Capabilities Overview

Matt Miller

April 16, 2019

Agenda

- **EMA Background**
- Installed Antenna Performance
- Cosite Interference

EMA
electro magnetic applications, inc.

- HIRF
- Lightning
- EMP
- EMI/EMC
- Cosite Interference
- Installed Antenna Performance
- Radar Signature

Modeling Software

Expertise on Real Problems

Software Validation

Consulting Services

Focus on Industrial Needs

Measurements

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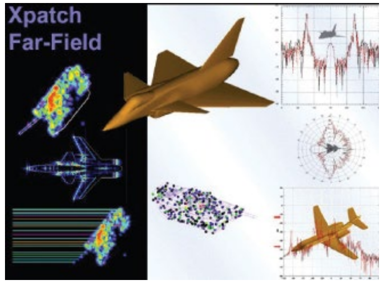
Software Tools

- Cosite Interference
  - ANSYS EMIT
  - Matlab
- Installed Antenna Performance
  - ANSYS HFSS
  - ANSYS Savant (SBR+)
  - Matlab
- Radar Signature Prediction
  - ANSYS HFSS & SBR+
- Lightning/HIRF/EMP
  - EMA3D
  - MHARNESS
- Also have experience with other tools



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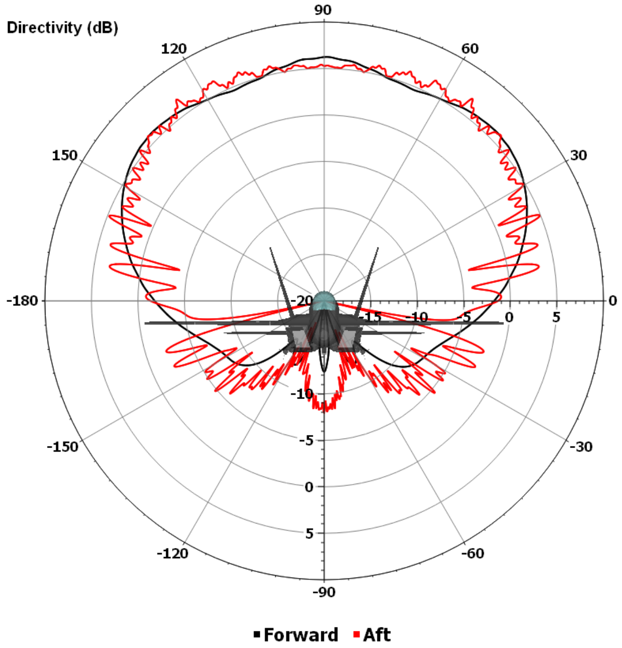
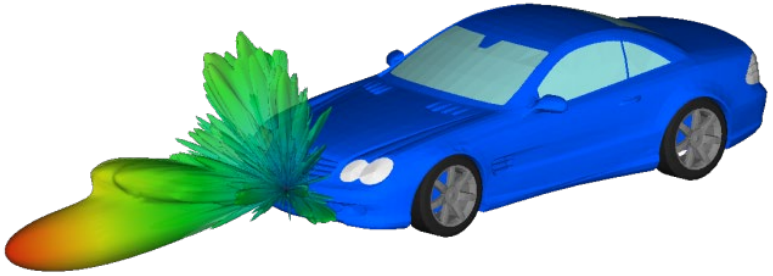
- EMA Background
- **Installed Antenna Performance**
- Cosite Interference

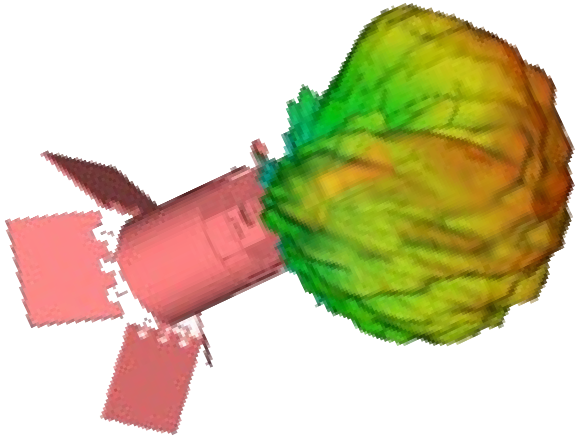
Installed Antenna Performance Problem

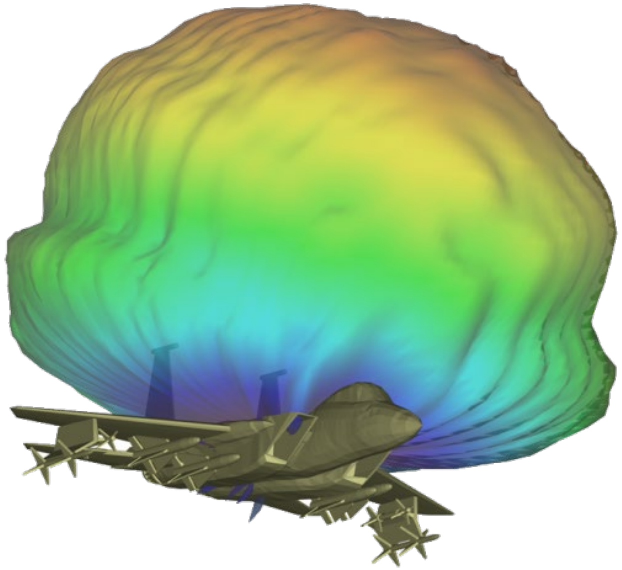
- Antennas interact with the vehicles on which they are installed
  - Multipath, diffraction, creeping waves, etc.
  - Changes antenna performance
- For many applications, need to accurately characterize antenna performance
  - Radar, EW, communications links, cosite, etc.
- Measurement vs. Simulation
  - Measurement is expensive, time consuming and difficult
    - Though still necessary at times!
  - Simulation is more affordable, faster, provides physical insight to results, and more flexible

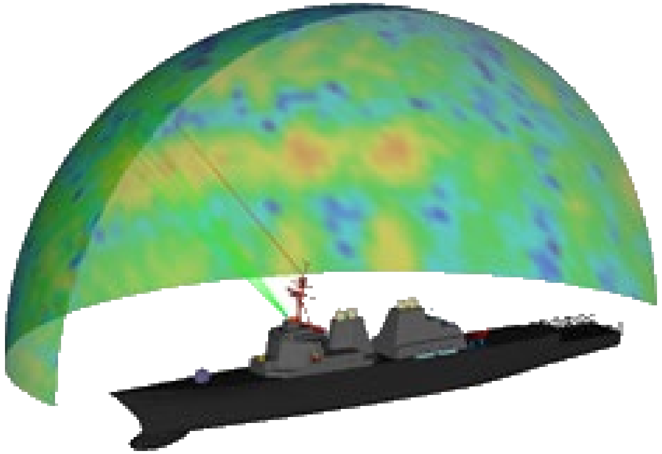


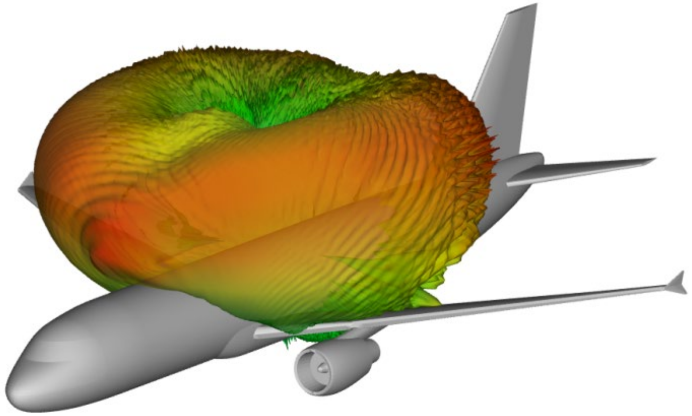
- Fast and accurate prediction of **installed patterns**, near-fields, and antenna coupling











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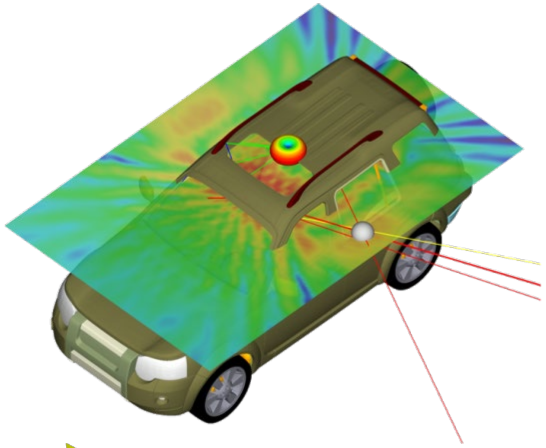
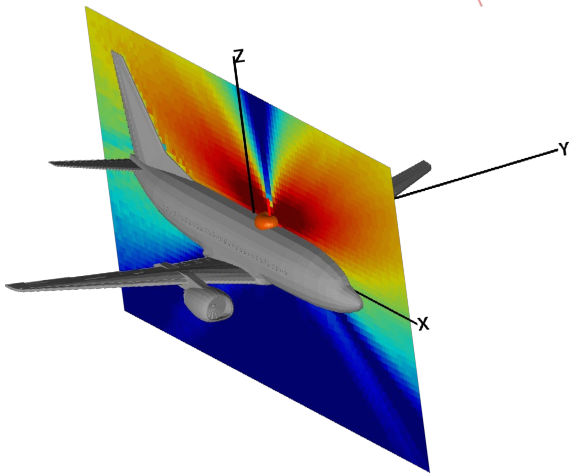
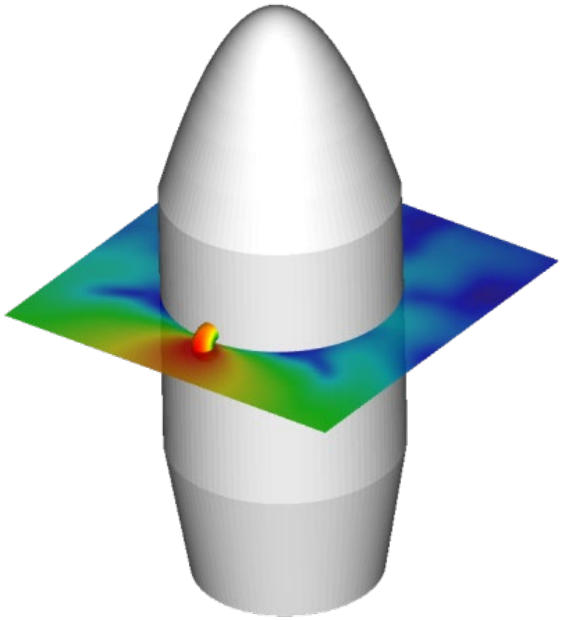
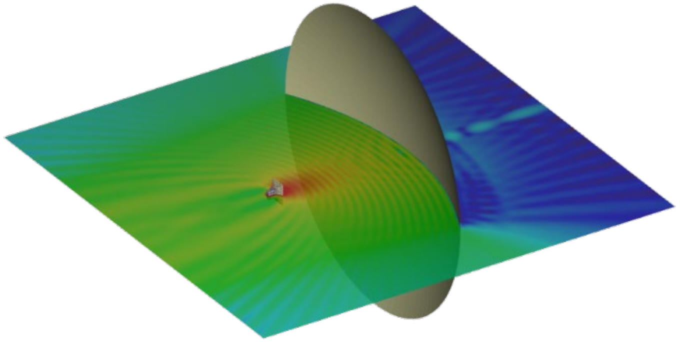
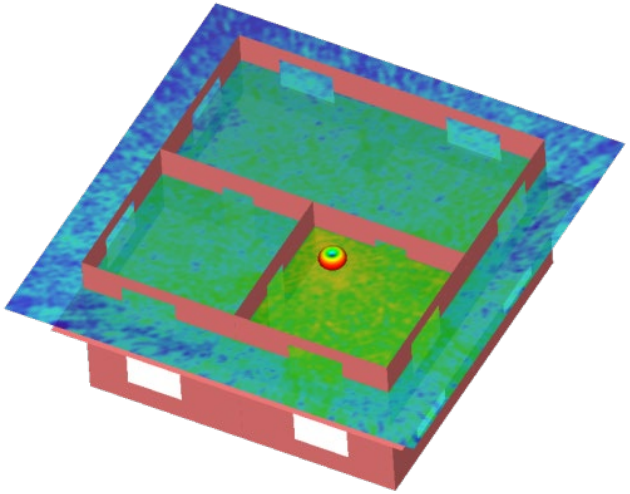


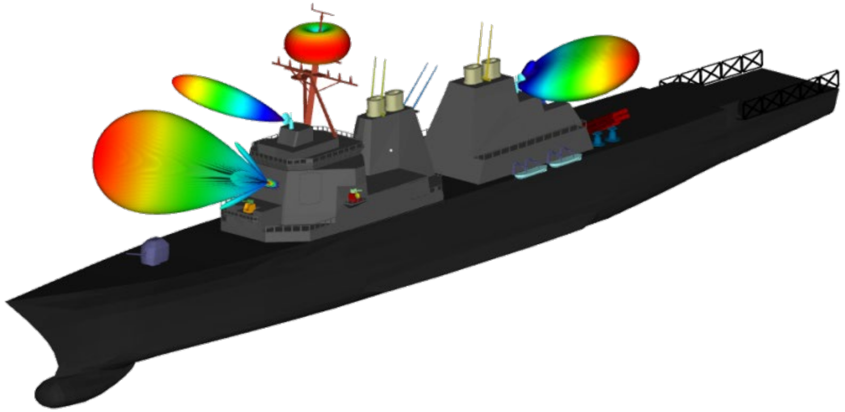


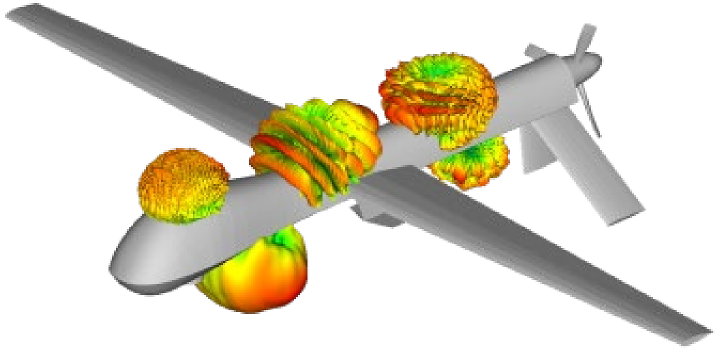


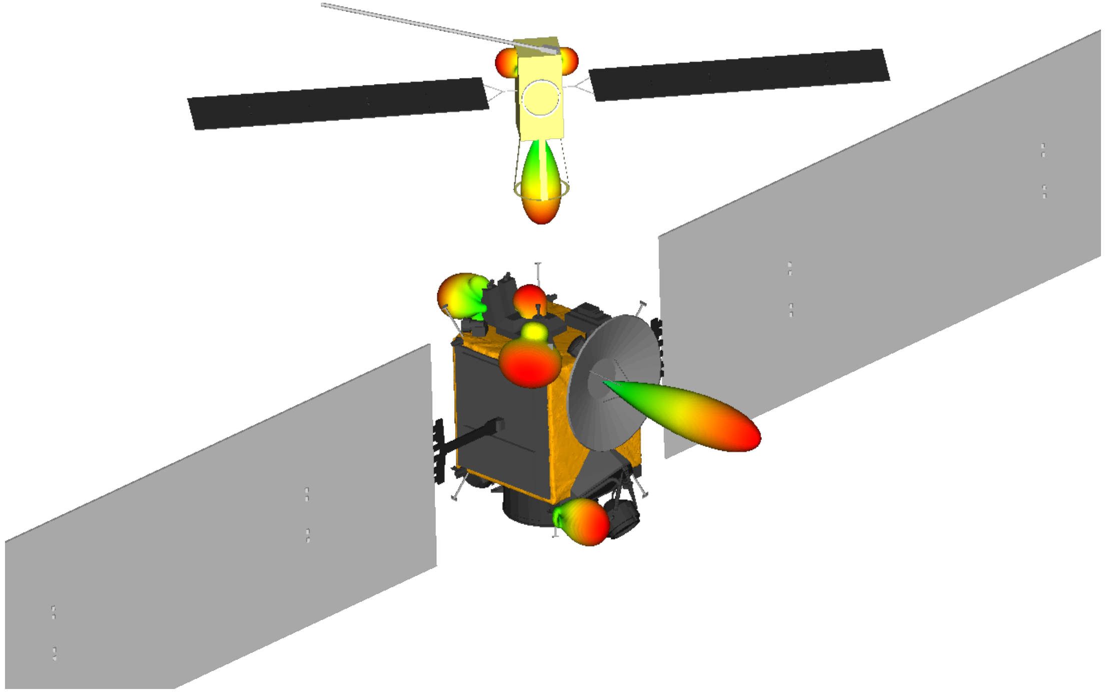




- Fast and accurate prediction of installed patterns, near-fields, and **<u>antenna coupling</u>**

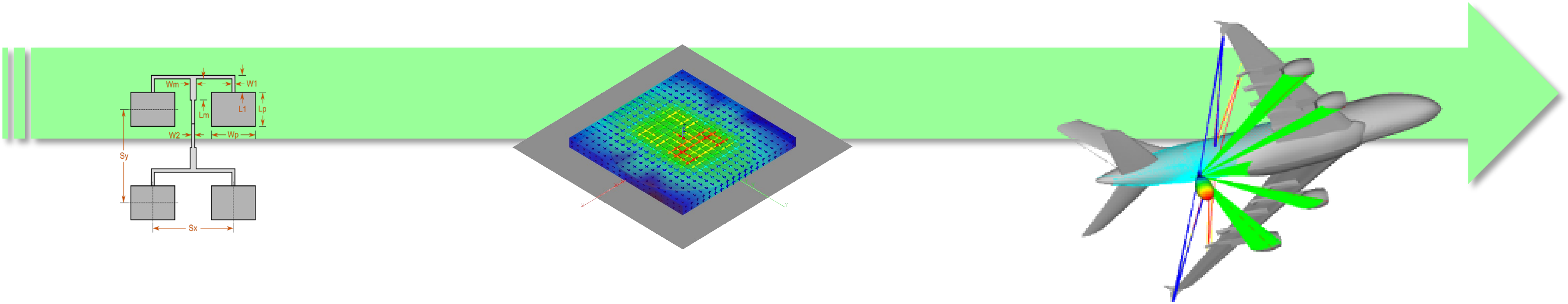






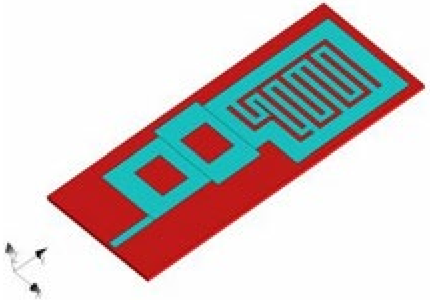
Hybrid Solutions

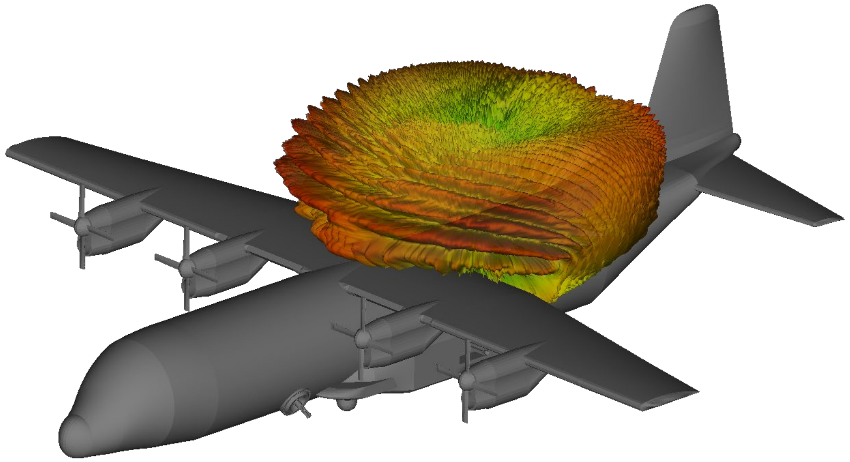
- Often need to hybridize full-wave and asymptotic techniques
  - Simulate the isolated performance of the antenna in a full-wave solver
  - Use equivalent representation in asymptotic solver to compute performance on electrically large platform
- For Savant, several hybrid solutions available
  - HFSS, CST, WIPL-D and measured data (NFS format from Microwave Vision Group)
  - Capture E/H fields over Huygens surface and convert to equivalent current sources
  - Savant launches rays from equivalent current sources to compute installed patterns and coupling



Reverse Engineering

- Antenna Designs and Installed Performance
  - Build models that match vendor spec sheet performance
  - Install on platform
  - Compute installed patterns and coupling
  - Must be broadband to cover the frequencies of interest





Agenda

- EMA Background
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- **Cosite Interference**

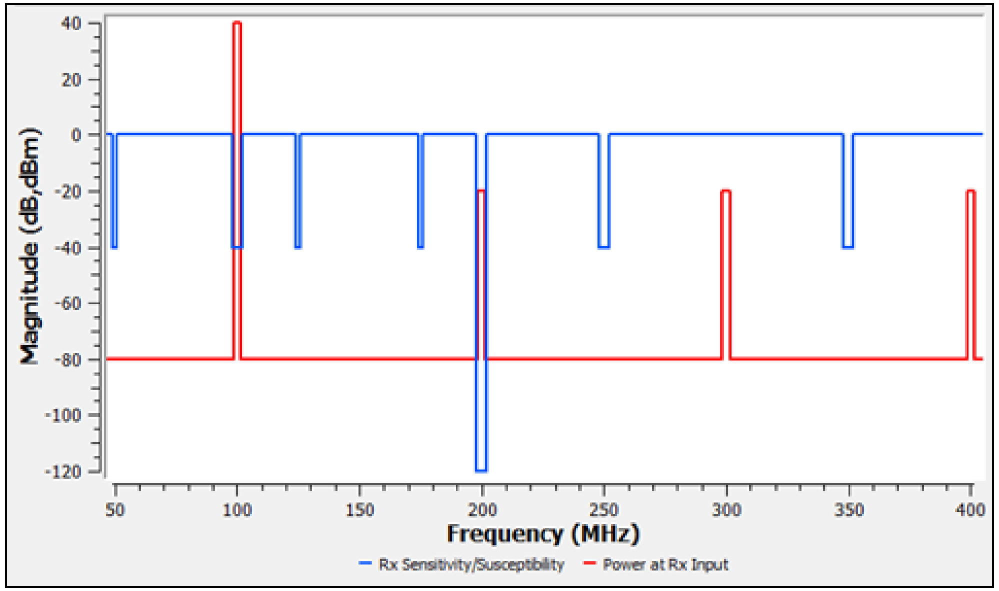
Problem Overview

- One or more source signals preventing a receiver from performing its intended role or degrading the performance
  - Snap, crackle, pop on a communication system headset
  - Jamming a GPS receiver
  - Reduced range due to desense
- Customer Impact
  - Reduced system capabilities
  - Expensive fixes and delayed release/deployment
  - Loss of life
- Our Value Proposition
  - Find problems early
  - Demonstrate ways to fix problems
  - Save money! Get to market on time!

HMS Sheffield

How Interference Happens

- In-Band
  - Tx signals fall in the passband of the receiver
    - Harmonics and spurious emissions from the Tx system
    - Intermodulation products from multiple Tx's & nonlinear devices
    - Broadband noise
- Out-of-Band
  - Tx signals fall in out-of-band responses of the receiver
    - Receiver mixer products
    - Spurious responses of receivers

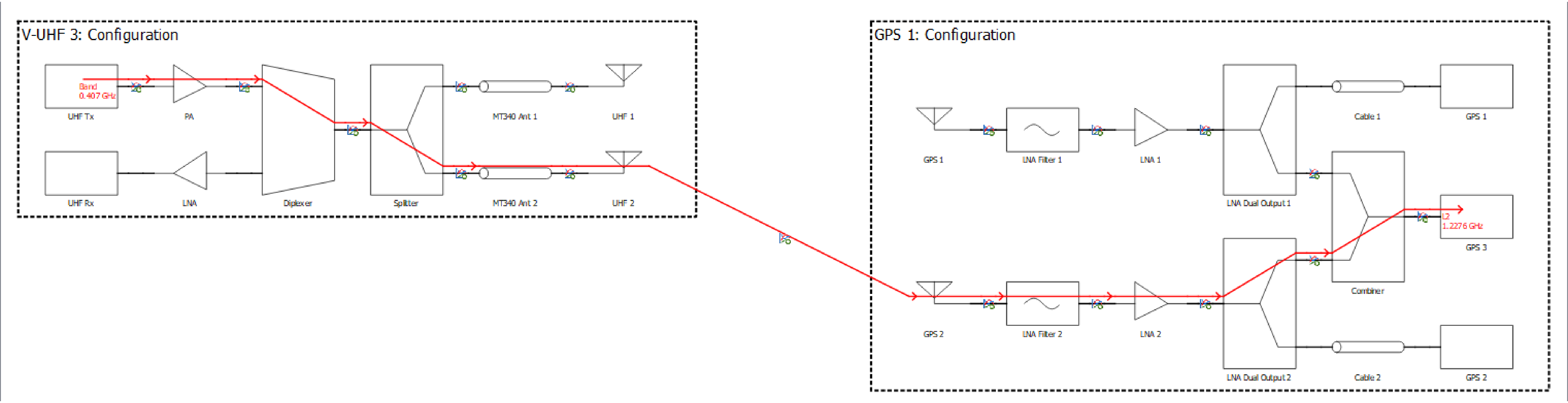


What our customers want to know

- Are there going to be problems?
- If yes, on what specific channels?
- What is the magnitude of the interference?
- What can be done to mitigate the problem?
  - Move antennas
  - Use different channels
  - Add filters
  - Adjust clock types or frequency
  - Change RF systems
  - Material treatments to reduce coupling
  - Etc.

RF Cosite Analysis

- End-to-End Analysis
  - Everything between Transmitter(s) and Receiver(s)
  - Broadband models/data



RF Cosite Analysis

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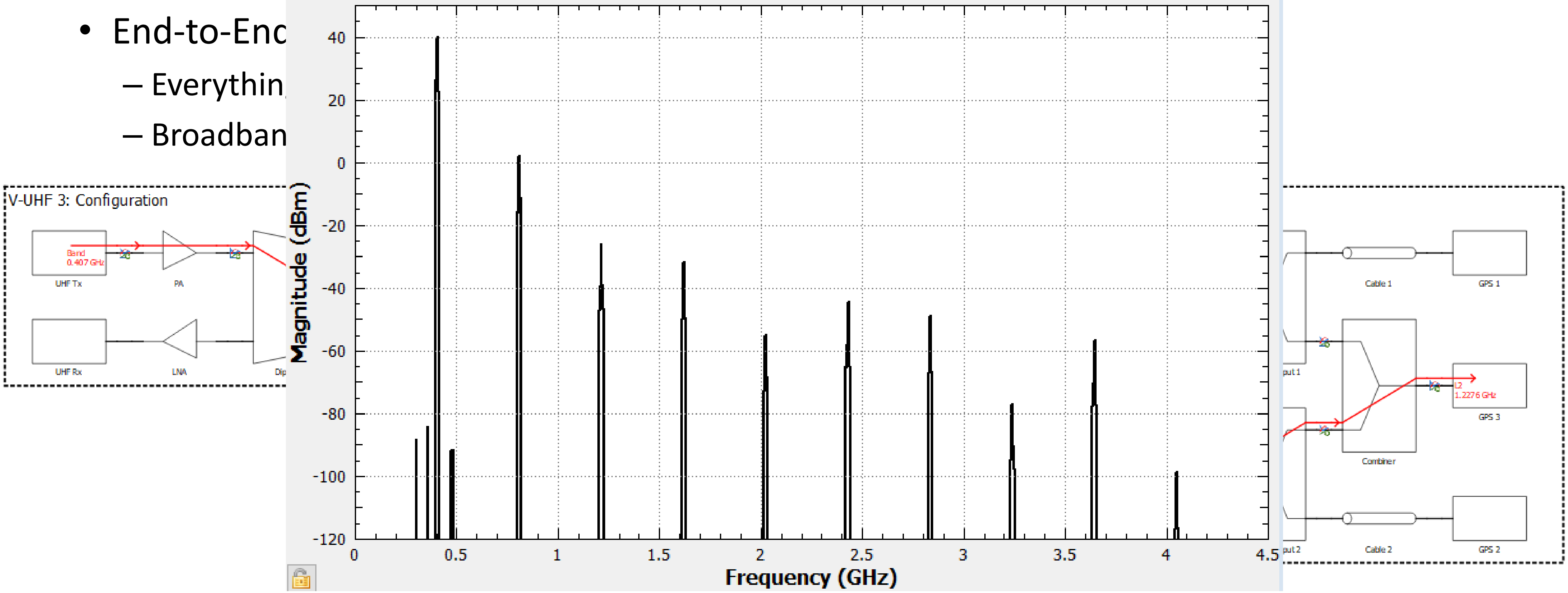

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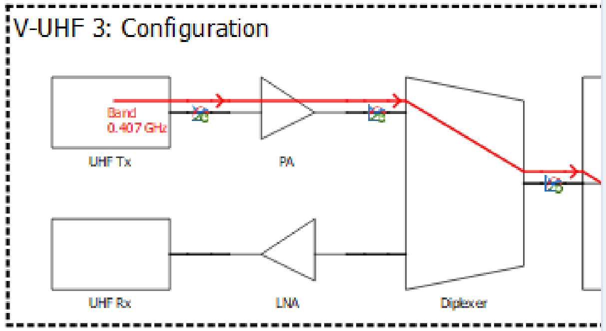

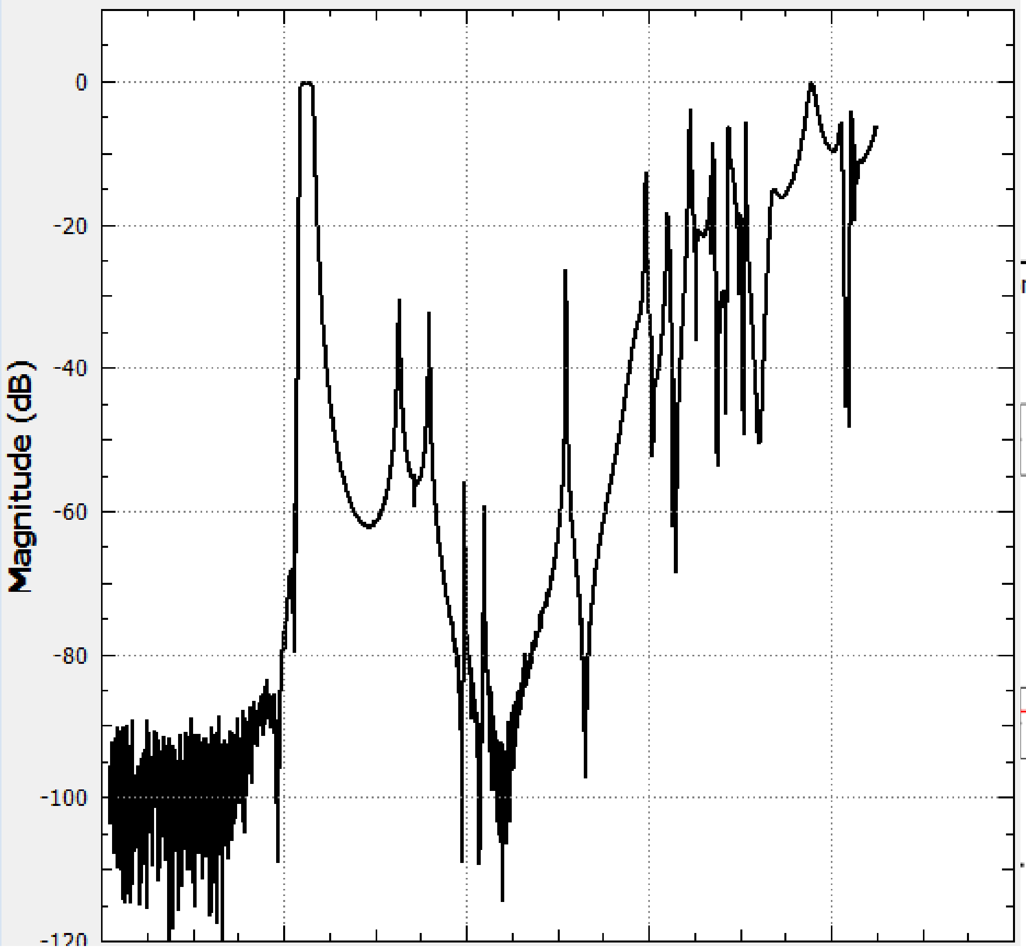

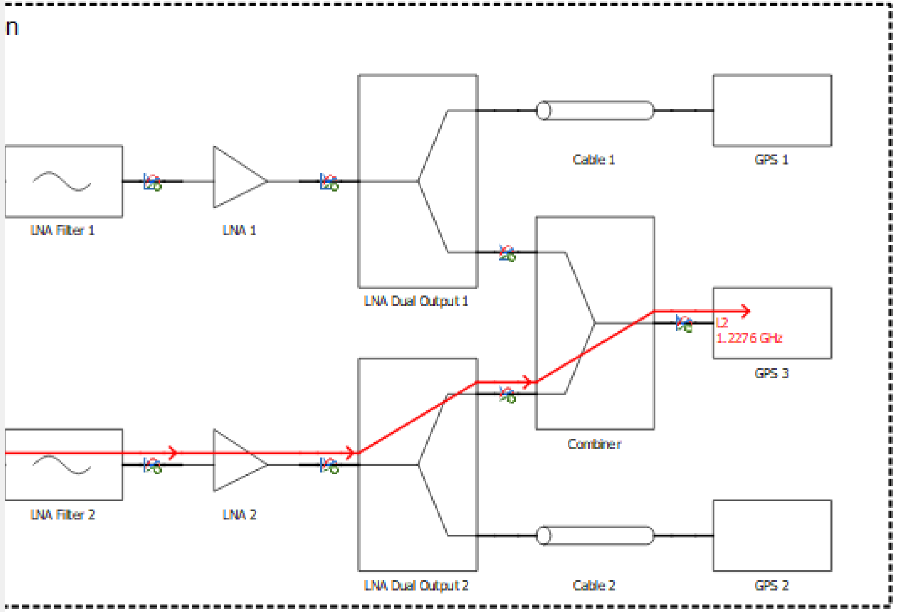

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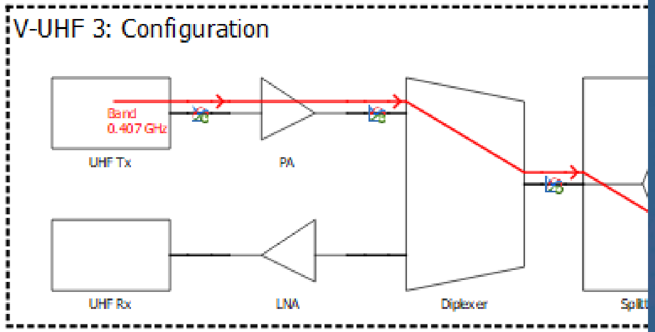

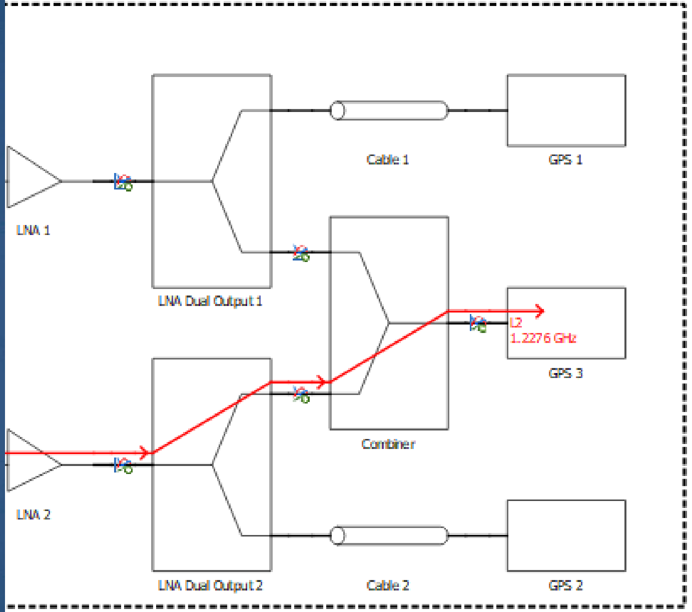

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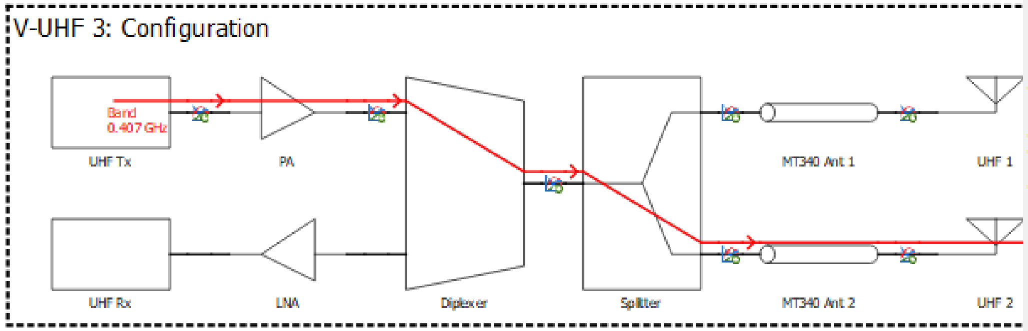
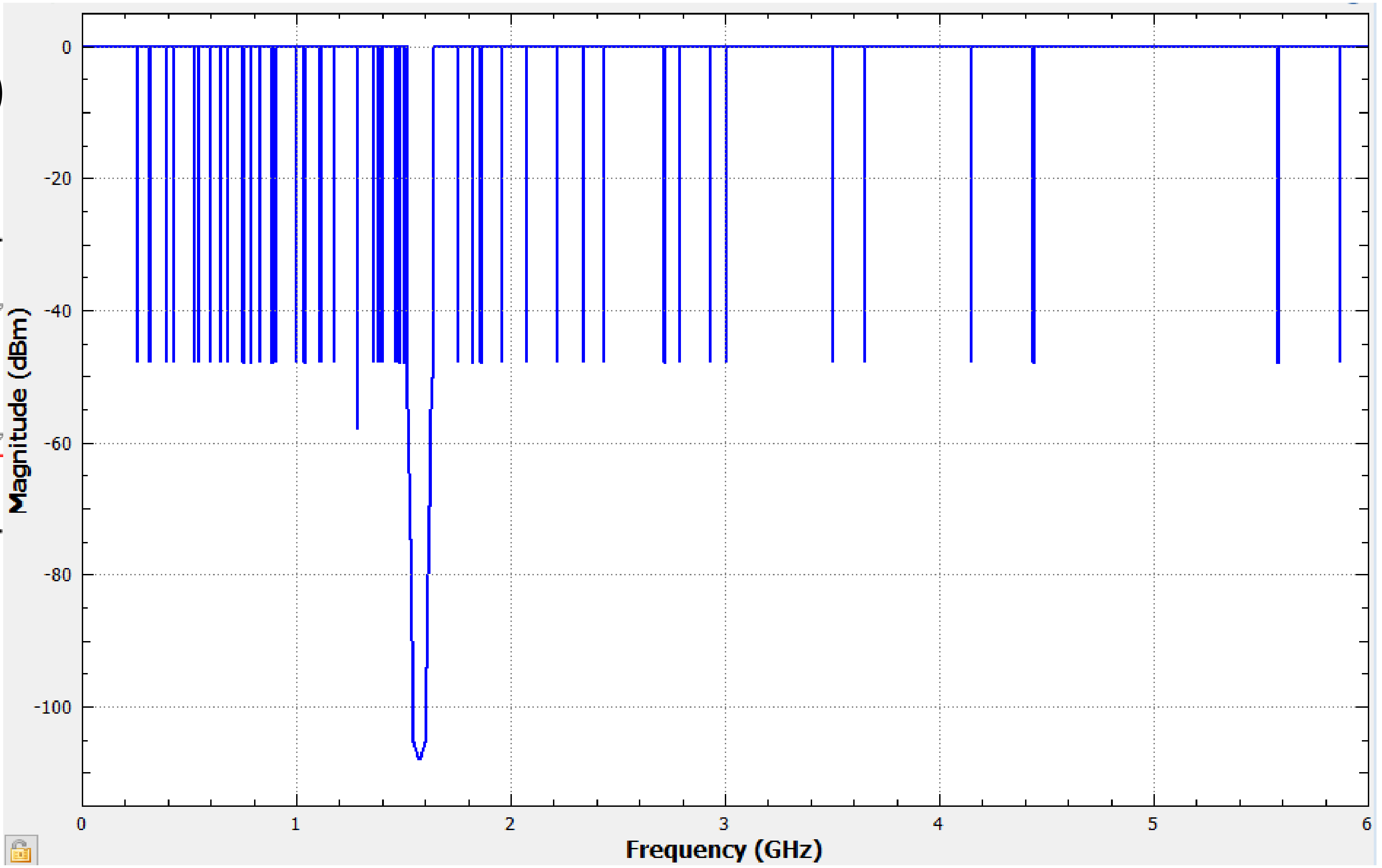
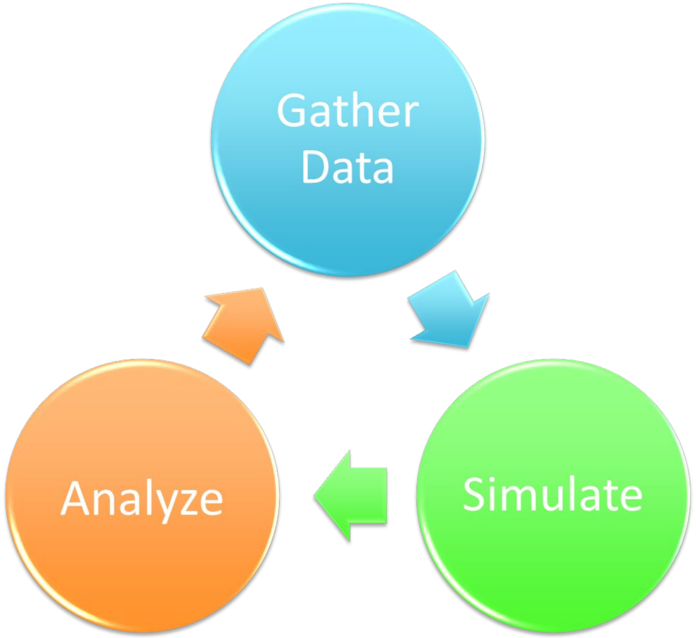




Iterative Approach

- Almost never have all of the data nor the fidelity that you want/need when you start the project
- You have to get started with the data available, which typically isn't very much
- An iterative approach is key to most cosite analyses
  - Crude assumptions/models
  - Parametric models
  - Simulation data
  - Measured data
  - Mix of all of the above
- Transmitter/Receiver Interactions
  - Single transmitter to single receiver
  - Multiple systems operating simultaneously



Operational Constraints and Channels of Operation

- Are there operational constraints on any of the systems?
  - Emergency location transmitter only operates after a crash or during testing
  - Subset of channels not allowed in different countries
  - Multiple communication systems on the same platform never operate on identical channels
- Just because a radio can support hundreds or even thousands of channels doesn’t mean they are all going to be used for the customer’s application
  - Rockwell Collins ARC-210 is a multi-mode RF system operating over HF, VHF and UHF bands

Spec Sheets

- Typically available for
  - RF systems, antennas, filters, cables, amps, etc.
- Contains high level performance parameters
- Useful but usually doesn't say much about out-of-band

Electrical Specifications

T_A = 25°C, DC bias for RF parameter is VDD = VSD = +2.85V @ 8mA (unless otherwise specified)

Table 1. Performance table at nominal operating conditions

VDD= VSD = +2.85V, R1 = 18K Ohm, Freq=1.575GHz – Typical Performance

Symbol	Parameter and Test Condition	Units	Min.	Typ	Max.
G	Gain	dB		14.3	
NF	Noise Figure	dB		0.8	
IP1dB	Input 1dB Compressed Power	dBm		1.8	
IIP3	Input 3rd Order Intercept Point (2-tone @ Fc +/- 2.5MHz)	dBm		4.7	
S11	Input Return Loss	dB		-11.8	
S22	Output Return Loss	dB		- 12.4	
Ids	Supply Current	mA		8	
Ish	Shutdown Current @ VSD = 0V	uA		0.1	
Vds	Supply Voltage	V		2.85	
$IP1dB_{1710M}$	Out of Band IP1dB (DCS 1710MHz) blocking	dBm		2.9	
$IIP3_{OUT}$	Out of Band IIP3 (DCS 1775MHz & 1950MHz)	dBm		5.5	

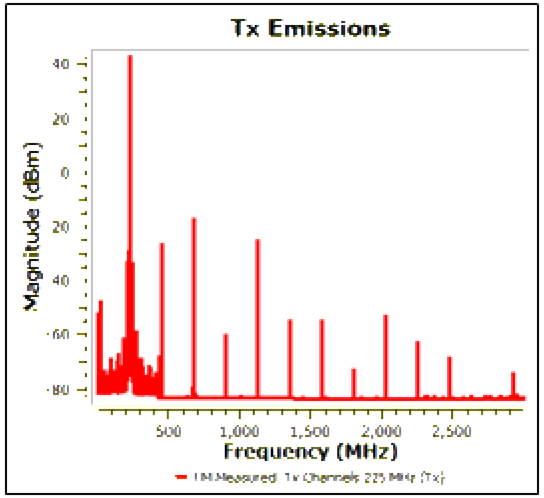
AC ELECTRICAL CHARACTERISTICS

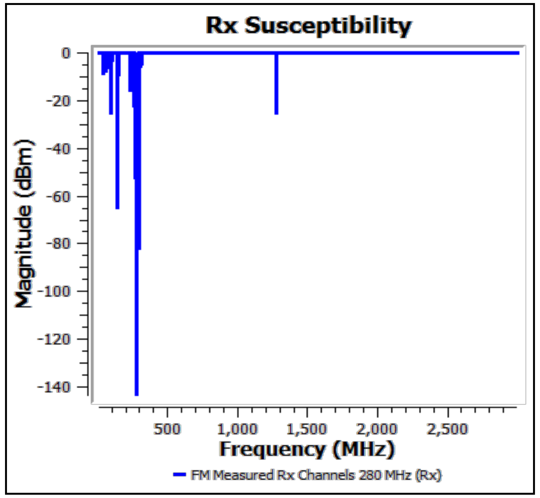
(MAX2769 EV kit, V_{CC} = 2.7V to 3.3V, T_A = -40°C to +85°C, PGM = GND. Registers are set to the default power-up states. LNA input is driven from a 50Ω source. All RF measurements are done in the analog output mode with ADC bypassed. PGA gain is set to 51dB gain by serial-interface word GAININ = 111010. Maximum IF output load is not to exceed 10kΩ II 7.5pF on each pin. Typical values are at V_{CC} = 2.85V and T_A = +25°C, unless otherwise noted.) (Note 1)

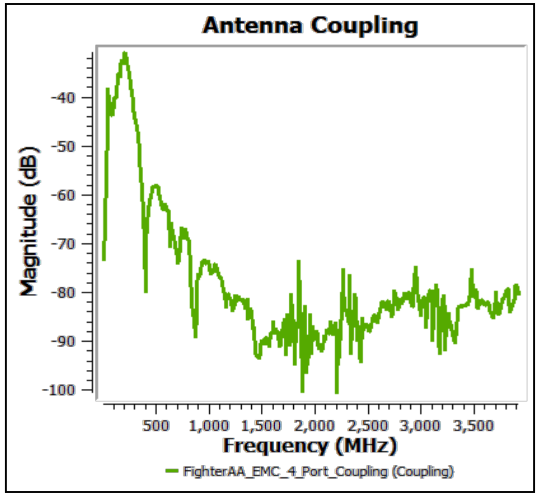
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
CASCADED RF PERFORMANCE					
RF Frequency	L1 band		1575.42		MHz
Noise Figure	LNA1 input active, default mode (Note 3)		1.4		dB
	LNA2 input active, default mode (Note 3)		2.7		
	Measured at the mixer input		10.3		
Out-of-Band 3rd-Order Input Intercept Point	Measured at the mixer input (Note 4)		-7		dBm
In-Band Mixer Input Referred 1dB Compression Point	Measured at the mixer input		-85		dBm
Mixer Input Return Loss			10		dB
Image Rejection			25		dB
Spurs at LNA1 Input	LO leakage		-101		dBm
	Reference harmonics leakage		-103		
Maximum Voltage Gain	Measured from the mixer to the baseband analog output	91	96	103	dB
Variable Gain Range		55	59		dB
FILTER RESPONSE					
Passband Center Frequency			4		MHz
Passband 3dB Bandwidth	FBW = 00		2.5		MHz
	FBW = 10		4.2		
	FBW = 01		8		
Lowpass 3dB Bandwidth	FBW = 11		9		MHz
Stopband Attenuation	3rd-order filter, bandwidth = 2.5MHz, measured at 4MHz offset		30		dB
	5th-order filter, bandwidth = 2.5MHz, measured at 4MHz offset	41	49.5		
LNA					
LNA1 INPUT					
Power Gain			19		dB
Noise Figure			0.83		dB
Input IP3	(Note 5)		-1.1		dBm
Output Return Loss			10		dB
Intput Return Loss			8		dB
LNA2 INPUT					
Power Gain			13		dB
Noise Figure			1.14		dB
Input IP3	(Note 5)		1		dBm
Output Return Loss			19		dB
Input Return Loss			11		dB

Measured Data

- Ideally, we would love to have measured data for all systems and all coupling
- Typically, do not have this luxury but should use measured data when possible
- Can work with S-parameters in Touchstone format or simple frequency-amplitude pairs







** 2010 EMC Symposium, "An Automated Measurement System for Cosite Interference Analysis", Delcross Technologies, LLC.*

Electro Magnetic Applications, Inc.

Installed Antenna Modeling

ANSYS HFSS The Industry's Premier EM Field Simulator

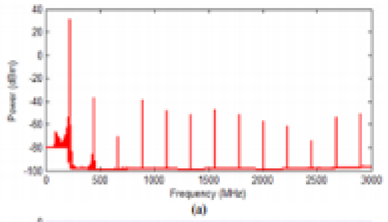
FEKO Comprehensive Electromagnetic Solutions

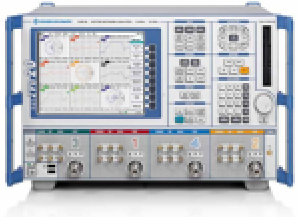
CST

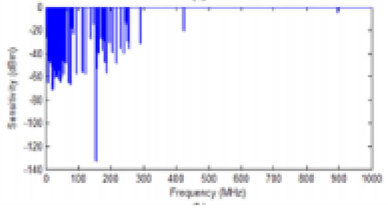
WIPL-D

GALILEO EMT

Measurements







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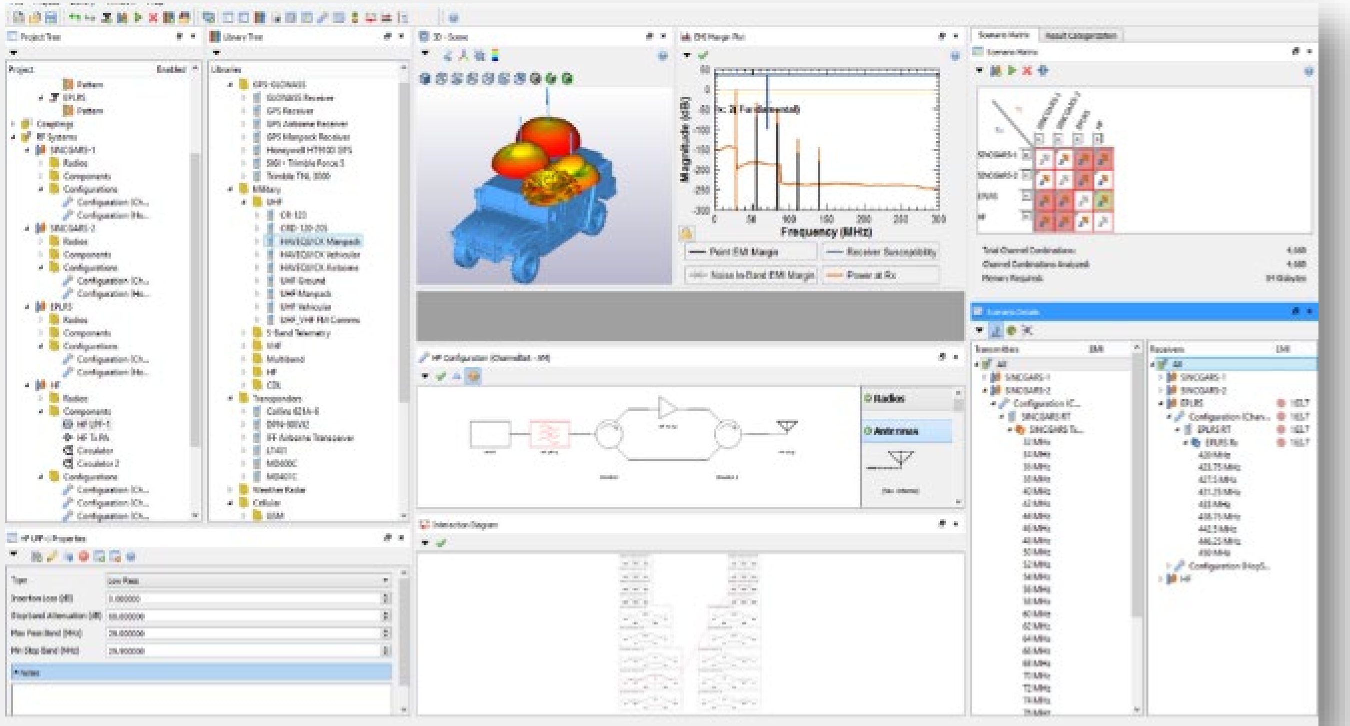
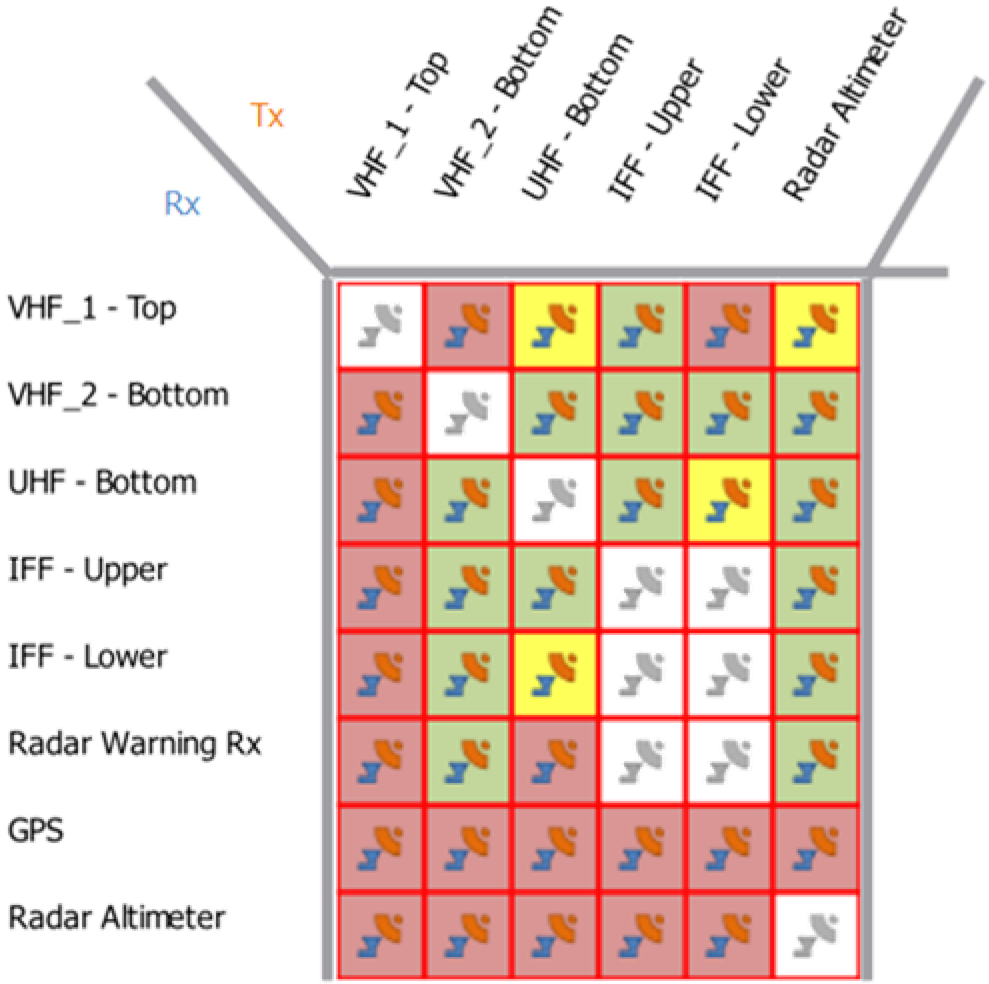


Output of Cosite Analysis



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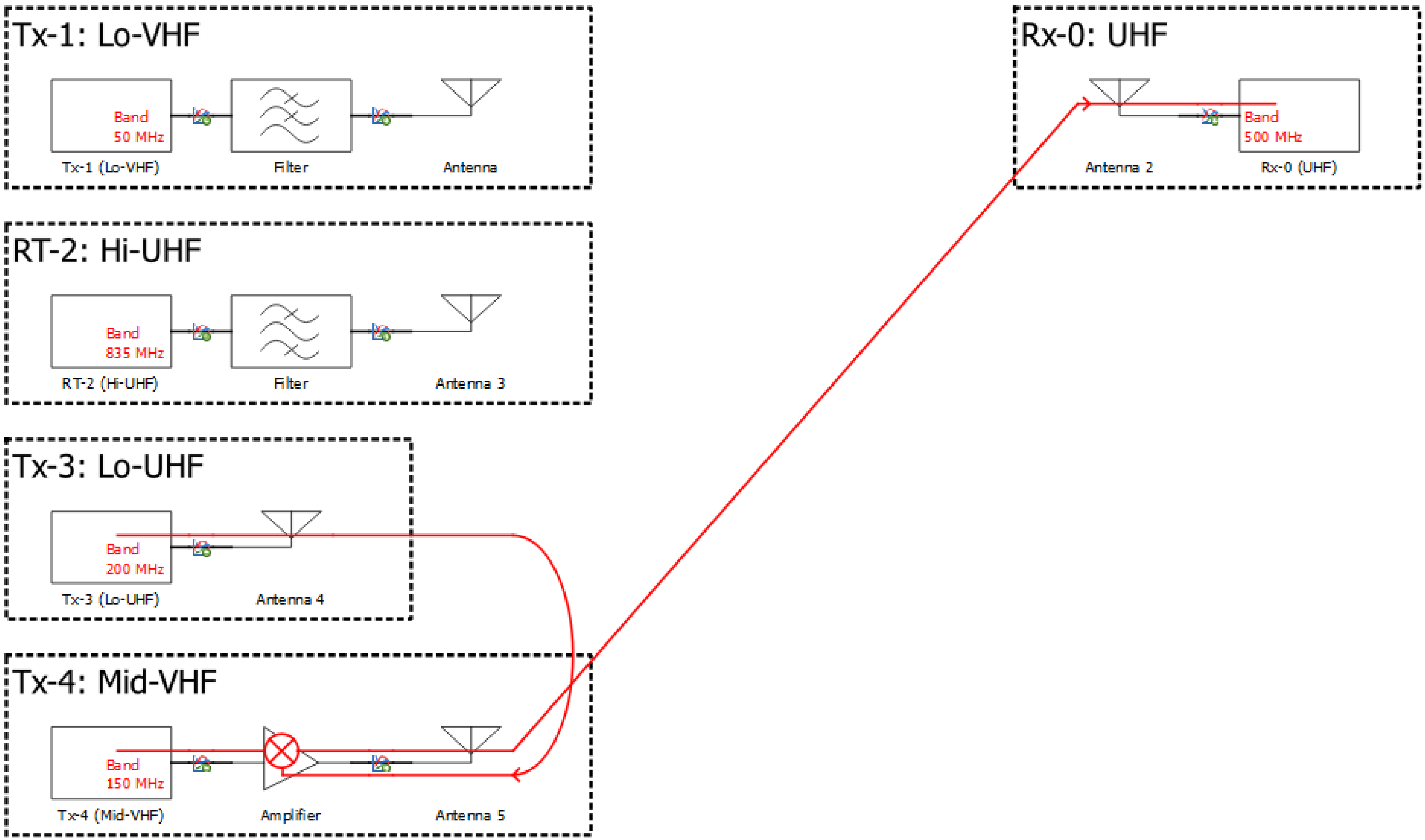

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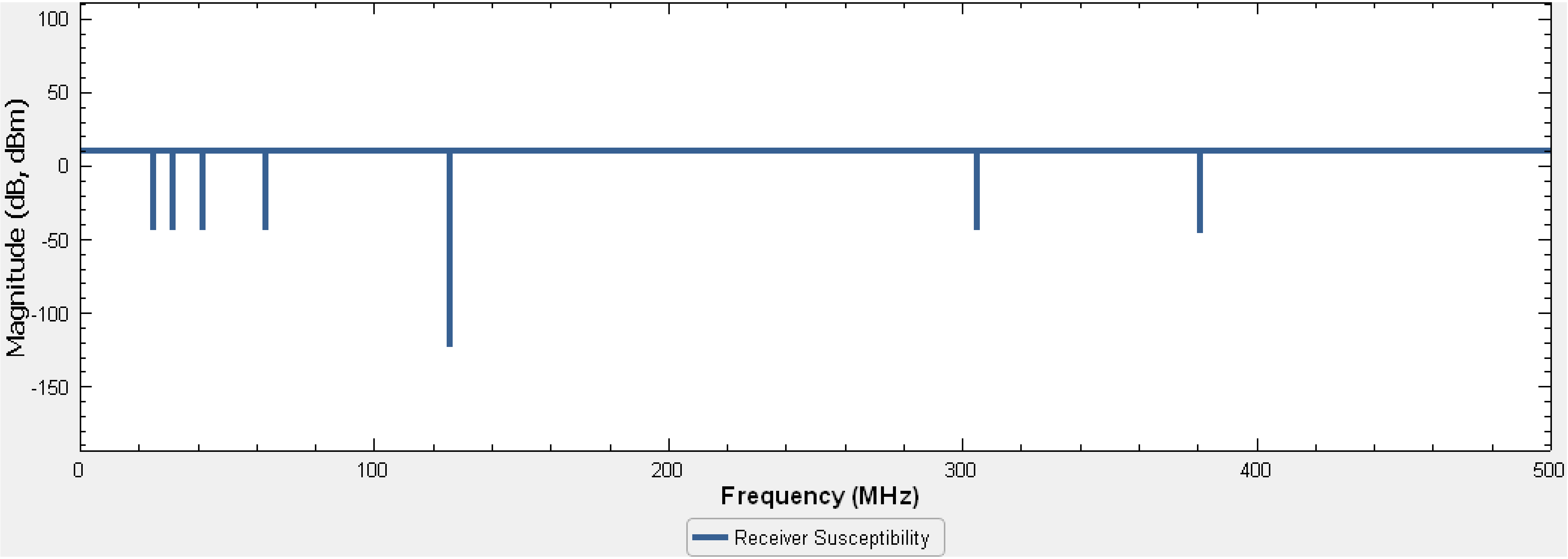

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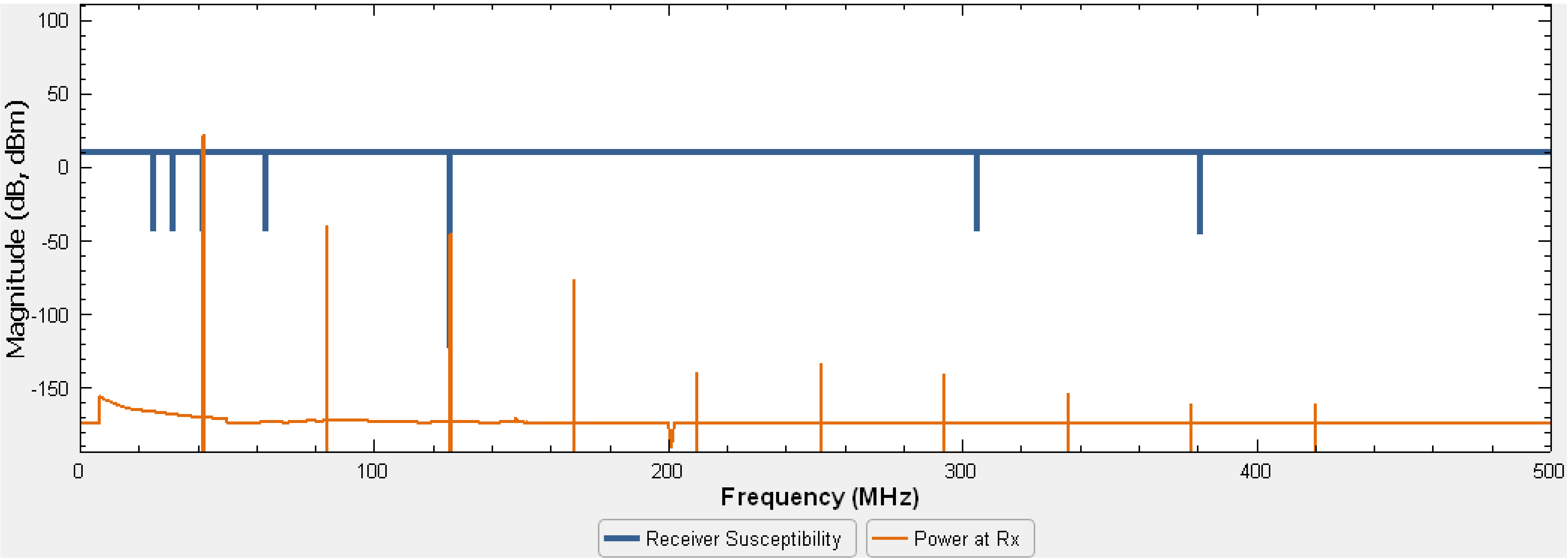

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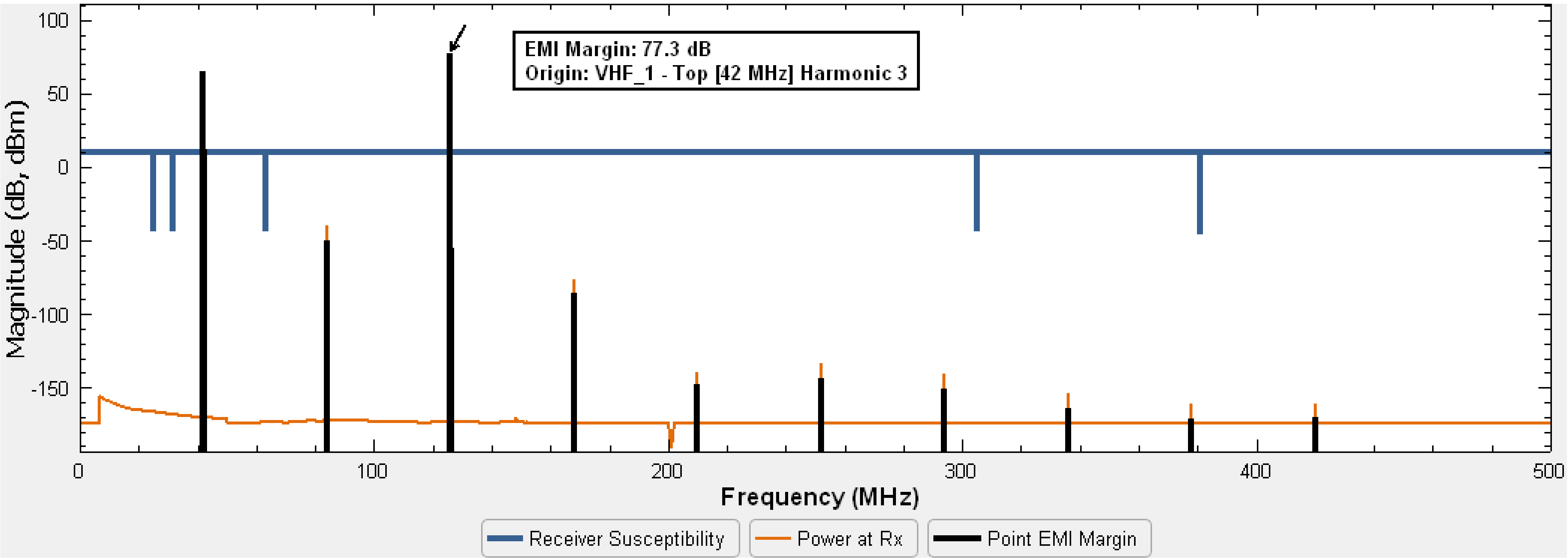

Summary

- Testing is important and necessary, but…
  - It is expensive
  - Time consuming
  - Does not provide insight to specific mechanisms
- Our team of experts works with you to
  - Find interference problems
  - Guide testing
  - Mitigate problems
  - Influence new designs to avoid problems
  - Save money
  - Get your product to market on time