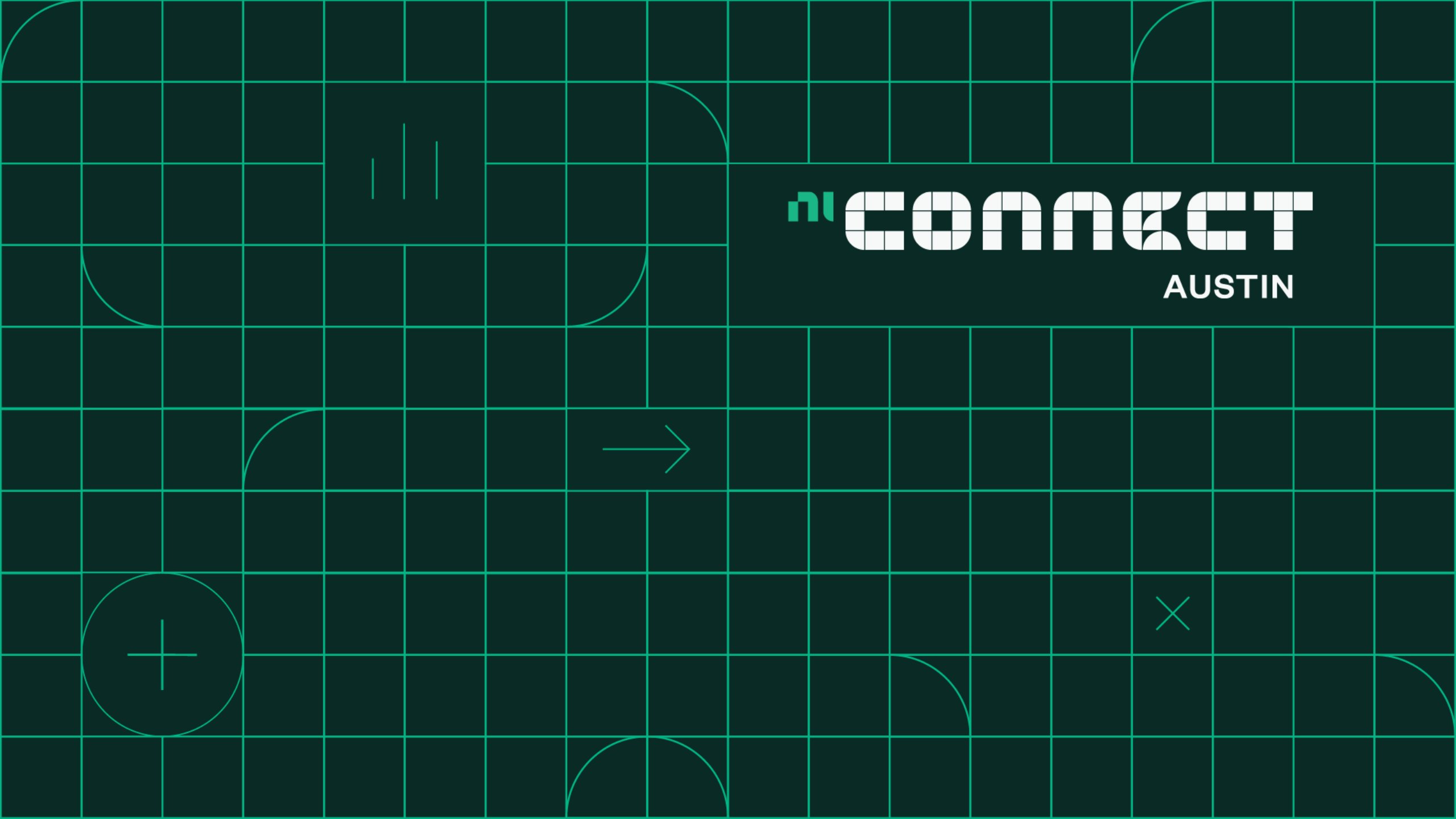
NI CONNECT
AUSTIN

Validate Radar with Radar Target Generation Software

Ahmed Khalid

Principal Offering Manager, ADG BU

Introduction

- Principal Offering Manager, Aerospace Defense and Government Business Unit
  - Radar System Test & Electronic Warfare System Test
  - RF Deployment, Prototyping and Research
- 12 Years at NI
  - Offering Management
  - Product Management
  - Sales, Sales Management, Systems/ Applications Engineering

Radar Target Generation

Agenda

- Introduction
- Market Trends & Innovation
- Challenges in Test
- NI's Approach to Radar System Test
- Radar Target Generation Software
- Q & A

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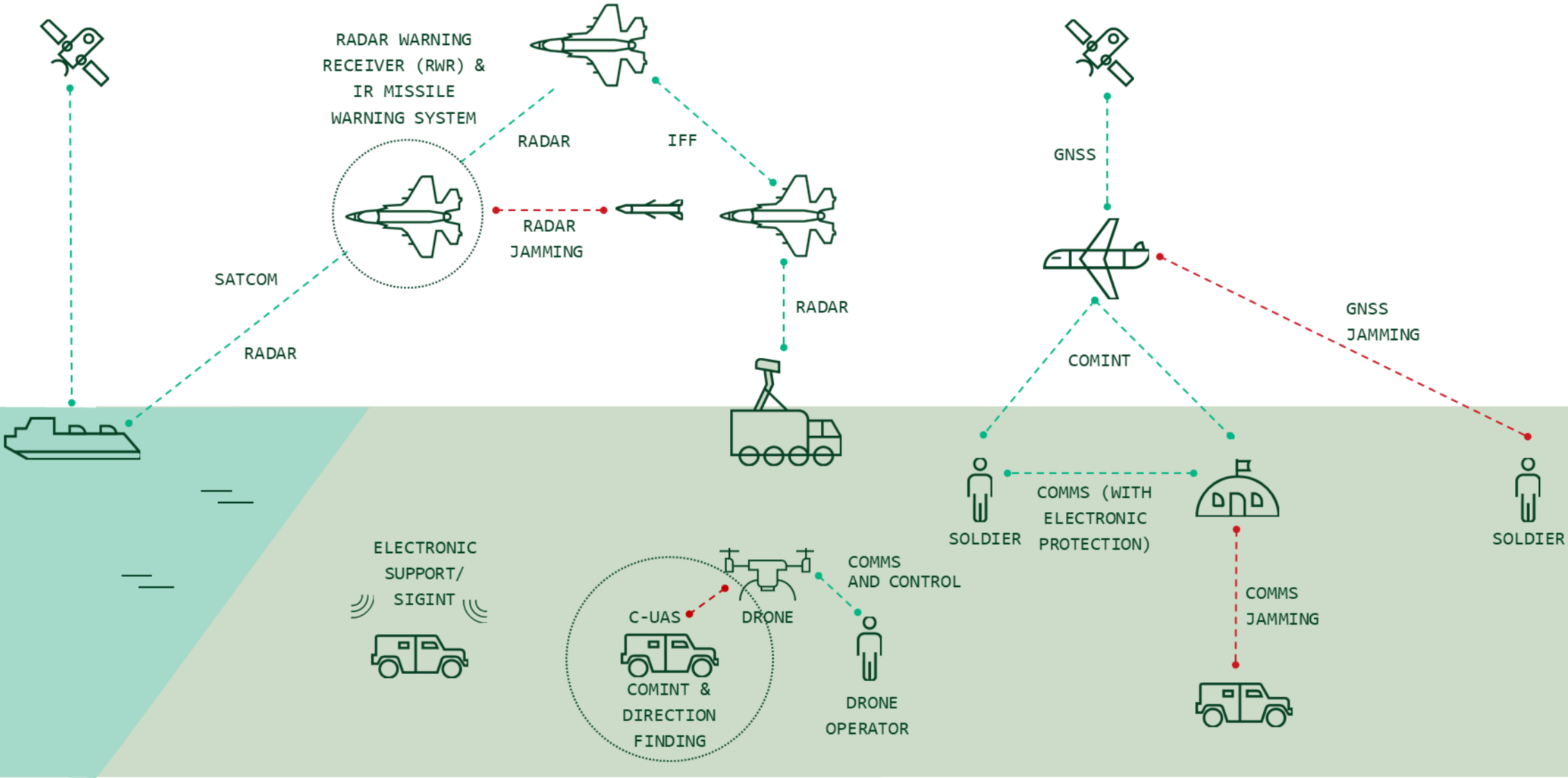
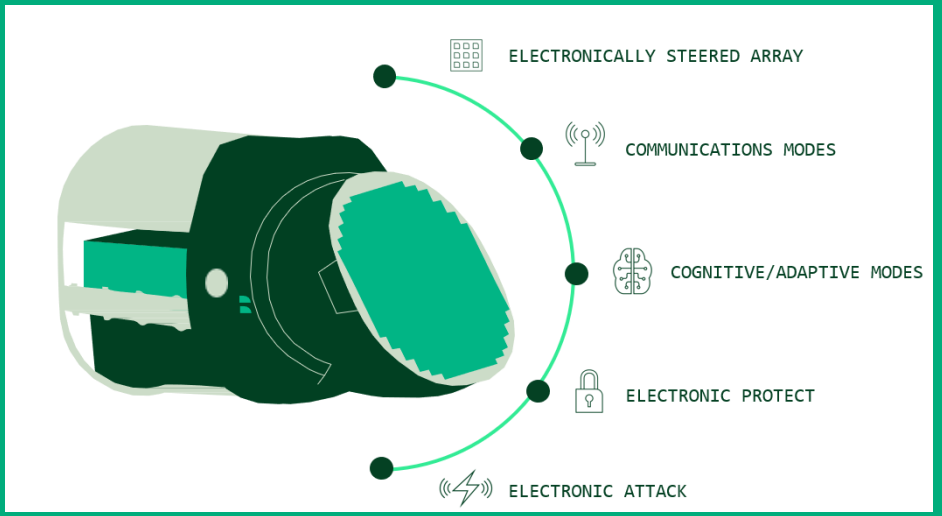
The Why? | Contested & Congested Electromagnetic Spectrum
Forcing Rapid Innovation

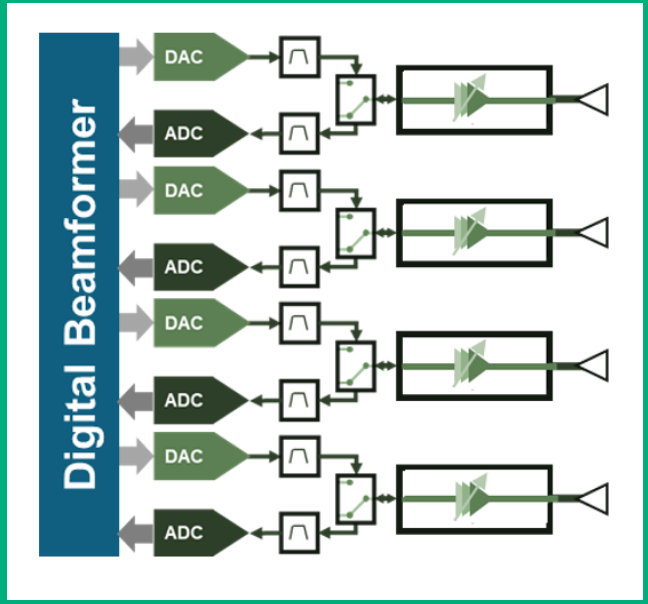


Market Trends & Innovation

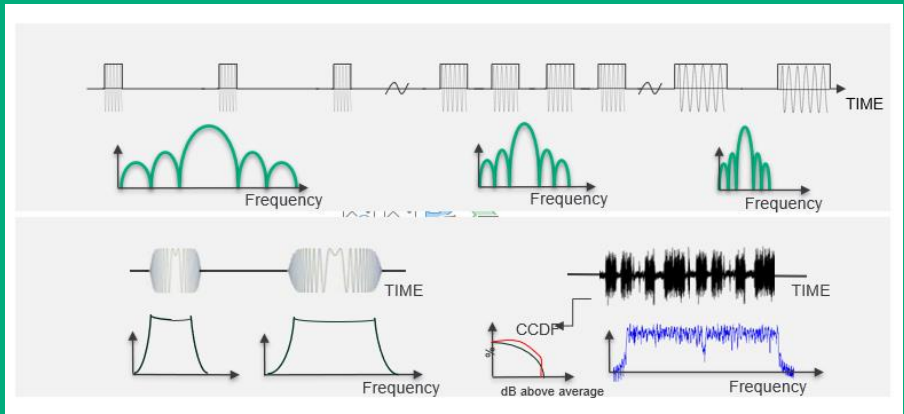
Multimode Radar Systems



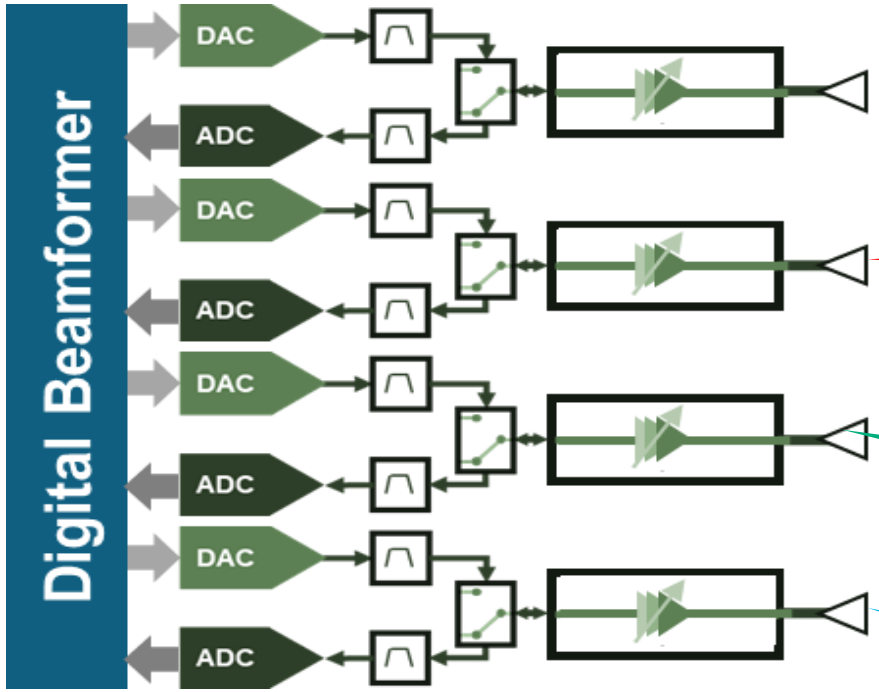
Digital AESA Arrays



Agile Radar Waveforms



Modern Radar Systems



Frequency 10GHz

Detect & Track

Frequency 8GHz

Communicate

Frequency 10GHz

Weather

Clutter

Frequency 9GHz

Imaging & Classification

Unintentional & Intentional Interference

Other Radars

New Capabilities:

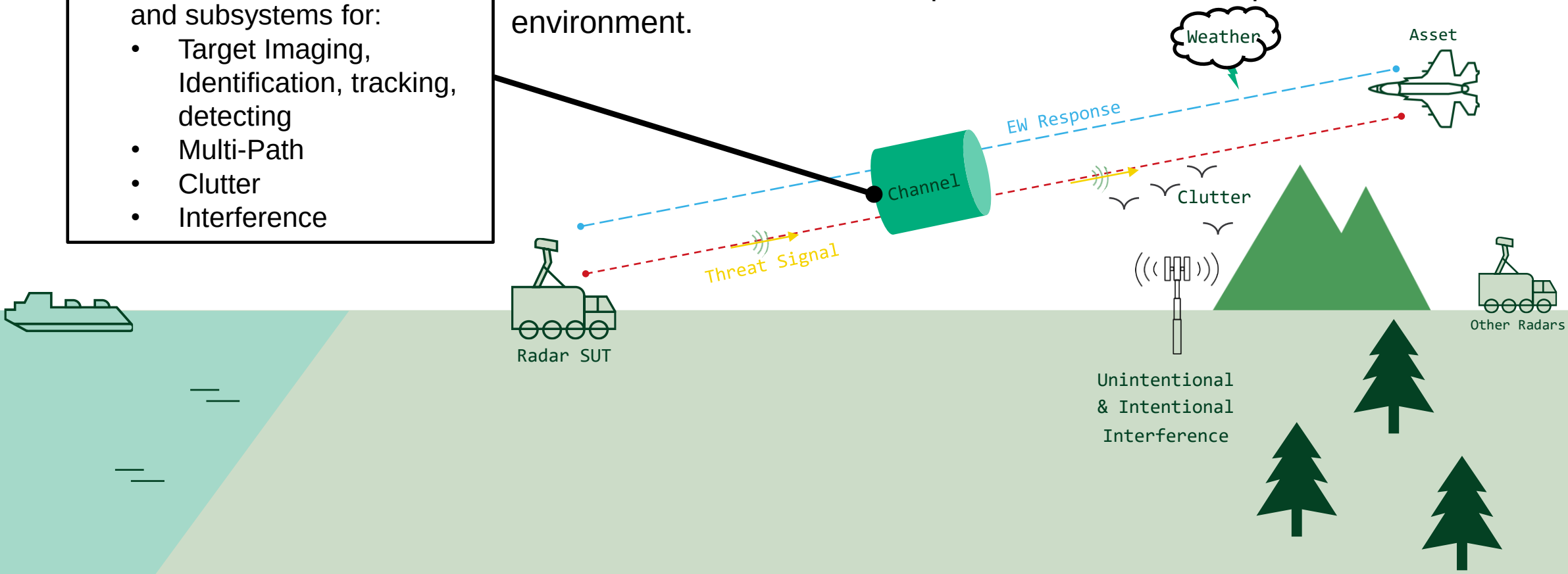
- Enhanced multi-function capability
- Increased Radar Bandwidth
- Multiple beams at different frequencies
- Increased antenna array elements
- Flexibility in waveforms

Challenges of Radar System Level Testers

Emulate Channel Effects to Validate Radar Processor and subsystems for:

- Target Imaging, Identification, tracking, detecting
- Multi-Path
- Clutter
- Interference

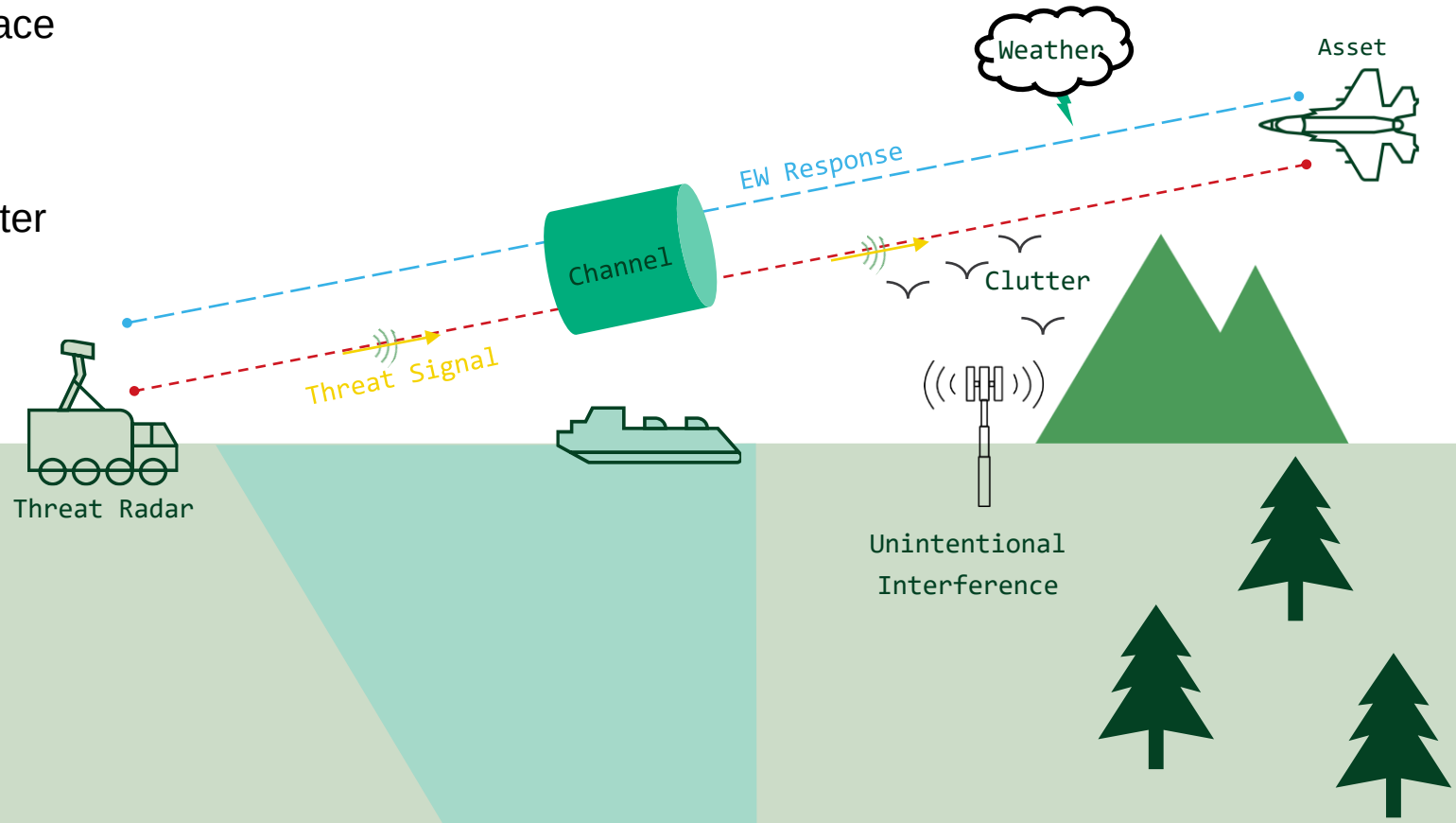
Radar Testers Ability to pull from terrain and threat data bases to build a realistic RF environment response. Give realistic representation of environment.



Challenges of Radar System Level Testers

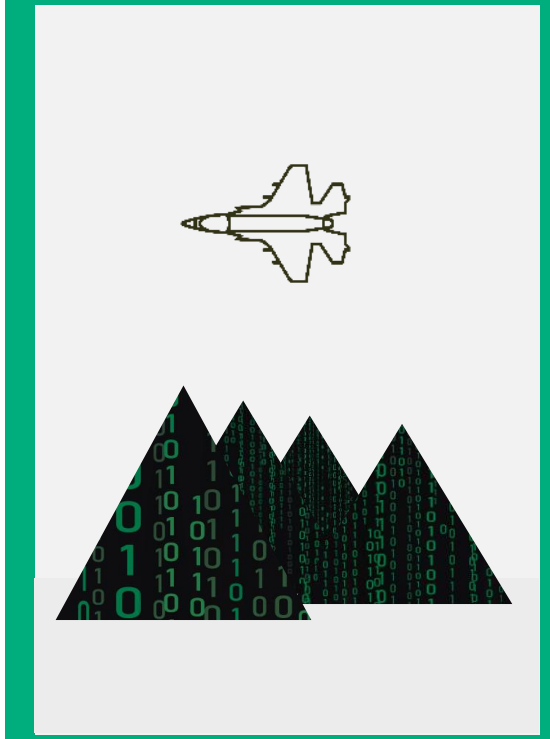
Radar Test System must have following capabilities:

- Wide Instantaneous Bandwidth & Frequency Range
- Phase Coherent Channels – Scalable System
- Waveform Agnostic – From narrow Pulses to CW signals
- Target Range – Close range to Space
- Ability to Generate:
  - Realistic multi-point targets
  - Support SAR, ISAR modes
  - Channel effects: weather, clutter
  - EA techniques
- Ability to Synchronize with Radar
- Generate Background Emitters
- Support Radar Test Workflows

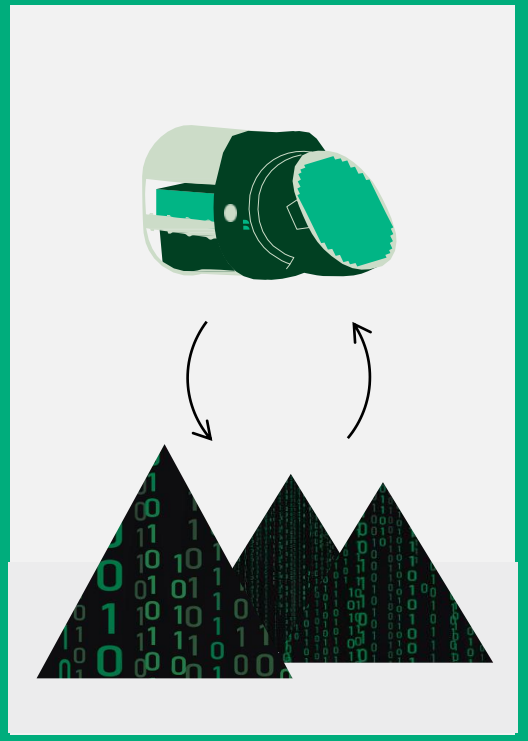


Phases of Radar Design Test & Evaluation

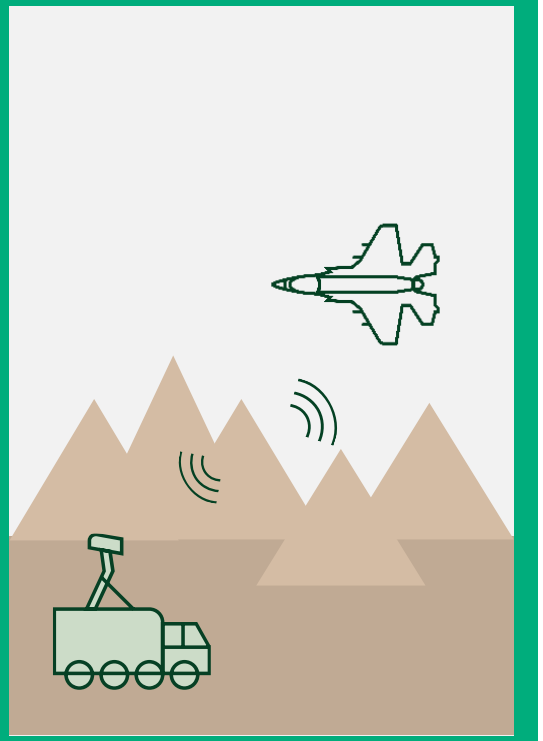
Modeling & Simulation
Digitally Simulated System



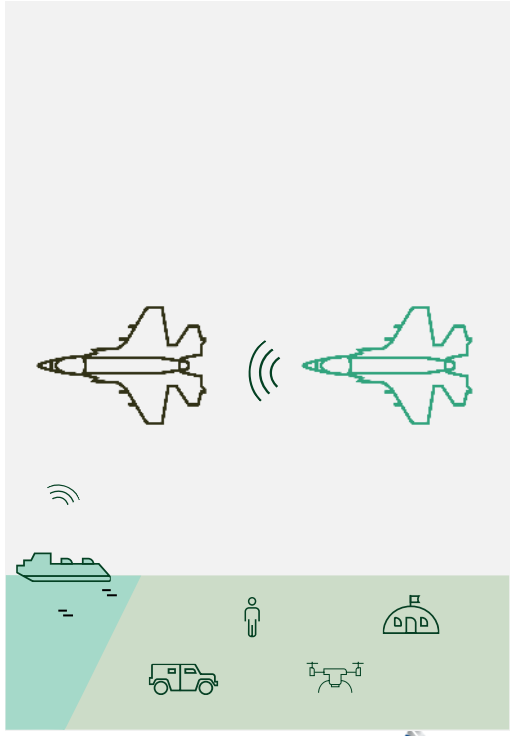
Integration Lab
Digital & RF Hardware in the Loop Testing



Open Air Range
Controlled Engagement Scenarios



Operational Mission
Active Engagement



NI Solutions For Radar System Test

Scope

- Component to System
- Digital to RF

Capabilities

- RF Parametric Test
- Radar Target Generation
- Digital Interface Test
- Digital Target Insertion
- Software Automation
- Multi-Instrument Test Systems

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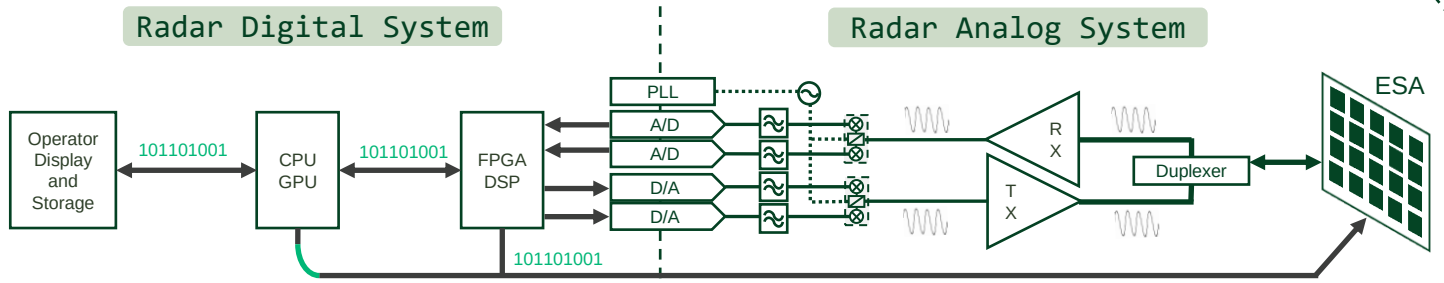
Common Radar System Building Blocks



NI Solutions for Radar System Test

Control and Automation

Octocore Xeon Controller

Test Development Automation System Control Software

Software Tools

NI Digital Instrumentation

28 Gbps, 8 Channel, Customer Serial Protocols

4 TB, 5 GB/s RAID Stream Custom Digital Test Scenarios to and from Disk

Digital System Test

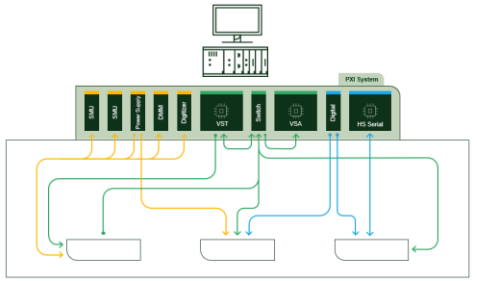
NI RF Instrumentation

44 GHz, 1 GHz BW VST

RFmx measurements Harmonic Distortion IMD, TOI, NF

RF Parametric Test

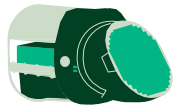
NI ESA Test Architecture



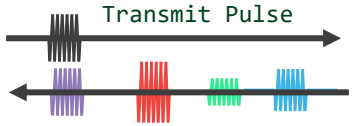
Multi-Channel mmWave, Pulse Profile, Pulse Stability, S-Parameters, PAE

RF Sub-Systems Test

Radar Target Generation End to End System Level Test



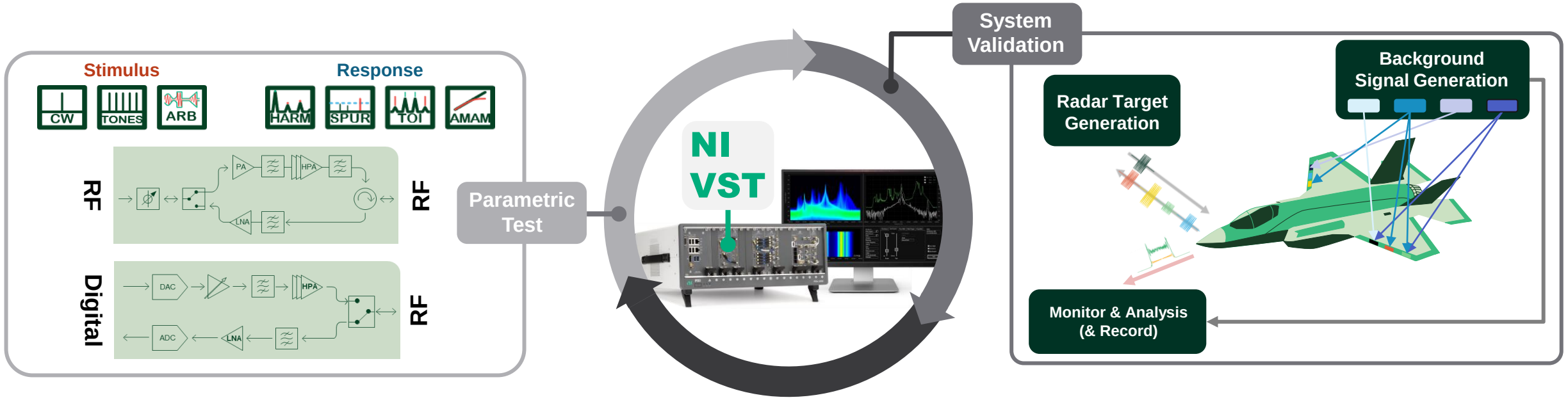
Radar Under Test



RTG Response (Precision Test Targets)

4 Independent Targets
3 Parameters: Range, Velocity, Attenuation
Full System Level Calibration

NI Solution | Modular, Software-Defined Instrumentation for Radar Test and Validation

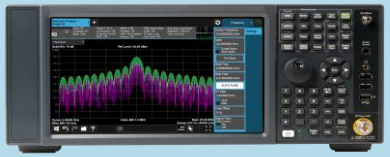


NI Solution | Vector Signal Transceiver (VST)

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

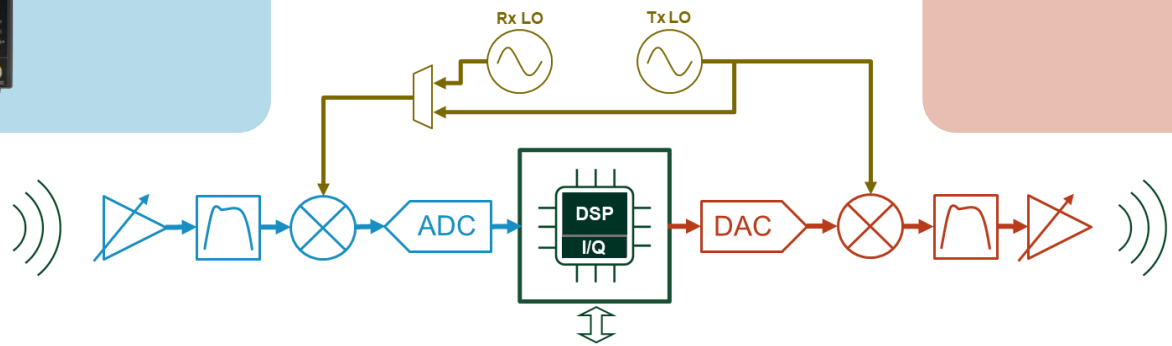
Calibrated, wideband vector signal analyzer:

- Frequency Range: 30 MHz to 26.5 GHz
- Programmable gain ranging: +25 dBm max,
- Up to 2 GHz Instantaneous IQ BW w/ planned 4 GHz expansion EoY ’24
- 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 w/ planned 4 GHz expansion EoY ’24
- Full bandwidth I/Q playback
- Integrated Analog Pulse Modulation optimized for >100 dB on/off ratios
- Independent or coherent operation with signal analyzer
- Supports multi-channel synchronization and coherency



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

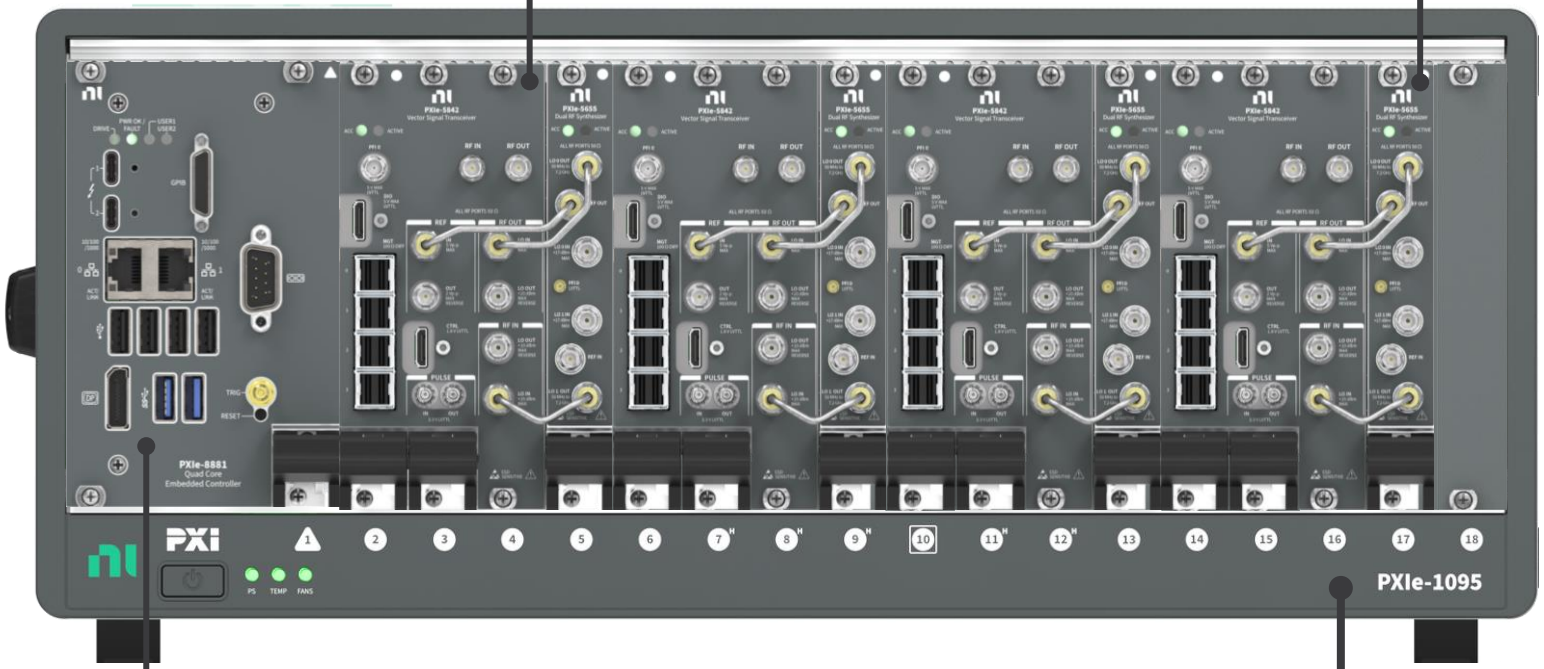
Frequency Extension

- 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 | Designed for Multi-Channel

Synchronize up to four 26.5GHz VST's in a Single 18-slot chassis

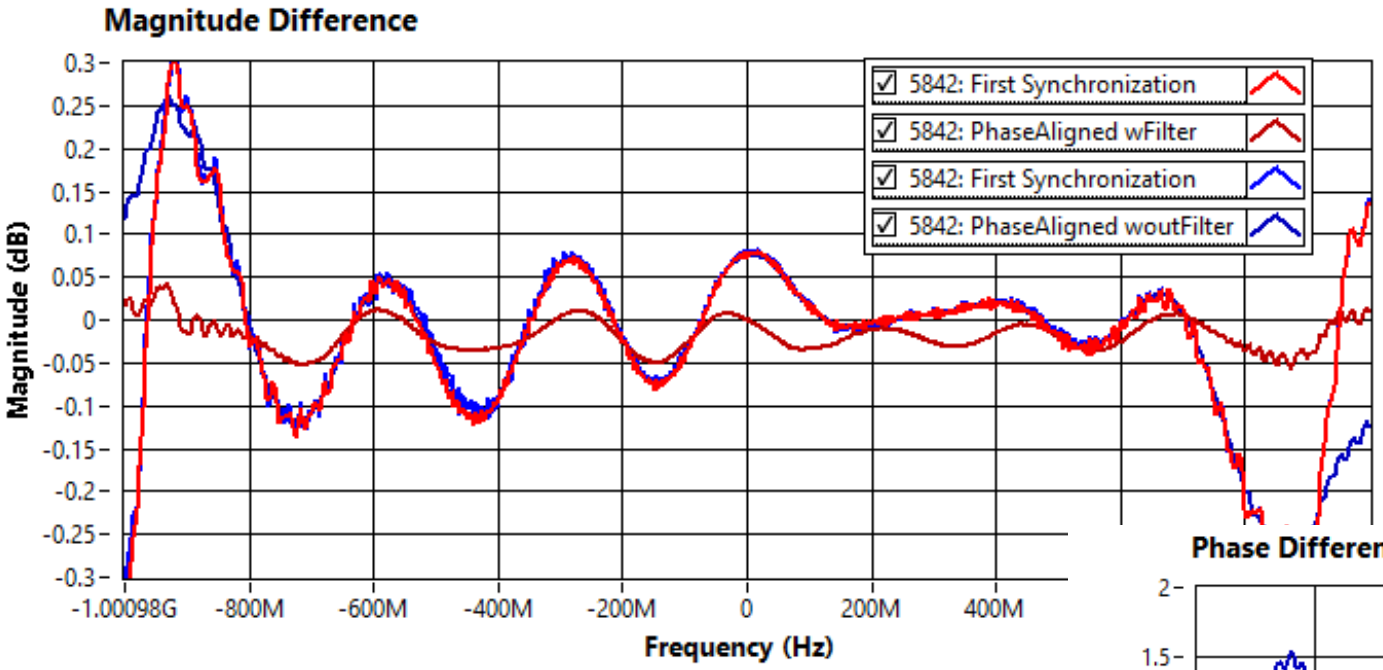
Shared LOs for MIMO Configurations

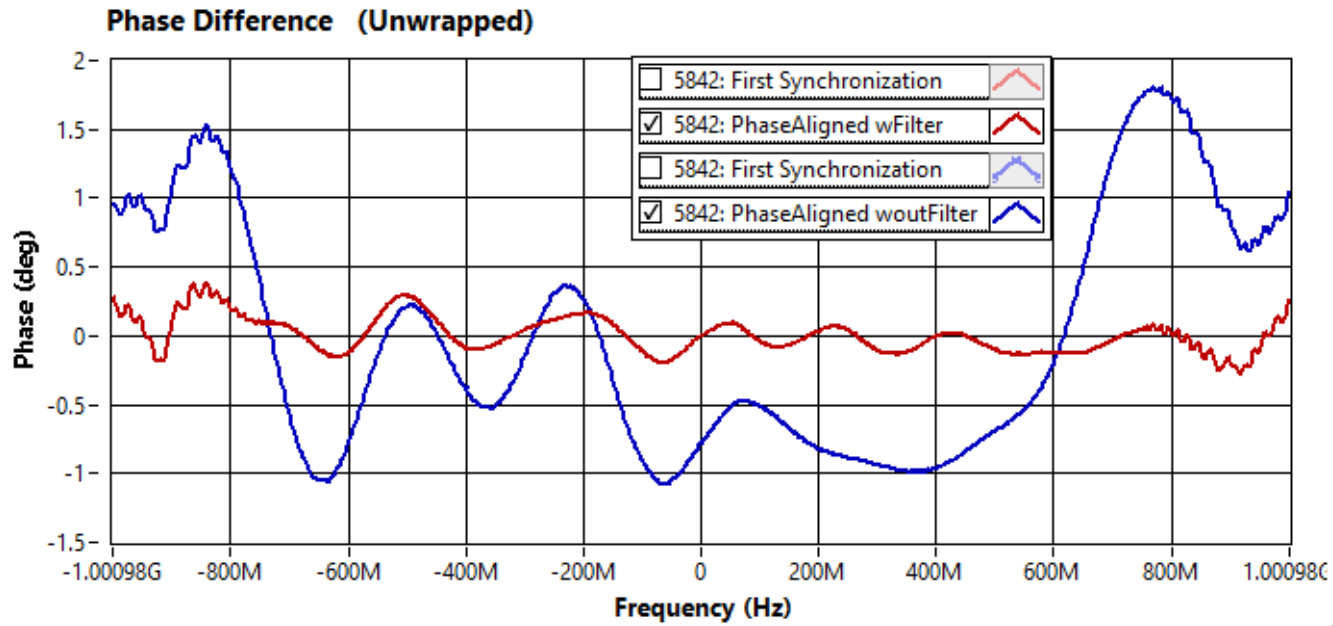


64 bit OS +
64 bit driver **Required**

82W Chassis **Required**
PXIe-1095 or PXIe-1092

Channel Alignment





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NI RTG | Interface w/ Real time Simulator

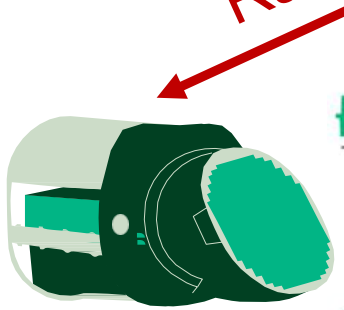
RTG used in Real Time Scenario Simulation

- Dynamic system simulation with Hardware-in-the-loop
- HWIL test in conjunction with other system functions: EW, Comms, Navigation, Etc..
- Target Parameters Applied
  - On Demand
  - Hardware Timed

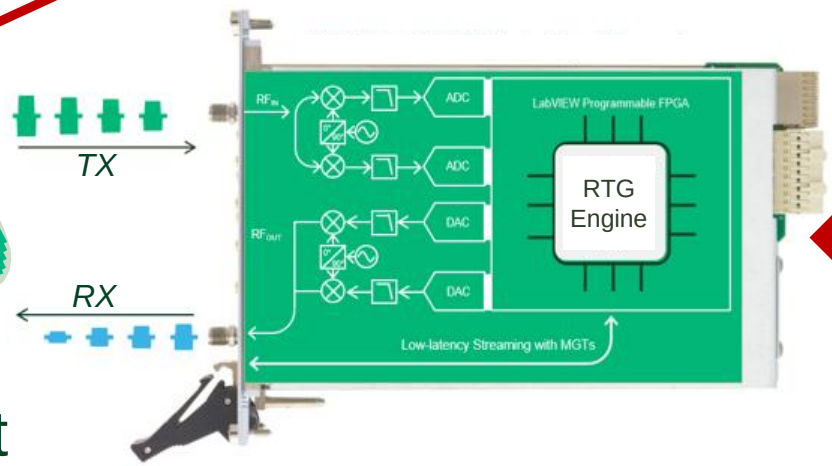
Radar Bus Communication

Ethernet

Streaming Target Parameters



Radar Under Test



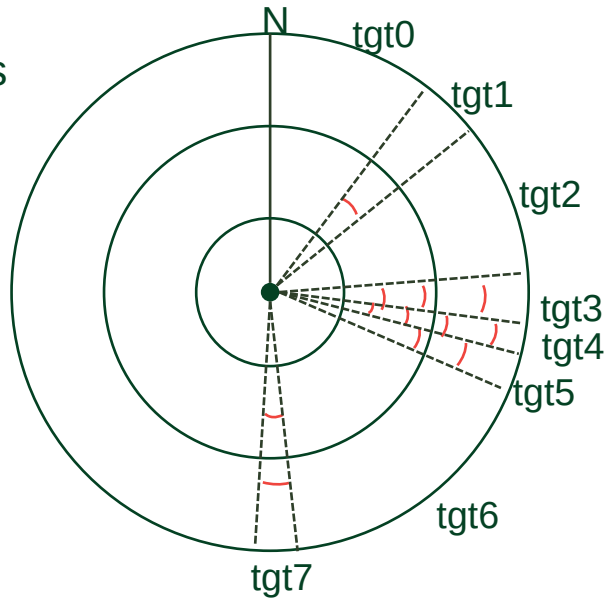
VST Module

PXI Test System

NI RTG | Pre-Generated Target Scenarios ‘List Mode’

NI RTG Features

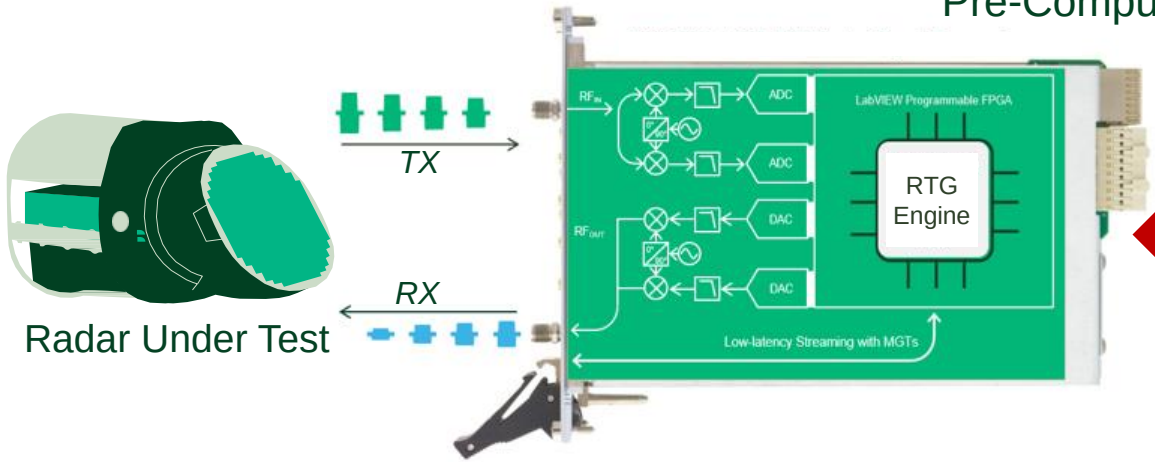
- Over 10 Million Targets
- Deterministic Timing
- Digital Triggered
- Software Triggered
- Time Reference Trig
- Synchronize to Radar
- File Driven
- Four Targets per Entry



TIME or SAMPLE	# TGT	Target Parameters (Atten, Doppler, Time)			
		TGT 1	TGT 2	TGT 3	TGT 4
0 ms	0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0
234 ms	1	3.2, -2.7, 234	0, 0, 0	0, 0, 0	0, 0, 0
324 ms	0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0
Conceptual Data Structure					
872 ms	4	1.7, 2.3, 234	1.9, 3.2,3.45	2.1,-2.1,4.1	1.1,-3.1,6.23
932 ms	2	3.2,5.5,222	1.1,3.2,943	0, 0, 0	0, 0, 0
1,343 ms	0	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0
13,187 ms	2	1.1,2.2,3.3	7.1, 1.7, 783	0, 0, 0	0, 0, 0

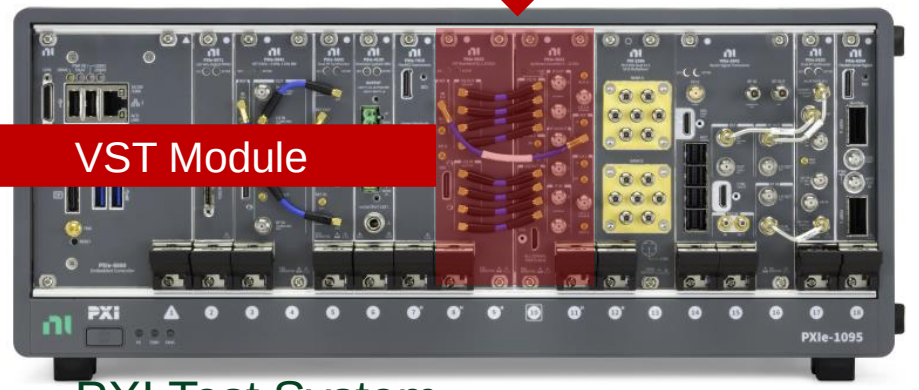
Pre-Computer Target Parameter List

RTG file format = .CSV



Radar Under Test

VST Module



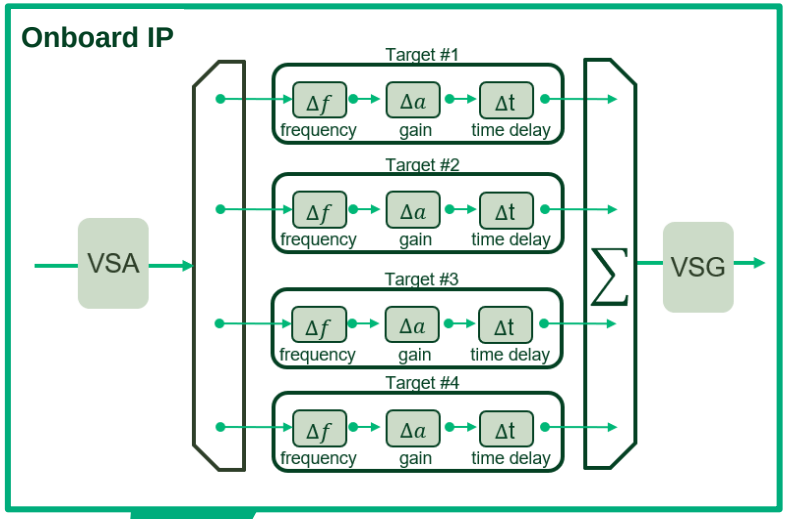
PXI Test System

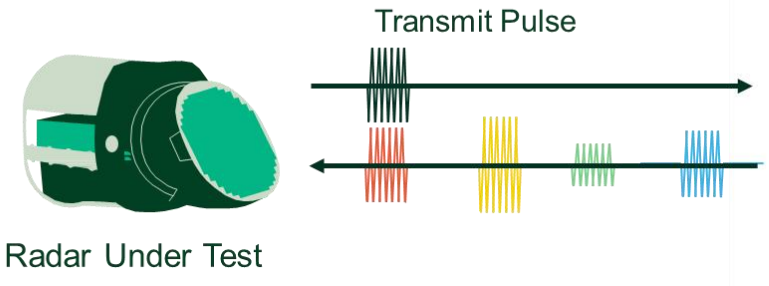
**Extra PXI Cards not required*

Shared Under NDA

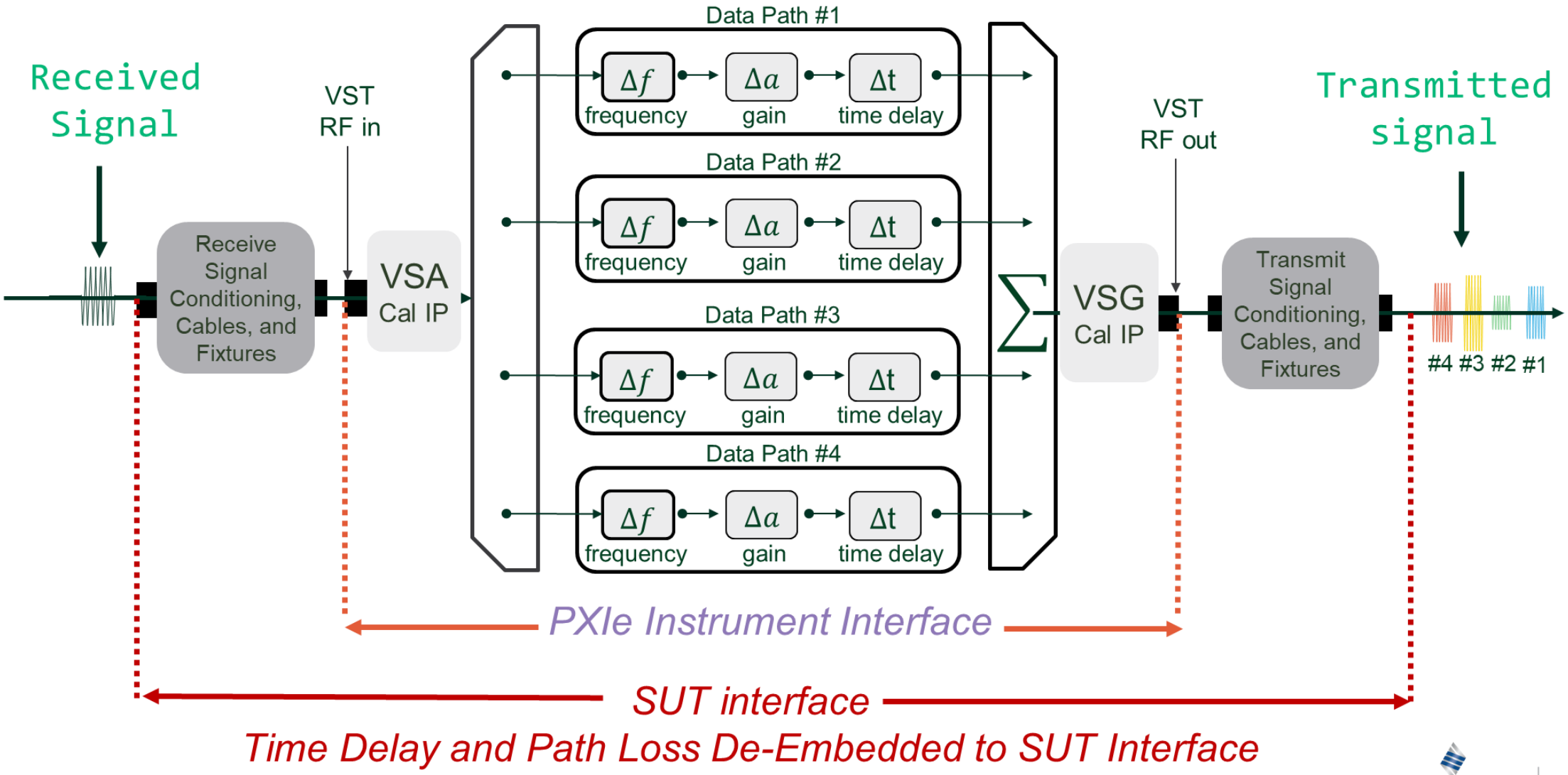
NI Solution | Radar Target Generation Software 1.3

Parameters	System Capability
Number of Real-Time Targets	1-4 per RF Port
Range (Time Delay)	Maximum: 64,000 km Minimum: 125 m (<1 m in low latency mode)
Velocity (Doppler)	± 2 MHz, <5Hz resolution
Path Loss	Supports Digital and Analog Attenuation (Enhanced Dynamic Range)
Analog Attenuation Range	120dB Nominal
System Level Calibration	Integrated System Self-Calibration De-embedding of Cable Loss and Time Delay
Frequency Range	10 MHz to **26.5 GHz** (Up to 54GHz supported)
Bandwidth	Up to **2 GHz**
Supported Trigger Modes	Software, Hardware, Pulse Edge, Relative Time
Motion Profiles	Direct Simulation of Simple Target Motions
Target RCS Models	**Swerling Models (1 – 5)**
Supported Modes	Live Mode (Interface with Dynamic Scenario Generator) List Mode (Pre-generated File based Scenario Generation)
Update Rate	< 70 usec (List Mode) < 1 msec (Live Mode)
List Mode Depth	>10 million Target Entries
Extensibility	Modifiable FPGA for Custom Target Models & Clutters

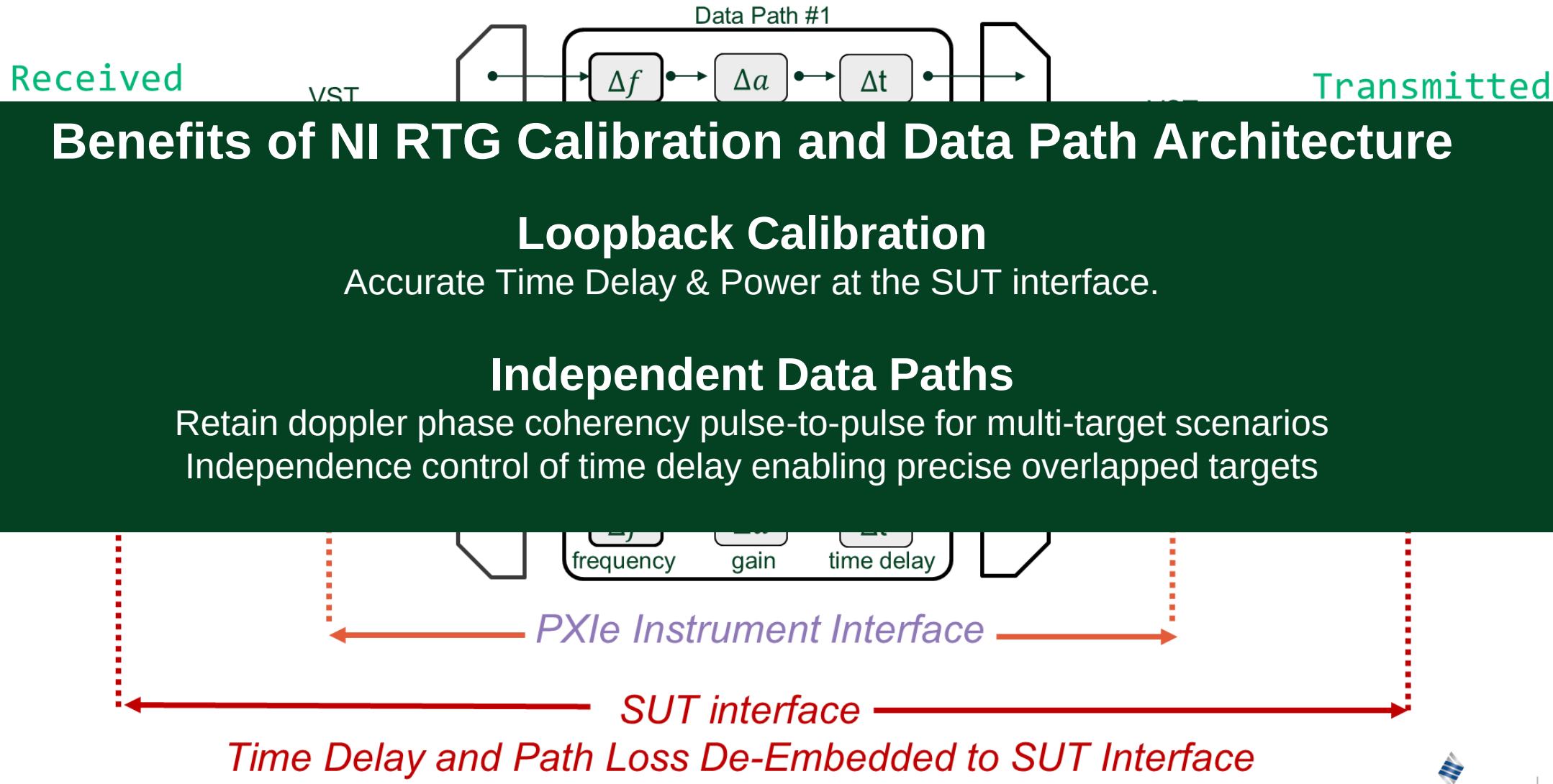




NI RTG | Basic Data Path & Calibration



NI RTG | Basic Data Path & Calibration



Benefits of NI RTG Calibration and Data Path Architecture

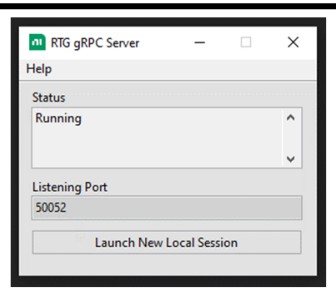
Loopback Calibration

Accurate Time Delay & Power at the SUT interface.

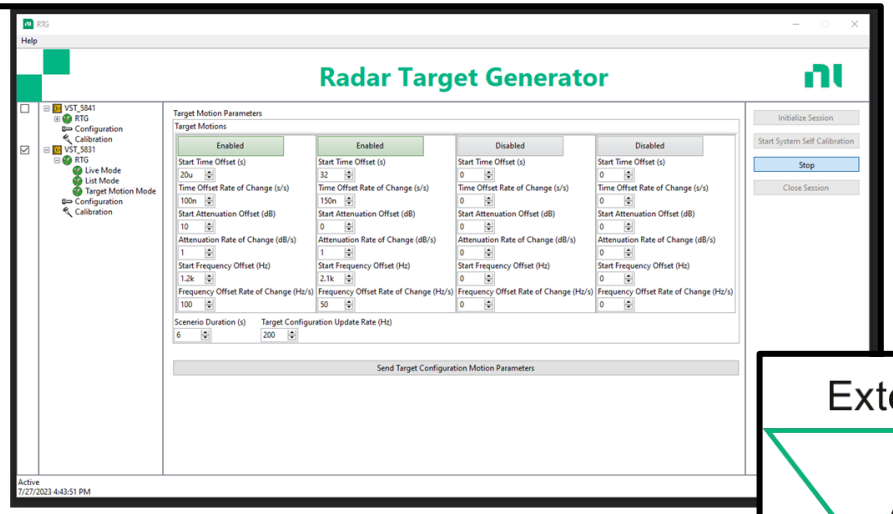
Independent Data Paths

Retain doppler phase coherency pulse-to-pulse for multi-target scenarios
Independence control of time delay enabling precise overlapped targets

NI RTG | Host Code and Application API



Local Server Client

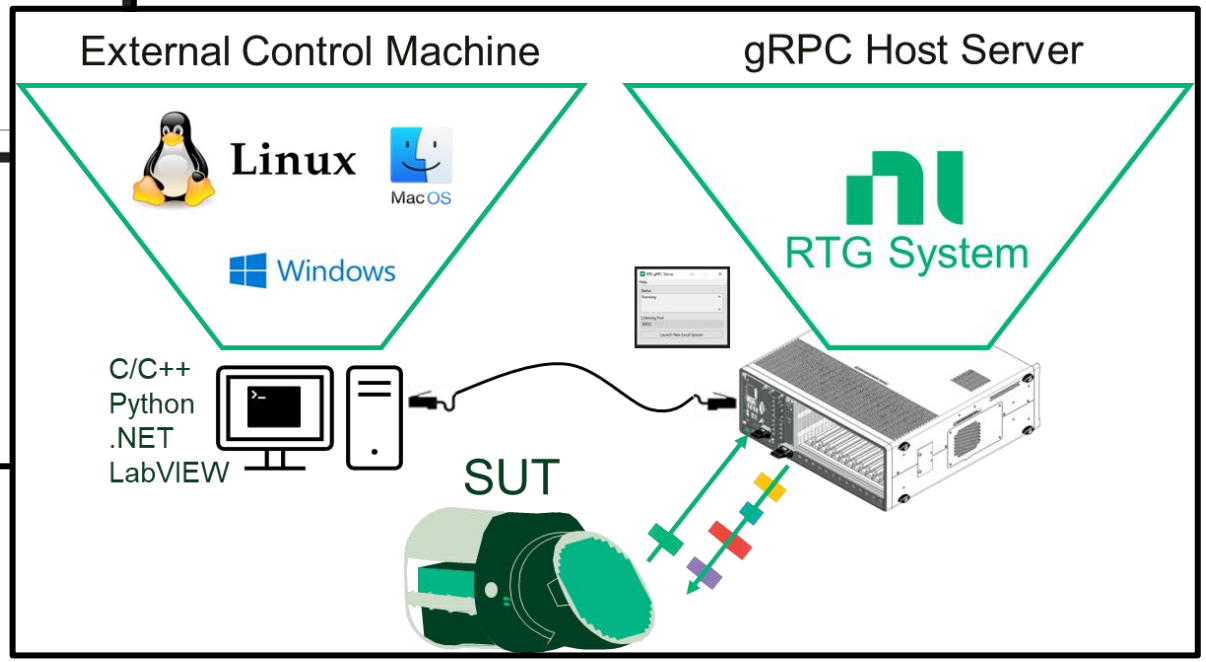


Host Code Details

- Remote API over Ethernet
- Operating System Windows 10
- Multiple Modules Per Chassis Supported

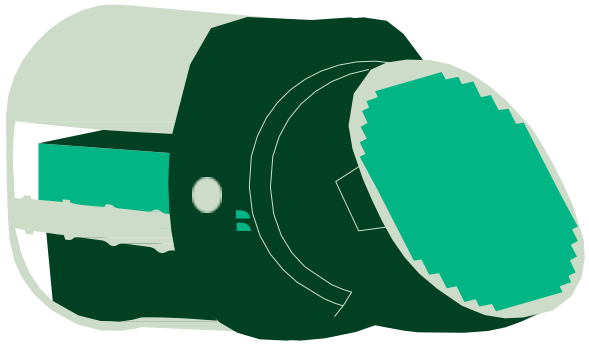
Interactive GUI

- Static Targets
- Calibration
- Motion Mode
- List Mode

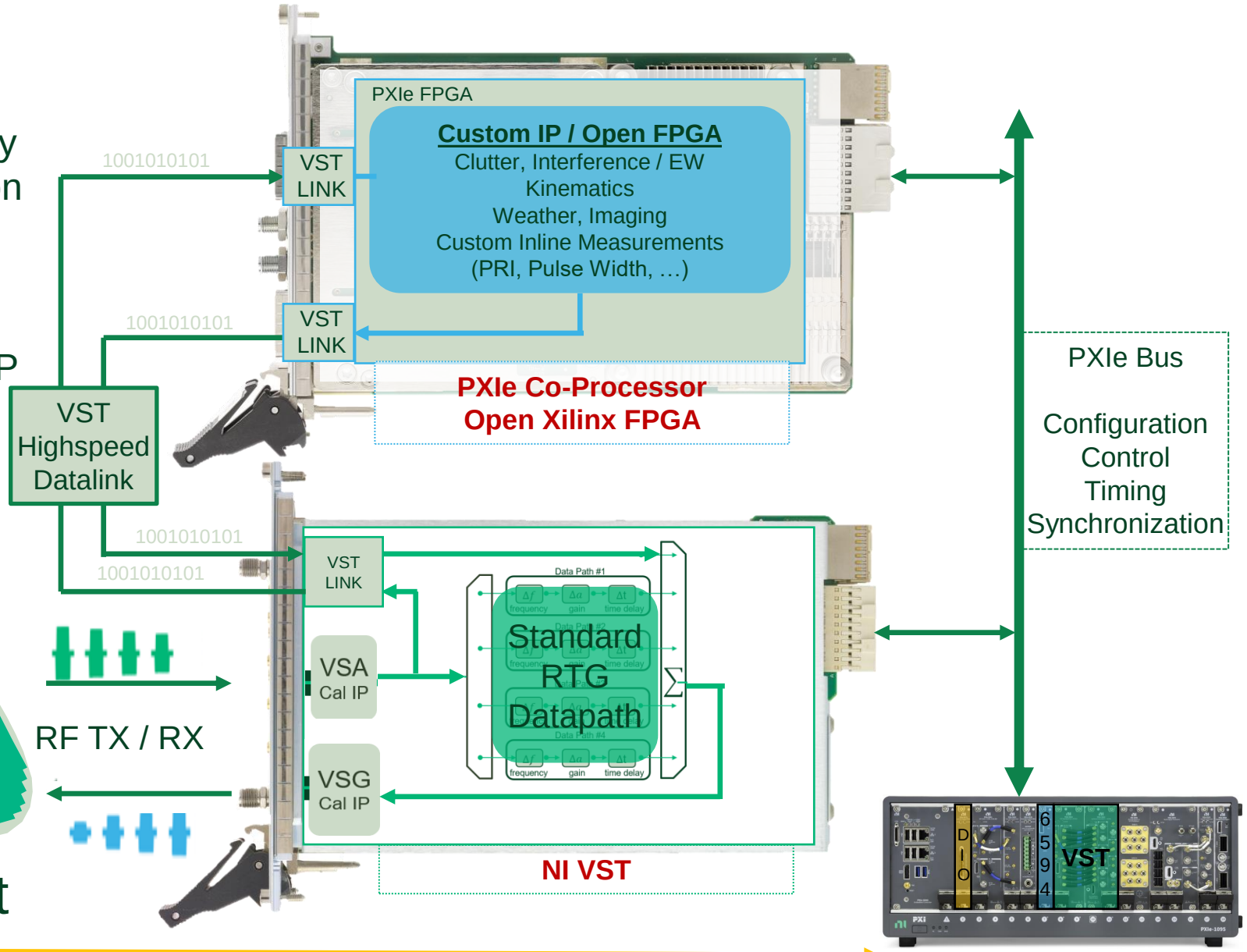


NI RTG | Extending RTG via User Defined Coprocessor

- NI RTG Datapath
  - Close range targets with low latency
  - Handles RTG system self calibration
  - VST Link is a known latency path
- NI RTG Co-processor
  - Extends NI RTG enabling custom IP integration while retaining calibration of NI RTG core.



Radar Under Test



NI PXIe-5699 | High Level Overview

Fast Analog Gain Ranging module for Enhanced Dynamic Range

Key Features

- Fast Analog Gain Ranging module to simulate:
  - Multiple Radar Target returns
  - Multiple emitters for EW Validation
- 1 slot PXI companion for VSTs
- Built-in loop back path for Calibration
- Onboard trigger port for external triggering

Parameter	Instrument Capability
Frequency Range	100 MHz – 26.5 GHz
Insertion Loss	7 dB @ 18 GHz 9 dB @ 26 GHz
Gain Range	90 dB nominal
RF transition speed	125 ns (estimate) *Time from the first observed change of more than 1 dB after the trigger, measured to RF amplitude settled to 1 dB and phase settled to 5 degrees.*
Latency	175 ns (estimate) *Time from input trigger edge, measured to RF amplitude settled to 1 dB and phase settled to 5 degrees.*