Solving Test Challenges for Satellite Avionics and Power Electronics

NI Connect 2023

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Electronic System Test

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Agenda

Space Industry Trends and Challenges

Satellite Avionics and Power Electronics

NI Solution for Satellite Test

- Hardware
- Software

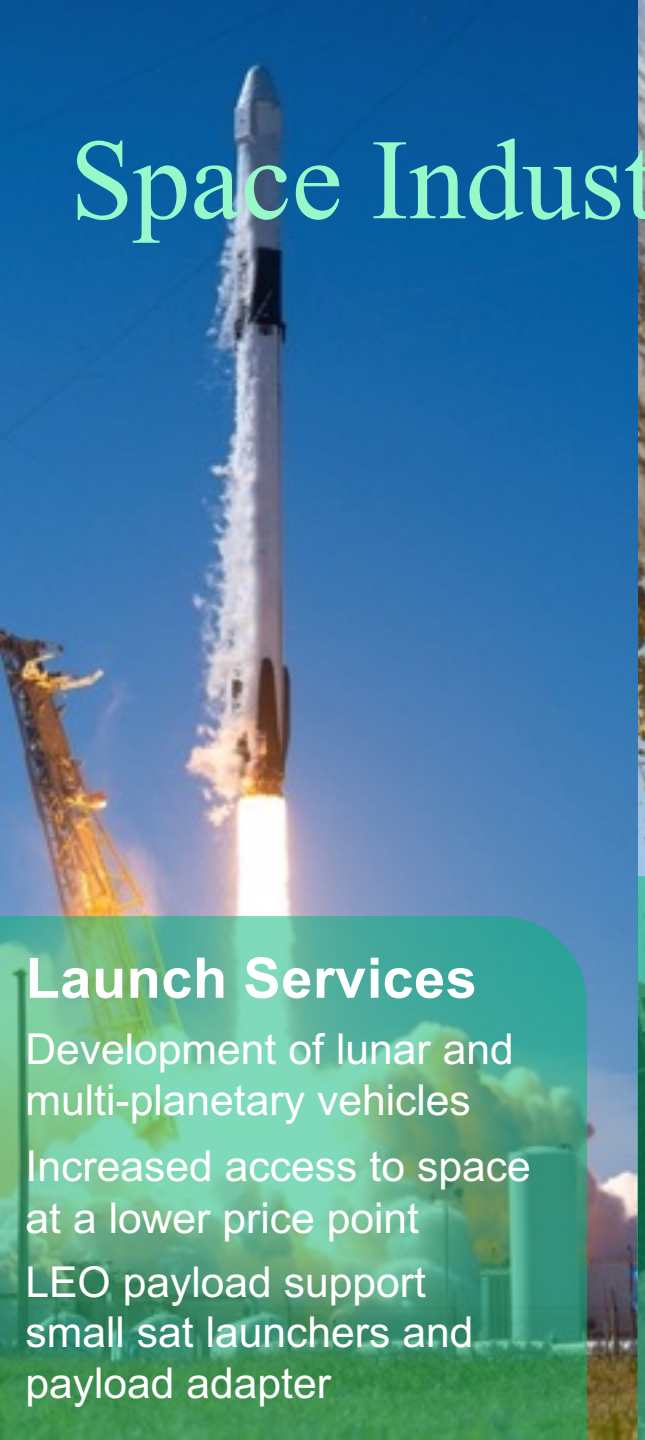
Benefits of NI for Satellite Test

2022 Space Highlights

Successful deployment of James Webb Space Telescope
Spacecraft impact and asteroid deflection with the DART mission
Successful Artemis I mission: SLS and Orion programs
Starlink deployment in Ukraine
186 launch attempts in 2022, 180 reached orbit

“2022 will go down in the history books as one of the most accomplished years across all of NASA’s missions,” - Bill Nelson
NASA Administrator

Space Industry Trends

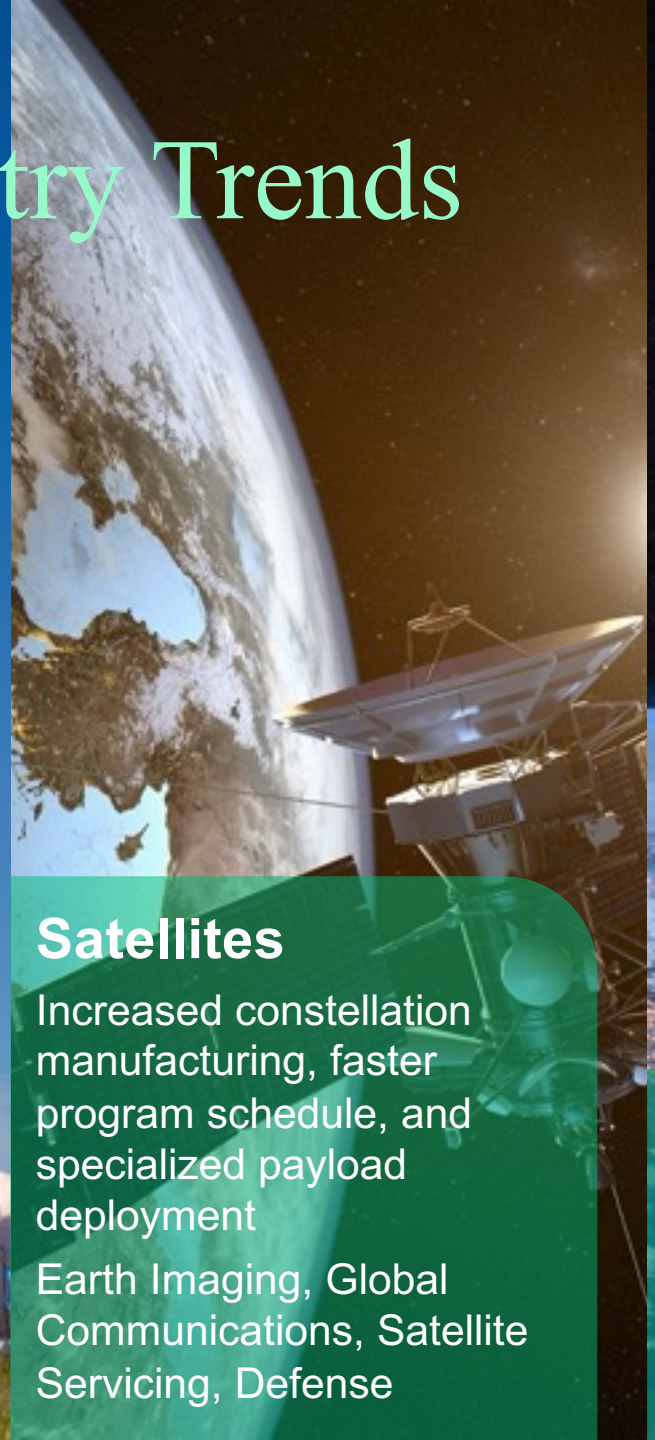


Launch Services

Development of lunar and multi-planetary vehicles

Increased access to space at a lower price point

LEO payload support small sat launchers and payload adapter



Satellites

Increased constellation manufacturing, faster program schedule, and specialized payload deployment

Earth Imaging, Global Communications, Satellite Servicing, Defense

Space Habitats

Growth of LEO Economy

ISS Decommission in 2030

Multiple Commercial Space Stations in Development

Ground Segment

Multi orbit and multi frequency ground station support

Cyber considerations for critical infrastructure

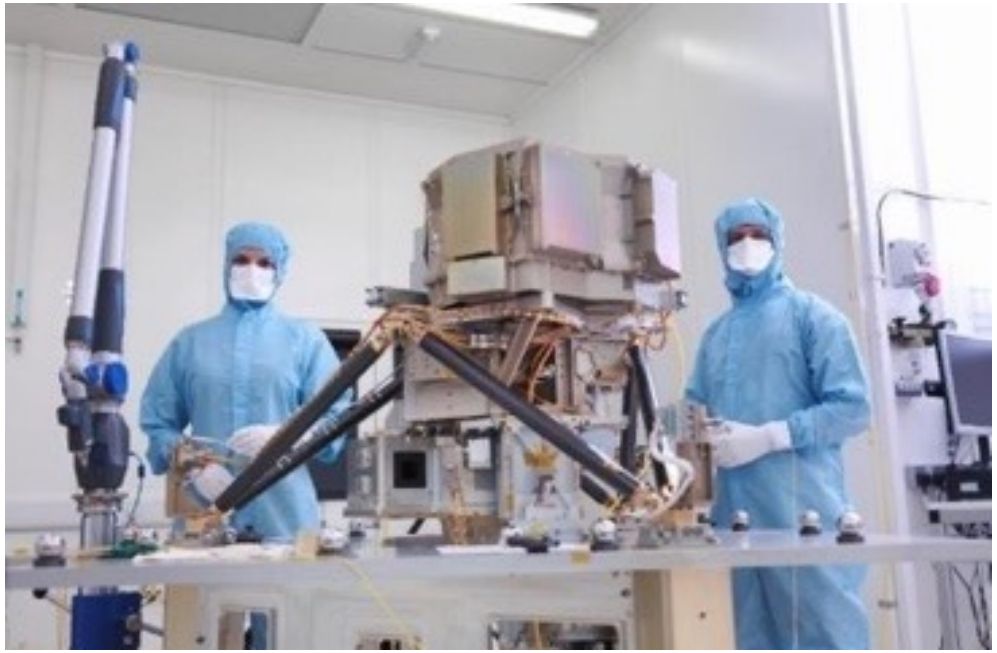
Space Industry Challenges

Market Challenges

- Increased customer cost pressure
- Increasing market competitors and investment from competition
- Time to market and customer delivery pressure
- Personnel bandwidth capacity and expertise recruitment

Technology Challenges

- Scaling production volumes
- More complex payloads
- HW quality and reliability
- More software and autonomy
- Digital engineering



NI Space Application Areas

Launch

Avionics HW Test

HIL and Integration & Test

TT&C, FTS, and RF Components

Launch Operations

Engine Test

Electronic Ground Support Equipment

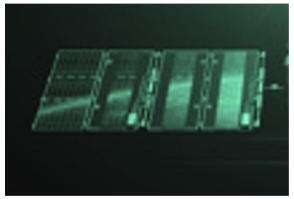
Environmental, Structural, and Mechanical Test

Satellites

Avionics HW Test

HIL and Integration & Test

TT&C, RF Comp., Channel Emulation,



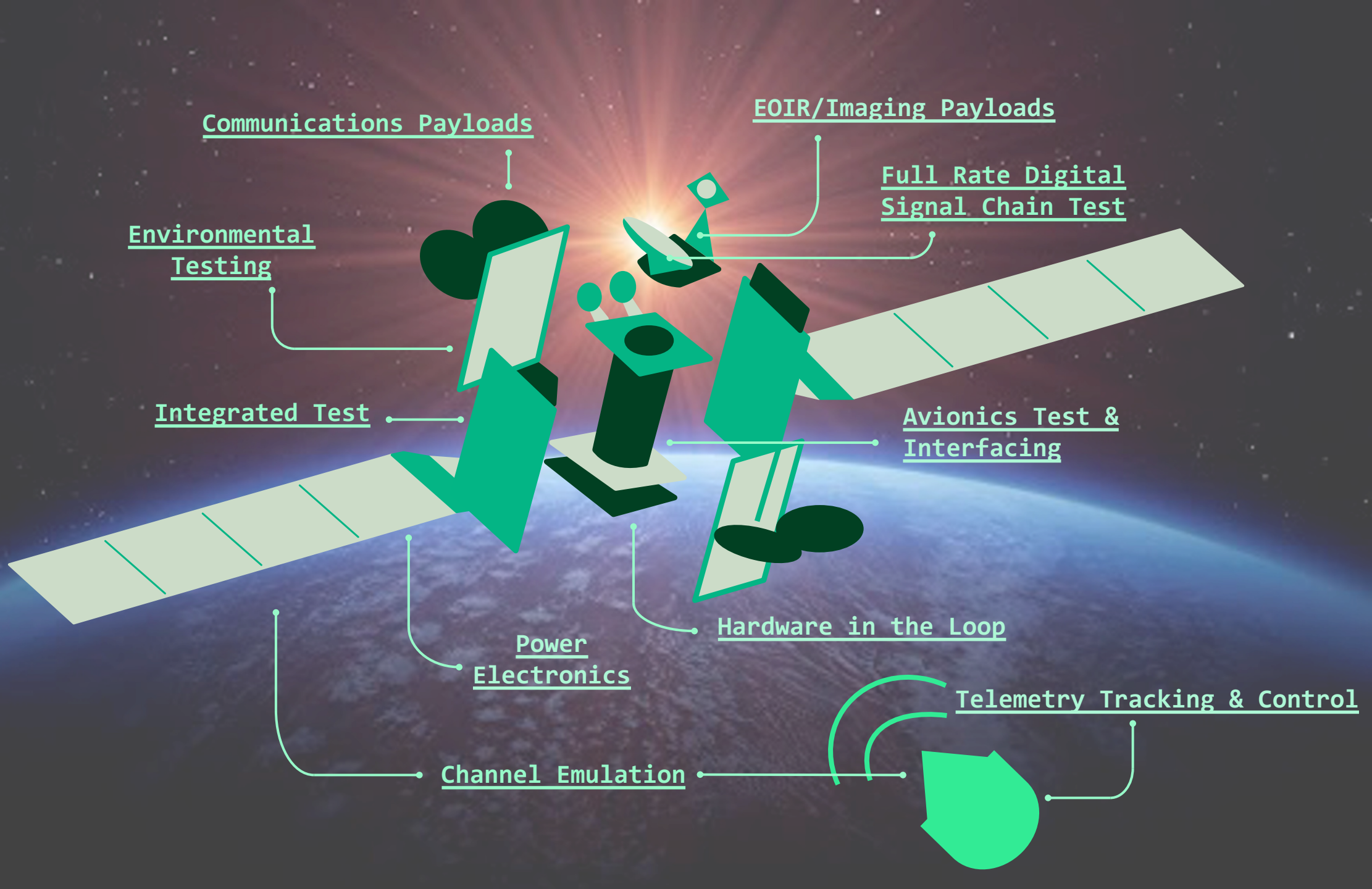
Power Systems Tests

EOIR, SAR, and Comms Payloads

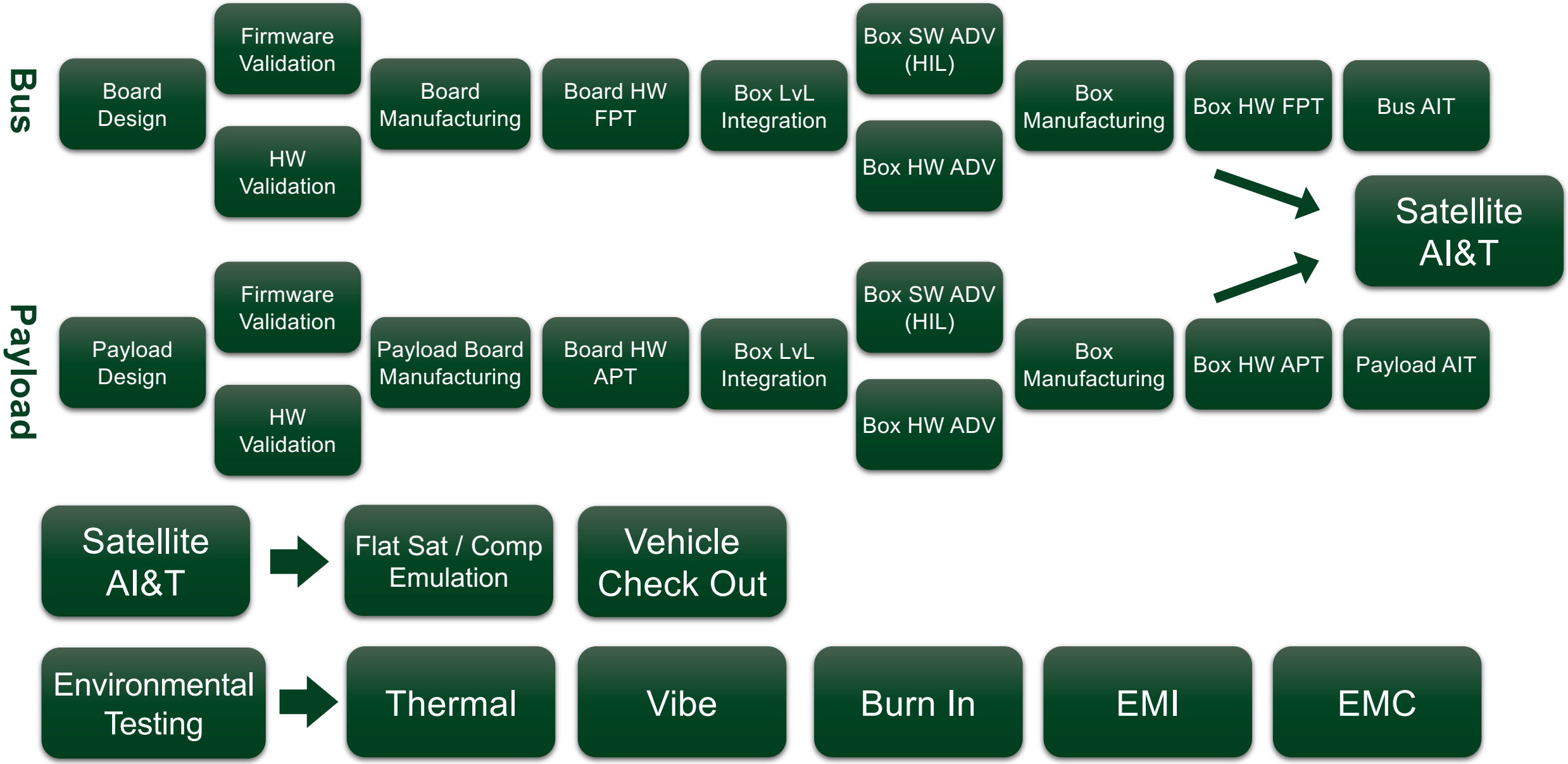
Electronic Ground Support Equipment

Environmental, Structural, and Mechanical Test

Enterprise Test, Data, and Systems Management Software


Communications Payloads
EOIR/Imaging Payloads
Full Rate Digital Signal Chain Test
Environmental Testing
Integrated Test
Avionics Test & Interfacing
Hardware in the Loop
Power Electronics
Telemetry Tracking & Control
Channel Emulation

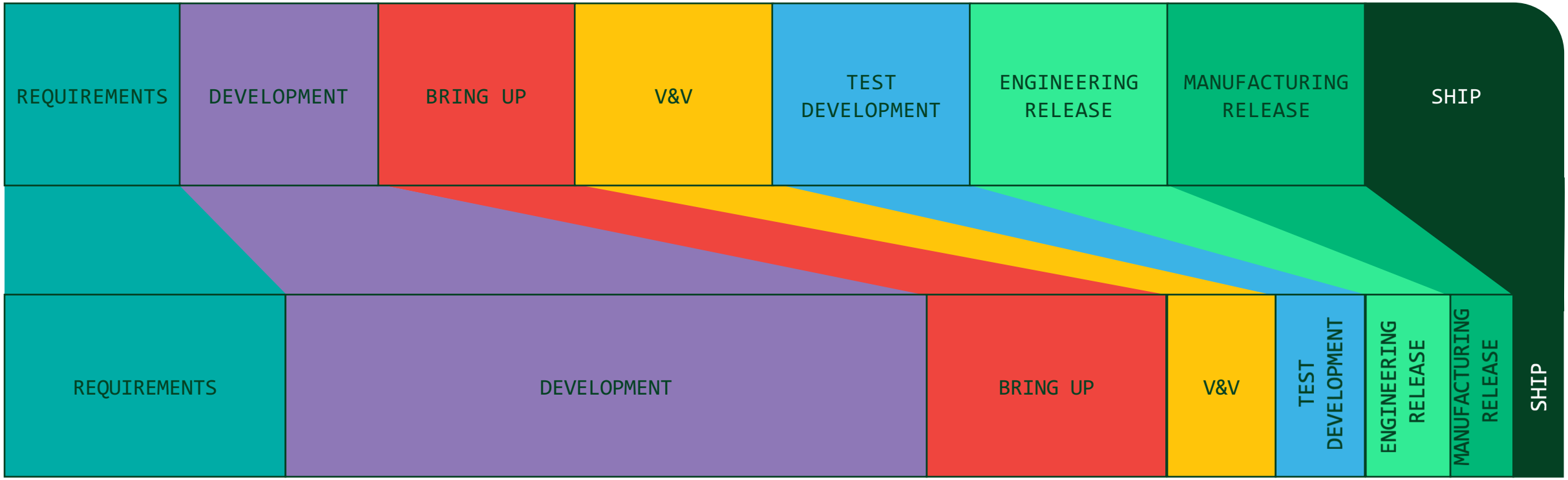
Typical Satellite Development and AI&T



Satellite Process and Test Operational Challenges

Project Kickoff

Hard Deadline



Sometime Later

NI APPROACH TO SPACE TEST

Manufacturing Execution System (MES)

Systems Management | Test Management | Data Management | Real-Time Dashboards | Operations Modeling

Analytics & Operations

Test UI | Sequence Editor | Data Connectivity and Publishing

Test Architecture/Sequence

Test Steps | Debug UI

Abstraction Layers

Instrument Drivers/Configuration Tools

DUT Control Functions

DUT Handler Functions

Station Health and Operation Functions

Application Software

Analog and Digital I/O | Digital Multimeter | Oscilloscope/Digitizer

Waveform Generator | Switch | Source Measure Unit

Programmable DC Power Supply | Electronic Load | Instrument Control and Synchronization

Instrumentation

Rack: Mechanical, Power, and Safety | Display | Test Station Health Monitoring Hardware | Computer/ Controller | Fixture and Chamber | Connector/ Mass Interconnect | DUT Handler

Infrastructure

DUT

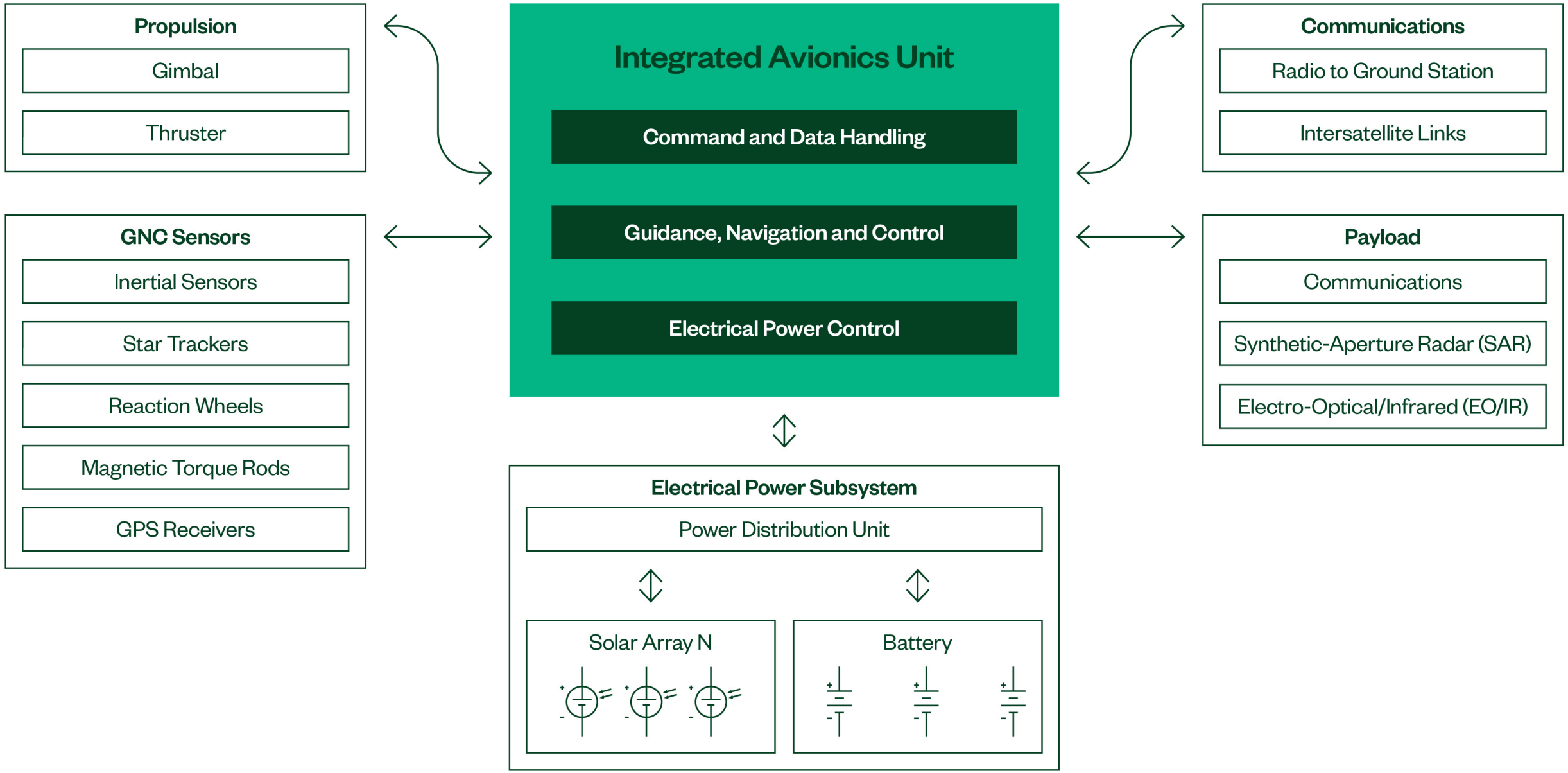
Device

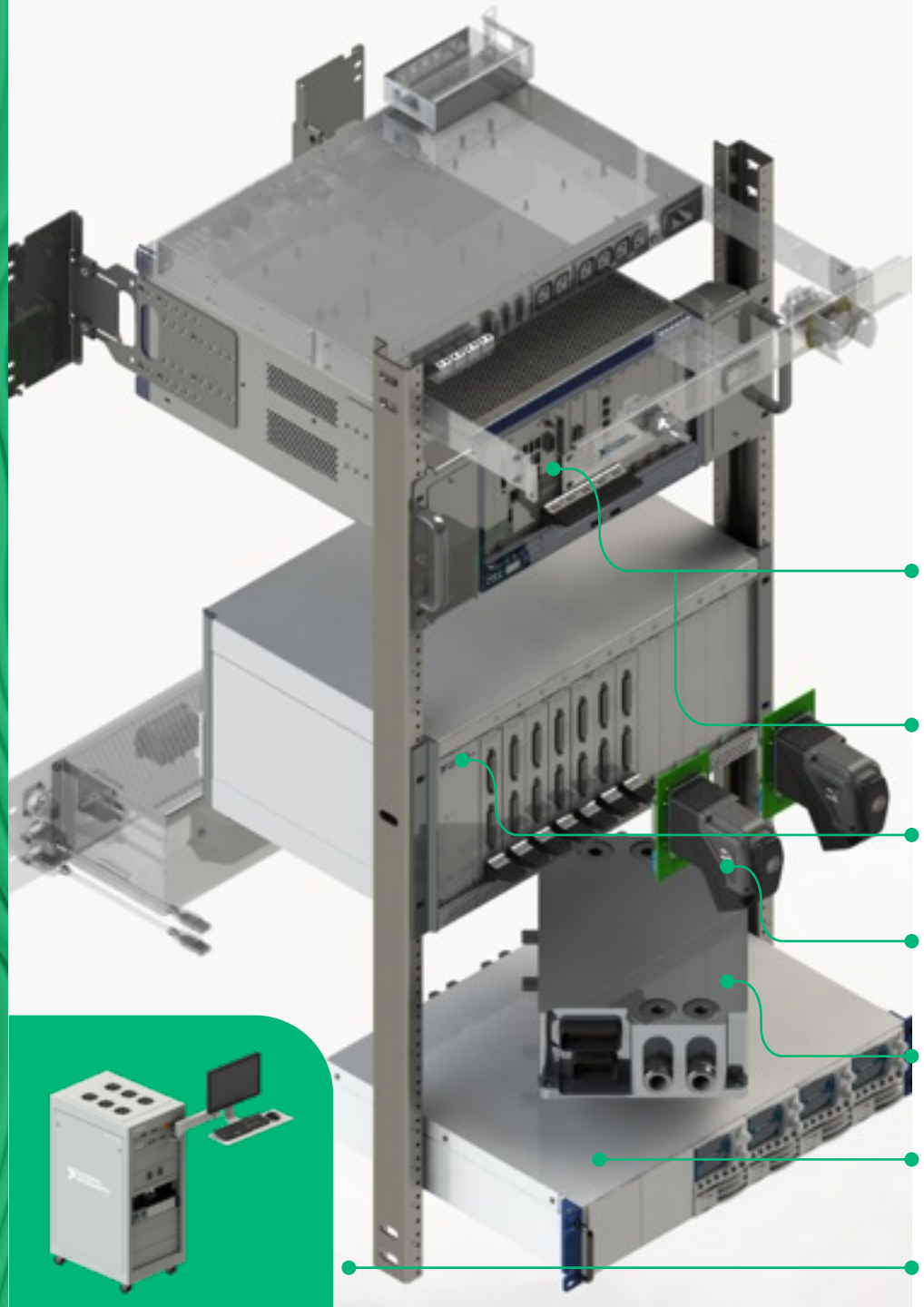
NI PRODUCT | BUILT USING NI PRODUCTS | BUILT USING NI ECOSYSTEM TOOLS | FROM END USER OR THIRD PARTY

LabVIEW | SystemLink | TestStand | InstrumentStudio | Instrument Specific Drivers and APIs | Switch Executive

Operation, Maintenance, and Regulatory Documentation

Anatomy of a Satellite



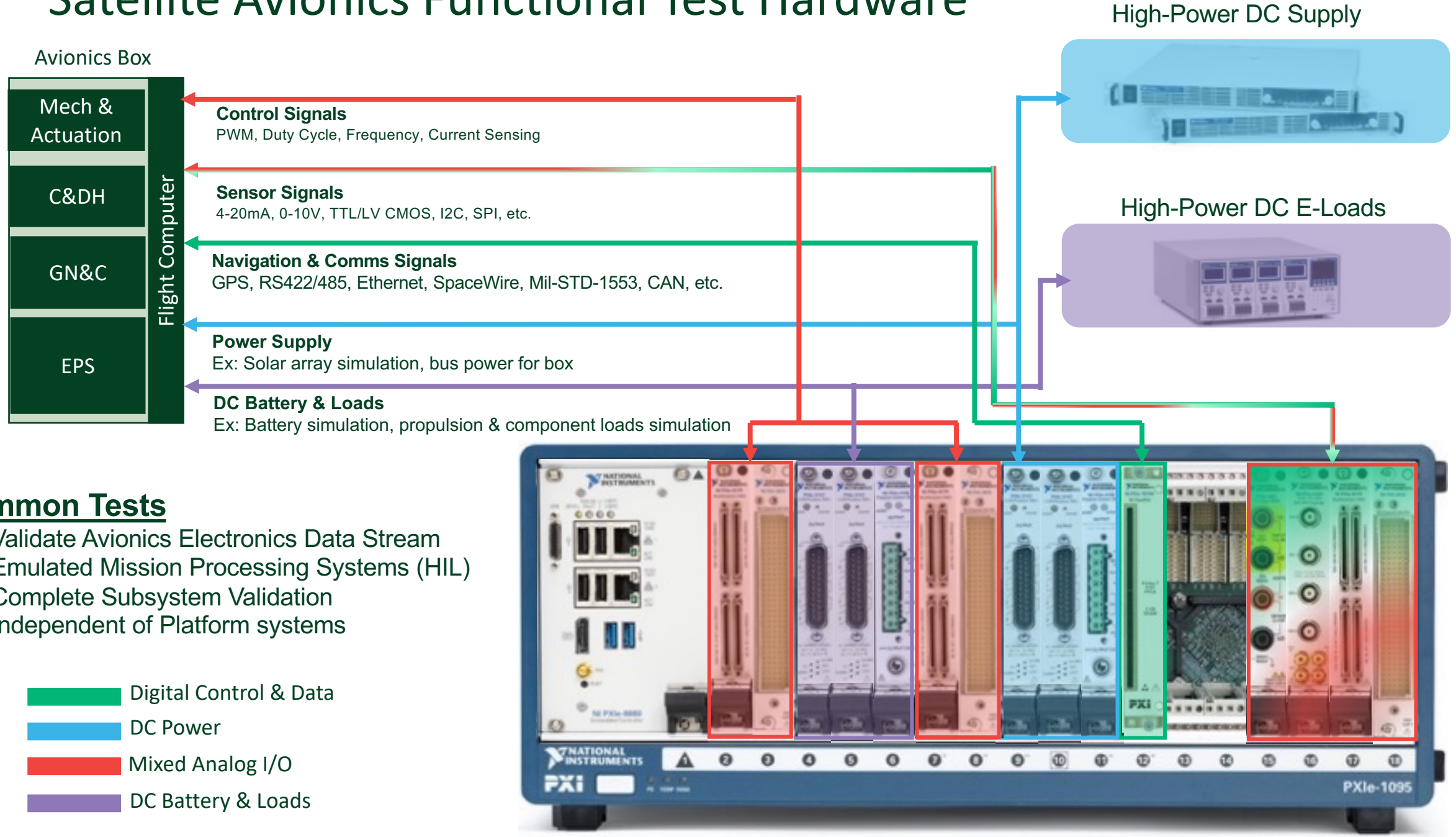


Avionics Test System

- 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 UUTs
UUT	Customer Unit Under Test
RMX	Programmable loads and UUT power
Additional Rack Elements	Complete Test Systems Delivered

Satellite Avionics Functional Test Hardware



Common Tests

- Validate Avionics Electronics Data Stream
- Emulated Mission Processing Systems (HIL)
- Complete Subsystem Validation Independent of Platform systems

Digital Control & Data

DC Power

Mixed Analog I/O

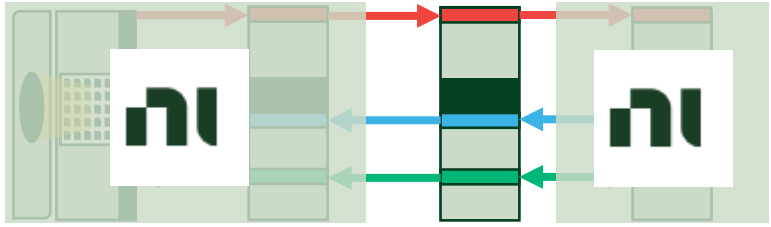
DC Battery & Loads

Avionics Design, Integration & Test Campaign Flow

Early-Stage Design → Mid-System Development → Final System Validation

Mission Algorithm Test

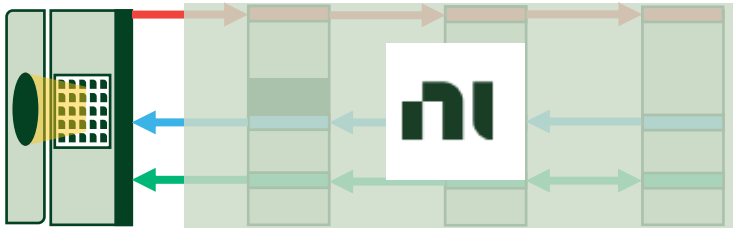
Flight Computer Algorithm Testbed



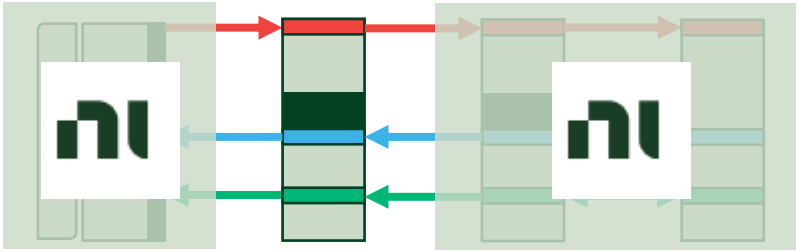
Note: These two test campaigns will be combined into a single test configuration for the purpose of this discussion

Subsystem Test

Sensor Test

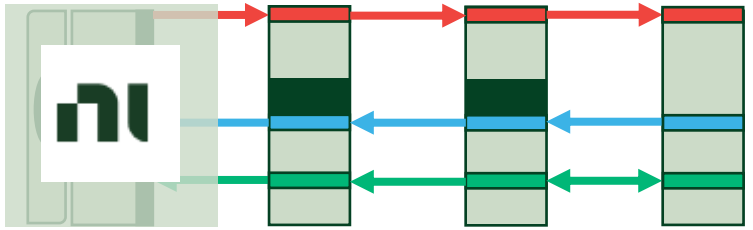


Avionics Electronics Test

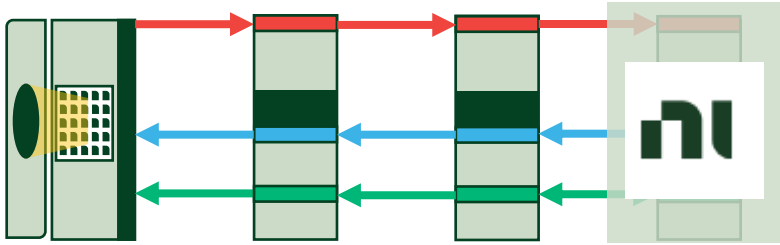


System Level Test

Sensor Simulator Test

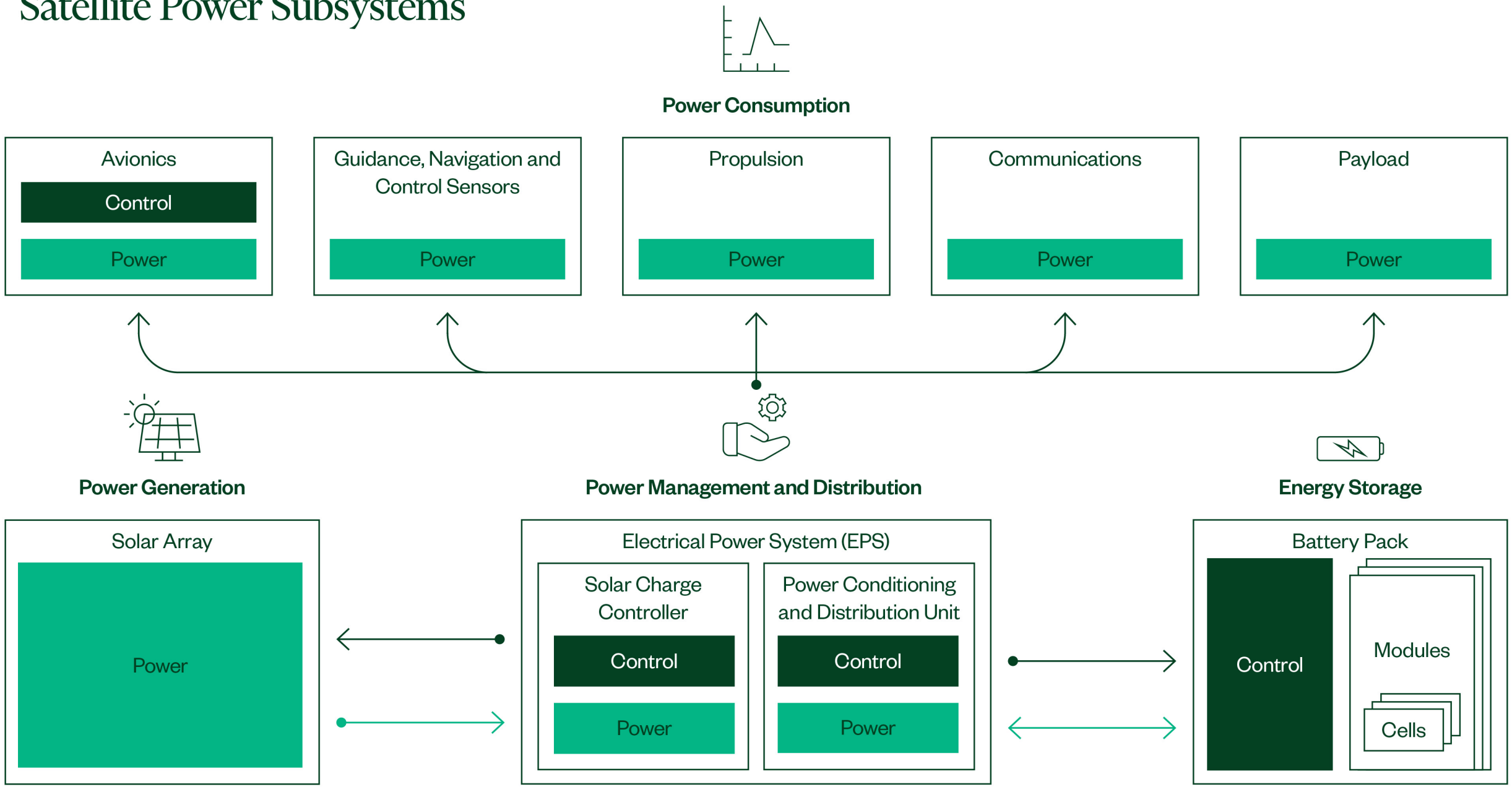


Telemetry Recorder Test



Modular NI Test Solutions Enable Complete Subsystem-Through-System Validation Throughout All I&T Campaigns

Satellite Power Subsystems



Satellite Classes and Power Requirements

Satellite Class*	Mass	Battery	Solar	NI Approach
Femto/Pico	<1 kg	0-75 Wh	0-100 W	PXI
Nano	1-10 kg	75-200 Wh	100-500 W	PXI/Rackmount
Micro	11-200 kg	200-2000 Wh	500-1200 W	PXI/Rackmount
Mini/Small/Medium	200-2,500 kg	2-10 kWh	1-10 kW	Rackmount
Intermediate+	>2,500 kg	10 kWh+	2 kW+	Rackmount

*Based on “The Annual Compendium of Commercial Space Transportation: 2018” compiled by US Federal Aviation Administration

NI Investment in Electrification

Strategic Investments and Acquisitions to Increase Portfolio and Capabilities

Power Electronics

NHR from NI

HEINZINGER AUTOMOTIVE GMBH

System Integration

kratzer AUTOMATION TEST SYSTEMS is now NI

NI Battery Cyclers Portfolio Overview

Flexible Power for Battery Cells, Modules, Packs and Energy Storage Systems (ESS)

			10KW . . . 100KW . . . 500KW 1.0MW 1.5MW 2.0MW 2.5MW
PACK-LEVEL			
NHR	**NHR-9300** 600/1200V 167A to 333A		1CH @ 100kW PARALLEL UP TO 2.4MW
NI	**HPS-17000** 750/1500V 240A to 480A		1CH @ 150kW PARALLEL UP TO 900kW PARALLEL UP TO 1.5MW
HEINZINGER	**ERS-BIC** 600/1200V 600A to 1200A		2CH @ 160kW, 250kW, 325kW, 400kW, 500kW, 600kW 1CH @ 250kW, 325kW, 400kW, 500kW, 600kW PARALLEL UP TO 2.4MW
MODULE-LEVEL			
NHR	**NHR-4800** 80V 400A		1CH @ 16KW 1CH @ 160KW
NHR	**NHR-9200** 120/600V 40A to 600A		3CH @ 12KW 1CH @ 36KW PARALLEL UP TO 144kW

Solar Simulation and Array String Test Hardware

Avionics Box

PDU

Telemetry

BMS

MPPT/DET

Electrical Power System (EPS)

Bulk DC Supply

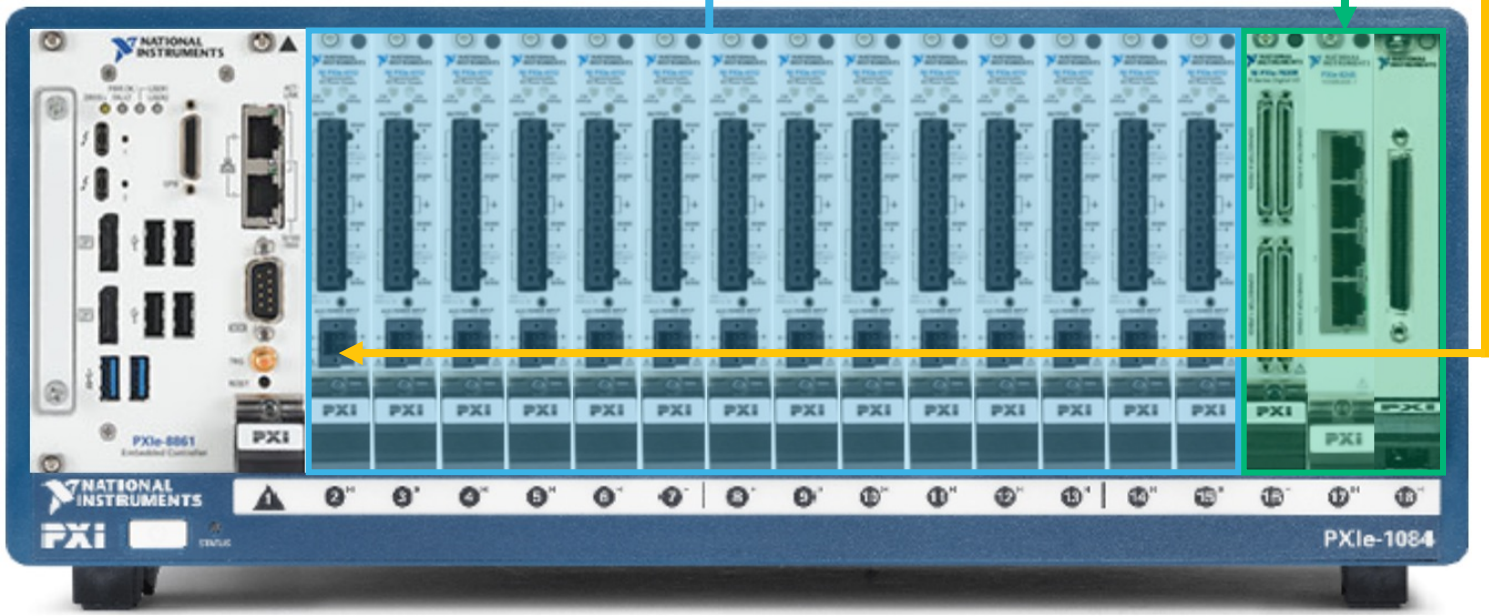
Telemetry Command/Control
RS422/485, TTL/LV CMOS, I2C, SPI, Ethernet, etc.

Power Supply
Ex: Solar array simulation, Solar string bulk power

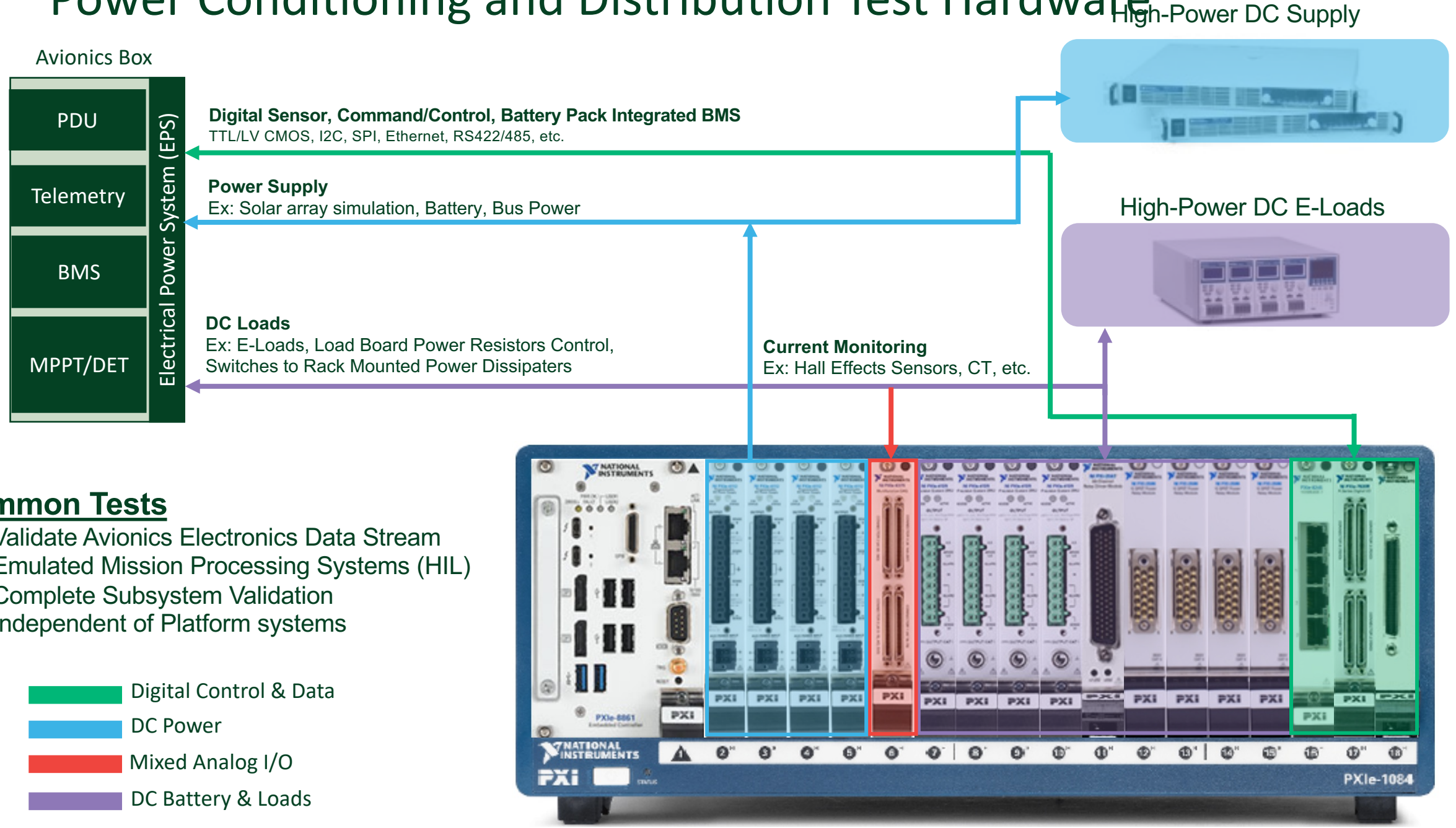
Common Tests

- Solar Simulation
- Solar String Bulk Power (Individual Strings)

Digital Control & Data
DC Power
DC Battery & Loads



Power Conditioning and Distribution Test Hardware



Common Tests

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- Emulated Mission Processing Systems (HIL)
- Complete Subsystem Validation Independent of Platform systems

Digital Control & Data

DC Power

Mixed Analog I/O

DC Battery & Loads

Satellite Battery System Hardware

Avionics Box

PDU

Telemetry

BMS

MPPT/DET

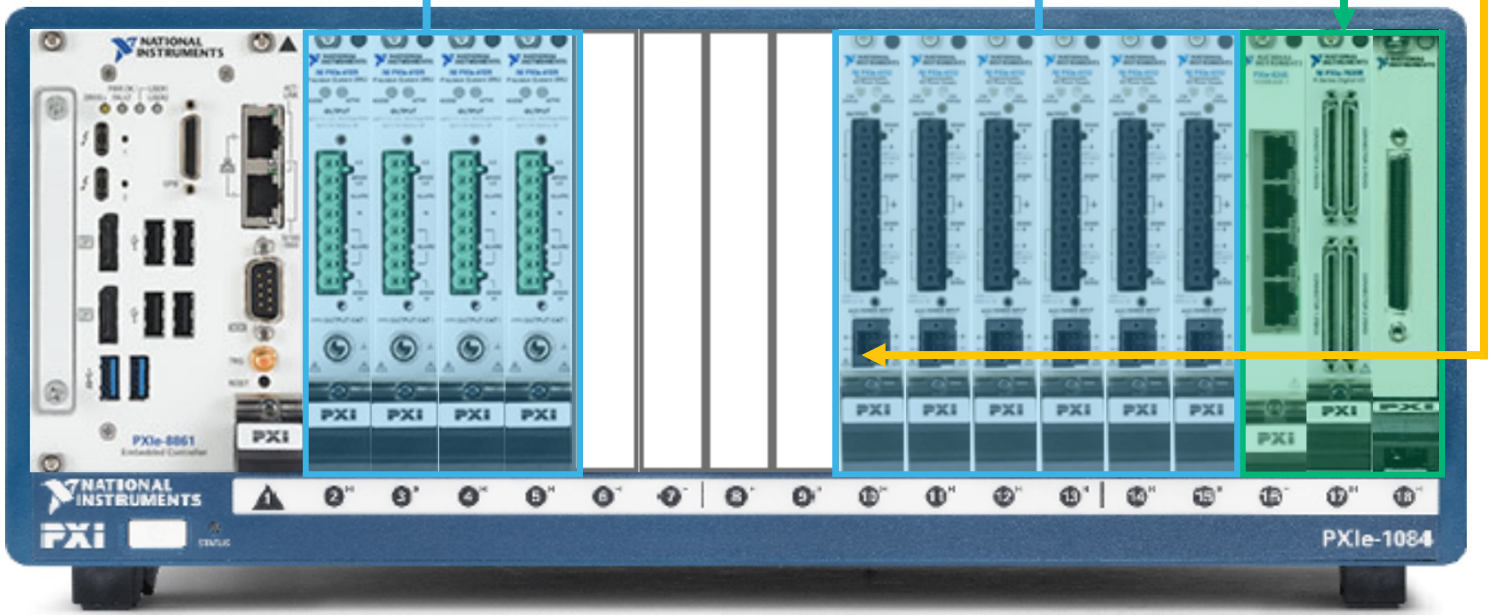
Electrical Power System (EPS)

Bulk DC Supply

Telemetry, Command/Control, Battery Module Integrated BMS
RS422/485, TTL/LV CMOS, I2C, SPI, Ethernet, etc.

Battery Cell Simulation
Ex: Cell Voltage and Passive Balance Current

Battery Cell Simulation
Ex: Cell Voltage and Active Balance Current



Common Tests

- Solar Simulation
- Solar String Bulk Power (Individual Strings)

Digital Control & Data
DC Power
DC Battery & Loads

Satellite Test User Workflow

MeasurementLink connects **interactive measurement, test automation, and debugging** workflows for validation and production test engineers using the same measurement IP across the flow.

Debug → Manual Test → Automated Test → Reuse

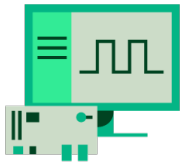
Program measurement in:

Use **pre-built** plug-in/add-on

Ex. Power Validation Add-on

Instrument Studio™

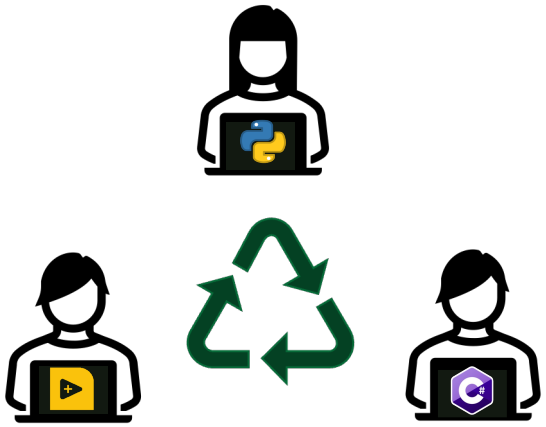
Used for **Interactive** Measurement Interface



TestStand™

Used for **Test Sequencing** & **Automation**

Interactive Debugging



Integrate hardware and software from any vendor in any language

Simplify the validation workflow for improved efficiency

Save time by reusing measurements regardless of programming language

Recap/Call to Action

- The NI solution for satellite avionics and power electronics test scales as the need for testing satellites becomes more complex and timelines accelerate
- NI hardware covers a broad array of satellite avionics signal types and we are increasing investment in power capabilities
- NI software allows for standardization of test processes and enables automation of test steps
- A solution for satellite test based on the NI approach scales across the design cycle and can be reused from program to program to accelerate development time and reduce cost