



802.11ax DVT Testing
3 Pitfalls You Need To Avoid
November 2017

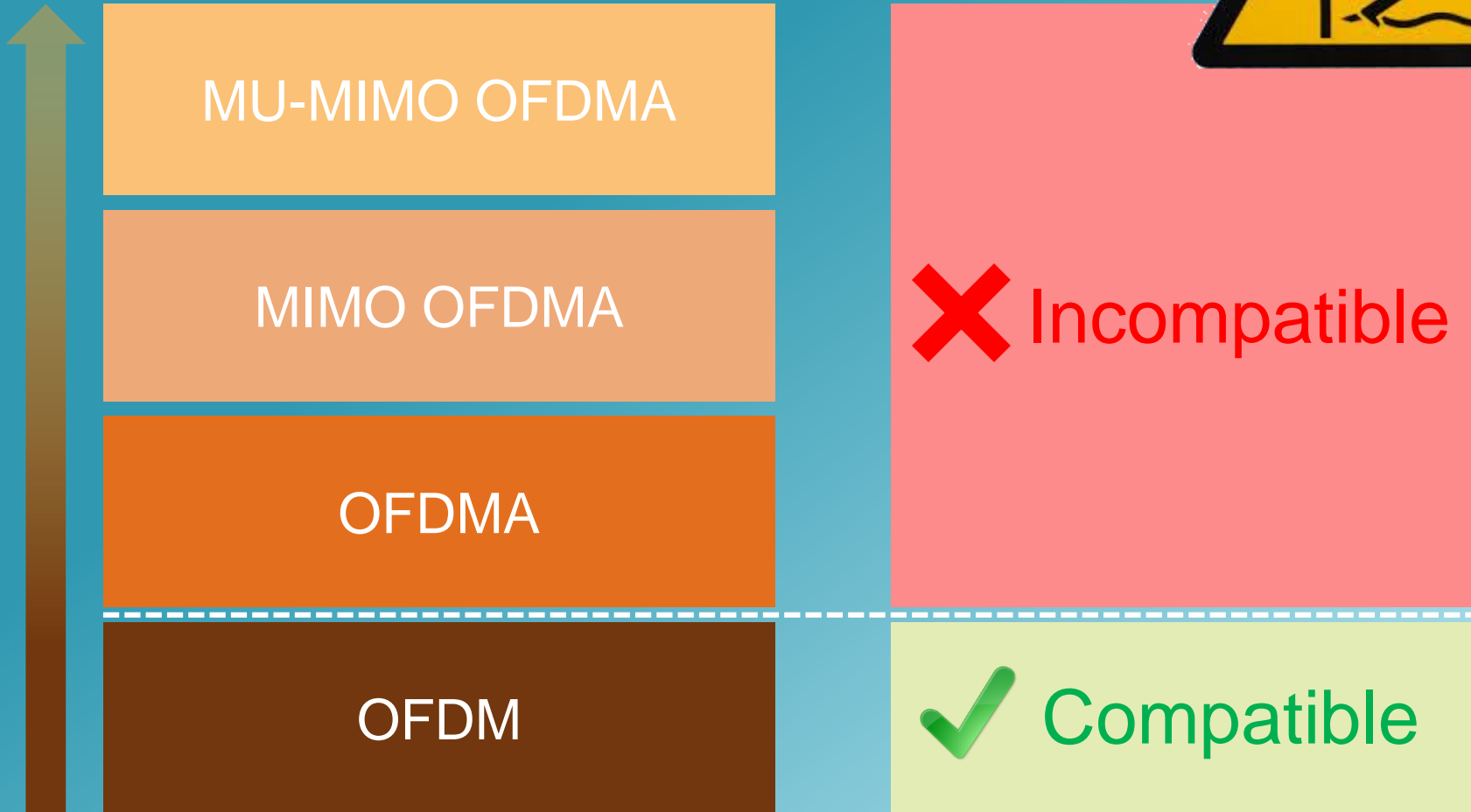
802.11ax High Efficiency (HE) Wi-Fi

Making Wi-Fi Hot Spots a Reality



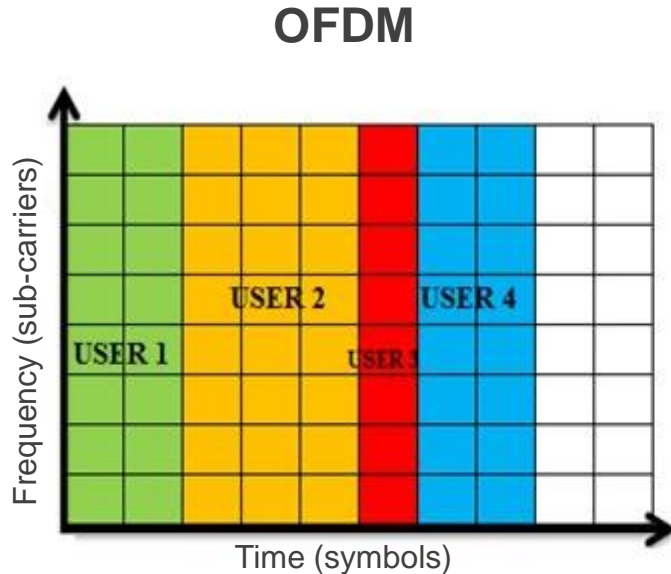
Can't Test 802.11ax Like 802.11ac

Technology Layers & 802.11ac Compatibility

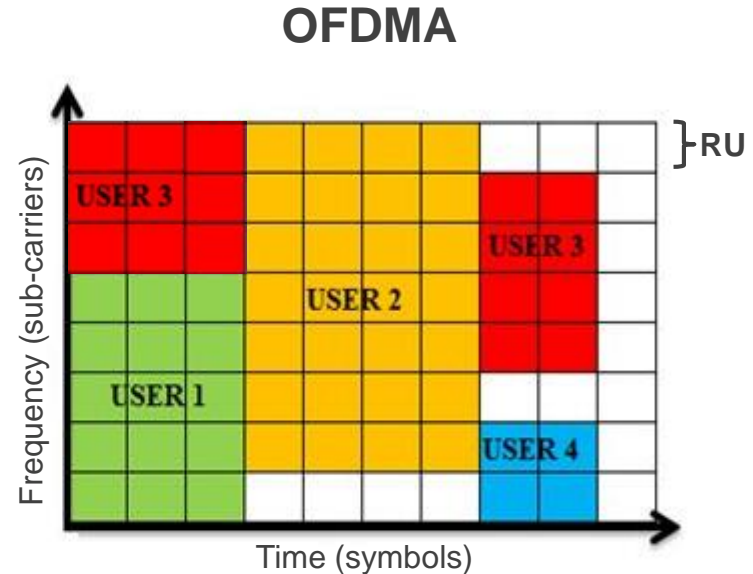


OFDMA

Support More Users with Dynamic Spectrum Allocation



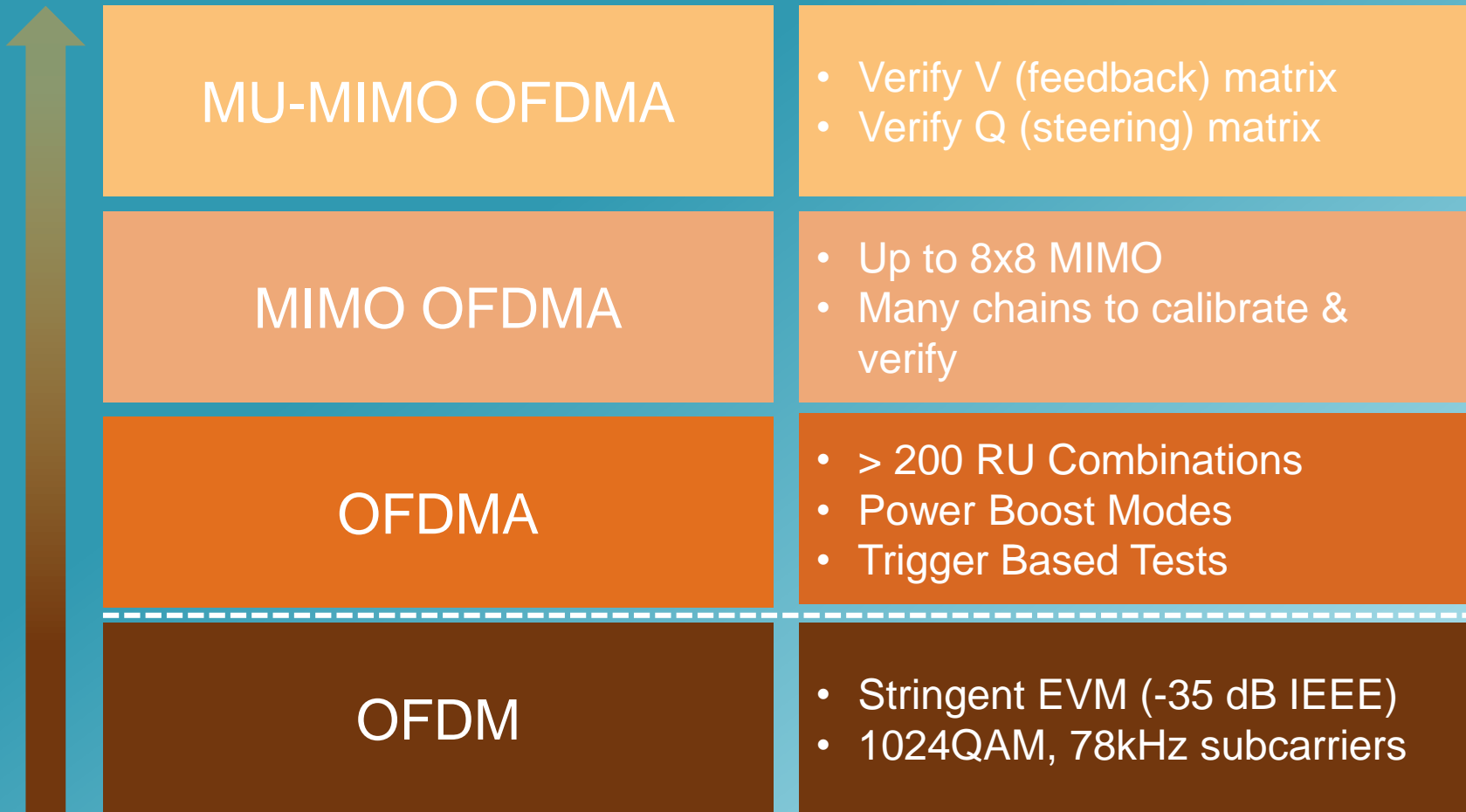
- Support one user at a time
- Same power level for all sub-carriers



- 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

Access Point (AP)



Station (STA)



	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 ($\Delta t < 400$ ns)
- 2) At the same carrier frequency ($\Delta f < 350$ Hz)



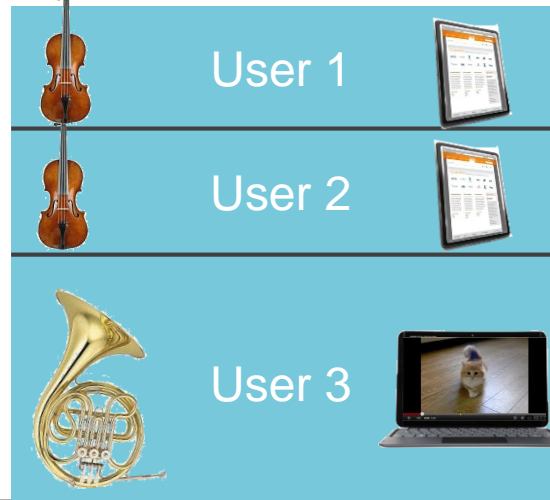
DVT Test Case #1 : Trigger Based Testing (TBT)



HE-Trigger PPDU



DL



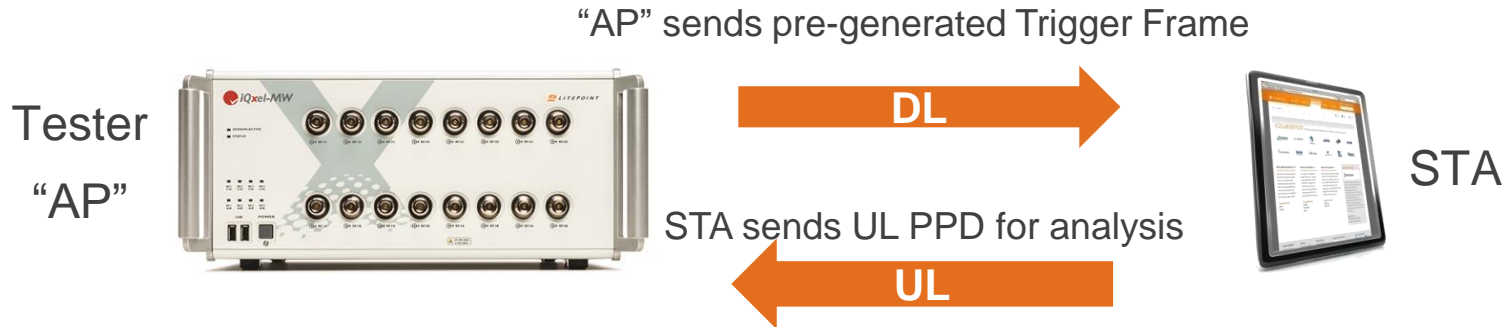
UL



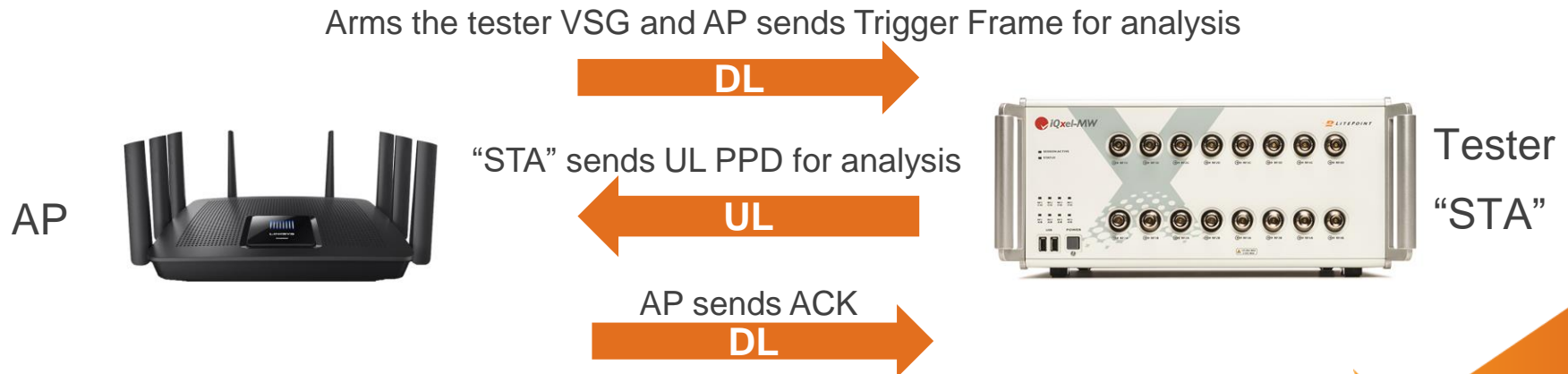
DL

Trigger Based Testing Examples

Station (STA) DUT



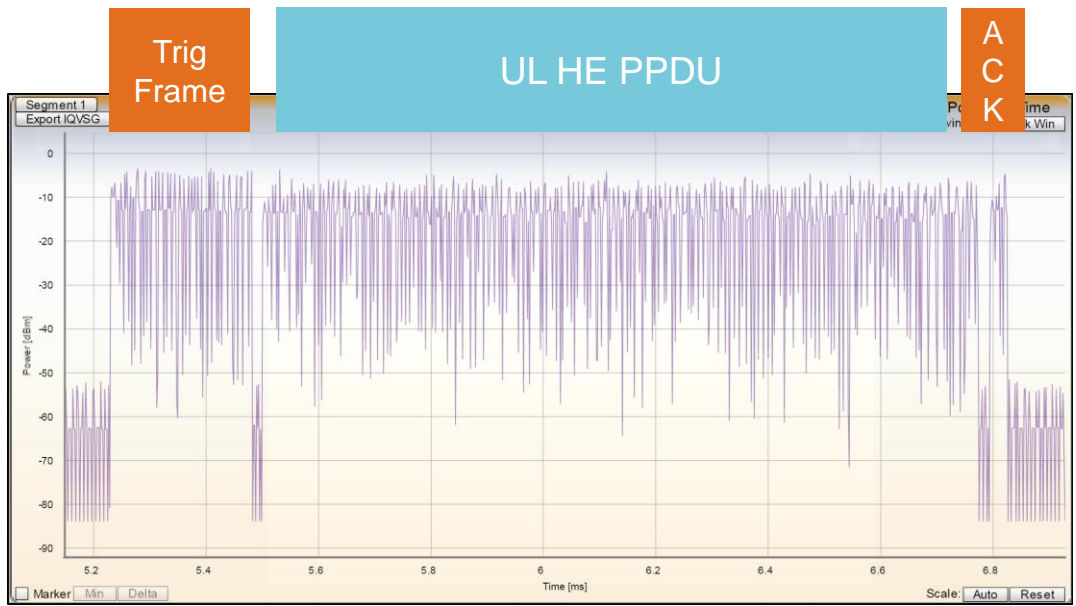
Access Point (AP) DUT



Introduce Impairments for Real World Testing



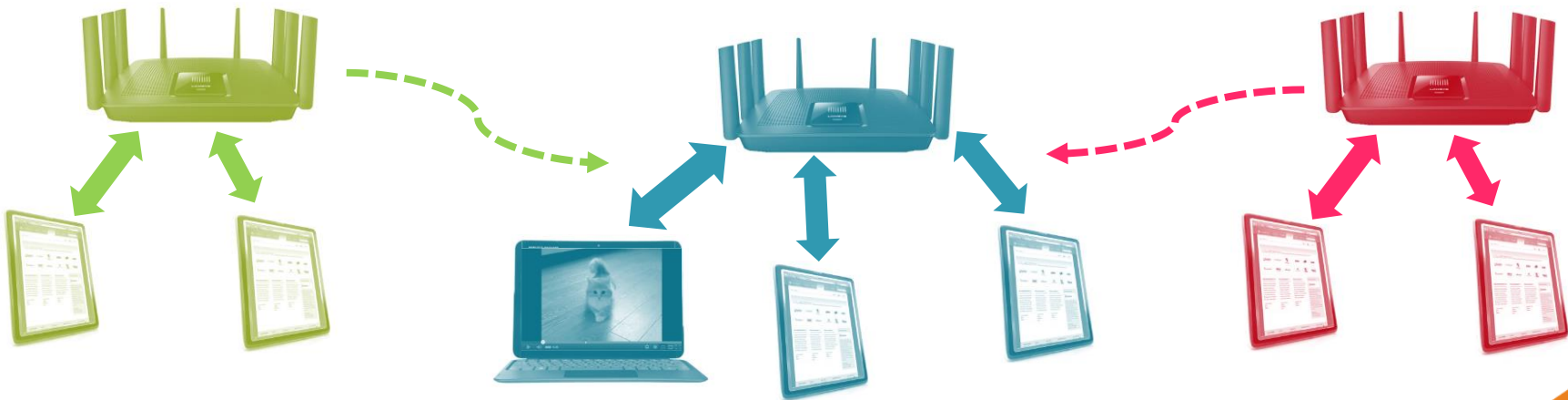
- Introduce impairments to stress-test a DUT
- Types of Impairments:
 - Center Frequency Offset
 - Sampling Frequency Offset
 - Timing differences
 - Power differences



From AP From STA From AP

DVT Test Case #2 : Interference / Coexistence Test

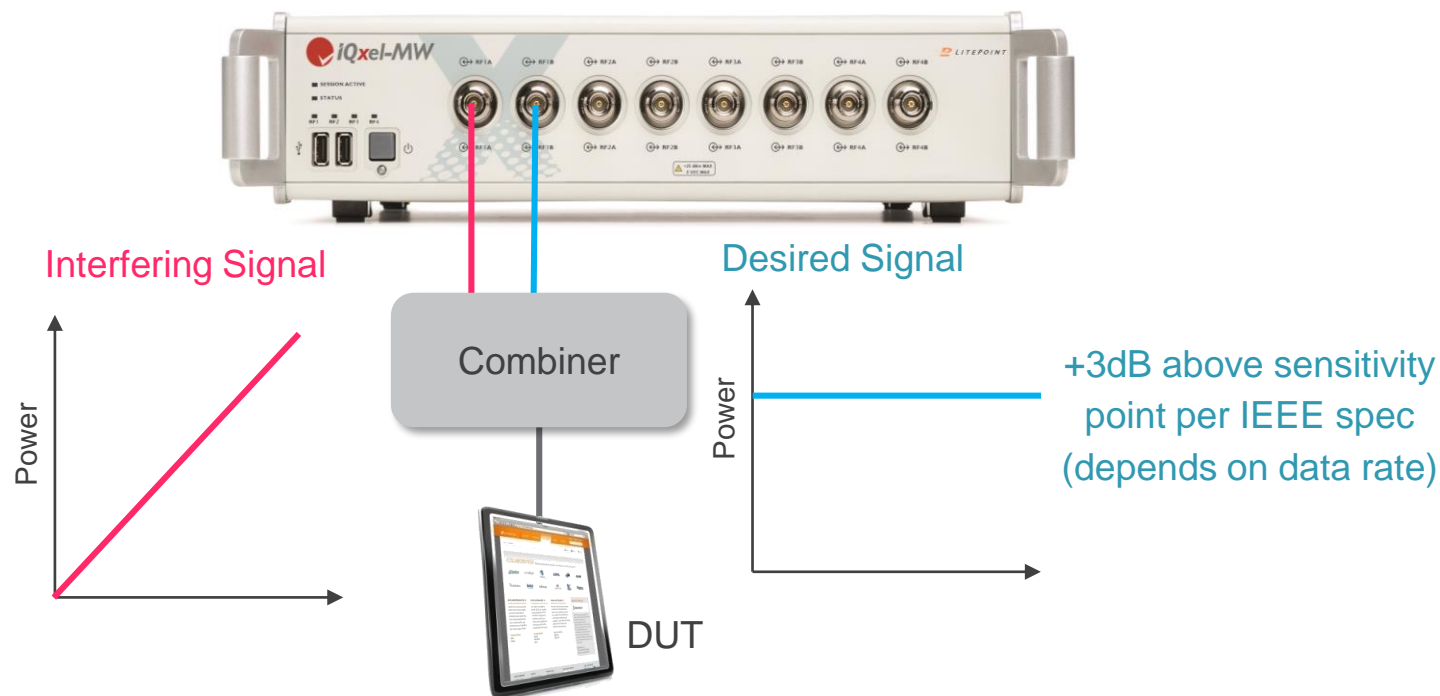
11ax needs to tolerate interference from other sources



Example Setup : Adjacent & Nonadjacent Channel Rejection Test

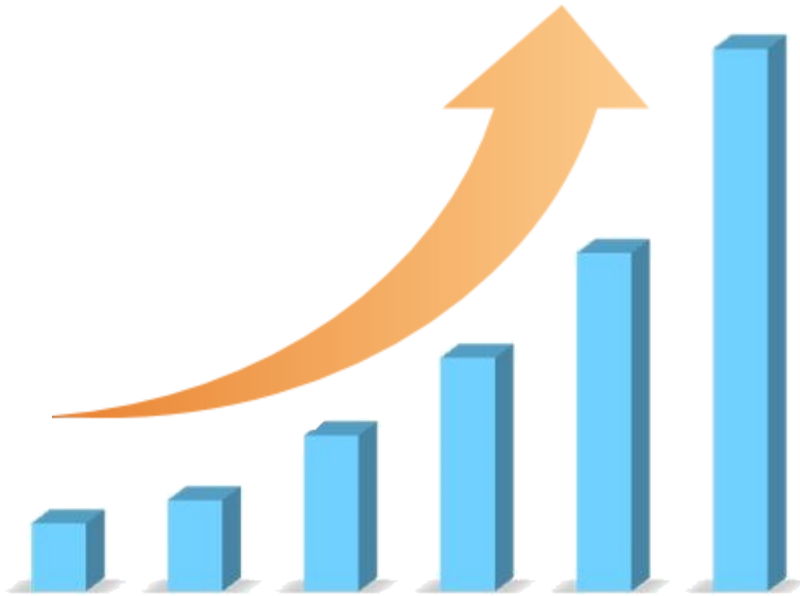


- Monitor the DUT's PER while varying the Interfering Signal's power level



802.11ax Devices Need More Test Combinations

Exponential Increase
in Test Permutations
and Test Time!!



Frequency

Frequency Offset

Power Level

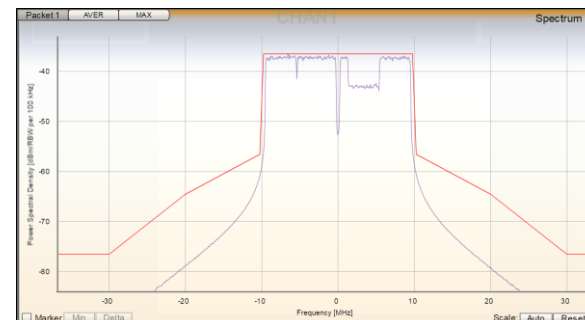
Timing Offset

MIMO streams

RU Combinations

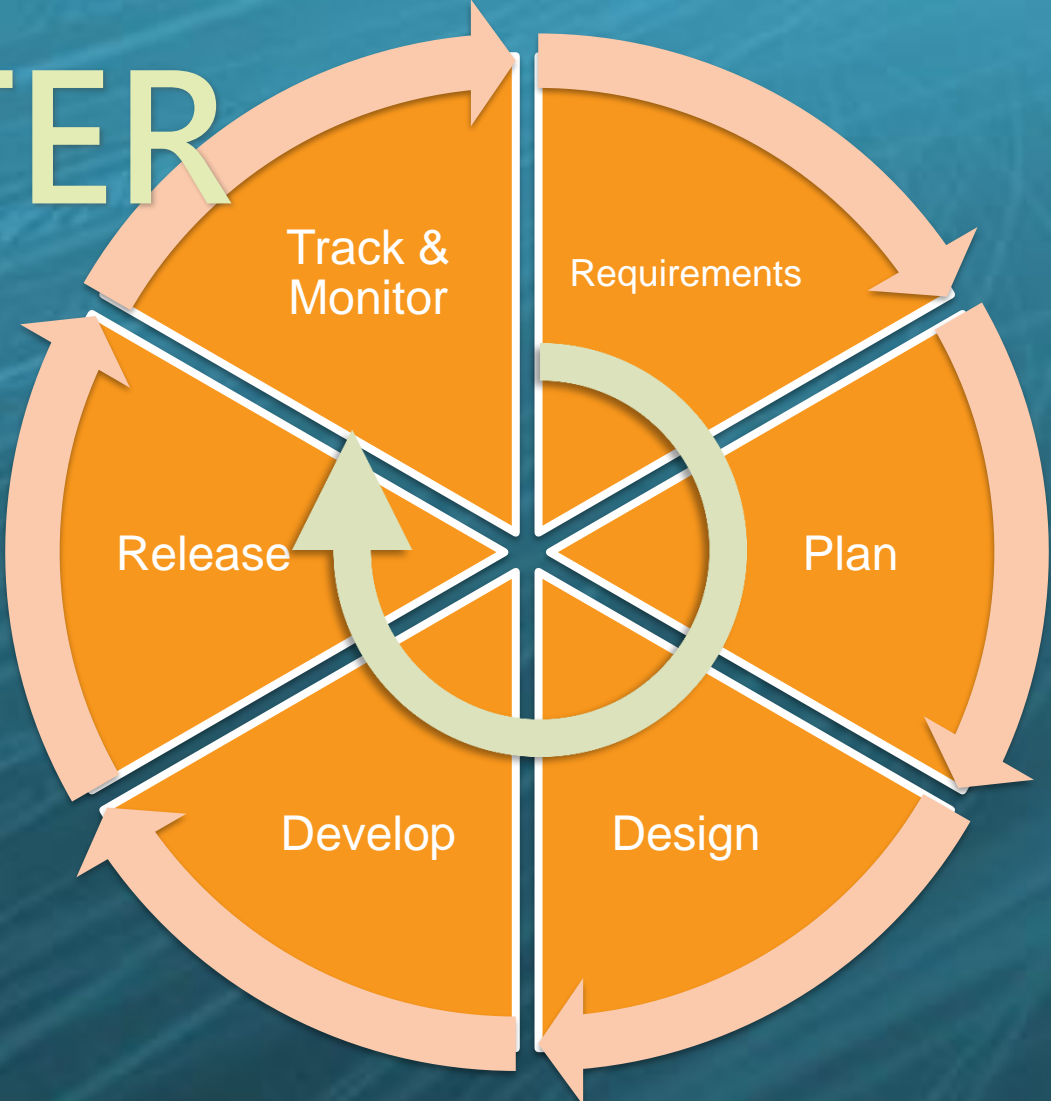
RU size

RU power



802.11ax Devices Need Agile Development

FASTER



Writing One Test at a Time Takes Forever



```
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 OFDM-6 BW-20 TX5
TX_MULTI_VERIFICATION 5180 OFDM-6 BW-20 TX6
TX_MULTI_VERIFICATION 5180 OFDM-6 BW-20 TX7
TX_MULTI_VERIFICATION 5180 OFDM-6 BW-20 TX8
TX_MULTI_VERIFICATION 5180 OFDM-6 BW-20 TX1
TX_MULTI_VERIFICATION 5180 OFDM-6 BW-20 RX4
TX_VERIFY_PER 5180 MCS2 BW-20 RX5
TX_VERIFY_PER 5180 MCS2 BW-20 RX6
TX_VERIFY_PER 5180 MCS2 BW-20 RX7
TX_VERIFY_PER 5180 MCS2 BW-20 RX8
TX_VERIFY_PER 5180 MCS2 BW-20 RX3
TX_VERIFY_PER 5180 MCS2 BW-20 RX7
TX_VERIFY_PER 4985 HALF-27 BW-10 RX1
TX_VERIFY_PER 5190 MCS2 BW-40 RX1
RX_SWEEP_PER 5180 OFDM-6 BW-20 RX1
RX_SWEEP_PER 5180 OFDM-6 BW-20 RX7
DISCONNECT
REMOVE
GLOBAL
INSERT
INIT
CONN
LOAD
MRVL
TEST
TEST
TEST_VERIFICATION ANT1
TEST_VERIFICATION BW-20 ANT2
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
```

```
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 timingOffset_9
          {
            for ruCombo = ruCombo_0 to ruCombo_199
            {
              MakeMeasurements();
            }
          }
        }
      }
    }
  }
}
```

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



IQfactStudio

File Edit Tools Window Help

Number of Runs: 1

New Test Flow

- WIFI_11AX
 - 1.GLOBAL_SETTINGS
 - 2.INSERT_DUT
 - 3.INITIALIZE_DUT
 - 4.CONNECT_IQ_TESTER
 - 5.LOAD_PATH_LOSS_TABLE
 - 6.TEST_BUILD_5520_BW-80_ANT1**
 - 7.ADD_USER1 MCS0 EVM MASK
 - 8.TEST_RUN
 - 9.DISCONNECT_IQ_TESTER
 - 10.REMOVE_DUT

Input Parameters

No filter	Name	Value	Type	Unit
1	TEST_CATEGORY	STA_TX_UL_SU	String	
2	NUM_USERS	1	Integer	
3	BSS_BANDWIDTH	BW-80	String	MHz
4	CH_BANDWIDTH	0	String	MHz
5	BSS_FREQ_MHZ_PRIMARY	5520	Integer	MHz
6	CH_FREQ_MHZ	5520	Integer	MHz
7	ANT1	1	Integer	
8	ANT2	0	Integer	
9	ANT3	0	Integer	
10	ANT4	0	Integer	
11	ANT5	0	Integer	
12	ANT6	0	Integer	
13	ANT7	0	Integer	
14	ANT8	0	Integer	
15	ARRAY_HANDLING_METHOD	0	Integer	
16	BSS_COLOR	1	Integer	
17	BSS_FREQ_MHZ_SECONDARY	0	Integer	MHz
18	CH_FREQ_MHZ_PRIMARY_20MHz	0	Integer	MHz
19	GL_LTF_TYPE	1	Integer	
20	NUM_HE_LTF	1	Integer	
21	AP_TX_POWER_TFR	-20	Double	dBm
22	CABLE_LOSS_DB1	0	Double	dB
23	CABLE_LOSS_DB2	0	Double	dB
24	CABLE_LOSS_DB3	0	Double	dB
25	CABLE_LOSS_DB4	0	Double	dB
26	CABLE_LOSS_DB5	0	Double	dB
27	CABLE_LOSS_DB6	0	Double	dB
28	CABLE_LOSS_DB7	0	Double	dB

Return Values

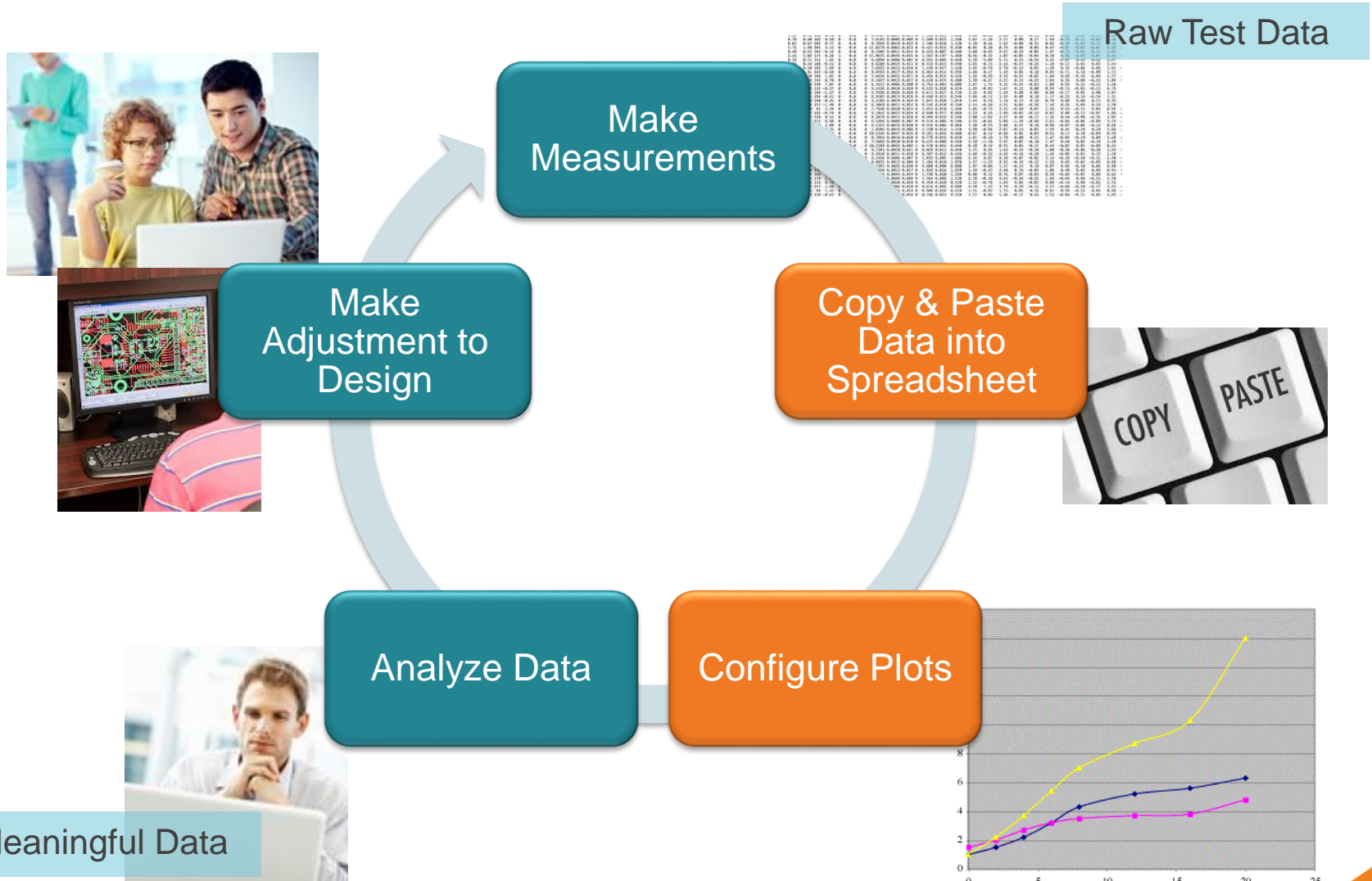
No filter	Name	Value	Type	Unit	Lower Limit	Upper Limit
1	ERROR_MESSAGE		String			

802.11ax Produces Massive Data



Raw Data

Can We Make Data Analysis Easier?

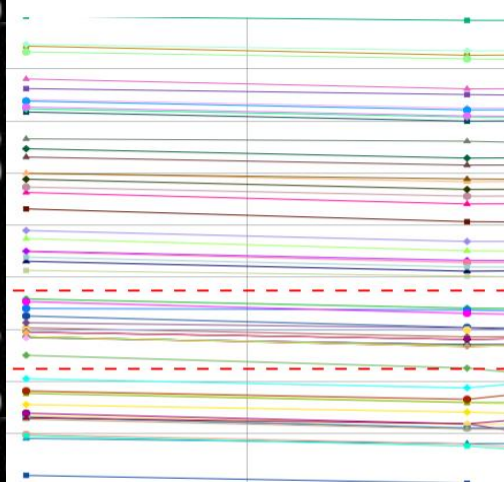


Dangers of Home-grown Data Analysis Solutions

Time



Incomplete Analysis

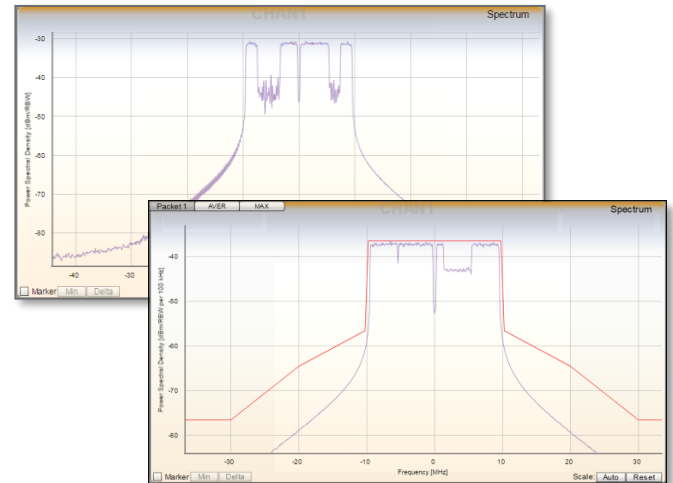
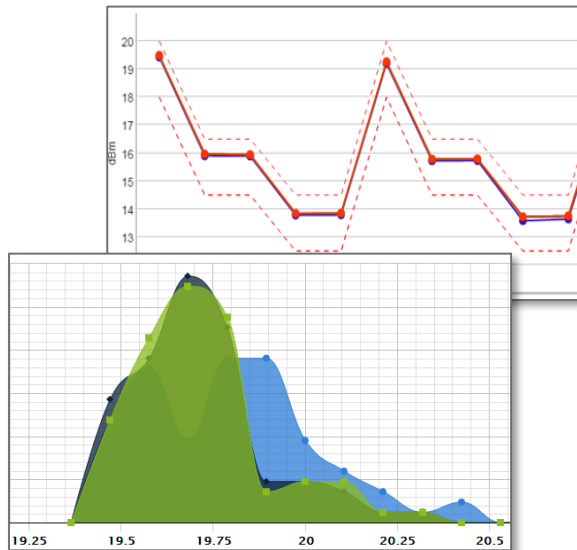


Boredom

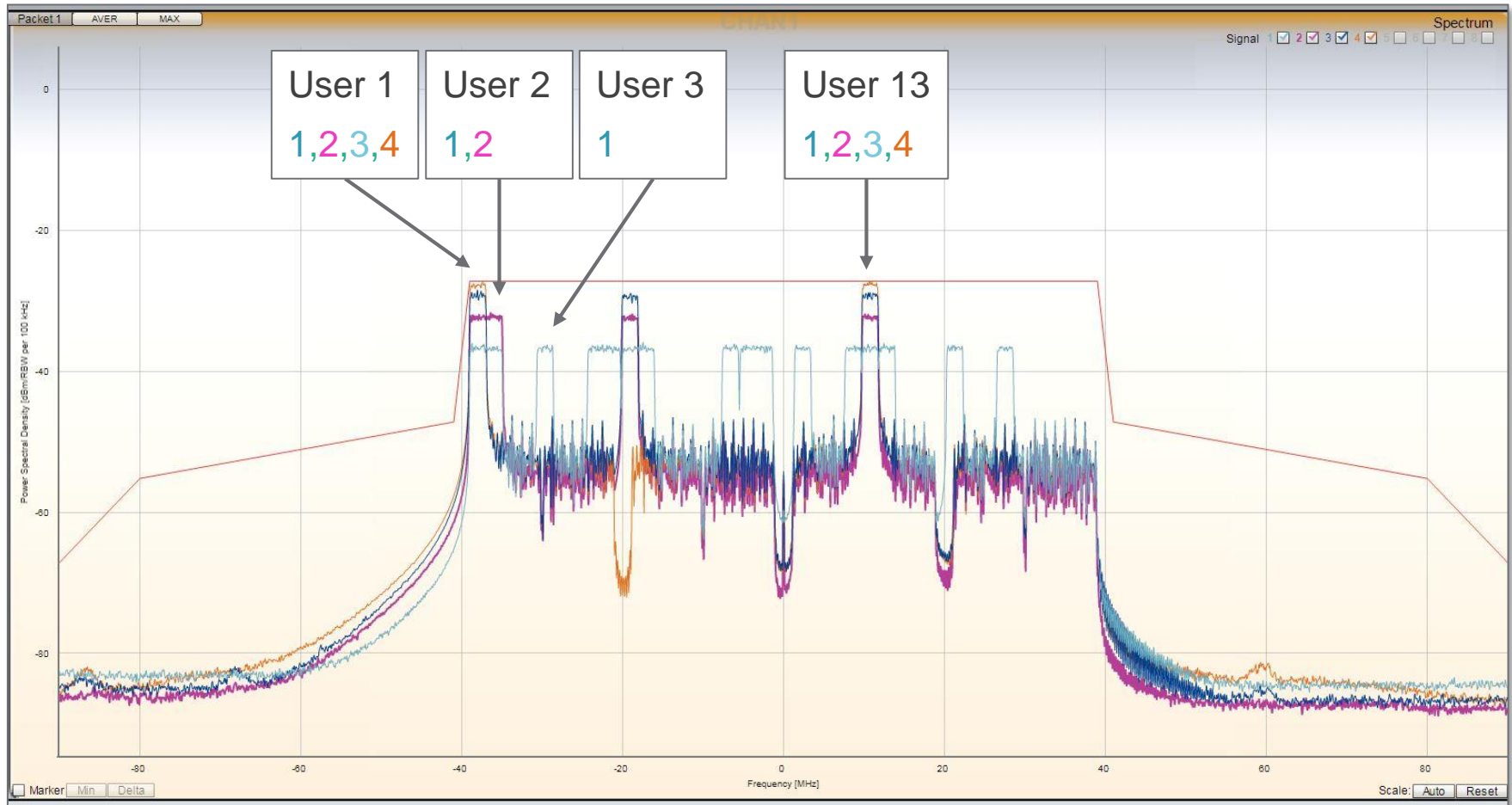


3 Requirements of Data Analysis

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



11ax DVT Data Requires More Thorough Analysis



11ax DVT Data Analysis



The screenshot shows the iQramp software interface. At the top, there are tabs for 'ANALYSIS', 'TEMPLATES', and 'REPORTS'. Below these are navigation icons for 'Datasets', 'Yield', 'Statistics', 'Plot', 'Pivot', and 'Scatter'. A toolbar contains buttons for 'Open', 'Save Selected', 'Start Over', 'Close Selected', 'Load settings', 'Rename Alias Name', 'Delete Runs', and 'Delete Results'. A search bar is located on the right. Below the toolbar is a table with the following data:

Auto Reload	Dataset	File Name	Program Name	Runs	Tests	Folder
<input checked="" type="checkbox"/>	measurement...	measurement_result	IQfactPlus	1	1764	C:\Program Files (x86)\LI...

Below the table is a large white area with a mouse cursor and the text: Open Datasets: Drop files here to open.

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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