

The background is a dark teal grid. It features several light teal geometric elements: a circle with a cross in the bottom left, a right-pointing arrow in the center, and an 'X' in the bottom right. There are also several quarter-circle arcs at the corners and intersections of the grid lines.

# connect

AUSTIN



# **Wideband RF Signal Record & Playback**

Real-time, Multi-Channel RF  
Recording, Analytics & Playback



# 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

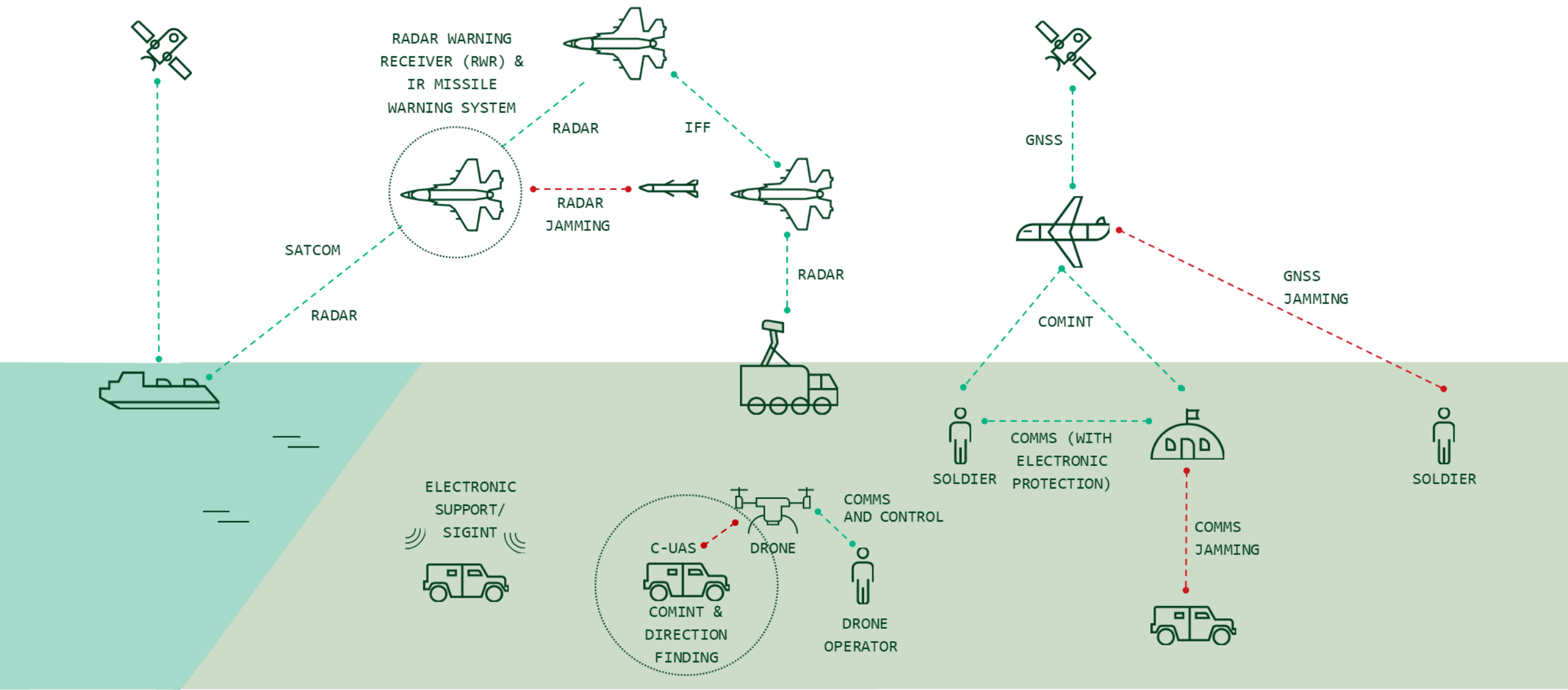
# Wideband Record & Playback



## Agenda

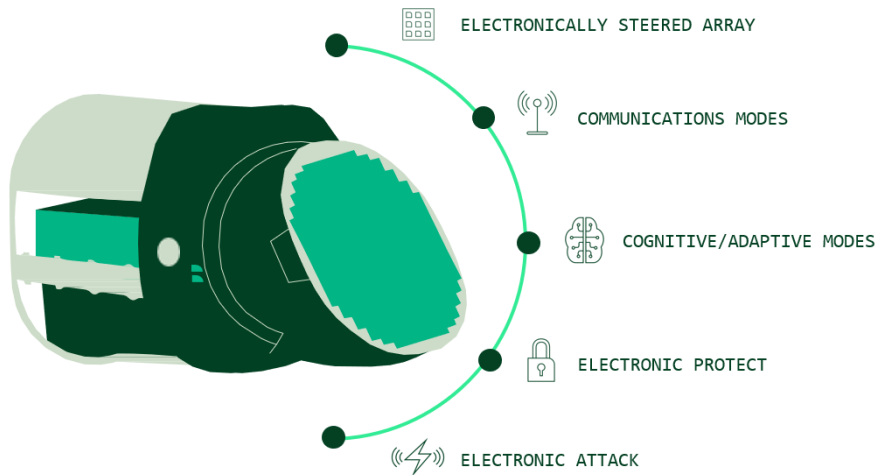
- Introduction
- Market Trends & Innovation
  - Example
  - Lifecycle of Test
- Challenges in Test
- NI's Approach to RF Record & Playback
  - Existing NI Solution
  - Expanding the horizon
- NI Record & Playback System Software
- Q & A

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

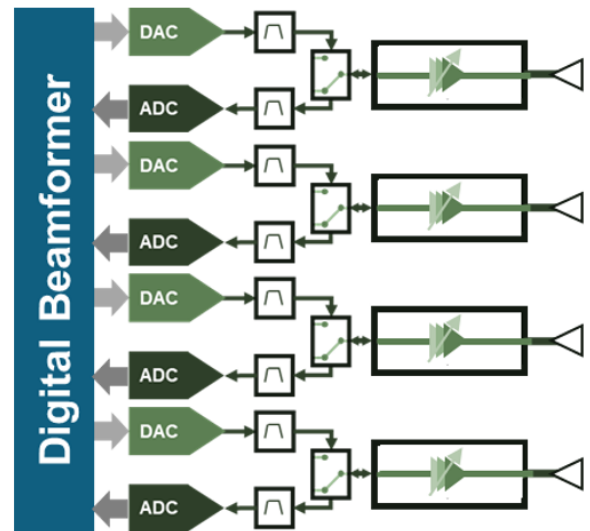


# Market Trends & Innovation

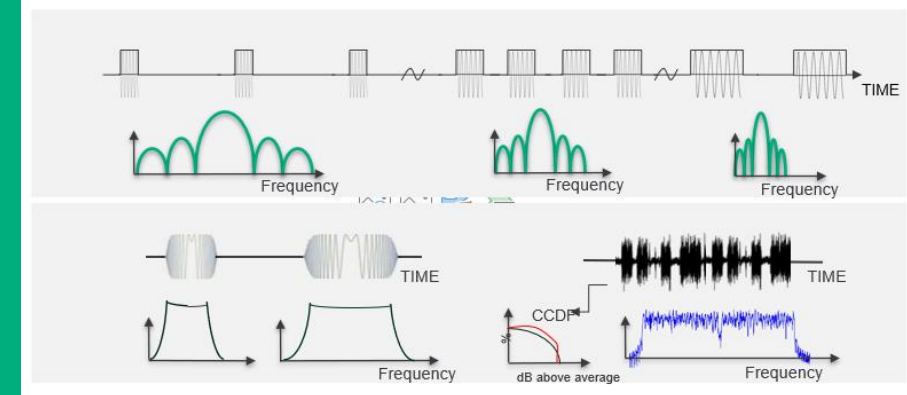
## Multimode Systems



## Digital Beamformers



## Agile System Waveforms





# Key Applications

- Whether you are designing a tracking radar for a next generation fighter, a high-resolution imaging satellite, or a cognitive multi-function electronic warfare package – Scalable RF Record and Playback Systems are a must to cater for evolving system needs

**RADAR**



**Electronic Warfare**



**Comms, Nav, & Survey**

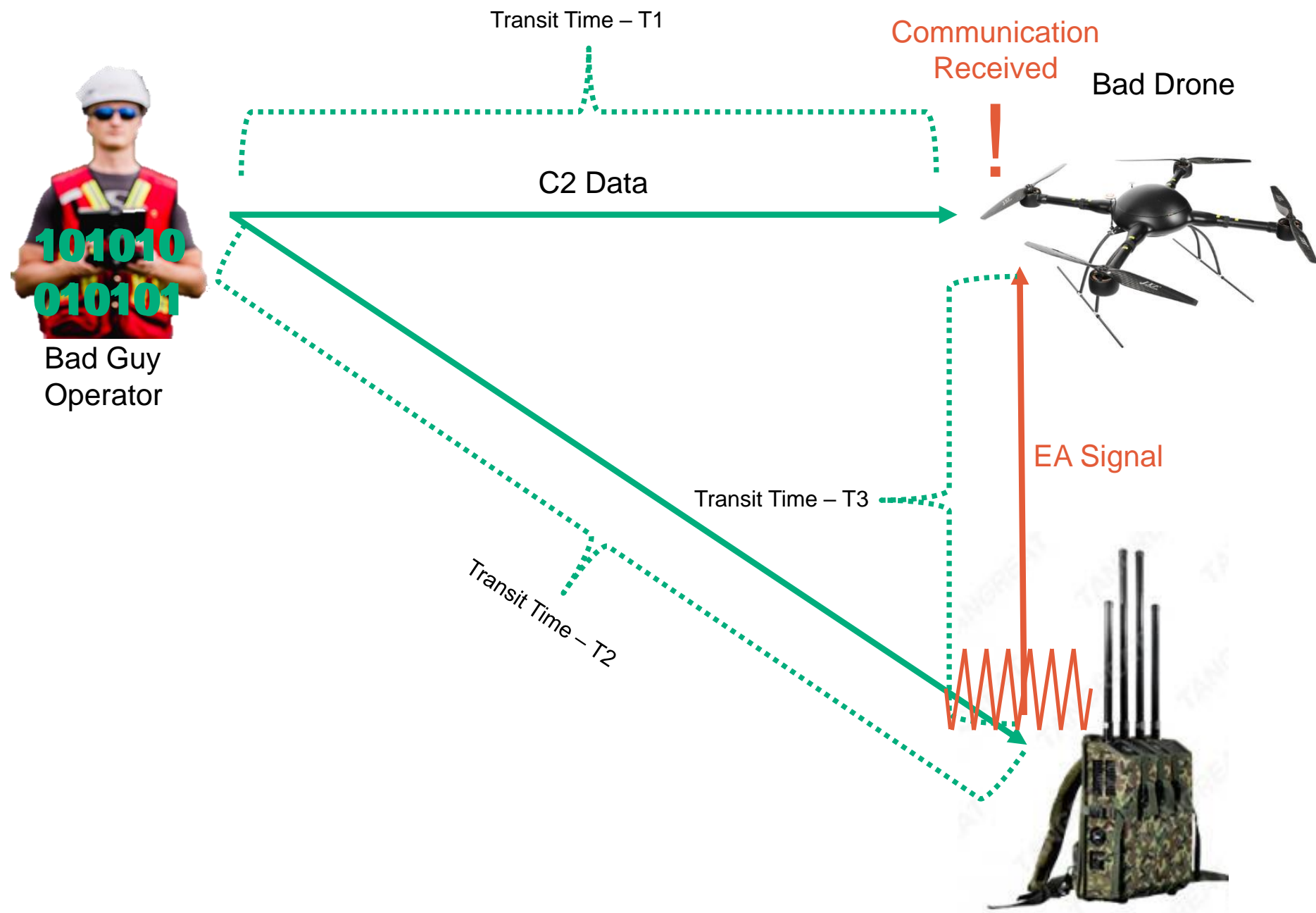


**Satellite**



**A Common Thread: Evolution of RF Systems**

# Critical Tests | Drone Defense Example

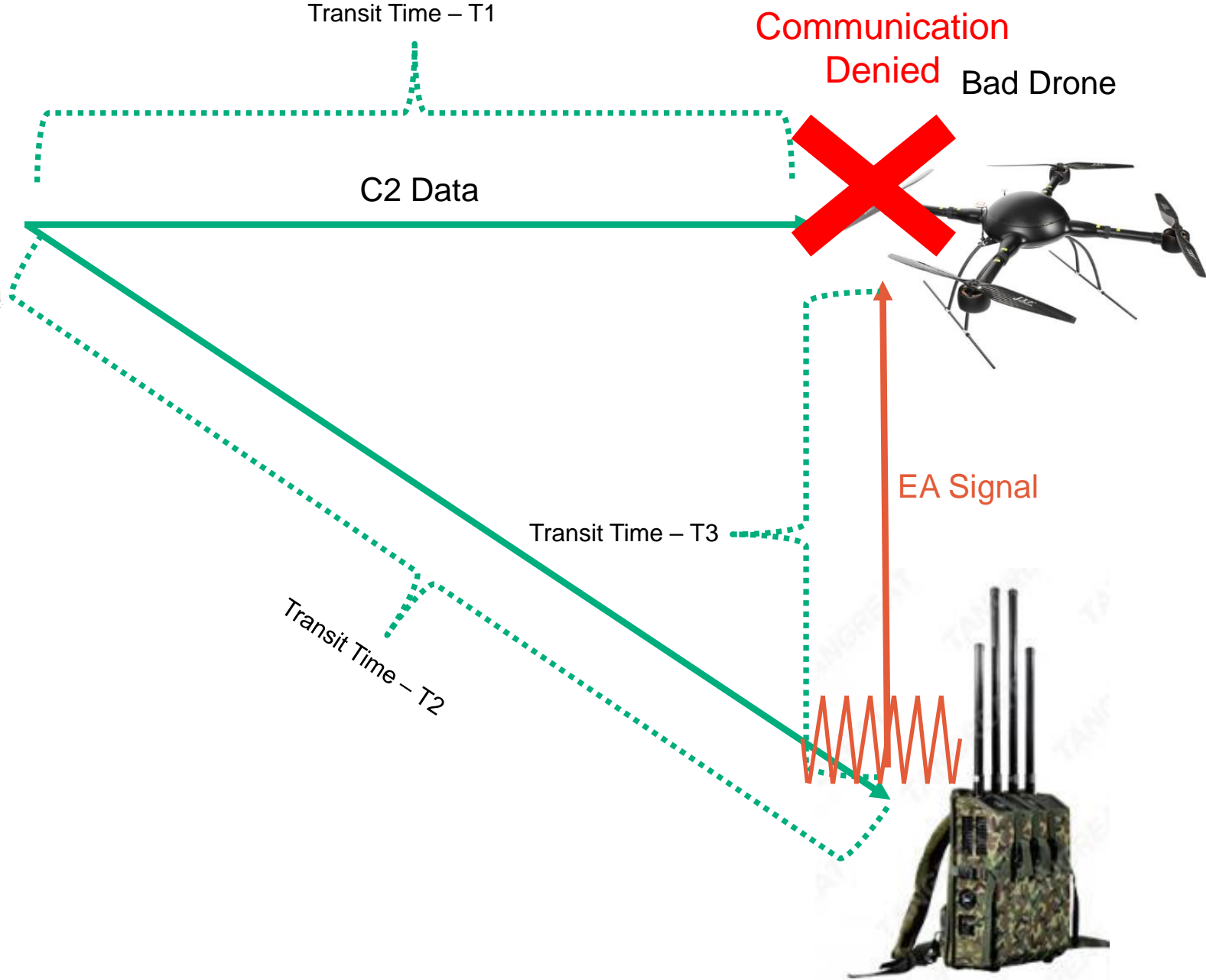




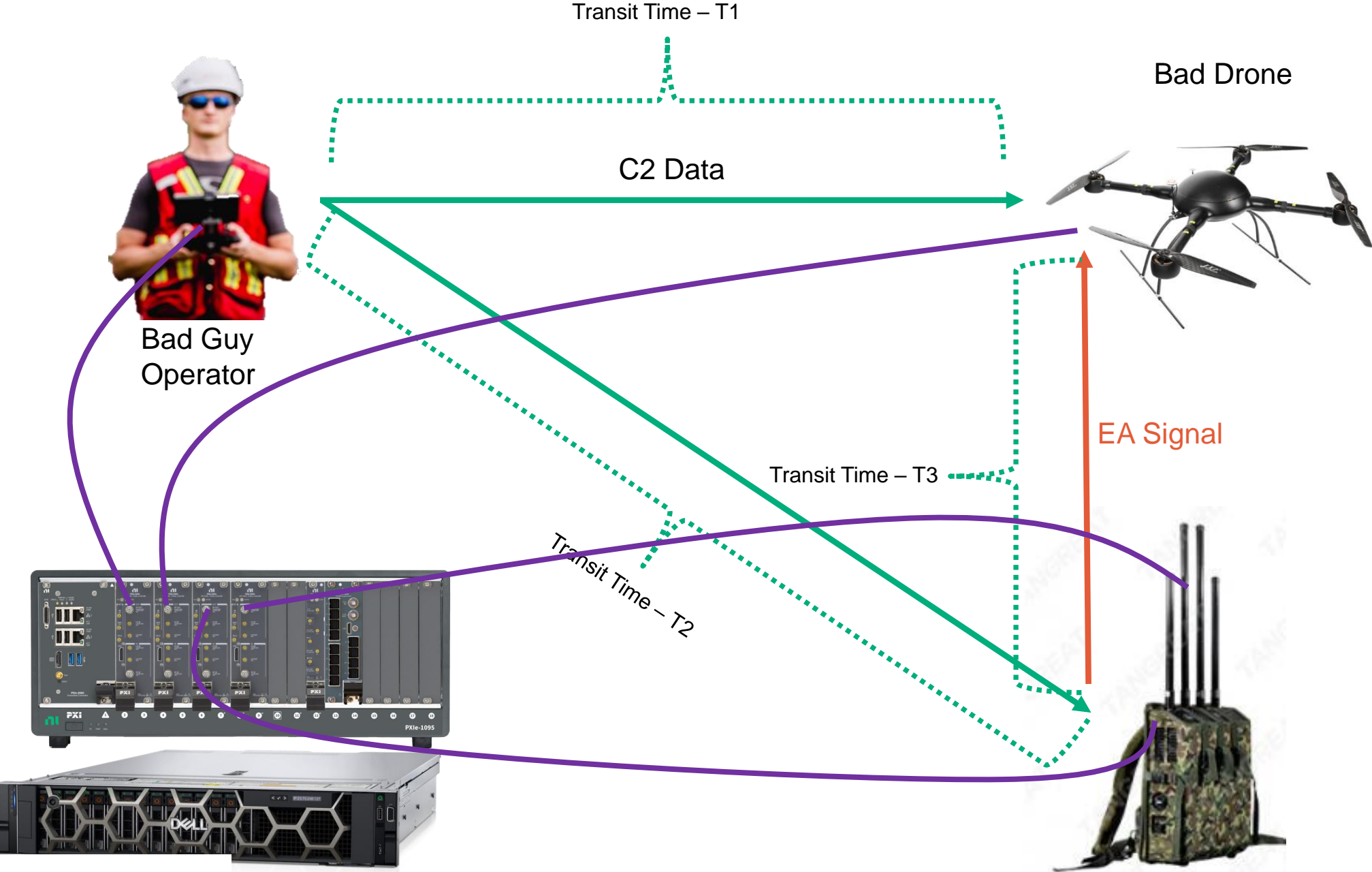
# Critical Tests | Drone Defense Example



Bad Guy Operator



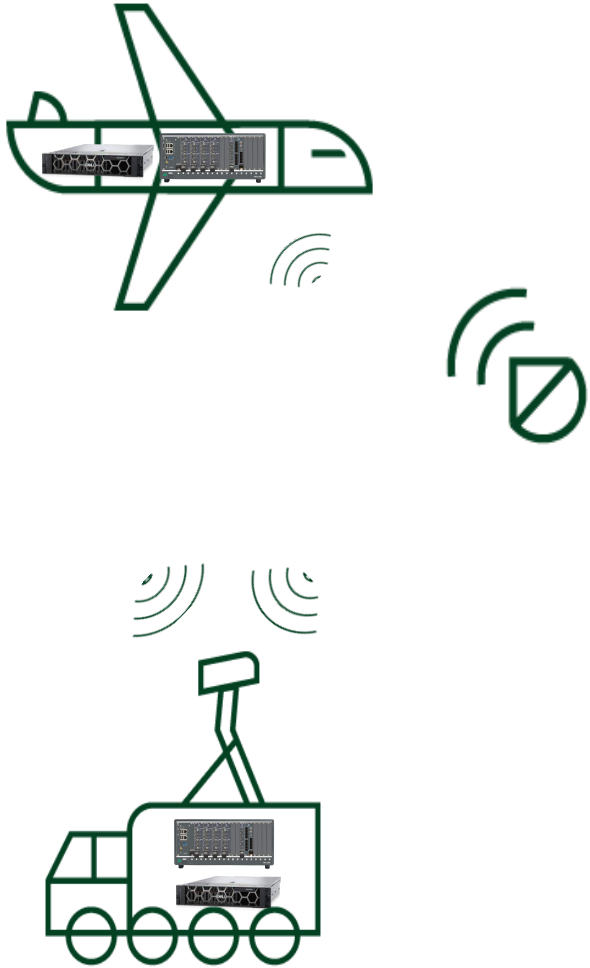
# Critical Tests | Drone Defense Example



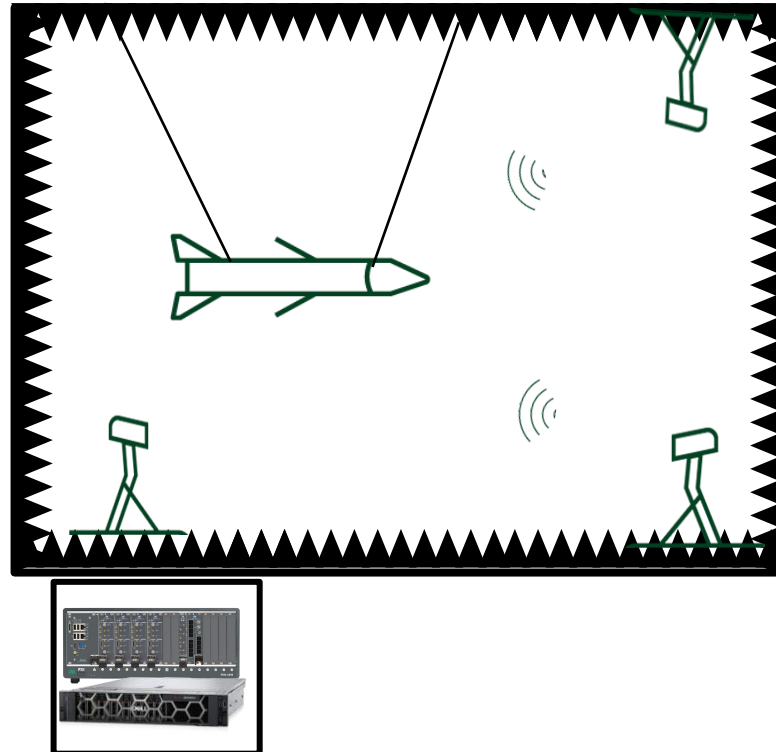


# Where are RF Recording & Playback Systems Used?

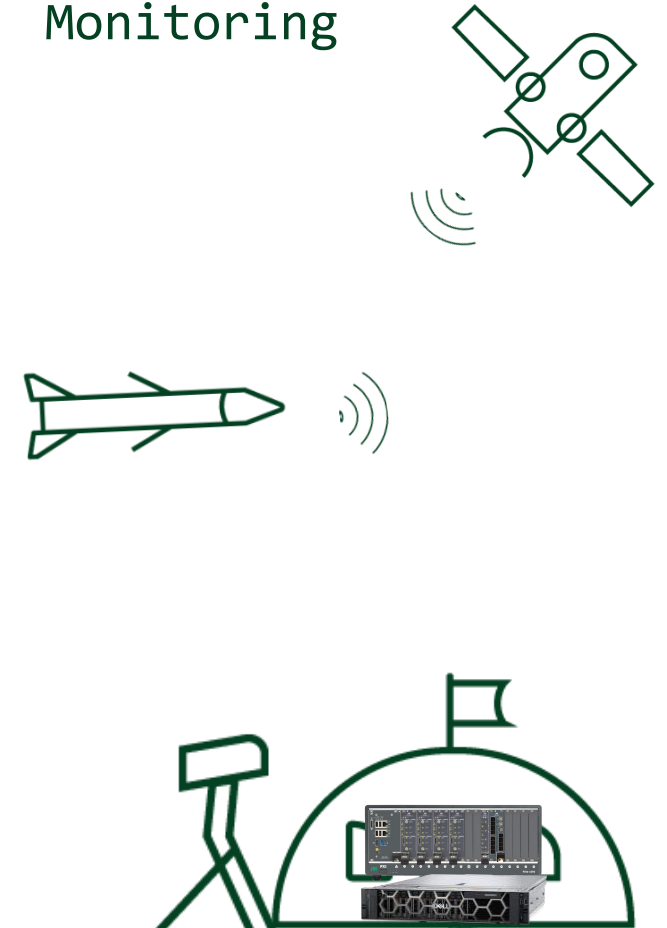
Range Data Recording  
(Sea, Air, Land)



Anechoic Chamber Testing

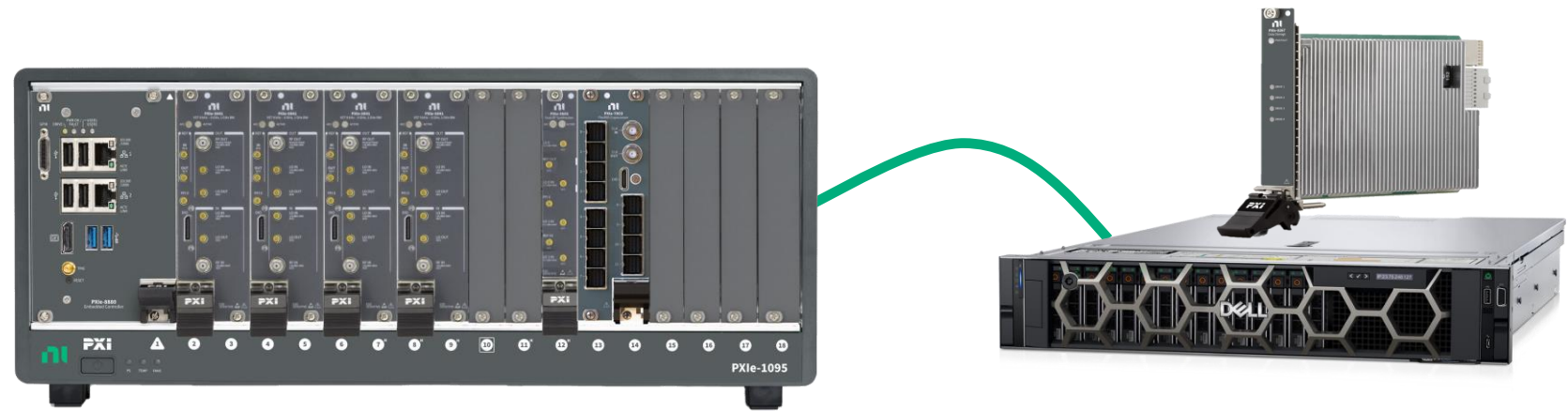


Deployed  
Spectrum  
Monitoring



# Challenges in Test | Complex RF Recording & Playback Systems

- Wide instantaneous bandwidth
- Broad frequency coverage
- Phase coherence for direction finding or phase-matched system test
- Time-aligned signals
- High-throughput, lossless data movement
- Low cost
- Small footprint



# NI Solution | Vector Signal Transceiver (VST)

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

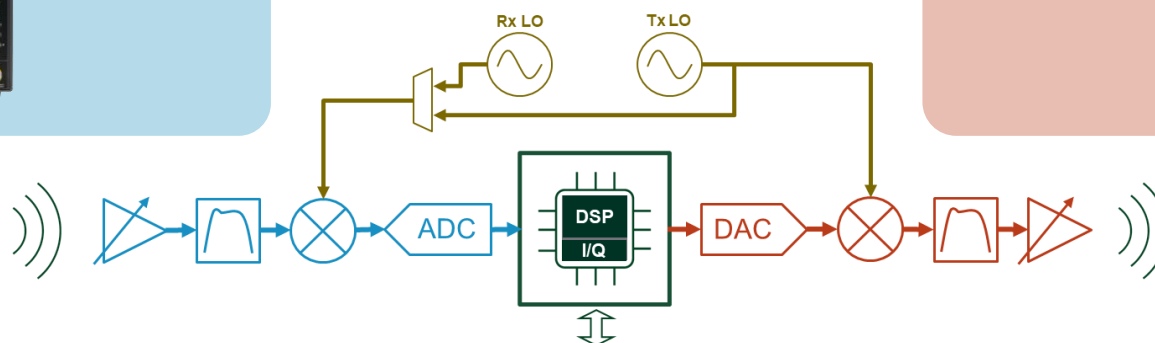
## Calibrated, wideband vector signal analyzer:

- 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)

# 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
- 3<sup>rd</sup> 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



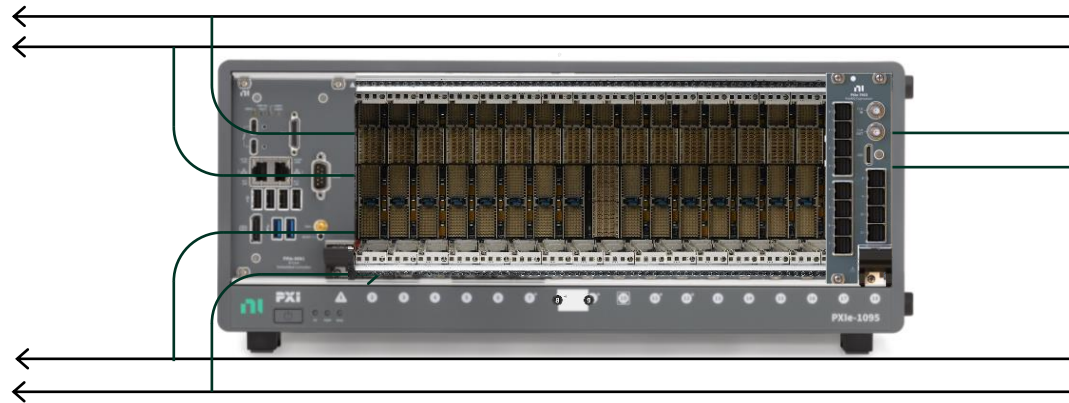


# Existing NI Technology | RF Record and Playback

## RF Vector Transceivers



## PXI Platform



## RAID Storage Drives



- 30 MHz to 26.5 GHz Fc
- Up to 2 GHz IBW
- 4-8 Channels Per Chassis  
(depends on VST model)

- PXI Chassis & Controller
- Timing / Synchronization
- High Performance Data Movement
  - Backplane & Front Panel

- Rackmount or PXI
- 4 TB to 64 TB

# Existing NI Technology | RF Record and Playback

## RF Vector Transceivers



## PXI Platform



## RAID Storage Drives



PXIE Gen 3 x8 allows only 8 GB/s

- 30 MHz to 26.5 GHz Fc
- Up to 1.6 GHz IBW
- $\leq 3$  Channels Per Chassis  
(depends on VST model)

- PXI Chassis & Controller
- Timing / Synchronization
- High Performance Data Movement
  - Backplane & Front Panel

- Rackmount or PXI
- 4 TB to 64 TB

Total system bandwidth limited to 24 GB/s (hence 3 or fewer channels at full IBW)

# Why is NI Building a Record & Playback Solution?

- ADG customers require full-rate, multi-channel, phase-coherent RF data recording and analysis capabilities across various use-cases, but primarily DUT simulation, field testing, and prototyping activities.
- Existing solutions include DIY or turnkey systems from competitors. These systems are often limited by:
  - Lack of synchronization across multiple channels
  - Low data streaming throughput
  - Lack of integration into software like InstrumentStudio
  - Significant custom work per system
  - Lack of support for COTS technologies like NI VST
- The NI Record & Playback Solution (RPS) moves the data away from the PXI backplane for additional flexibility and expandability.
- RPS enables wideband, multichannel RF data recording applications. RPS is a configuration of RF instruments, digital interfaces, FPGA coprocessors, external servers, and data storage combined with system-level IP.

# Application | Complex RF Recording Systems

## Common Requirements and System Capabilities

Wide Instantaneous Bandwidth

Broad, Continuous Frequency Coverage

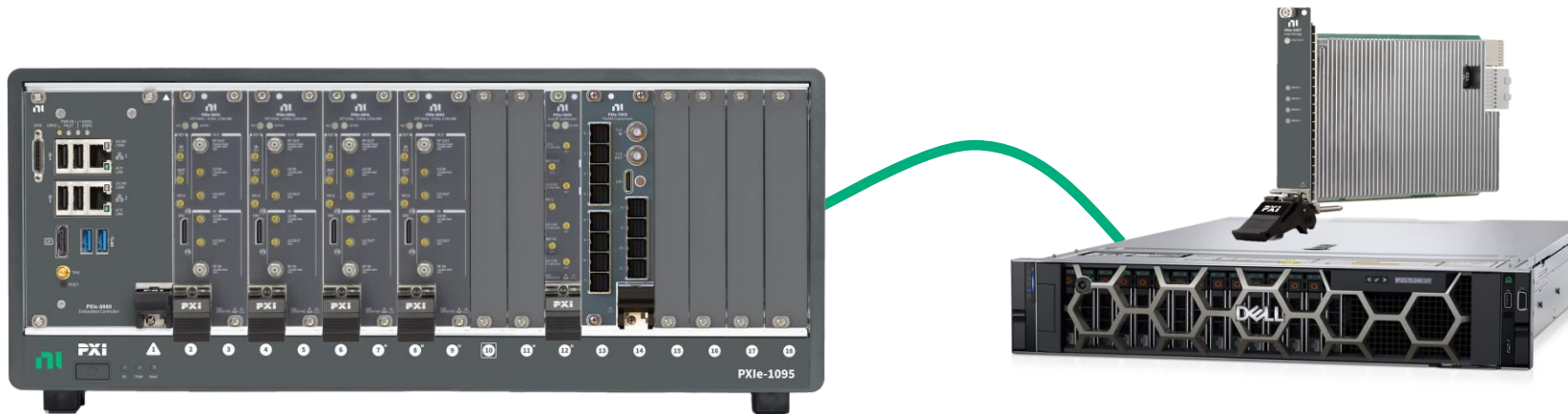
Phase Coherence for Direction Finding or Phase-Matched System Test

Time-Aligned Signals and Events

High-Throughput, Lossless Data Movement

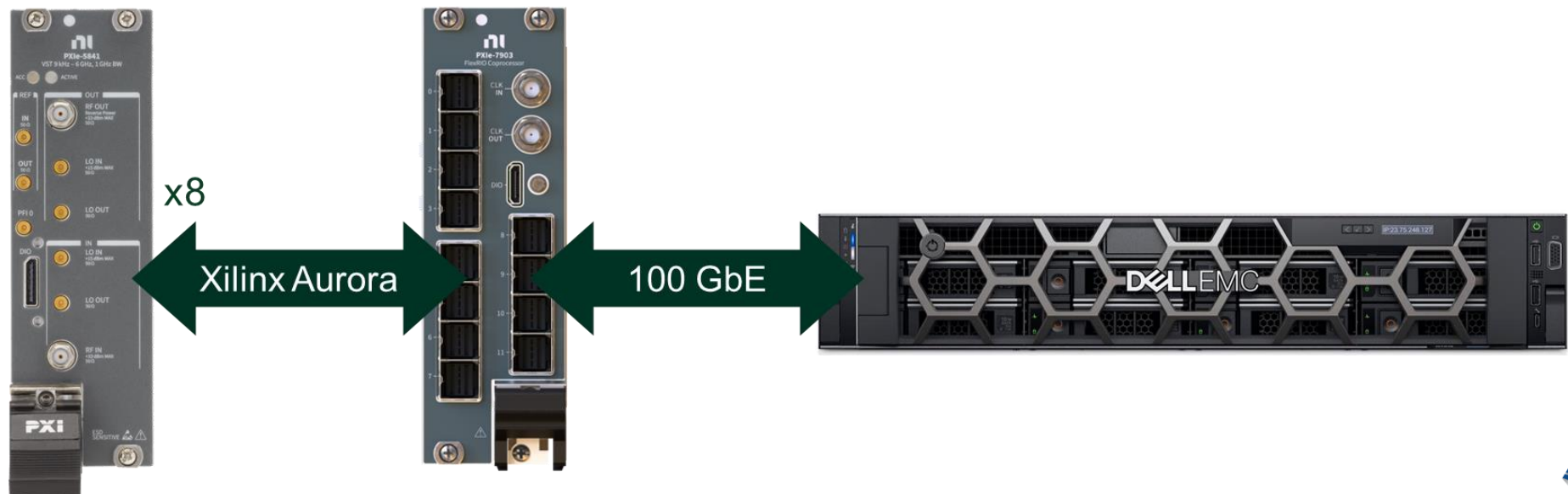
Lower Cost per Bit and per Channel

Smaller Footprint



# NI Solution | An Improved Approach

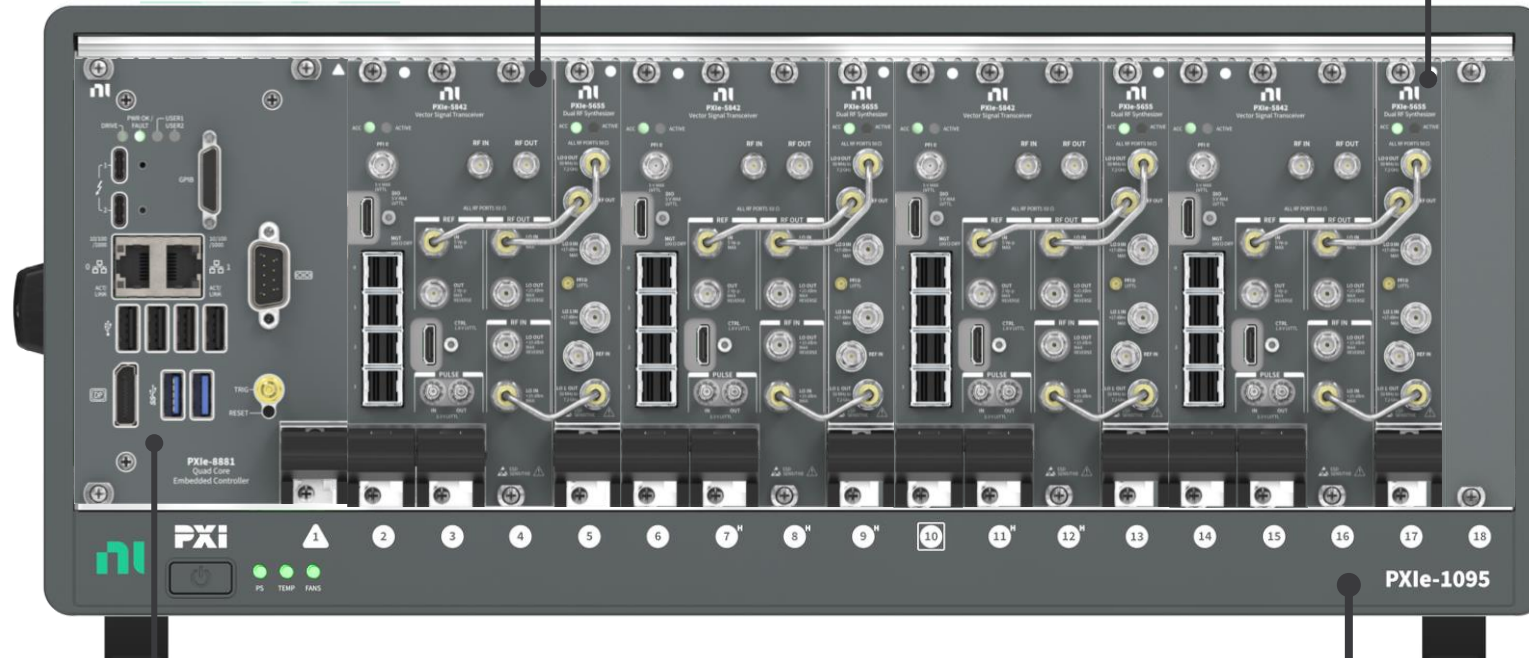
- 8x Aurora streams of up to ~10 GB/s from VSTs to PXIe-7903 coprocessor, up to 40 GB/s total
  - Allowing support of up to 2 GHz instantaneous bandwidth/ VST
- 100 GbE UDP packets transmitted to 2 NICs on the Dell PowerEdge R7525
  - 10 GB/s per 100 GbE connection, up to 40 GB/s total
- At max capacity, each R7525 can hold up to 24, 15 TB NVMe drives ~ 2.5hours of Record time!



# 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

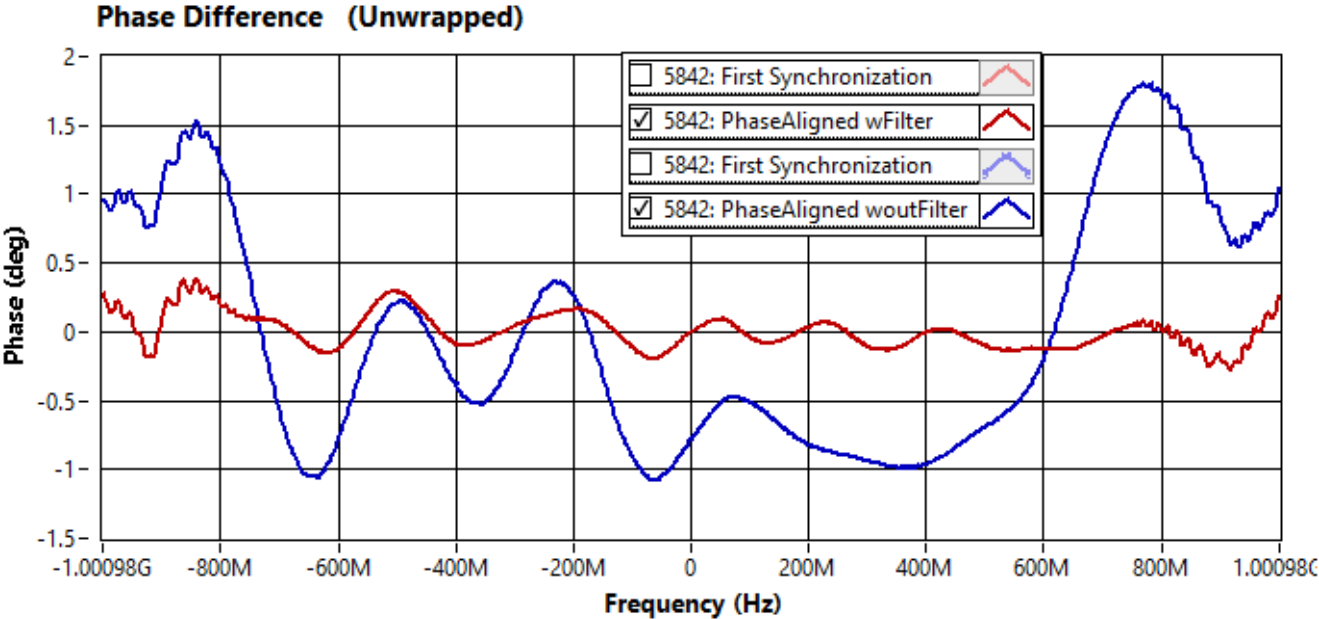
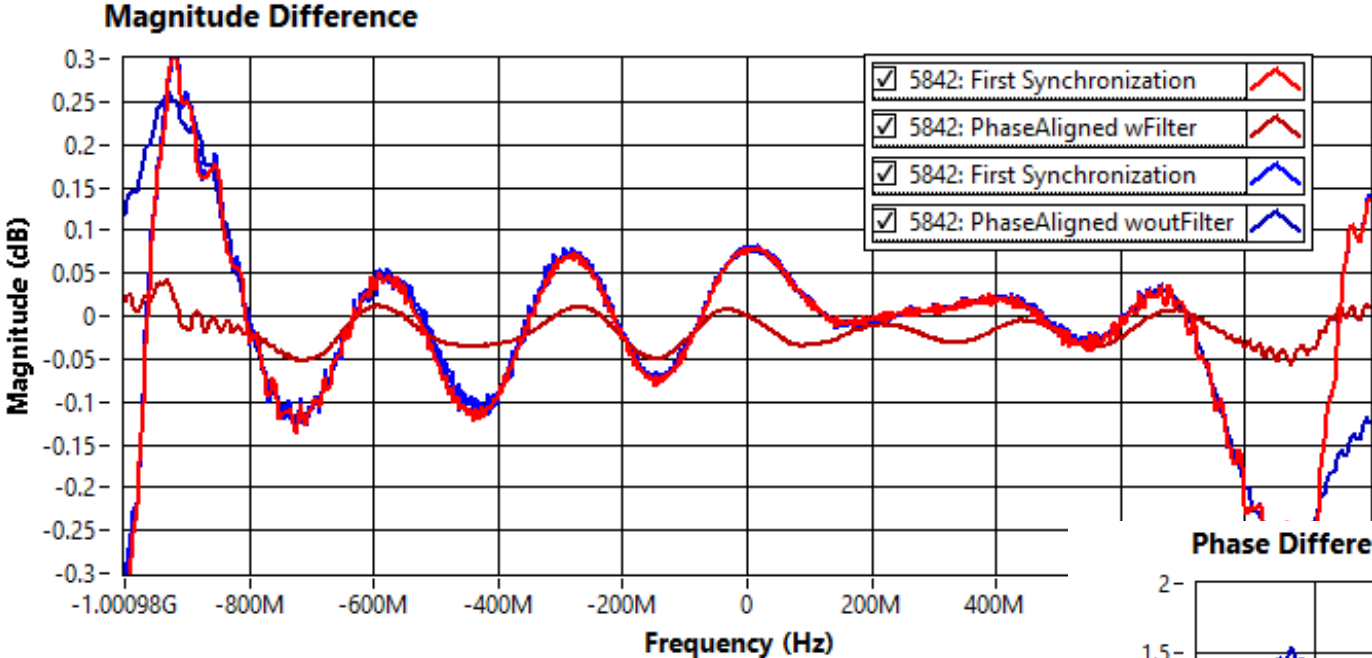


64 bit OS +  
64 bit driver **Required**

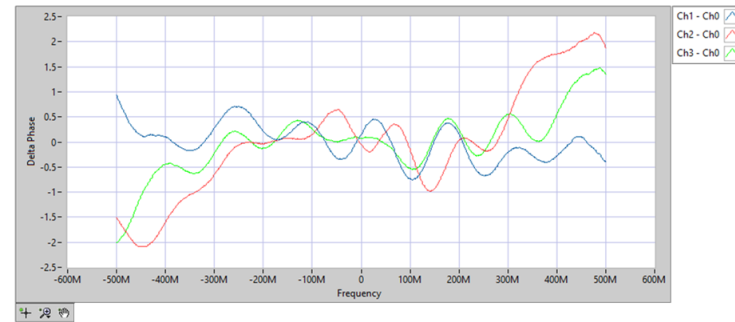
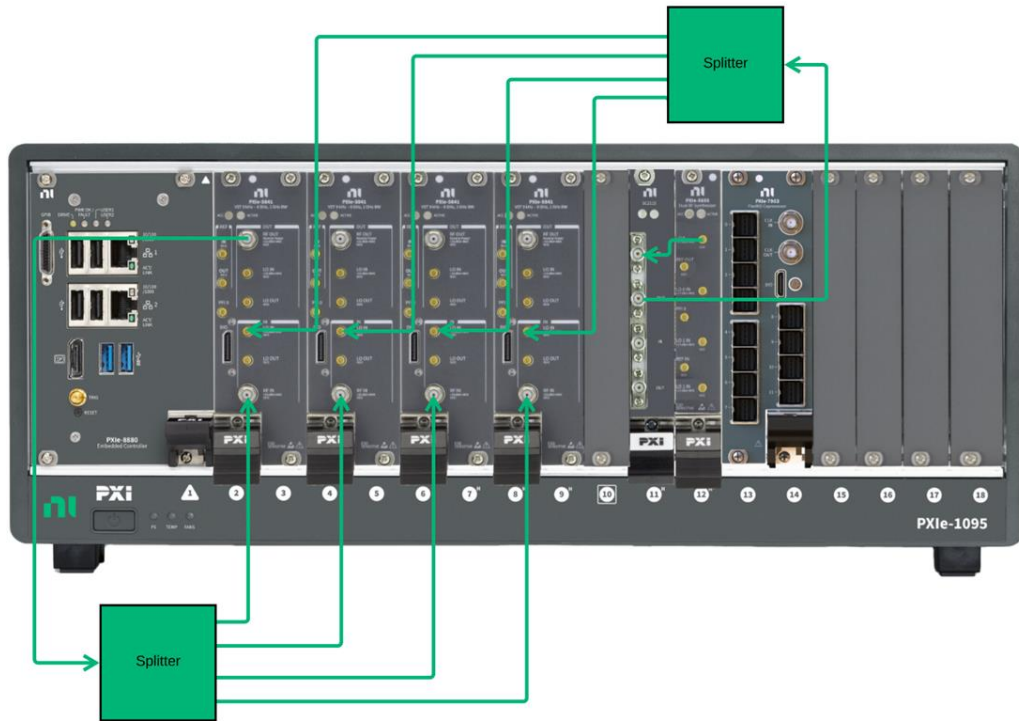
**82W Chassis Required**  
PXIe-1095 or PXIe-1092



# Channel Alignment

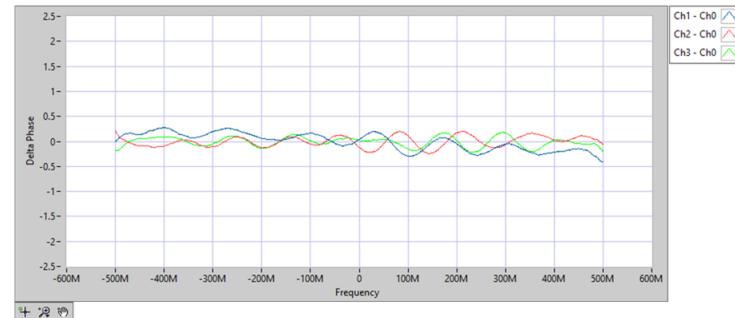


# NI RPS | Acquisition Phase Calibration



## Phase Coherent Calibration

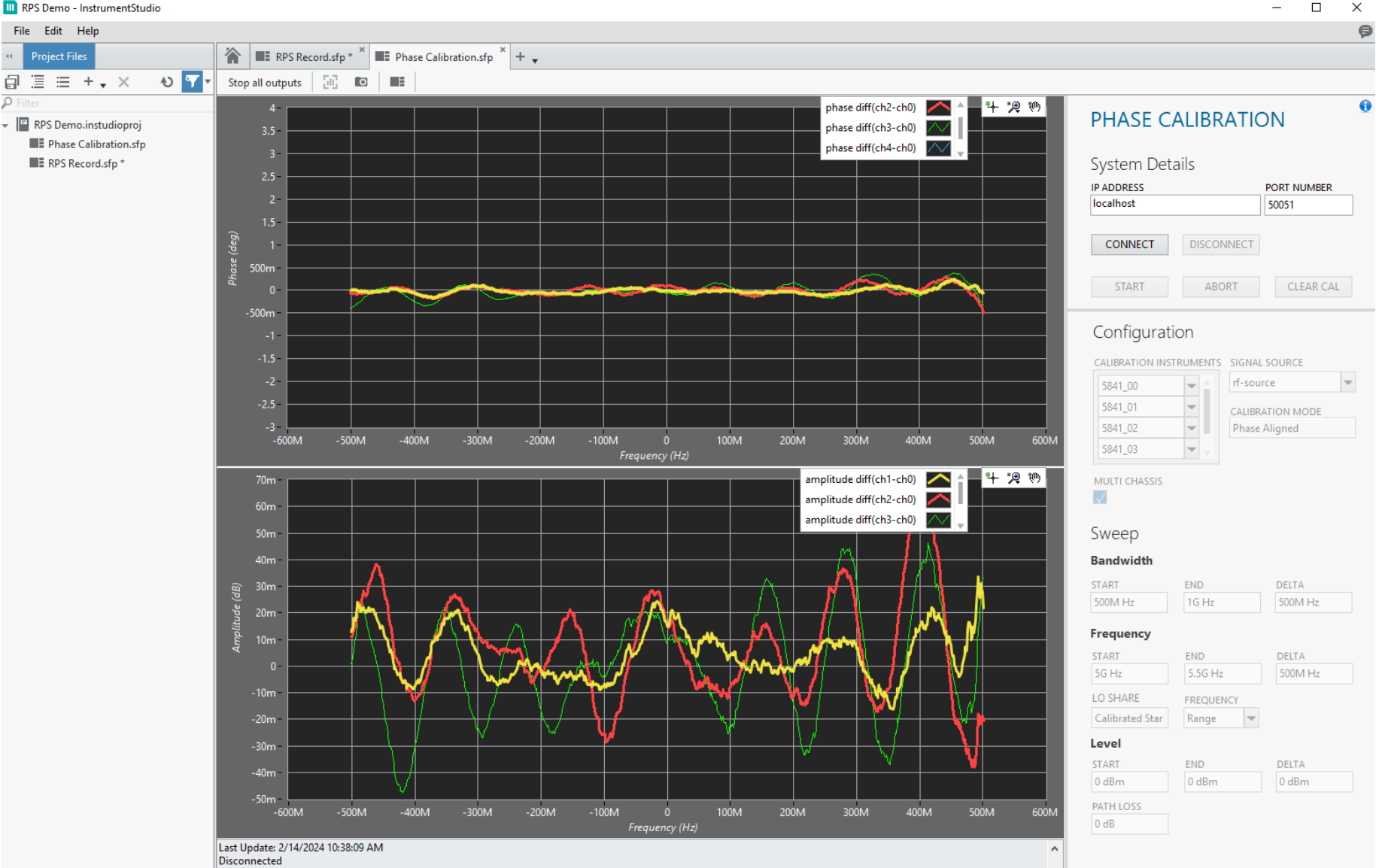
- Image shows a snapshot of phase coherent performance with 1 GHz IBW at a center frequency of 3 GHz
- LOs are shared via a star connection
- Approximately +/- 2.5 degree different for the entire IBW



## Phase Alignment Calibration

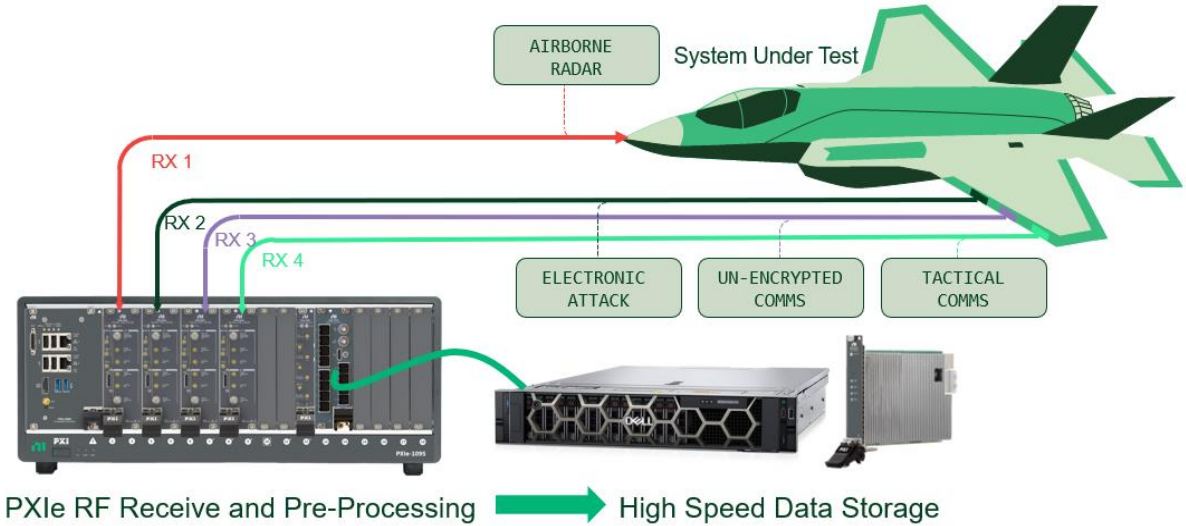
- Image shows a snapshot of phase alignment performance with 1 GHz IBW at a center frequency of 3 GHz
- Filters were adjusted relative to the reference VST, Ch0
- Approximately +/- 0.5 degree different for the entire IBW

# NI Solution | Multi-Channel RF Record & Playback 1.0

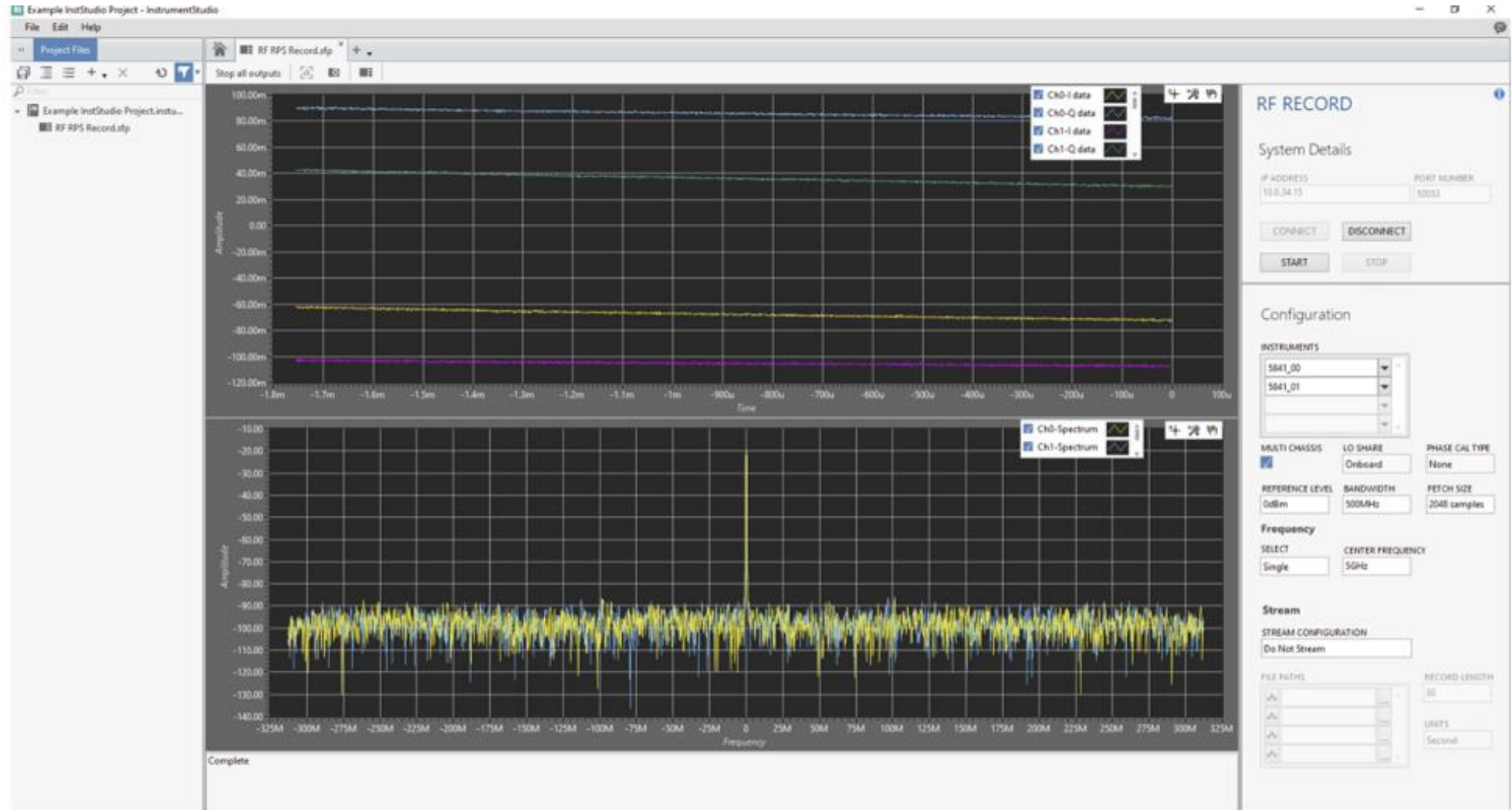


# NI Solution | Multi-Channel RF Record & Playback 1.0

Parameters	System Capability
Frequency Range	9 kHz – 6 GHz
Bandwidth	Up to 1 GHz (Instantaneous)
Operation Mode	Record Only
Number of RF Channels	Up to 32
System Level Calibration	<ul style="list-style-type: none"><li>• LO Power calibration</li><li>• Phase Coherent Calibration</li><li>• Wideband Phase aligned Calibration</li></ul>
Trigger Modes	Software
Storage Options	<u>Ethernet Based Storage:</u> <ul style="list-style-type: none"><li>• More than 300 TB of storage</li><li>• 1 GHz of IBW recording up to 32 channels</li></ul> <u>PCIe Based storage:</u> <ul style="list-style-type: none"><li>• Up to 24 TB per channel</li><li>• Recording IBW of 1GHz BW up to 2 channels (reduced IBW beyond 2 channels)</li></ul>
Phase Synchronization Performance	<1 degrees (across IBW after calibration)
LO Configuration	<ul style="list-style-type: none"><li>• Independent LO setting/ Center frequency per channel</li><li>• LO sharing option for phase alignment</li></ul>
Graphical User Interface	Ready to use GUI for: <ul style="list-style-type: none"><li>• Performing Power LO Calibration</li><li>• Phase coherency/ phase alignment</li><li>• Data preview and data recording</li></ul>
Programming Software	gRPC supported API (Remote operation supported)
Data Storage Format	Support for SigMF format <ul style="list-style-type: none"><li>• Suitable for Machine learning</li><li>• Human readable json Header file</li><li>• Per channel binary Data file</li></ul>

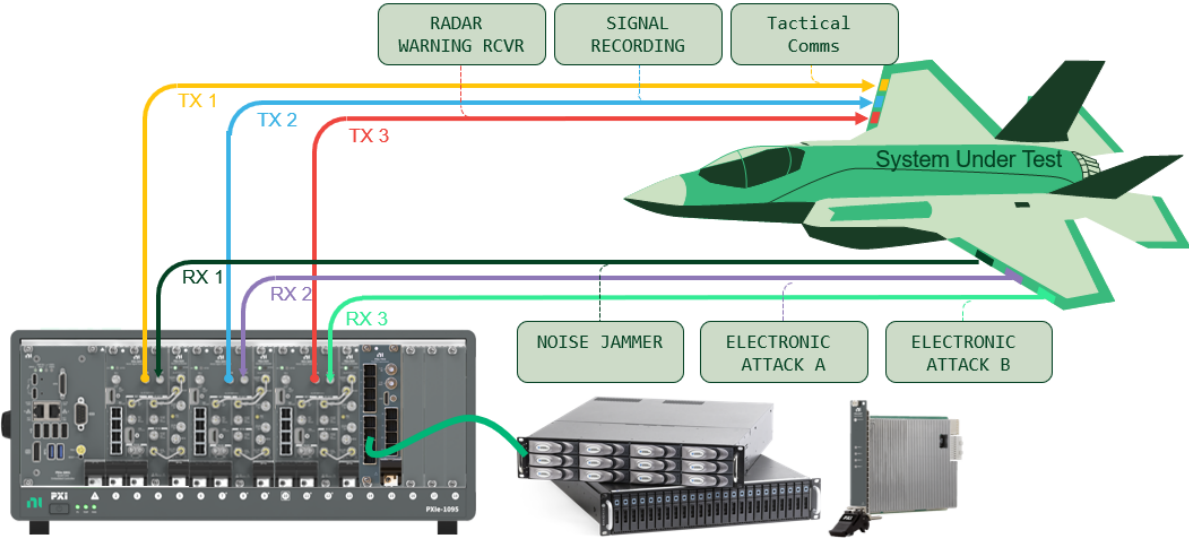


# NI Solution | Multi-Channel RF Record & Playback 1.0



# NI Solution | Multi-Channel RF Record & Playback 1.x

Parameters	System Capability
Frequency Range	30 MHz – 26.5 GHz
Instantaneous Bandwidth	Up to 2 GHz (4 GHz Planned, EoY'24)
Operation Mode	Record & Playback
Number of RF Channels	Up to 16
Inline Signal Processing	FPGA Reference Design for Inline Signal Processing
System Level Calibration	<ul style="list-style-type: none"><li>• LO Power calibration</li><li>• Phase Coherent Calibration</li><li>• Wideband Phase aligned Calibration</li></ul>
Trigger Modes	Software, Digital Trigger (GPS, IRIG, Pulse)
Storage Options	<u>Ethernet Based Storage:</u> <ul style="list-style-type: none"><li>• More than 300 TB of storage</li><li>• 2 GHz of IBW record up to 16 channels</li></ul> <u>PCIe Based storage:</u> <ul style="list-style-type: none"><li>• Up to 24 TB per channel</li><li>• Record IBW of 1GHz BW up to 2 channels (reduced IBW beyond 2 channels)</li></ul>
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# Questions?

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NI is now part of Emerson.