# NI connect

## 2024 AUSTIN

EMERSON

# Validating Telemetry & Data Links

Software Defined Methodologies for Electronic Ground Support Equipment (EGSE)

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# Agenda

| | |
|---|---|
| **Introduction** | Mission Critical Data Links Everywhere – Between Everything |
| **The Challenge** | Achieving Cost RF Effective Electronic Ground Support Equipment (EGSE) |
| **An NI Approach** | Software Defined, Modular RF and Digital Instrumentation |
| | Scaling From Functional Parametric Testing to Hardware in the Loop System Validation |
| | Integrating Domain Expertise and IP Centric to the Mission - INGENIArs |
| **Conclusion** | **Cost effective EGSE with Scalable Software and Hardware Functionality** |

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# Introduction

Mission Critical Data Links Everywhere – Between Everything

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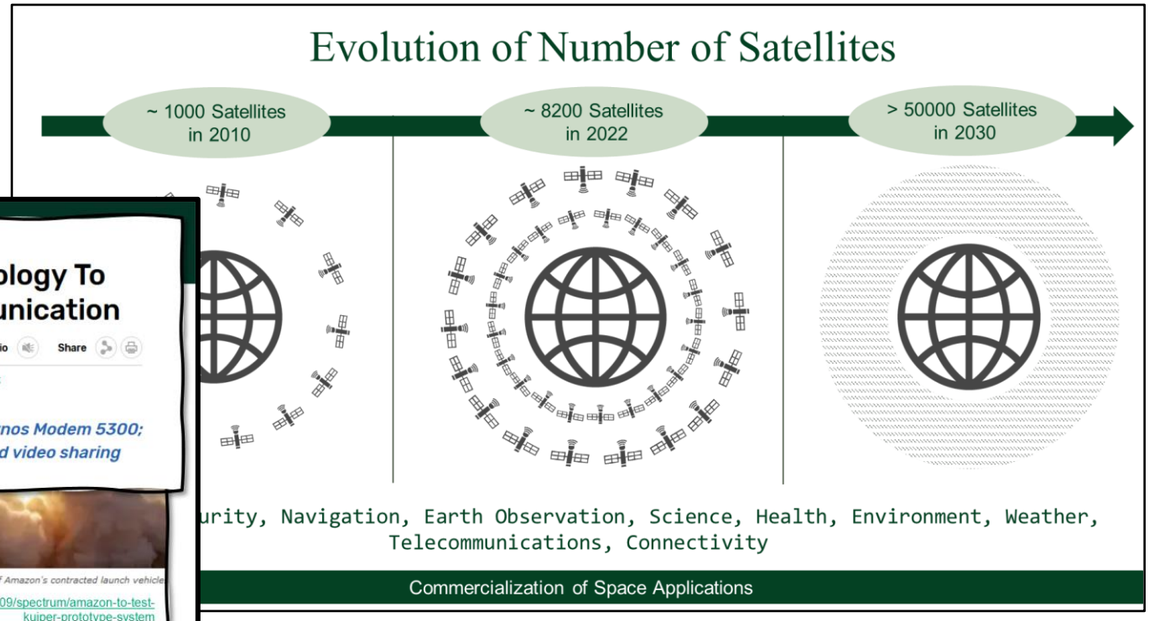
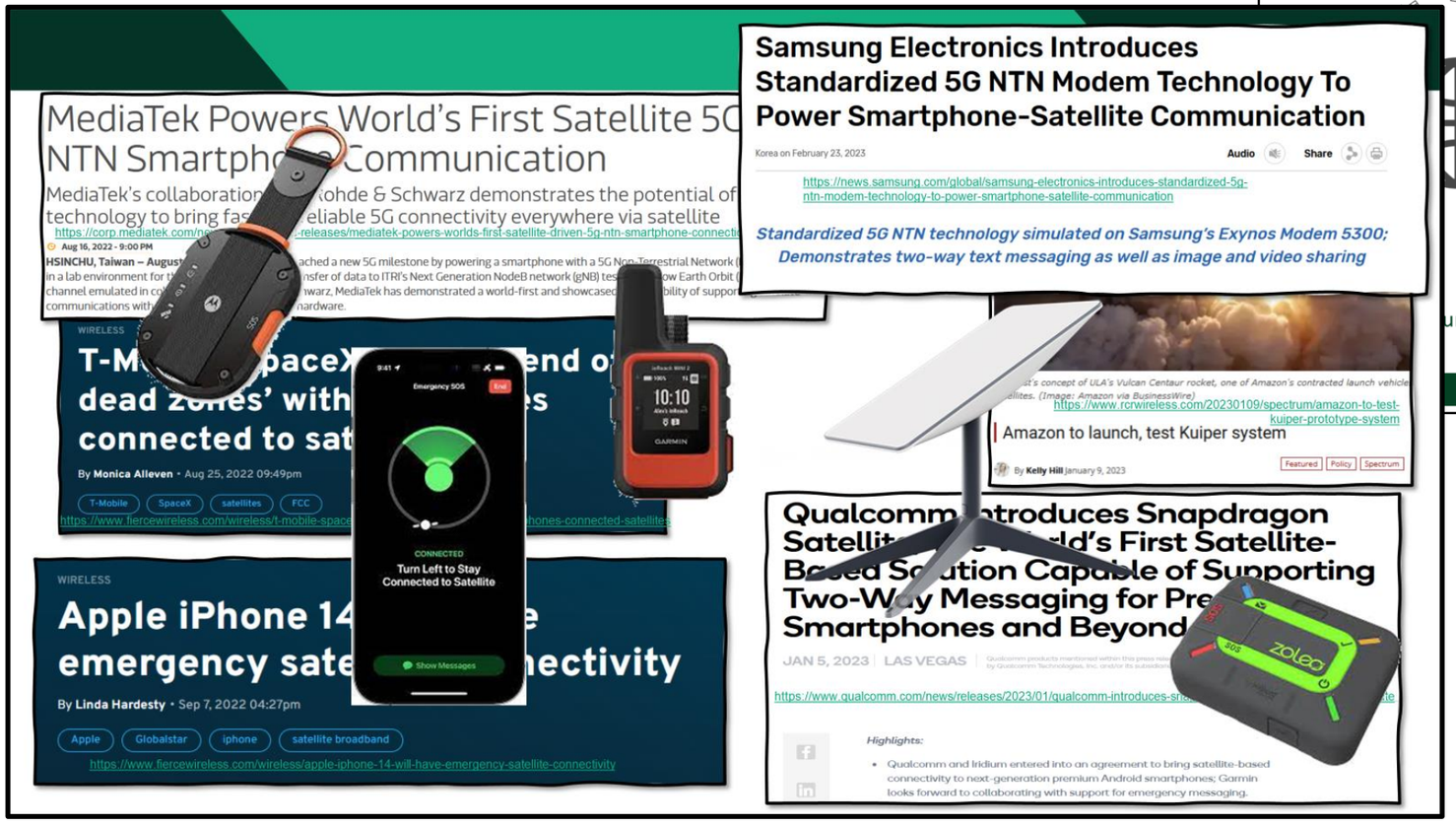
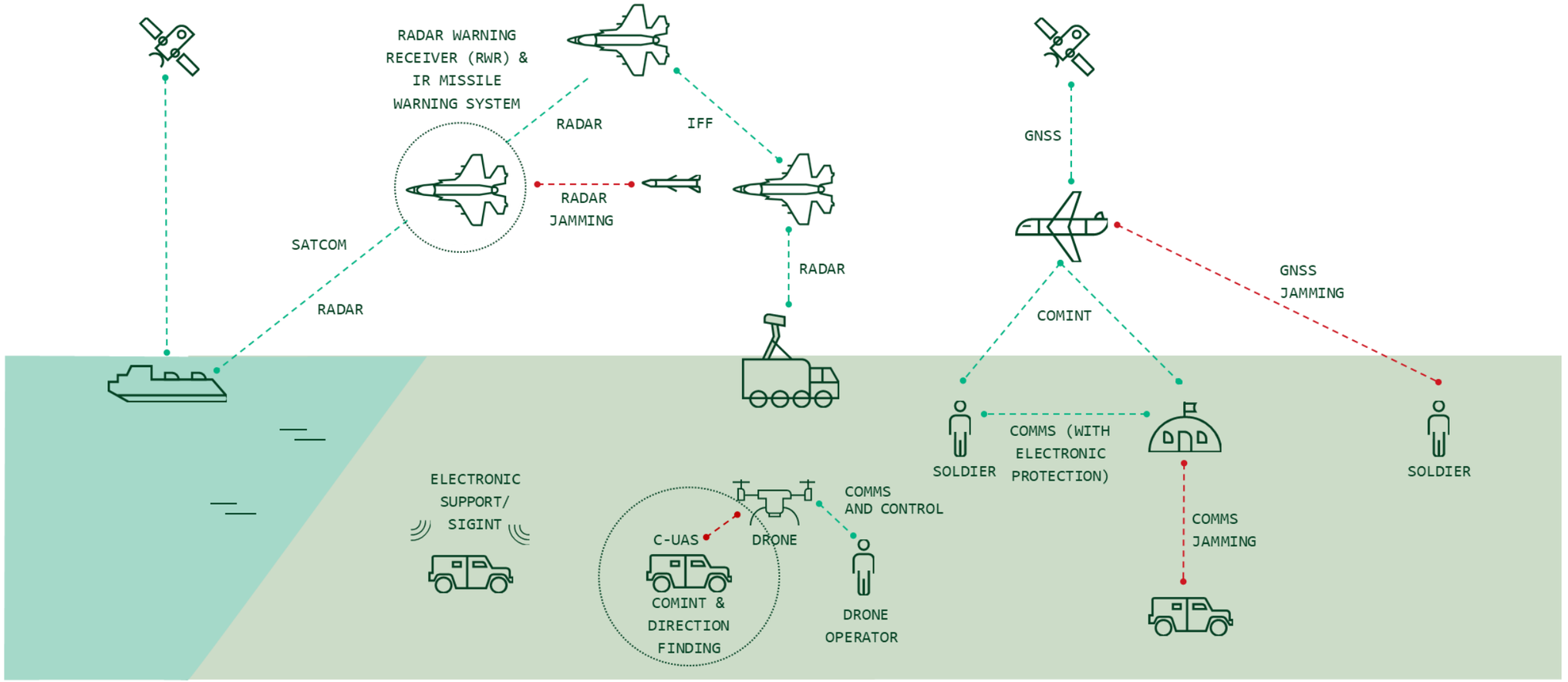
# Data Links On Everything - Everywhere



# Defense EMSO – Connected and Congested



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# The Challenge

## Achieving Cost Effective Electronic Ground Support Equipment (EGSE)

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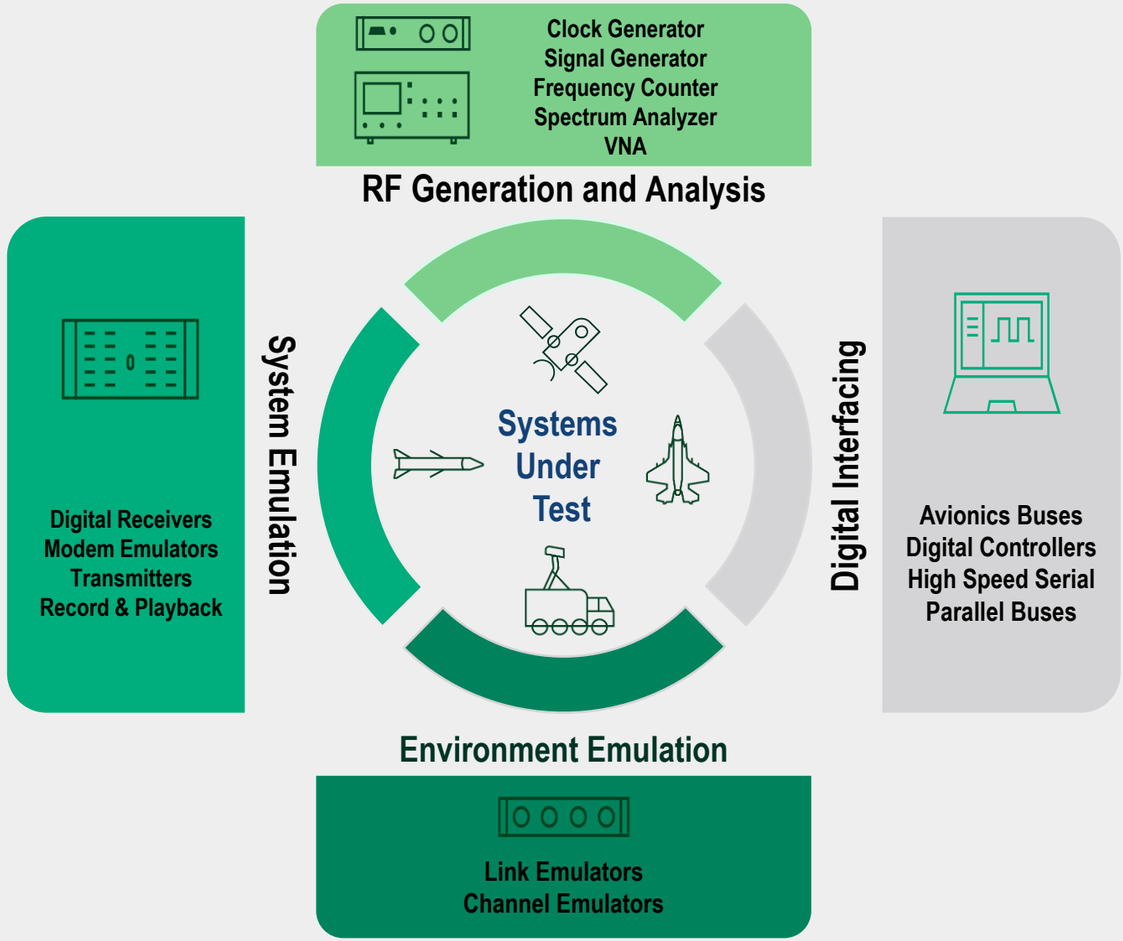
# RF Electronic Ground Support Equipment (EGSE)

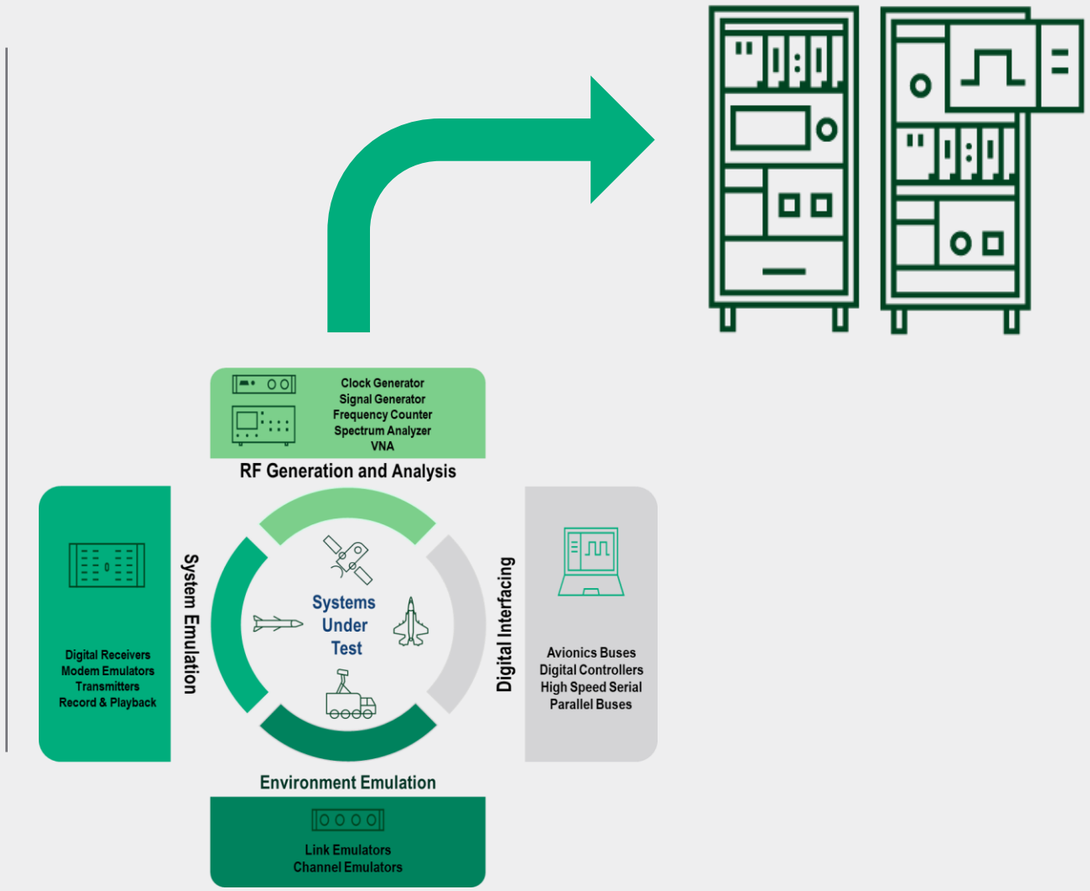
In addition to power and control - System validation in an RF System Integration Lab (SIL), or similar environment, requires the aggregation of key test capabilities:

- RF Signal Generation
- RF Characterization & Analysis
- System/Payload Emulation
- RF Environment Simulation
- Digital Interfacing & Data Movement

These test needs are commonly implemented by single-function instruments and software from a mixture T&M and “mission-centric” (i.e. deployed system) vendors.



# EGSE Testers | Complexity in “Rack & Stack”




## Challenges of Approach:

- Expansive, multi-bay racked systems – large footprint testers
  - Limits ability to meet accelerating demand
- Increased cost per measurement or function
  - 1:1 Instrument vs Function
  - Sub-optimal utilization of equipment
  - Common redundancy (or dependency) of capabilities
    - I.e. A VNA and SpecAn can make similar measurements
    - A digital receiver/modem may require a SpecAn to acquire the signal from the DUT
- Increased complexity of HW and SW integration
  - Integration and synchronization of multi-vendor tools
  - Signal routing/conditioning necessary to map instruments to test ports
- Limited ecosystem for modification/customization
  - Challenging to adapt to SUT test needs as it transitions across the development lifecyle.

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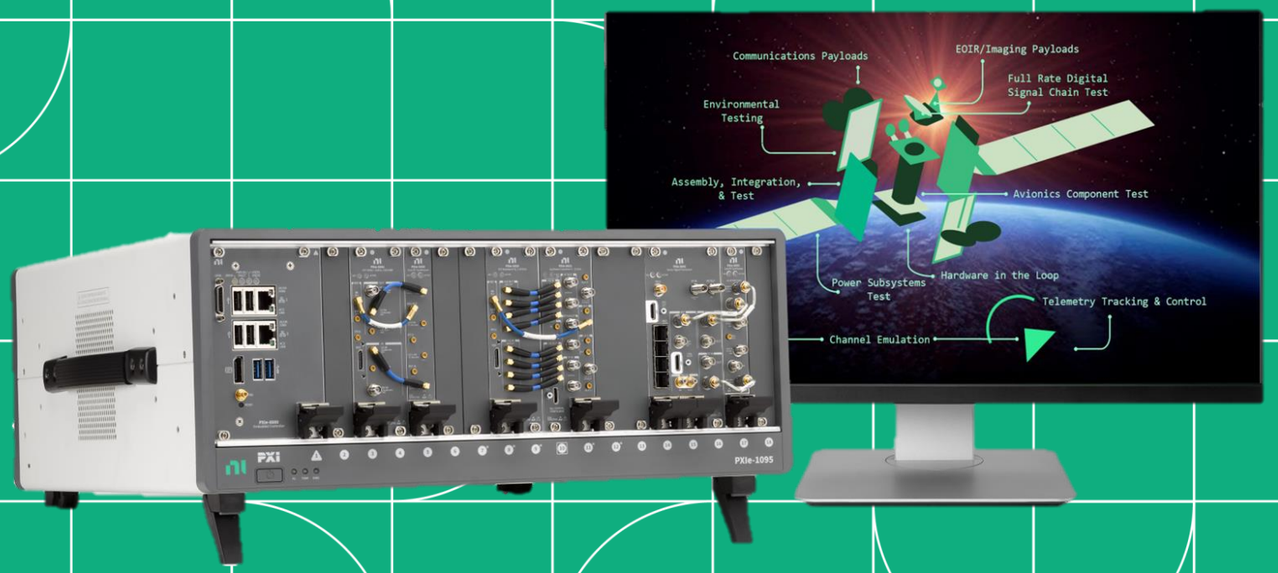


# An NI Approach

## Software Defined, Modular RF and Digital Instrumentation

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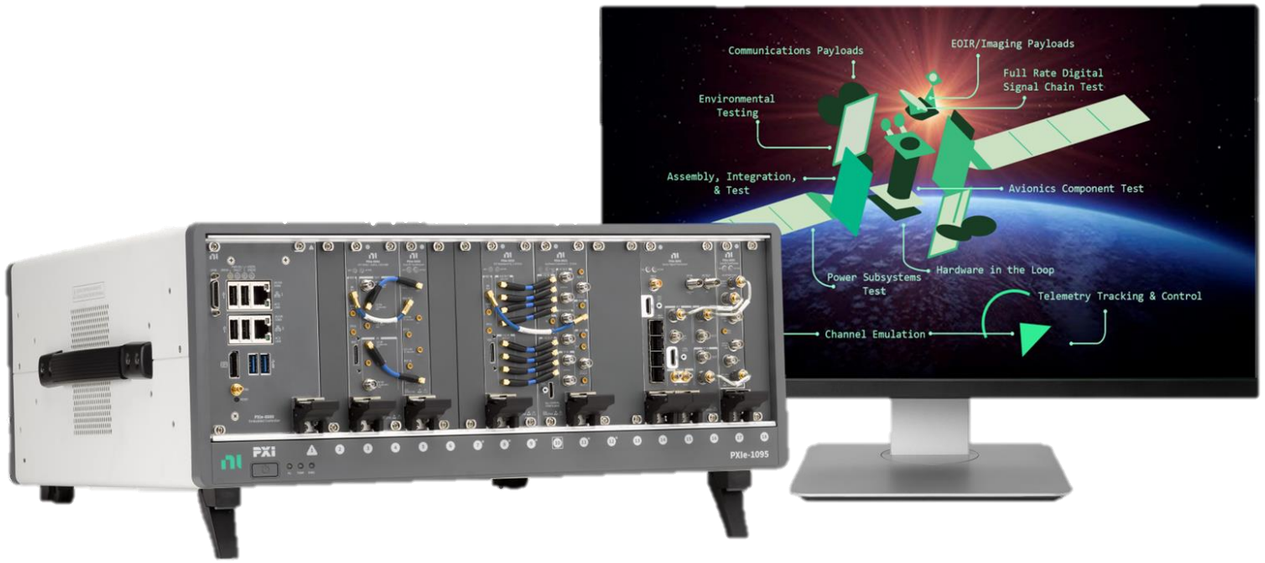
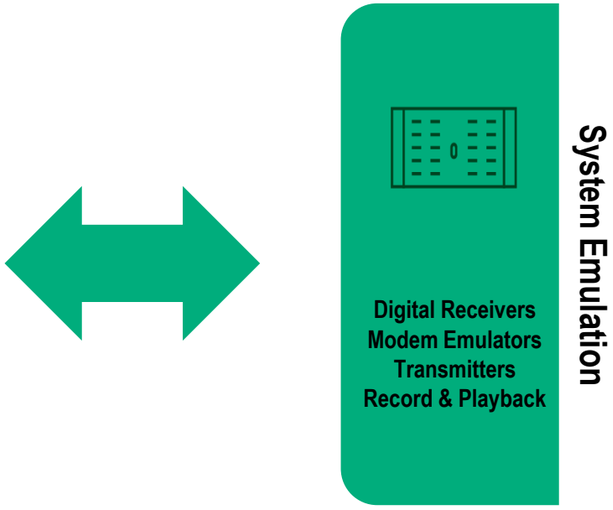
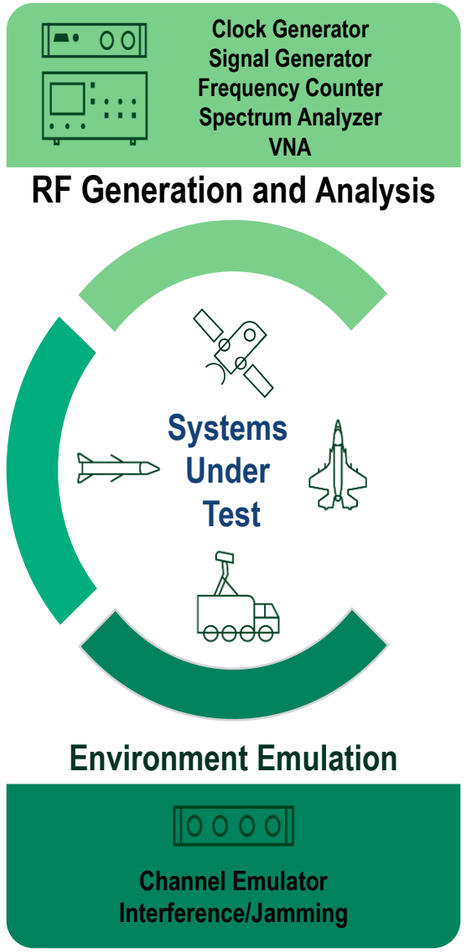
# NI Solution | Modular, Software Defined EGSE



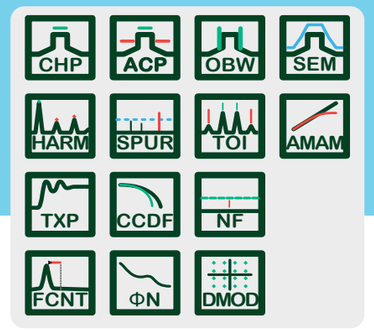



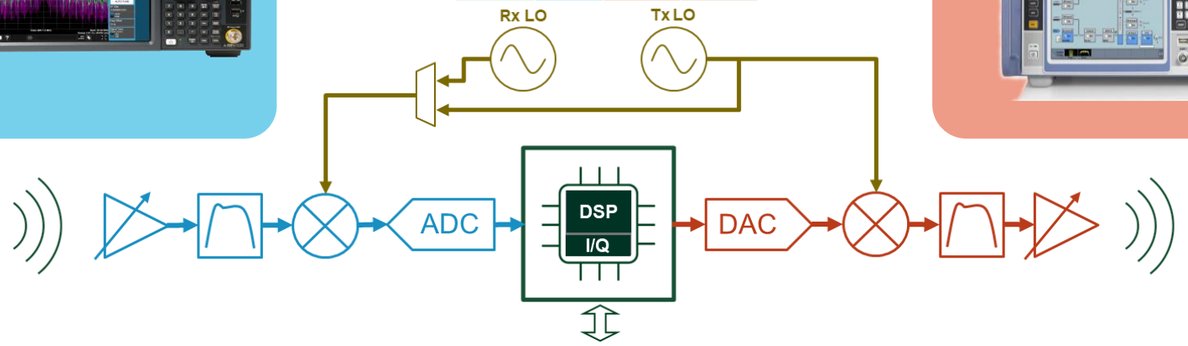
# NI Solution | Vector Signal Transceiver (VST)

NI VST = Vector Signal Analyzer + Vector Signal Generator + Software Defined Radio

**Calibrated, wideband vector signal analyzer:**

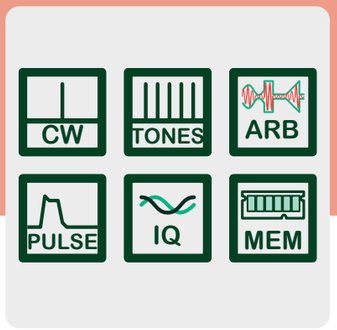
- Frequency Range: 30 MHz to 26.5 GHz
- Programmable gain ranging: +25 dBm max,
- Up to 2 GHz Instantaneous IQ BW
- Full bandwidth I/Q recording (or real-time processing)
- Independent or coherent operation with signal generator
- Supports multi-channel synchronization and coherency




**Calibrated Wideband Signal Generator:**

- Frequency Range: 30 MHz to 26.5 GHz
- RF Output Power: > +20 dBm up to 18 GHz,
- Up to 2 GHz Instantaneous IQ BW
- Full bandwidth I/Q playback
- Integrated Analog Pulse Modulation with >100 dB on/off ratios
- Independe and coherency
- Supports multi-channel synchronization




Software defined, FPGA backend allows for evolution of applications over time, including real-time digital streaming of full RF IBW (up to 4 GHz)

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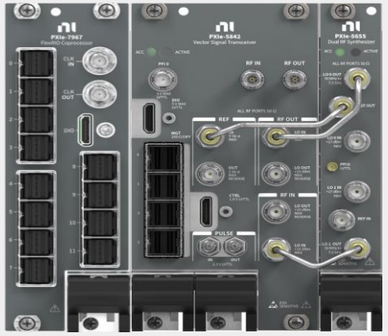
# NI Solution | VST Ecosystem

## Real-Time Processing and Data Movement

- Scalable, open FPGA extensibility via NI FlexRIO products for real-time processing and DSP
- Up to 28.2 Gbps digital interfacing for bi-direction, full rate I/Q streaming
- 3rd party HW or System Under Test interfacing (i.e. 100 GbE)



## Inline S-parameters

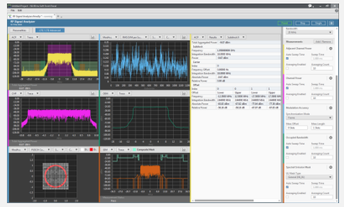
- Integrated, inline VNA functionality for adding S-parameters and de-embedding to VST applications.
- Out of the box interactive GUI for quickly setting up S11/22, and S12/21 measurements.
- Includes CW or pulsed stimulus

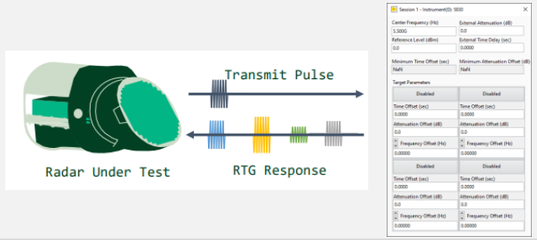
## Frequency Extension

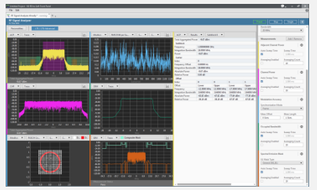
- Extended frequency coverage of analysis and generation up to 54 GHz
- Integrated software control and calibration
- Bi-directional connectivity for conductive or over-the-air (OTA) integration

# NI Solution | Interchangeable Firmware, Scalable Functionality

App Software





\+ Channel Emulation
Modem IP
Event Triggers & Detection
Record & Playback

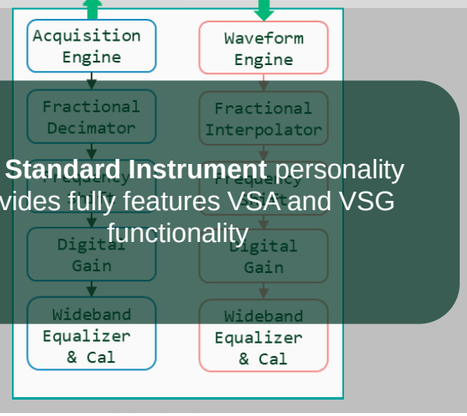
Host API

NI RFSA API | NI RFSG API

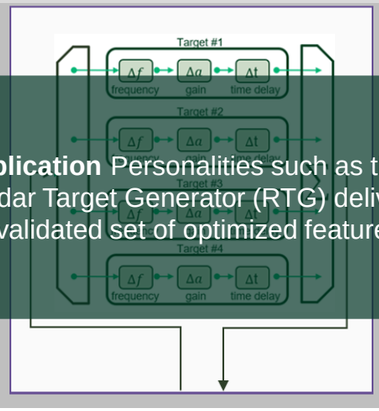
NI RTG API

NI RFSA API | NI RFSG API | Application API

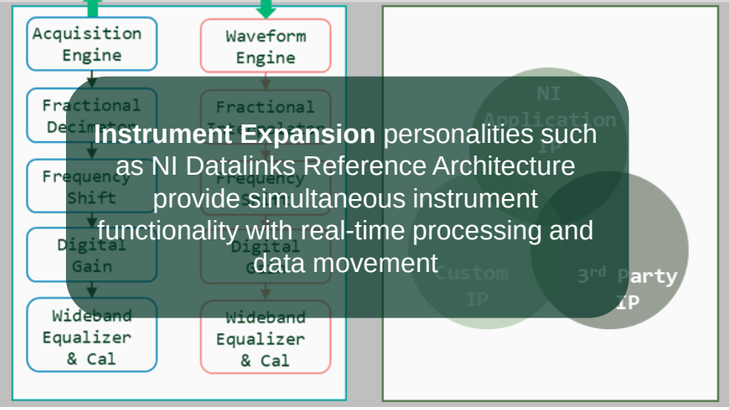
Device Firmware (Bitfile)




The **Standard Instrument** personality provides fully features VSA and VSG functionality




**Application** Personalities such as the NI Radar Target Generator (RTG) deliver a validated set of optimized features




**Instrument Expansion** personalities such as NI Datalinks Reference Architecture provide simultaneous instrument functionality with real-time processing and data movement

Device

Standard Instrument

Application Personality

Full Rate, Bidirectional Link & Triggers

Instrument Expansion

**Device Firmware Bitfiles – Programmatic and Automatable**

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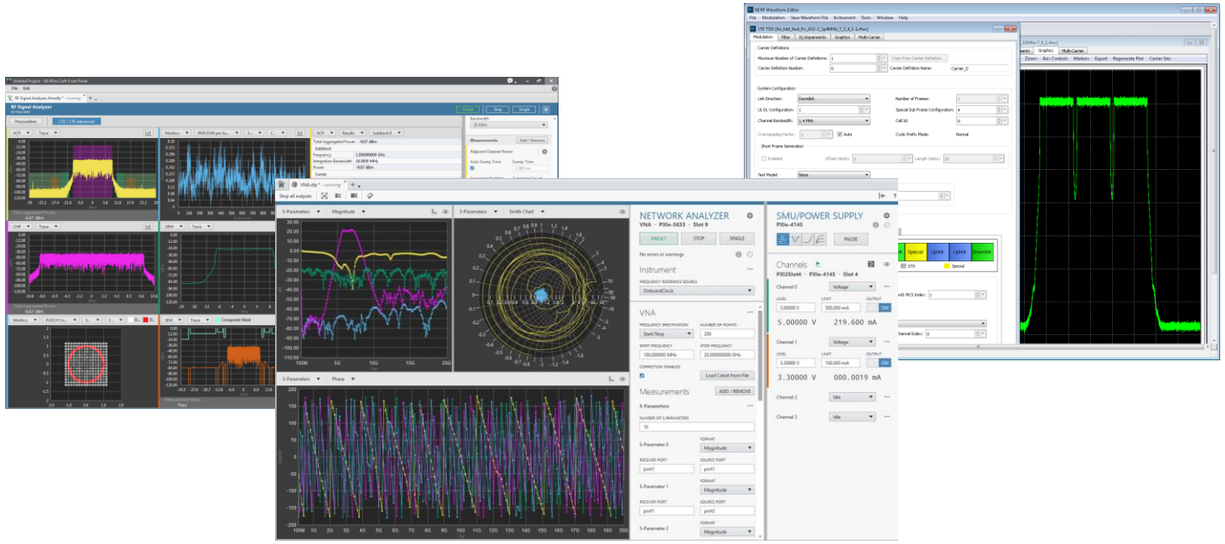
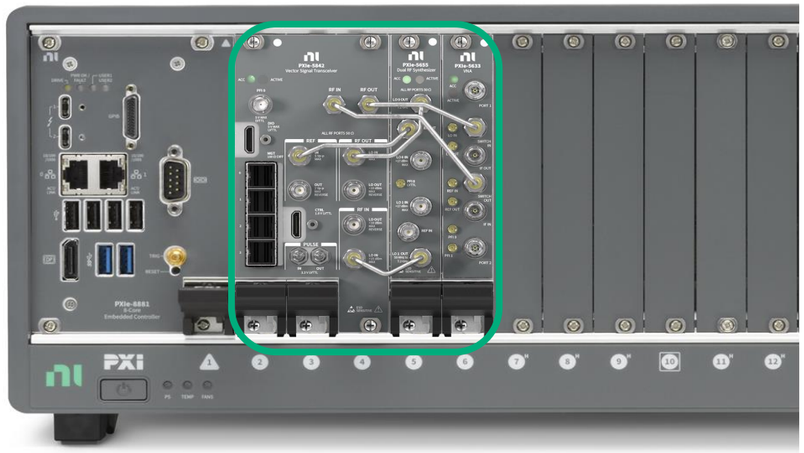
# NI Solution | RF Signal Generation & Analysis




Clock Generator
Signal Generator
Frequency Counter
Spectrum Analyzer
VNA

RF Generation and Analysis

Digital Receivers
Modem Emulators
Transmitters
Record & Playback

System Emulation

Systems Under Test

Environment Emulation

Channel Emulator
Interference/Jamming

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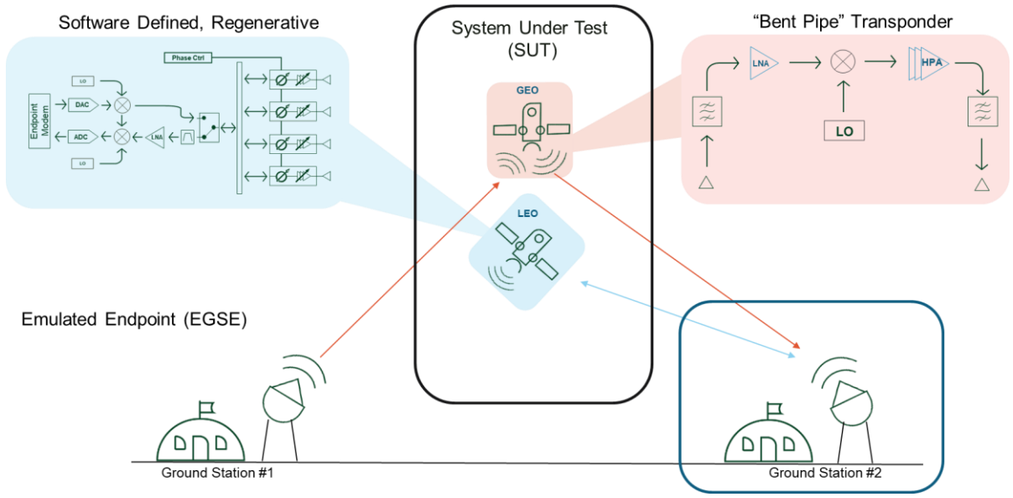
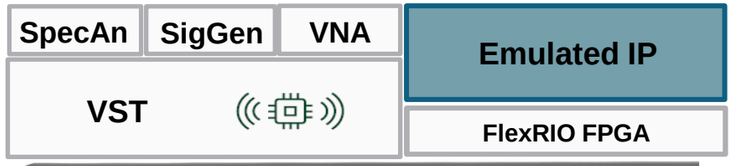
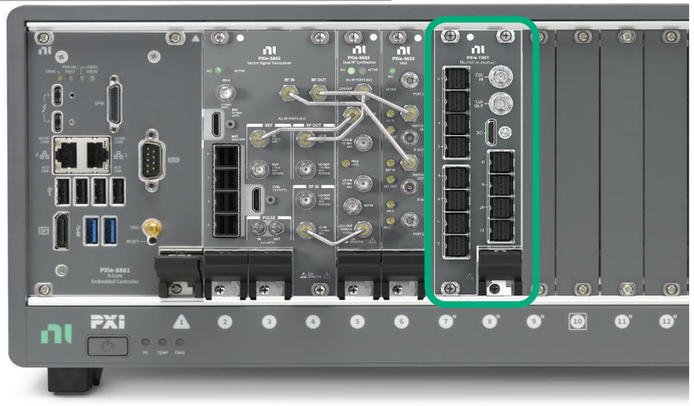
# NI Solution | Reconfigurable Data Link Emulation



3rd Party Data Link IP

Digital Receivers
Modem Emulators
Transmitters
Record & Playback

System Emulation

Clock Generator
Signal Generator
Frequency Counter
Spectrum Analyzer
VNA

RF Generation and Analysis

Systems Under Test

Environment Emulation

Environment Emulation
Channel Emulator

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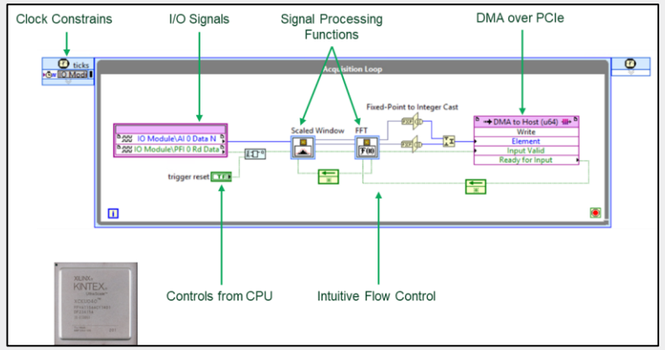
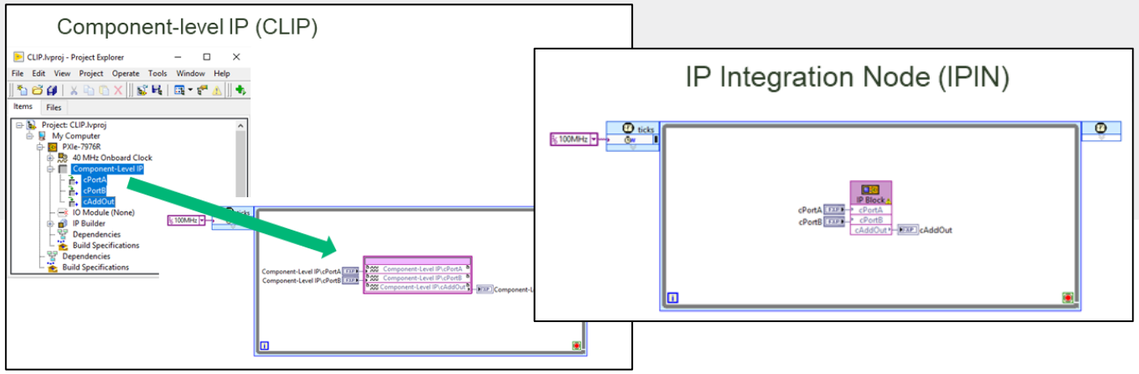
# NI Solution | 3rd Party IP Integration Workflows

## Design or Integrate in LabVIEW FPGA

- Design FPGA IP directly in LabVIEW FPGA

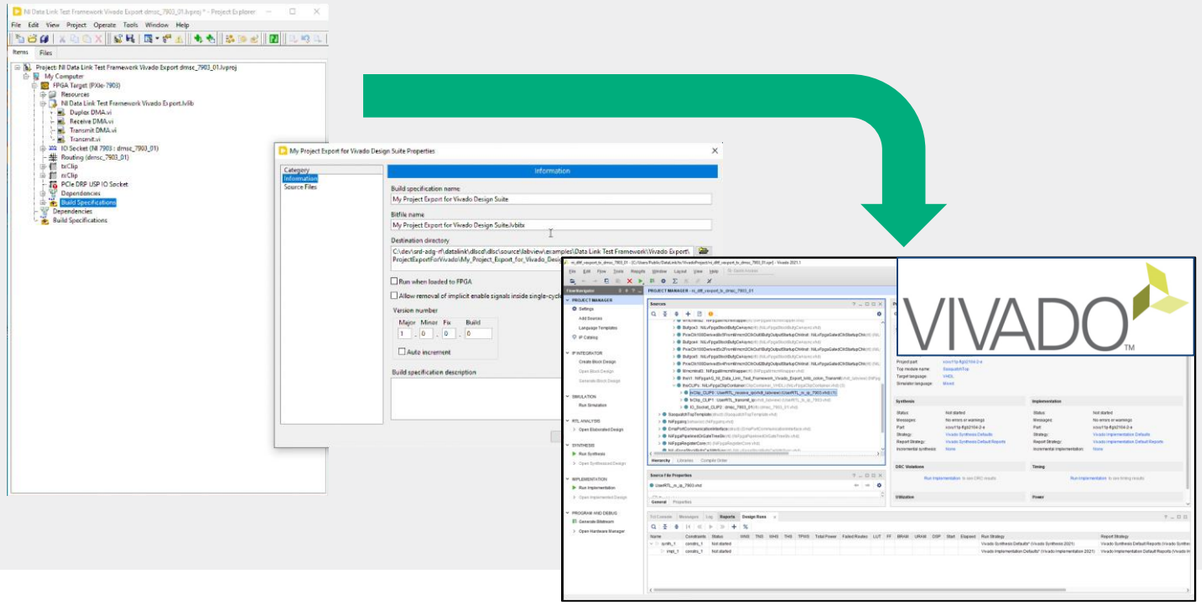



- Integrate external HDL IP into your LabVIEW FPGA Design




## Export to AMD Vivado

- Export NI FPGA Hardware Support and Interfaces into Vivado
- Implement User IP natively in Vivado environment
- Export and Compile to bitfile that is deployable to NI targets



INGENIArs

The Art of Engineering


## WE OFFER

- ❑ FLIGHT ELECTRONIC BOARDS
- ❑ FPGA/ASIC DESIGN & PROTOTYPE
- ❑ EMBEDDED SYSTEMS
- ❑ HW/SW CO-DESIGN
- ❑ FLIGHT IP CORES & DESIGN
- ❑ VERIFICATION
- ❑ EGSEs

## APPLICATION AREAS

- ❑ HIGH-SPEED DATA INTERFACES
- ❑ SATELLITE COMMUNICATION
- ❑ ON-BOARD DATA PROCESSING
- ❑ DIGITAL SIGNAL PROCESSING
- ❑ DATA-HANDLING
- ❑ INSTRUMENT CONTROL UNITS
- ❑ ARTIFICIAL INTELLIGENCE

SpaceWire

SpaceFibre

AMD Adaptive Computing Partner SELECT CERTIFIED

AUTHORIZED MICROCHIP DESIGN PARTNER

Consultative Committee CCSDS for Space Data Systems

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# IngeniArs RF Communications IP Cores

## CCSDS 131.2-B ENCODER MODULATOR

**Core for payload data transmission with supporting all 27 ModCods and high data-rate (up to 1GSymb/s)**

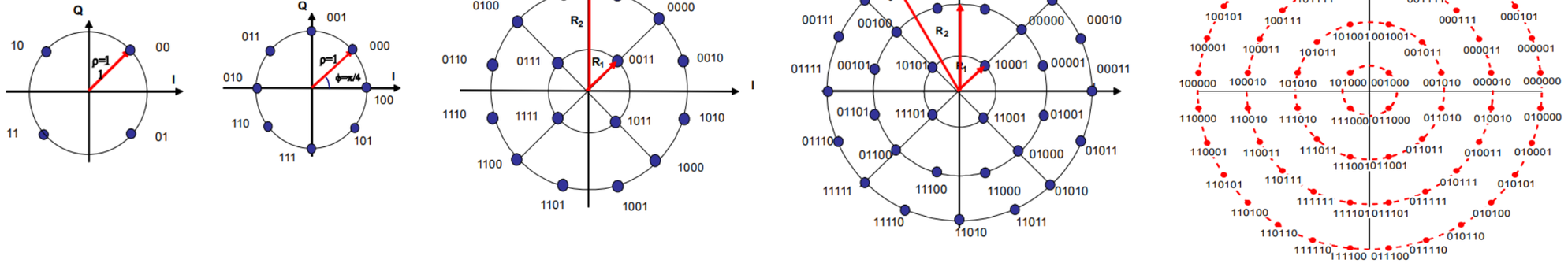
## CCSDS 131.2-B RECEIVER

**Core implementing receiver chain from the input I/Q baseband signal up to the SCCC decoder. Selectable symbol rate in the range from 10MBaud to 500MBaud for ground applications. Version available for space application.**

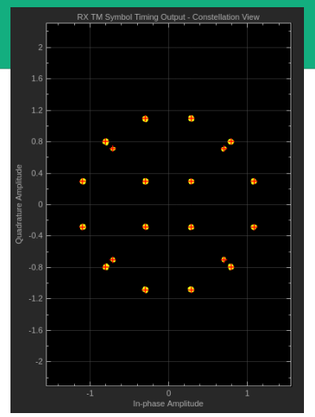
**Serially Concatenated Convolutional Code (SCCC)**

**19 different coding rates**

**5 different constellations**



# SCCC Transmitter




**FPGA**

**Input bit stream**

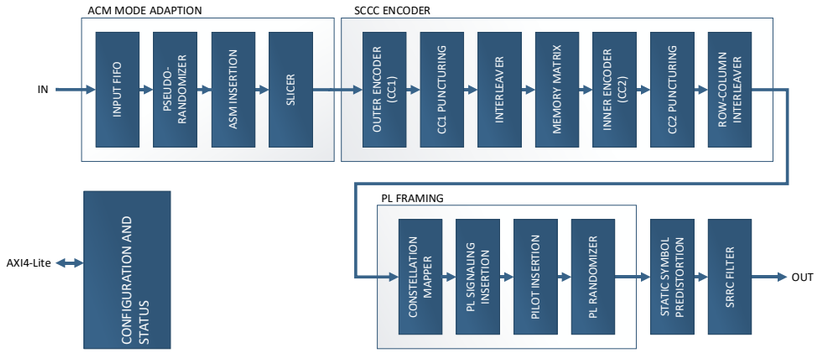
Input Interface

SCCC TX IP Core

DAC Interface

DAC/DUC

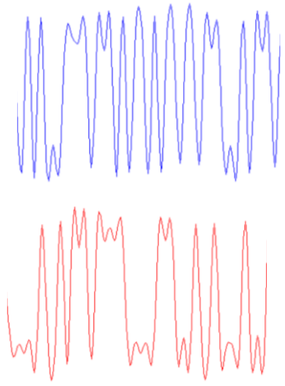
**Analog Baseband/IF signal**



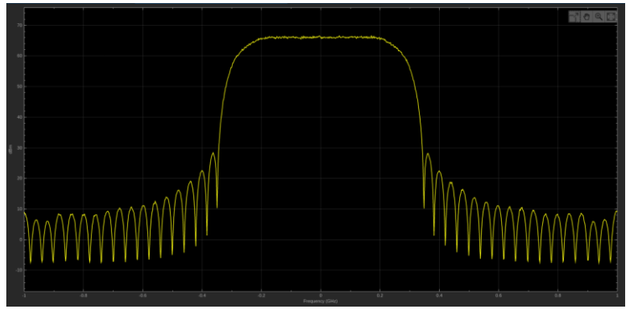

**Baseband signal in the time domain**

**I Signal**

**Q Signal**

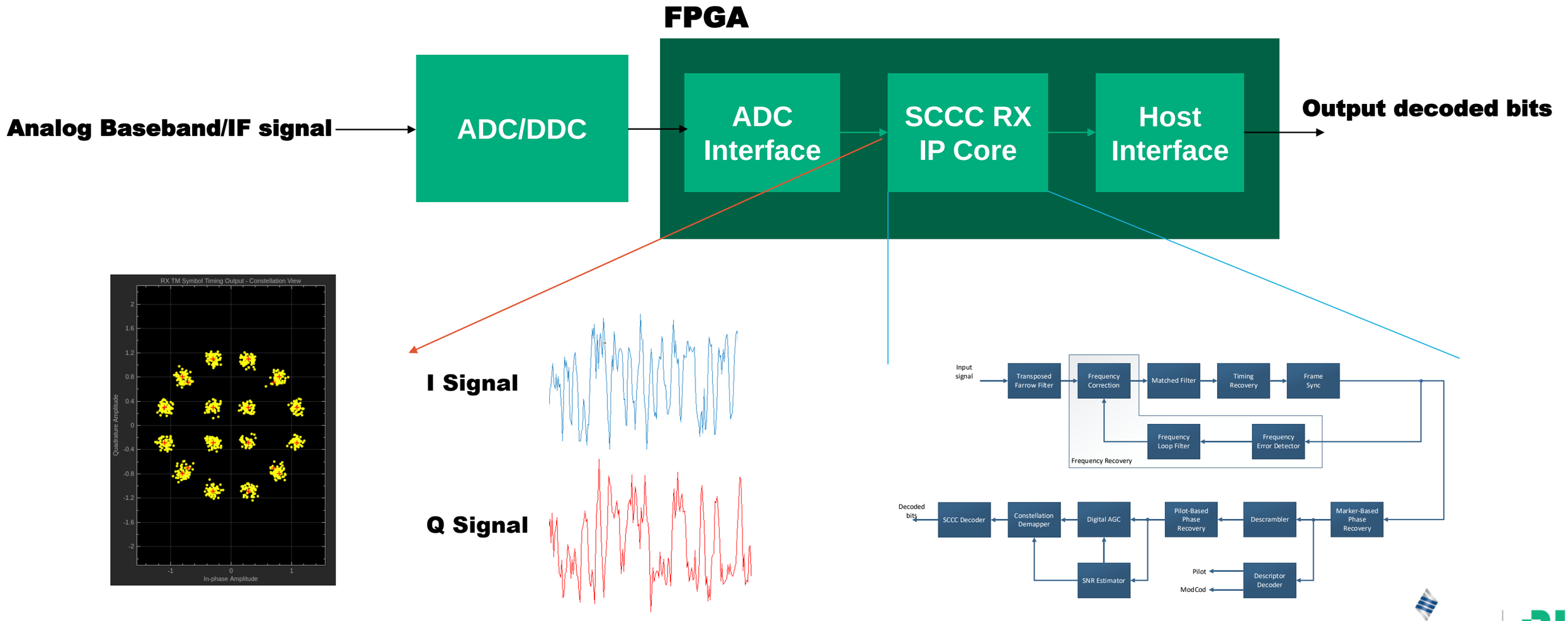


**Baseband signal spectrum**

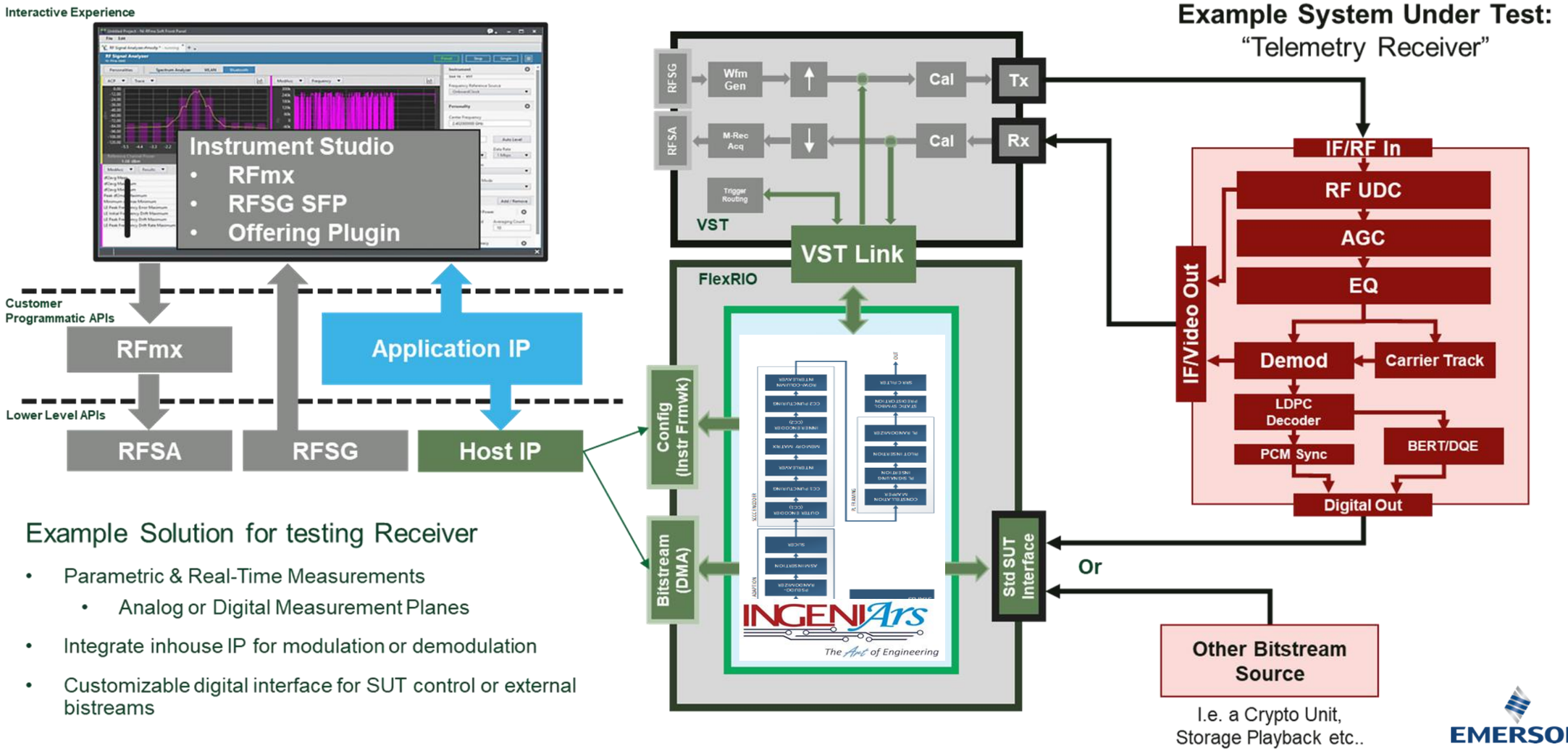


# SCCC Receiver

**I/Q sample input @ 2GSample/sec**



# Example | CCSDS Receiver Validation with NI + IngeniArs




## Example Solution for testing Receiver

- Parametric & Real-Time Measurements
  - Analog or Digital Measurement Planes
- Integrate inhouse IP for modulation or demodulation
- Customizable digital interface for SUT control or external bistreams

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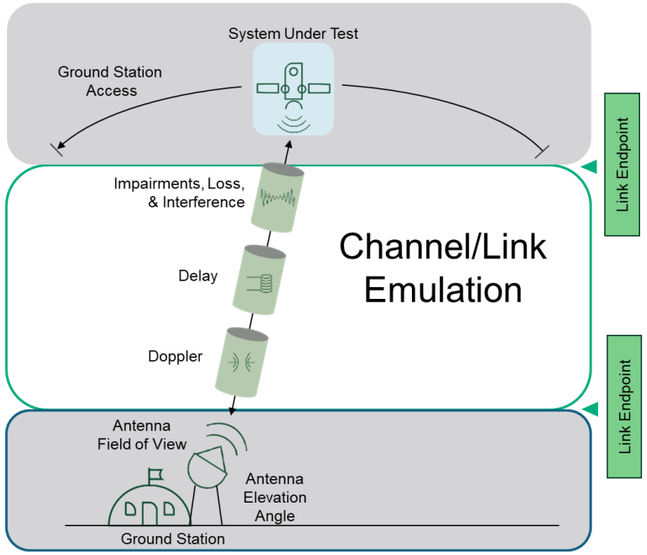
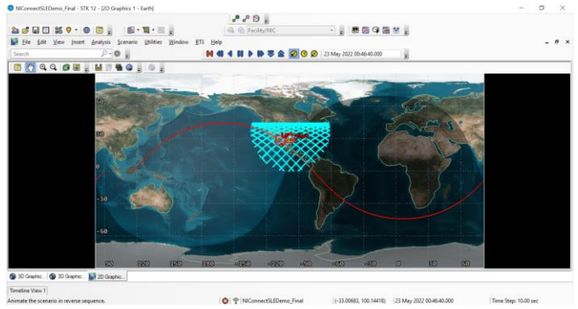
# NI Solution | Dynamic Environment Emulation



3rd Party Simulation Software

STK

Simulated Channel

3rd Party Data Link IP

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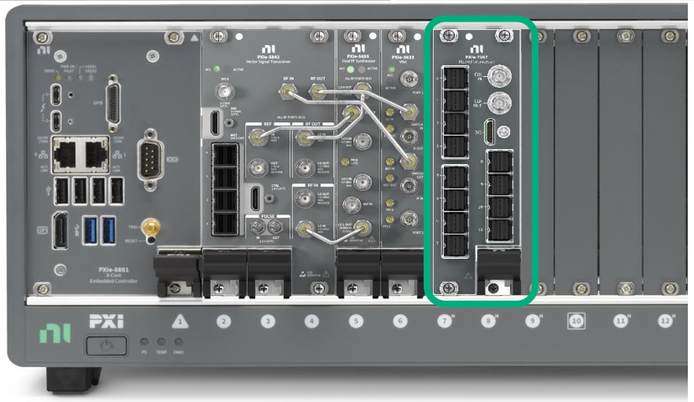
SpecAn | SigGen | VNA | Channel Model

VST | Emulated IP

FlexRIO FPGA



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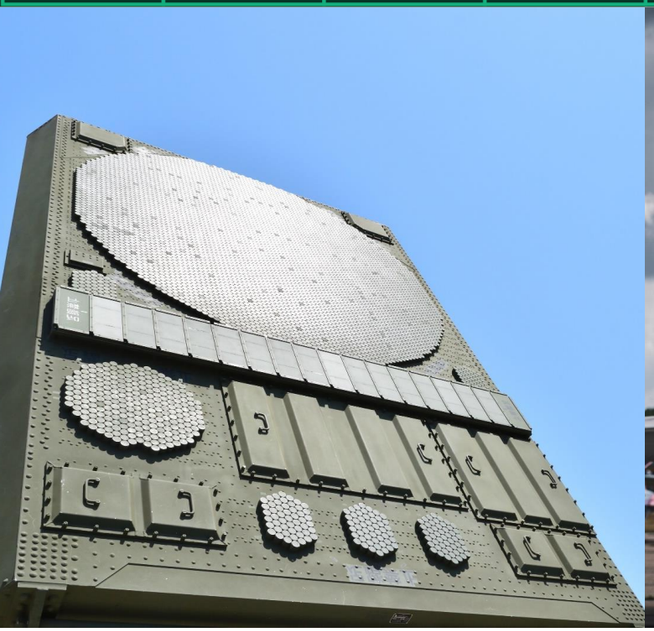
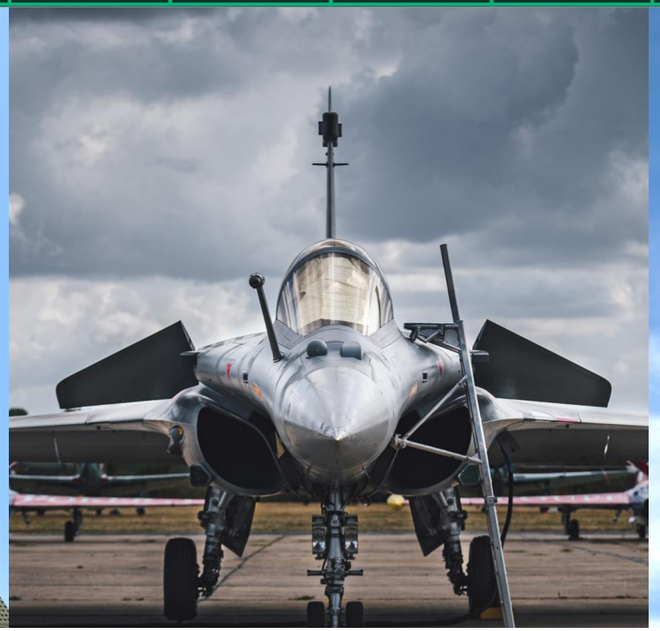
CONNECT

Today’s modern Telemetry and Datalink Systems are increasingly mission-critical to dynamic Aerospace & Defense Applications such as Satellite Communications.

To reduce risk and get to market faster – it’s crucial to combine traditional RF parametric measurements with real-time, application specific HIL validation. This includes not just the SUT in a static condition, but under the real mission parameters of the end system.

NI approaches this challenge by combining high performance RF instrumentation with scalable FPGA co-processors to provide the SUT and environment emulation needed to design, validate, and product these key systems.
- See it in action in the Aerospace and Defense Experience Lounge or contact your NI representative for more information!

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# See it live in the Aerospace & Defense Experience Lounge!


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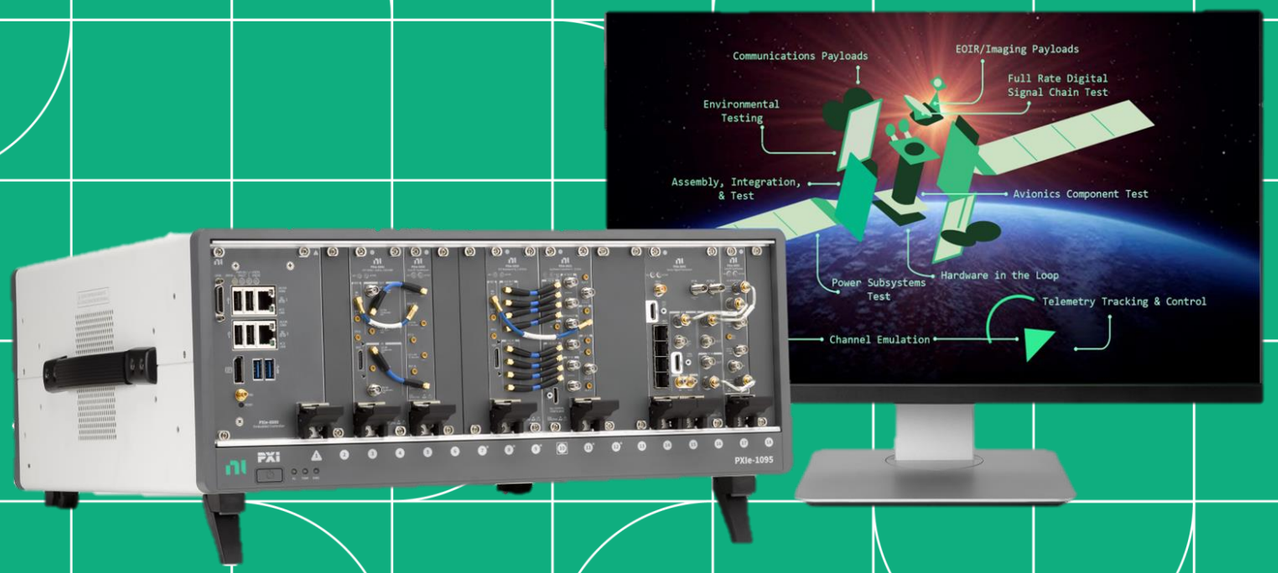


# Conclusion

**Cost effective EGSE with scalable software and hardware functionality**

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