



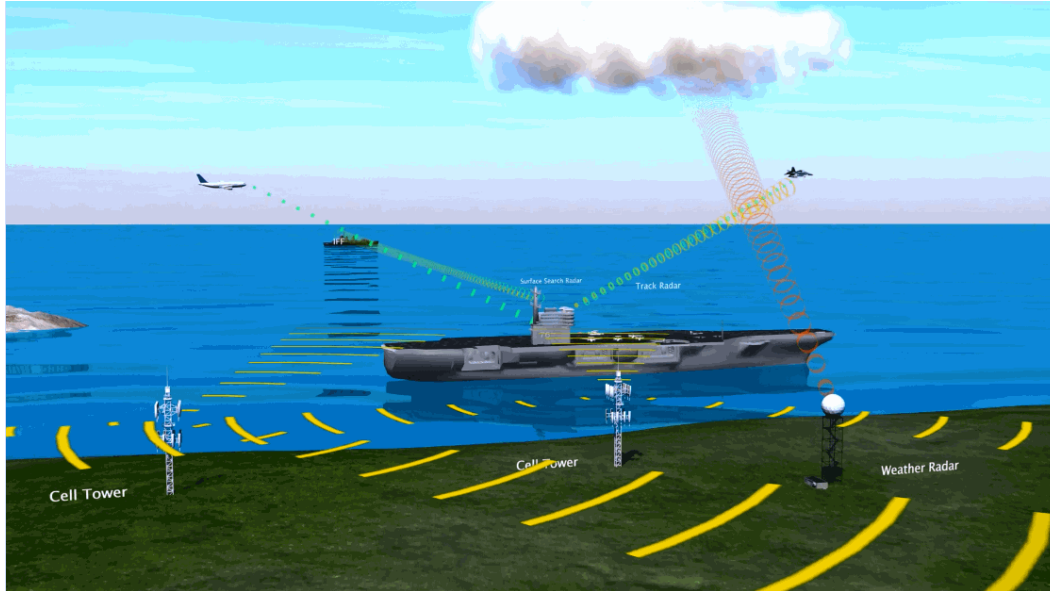
## ***Creating and Analyzing Multi-Emitter Environment Test Signals with COTS Equipment***

Gwang-Yeol You, Agilent Technologies



- Today's Cluttered Spectral Environment
- Creating Realistic Multi-Emitter Radar Test Signals
- Creating Realistic Multi-Emitter Radar and Communications Test Signals
- Evaluating Co-Existence Issues Between Radar and Wireless Signals

# Today's Cluttered Spectral Environment



Today's cluttered spectral environment:

- Spectrum is becoming increasingly crowded
- Signals are more complex and dynamic
- Challenging operating environment for systems

***This Highlights the Need to Test Hardware Under Realistic Signal Scenarios...***

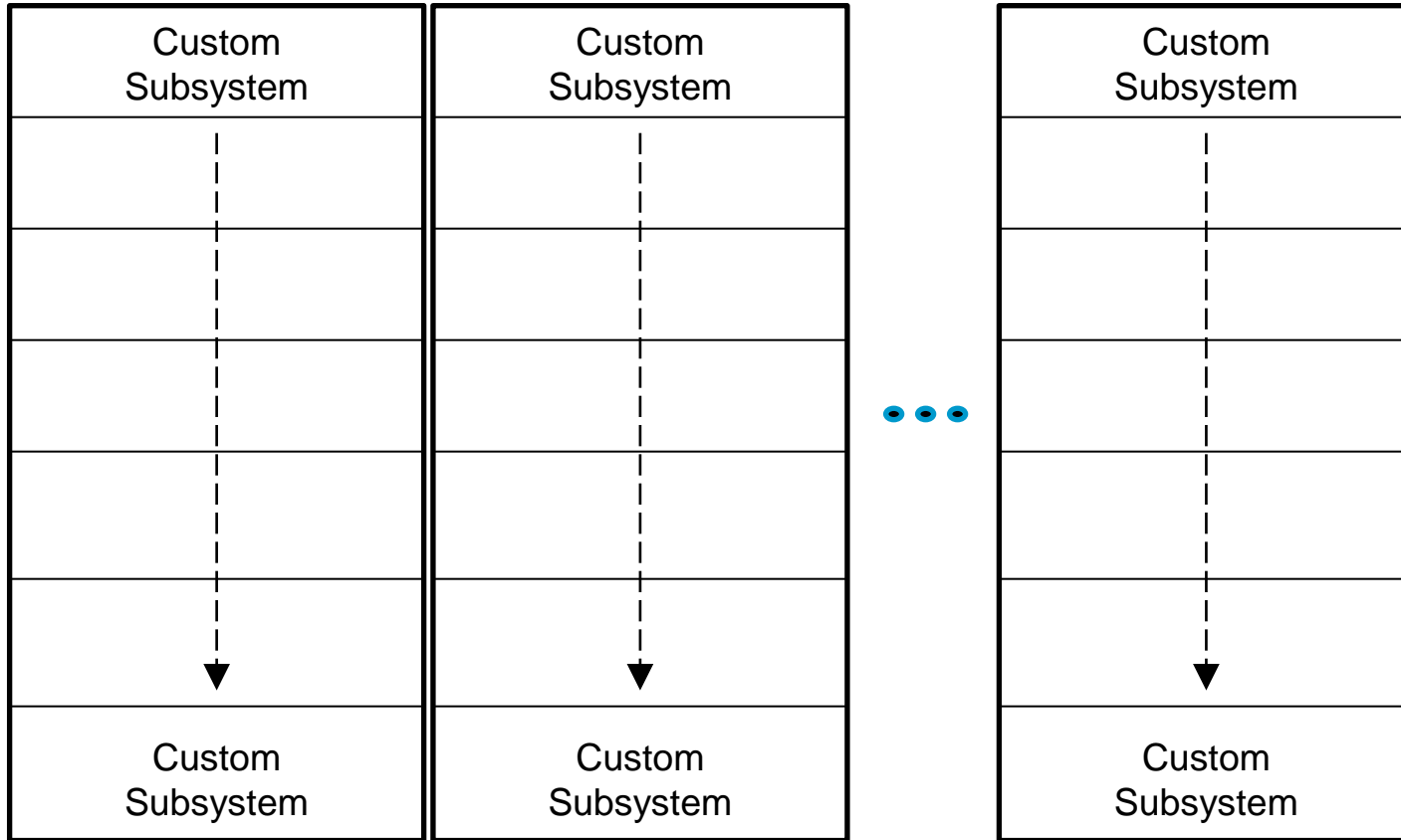
# Today's Approach to Generating Realistic Signal Scenarios



Equipment Rack 1

Equipment Rack 2

Equipment Rack N



Custom Test Equipment: \$\$\$

*What if Less Capability is Needed with a Lower Cost and Footprint for R&D Lab Testing?*

# Evaluating Hardware Under Realistic Signal Scenarios



- 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





- Today's Cluttered Spectral Environment
- Creating Realistic Multi-Emitter Radar Test Signals
- Creating Realistic Multi-Emitter Radar and Communications Test Signals
- Evaluating Co-Existence Issues Between Radar and Wireless Signals

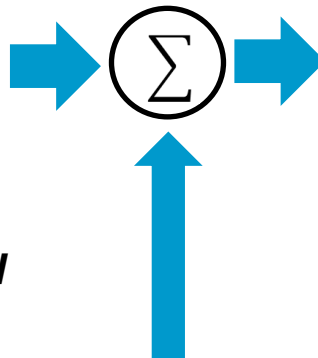
# Creating Multi-Emitter Waveforms with Simulation and High-Performance AWGs



**Agilent SystemVue  
Creates Emitters:**



Radar  
Wireless  
Others

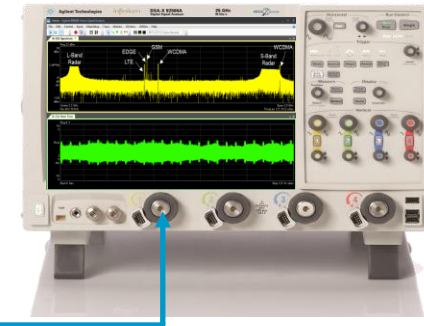


**M8190A AWG**



**PSG signal generator**

**Scope &  
89600 VSA**

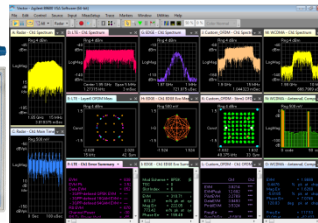
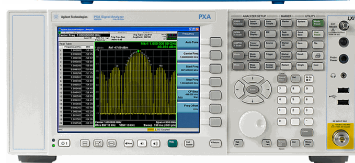


**Capture, Record, and  
Add Other Signals:**

**M9703A  
digitizer**



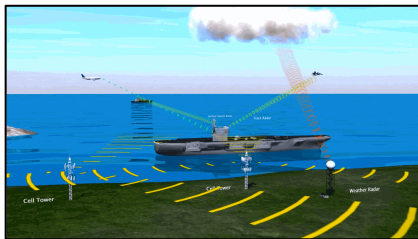
**PXA signal  
analyzer**



**RF In**



**89600 VSA  
software**



**Anticipate — Accelerate — Achieve**



**Agilent Technologies**

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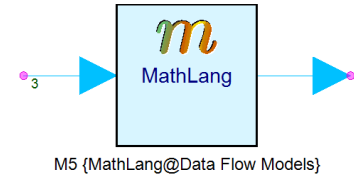
# Creating Waveforms in SystemVue



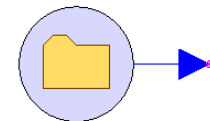
## SystemVue “Add-on” Libraries:

| 3G/4G MOBILITY  | NETWORKING  |
|---|---|
| LTE-Advanced (Rel 10)<br>LTE (Rel 8,9)<br>WCDMA, HSDPA, HSUPA<br>CDMA, CDMA2000 | WiMAX / 802.15e<br>WLAN /802.11abgn/ac/ad<br><i>Custom OFDM*</i>  |
| LOCAL CONNECTIVITY  | BROADCAST & SATCOMM   |
| WPAN / 802.15.3c<br>802.11ad<br>Zigbee* / 802.15.4                              | DVB-S2/T2<br>ISDB-T<br>GNSS<br><i>general Digital Modulation*</i> |
| * available with W1461BP<br>core environment                                    | DEFENSE   |
|   | RADAR: PD, UWB, FMCW,<br>SAR, DAR, SFR, MIMO,<br>Phased Array     |

## In addition:

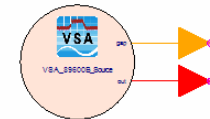


Math-based



File='Myfile.txt'  
Periodic=YES

Read IQ data files



VSA Title='Simulation output'  
OutputType=Timed (Envelope/Real Baseband...)  
VSATrace=B

Capture signals from  
test equipment



# Combine Emitters in SystemVue and Download to High-Performance AWG



## Emitter #1

- Center frequency =  $F_{c1}$
- Bandwidth = BW 1
- Sample rate = SR 1

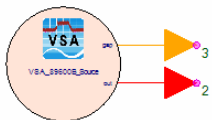
## Emitter #2

- Center frequency =  $F_{c2}$
- Bandwidth = BW 2
- Sample rate = SR 2



## Emitter #N

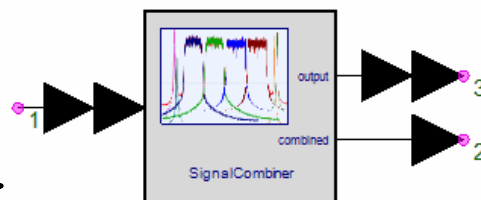
- Center frequency =  $F_{cN}$
- Bandwidth = BW N
- Sample rate = SR N



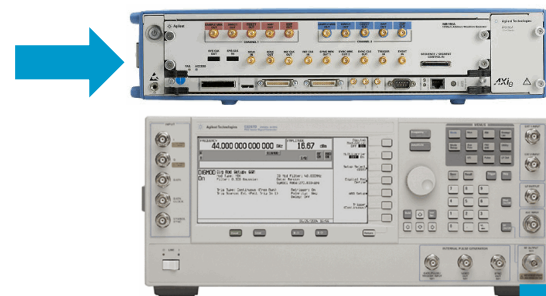
V1 {VSA\_89600B\_Source@Data Flow Models}  
 VSATitle=Simulation output  
 OutputType=Timed (Envelope/Real Baseband)  
 VSATrace=B

Capture signals from  
test equipment

## “SignalCombiner” Element

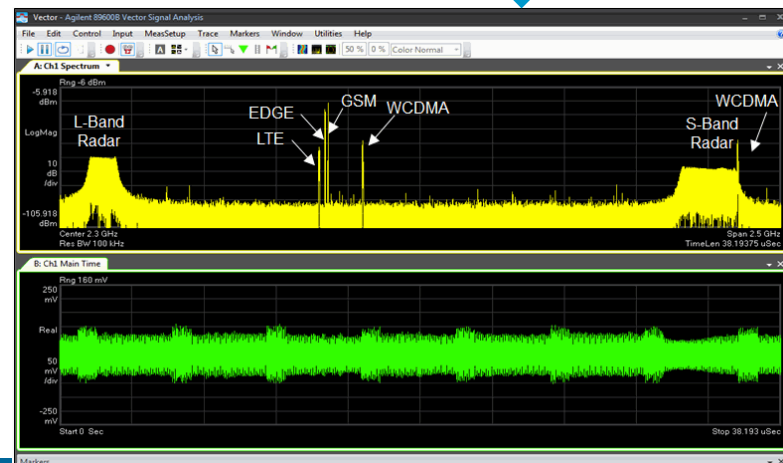


**Multi-emitter output:**  
 Output center frequency  
 Output sample rate



M8190A  
AWG

PSG signal  
generator

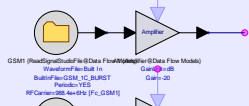


# SystemVue "SignalCombiner"

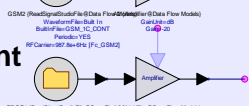
*Validate system performance, receiver algorithms*



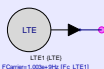
Stored I,Q  
Waveform  
Files



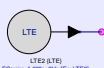
Measurement  
Data



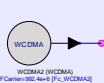
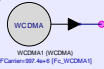
Active  
Subnetworks



User IP  
(.m, C++, HDL)

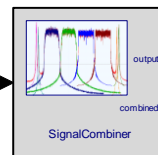


Standards  
IP reference  
libraries



Simulation based  
re-sampling and  
signal combining

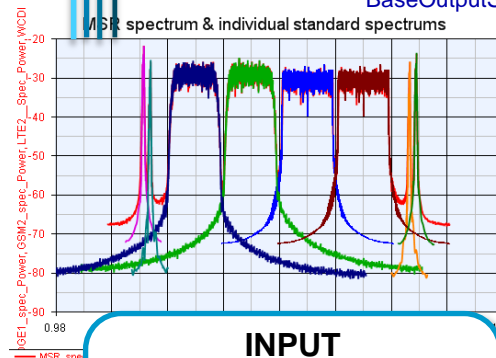
SignalCombiner



S1 {SignalCombiner@Data Flow Models}  
SampleRate=15.36e+6;15.36e+6;30.72e+6;30.72e+6;3... [SampleRates]  
Fc=1.003e+9;1.008e+9;997.4e+6;992.4e+6;9... [Fcs]  
Bandwidth=5e+6;5e+6;5e+6;5e+6;600000;600000;600... [Bandwidths]  
OutputFc=1e9  
OutputSampleRateOption=Auto  
BaseOutputSampleRate=15.36e6

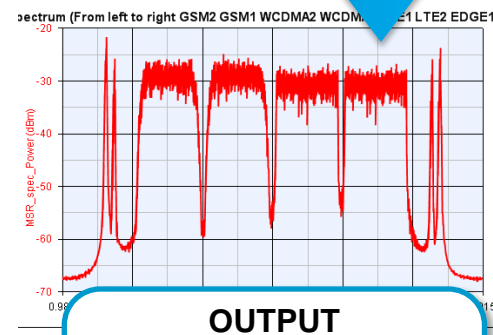
## APPLICATIONS

- 3GPP Rel 9 MSR
- Interferer Studies
- Cognitive Radio
- RX Verification
  - Desensitization
  - Cross-modulation
  - ADC/AGC range
  - Selectivity
- Download to Test



### INPUT

- Multiple inputs
- Different sample rates
- Nearby carrier freqs
- Individual amplitudes



### OUTPUT

- Single sample rate
- Single carrier freq
- Time-aligned
- Composite crest factor

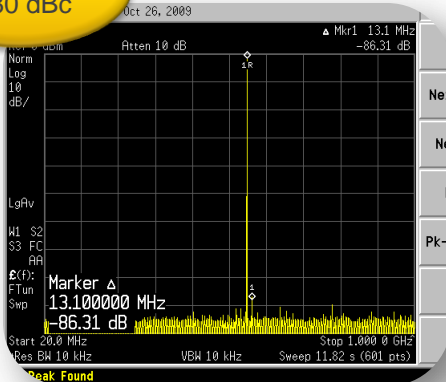


# Agilent M8190A Arbitrary Waveform Generator

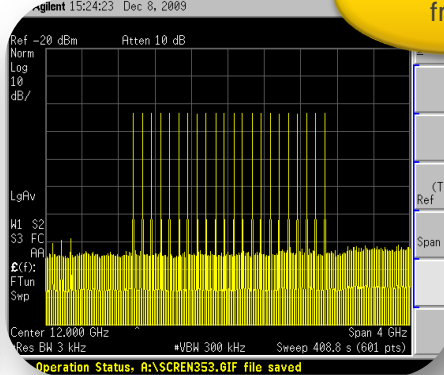


Up to  
-80 dBc

**Best signal quality**



Distortion-free



## M8190A

- 14 bit 8 GSa/s and 12 bit 12 GSa/s mode
- 2 GSa memory for long playtime
- 5 GHz analog bandwidth
- Signals up to 5 – 7 GHz in doublet mode

Baseband

&

Up-converted

## Digital Up-Conversion

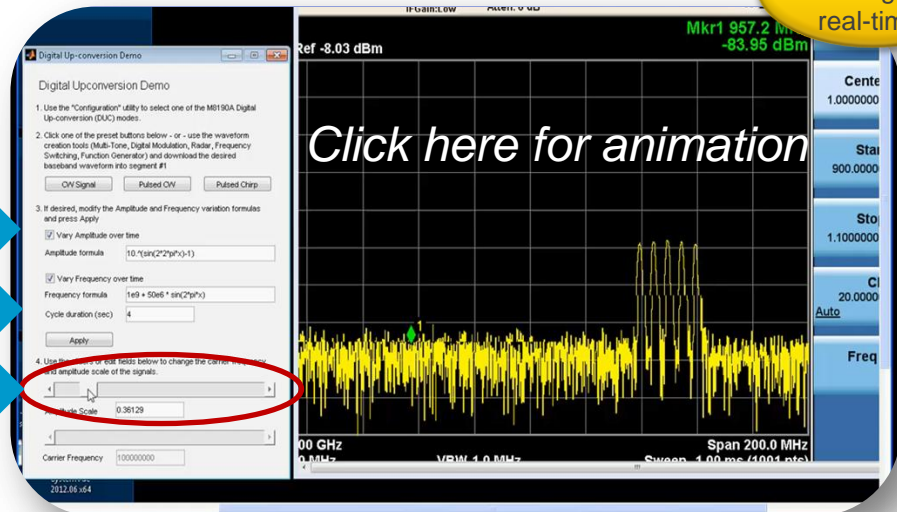
- Real-time signal processing in Agilent's proprietary ASIC. Sequence mechanism stays the same
- Change Waveform parameters such as frequency, amplitude & phase on the fly without re-loading new waveforms
- Better frequency resolution (< 1 nHz)
- Longer playtime for repetitive waveforms, optimized setup

Parameters

Phase

Frequency

Amplitude



Parameter changes real-time!



# Agilent M9703A High-Speed Digitizer



***Reduce the test time of your DUT with the new M9703A!  
Higher number of synchronous acquisition channels, wider signal capture with the  
best accuracy and flexibility, and optimized throughput***



**AXIe**



## 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 3dB 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)

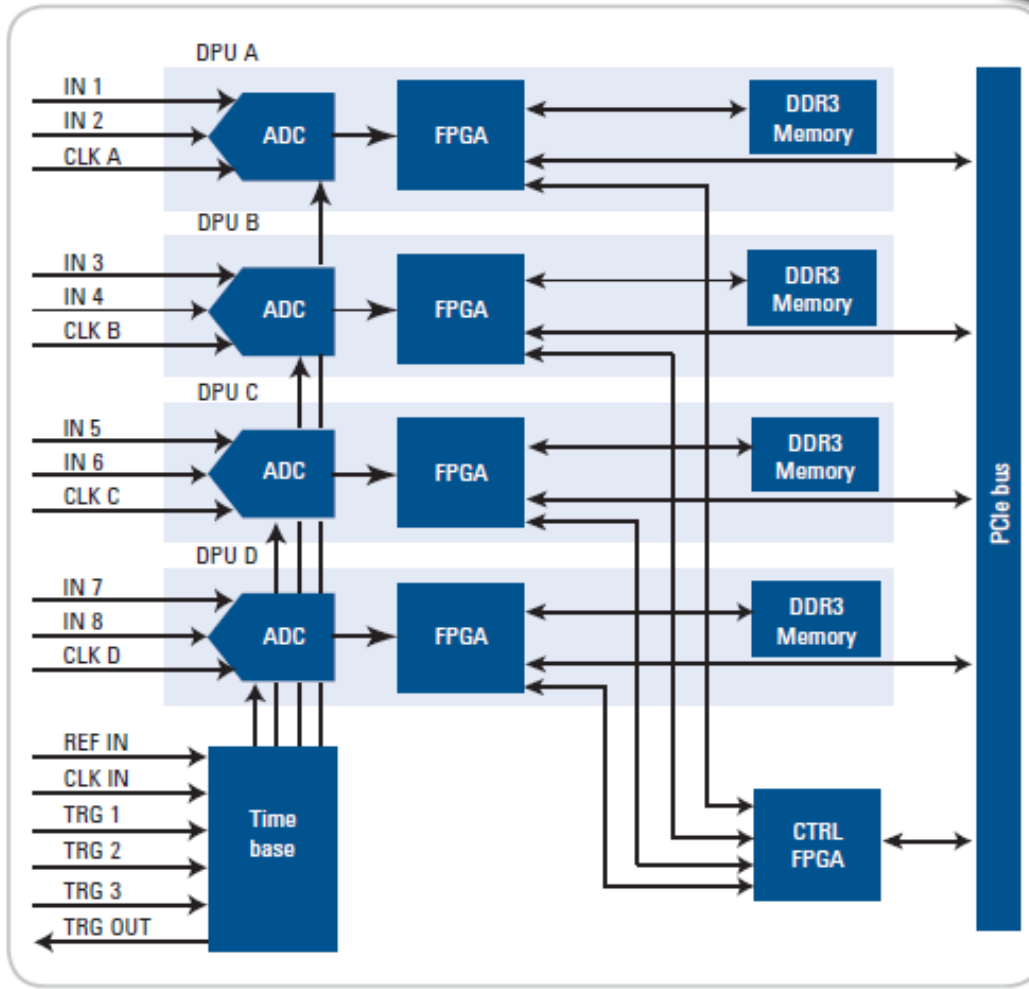
## OTS application software

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





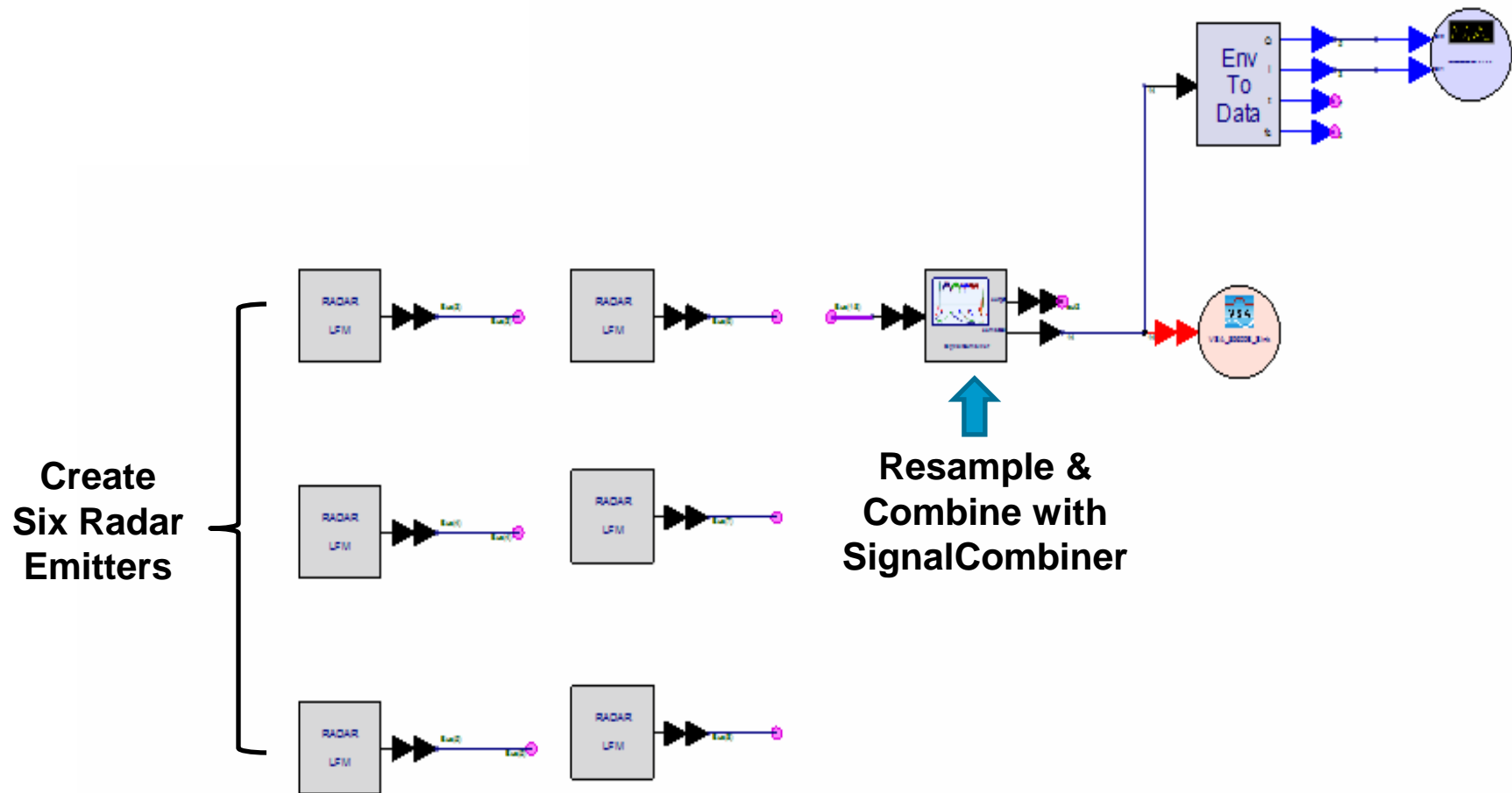
# M9703A High-Speed Digitizer



- ❑ 8 channels digitizer
- ❑ 12-bits ADC
- ❑ 1.6 GSa/s
- ❑ DC to 2 GHz
- ❑ 4 Ch BBIQ measurement

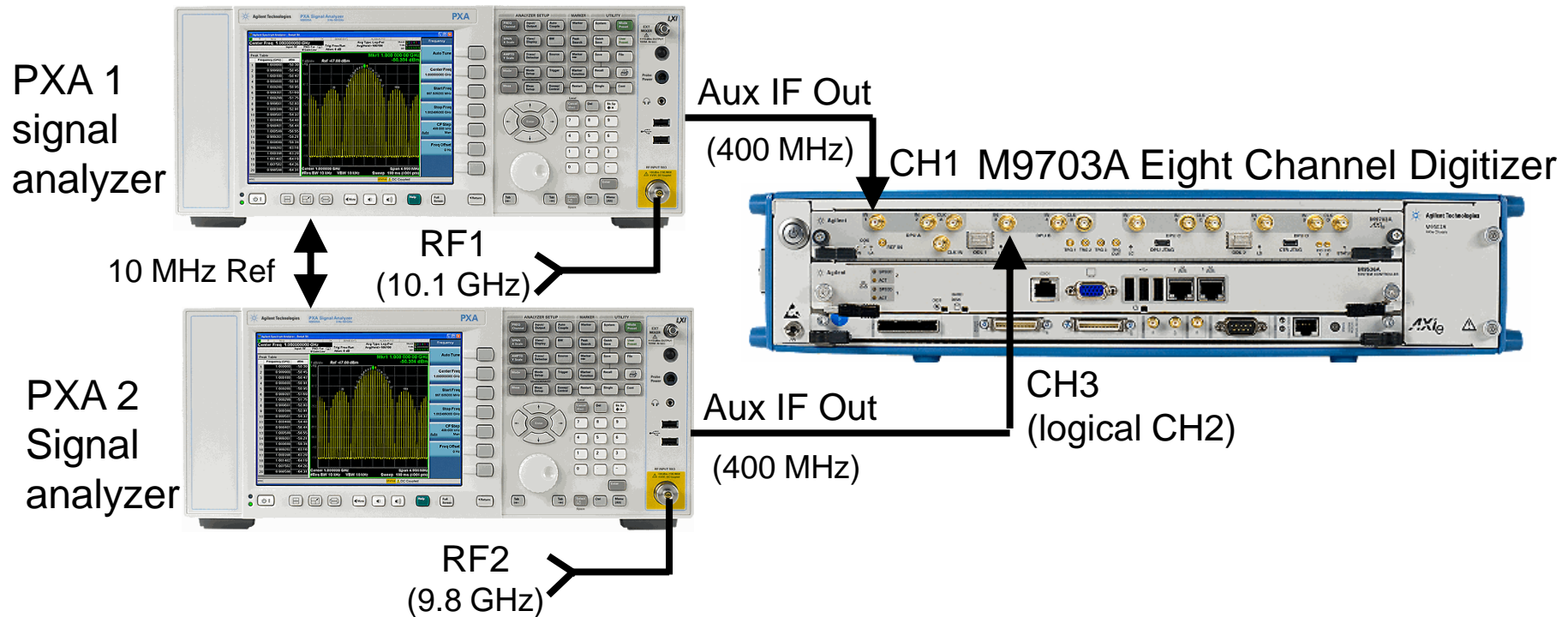


# Create Radar Emitters in SystemVue



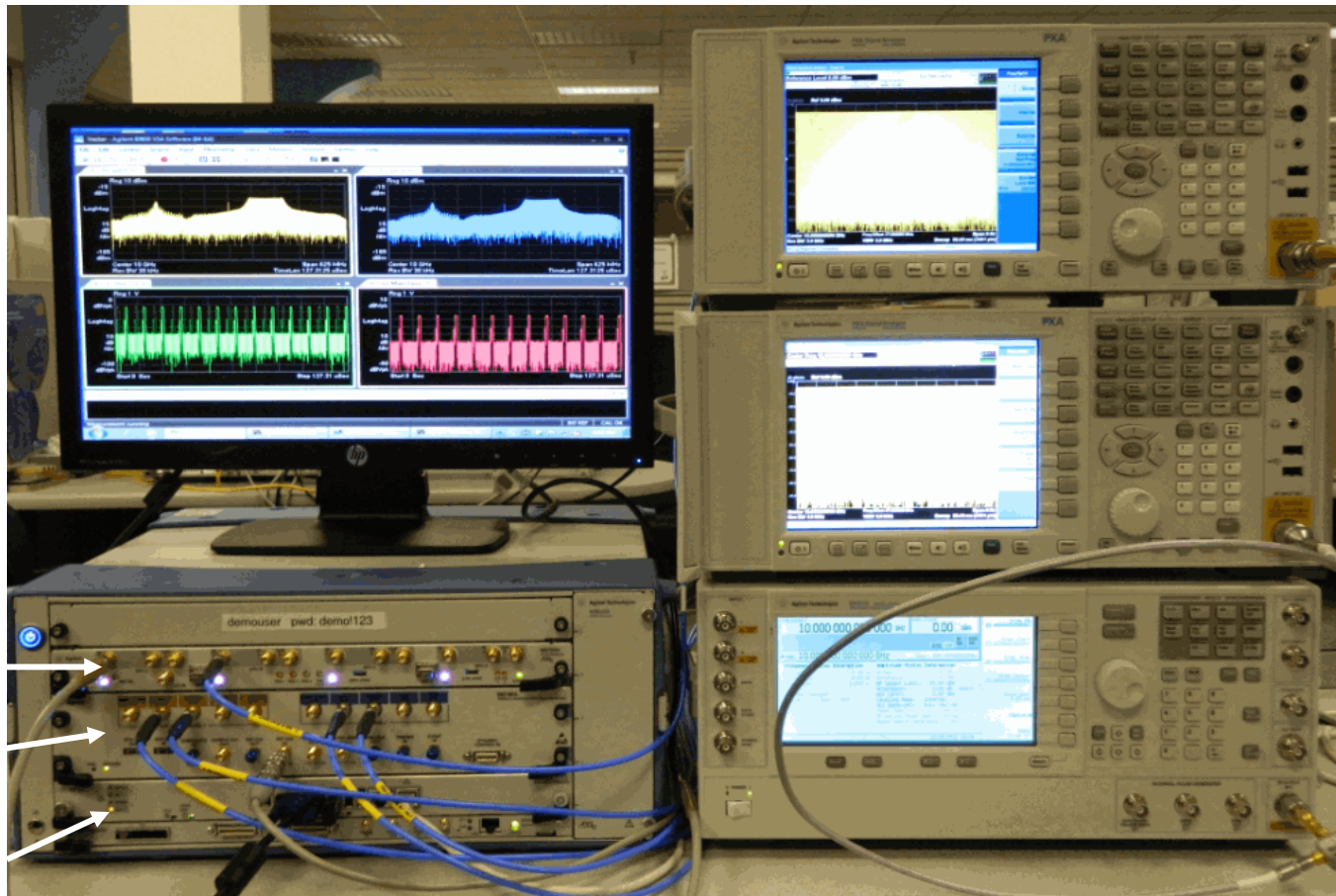
***Now let's also add some test signal emitters which have been captured from test equipment....***

# Connection Diagram for Test Setup to Capture and Record Signals to Add to Simulated Emitters(X-Band)





# Picture of Capture/Playback Test Setup



PXA 1  
(Down-  
converter)

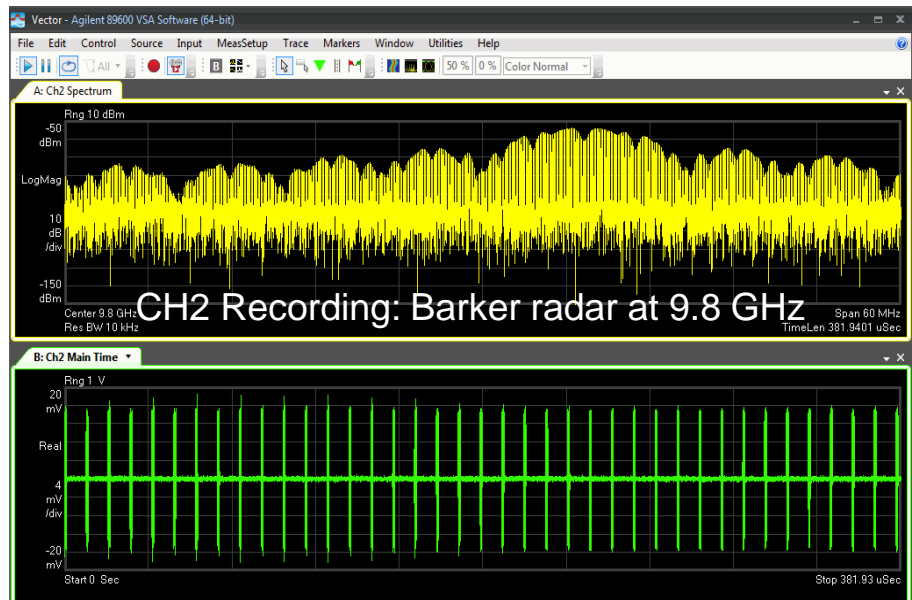
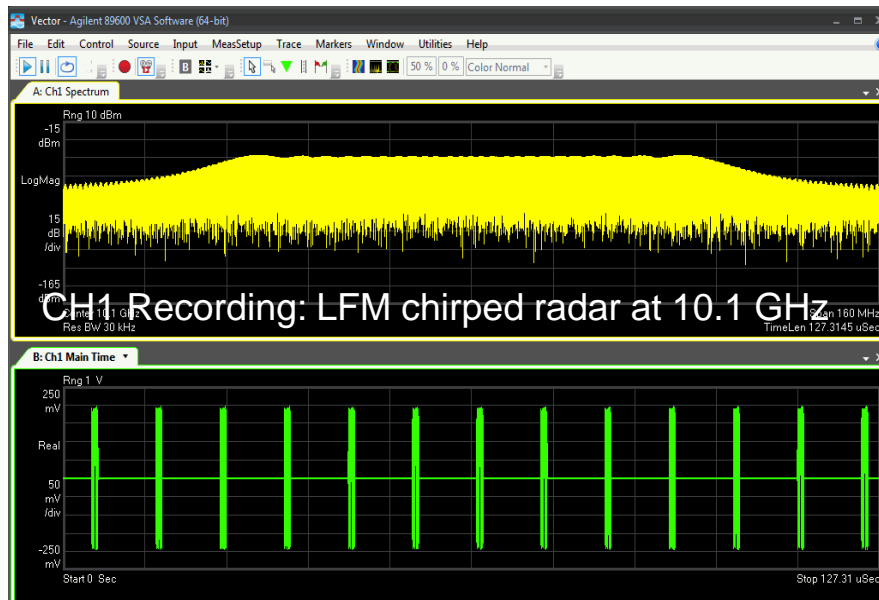
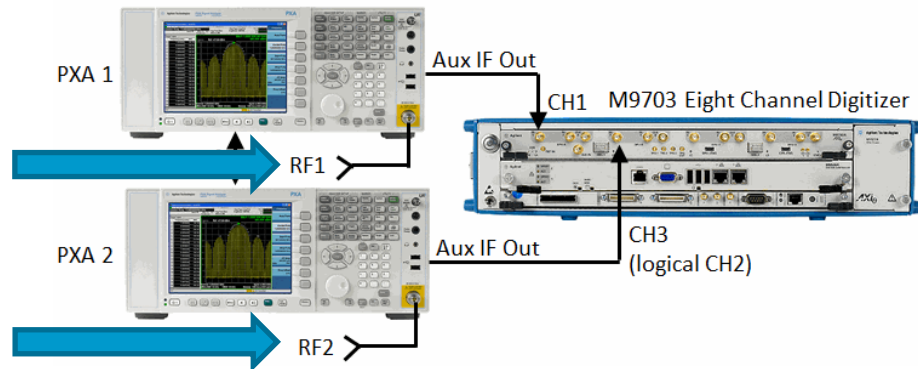
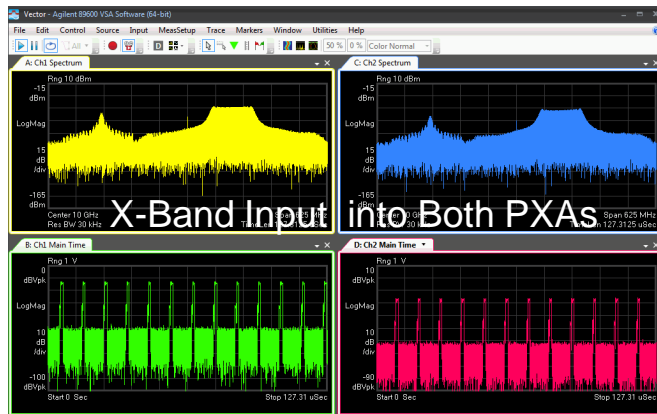
PXA 2  
(Down-  
converter)

PSG  
(Test  
Signal)

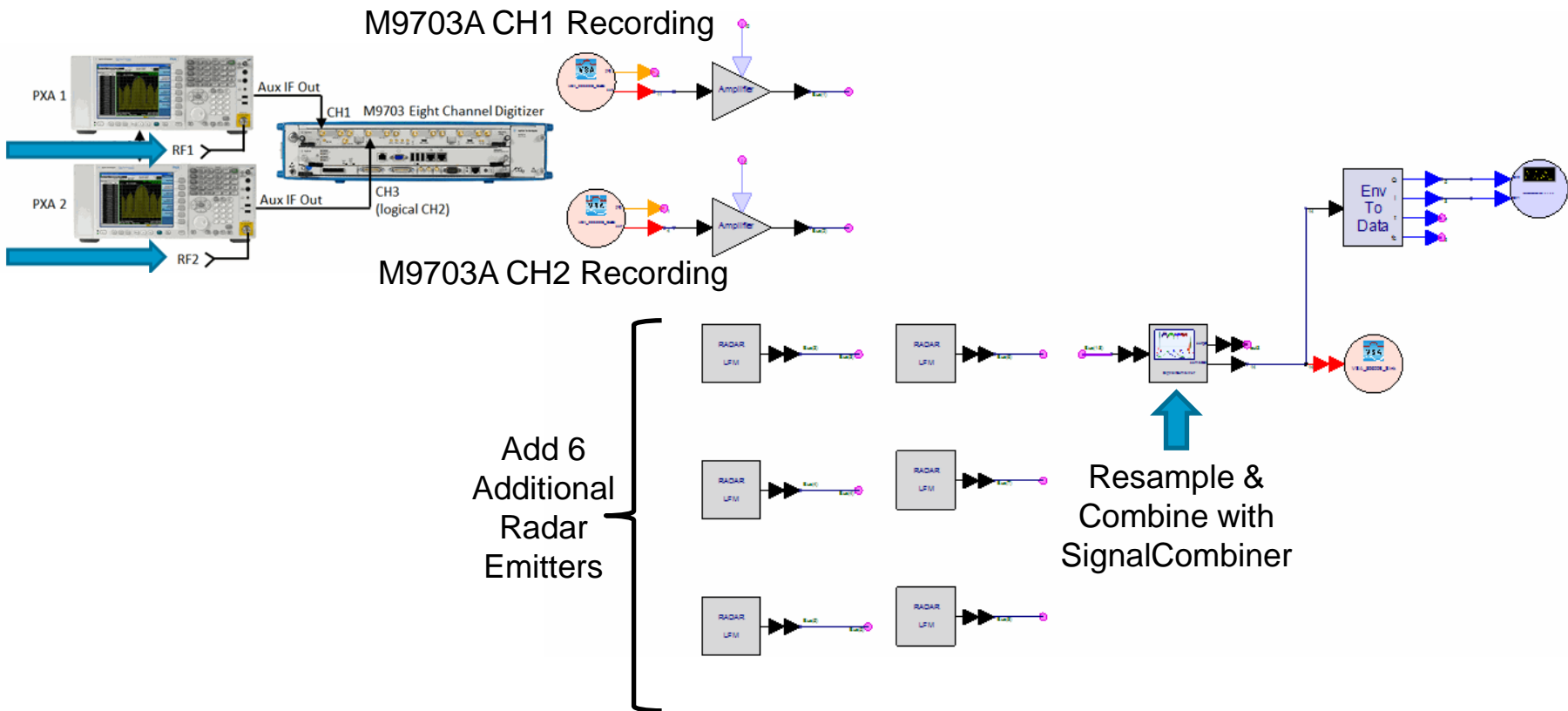
M9703A multi-  
channel digitizer  
M8190A multi-  
channel AWG

SystemVue  
(installed on  
controller)

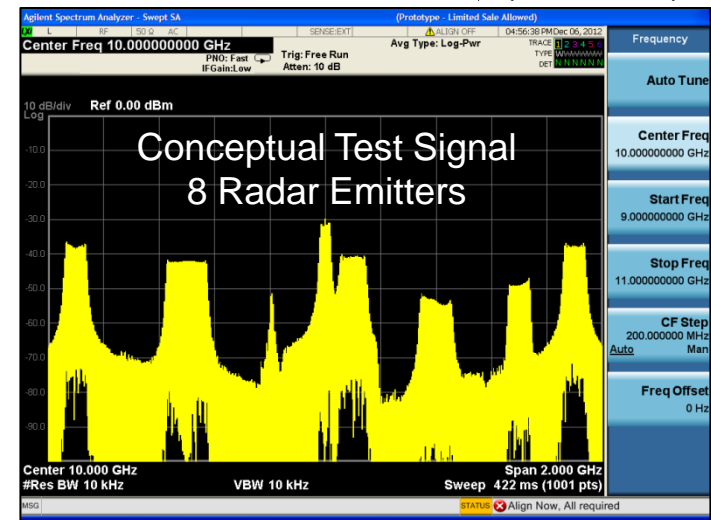
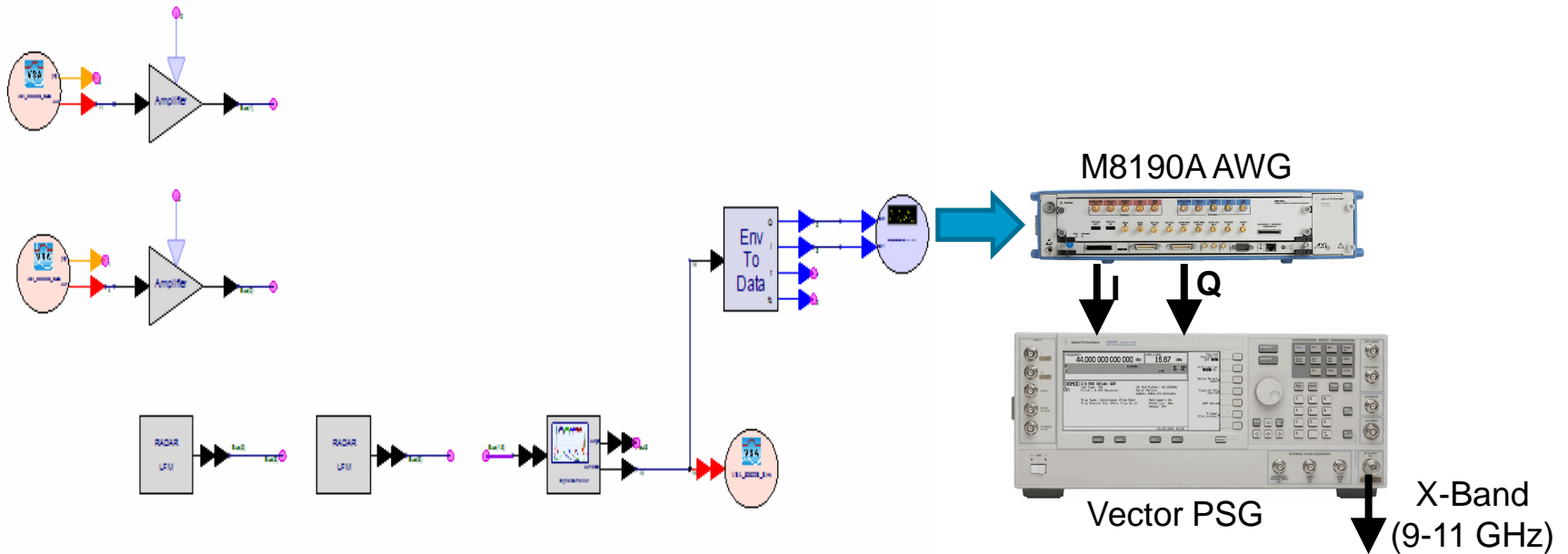
# Capture Two X-Band Signals with PXAs and M9703A Multi-Channel Digitizer



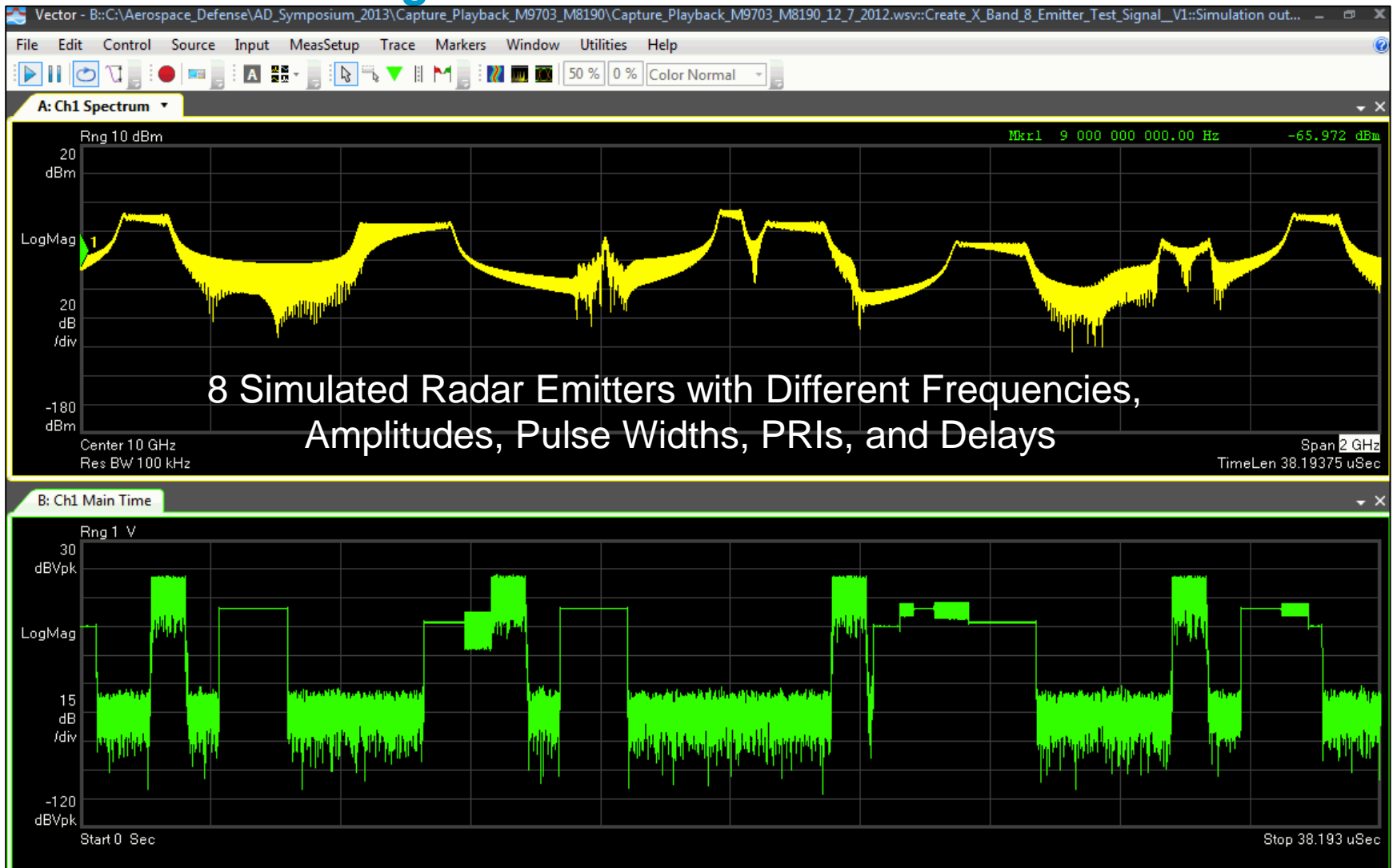
# Add M9703A Captured Recordings to SystemVue-Created Emitters: 8 Emitters



# Download 8 Emitters Test Signal to M8190A



# Conceptual Test Signal: Simulated 8 Emitter Waveform in SystemVue Before Downloading to M8190A AWG



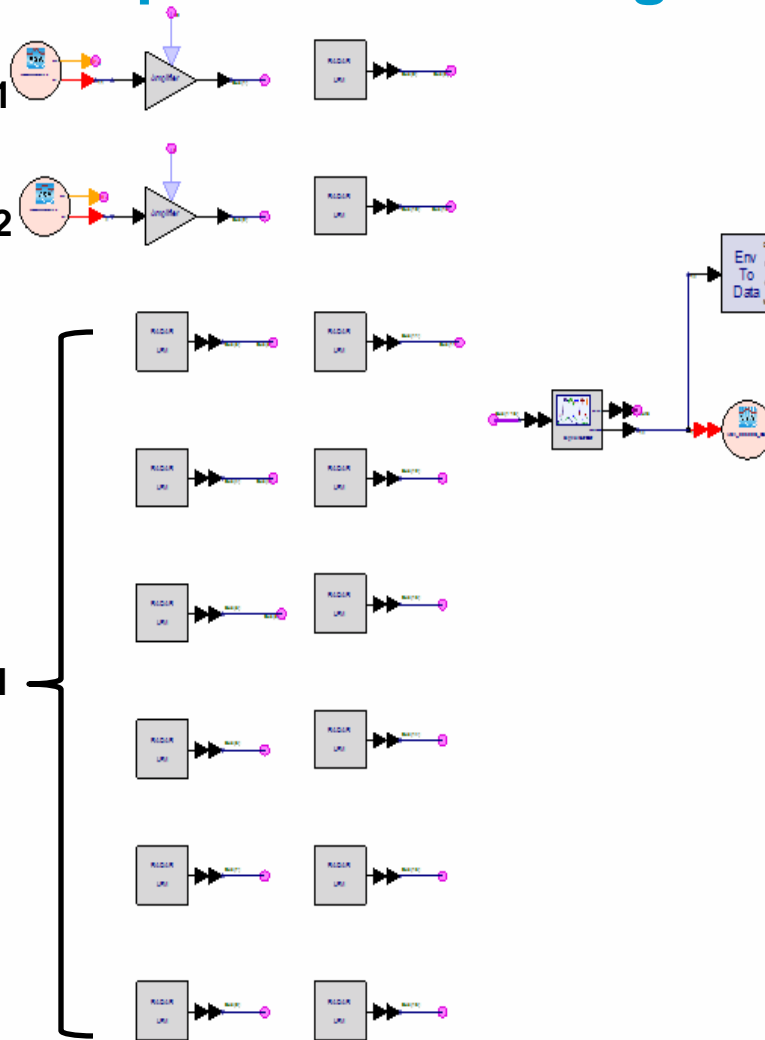
# Add Additional Emitters in SystemVue to M9703A Captured Recordings: 16 Emitters



M9703A CH1  
Recording

M9703A CH2  
Recording

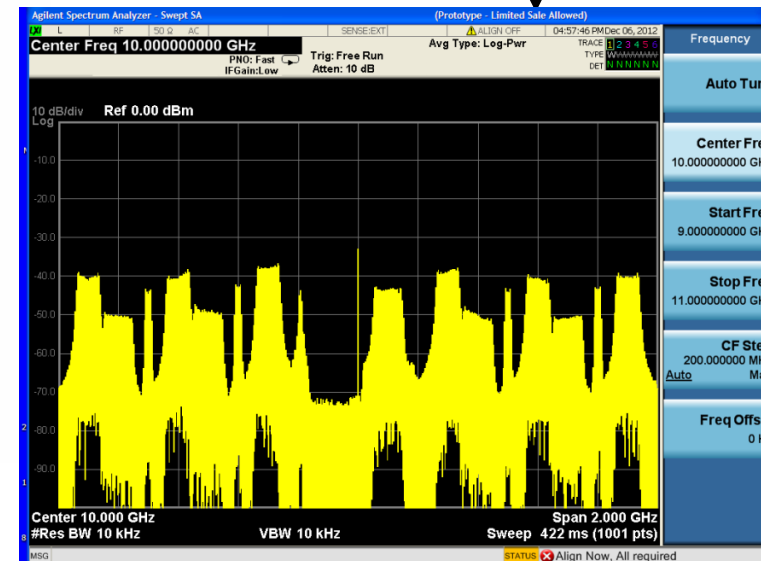
Add 14  
Additional  
Radar  
Emitters



M8190A AWG

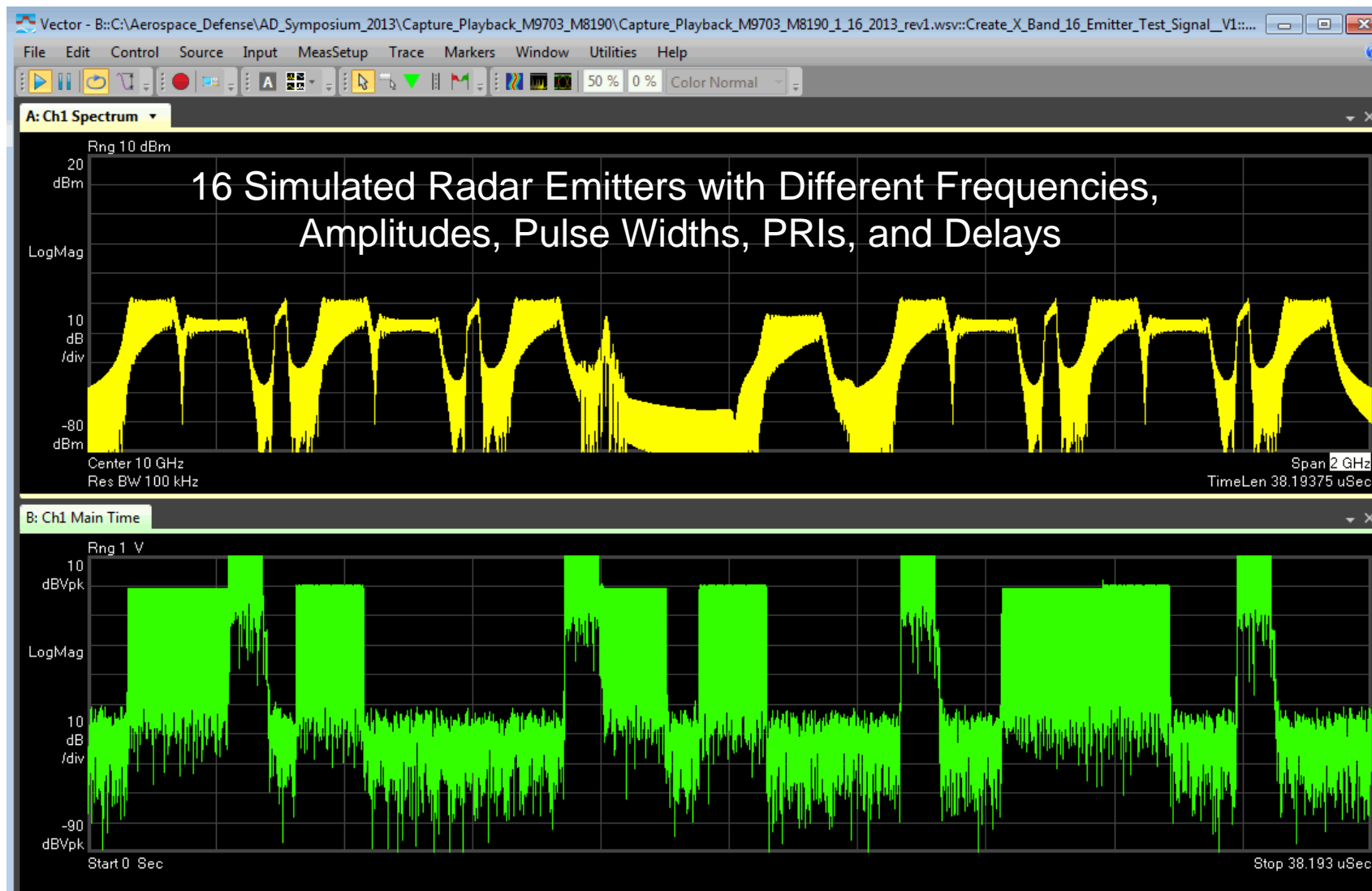


X-Band  
(9-11 GHz)





# Conceptual Test Signal: Simulated 16 Emitter Waveform in SystemVue





# Considerations



- M9703A digitizer capture: 256 Msa/ch memory
- M8190A AWG playback: 2 GSa/ch memory
- Simulation-time: not real-time
- Dynamic range versus the number of emitters
- Others...





- Today's Cluttered Spectral Environment
- Creating Realistic Multi-Emitter Radar Test Signals
- **Creating Realistic Multi-Emitter Radar and Communications Test Signals**
- Evaluating Co-Existence Issues Between Radar and Wireless Signals



# Evaluating Hardware Under Realistic Signal Scenarios for EW



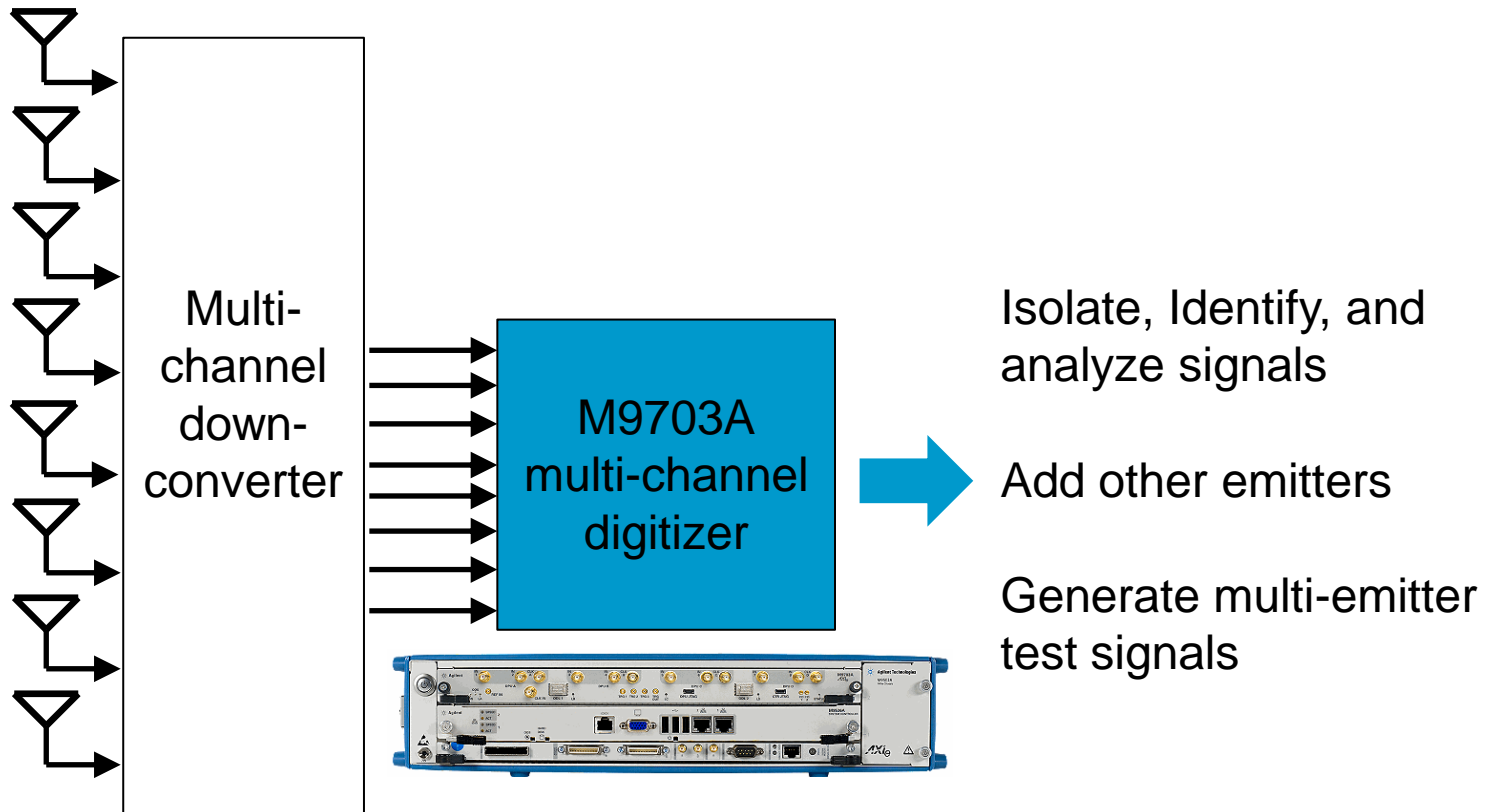
- Today's cluttered spectral environment may contain many sources of interference:

Wireless infrastructure, military assets, radars, EW, other..

- May need to capture offending signals in the actual environment
- May need to generate mixed radar and communications signals to evaluate hardware under different scenarios



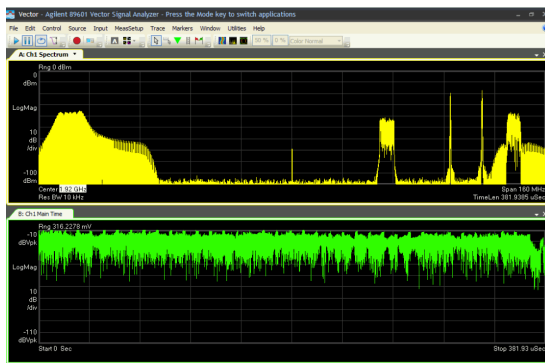
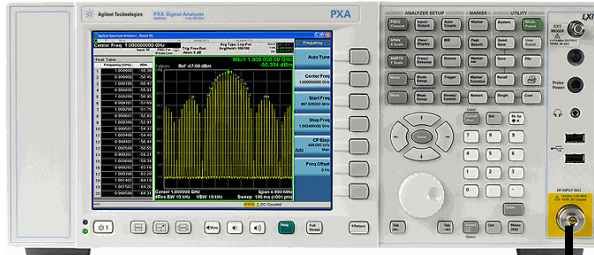
# Multi-Channel Capture



# Capture 5 IF Channels with M9703A



PXA



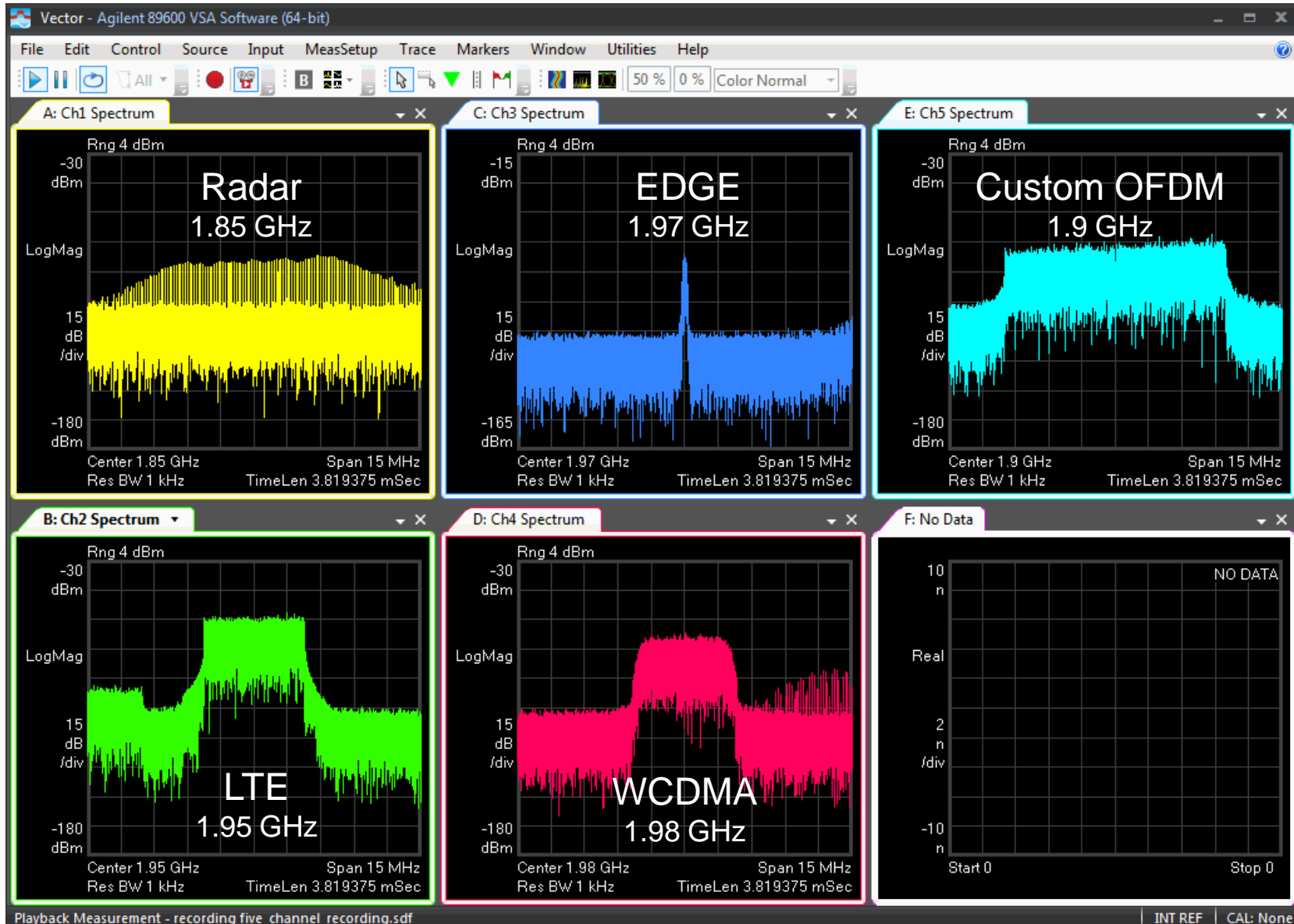
Spectral environment to  
be captured

IF is split into 5 outputs  
Aux IF Out



M9703A eight channel digitizer

# 5 Channel IF Signal Captured with M9703A



Anticipate — Accelerate — Achieve

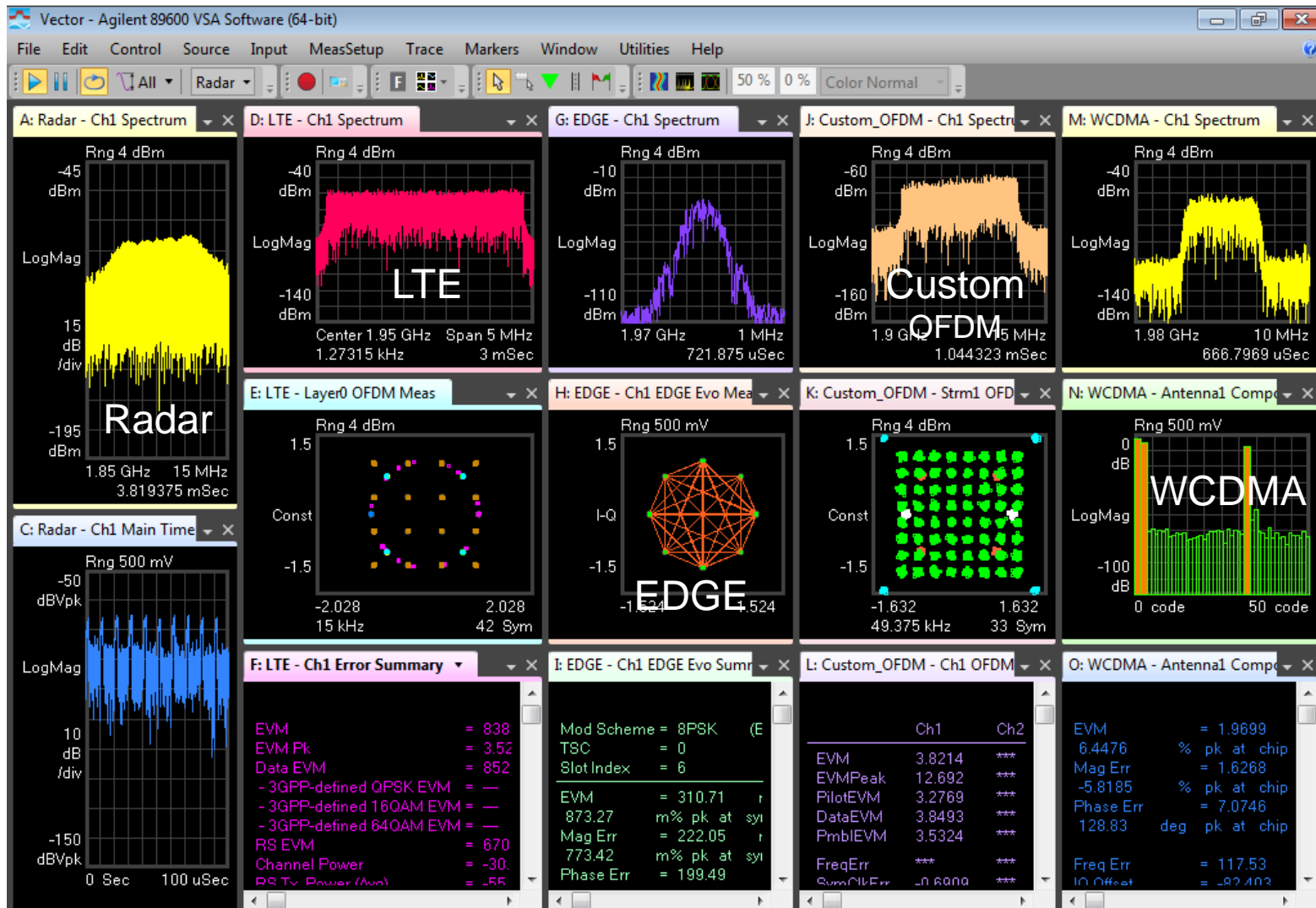
Work-in-Progress



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# 5 Channel Demodulation Performed Simultaneously with M9703A and VSA Software

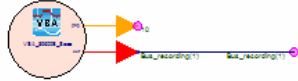




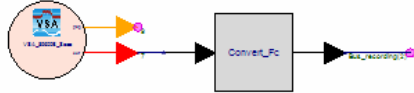
# Download the Multi-Channel M9703A Recordings to CH1 on M8190A AWG



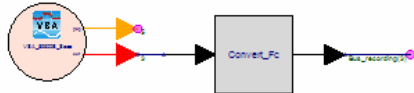
M9703  
Channel 1  
Recording



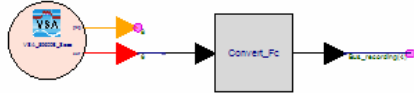
M9703  
Channel 2  
Recording



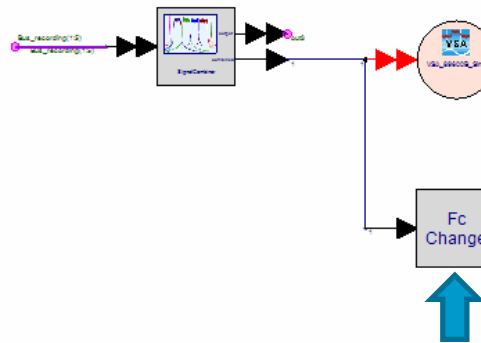
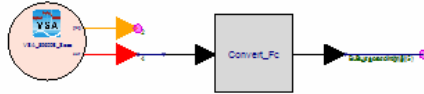
M9703  
Channel 3  
Recording



M9703  
Channel 4  
Recording



M9703  
Channel 5  
Recording

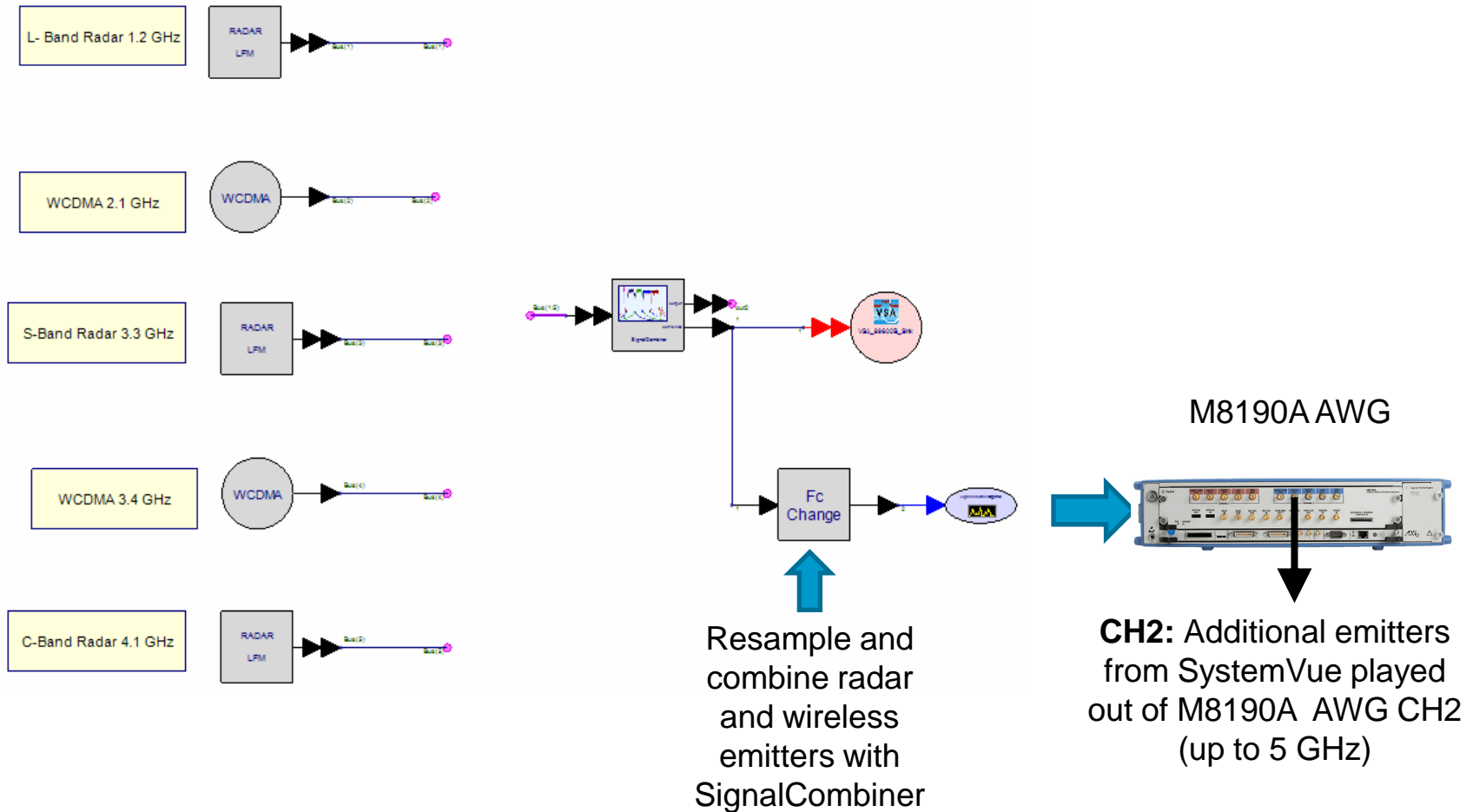


Resample and combine  
recordings with  
SignalCombiner

M8190A AWG

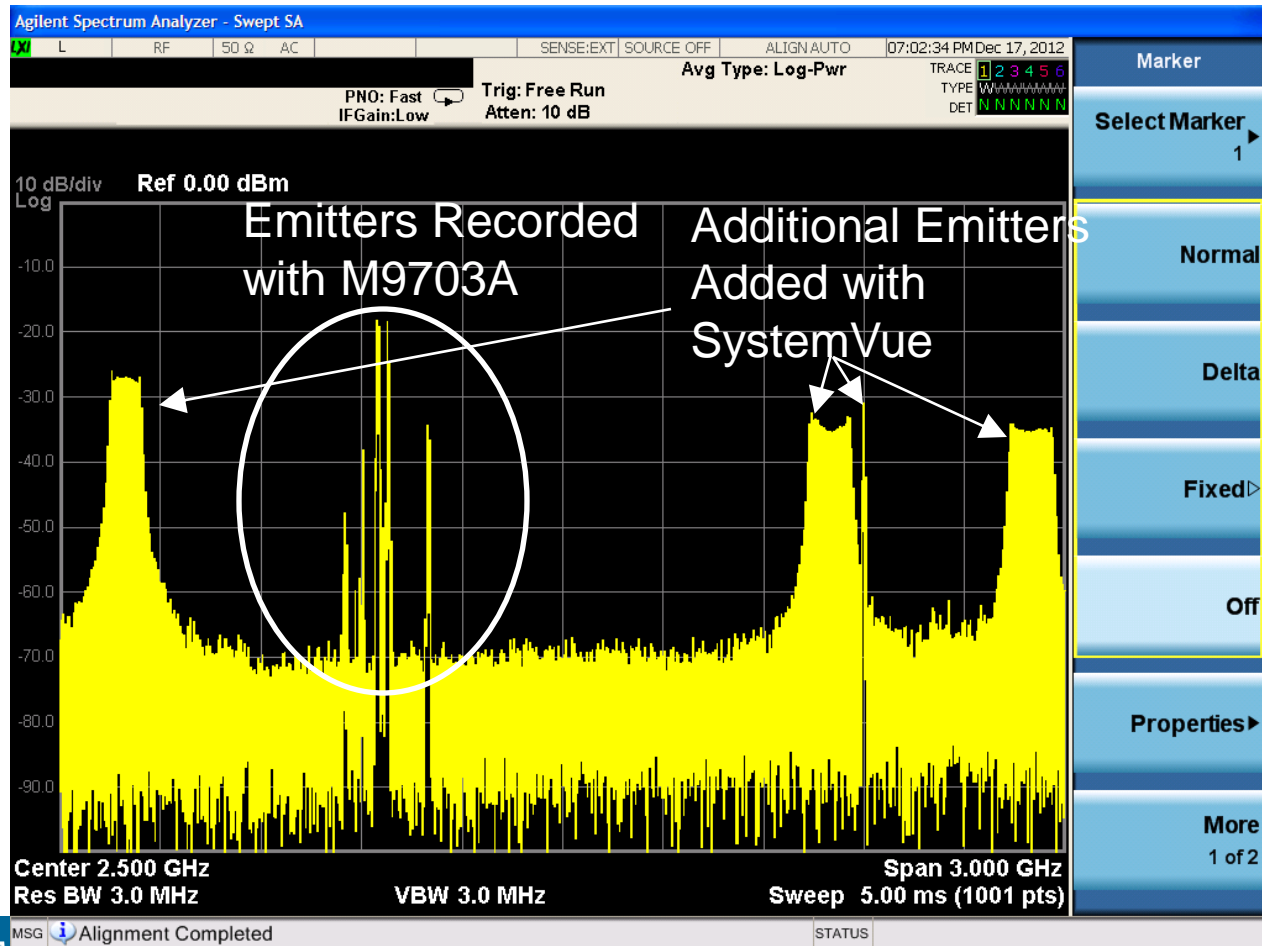
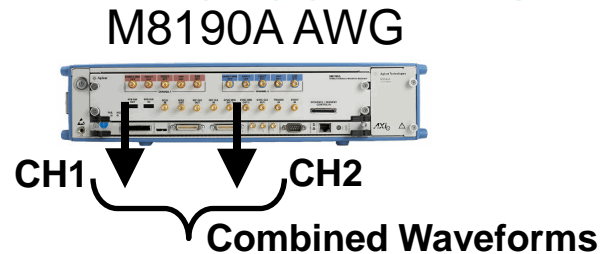
**CH1:** Captured signals  
from M9703A played out of  
M8190A AWG CH1  
(up to 5 GHz)

# Download Additional Emitters to CH2 on M8190A AWG



# Conceptual Test Signal

## Combine CH1 and CH2 on M8190A AWG



Anticipate — Accelerate — Achieve

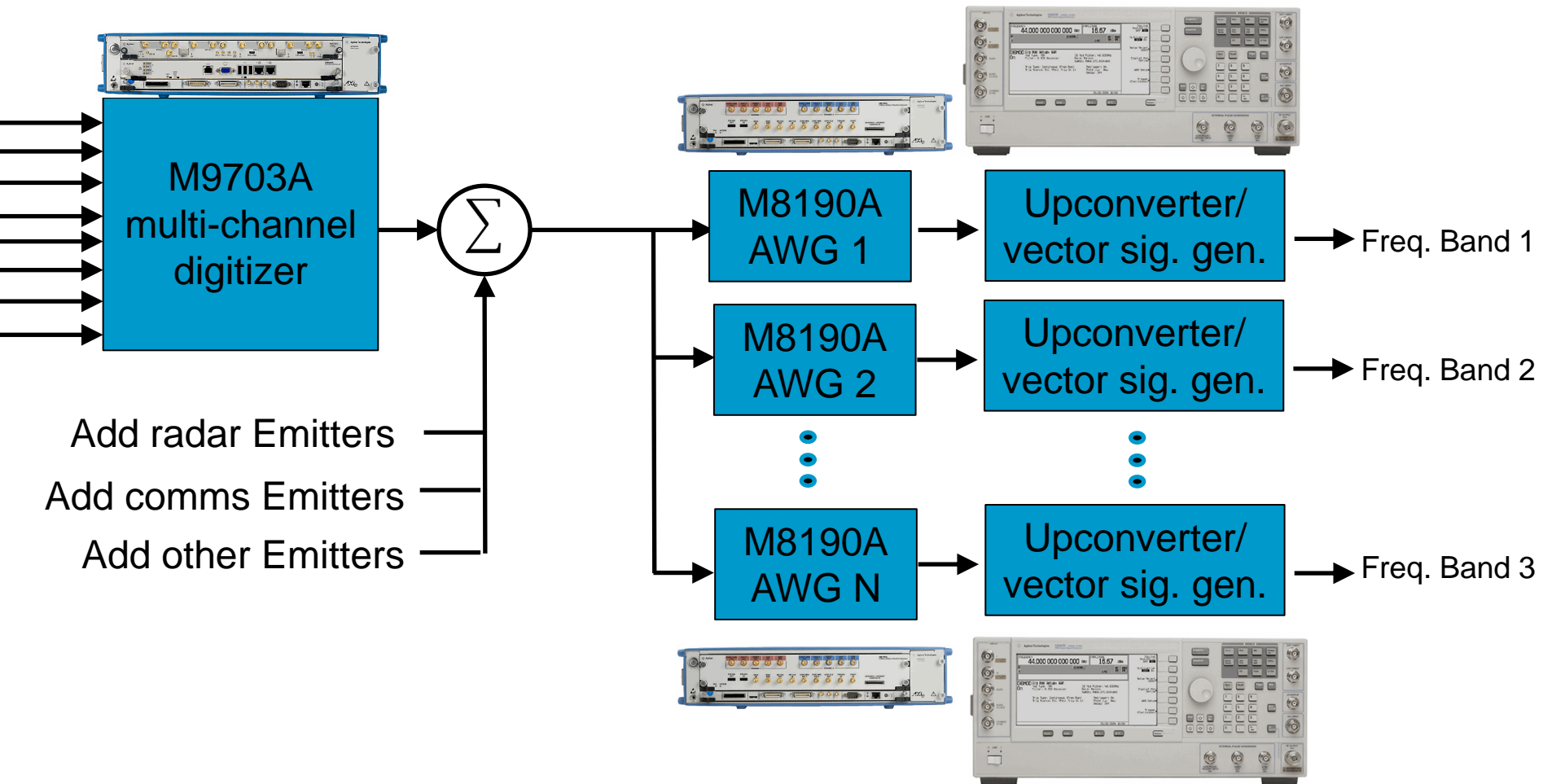
Work-in-Progress



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# Multiple AWGs for Frequency Band Upconversion/ Vector Modulation

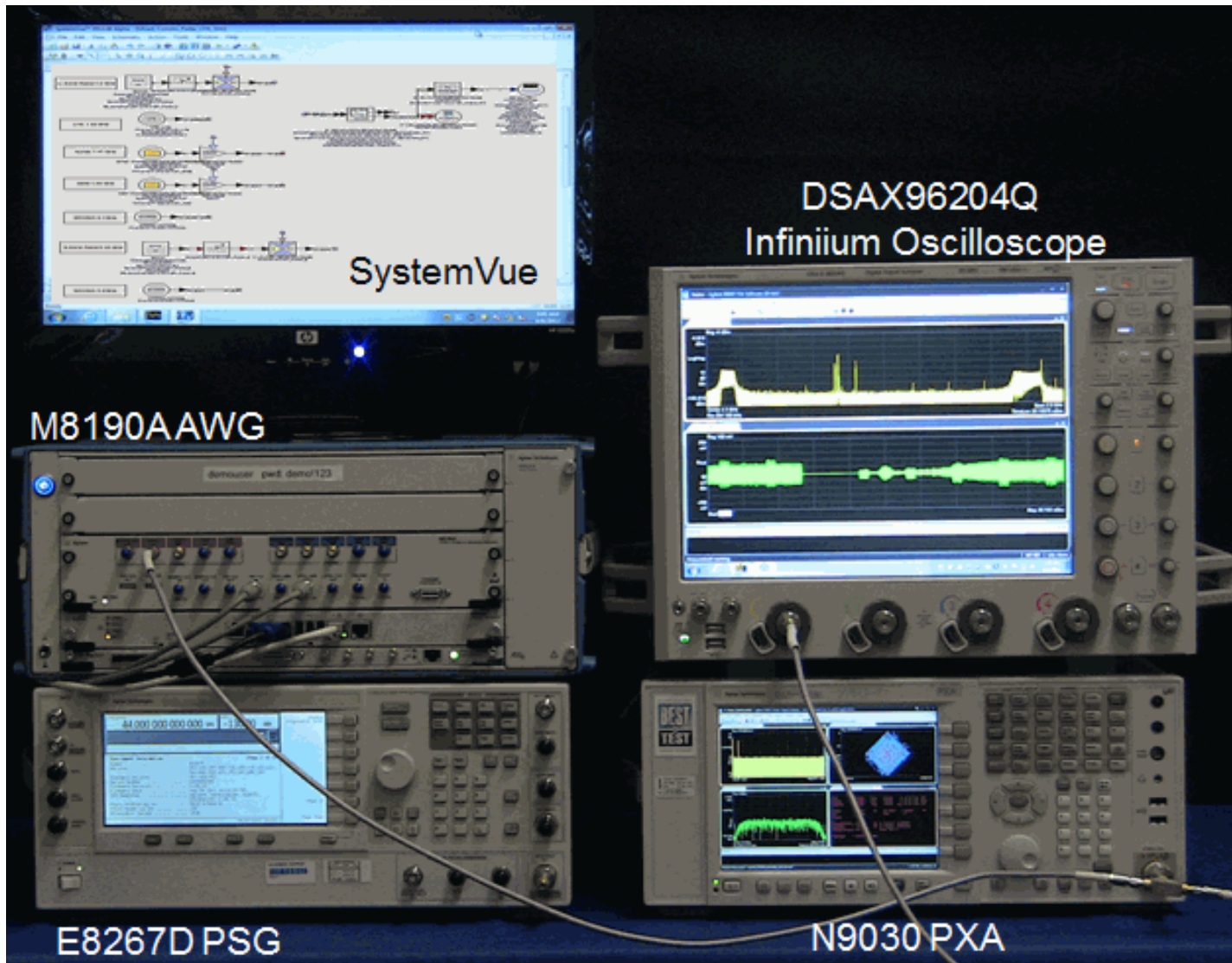




- Today's Cluttered Spectral Environment
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- Creating Realistic Multi-Emitter Radar and Communications Test Signals
- Evaluating Co-Existence Issues Between Radar and Wireless Signals

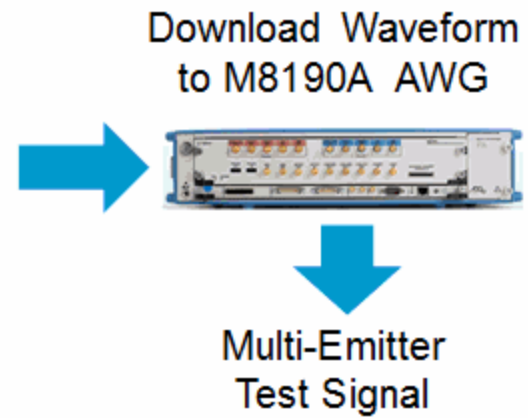
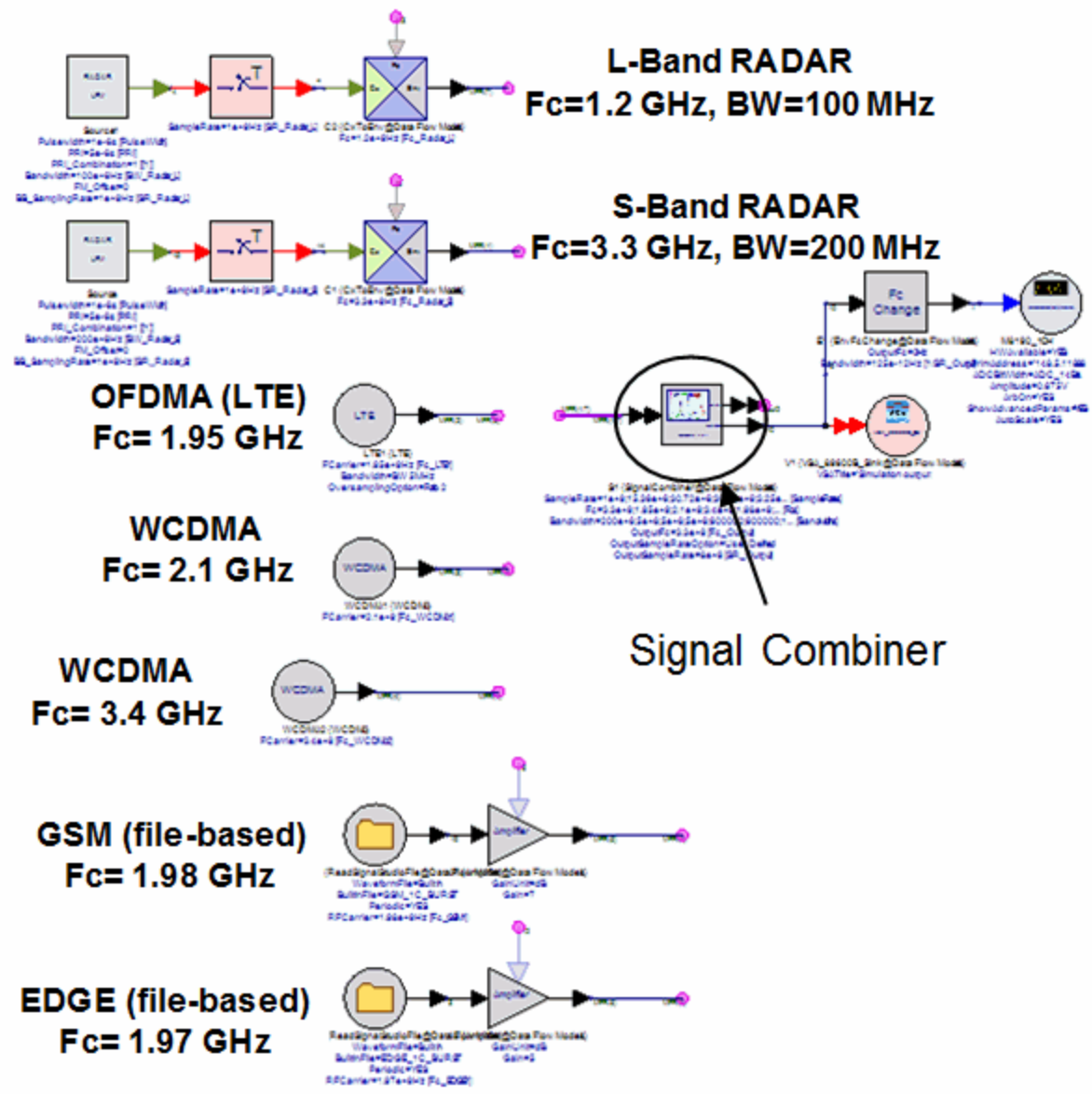


# Picture of Test Setup



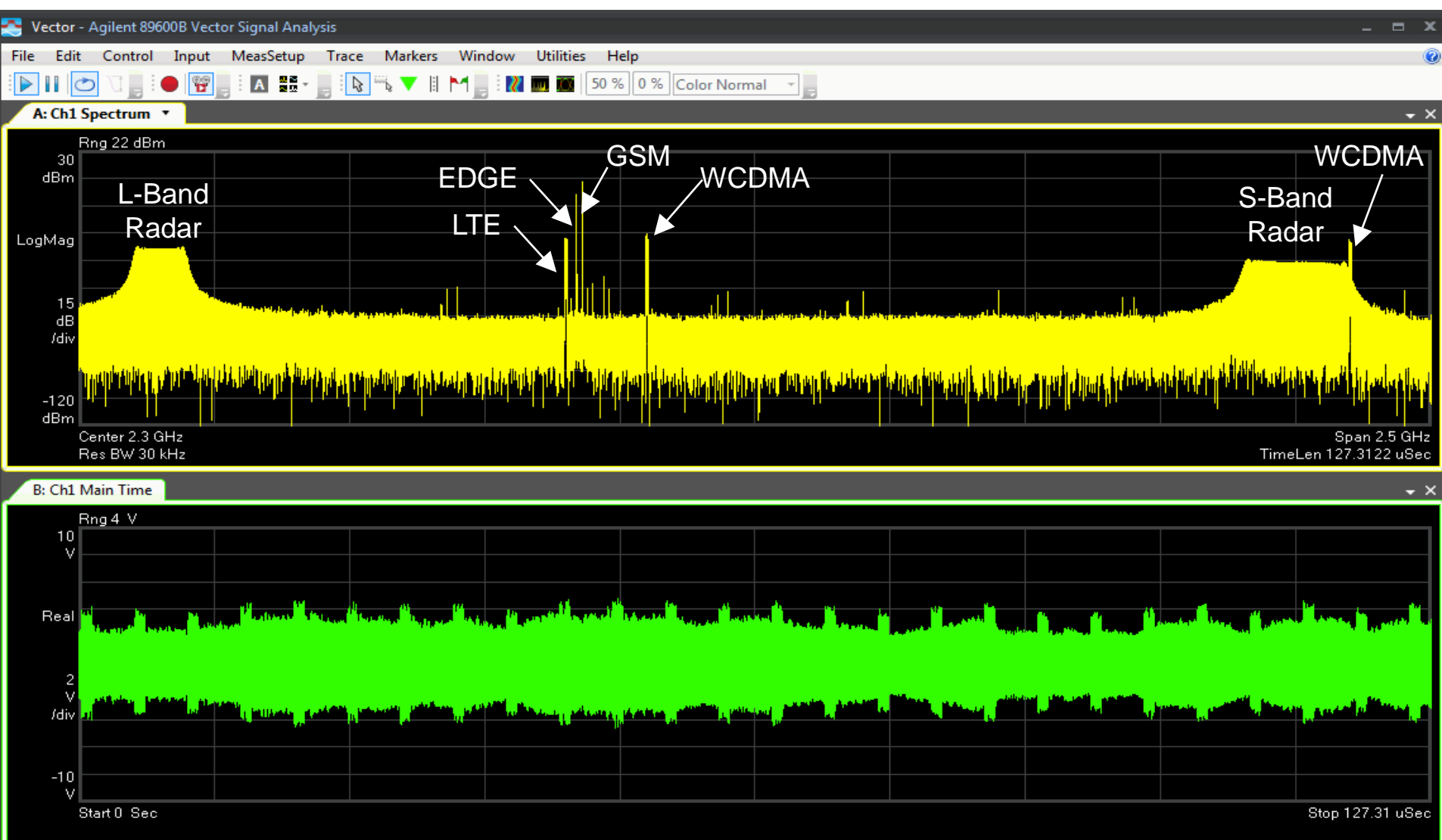


# Multi-Emitter Signal Creation with SystemVue

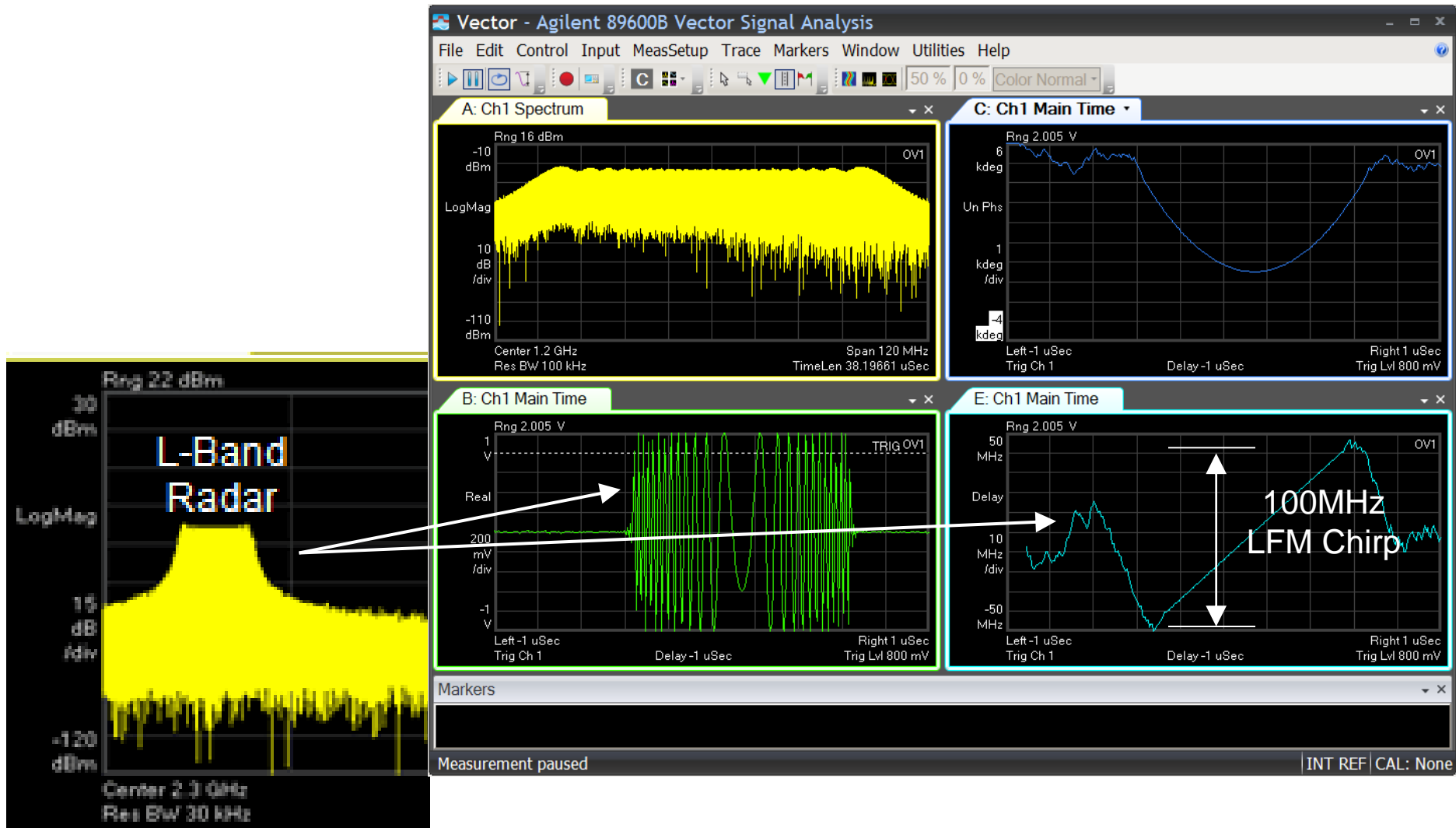




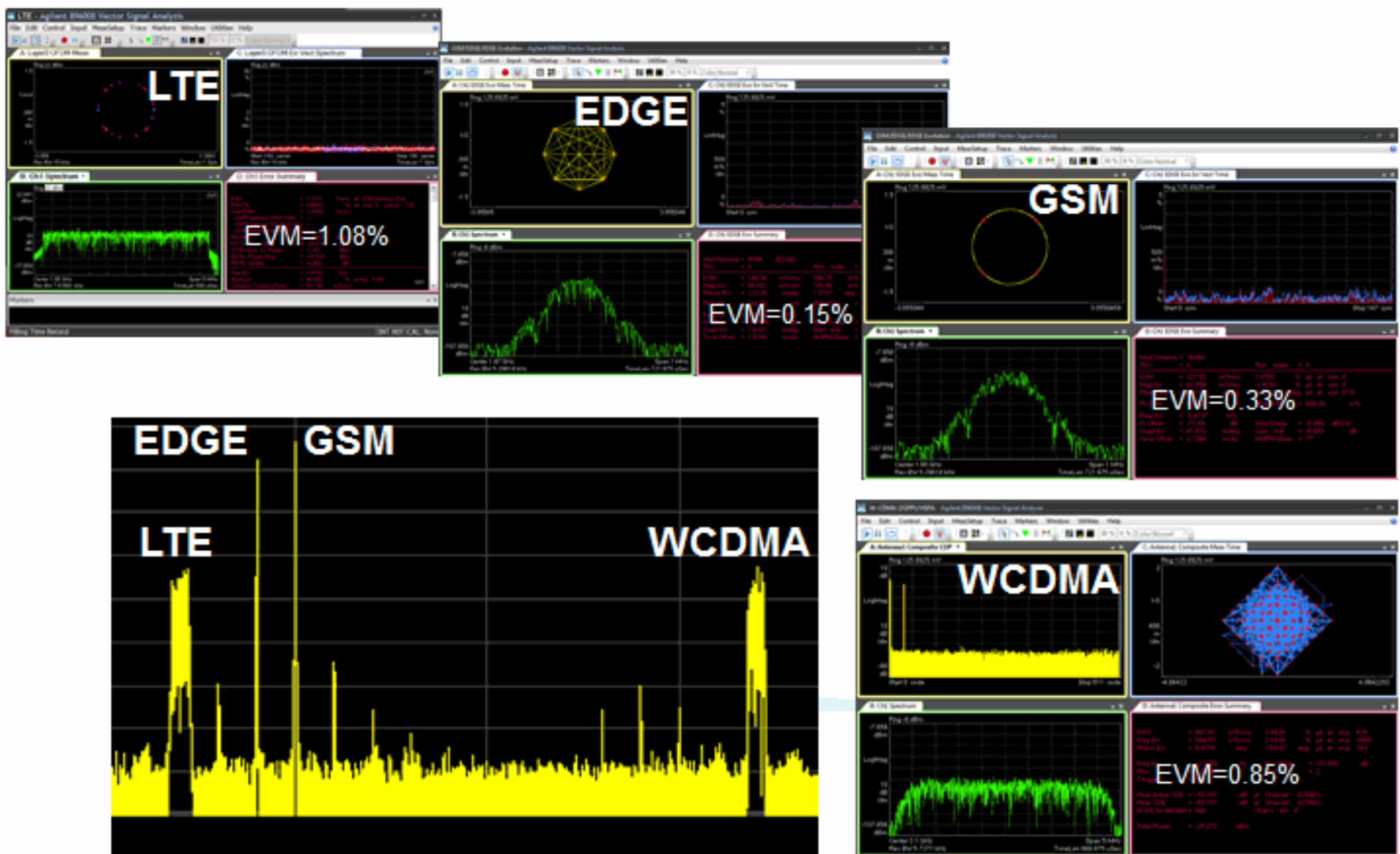
# Measured Waveform on DSA91304A and VSA



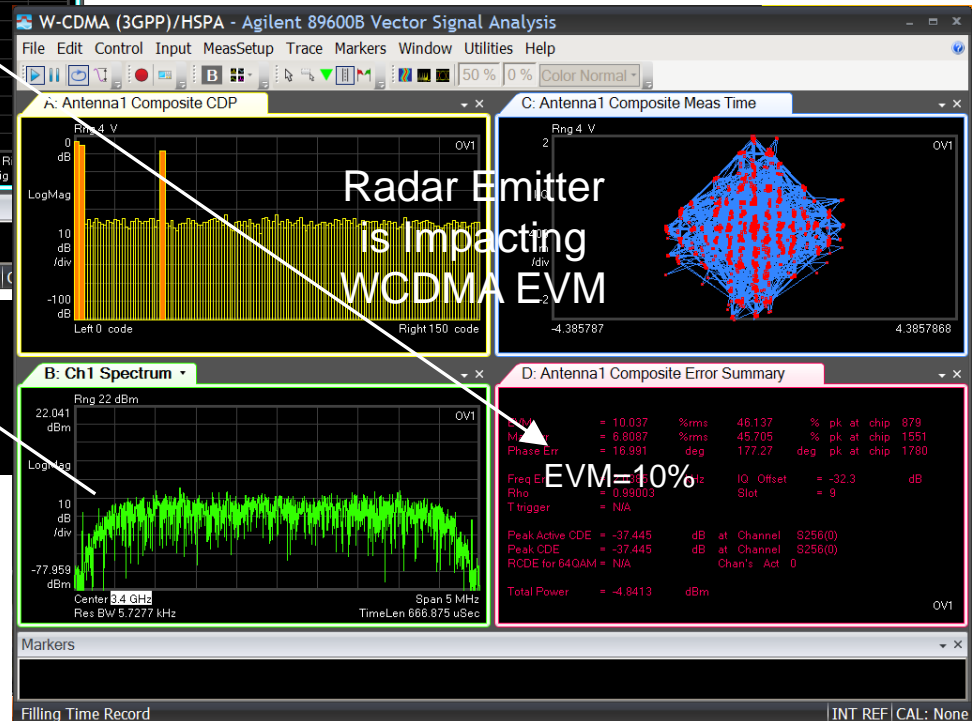
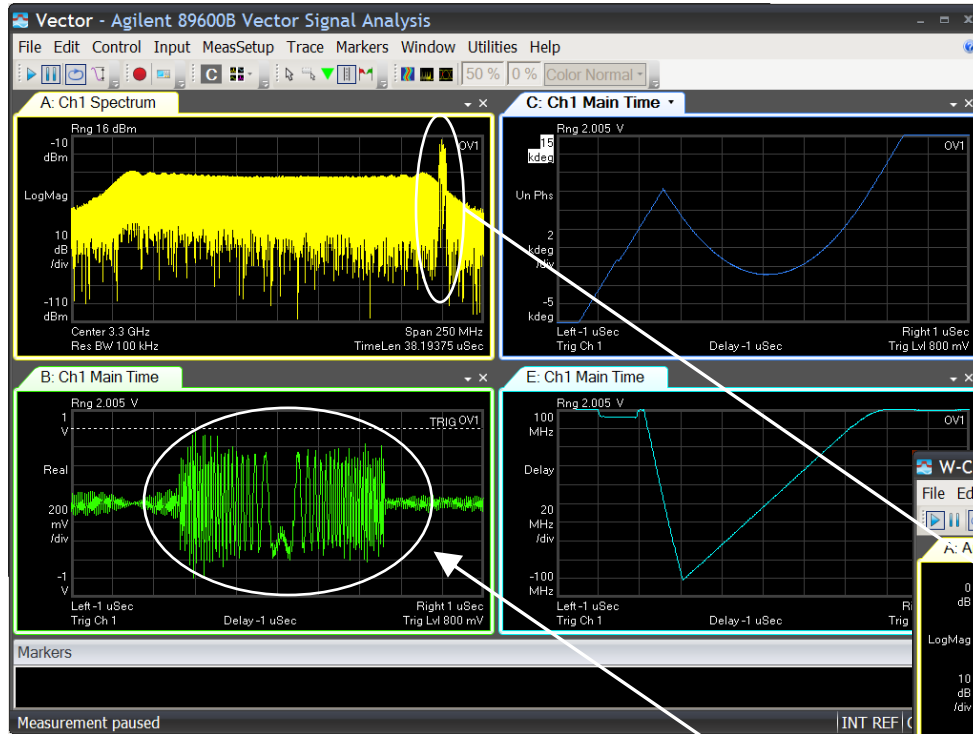
# Close-Up: S-Band Radar Emitter



# Close-Up: Demodulating Wireless Emitters

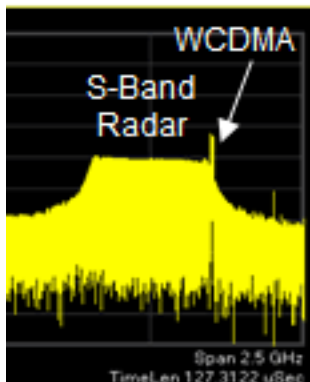


# Close-Up: S-Band and WCDMA Emitter



Radar Emitter  
is Impacting  
WCDMA EVM

...and WCDMA  
Emitter is Impacting  
Radar



**C-Band Radar 5.5 GHz**

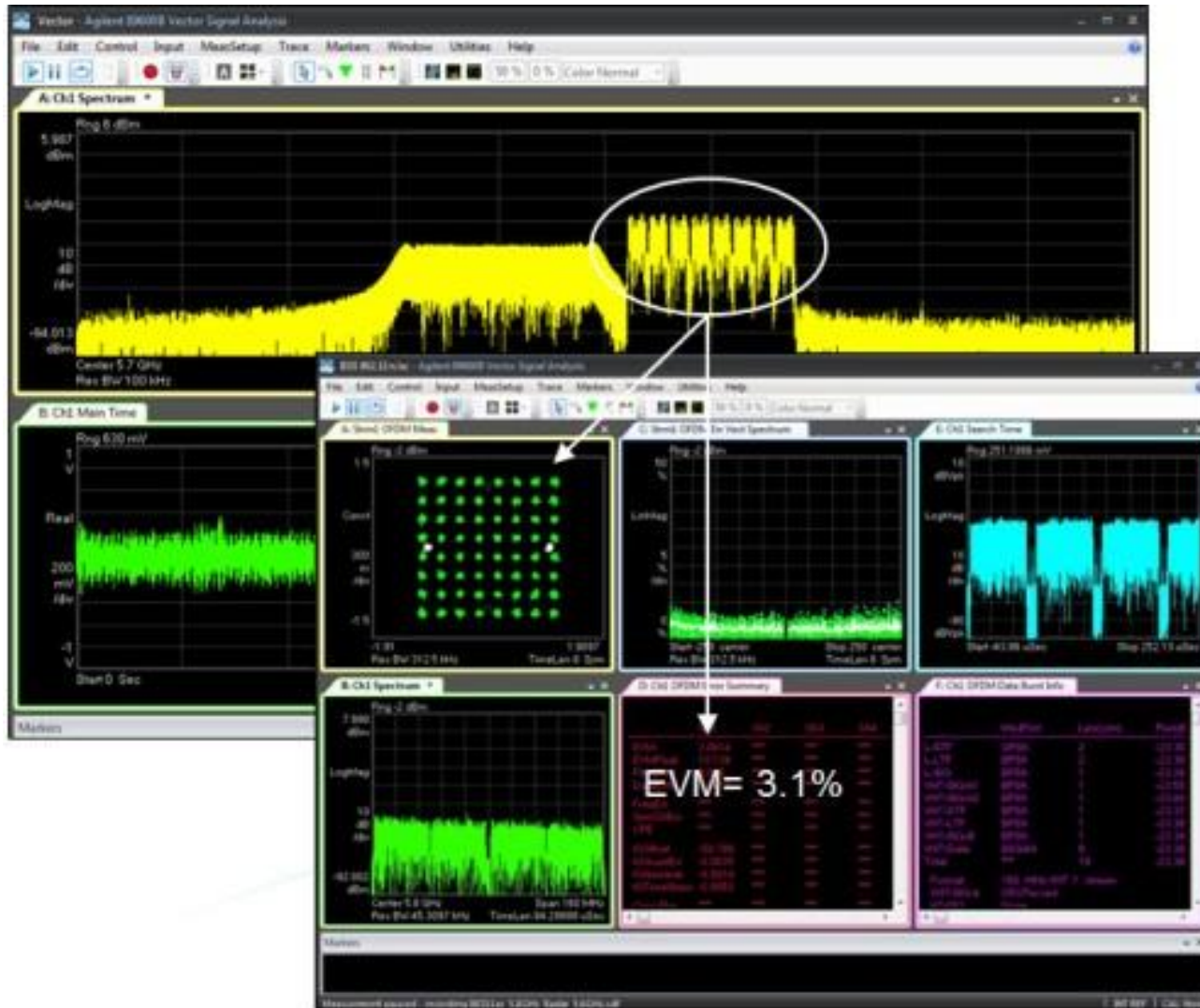
**VHT WLAN 5.8 GHz**

**802.11ac WLAN**

Multi radar environment

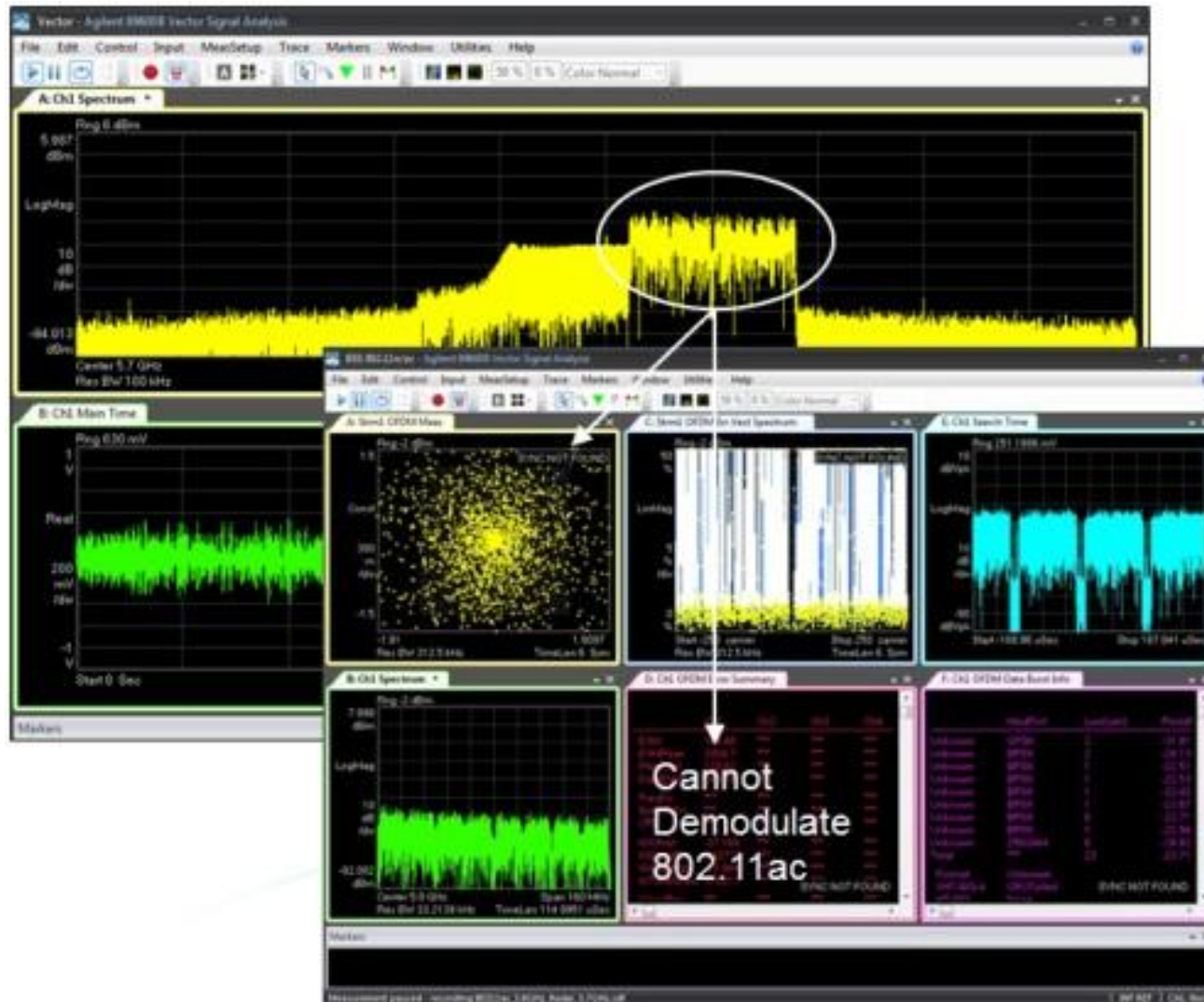


# Scenario 1- WLAN 802.11ac and Radar Co-Existence





# Scenario 2- WLAN 802.11ac and Radar Co-Existence







- Today's cluttered spectral environment may contain many sources of interference
- Highly realistic test signals are needed to test R&D hardware
- May need to generate mixed radar and communications signals to evaluate hardware under different scenarios
- May need to combine capture signals with created signals
- M9703A digitizer, M8190A AWG, and SystemVue offer a flexible and re-configurable approach
- Cost-effective and suitable for R&D lab environments

