802.11ax DVT Testing

3 Pitfalls You Need To Avoid

November 2017

802.11ax High Efficiency (HE) Wi-Fi

Making Wi-Fi Hot Spots a Reality

Can’t Test 802.11ax Like 802.11ac

Technology Layers & 802.11ac Compatibility

MU-MIMO OFDMA

MIMO OFDMA

OFDMA

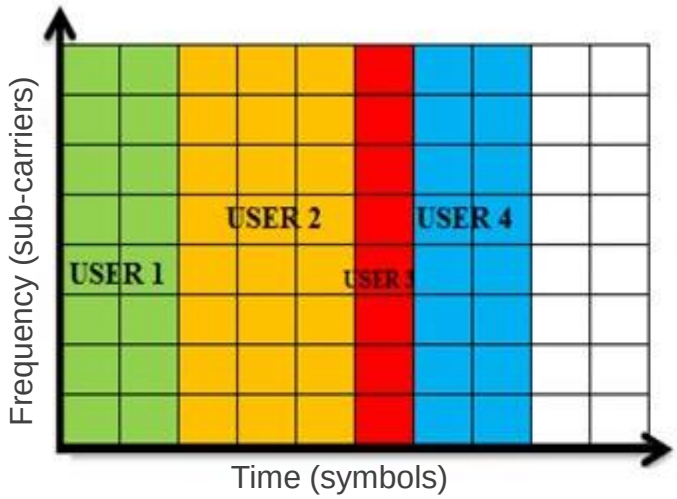
OFDM

✗ Incompatible

✓ Compatible

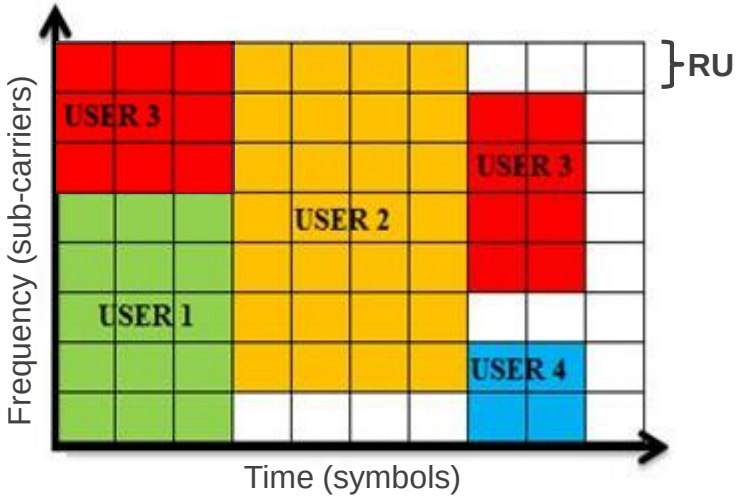
OFDMA
Support More Users with Dynamic Spectrum Allocation

OFDM



- Support one user at a time
- Same power level for all sub-carriers

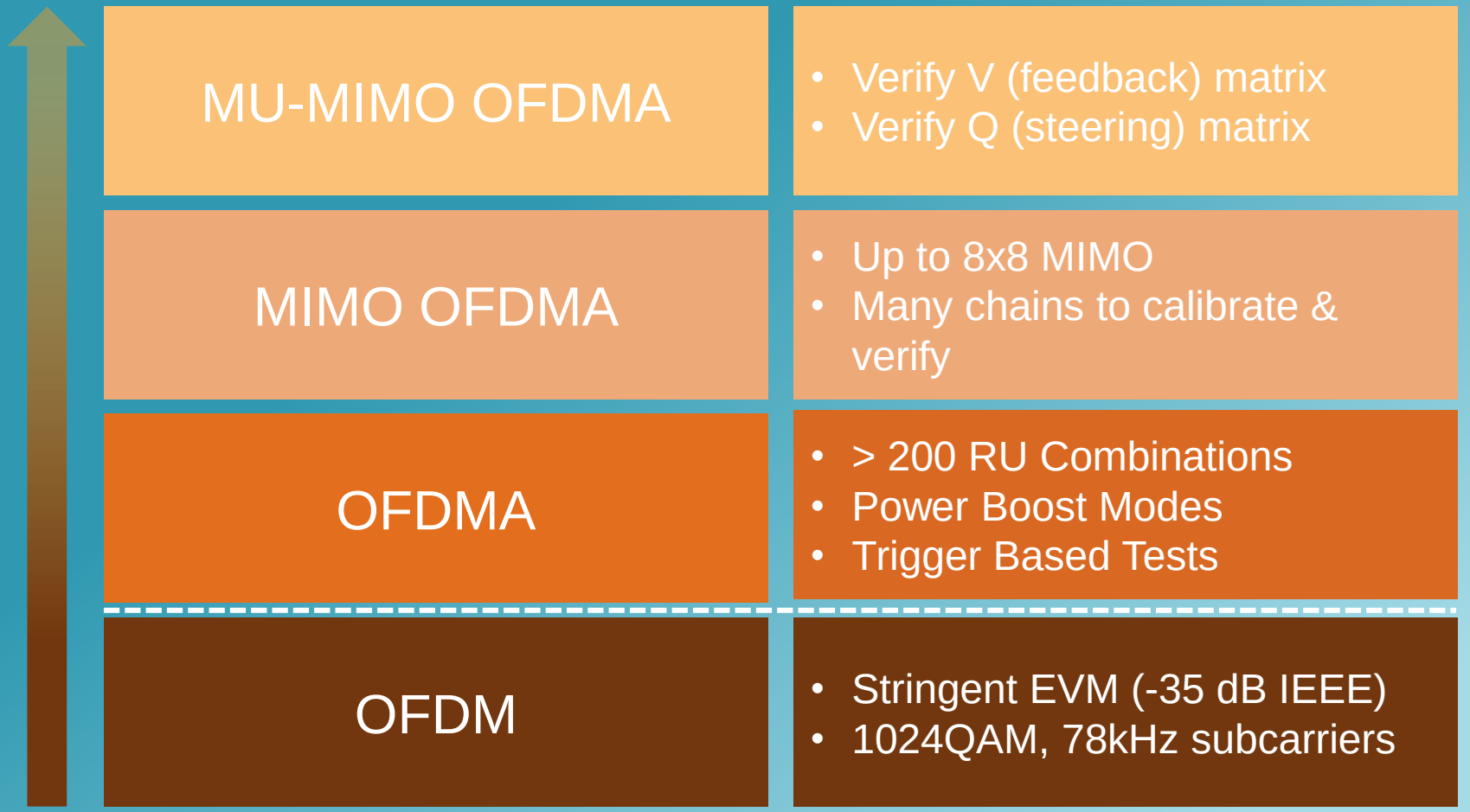
OFDMA



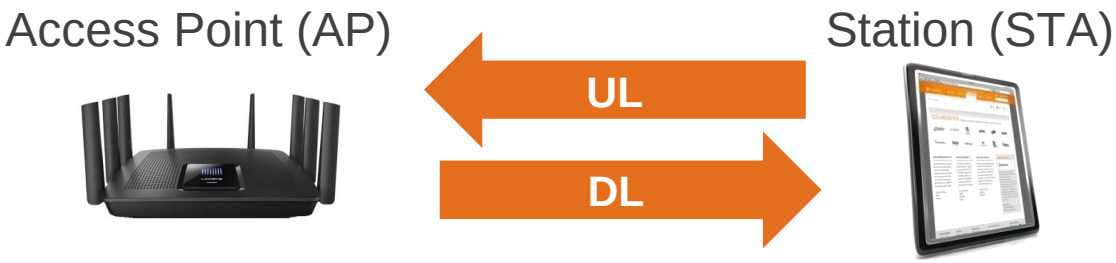
- Can support multiple users at a time
- Varying power levels

Can’t Test 802.11ax Like 802.11ac

Technology Layers & Key Test Coverage



Understanding 802.11ax Key DVT Test Items

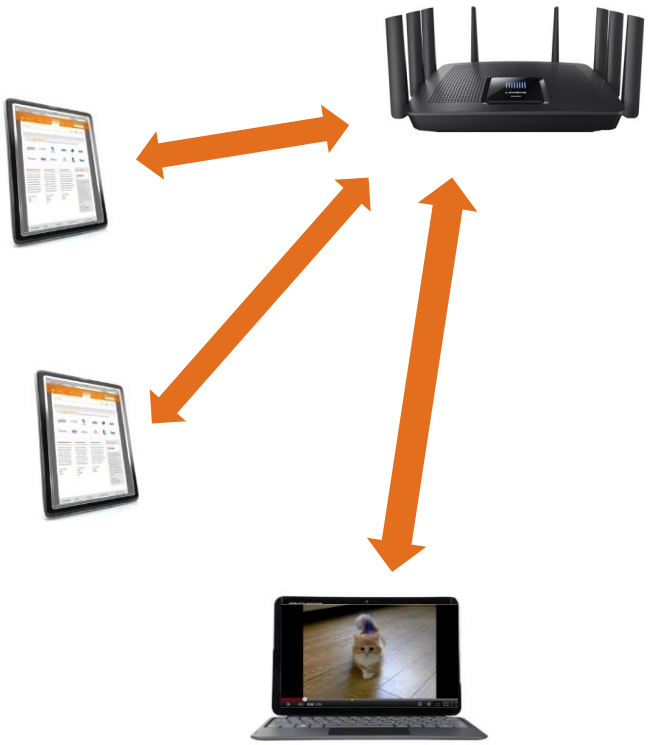


	AP	STA
Synchronization		Carrier Frequency Offset (CFO)
		Timing Synchronization
Rx	Interference / coexistence	Interference / coexistence
Power	Power Boost Mode	
		Power Control
		RSSI CAL / Verify
EVM	EVM to individual RUs	EVM of individual RUs
	EVM vs. Power	EVM vs. Power
Data Rates	More rates and more user combinations	More rates and more user combinations

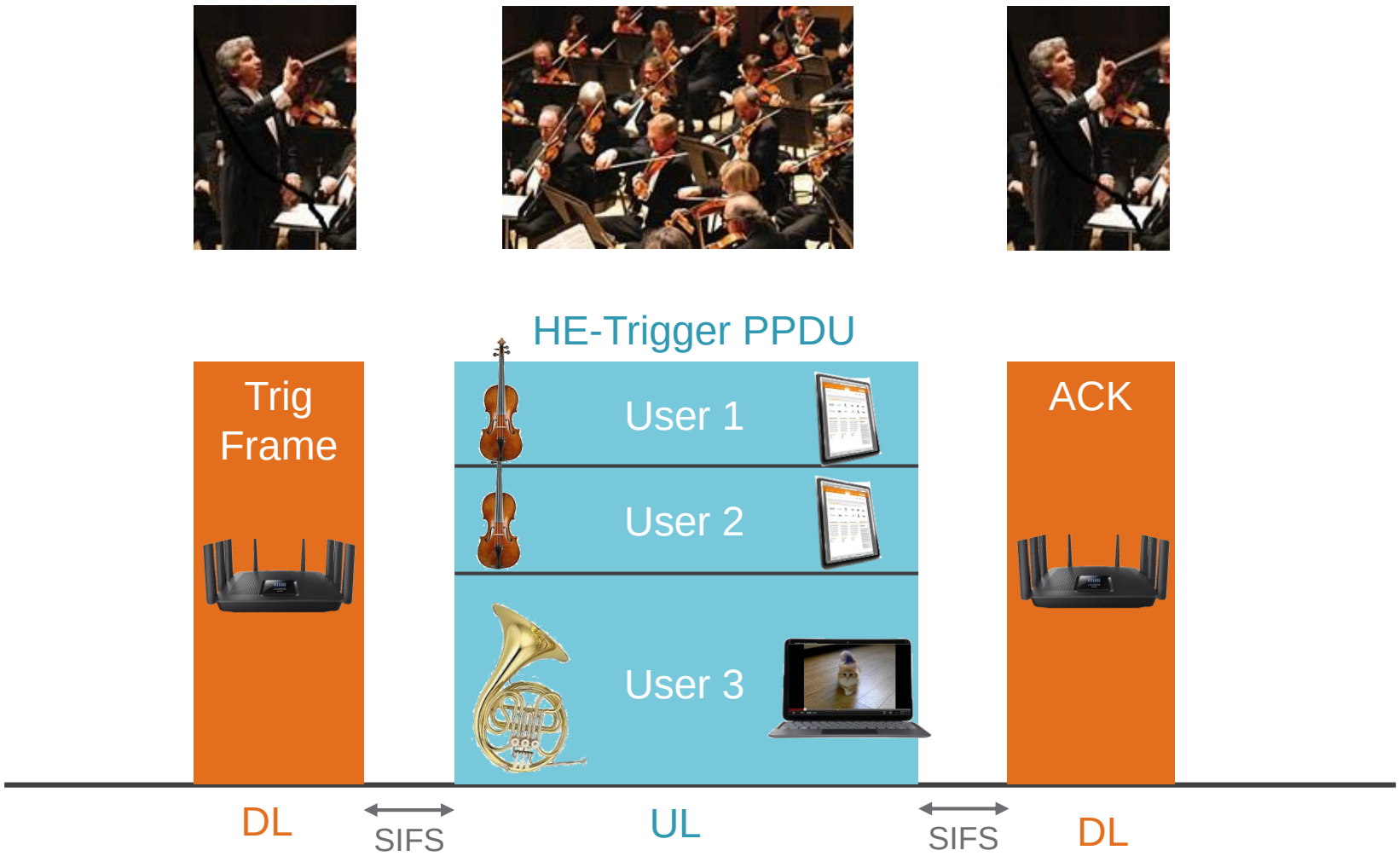
DVT Test Case #1 : Trigger Based Testing (TBT)

11ax requires precise synchronization of stations

1) At the same time (Δt < 400 ns)
2) At the same carrier frequency (Δf <350 Hz)



DVT Test Case #1 : Trigger Based Testing (TBT)



Trigger Based Testing Examples

Station (STA) DUT

"AP" sends pre-generated Trigger Frame

Tester

"AP"

DL

STA

STA sends UL PPD for analysis

UL

Access Point (AP) DUT

Arms the tester VSG and AP sends Trigger Frame for analysis

DL

AP

"STA" sends UL PPD for analysis

UL

Tester

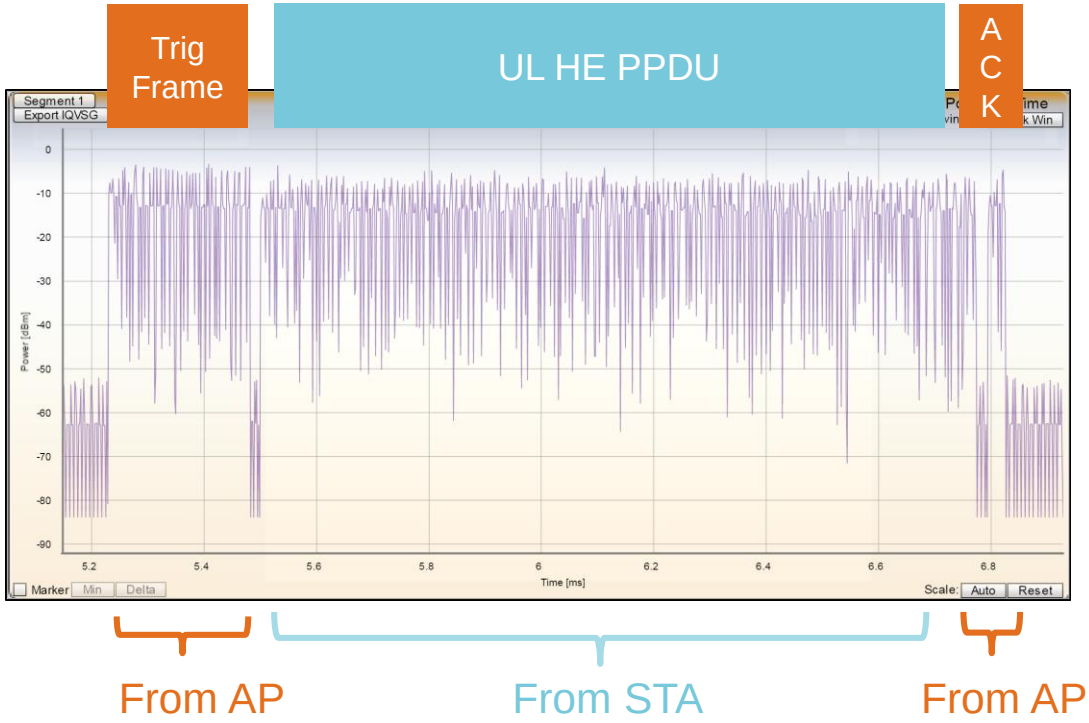
"STA"

AP sends ACK

DL

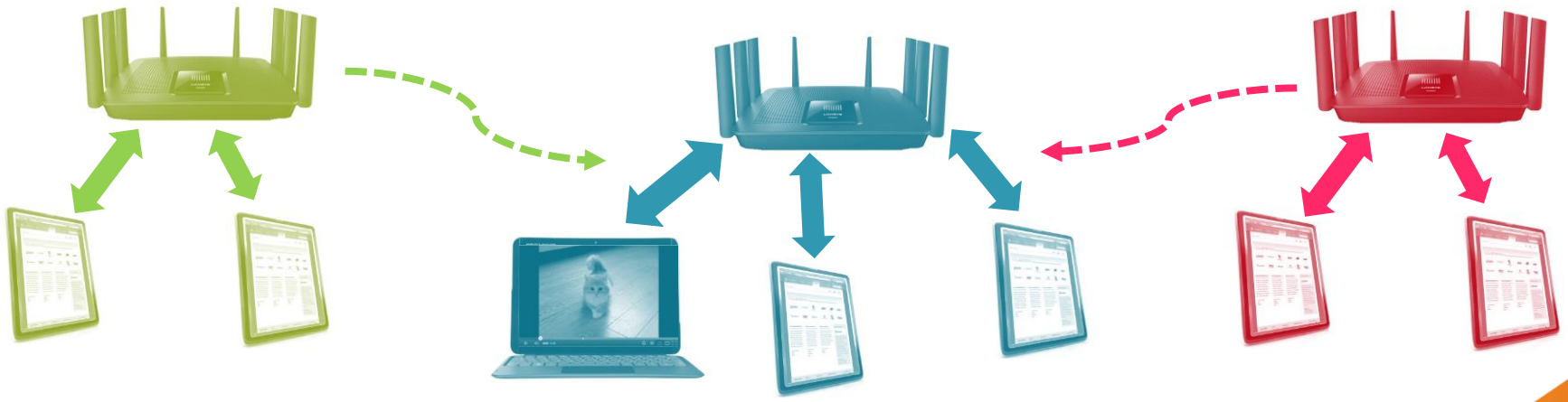
Introduce Impairments for Real World Testing

- Introduce impairments to stress-test a DUT
- Types of Impairments:
  - Center Frequency Offset
  - Sampling Frequency Offset
  - Timing differences
  - Power differences



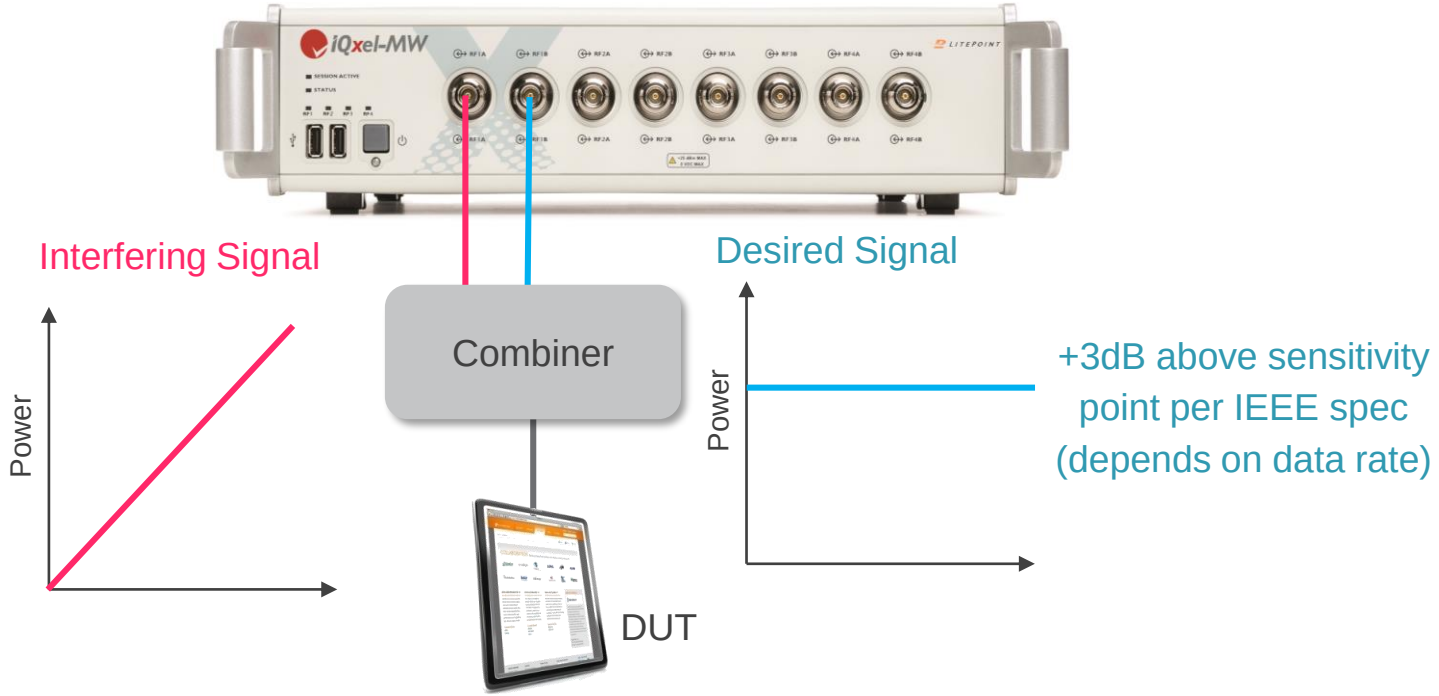
DVT Test Case #2 : Interference / Coexistence Test

11ax needs to tolerate interference from other sources



Example Setup : Adjacent & Nonadjacent Channel Rejection Test

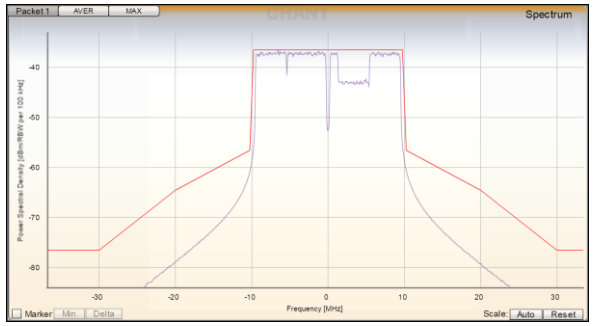
- Monitor the DUT's PER while varying the Interfering Signal's power level



802.11ax Devices Need More Test Combinations

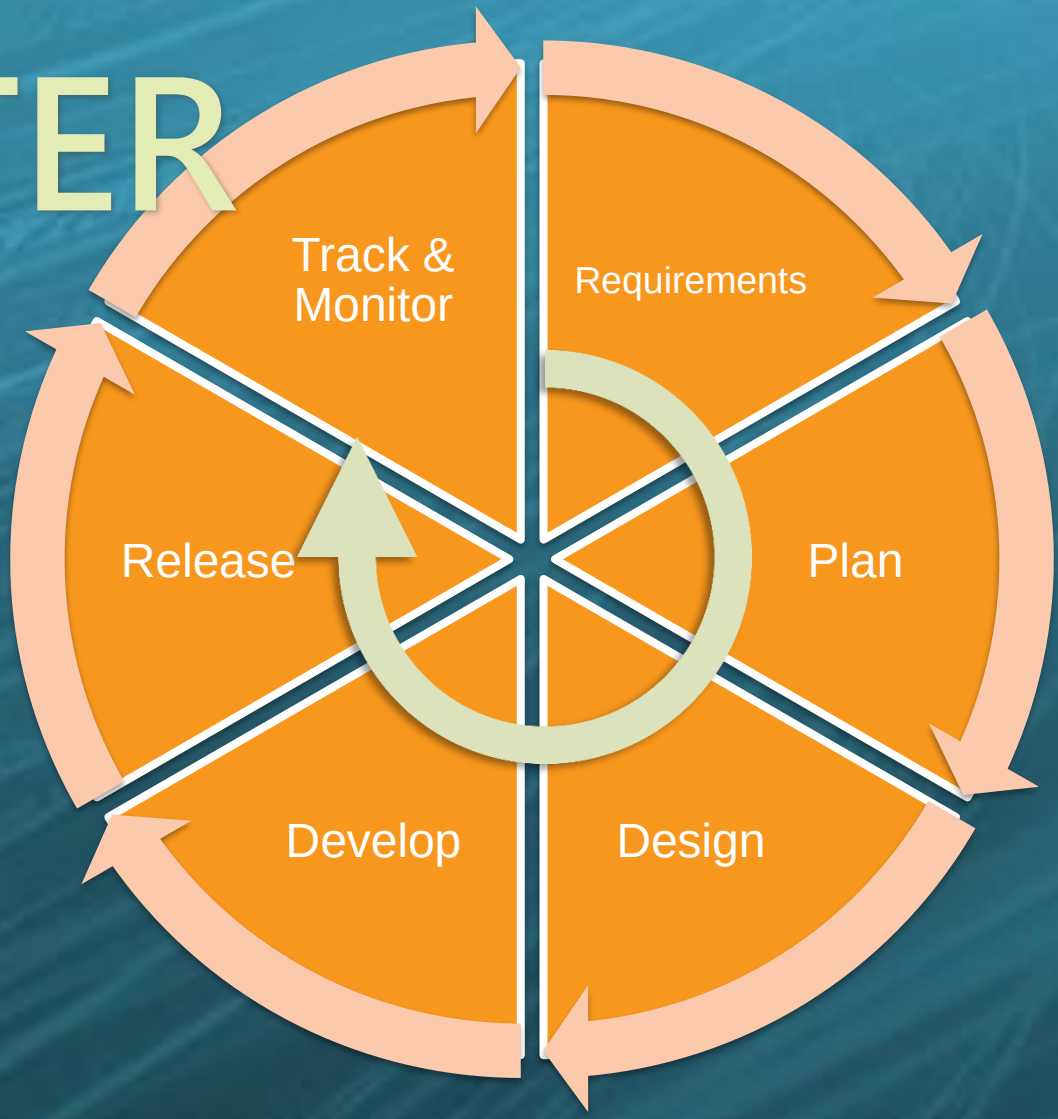
Exponential Increase
in Test Permutations
and Test Time!!

- Frequency
- Frequency Offset
- Power Level
- Timing Offset
- MIMO streams
- RU Combinations
  - RU size
  - RU power



802.11ax Devices Need Agile Development

FASTER



Writing One Test at a Time Takes Forever


```
for txText = txTest_0 to txText_14
{
    for freq = freq_0 to freq_9
    {
        for power = power_0 to power_9
        {
            for dataRate = dataRate_0 to dataRate_9
            {
                for freqOff = freqOff_0 to freqOff_9
                {
                    for timingOffset = timingOffset_0 to timingOffse
                    {
                        for ruCombo = ruCombo_0 to ruCombo_199
                        {
                            MakeMeasurements();
                        }
                    }
                }
            }
        }
    }
}
```

```
TX_MULTI_VERIFICATION   5180 MCS1 BW-20 TX1
TX_MULTI_VERIFICATION   4945 HALF-27 BW-10 TX1
TX_MULTI_VERIFICATION   5180 MCS7 BW-20 TX1
TX_MULTI_VERIFICATION   5190 MCS5 BW-40 TX3
TX_MULTI_VERIFICATION   5180 OFDM-6 BW-20 TX1
TX_MULTI_VERIFICATION   5180 OFDM-6 BW-20 TX2
TX_MULTI_VERIFICATION   5180 OFDM-6 BW-20 TX3
TX_MULTI_VERIFICATION   5180 OFDM-6 BW-20 TX4
TX_MULTI_VERIFICATION   5180
TX_MULTI_VERIFICATIO
TX_MULTI_VERI
TX_MULTI_VE
TX_MULTI_VE
TX_MULTI
TX_MULTI
TX_SWEEP
TX_SWEEP
TX_SWEEP
RX_VERIF
RX_VERIFY_
RX_VERIFY_PER
RX_VERIFY_PER
RX_VERIFY_PER   5180 MCS
RX_VERIFY_PER   5180 MCS2 BW-20 RX6
RX_VERIFY_PER   5180 MCS2 BW-20 RX7
RX_VERIFY_PER   5180 MCS2 BW-20 RX8
RX_VERIFY_PER   5180 MCS2 BW-20 RX3
RX_VERIFY_PER   5180 MCS2 BW-20 RX7
RX_VERIFY_PER   4985 HALF-27 BW-10 RX1
RX_VERIFY_PER   5190 MCS2 BW-40 RX1
RX_SWEEP_PER
RX_SWEEP_PER
DISCONNE
REMOVE_
GLOBAL_
INSER
INIT
CONN
LOAD_
MRVL_
TEST_
TEST_
TEST_VERI
TEST_VERIF
TEST_VERIFY PER   5180 MCS3 BW-20 ANT3
TEST_VERIFY PER   5180 MCS3 BW-20 ANT4
TEST_VERIFY PER   5180 MCS5 BW-20 ANT5
TEST_VERIFY PER   5180 MCS3 BW-20 ANT6
TEST_VERIFY PER   5180 MCS3 BW-20 ANT7
TEST_VERIFY PER   5180 MCS3 BW-20 ANT8
TEST_VERIFY PER   5180 MCS3 BW-20 ANT3
```

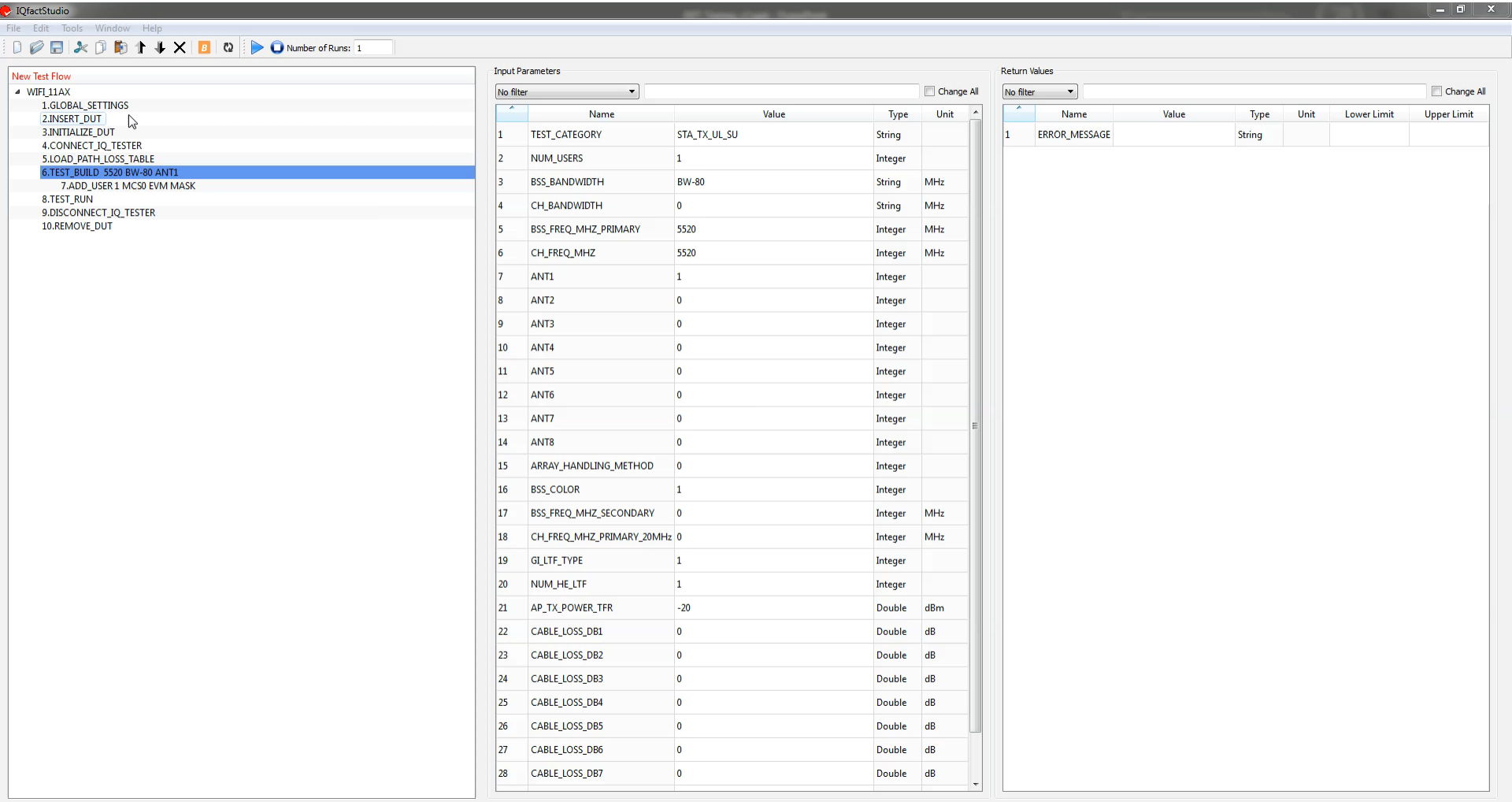
How am I going to cover all these tests??

Did I cover all the tests??

Can't tweak if I program the tests in loops

Batch Generation Tool

Create DVT Test Flows with IQfactStudio



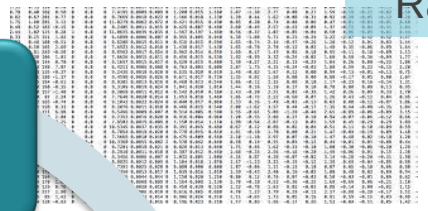
802.11ax Produces Massive Data

Raw Data

Can We Make Data Analysis Easier?

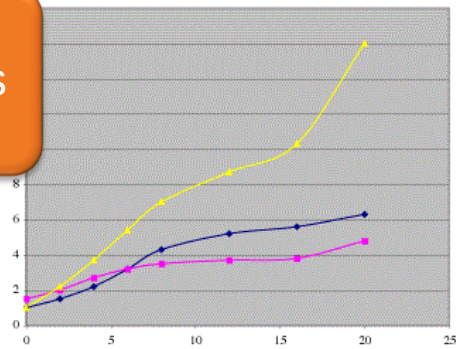
Make Measurements

Raw Test Data



Copy & Paste Data into Spreadsheet

Configure Plots



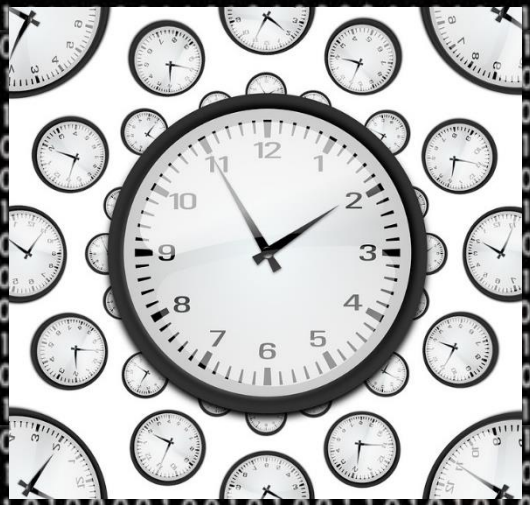
Analyze Data

Make Adjustment to Design

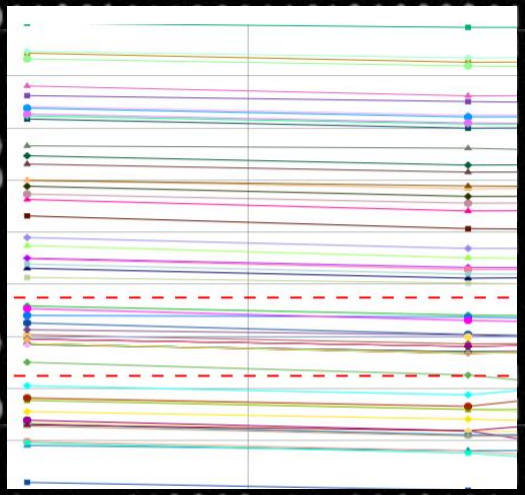
Meaningful Data

Dangers of Home-grown Data Analysis Solutions

Time



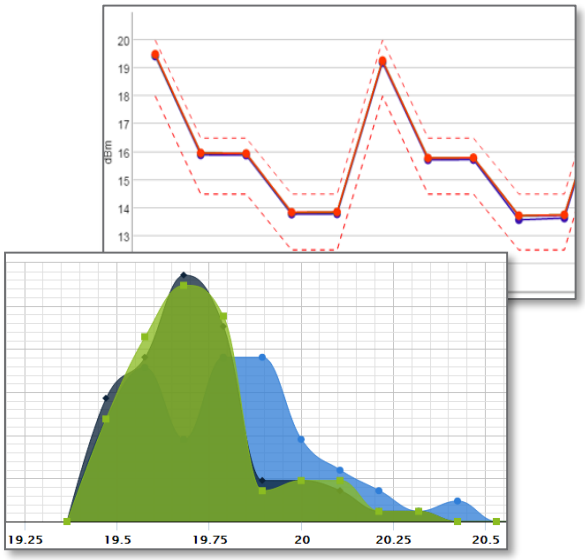
Incomplete Analysis

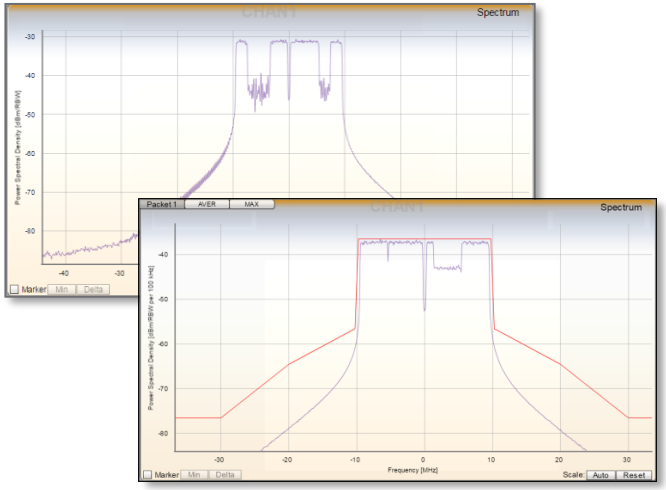


Boredom

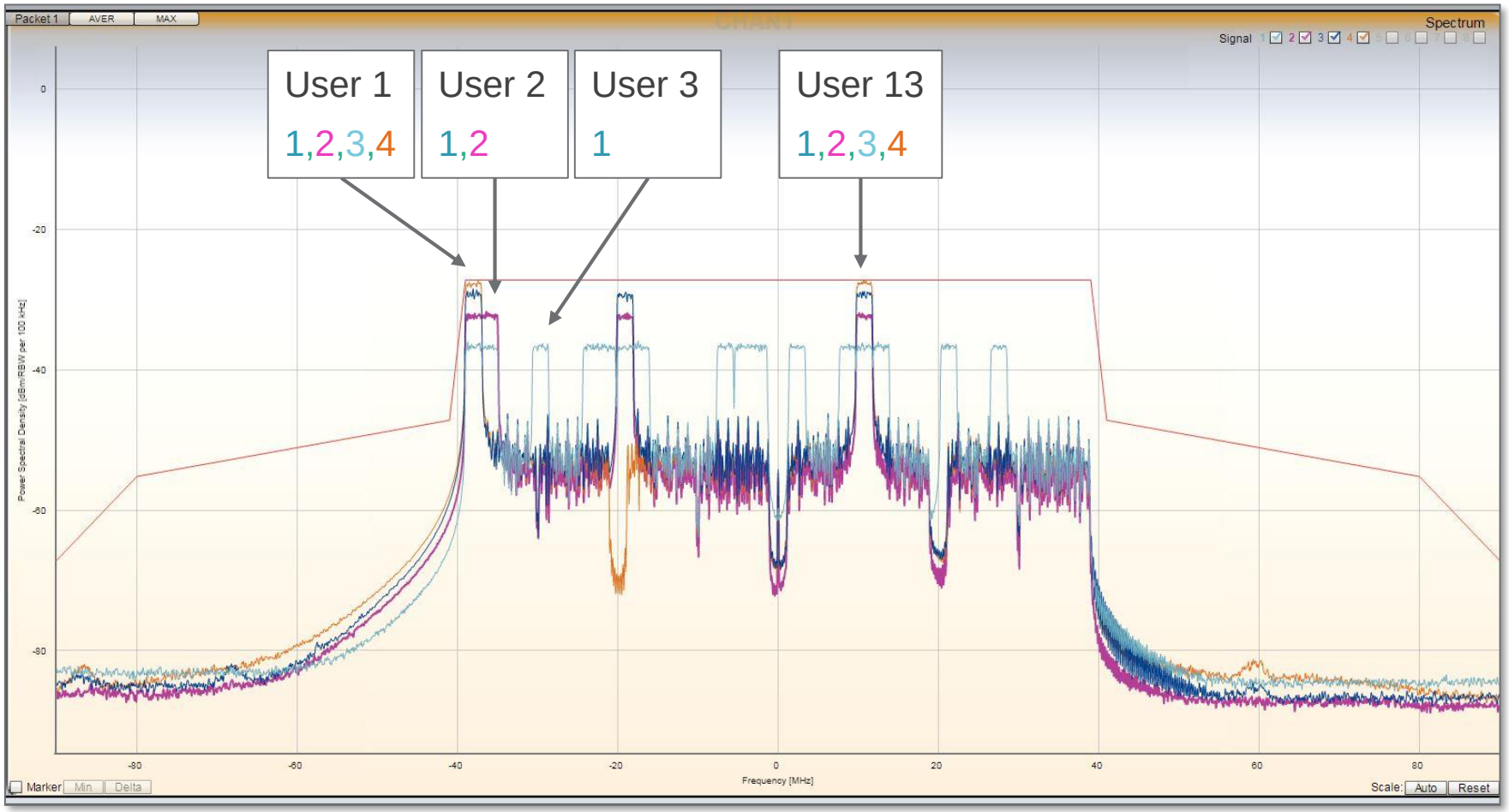
3 Requirements of Data Analysis

- Quickly Visualize Data
- Maximize Engineering Resource Efficiency
- Adapt to Changing Datasets

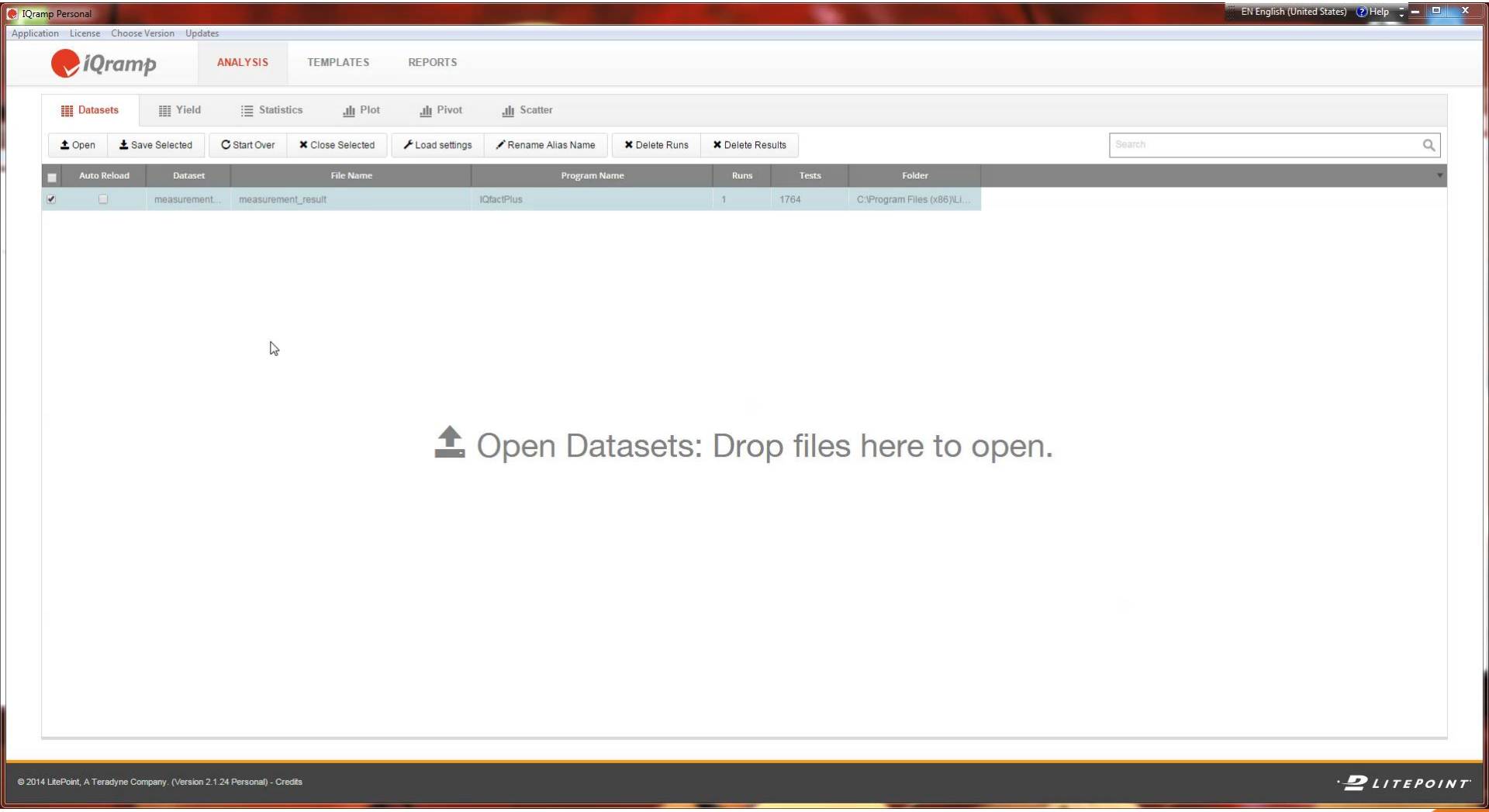




11ax DVT Data Requires More Thorough Analysis



11ax DVT Data Analysis



802.11ax DVT Testing Pitfalls

1. Testing 11ax like 11ac
   - ✓ Apply new test methodologies to fully test 11ax devices

2. Not enough coverage
   - ✓ Create complex test flows quickly

3. Overwhelming amount of data
   - ✓ Select optimized data analysis tool

Q & A