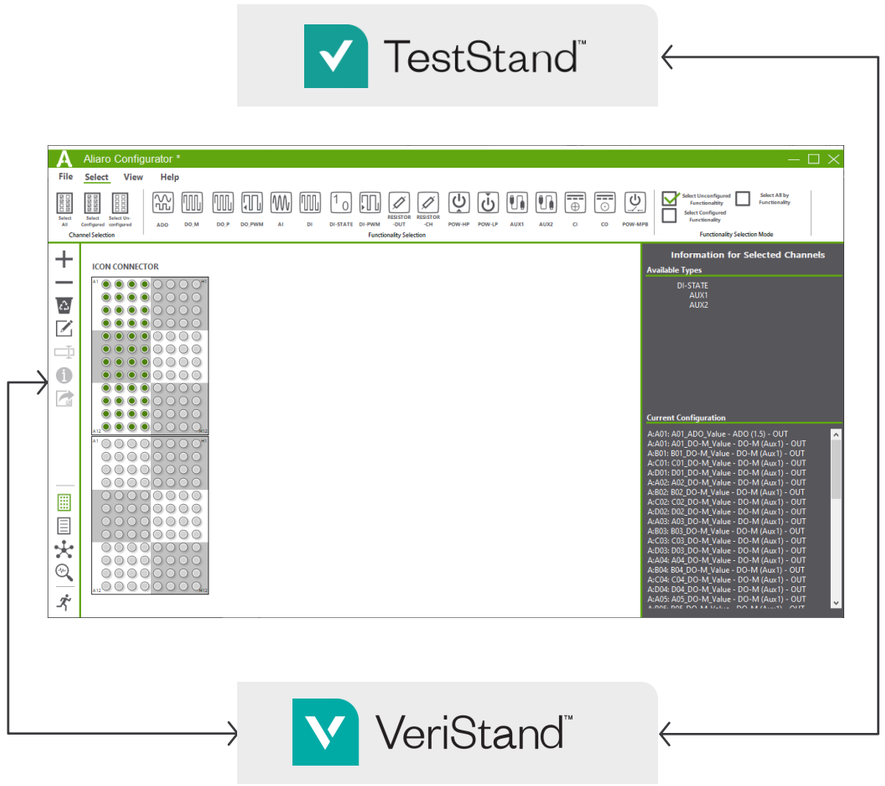
Traditional HIL Systems

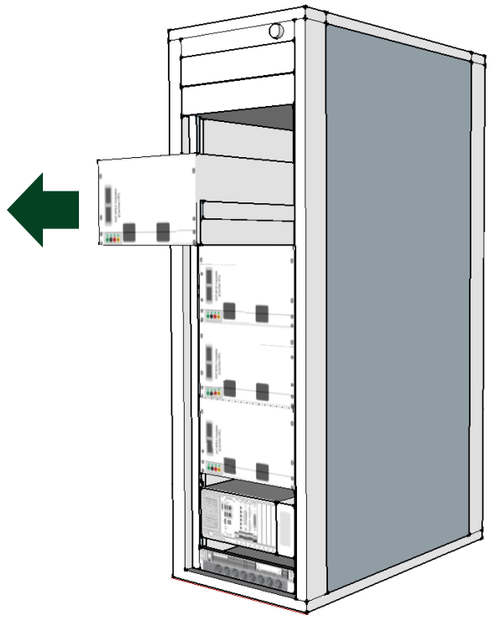


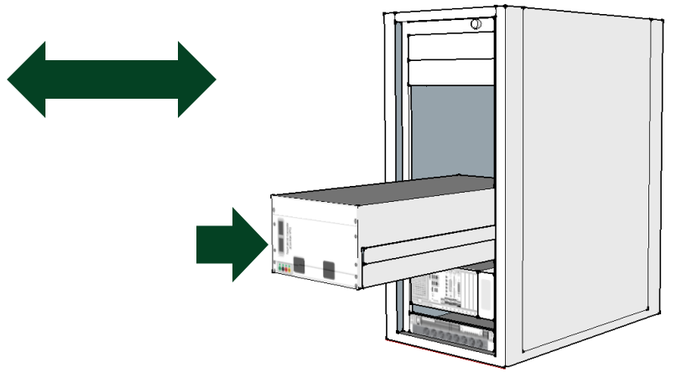
Aliaro xMOVE Platform



Software Based Configuration of the Test Systems







Sub-System HIL

Pre-defined system definition file for Sub-system HIL + xMove Configurator for setting signal types on PIN level do create unique setup

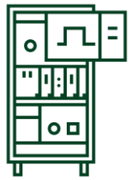
System HIL

Pre-defined system definition file for System HIL + xMove Configurator for setting signal types on PIN level unique setup ***(Merging the system definition files to create system HIL)***

NI Performance Advantage

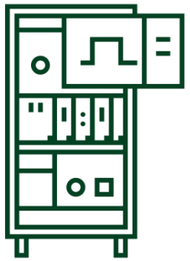
MODULARITY → **VIRTUALISATION** → **SCALABILITY**

Start with base component configuration



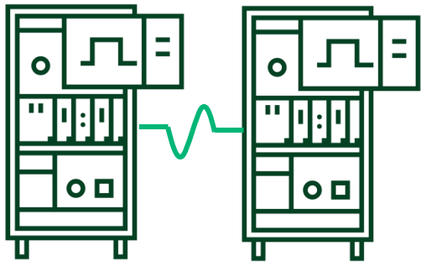
COMPONENT HIL

Add modules when needed for sub-systems



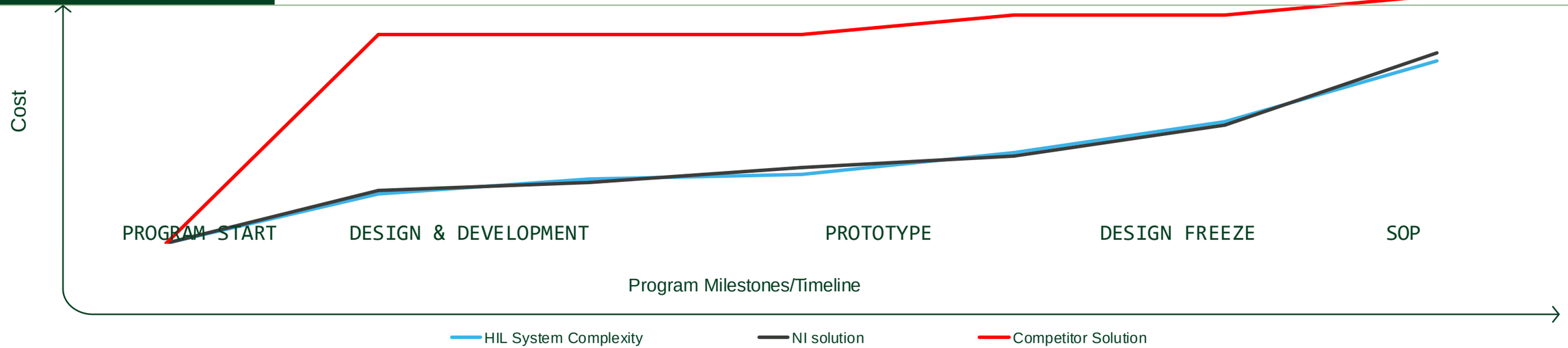
SUB-SYSTEM HIL

Enhance and replicate HIL for complete system validation



SYSTEM INTEGRATION HIL

Total Cost (NI)	$	$$	$$$
Incremental Cost (NI)	-	$	$
Total Cost (Competitor)	$$$	$$$	$$$$
Incremental Cost (Competitor)	-	$	$



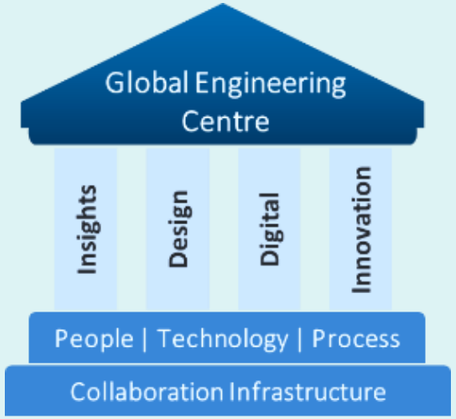
TATA ELXSI

EV – Bi-directional On Board Charger

Date: 22 May 2024

Tata Elxsi Business Overview

Home to a Billion Possibilities



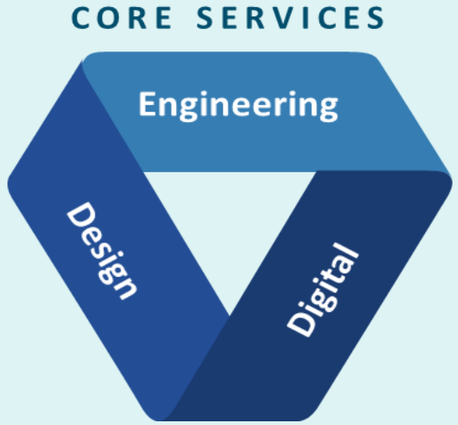
34+ Years in Business

13200+ Strong Engineers

Annual Revenue **$400** Million FY '23

13% YoY Growth FY'24

33 Cities Worldwide



Transportation

AUTOMOTIVE | OFF HIGHWAY

- User Experience
- Connected & Autonomous
- Electrification

AEROSPACE | MARINE |RAIL

- Embedded & Industrial
- Service design
- Rolling Stock

Media & Communication

BROADCAST & MEDIA

- OTT Streaming
- RDK, Android TV, CPE
- QoE, QoS, Customer Experience

COMMUNICATIONS

- 5G, SDWAN
- Network Transformation
- Digital Transformation

Healthcare

MEDICAL DEVICES

- Product Design
- Systems Engineering
- Regulatory Compliance

PHARMACEUTICALS

- Safety
- Packaging & Labelling
- Pharmacovigilance

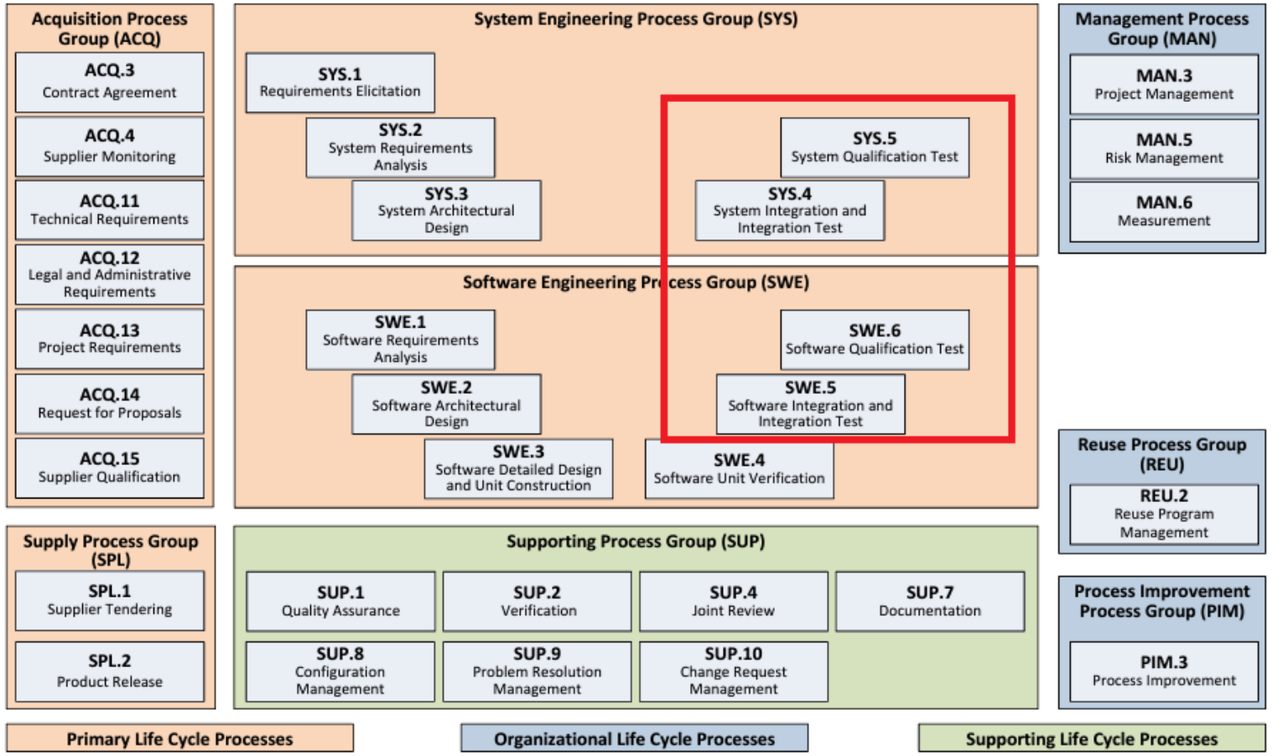
Established 1989 **Global HQ Bangalore**

Overview

As the industry moves towards a Shorter Product Development Life Cycle, verification and validation of software or systems are required at the early stages of the life cycle. This helps to find bugs early, which significantly reduces cost and time.

ASPICE (Automotive Software Process Improvement Capability dEtermination) provides a structured approach to defining, developing, and testing an automotive system.

Case Study: Software and System testing of an On Board Charger ECU, compliant with the ASPICE process.



Automotive SPICE process reference model - Overview

Courtesy: https://vda-qmc.de/wp-content/uploads/2023/02/Automotive_SPICE_PAM_31_EN.pdf

Overview of On-Board Charger (OBC)

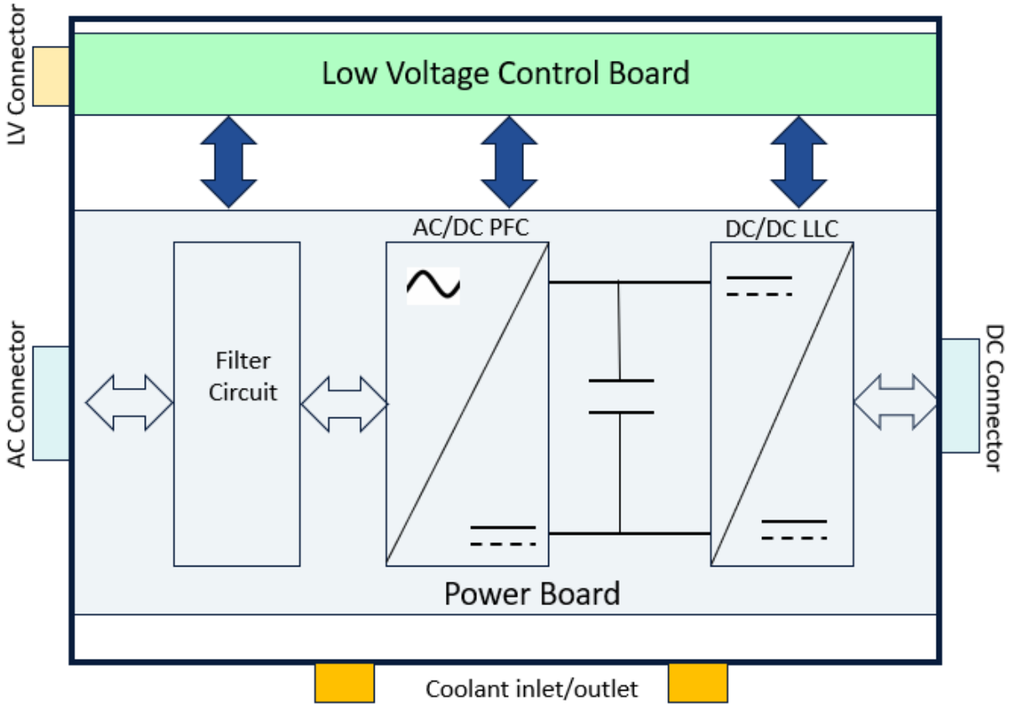
DUT Specifications

- 800 V Bidirectional OBC
- 2 variants:
  - Single phase 19.2kW
  - Three phase 22kW

Tata Elxsi Responsibilities

- Test Environment Setup – Hardware, Software, and test framework
- Analyzing the requirement and creation of Test cases
- Test Automation
- Test Execution, Data Analysis, Test report generation

OBC System Architecture



Scope of the project

Software and System Testing of OBC

SWE.5 : SW Integration Testing - (NI based LV Test System)

SWE.6 : SW Qualification - (NI based LV HIL + HV HIL)

SYS.4 : System Integration Testing - (NI based LV HIL + HV HIL)

SYS.5 : System Qualification - (NI HV HIL)

HIL and Test Benches

SW Integration Testing

SW Qualification Testing

System Integration Testing

TATA

TATA ELXSI

System Qualification Testing

Software Tests and System Integration Tests

SWE.5 & SWE.6 – SI and SQ Testing

The Software Integration Test is to verify the individual elements of software architecture.

The testing assesses the interfaces, dynamic behavior, and resource consumption, aligning with the Software Architectural Design (SWE.2).

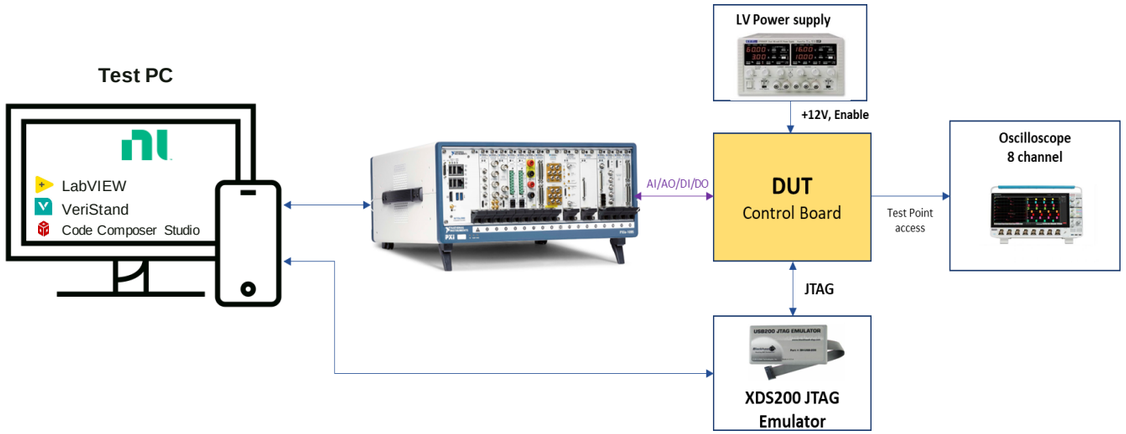
The Software Qualification Test is to verify that the integrated software meets the specified software requirements (SWE.1).

SYS.4 – System Integration

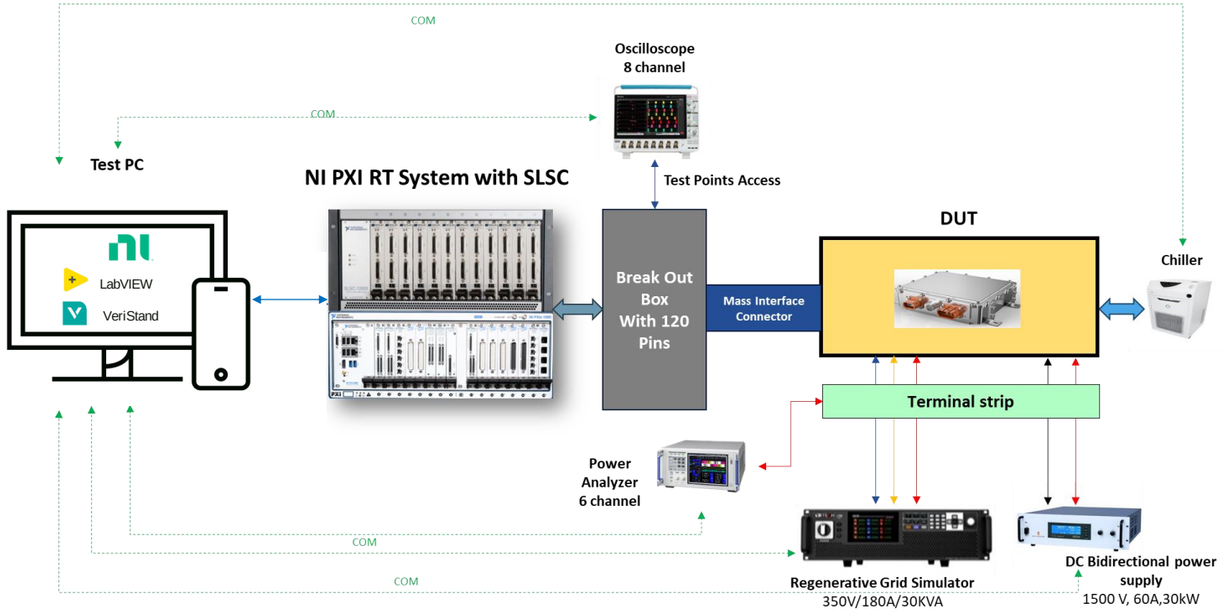
The primary focus of the System Integration Test is to verify that the integrated hardware and software meet the system architecture design (SYS.2).

The testing is performed at both power and signal levels by monitoring the board level signals and SW variables.

Signal Level Validation : LV HIL



Power Level Validation : HV HIL

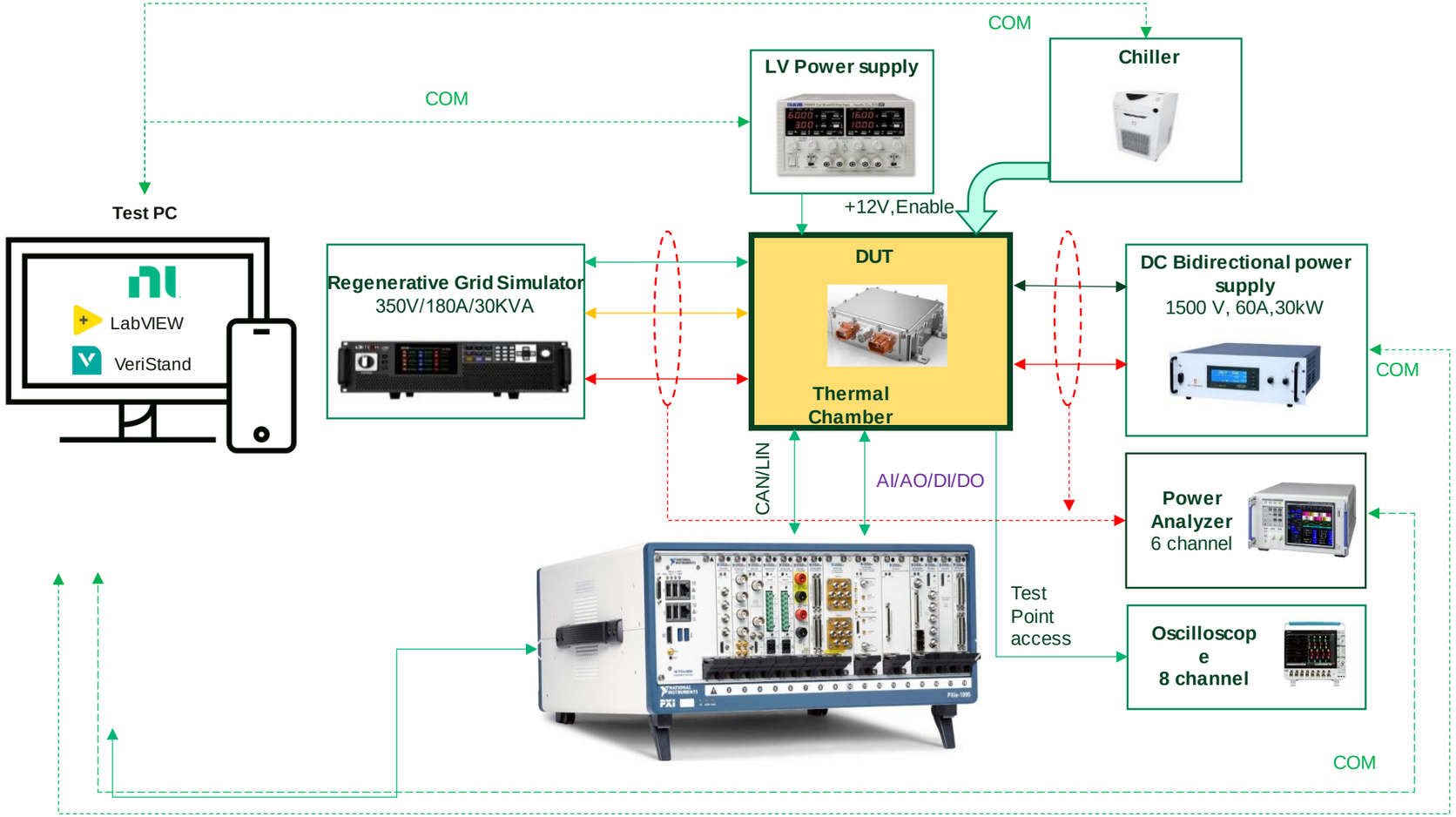


SYS.5 : System Qualification test

The primary focus of the System Qualification Test is to verify the DUT is functional as per the system requirements SYS.2.

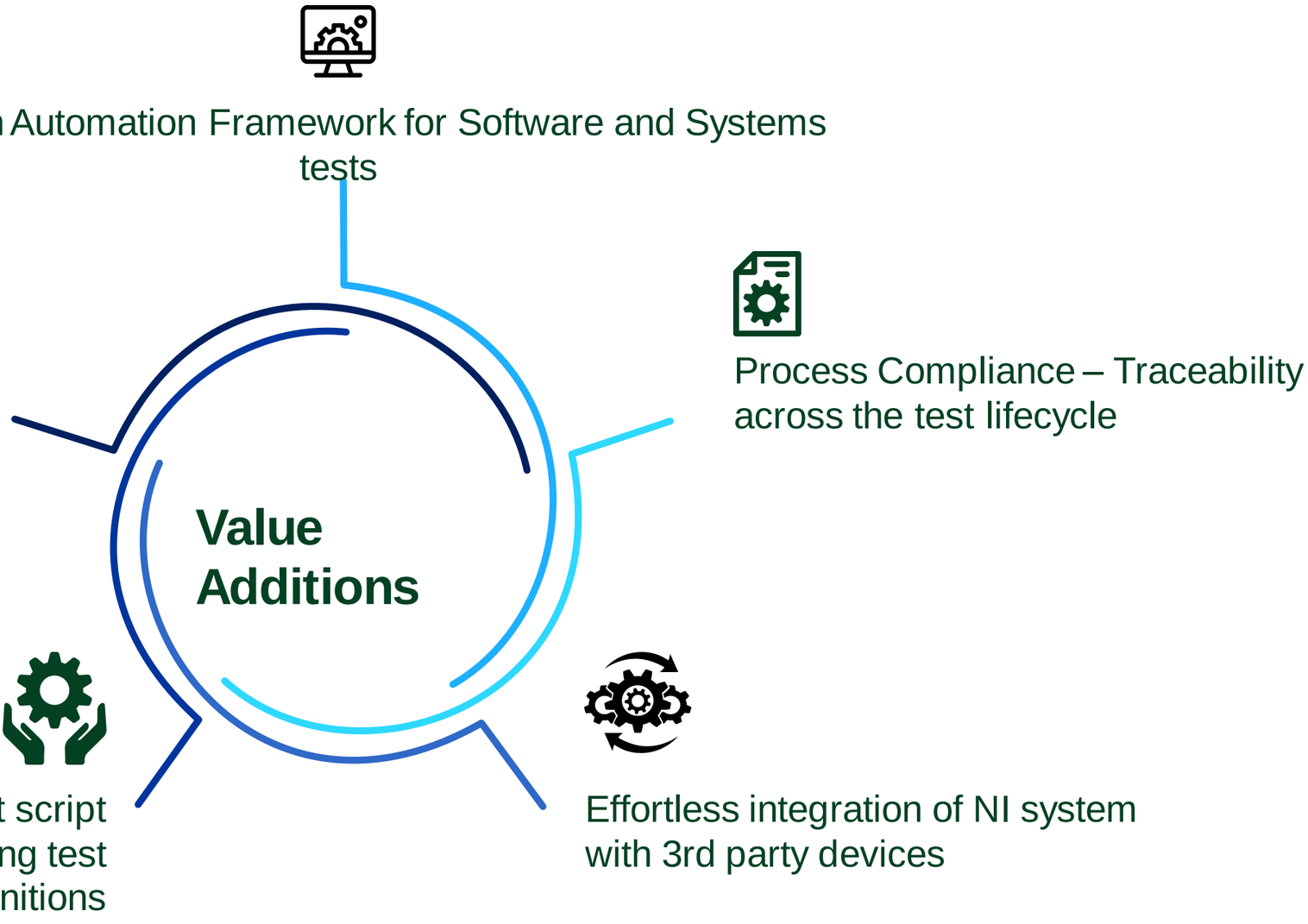
Features functionality:

- PFC Monitoring and Control
  - Forward Charging
  - Reverse charging
- HV DCDC Monitoring and Control
- LV System Monitoring and Control
- Power Modes
- HV safety
- Diagnostics



Power Level Validation : HV HIL

Value Additions



THANK YOU

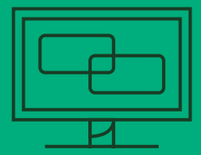
TATA ELXSI

FIND OUT MORE

www.tataelxsi.com

The NI HIL Advantage

Software



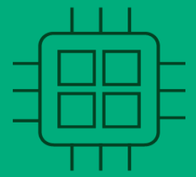
MODEL INTEGRATION

Execute power electronics, motor, and vehicle dynamics models across desktop, real-time, and FPGA compute paradigms in a single platform

VeriStand

MathWorks Collaboration

Technology



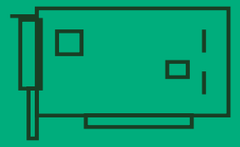
ADVANCED COMPUTING

Test with higher fidelity through high-speed deterministic execution of parameterized and configurable models in I/O connected FPGAs

LV FPGA

OPAL-RT Partnership

Equipment



I/O BREADTH

A broad range of I/O ensures you can meet the test requirements of advancing technology

PXI

SLSC

Operations

CUSTOMIZABILITY

A customizable, open platform lets you adapt to changing requirements and lowers the risk of purchasing a system

Modular I/O

Flexible Software

Integration

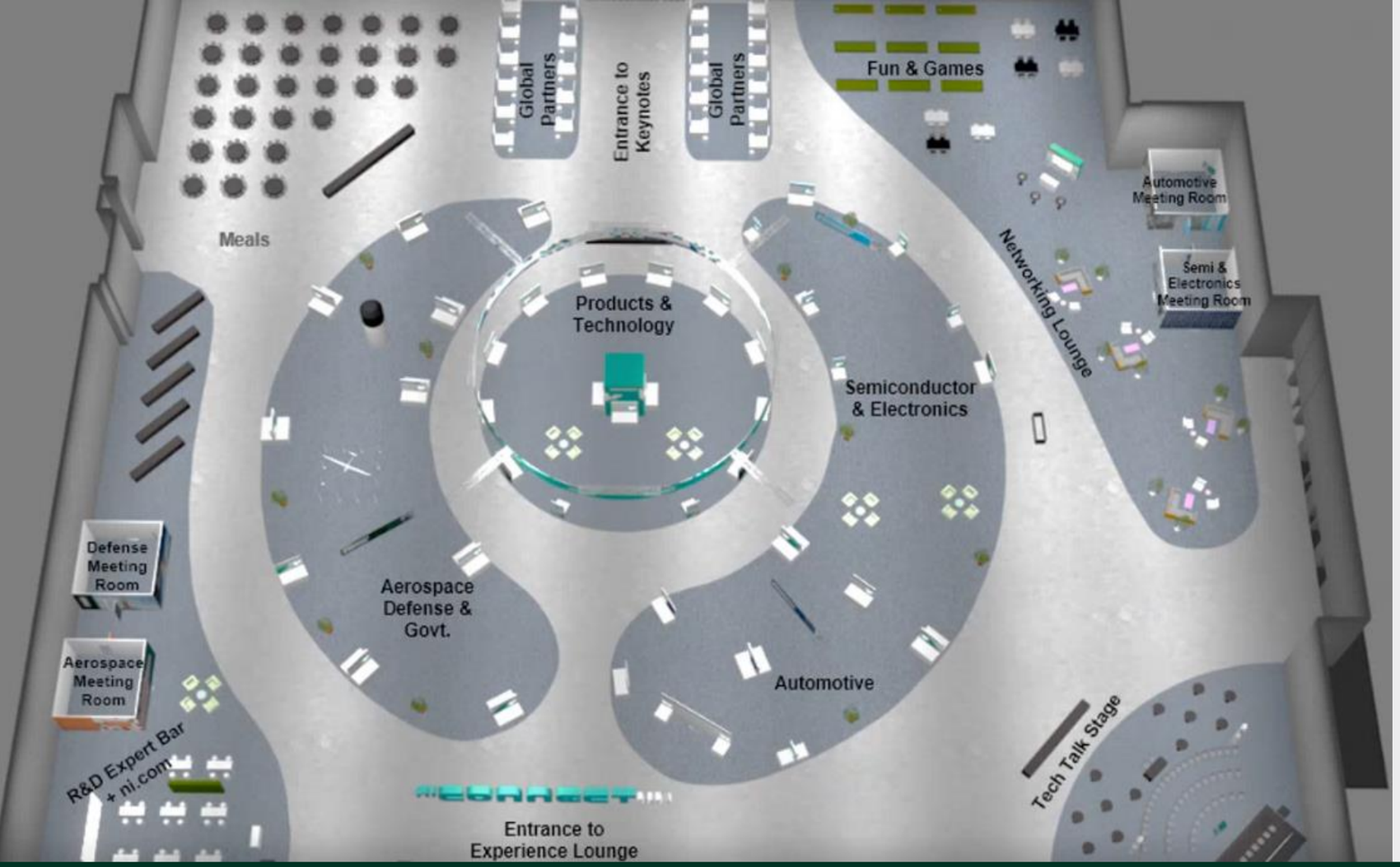
INTEGRATION

Integration with standards like ASAM XIL, FMI/FMU, OSI and 3rd party systems helps you adapt to changing requirements and lowers the investment risk

Standards

Open Ecosystem

EMERSON | NI



Visit HIL 4 X Demo in the Expo Center

For more Information Contact:
Austin/Brian/Luis/Ritesh

EMERSON | NI