Assembling a Cost Effective Development & Verification Solution for Electronic Warfare Systems

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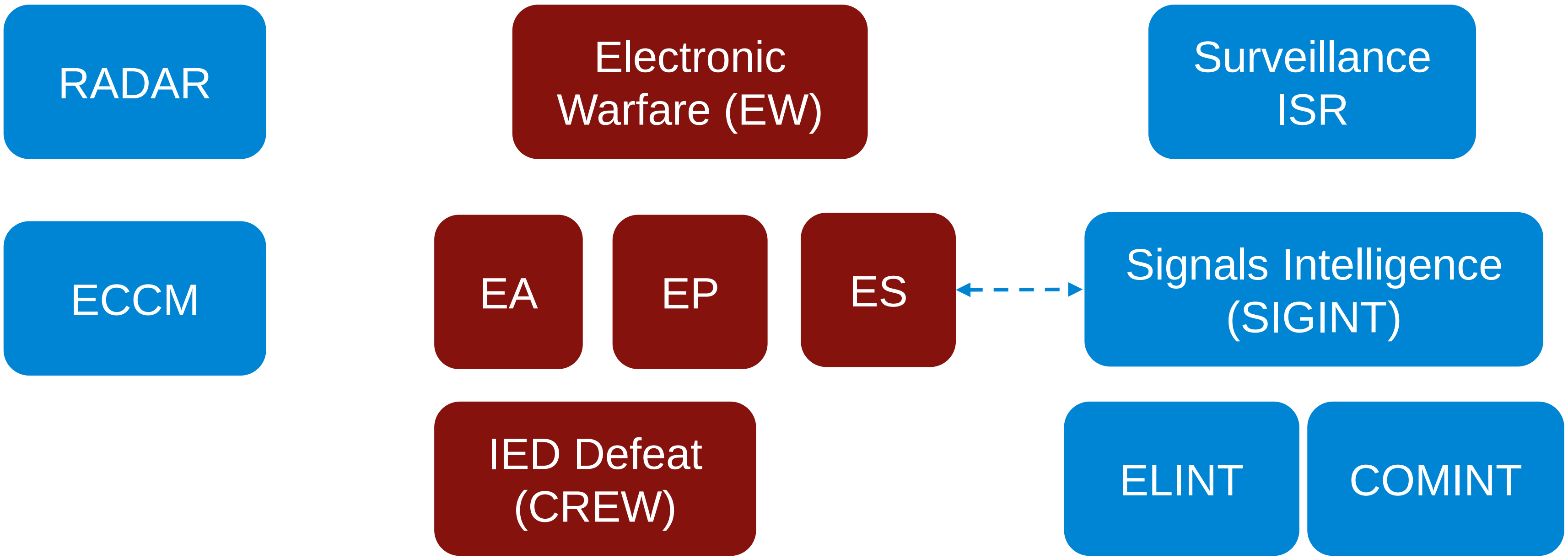
Agilent Technologies, Inc.

Agenda

- **The EW application space and a few definitions**
- **The differences between radar and EW**
- **The EW system test and evaluation process**
- **Notional COTS Solution Proposal**
- **The Details of Multiple Emitter Signal Simulation**
- **Array Antenna and Transmit / Receive Module (TRM) Test**
- **Radar & Jammer Range and Power Level**
- **Radar Target Simulation**
- **Appendix**
  - Jammer types
  - Agilent instruments & solutions

Vintage F-105G Wild Weasel Electronic Attack Aircraft from 1960s & 70s

EW Application Space



ECM = Electronic Counter Measures
ECCM = Electronic Counter Counter Measures
ISR = Intelligence, Surveillance & Reconnaissance
ELINT = Electronic Intelligence
COMINT = Communications Intelligence

EA = Electronic Attack
EP = Electronic Protection
ES = Electronic Support
IED = Improvised Explosive Device
CREW = Counter Radio Controlled Improvised Explosive Device Electronic Warfare

Some EW Terms & Definitions

EA: Electronic Attack involves the use of EM energy or anti-radiation weapons to attack personnel, facilities, or equipment

EP: Actions taken to protect personnel, facilities, and equipment from any effects of friendly or enemy use of Electromagnetic Spectrum (EMS)

ES: Electronic Warfare Support is a subdivision of EW involving search for, intercept, identify, and locate sources of EM energy for the purpose of threat recognition or targeting

ESM: Electronic Warfare Support Measures, equipment to identify and locate radar systems or EM emitters

RWR: Radar Warning Receiver, warns a pilot of a SAM or radar lock on

Jammer: EW transmitter used to interfere, upset, or deceive a victim radar, communications, or navigation system

ECM: Electronic counter measures, such as jamming and chaff, used to deny or degrade the enemy's use of communications or radar systems

DECM: Defensive ECM, such as a jammer used to protect an aircraft from missile fire

ECCM: Electronic counter-counter measures, countermeasures used to protect a radar from a jammer

EME: Electromagnetic Environment

EOB: Electronic Order of Battle

SIGINT: Signal Intelligence, is intelligence-gathering by interception of signals, whether between people (COMINT) or from electronic signals not directly used in communication (ELINT), or a combination of the two.

ELINT: Electronic Intelligence

COMINT: Communications Intelligence

J/S: Jam to signal ratio

A Closer Look at the EW Application Space

ELECTRONIC WARFARE

ELECTRONIC ATTACK

- EM Jamming
- EM Deception
- Anti-radiation Missiles
- Active Decoys

ELECTRONIC PROTECTION

- Spectrum Management
- EM Hardening
- Emission Control

ELECTRONIC SUPPORT

- Threat Warning
- Signal Collection
- Cataloging Threats
- Direction Finding

The Military Pilot's Best Friend May Be:

His Radar Warning Receiver

EW Threat Identification Today

- **Modern EW receivers must able to keep up with current and future threats and must be highly adaptable**
- **Today's threat environment is constantly evolving with modern digital processing and as international relations can change on a moments notice:**
  - Modern radar systems use frequency agile TR modules that can be programmed to adapt to a dynamically changing electromagnetic environment and specific mission requirements
  - Modern radar systems pulse characteristics are dynamically programmed to extract the most information from the target
  - Modern radar systems generally utilize phased array antenna systems which allow for dynamic changes in antenna characteristics and allow tracking of multiple targets at the same time.
  - Most modern radar systems are multi-mode multi-functions systems whose RF signature is constantly changing, complicating identification.

The Differences between EW and Radar

Bandwidth

- EW systems require wider instantaneous bandwidths

Power

- Radar requires very high power at low duty cycle where EW applications require high power at close to 100% duty cycle for certain modes of operation

Frequency Range

- EW systems have a wider frequency range of operation where separate units are divided into low, mid and high range of operation

Antenna Characteristics

- Both applications benefit from AESA technologies allowing flexibility in beam shaping, multiple beams & beam steering. Generally the fundamental beam shapes can be very different, where perhaps the beam of a jammer may be quite broad and a radar narrow

Signal Processing

- Radar signal processing is centered on measuring the range and velocity of a target and calculating the acceleration in order to sustain tracking. EW signal processing involves identifying threat signals and characterizing them to then produce an appropriate response (e.g., wideband, narrowband, deceptive)

The EW System Test and Evaluation Process

System Integration Lab

APR-39A(V)2

- Receiver & processor performance
- Component compatibility

Hardware in the Loop

- Jammer effectiveness
- Tactics
- Technique evaluation & optimization
- Effectiveness in a high density environment

Installed System Test Facility

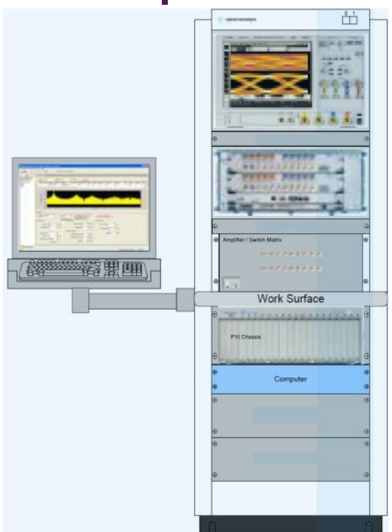
- Installed receiver, jammer & processor performance
- Full EOB performance evaluation and algorithm verification

Open Air Range

- Jammer effectiveness & suitability
- Tactics
- In-flight receiver & processor effectiveness & suitability

Solutions Along the Test & Evaluation Process

System Integration Lab	Hardware in the Loop	Installed System Test Facility	Open Air Range



Courtesy Northrop-Grumman

Courtesy L-3

Courtesy L-3

Relative Solution Complexity and Cost of Test

Lower — Higher

Electronic Warfare Threat Simulators

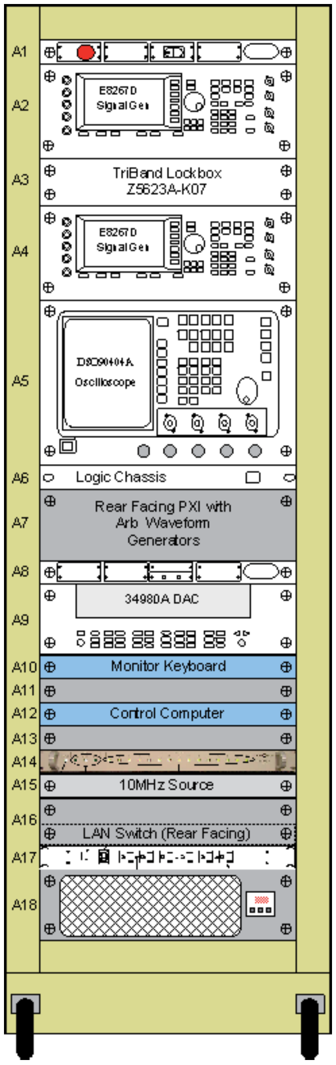
Complex multi-emitter simulators are well suited for EW testing in a complex electromagnetic environment and perhaps an entire EOB, however:

- Can be overkill for simple and iterative System Integration Testing or RWR/ESM threat identification testing
- Scheduling time on such a valuable capital asset is difficult
- Can be costly and time consuming to reprogram, as new threats are added.

Fidelity of Simulation

What level of fidelity or quality is required?

- Fidelity of the model and data presented to systems and operators must be adequate.
- In training simulation must be good enough to prevent the operator from noticing any inaccuracies.
- In T&E simulation, must be adequate to provide injected signal accuracy better than the perception threshold of the system under test (SUT).
- In most cases, cost rises exponentially as a function of fidelity provided. At some point a situation of diminishing returns will be reached.



Needed: A Simplified EW Threat Simulation Solution

RWR and ESM system testing and verification requires:

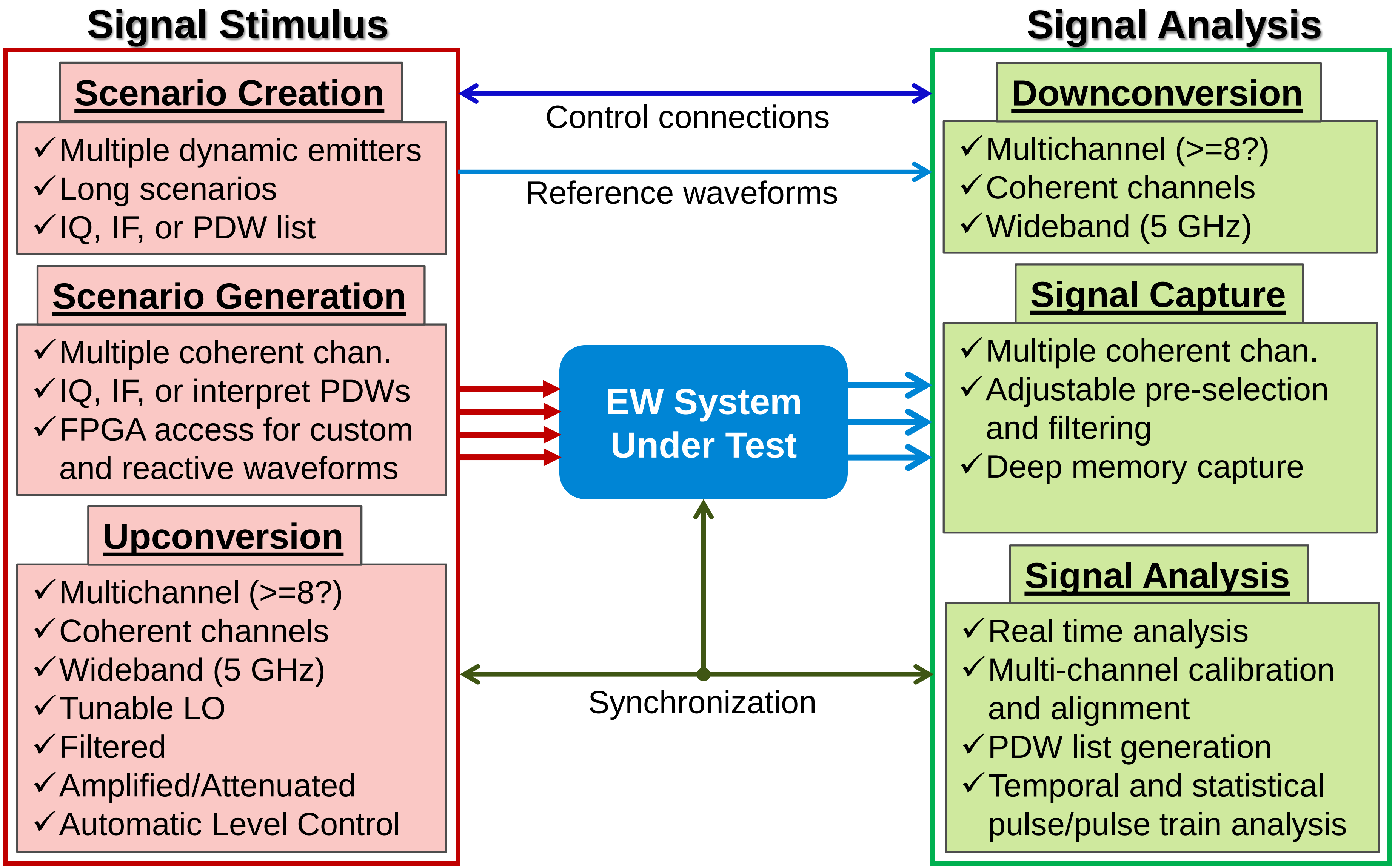
- Ability to quickly verify performance for newly programmed threats
- Simple set up
- Minimum programming time
- Lower cost solution, as opposed to large multi-emitter simulators

Russian SA-2 Surface to Air Missile (SAM)

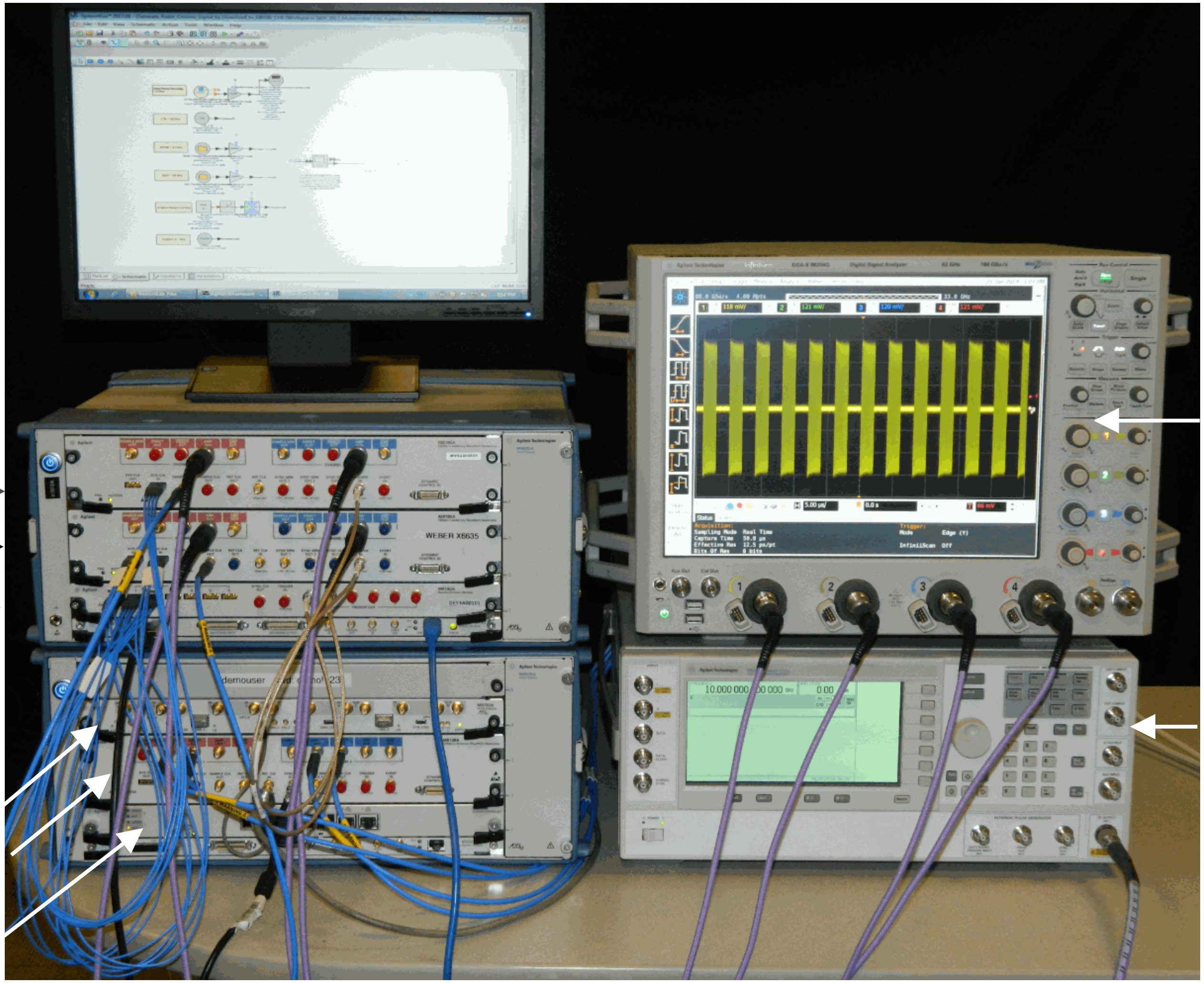
A threat simulator must be able to correctly simulate:

- Temporal radar pulse characteristics
  - Rise/fall time, pulse width, etc.
- Pulse repetition frequency and patterns
- Modulation on pulse
- Correct frequency and spectral characteristics
- Correct signal amplitude levels
- Radar antenna patterns
- Antenna scanning patterns

The Basic Building Blocks of an Off-the-Shelf Solution



Sample EW Workbench



AXIe Setup 1

M8190A #2

M8190A #1

M8192A Synchronization Module

AXIe Setup 2

M9703A Digitizer

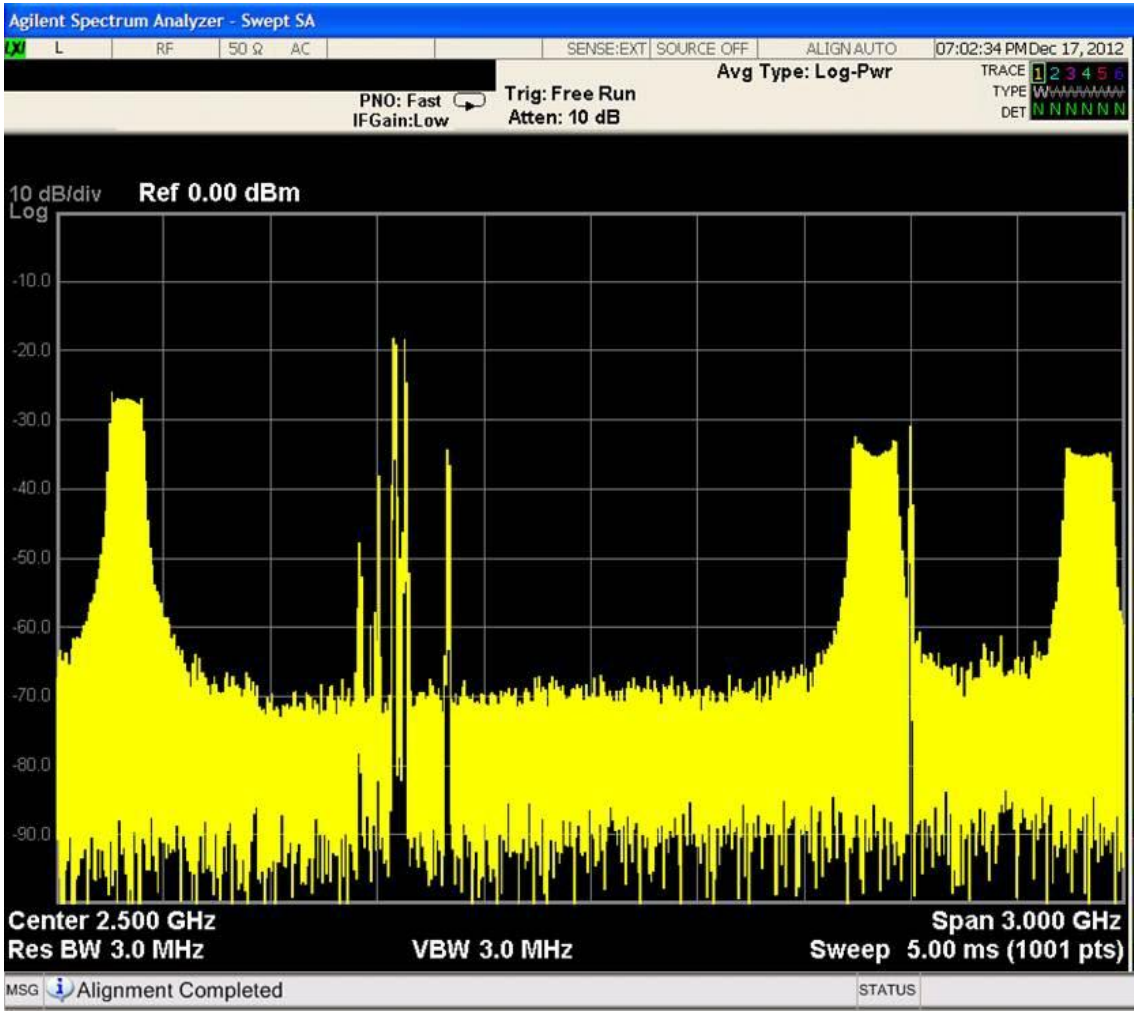
M8190A

Embedded Controller

Infiniium 62GHz Oscilloscope

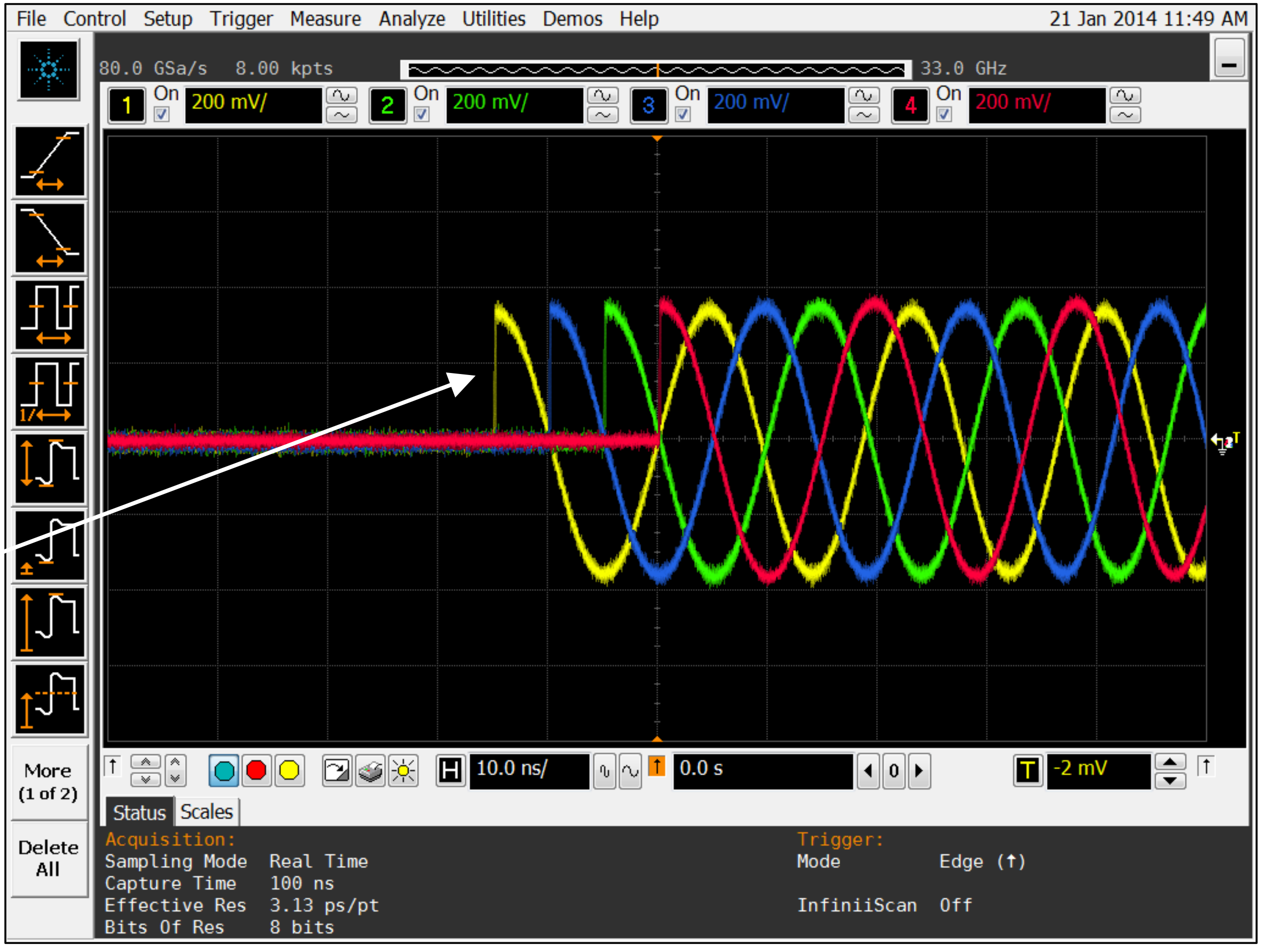
Vector PSG with Wideband IQ Inputs

The Details of Multiple Emitter Signal Simulation

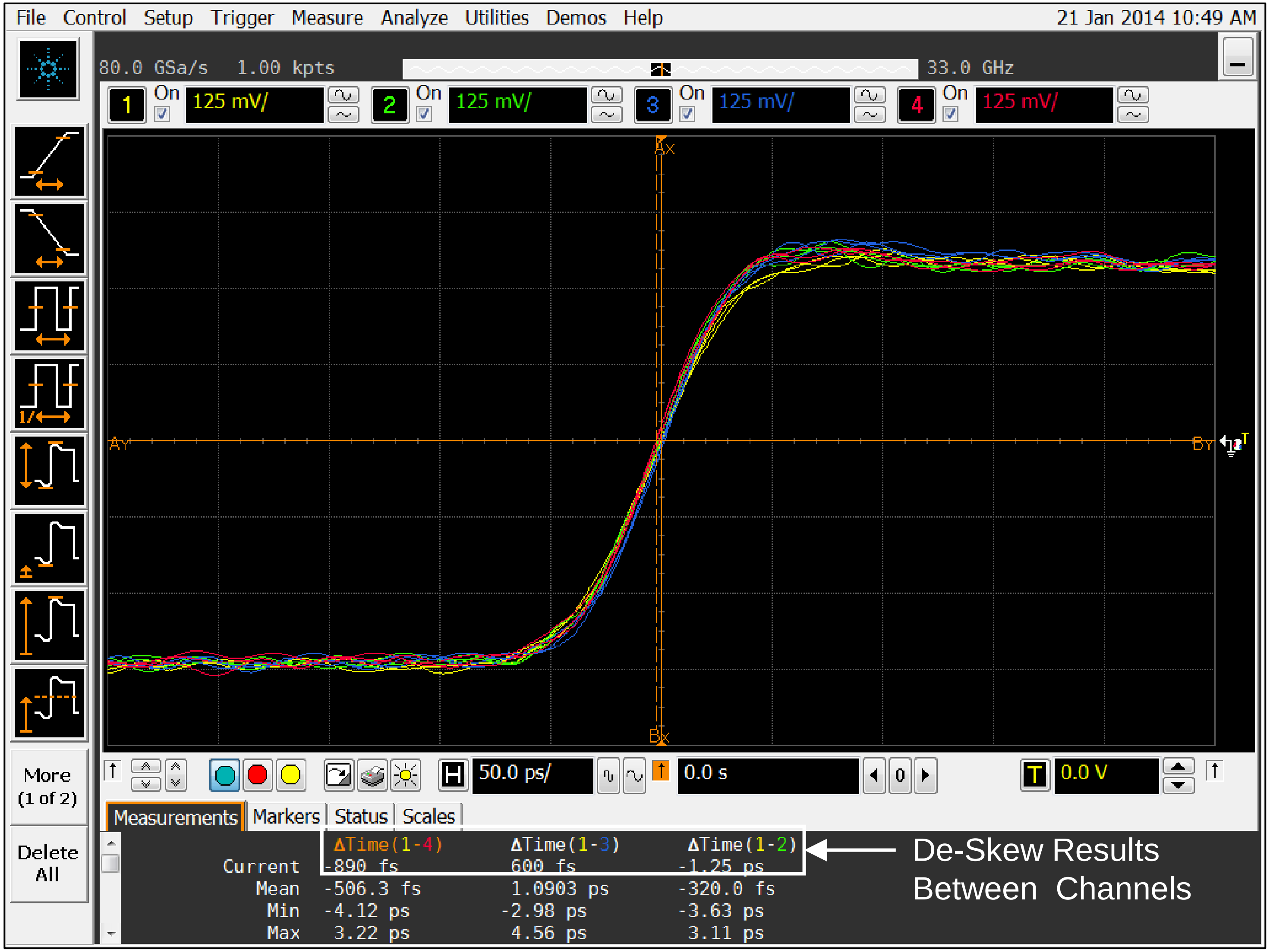


Four Channel Phase Alignment Measurements
RF Pulsed Signals with 45° Phase Offset Applied after Alignment

Four channels aligned and offset by 45°



Time Alignment Measurements
Multiple M8190A AWG Modules (4 channels) Using Oscilloscope



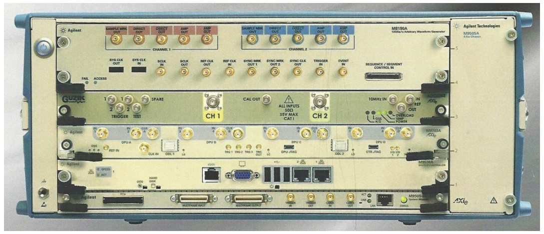
Signal Capture and Playback Challenges

- Key challenge is getting the wideband data from the digitizer to a large storage device or from storage to an AWG in real time
- Need to transfer data representing 500 MHz to 1 GHz of spectrum bandwidth. More is even better.

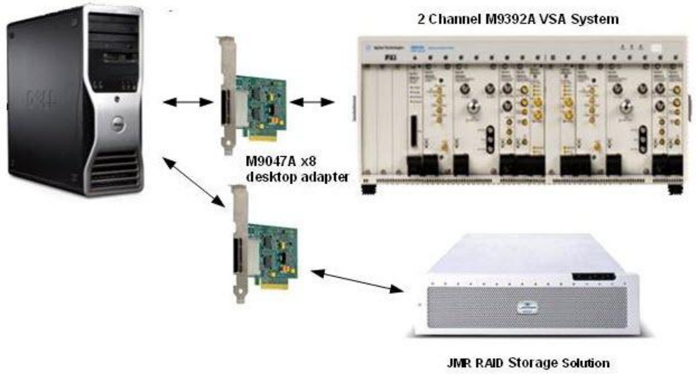
<u>A couple of alternatives:</u>

Backplane bus of a modular system:

Faster but limited to chassis



Cabled PCIe connection:



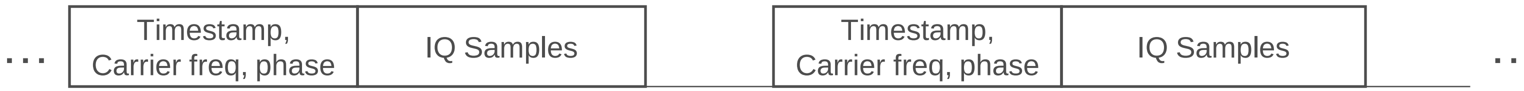
~250 MSample/s (32 bit I/Q pairs) or about 200 MHz RF modulation BW

PCIe Per lane:
v1.x: 250 MB/s
v2.x: 500 MB/s
v3.0: 985 MB/s

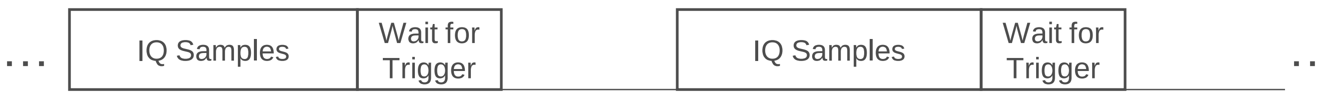
Transmissions over the streaming interface

Continuous stream of IQ samples

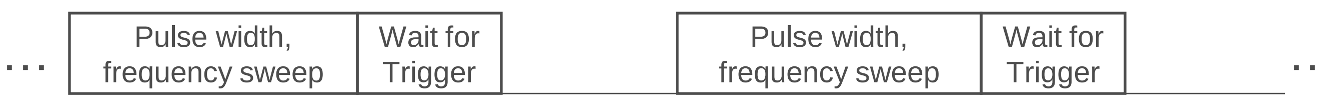
Blocks of IQ samples with meta data



Blocks of IQ samples which will be transmitted following a hardware trigger signal

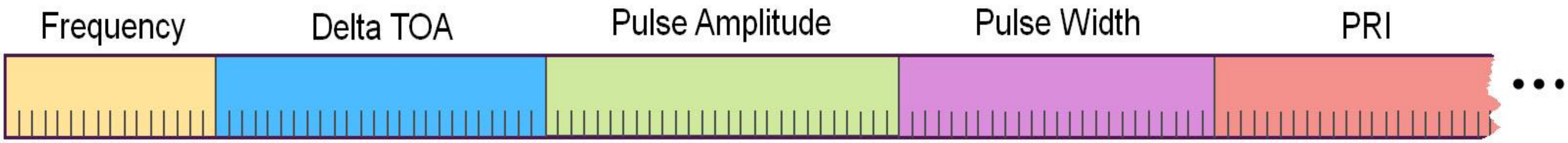


Blocks of meta data or pulse descriptor words (PDWs) that are converted into a waveform inside the FPGA



The ability to stream a reduce data set of PDWs enables higher RF bandwidth

Pulse Descriptor Words (PDW)



- **Contains temporal pulse information for each pulse received**
  - **Example: Frequency, amplitude, PRI, pulse width, delta TOA, TOA, target designator or ID, range, velocity, etc.**
- **The structures of PDWs vary widely depending on required detail and application**
  - **There are standardized formats**
- **Use deinterleaving of pulses in a multi-emitter environment to isolate the train from each specific emitter**
  - **Separate PDWs into groups of pulses with parametric and inter-pulse consistency**
  - **Pulse overlap handling determined on a user defined priority basis (e.g., strongest signal)**

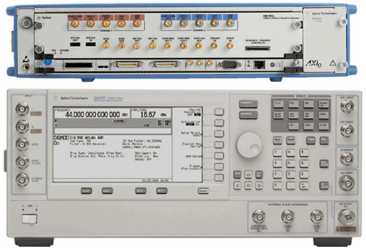
Creating and Generating Multi-Emitter Waveforms

Agilent SystemVue Creates Emitters:

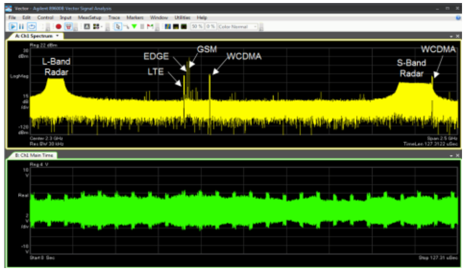
Radar
Wireless
Others

∑

M8190A AWG



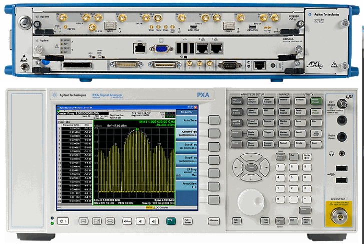
PSG

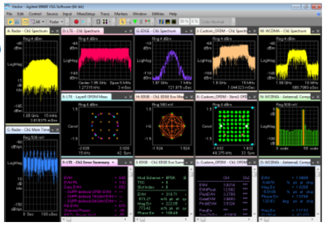


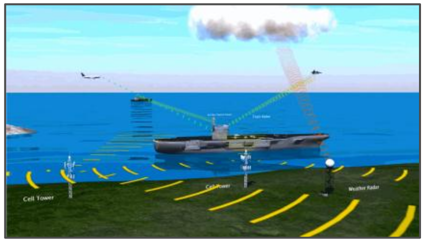
Capture, Record, and Add Other Signals:

M9703A Digitizer

PXA Signal Analyzer







RF In

89600 VSA Software

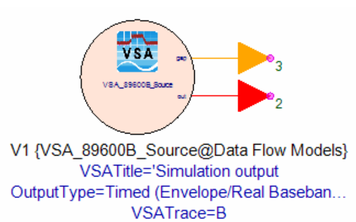
Combine Emitters into a Single Waveform File and Download to High-Performance AWG

Emitter #1
- Center Frequency = Fc1
- Bandwidth = BW 1
- Sample Rate = SR 1

Emitter #2
- Center Frequency = Fc2
- Bandwidth = BW 2
- Sample Rate = SR 2

⋮

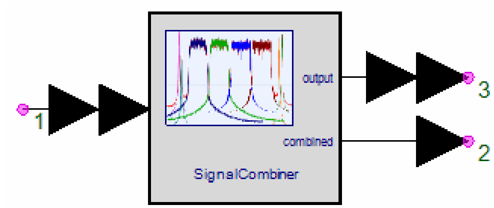
Emitter #N
- Center Frequency = FcN
- Bandwidth = BW N
- Sample Rate = SR N



Capture signals from test equipment

Agilent SystemVue

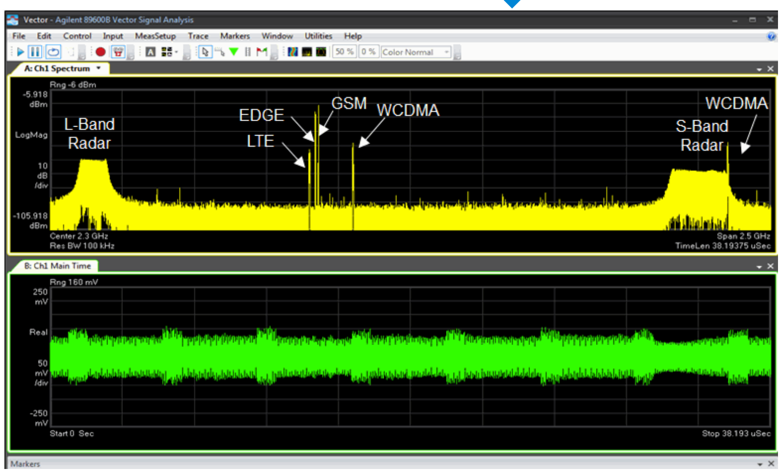
"SignalCombiner" Element



M8190A AWG

PSG

Multi-Emitter Output:
Output Center Frequency
Output Sample Rate

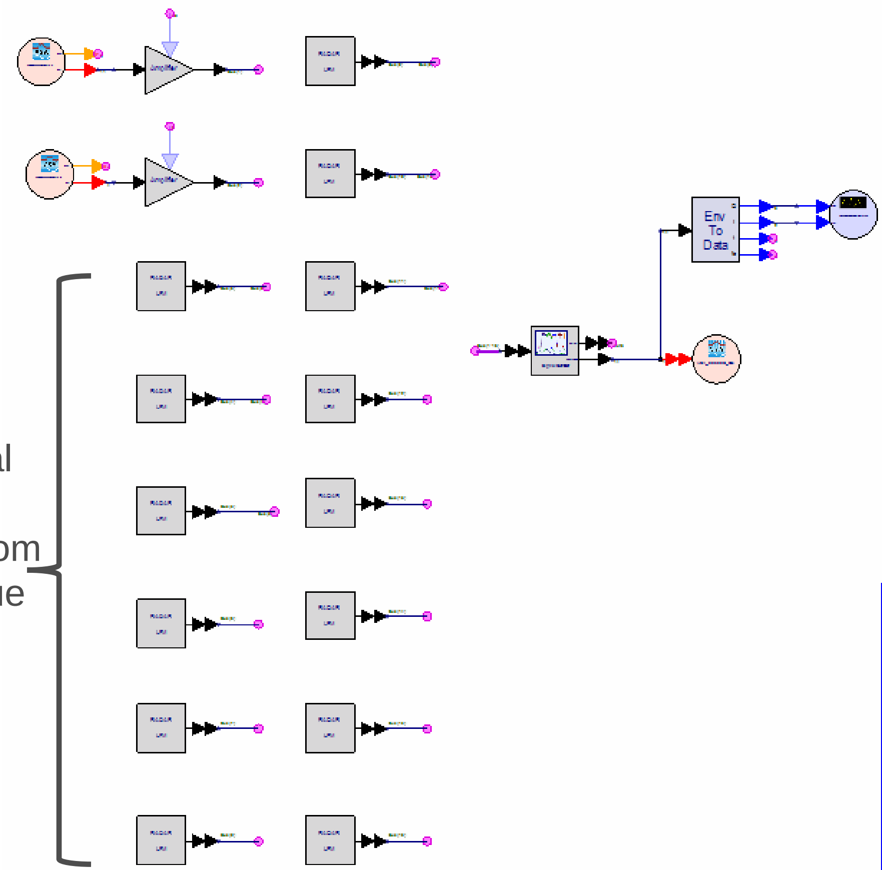


Add Programmatically Created Emitters to Captured Recordings
16 Total LMF Chirp Pulsed Emitters

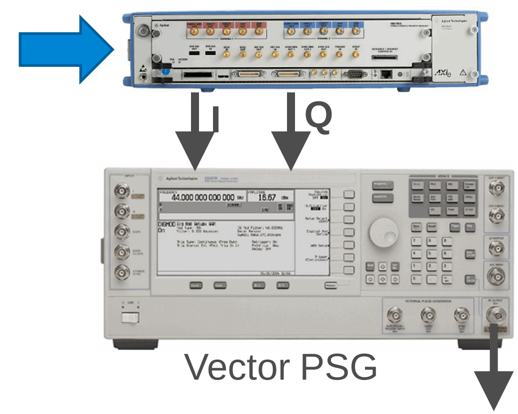
M9703 CH1 Recording

M9703 CH2 Recording

Add 14 Additional Radar Emitters from SystemVue Library

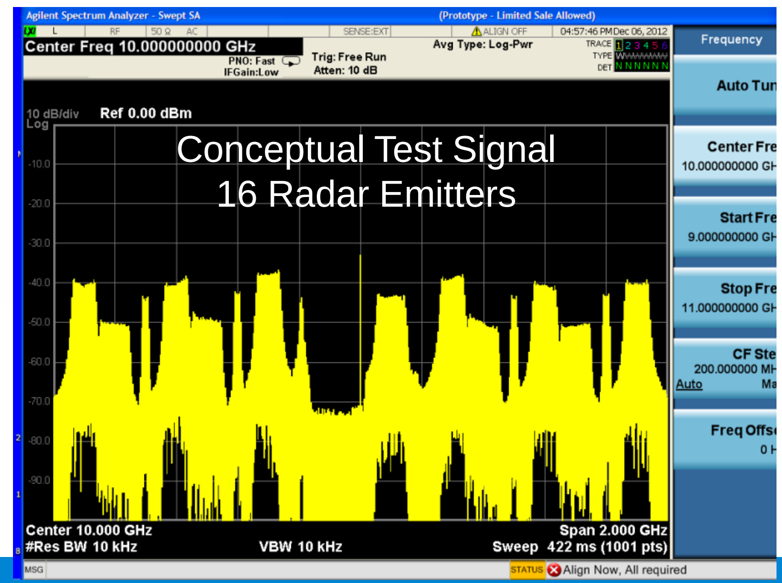


M8190A AWG

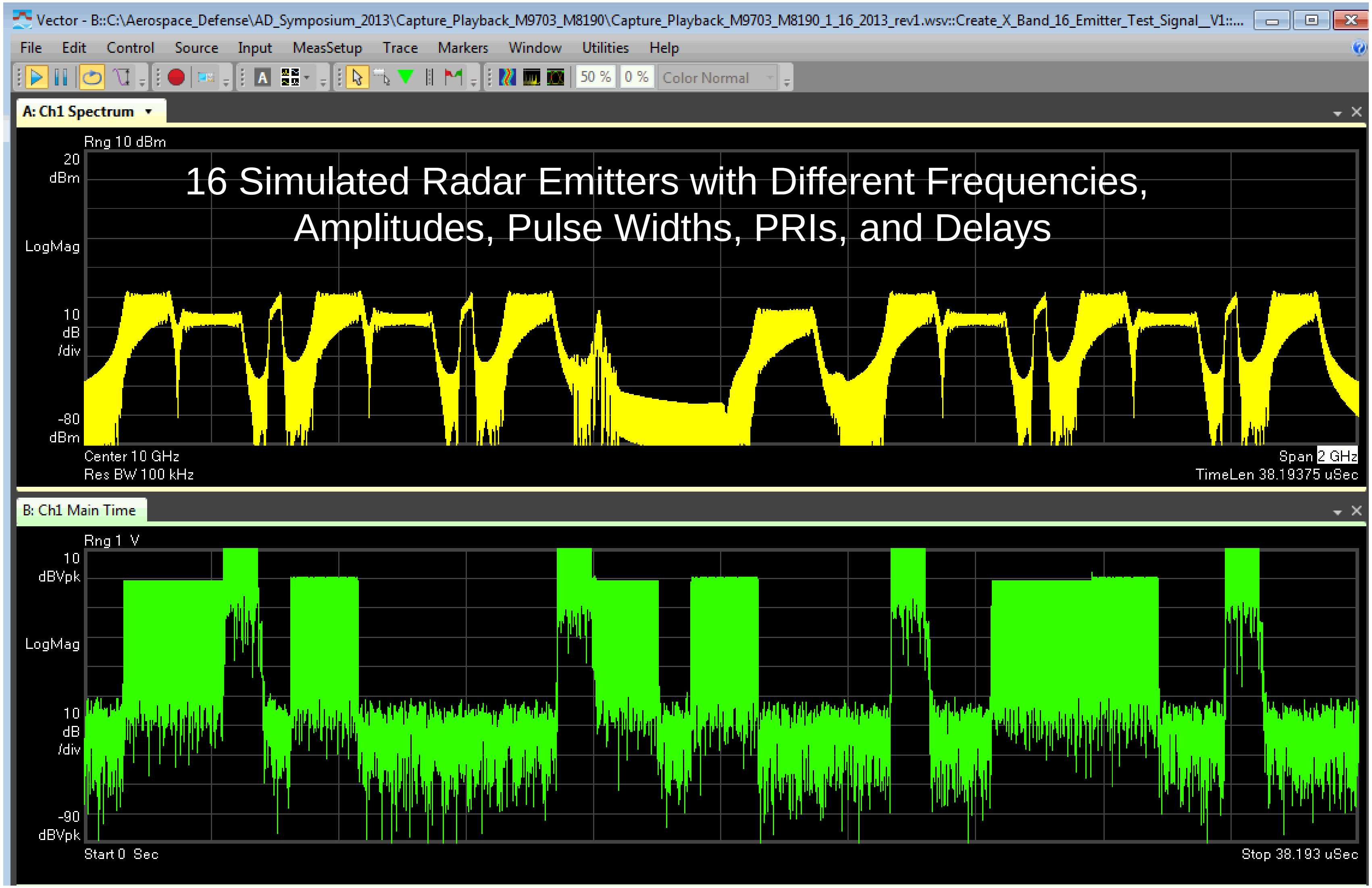


Vector PSG

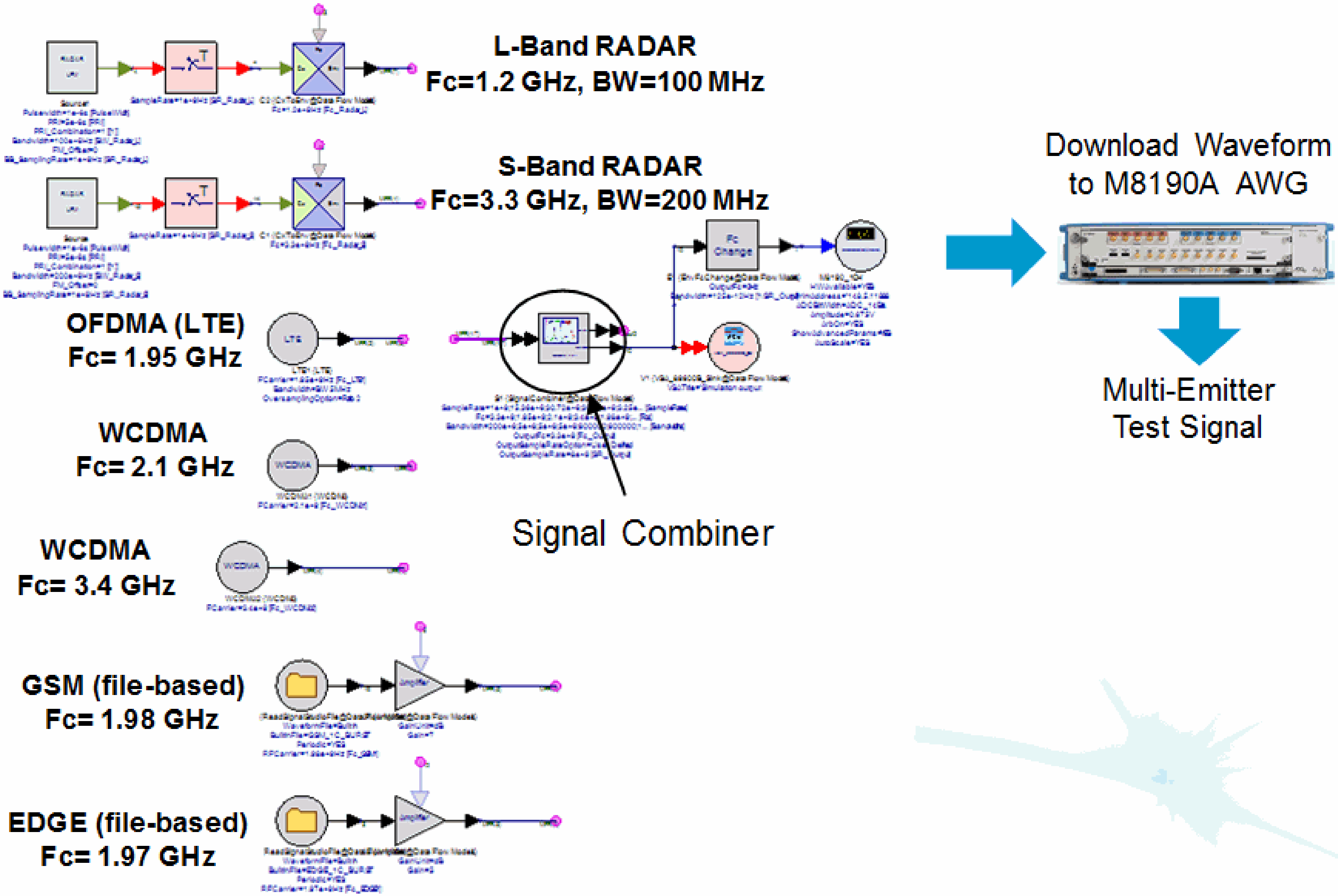
X-Band (9-11 GHz)



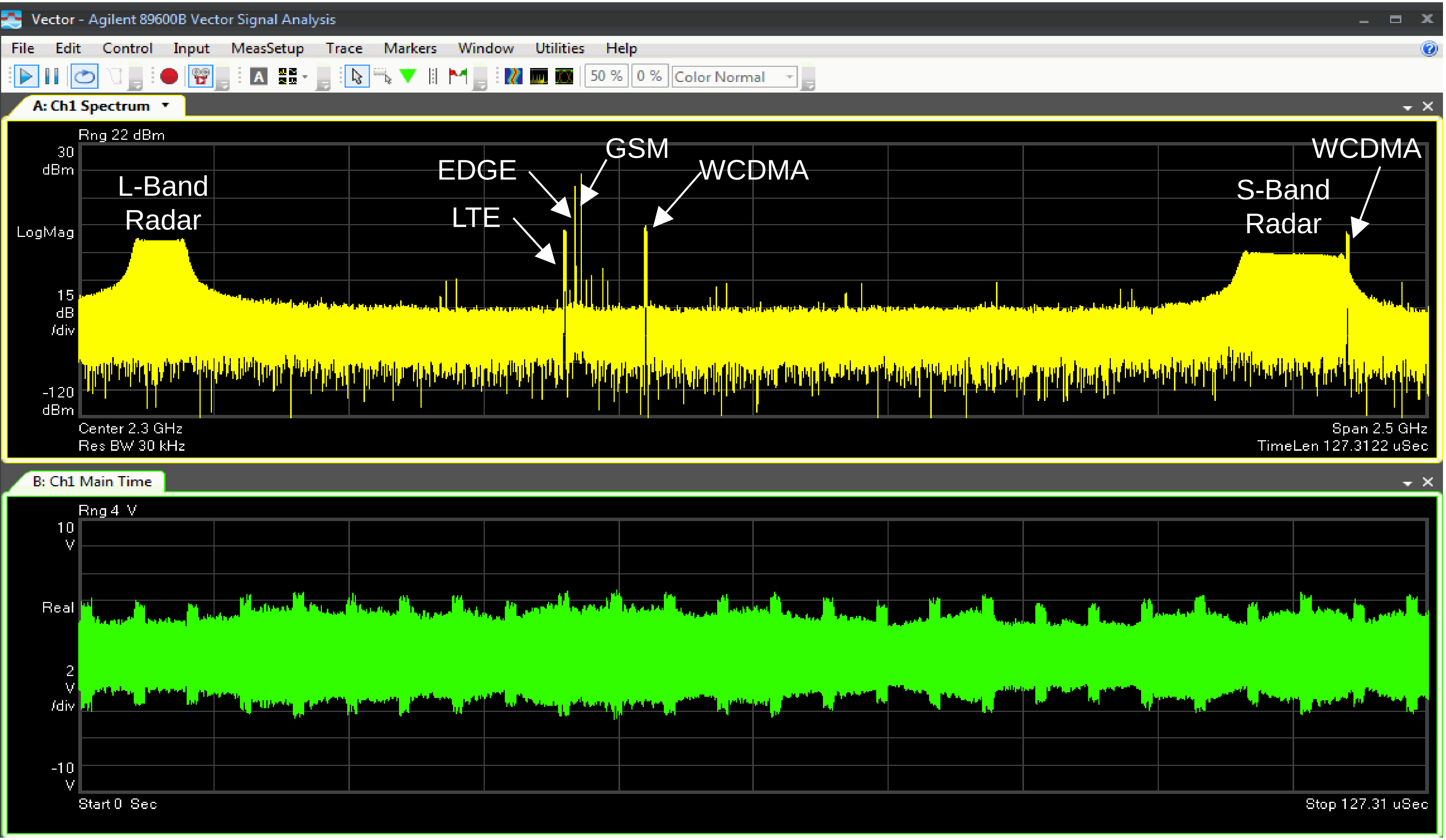
Simulated 8 Emitter Waveform: LFM Chirp Pulses



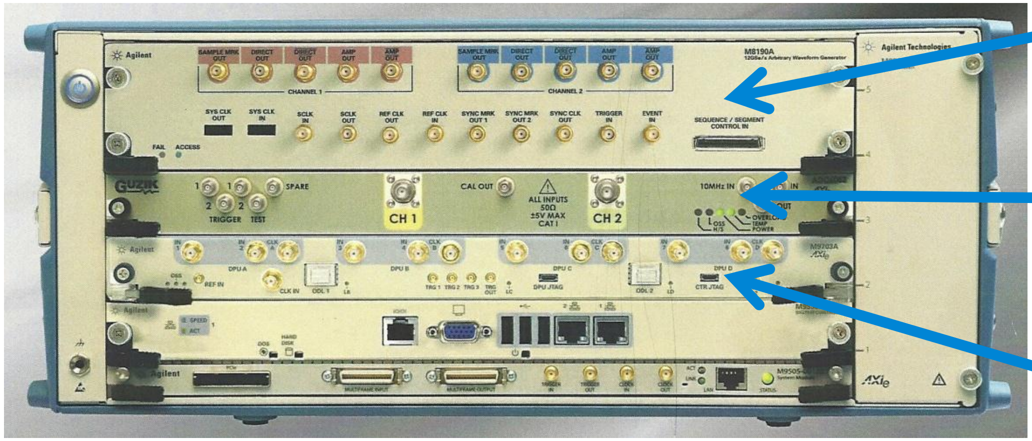
Multi-Emitter Signal Creation Mixed Communications & Radar for Full EM Spectrum Simulation



Resulting Spectrum Simulation



Agilent AXIe Instrument Measurement Capabilities



ARB, 2 channel 5GHz analog BW, 12-14bit, 12-8Gs/s, SFDR: typical -75 dBc

Digitizer, 2 channel, 8 GHz wide 8 bit, 10 Gs/s

Digitizer, 8-4 coherent channels, 1.6-3.2 Gs/s, 1 GHz wide, 12 bit resolution, FPGA based DDC

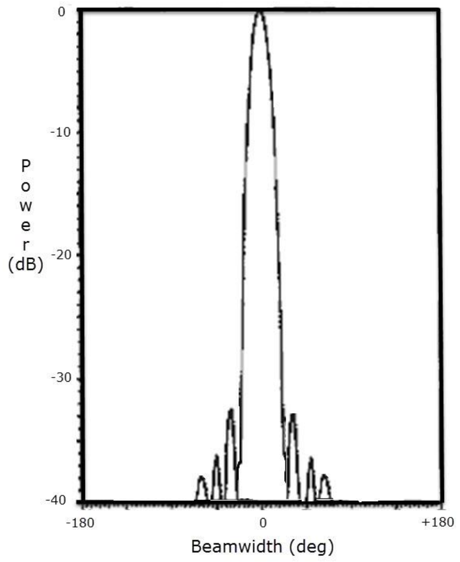
Array Antenna and Transmit / Receive Module Test

AESA Radar Installed on US Air Force F15

The Importance of AESA Technology to Radar *and* EW

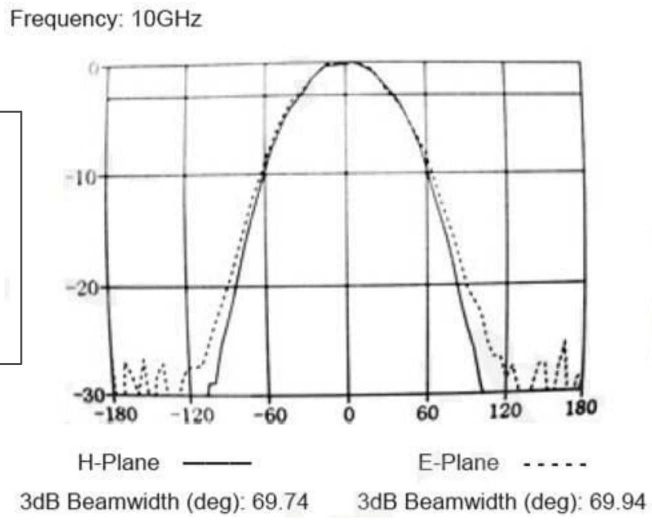
- **Antenna requirements for radar and EW are different but AESA allows use of a single aperture for both applications through beamforming and multi-beam capability**
- **Enables multifunctional systems – for EW it means engaging several threats independently or performing EA and ES functions at the same time**
- **The test system must be flexible to provide simulation and analysis across a variety of functions and scenarios**

Typical Radar Beamwidth



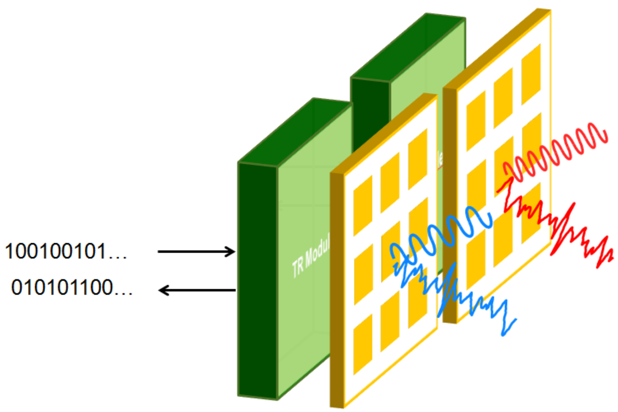
Modern applications of EW and radar require a variety of beam shapes from both system types

Typical EW Beamwidth

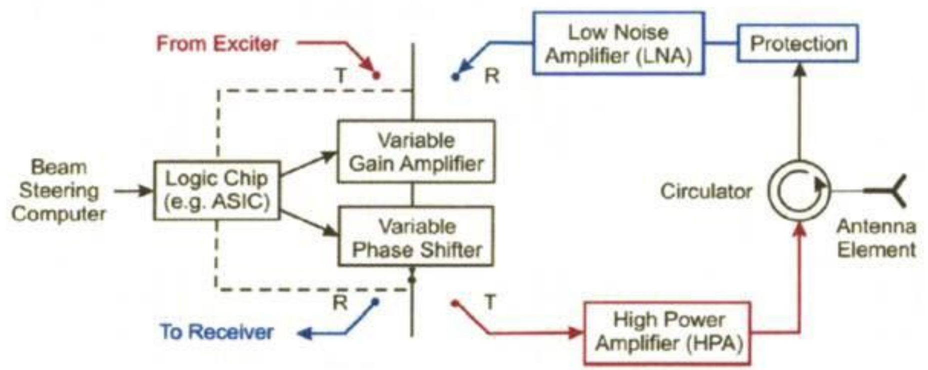


Transmit/Receive Modules (TRM)

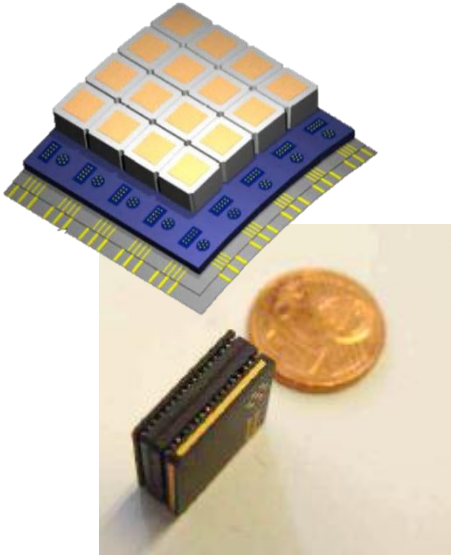
The digitized form of the signal is moving closer to the antenna



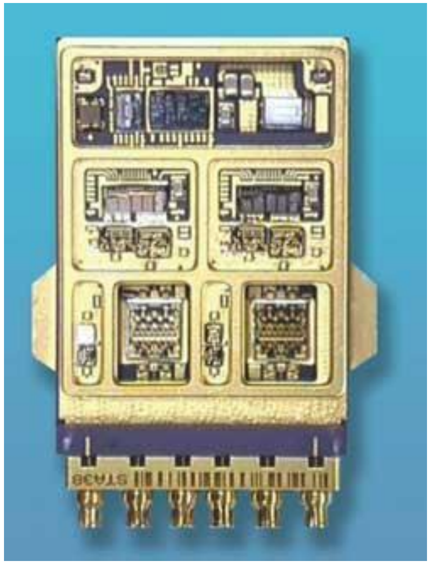
Eventually the A to D conversion will be moved into the TRM creating a device with an analog port and a digital port bringing new test challenges



Typical TRM Block Diagram



Tile Style



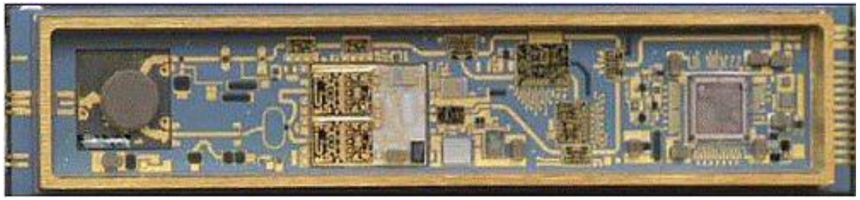
Brick Style

EW Threat Identification Today

Electronically Scanned Phased Array Radar

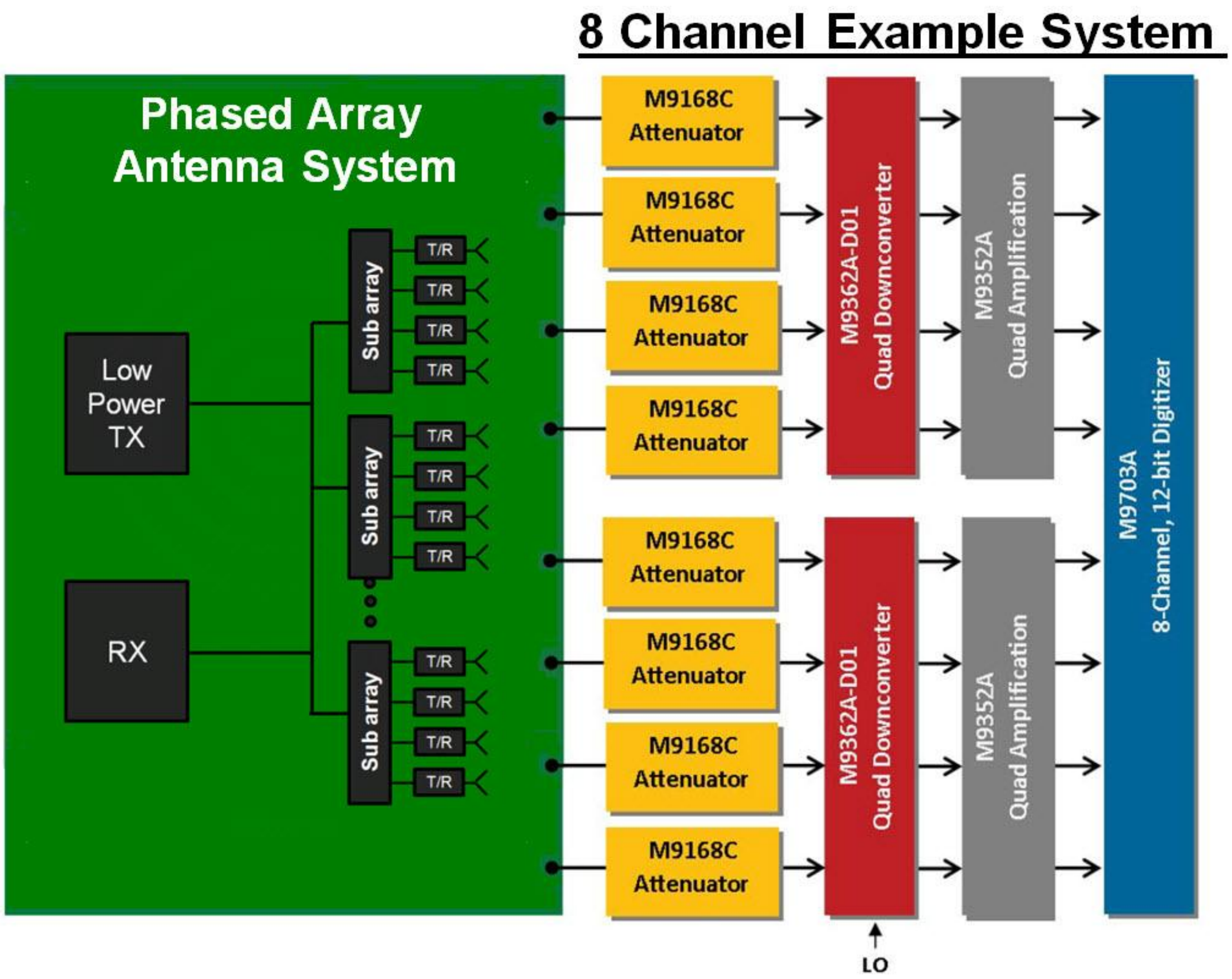
Can track multiple targets simultaneously with multiple antenna beams

Typical radar TR module



- Several thousand TR modules would be used in a typical AESA radar
- Module controls amplitude and phase for each antenna array element
- Frequency diversity can be simply programmed at the manifold feed.

Phased Array Antenna Alignment and Calibration

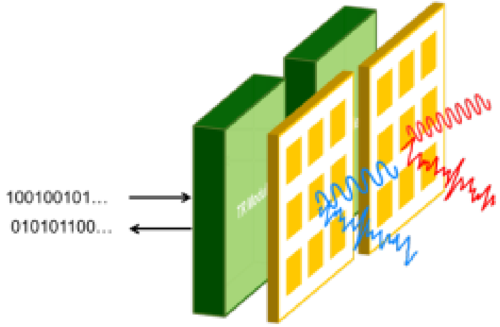


A multi-channel coherent test capability is optimum for array antenna testing

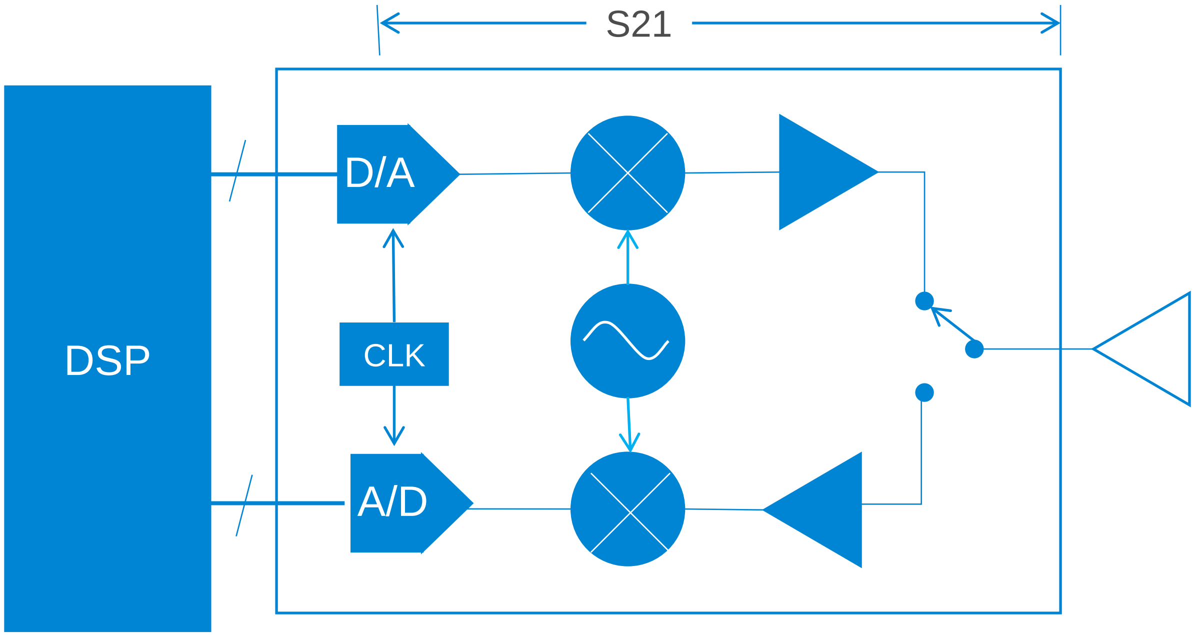
This example system uses a multi-channel digitizer in place of a network analyzer

This configuration provides more channels for simultaneous testing and the ability to provide wideband analysis greatly improving measurement speed

Impact of Digital Moving Closer to the Antenna



- Potentially no analog S21 measurements
- DSP generated phase and gain shift (wideband)
- Signals have bandwidth (flatness, spurious issues)
- Signals may be amplitude modulated (linearity issues)
- Digital plumbing (interconnects, signal integrity)
- New performance metrics (plus some old)
- Calibrations
- Test modes & signals
- Test points (probing)
- Test methods



Radar & Jammer Range and Power Level

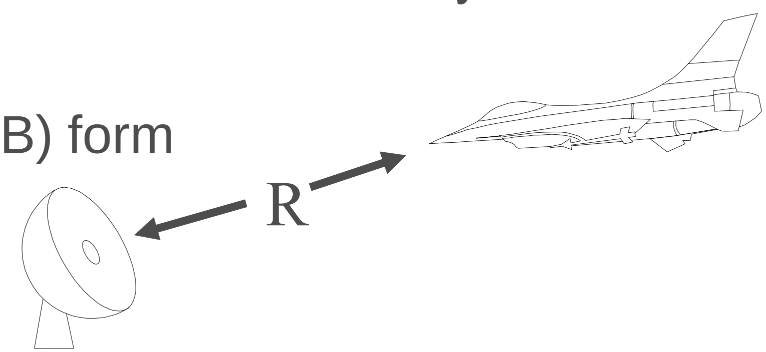
Prediction of Maximum Radar Range

By equating our equation for minimum signal with the equation describing signal level as a function of power, antenna gain, and range we can solve for the maximum range of our radar system

$$S_{\min} = kT_0 B_n F_n \left(\frac{S_o}{N_o} \right)_{\min} = \frac{P_T G^2 \lambda^2 \sigma}{(4\pi)^3 R^4{}_{\max}} \quad \rightarrow \quad R^4 = \frac{P_T G^2 \lambda^2 \sigma E_i(n)}{kTB_n F_n (S/N)(4\pi)^3 L_T L_R}$$

As you can see we've added three new terms to account for system losses and integration improvement

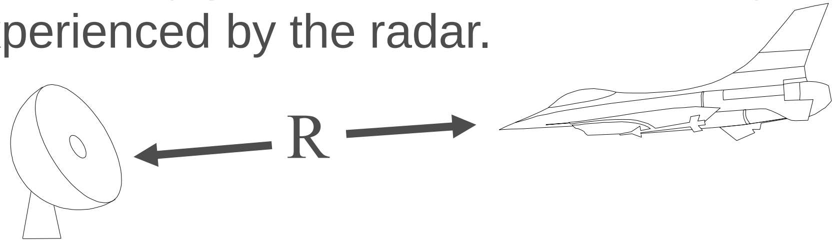
Now, we will convert our equation to log (dB) form



$$40Log(R) = P_T + 2G + 20Log_{10}\lambda + \sigma + E_i(n) + 204dBW/Hz - 10Log(B_n) - F_n - (S/N) - L_T - L_R - 33dB$$

The Jammer Range Equation

Since the jammer signal only has a one-way path to the radar it will only experience a $1/R^2$ loss, verses the $1/R^4$ loss experienced by the radar.



Again, we will start by looking at the free-space power density at the radar as produced by the jammer, assuming spherical scattering.

$$\rho_j = \frac{P_j G_j}{(4\pi) R^2}$$

The input power to the radar receiver, from the jammer, will then be the jammer's power density multiplied by the effective area of the radar's antenna.

$$S_{jR} = \frac{P_j G_j A_e}{4\pi R^2}$$

Where: $$A_e = \frac{G\lambda^2}{4\pi}$$

Therefore: $$S_{jR} = \frac{P_j G_j G_R \lambda^2}{(4\pi)^2 R^2}$$

Range Equation for the Jammer Cont'd.

Now we have an equation for the jammer's signal power at the radar we can compare it to the equation previously developed for the signal power at the radar's receiver due to the target's skin return.

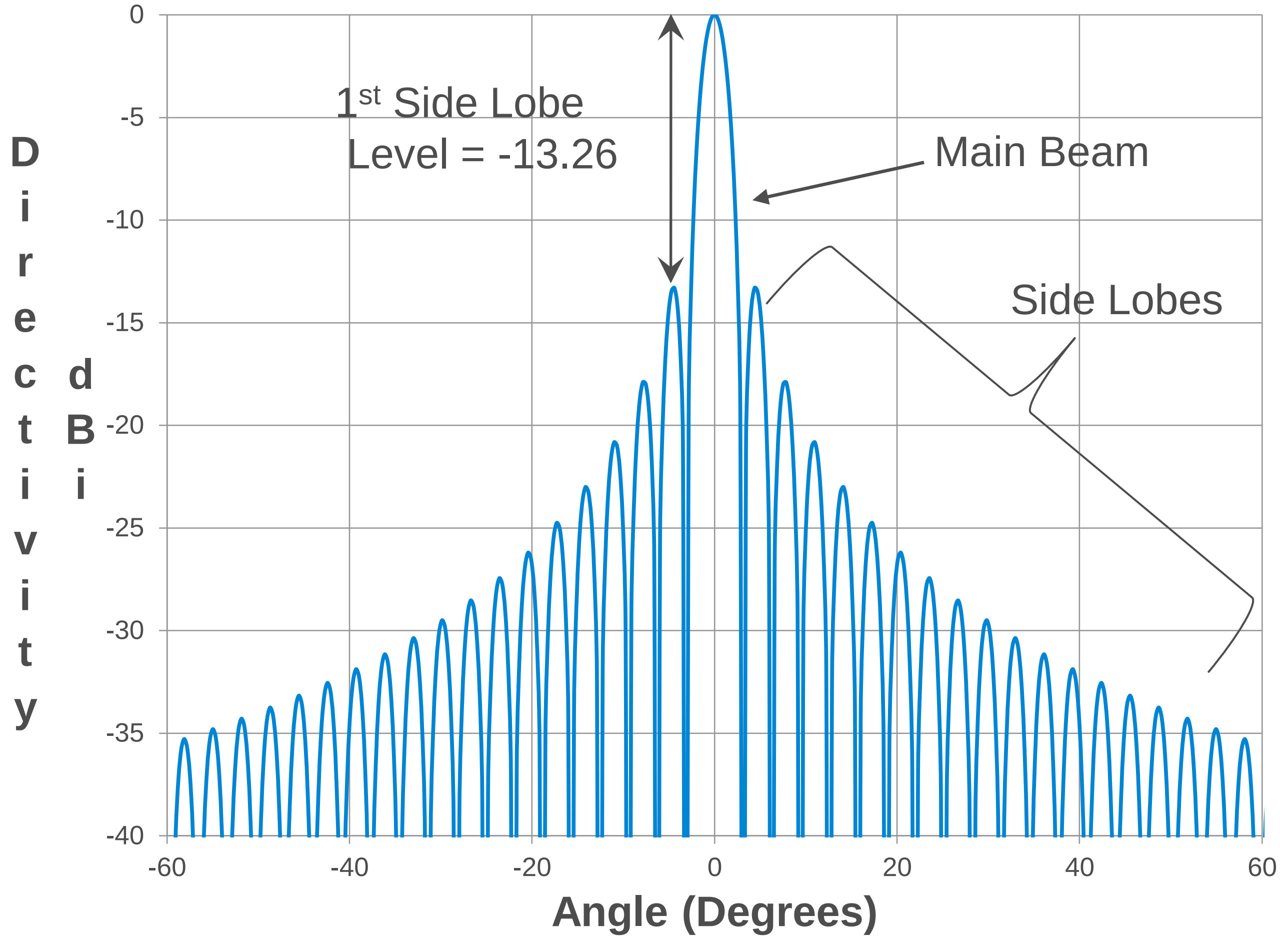
For the Jammer: $$S_{jR} = \frac{P_j G_j G_R \lambda^2}{(4\pi)^2 R_j^2}$$ And for the radar: $$S = \frac{P_T G_T G_R \lambda^2 \sigma}{(4\pi)^3 R_R^4}$$

It is often convenient to relate the jamming signal strength to that of the radar's skin return strength as a jam to signal ratio (J/S).

$$\frac{J}{S} = \frac{P_j G_j (4\pi) R_R^4}{P_T G_T \sigma R_j^2}$$ If the jammer and radar range are equal, then $$\frac{J}{S} = \frac{P_j G_j (4\pi) R^2}{P_T G_T \sigma}$$

Note: The above analysis assumes that the jammer antenna and the radar antenna are pointed directly at each other (main lobe), which is very seldom the case. Generally jamming is done on the radar antenna's side lobes and a function must be used to account for the difference in antenna gain. However, from this analysis it is easy to see that the jammer has the advantage in most situations.

Antenna Pattern of a Pencil-Beam Antenna Rectangular Aperture w/Uniform Weighting



Jammer Power Budget Example

$$\left(J/S\right)_{dB} = P_{j(dBW)} + G_{j(dBi)} + 11dB + 20Log_{10}R_m - P_{T(dBW)} - G_{T(dBi)} - \sigma_{dBsm}$$

Victim Radar

- Power P_T = 250 kW = 54 dBW
- Ant Gain G_T = 30 dBi
- RCS = σ = +20 dBsm

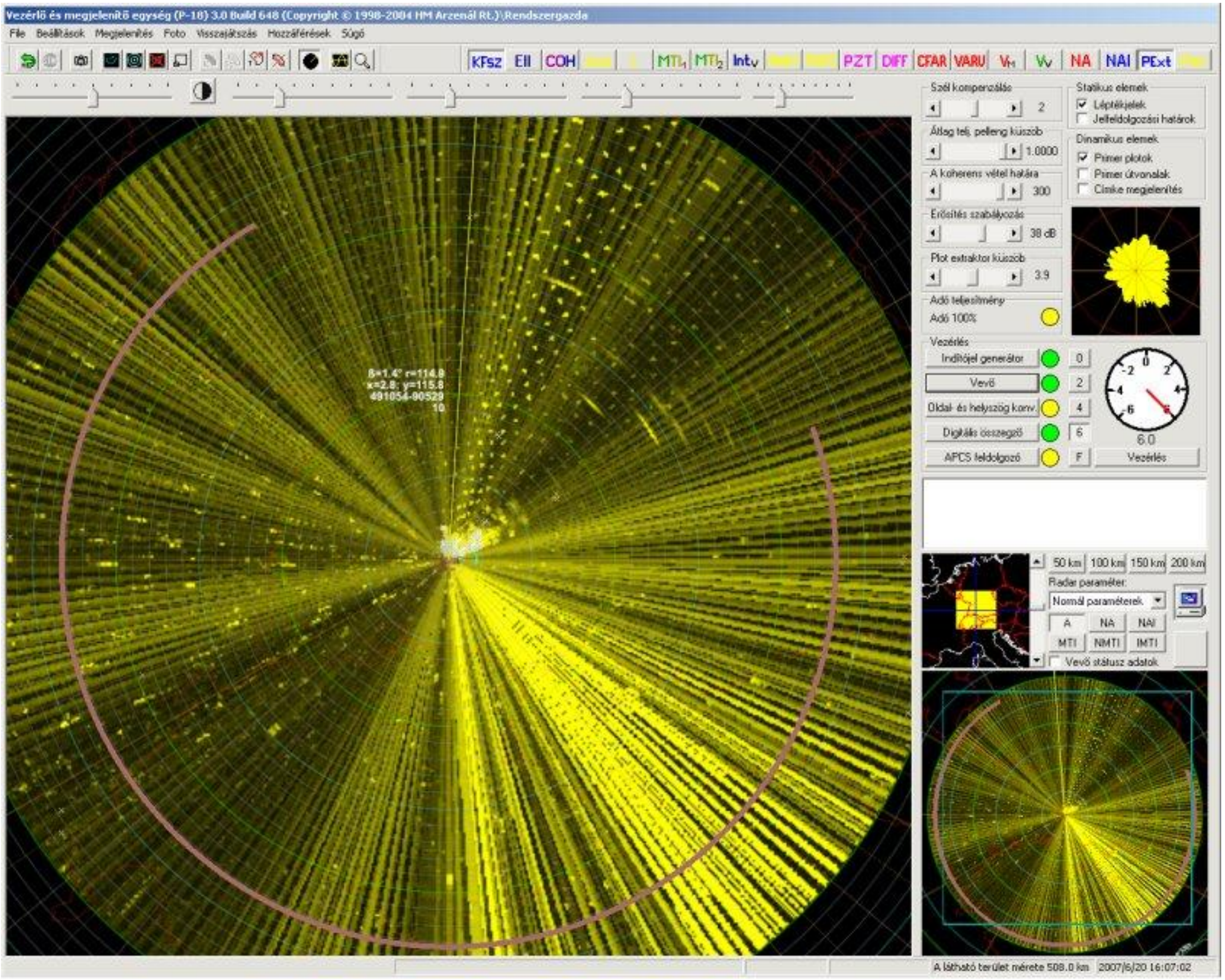
Jammer

- Power PJ = 1 kW = 30 dBW
- Ant Gain GJ = 6 dBic
- Correction to H-Pol = -3 dB
- Range = 50 km = 94 dB

J/S = 30 dBW + 6 dBic – 3dB + 11 dB + 94 dB – 54 dBW – 30 dBi – 20 dBsm
= 34 dB

With 34 dB J/S the jammer could maintain a minimum 10 dB J/S ratio and still fully Jam the radar down to a – 24 dB side-lobe level, which would obliterate radar performance over most of the radar scan.

Noise Jamming on Sidelobes



Review of Amplitude Issues for Simulation

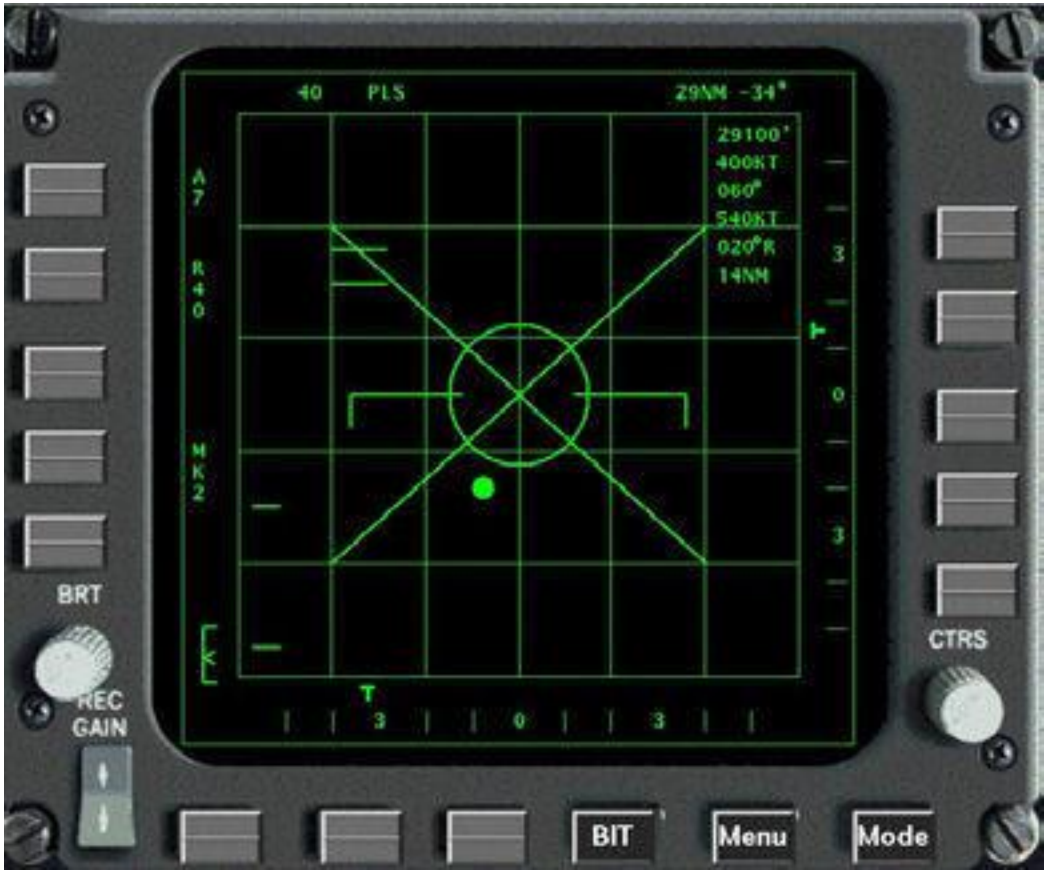
- Careful consideration of target range, aspect angle, and antenna patterns is necessary to correctly simulate radar signals in an EW test.
- Similarly, target range, aspect angle, and radar cross section of targets is necessary when using simulation for radar miss distance scoring.
- Evaluate required minimum and maximum power to determine power requirements and required dynamic range for the simulation.
  - What portion of the power control budget can be controlled with simple step attenuators?
  - What portion must be under dynamic control from an arbitrary waveform generator?
- Direct Digital Sequencing (DDS) may be required to create a dynamic simulation with simulated moving targets and or jammers.
- As discussed under pulse characteristics, a multi-emitter simulation may be required to fully test a radar or EW system.
- Evaluate cost verses fidelity trade offs for your situation.

Other Driving Technologies Looking for a Wideband, Multi-Channel, Capture/Playback Test & Evaluation Solution

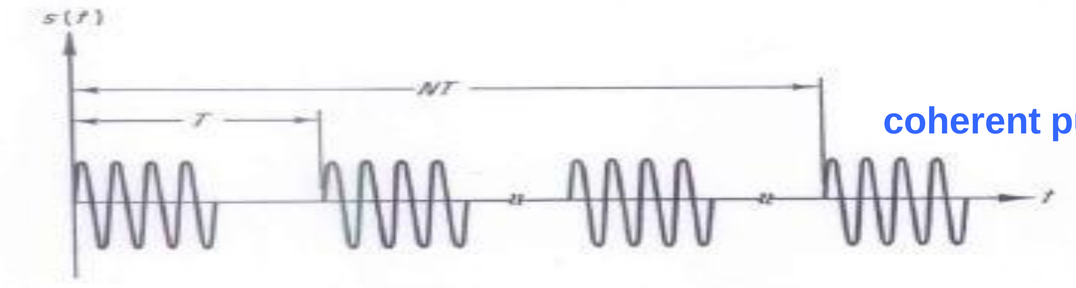
- Adaptive Radar Signals
- New EW Systems Designs
- Active/Passive Radar Antenna Designs
- Cognitive Radio Systems
- Dynamic Spectrum Access
- Spectrum Sharing
- MIMO – RF Communications & Radar
- Distributed, Multi-Static & Passive Radar
- Multi-function Radars
- UAS/ UAV Low Latency Communications
- Secure Environment Testing

US Patriot missile radar

Radar Target Simulation



Radar Target Signal Simulation



coherent pulse train

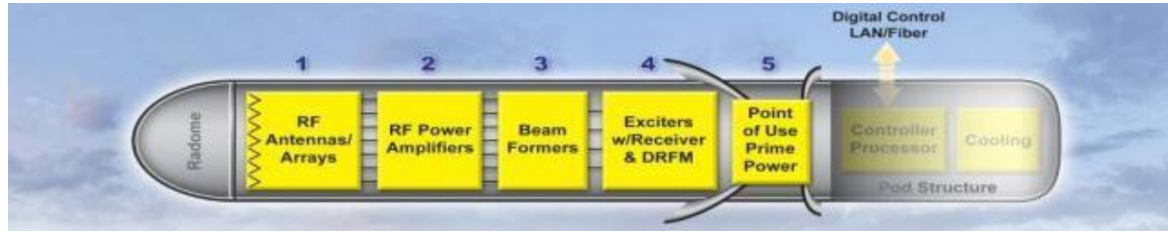
Simulation systems for use with active and coherent radar systems are currently almost always based on digital RF memories (DRFM)

Passive, bi-static or multi-static radars that use non-coherent detection methods, also benefit from simulation tools based on commercial off-the-shelf (COTS) arbitrary waveform generators

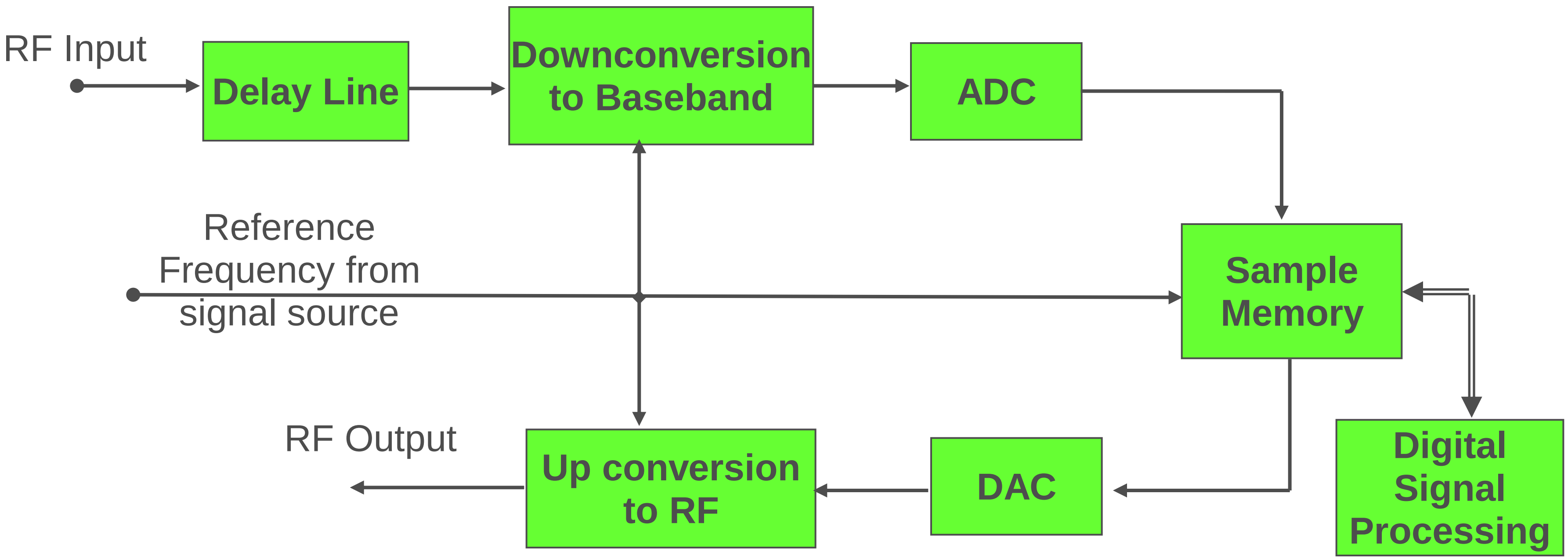
Passive radar antenna – Courtesy of Cassidian

Digital RF Memories (DRFM)

Source to Receiver Coherency



Anatomy of an airborne jammer pod



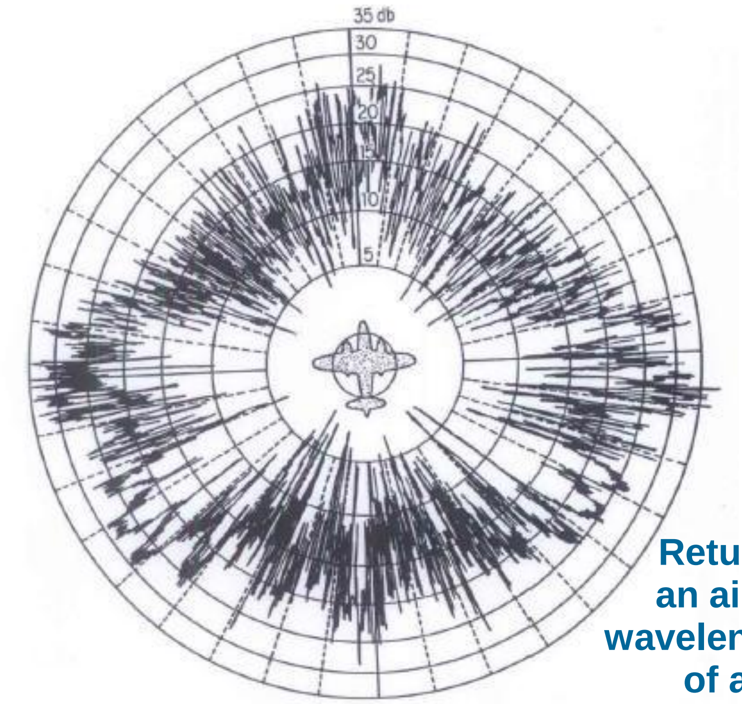
- **Intrinsically phase coherent with the signal source such as the transmitting radar**
- **Developed for EW applications, also used for coherent target simulation**

Radar Cross Section (RCS)

The amplitude and phase of the radar return signal changes as the aspect angle of the target changes

RCS is very dependent of the target size, shape and construction material

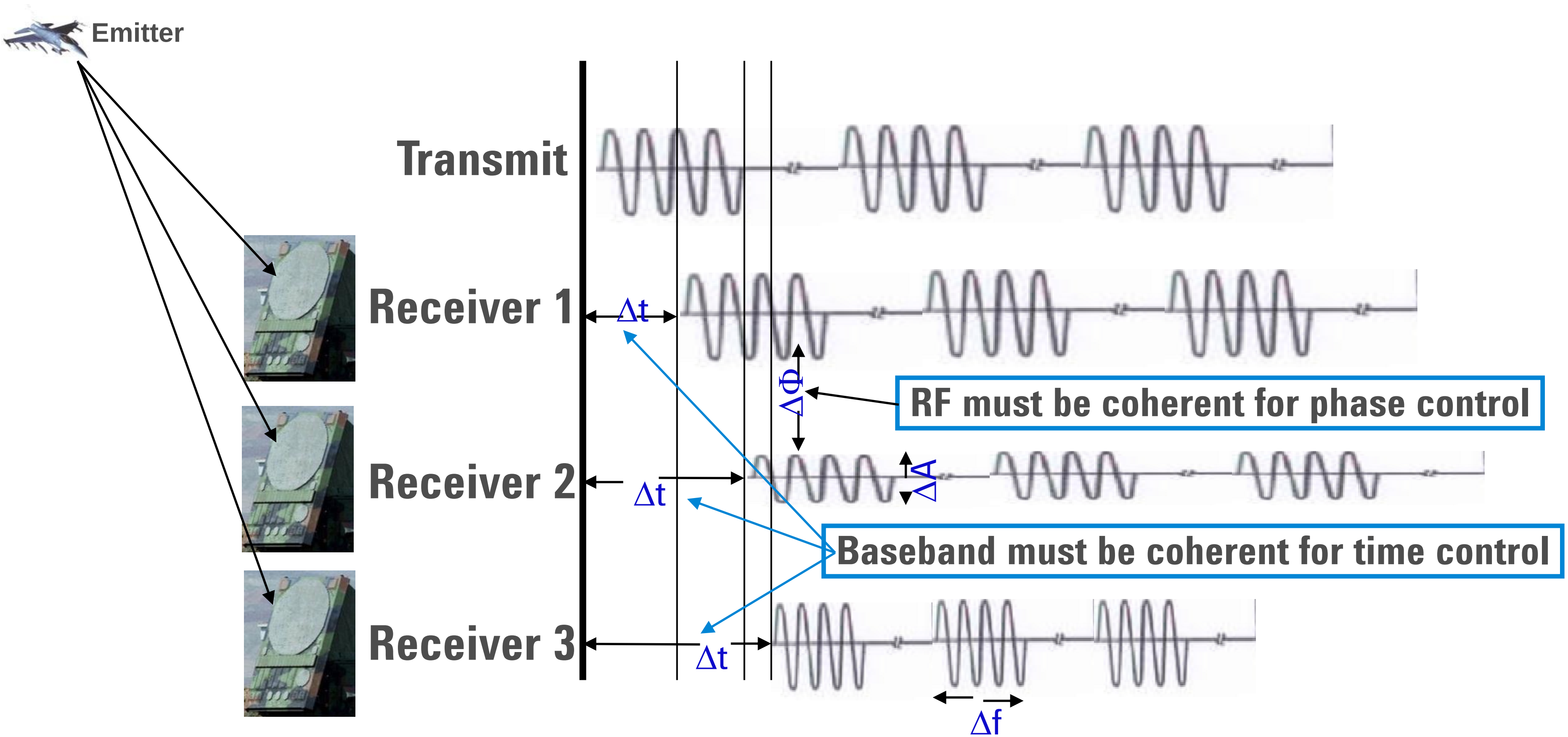
Radar return RCS simulated using Swerling models (I – IV) and recorded or customized signal returns



Return power from an aircraft at 10 cm wavelength as a function of azimuth angle

In order to evaluate the radar performance in terms of ability to find and track various target types as they maneuver, many different long scenarios are required.

Emitter as Seen by Multiple Receivers in the Time Domain
Multiple Source to Source Coherency



All received signal can have:

Δt(time & delay), $\Delta\Phi$(phase), ΔA(amplitude), Δf(frequency & Doppler)

from original transmitted signal

Summary

- EW Receiver programming must be kept up to date with current threat data
- Testing is required to ensure the receiver responds to newly programmed threats
- Commercial off-the-shelf test equipment can provide a cost effective method to verify performance
- New software tools can greatly simplify the development complex radar and EW simulations.
- Complex test systems may be $$$ with multiple racks of equipment– utilization of these test resources may be prohibitive due to cost and space constraints
- Lower-cost, smaller footprint commercial-off-the-shelf (COTS) solution may be suitable for some R&D and lab testing applications that require less capability
- Spectral environments may require a combination of Radar, wireless, wireless networking, and recorded signals

Appendix

Pantsir S1 (SA-22 Greyhound) SAM system
This is a mobile, short-range, fully autonomous air defense system combining two 2A38M 30mm anti-aircraft guns and up to 12 x 57E6-E ready-to-fire missiles in steered launch containers.

Radar Jammer Types

- **CW**
- **Barrage Jammers:** An attempt to "outshout" the opposing equipment through continuous or high-duty cycle power within the desired frequency band—blot out the sun technique
- **Noise Jammer:** Brute-force jamming by modulating the jamming signal with AM or phase noise.
- **Deceptive:** Uses a repeater or frequency memory to provide a precise return that is modified in time or frequency to interfere with missile fire control.
- **Repeater Jammer:** A jammer that modifies and retransmits hostile radar signals to deny accurate position data
- **Transponder Jammer:** A repeater jammer that plays back a stored replica of the signal after being triggered by the radar.
- **Set-On-Jammer:** A jammer that measures the threat radar frequency and adjusts a sine-wave oscillator to retransmit the threat frequency
- **Swept Spot Jammer:** A jammer that sweeps an oscillator over a band of frequencies to excite receivers tuned to frequencies in the band.
- **Stand-In-Jamming (SIJ):** A Jammer (aircraft) that accompanies a strike force into combat air space—inside the range of defensive weapons
- **Stand-Off-Jamming(SOJ):** A system which provides jamming coverage for a strike force, but does not enter inside the range of defensive weapons

Agilent Instruments and Solutions

Agilent M9703A High-Speed Digitizer

Reduce measurement time with the new M9703A.
Higher number of synchronous acquisition channels, wider signal capture and best accuracy.

Key Features

- **12 bit Resolution**
- **8 channels @ 1.6 GS/s**
- Interleaving option to get **4 ch @ 3.2 GS/s**
- DC to 2 GHz analog 3 dB bandwidth
- **Optional real-time digital downconversion (DDC) on 8 phase-coherent channels**
- Up to 256 MS/ch memory and segmented acquisition
- > 650 MB/s data transfer
- **Agilent 89600 Software support**

M9703A OS support

- Windows
- XP (32-bit)
- Vista (32/64-bit)
- 7 (32/64-bit)
- Linux

Drivers – MD1 software

- IVI-C, IVI-COM
- LabVIEW
- MATLAB (through IVI-COM)

OTS application software

- MD1 soft front panel
- AcqirisMAQS U1092A-S01/S02/S03
- 89600 VSA software

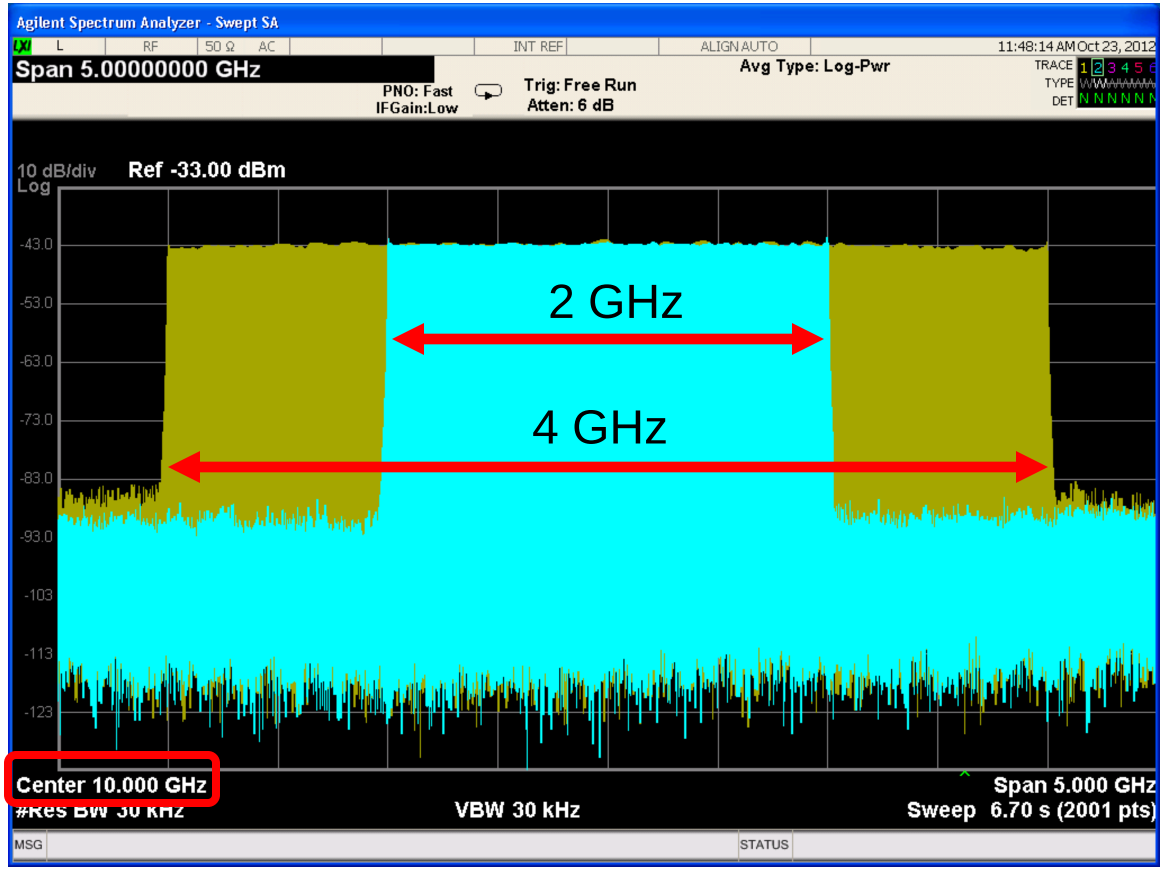
Advanced AWG Solutions

M8190A Arbitrary Waveform Generator

- ✓ 14 bit up to 8 GSa/s
- ✓ 12 bit up to 12 GSa/s
- ✓ Up to 5 GHz analog bandwidth per channel
- ✓ **Up to 2 GSa memory per channel**
- ✓ **Signal Studio for Pulse Building and SystemVue support**
- ✓ **AXIe form factor**
- ✓ DC and AC amplifier
- ✓ SFDR: -80 dBc typical / Harmonic distortion: -72 dBc typical
- ✓ Advanced sequencing scenarios define stepping, looping, and conditional jumps of waveforms or waveform sequences
- ✓ 2 markers per channel (does not reduce DAC resolution)
- ✓ **ISO 17025 or Z54 calibration**

www.agilent.com/find/M8190

M8190A / N7620B / E8267D – Wideband Chirp

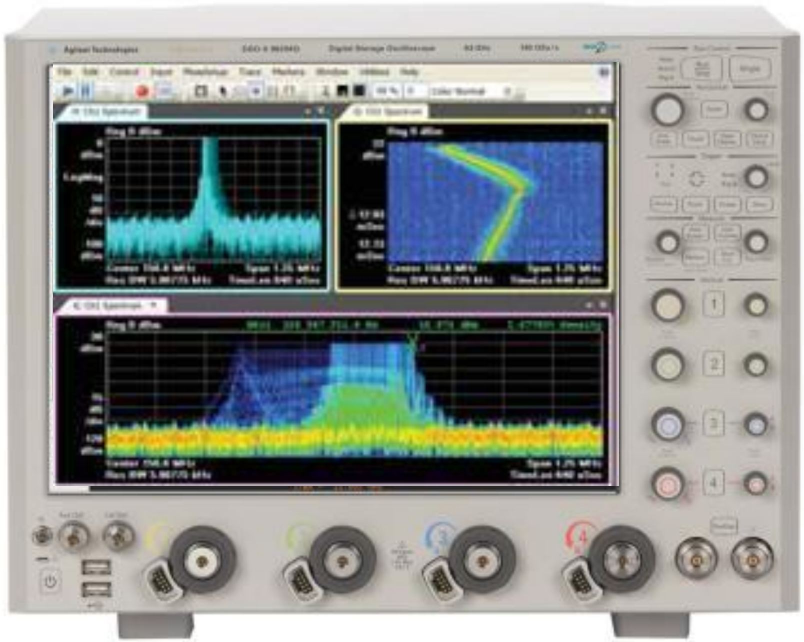


>2 GHz Chirp @ 10 GHz Carrier!!!

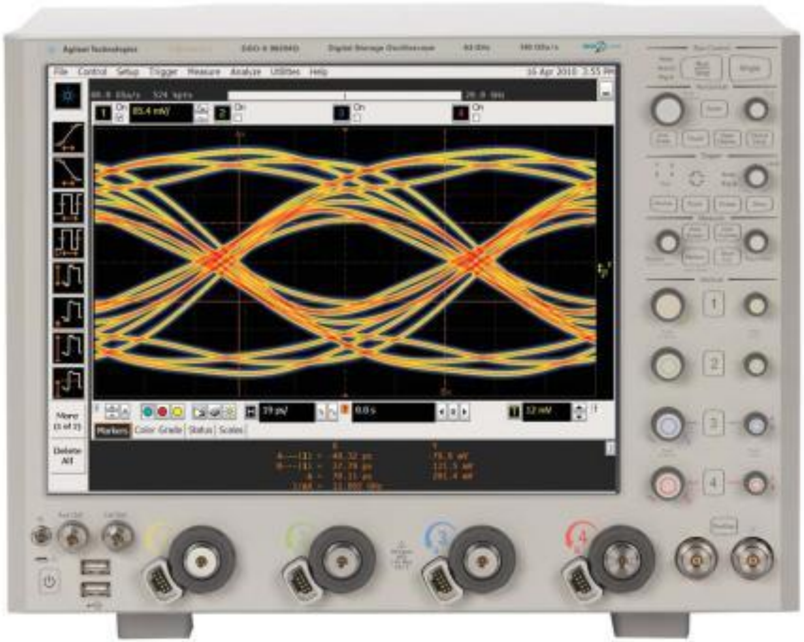
Oscilloscopes

New: Infiniium 90000 Q-Series Oscilloscopes

63 GHz of real-time bandwidth on 2 channels
33 GHz of real-time bandwidth on 4 channels

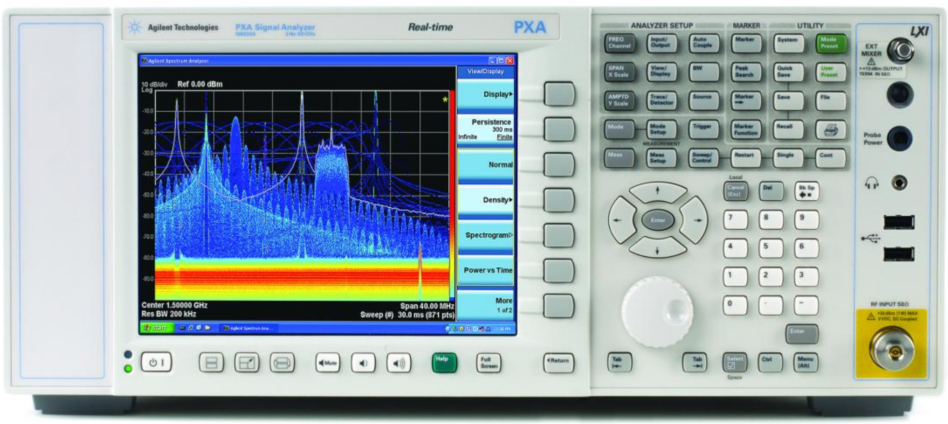


Analog Signal Analysis



Test High Speed Digital Interconnects

Agilent's Real-Time Spectrum Analysis



See, capture and understand the most elusive signals—

known or unknown

- **Provides highest-performance real-time spectrum analysis**
- **Adds real-time to industry-leading PXA signal analyzer**
  - *Upgradable option to new and existing PXAs*
- **Supports thorough analysis of complex signals**
  - *Seamless integration with 89600 VSA software*

PXI Dual-Channel Wideband Gapless Data Capture

Problem:

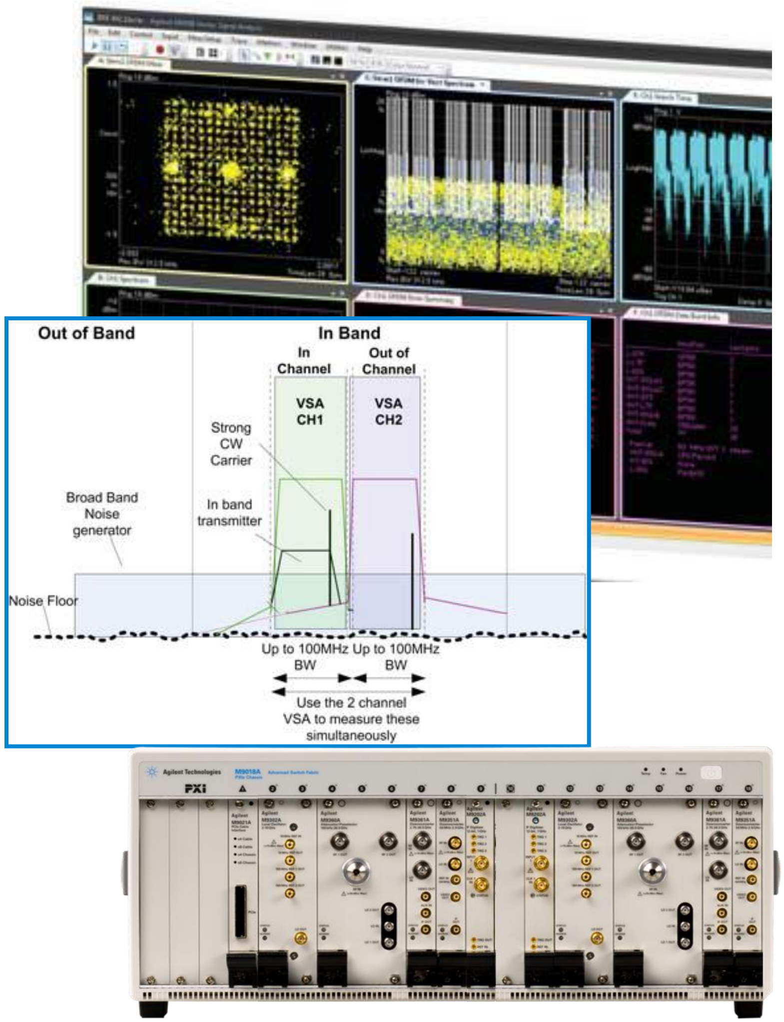
Need to make continuous wide bandwidth RF and microwave measurements in two different frequency spans over extended periods without signal loss

Solution:

Industry's **widest bandwidth dual channel** PXI Vector Signal Analyzer with continuous, gapless capture of RF/uW signals up to 100 MHz BW

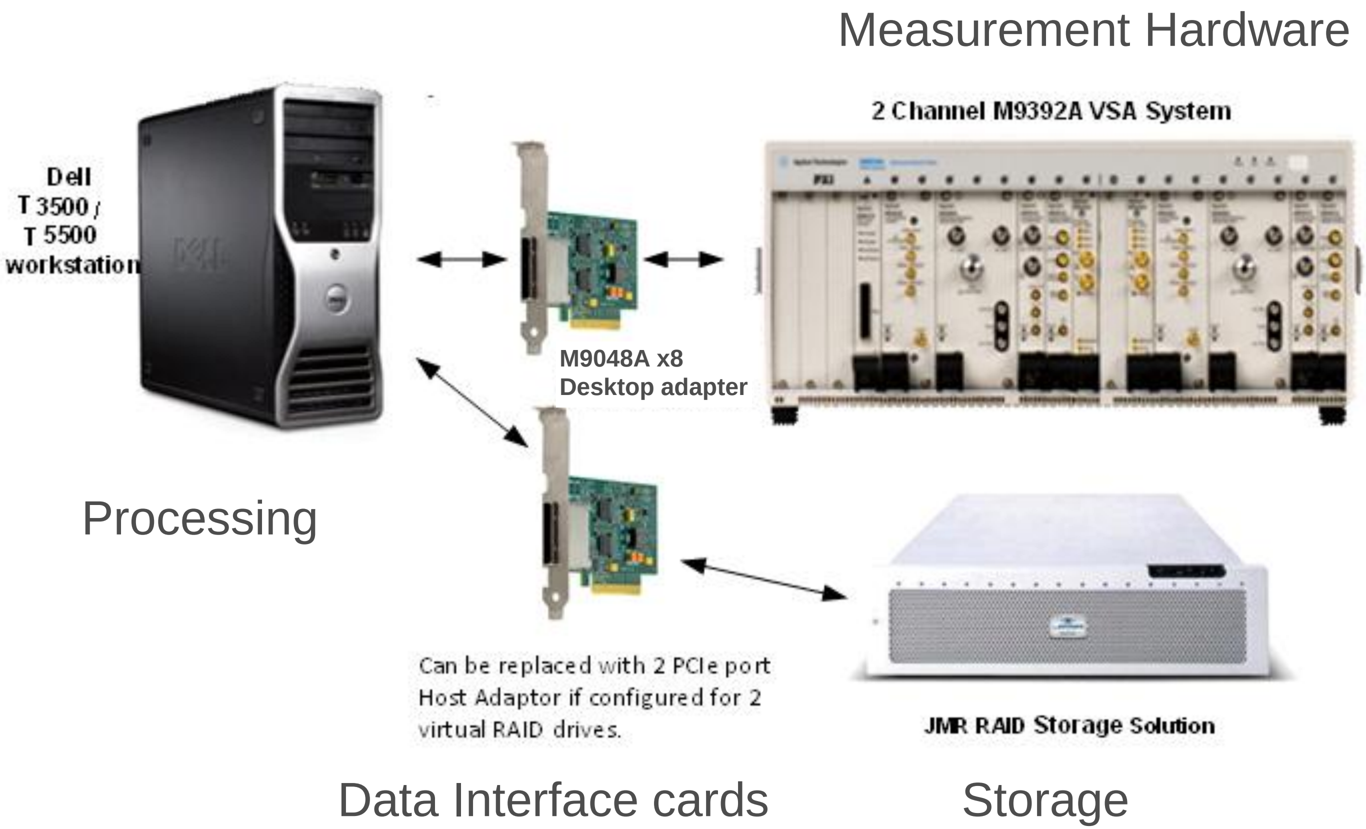
Benefits:

- Greater than **6 hours** of gapless capture of RF & Microwave signals on 2 channels
- Up to **2 synchronized channels** with **100 MHz BW** for environment recording
- Create coherent recordings using post processing technique
- Captured digitizer data format is open for customer analysis tools
- Small Form Factor – 2 channels in 1 chassis



www.agilent.com/find/pxi-vsa-dualchannel

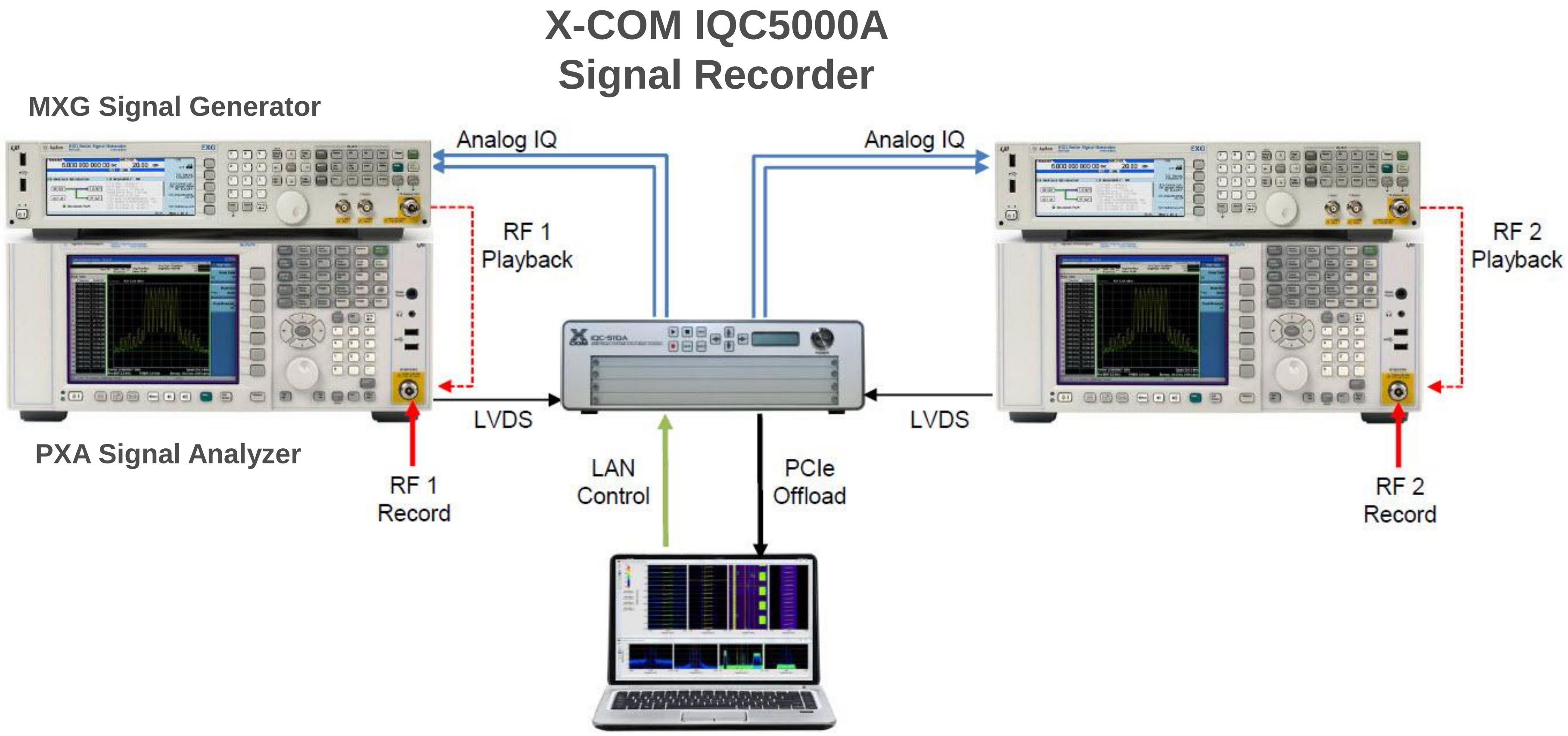
Gapless Recording Hardware Solution



- 2 x M9392A PXI VSA
- M9018A PXI Chassis
- M9021A Interface
- 10 MHz - 26.5 GHz
- 100 MHz Recording Bandwidth

- Single Controller / Dual Controller
- 8, 16, 32 TB

Agilent / X-COM Solution for Gapless Capture and Streaming Playback



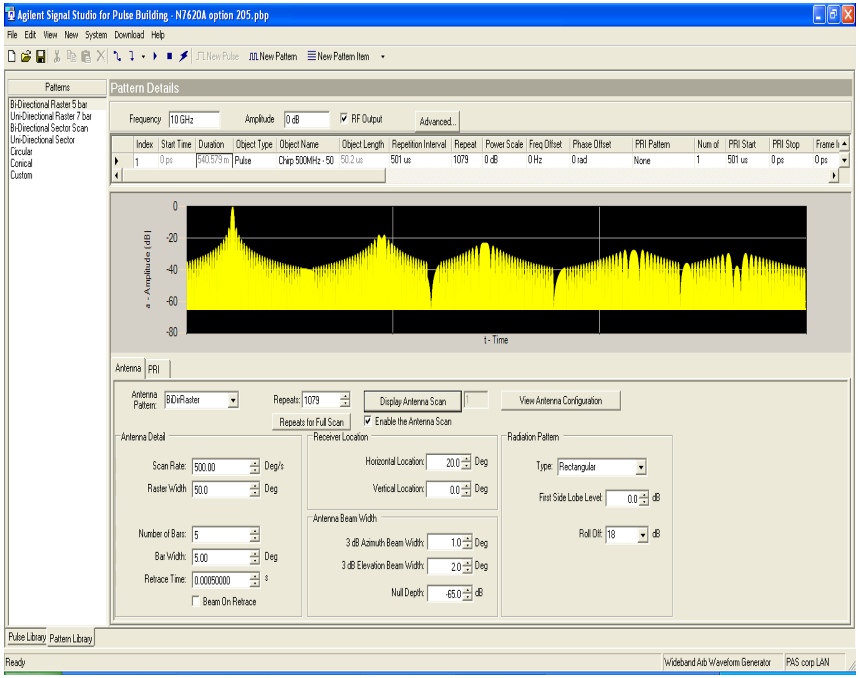
- Record and Playback 40 MHz through 50+ GHz
- Store over 20 hours at 40 MHz bandwidth

Agilent N7620B Signal Studio for Pulse Building Software

Signal Studio for Pulse Building

N7620B software Provides:

- A simple graphical user interface
- Pulse repetition interval patterns
- Pulse width timing patterns
- Modulation on pulse (MOP)
- Antenna radiation patterns
- Antenna scanning patterns
- Import and Export CSV files defining waveform generation.



Pulse Timing / Pattern Controls

Pulse Repetition Interval

- Constant (none)
- Gaussian Jitter
- Uniform Jitter
- U shaped Jitter
- Linear Ramp
- Stepped
- Staggered
- Bursted
- Saw tooth Wobbulation
- Sinusoidal Wobbulation
- Triangle Wobbulation

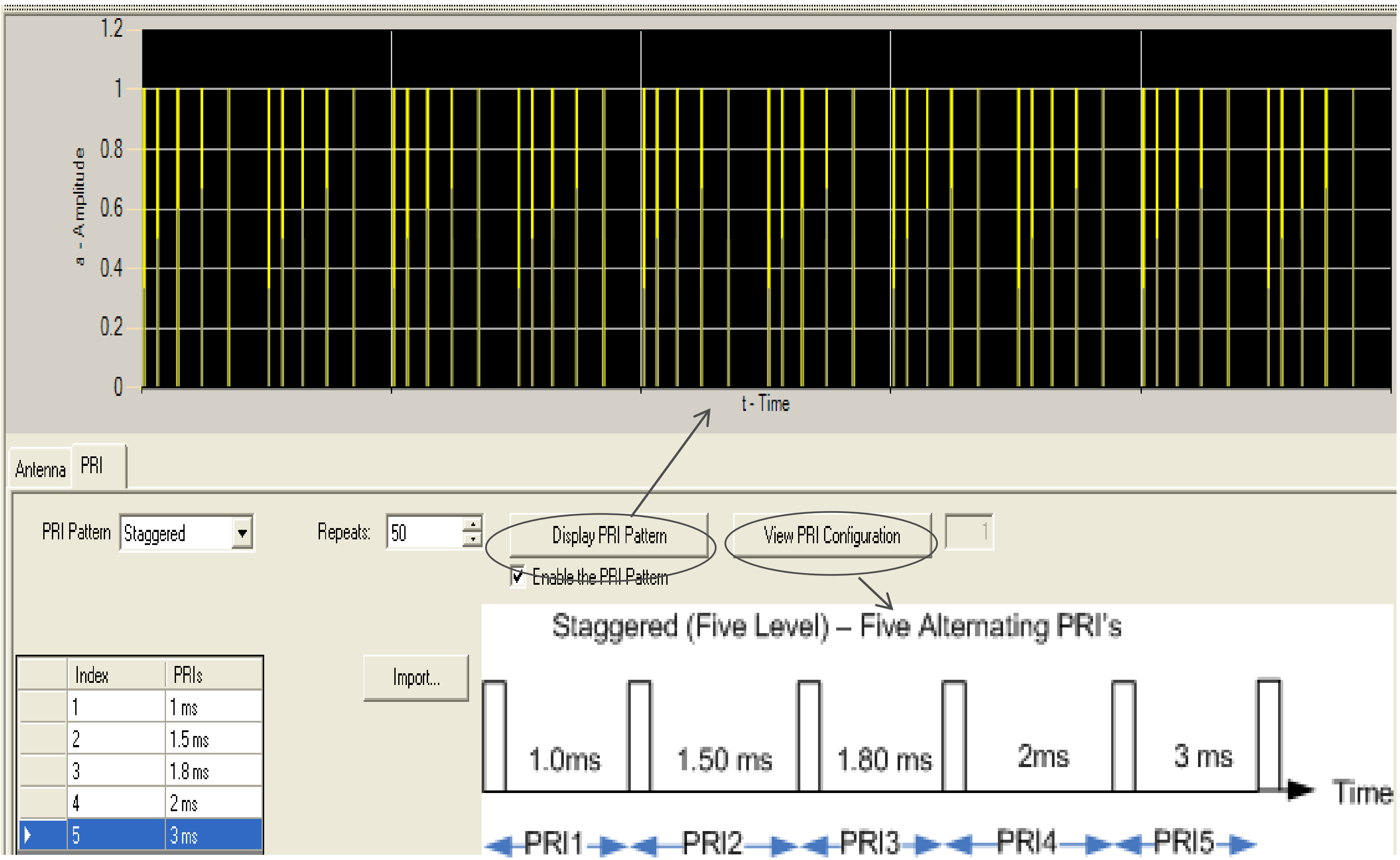
Pulse Width Patterns

- Constant
- Gaussian Jitter
- Uniform Jitter
- Linear Ramp
- Stepped

MOP

- Barker Code
- Frank Code
- Polyphase Codes
- FM Chirp
- User defined

Example of Staggered PRI



PRI
Time

Supported Antenna Parameters

Antenna Scanning Modes

- None
- Custom
- Circular
- Conical
- Bidirectional Sector
- Unidirectional Sector
- Bidirectional Raster
- Unidirectional Raster

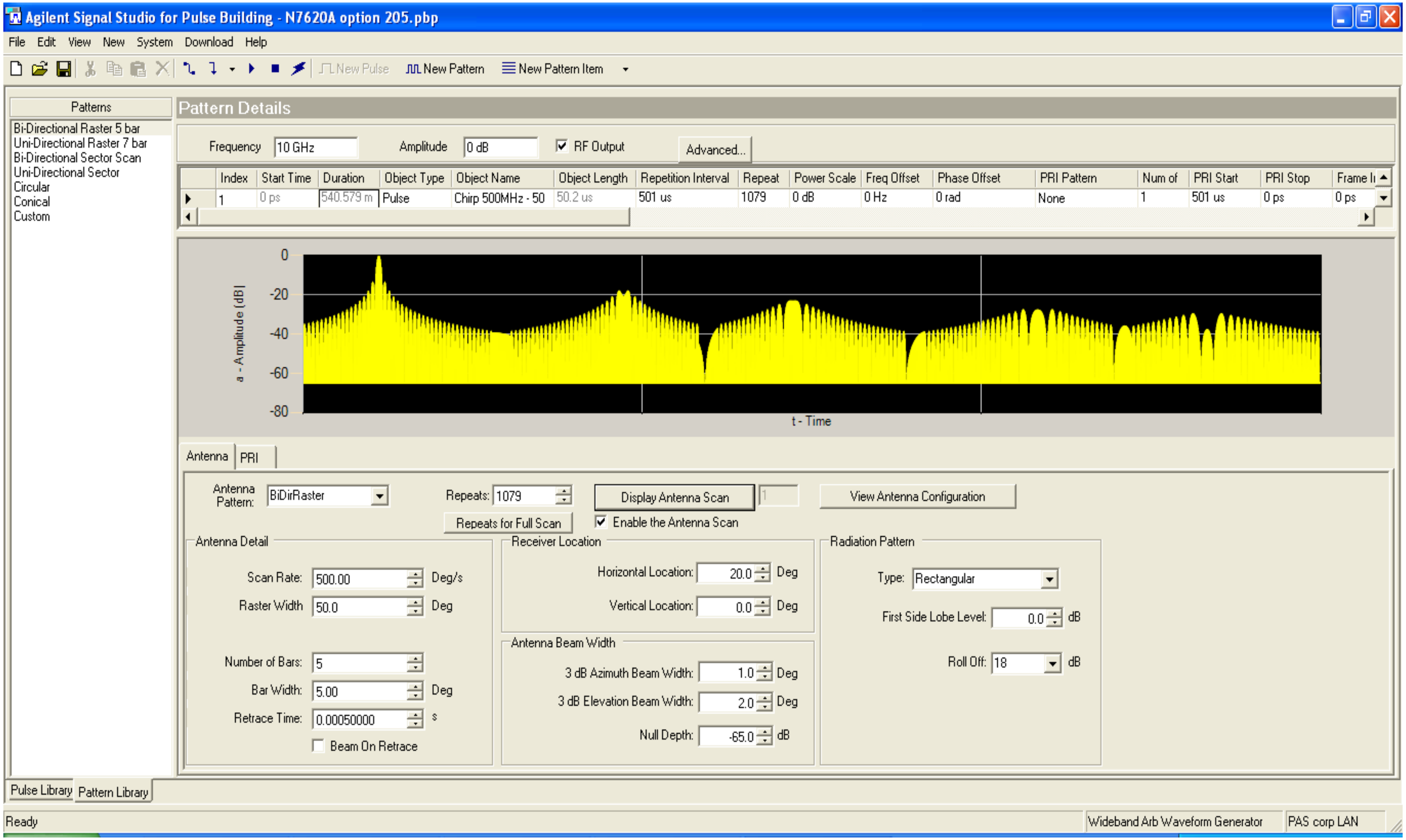
Antenna Properties

- Azimuth 3 dB Beam Width
- Elevation 3 dB Beam Width
- Null depth - dB

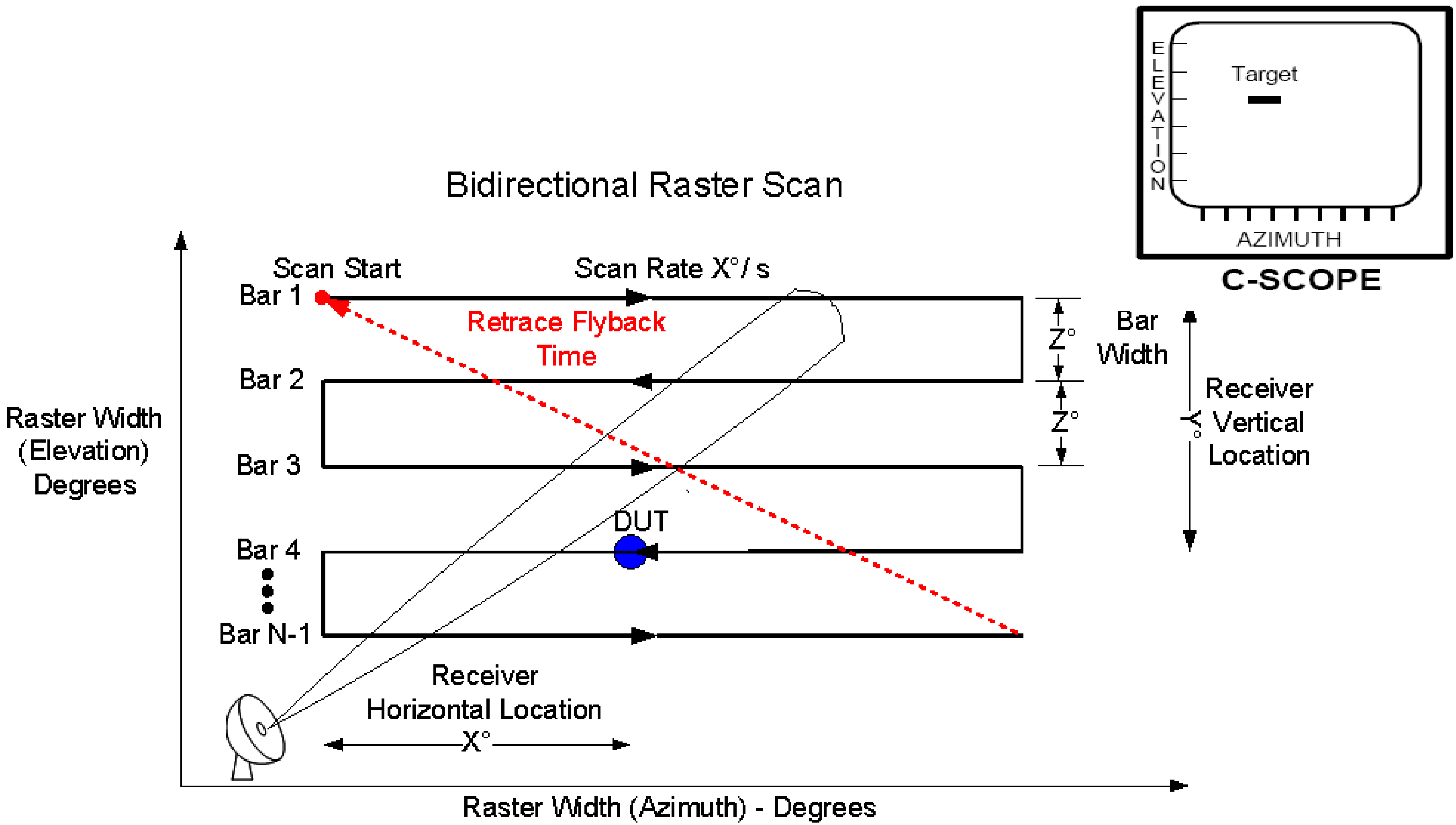
Antenna Radiation Patterns

- Blackman
- Hamming
- Hanning
- Rectangular
- 3 Term
- Cosine1
- Cosine2
- Cosine3
- Cosine4
- Cosine5
- Programmable

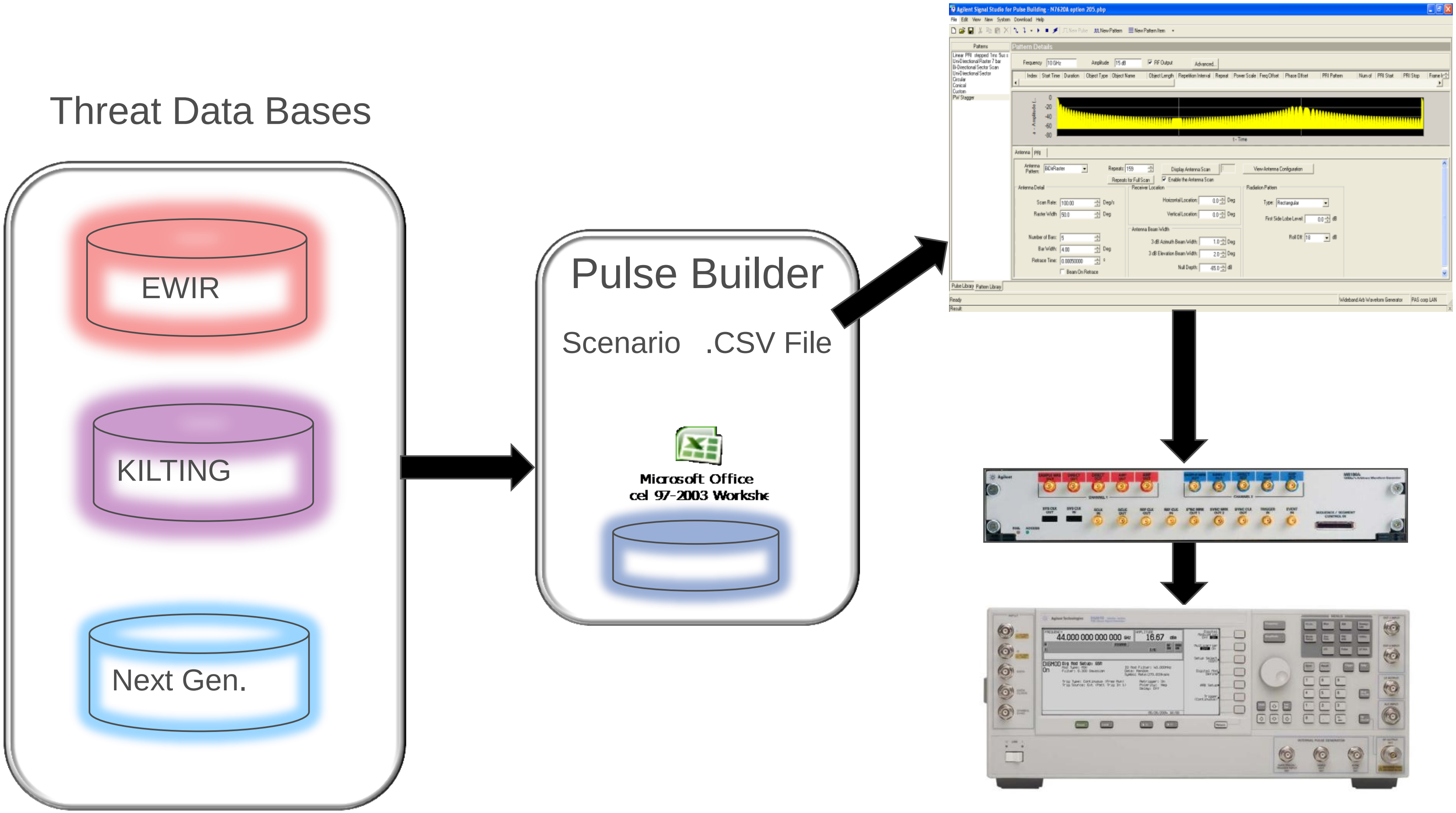
Example of Antenna Scan Patterns



Bidirectional Raster Antenna Scan



Scenario Data Base Import/Export



Scenario Data Base Import & Exporting

CSV – Comma Delimited File created in Excel

- Scenario Name
- Source Parameters
- Pulse Envelope properties – tr, tf, PW
- Pulse Width Patterns
- PRI Patterns
- Modulation on Pulse Properties – Chirp, Barker, FSK, etc
- Antenna Scanning Type
- Antenna Radiation Type
- Antenna Beam Width – AZ, EL
- Antenna Null Depth
- Receiver Location

End