

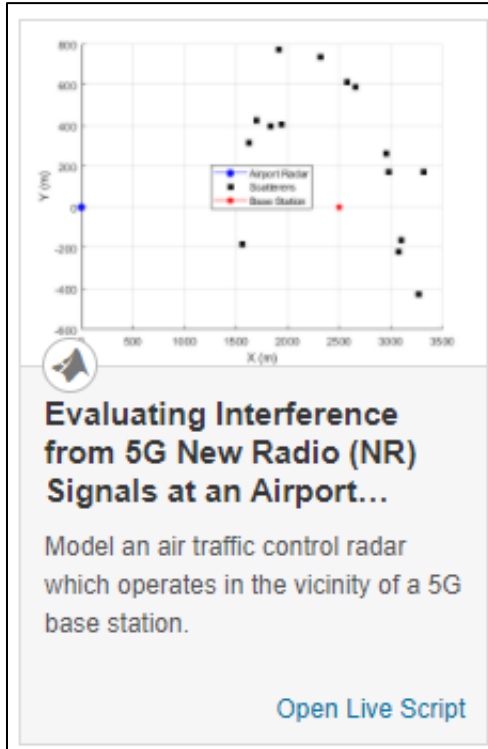
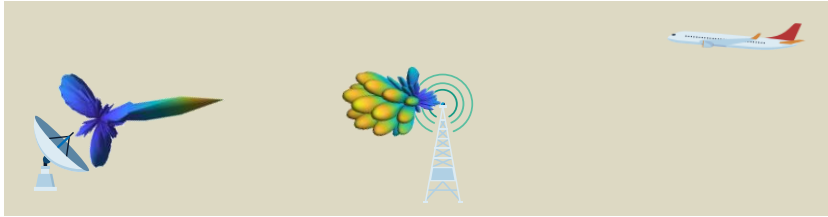
MATLAB EXPO

무선 통신 표준 및 인공지능: 미래의 무선 연결

서기환 부장, 매스웍스코리아



Recent 5G Deployment Challenge at US Airports



Airport Surveillance Radar & 5G Base Station

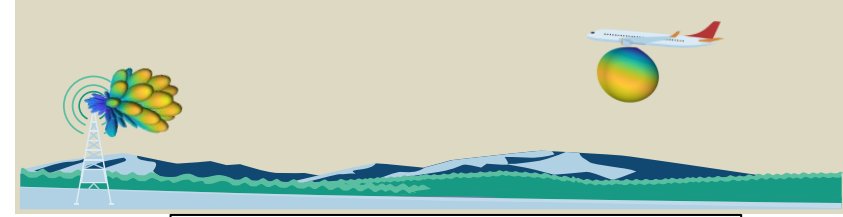
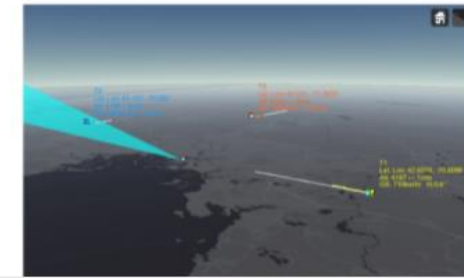


Image Credit: Toronto Star



C-Band 5G Telecom Delays and Airline Frustration

The airlines made their case to the FAA earlier this week, warning that the rollout of 5G service near airports could cause catastrophic disruption...



Lisa Harvey on Jan 22, 2022

Behind the Headlines

Radar Altimeter & 5G Base Station

Future of Connected World

Diverse standards

Diverse frequencies

Diverse Use cases

Diverse technologies



3 Challenges of achieving ubiquitous connectivity

Handle Complexity

Coordinate Early



Need standards

Ensure Reliability

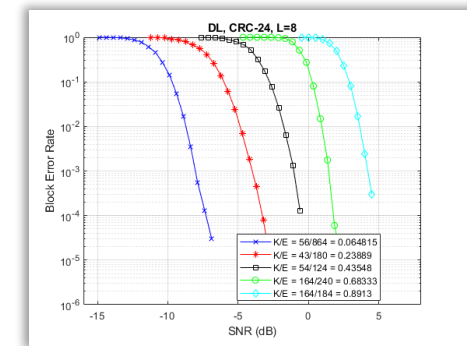
Test Everything



Need lots of testing data

Push for Performance

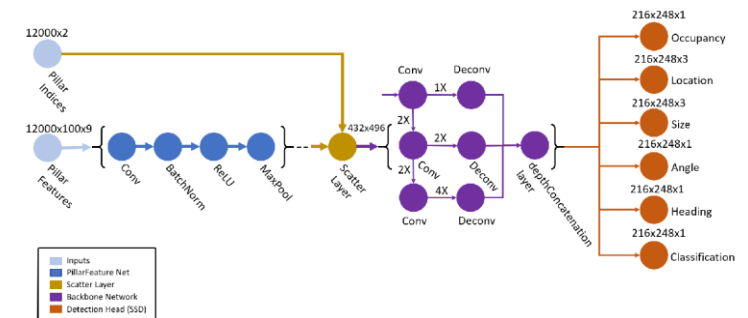
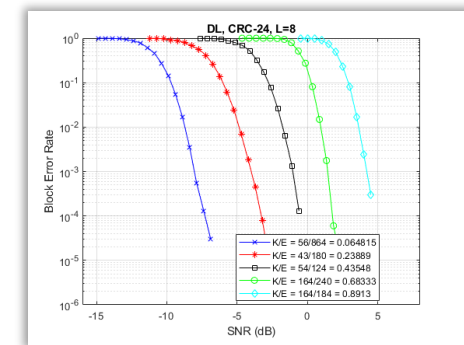
Optimize Everything



Need AI deployment

Agenda

- 1 Handle Complexity with Standards
- 2 Test Everything with Hardware Connectivity
- 3 Optimize Everything with AI
- 4 Summary



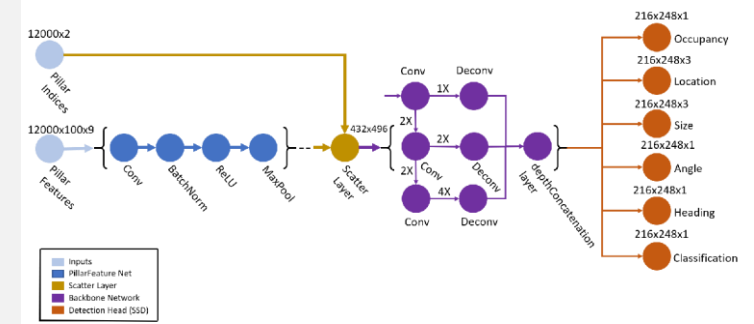
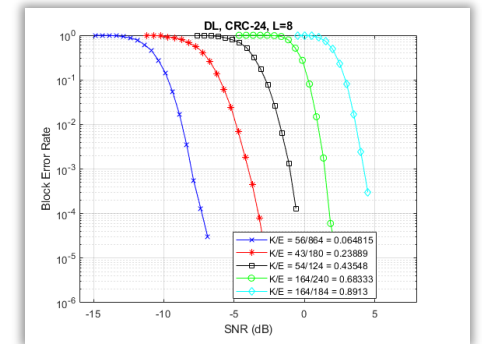
Agenda

1 Handle Complexity with Standards

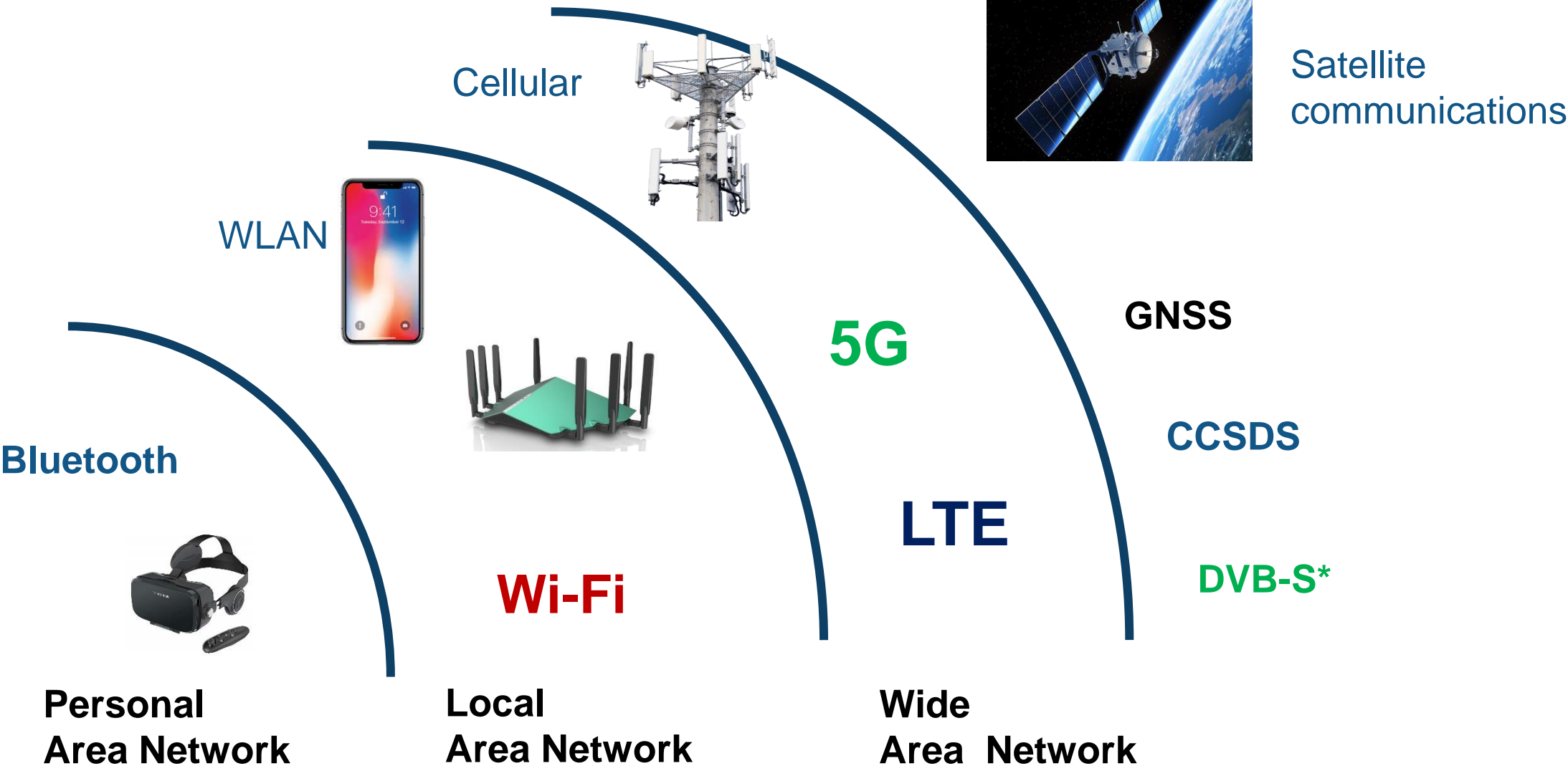
2 Test Everything with Hardware Connectivity

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4 Summary



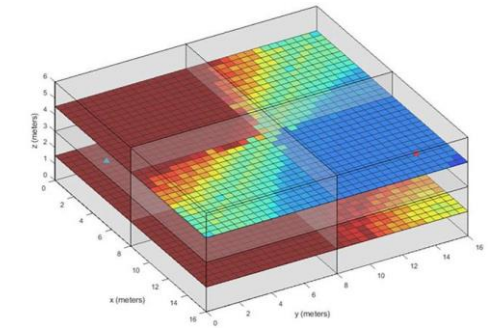
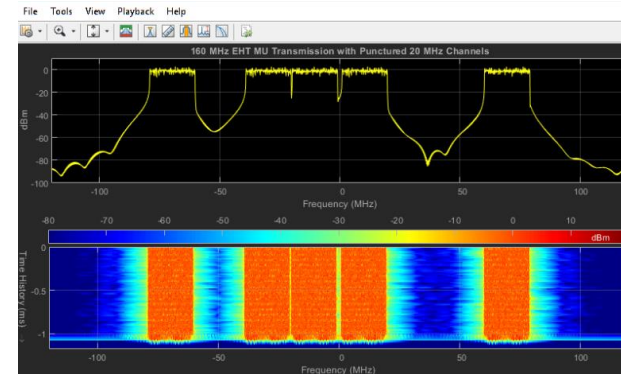
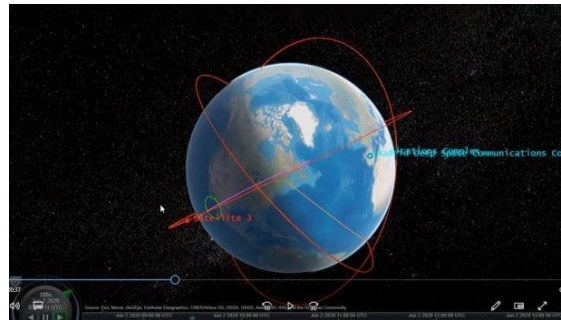
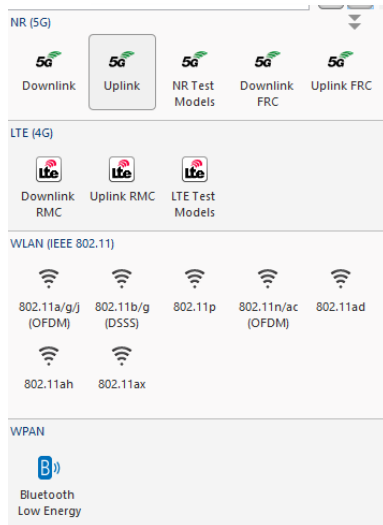
Ubiquitous connectivity – technologies & standards



Our new investments in Wireless standards ...



Satellite Communications



**Waveform
Generation**

**Non-terrestrial
Networks
(NTN)**

**Wi-Fi 7
IEEE 802.11be**

**New Bluetooth
Toolbox**

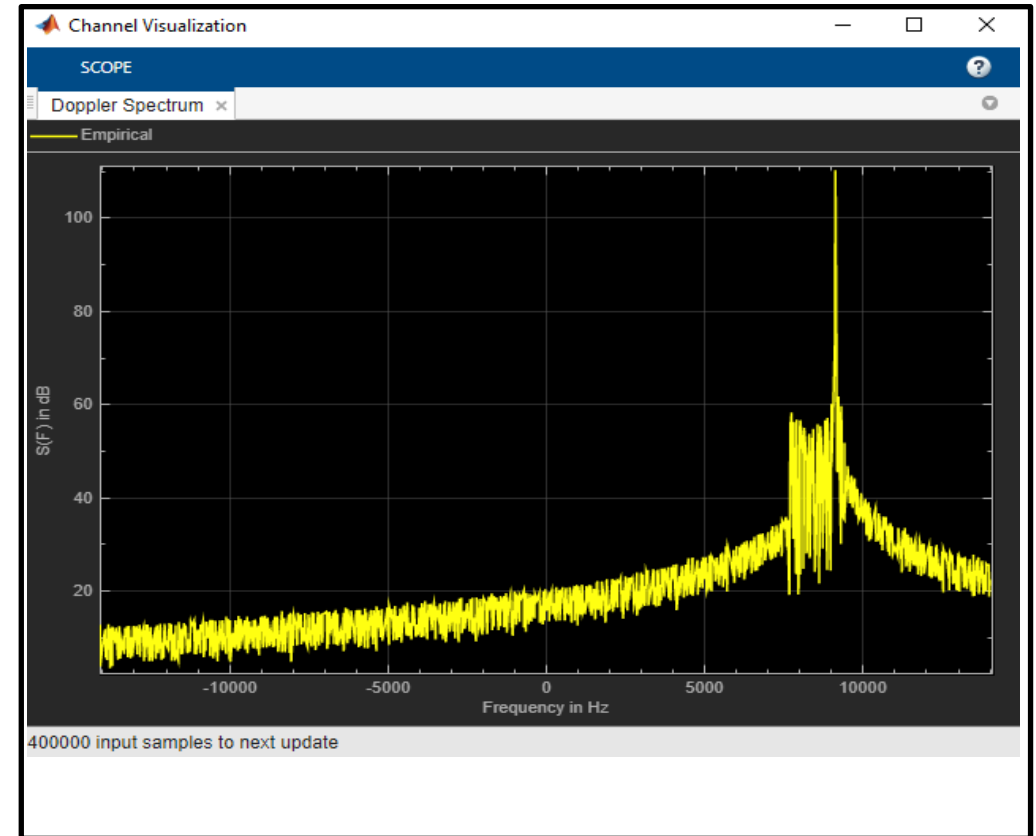
Wireless Waveform Generator App

The screenshot displays the 'Wireless Waveform Generator - Spectrum Analyzer' application window. The interface is divided into several sections:

- Top Bar:** Contains tabs for 'GENERATOR' and 'TRANSMITTER', and a toolbar with icons for file operations (New, Open, Save), waveform selection (OFDM, QAM, PSK), and generation/export actions (Generate, Export).
- Left Panel (Waveform Configuration):**
 - OFDM Waveform Configuration:** Includes fields for FFT length (64), Guard band subcarriers ([6;5]), Cyclic prefix lengths ([16]), OFDM symbols (100), and Transmit antennas (1). It also has checkboxes for 'Insert DC null' and 'Windowing', and a dropdown for 'OFDM input type' set to 'QAM'.
 - QAM Waveform Configuration:** Includes a dropdown for 'Modulation order' (4), 'Symbol mapping' (Gray), 'Bit source' (User-defined), and 'Size of input bits' ([10600 1]). The 'Input bits' field contains the MATLAB code `randi([0 1], 10600, 1)`.
 - Filtering Configuration:** Includes a dropdown for 'Filtering' set to 'None'.
- Right Panel (Spectrum Analyzer):** Features a plot with 'dBm' on the vertical axis (ranging from -80 to 20) and 'Frequency' on the horizontal axis. The plot area is currently empty, and the status below it reads 'Stopped'.
- Bottom Panel (OFDM Subcarrier Mapping):** This section is currently blank.

Non-terrestrial network (NTN) Narrowband Channel

- Supports flat fading narrowband channel model as per 3GPP TR 38.811
- Supports different frequency ranges and types of environment as per ITU-R P681.11
- Supports visualization of Doppler spectrum, impulse & frequency responses)



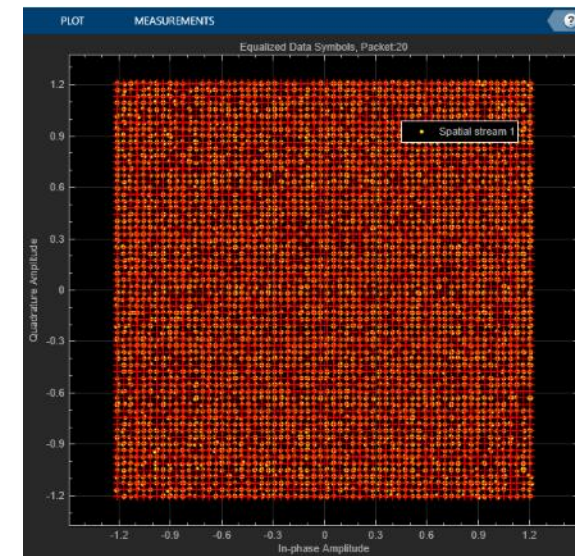
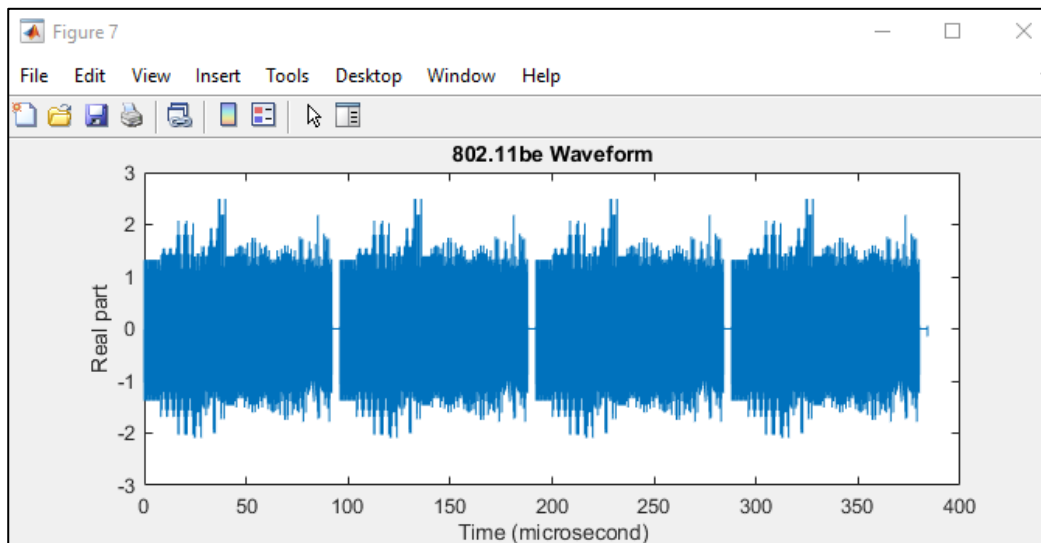
Generate 802.11be (Wi-Fi 7) Waveforms

- Up to 320 MHz channel bandwidth
- Up to 4096QAM

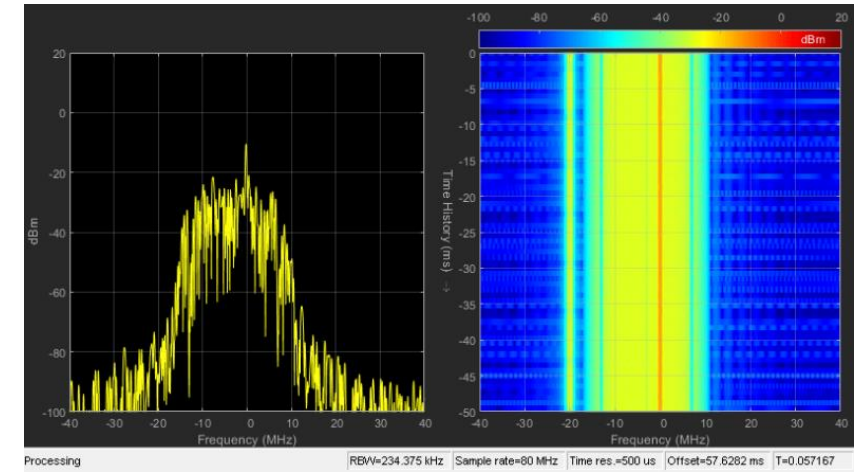
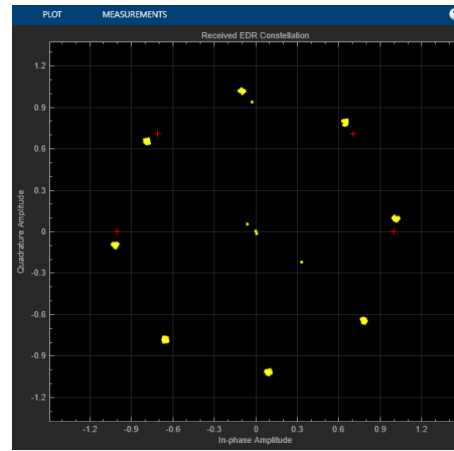
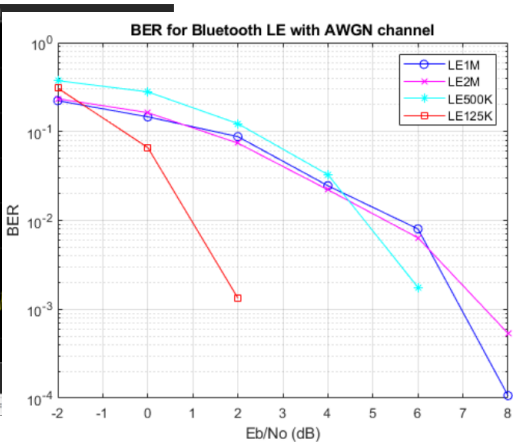
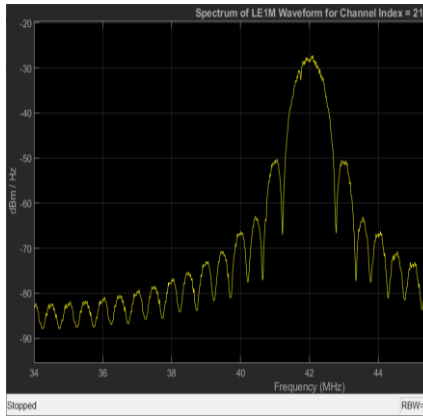


Command Window

```
>> cfgEHT = ehtMUConfig('CBW320');  
>> txWaveform = ehtWaveformGenerator(data, cfgEHT, 'NumPackets', 4, 'IdleTime', 4*1e-6);  
fx >>
```



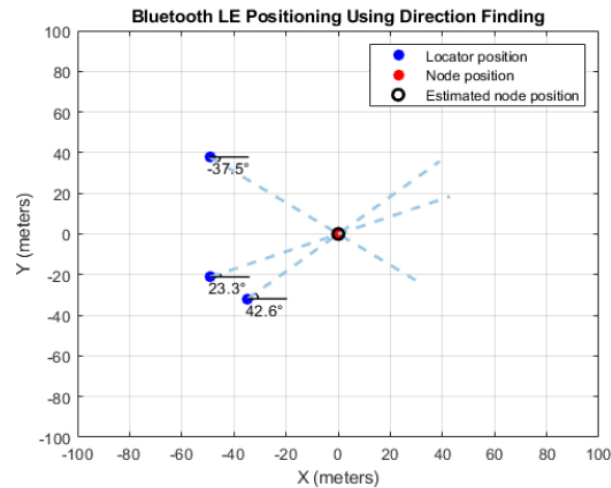
Bluetooth Toolbox



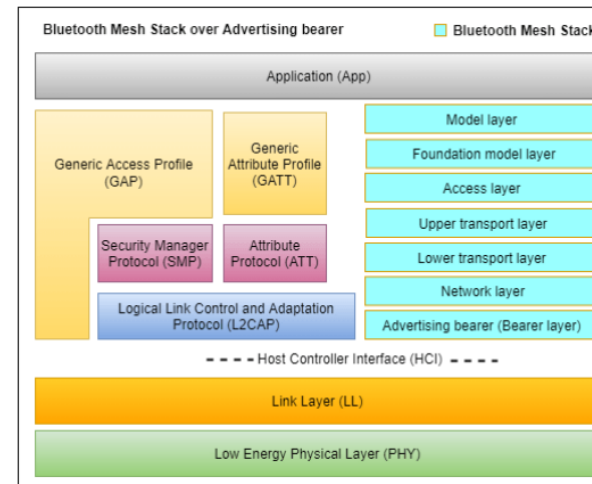
Waveform Generation and End-to-End Link Simulation

Signal Recovery and Analysis

Bluetooth/WLAN Coexistence



Localization



Network Modeling

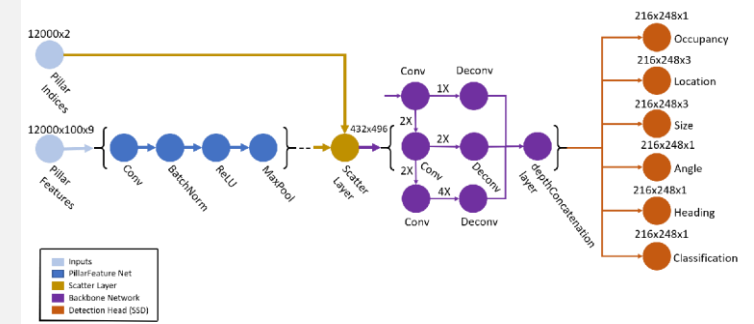
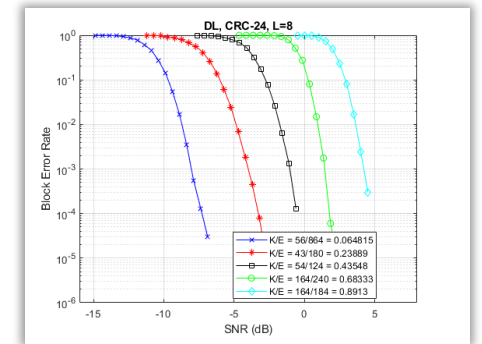
Agenda

1 Handle Complexity with Standards

2 Test Everything with Hardware Connectivity

3 Optimize Everything with AI

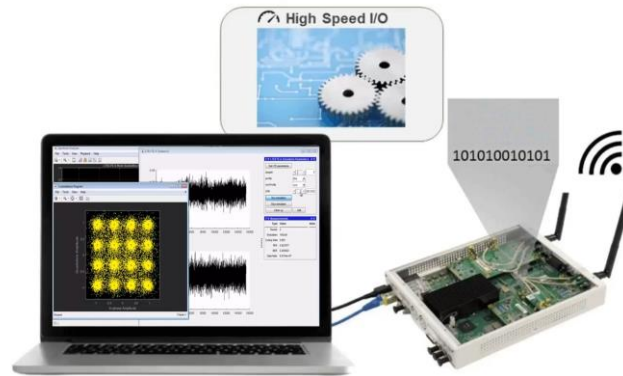
4 Summary



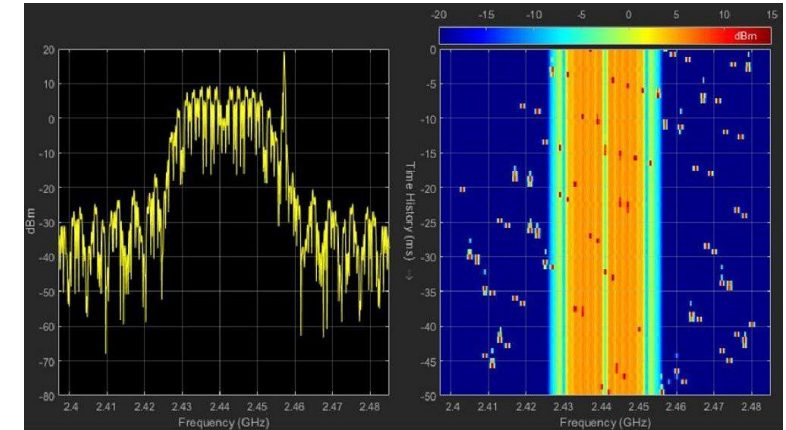
Our new investments in Wireless testing



**SDR
Connectivity**



**Wireless
Testbench**

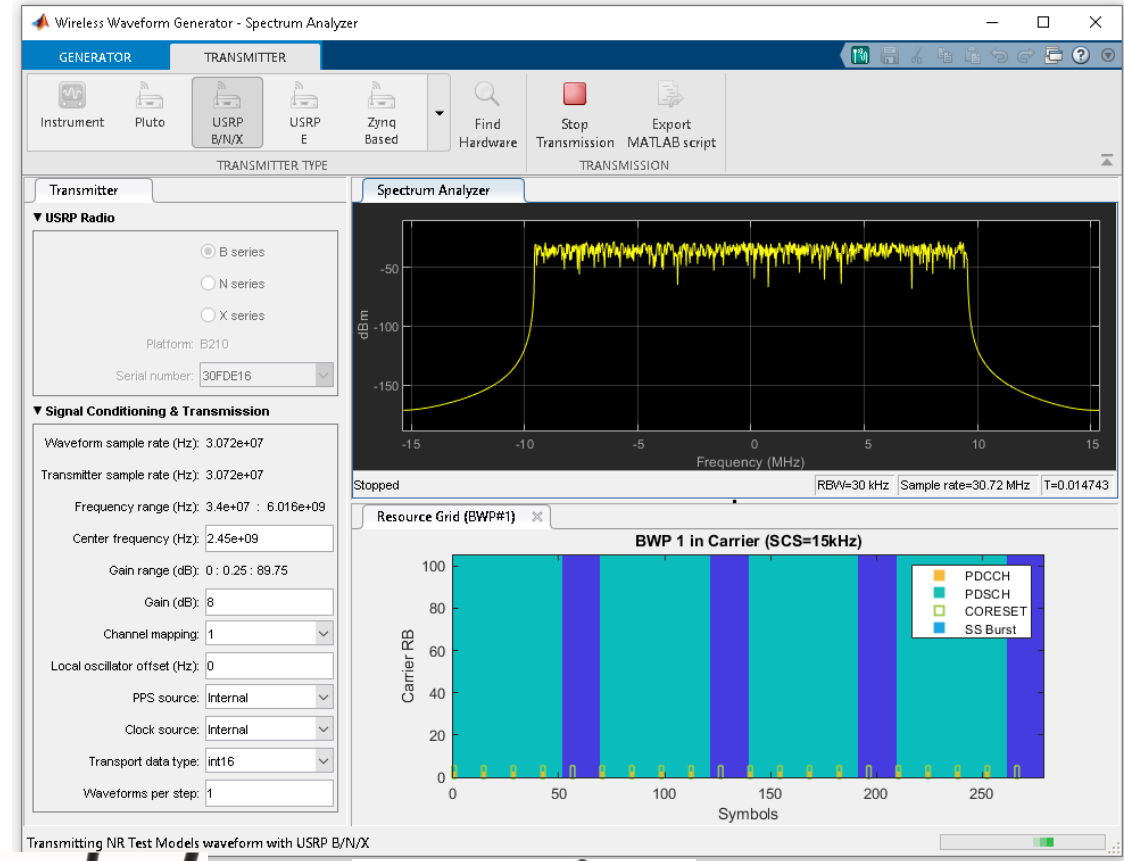


**Interference &
Coexistence**

Connect easily to SDRs in Wireless Waveform Generator App

Easy and graphical transmission of wireless signals with Pluto, USRP B/N/X, USRP E, Zynq software-defined radios

- Support for all waveform types (5G, WLAN, LTE, Bluetooth, Comms)
- Automatic sample rate selection for USRP B/N/X and waveform resampling
- Generation of equivalent MATLAB code



Wireless Testbench

Explore and test wireless designs using intelligent, high-speed data transmit/capture

Use cases/Applications

- Spectral conformance
- Signal detection
- Spectrum monitoring
- Signal classification
- Cognitive radio



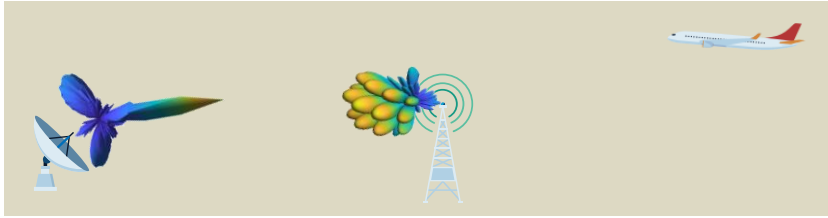
Transmit and capture wideband signals at up to 250 Msps

End-to-end transceiver design, standard-based and custom signal transmitter/receiver design

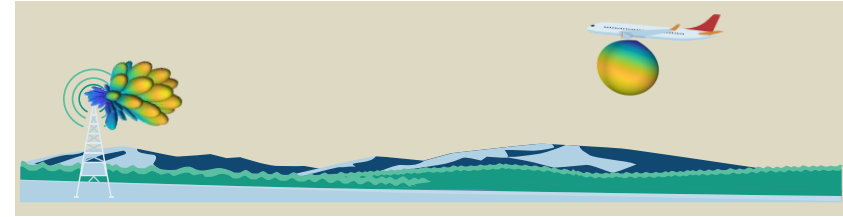
Intelligent data capture

Reduce data sent to host computer by capturing only waveforms of interest by preamble detection

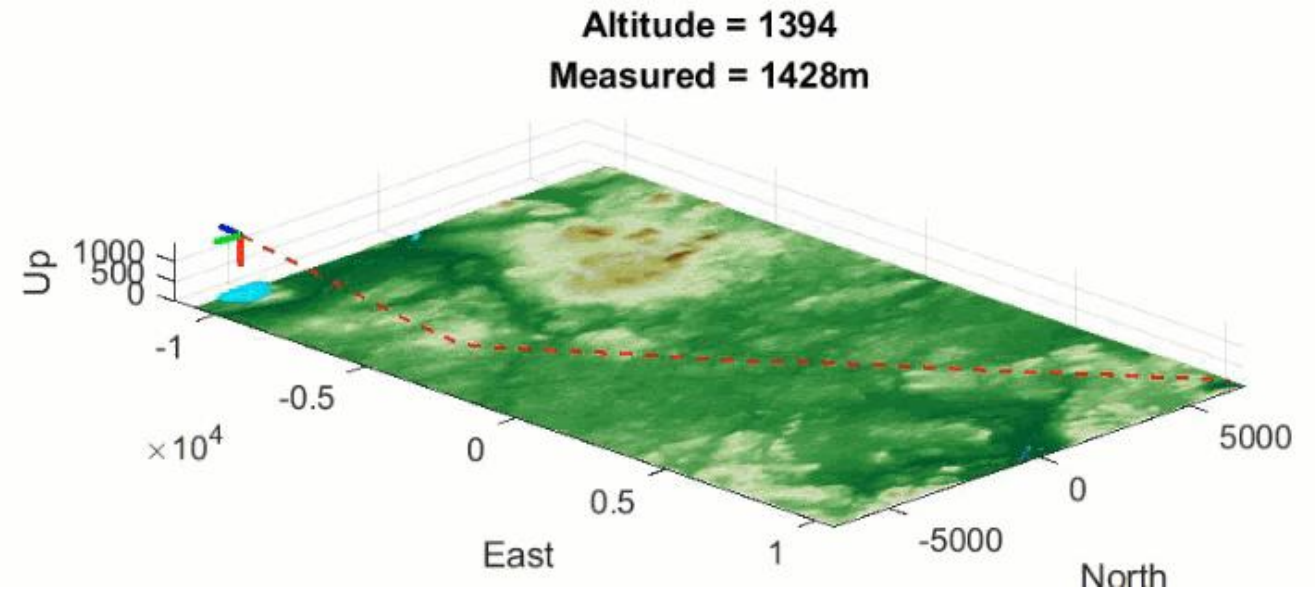
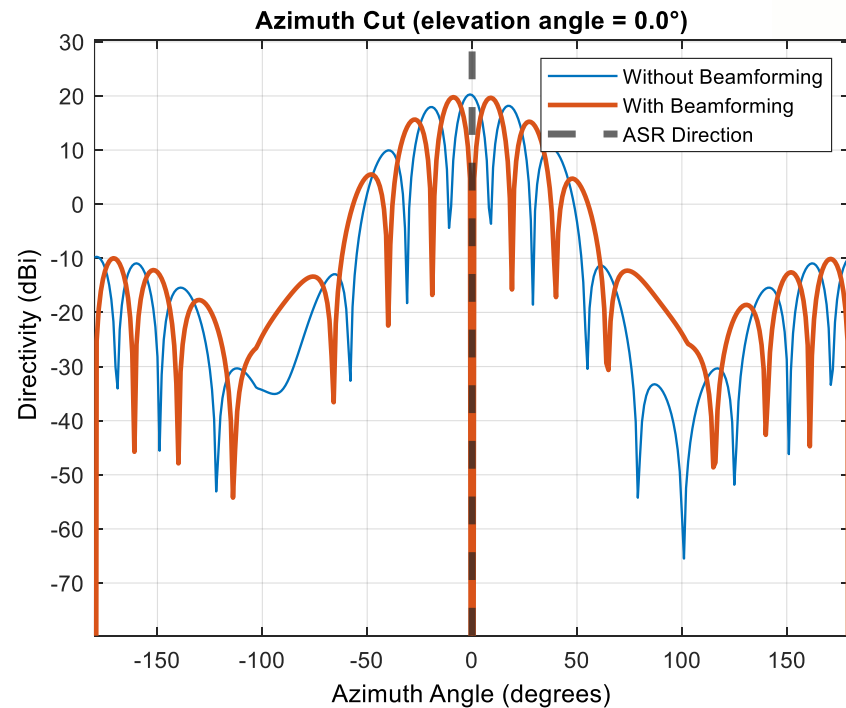
Ensure Reliability and Coexistence with Interference Mitigation



Airport Surveillance Radar & 5G Base Station



Radar Altimeter & 5G Base Station



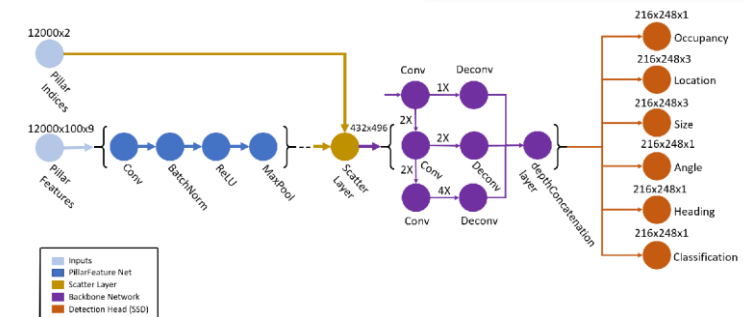
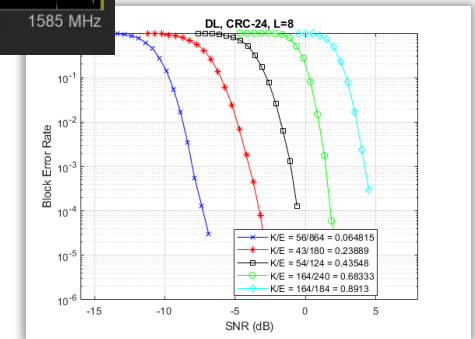
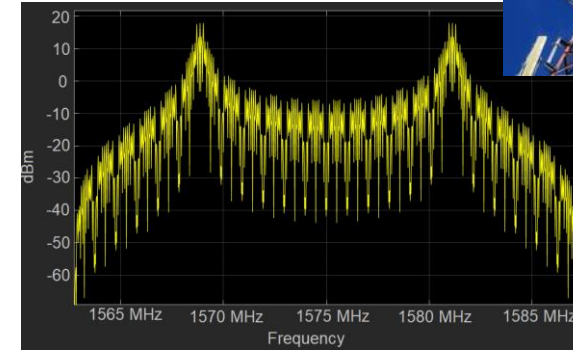
Agenda

1 Handle Complexity with Standards

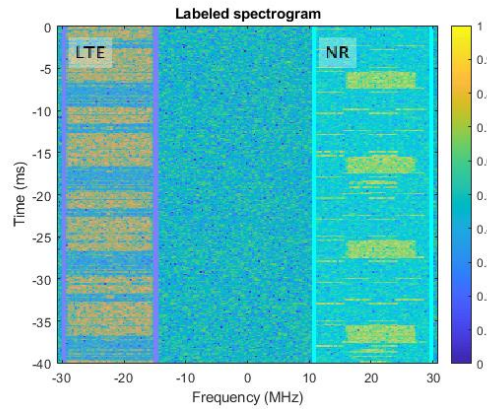
2 Test Everything, Ensure Reliability

3 Optimize Everything with AI

4 Summary



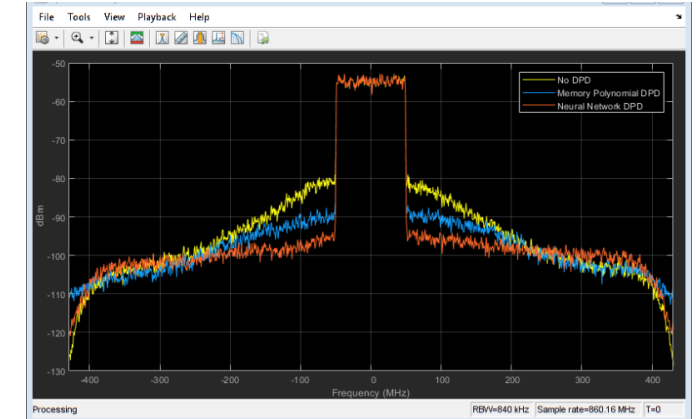
Our new investments in AI for Wireless Communications



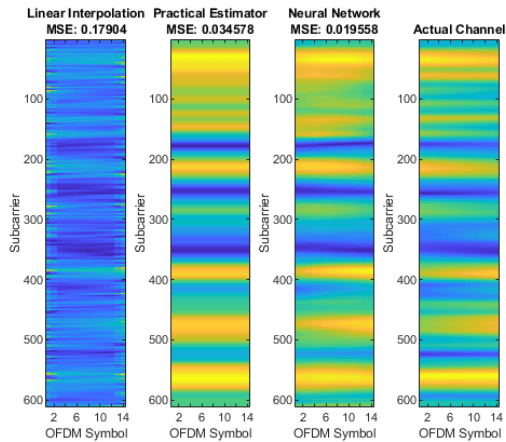
Spectrum Sensing & Signal Classification



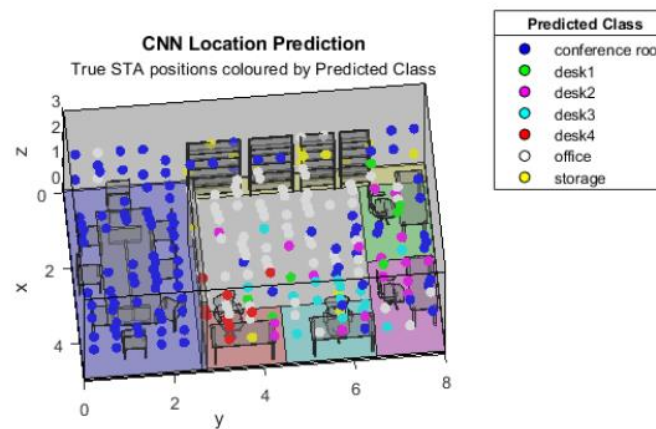
Device Identification



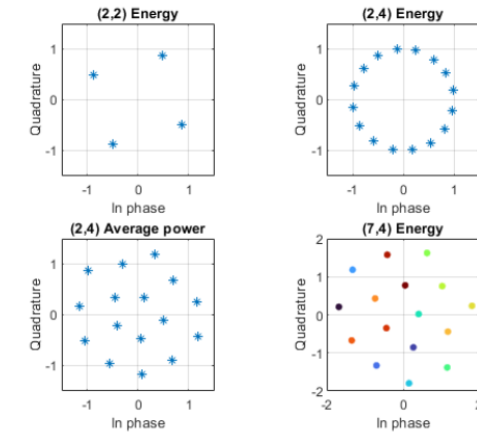
Digital Pre-Distortion



Beam Management & Channel Estimation




Localization & Positioning




Transceiver design

AI-Driven Wireless System Design

Data Preparation

 Data cleansing and preparation

 Human insight

 Simulation-generated data

AI Modeling

 Model design and tuning


 Hardware accelerated training

 Interoperability

Simulation & Test

 Integration with complex systems

 System simulation

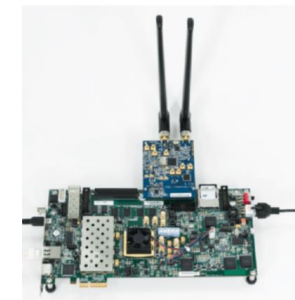
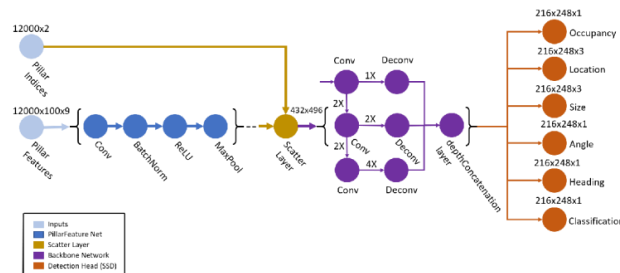
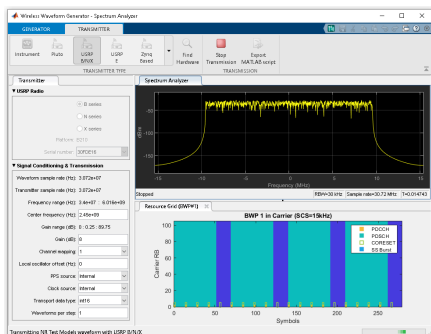
 System verification and validation

Deployment

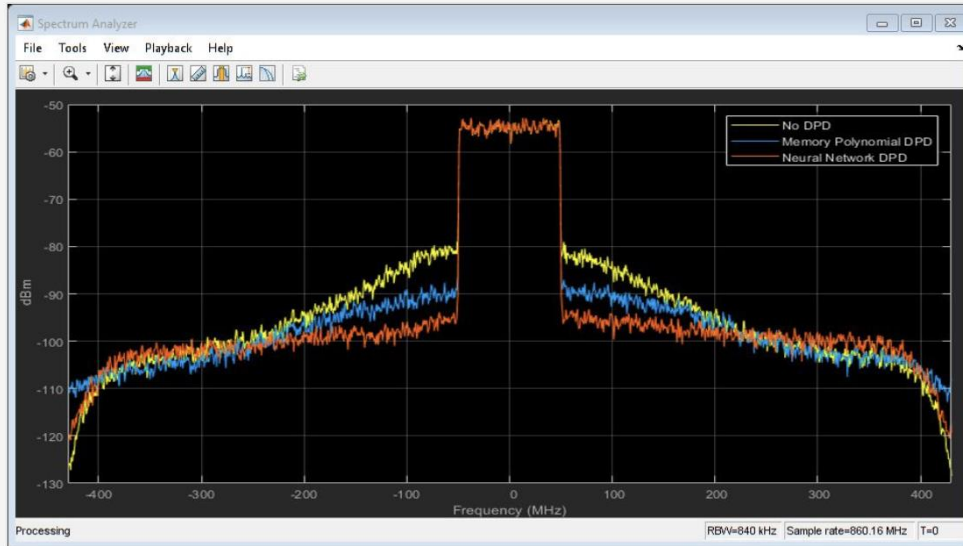
 Embedded devices

 Enterprise systems

 Edge, cloud, desktop



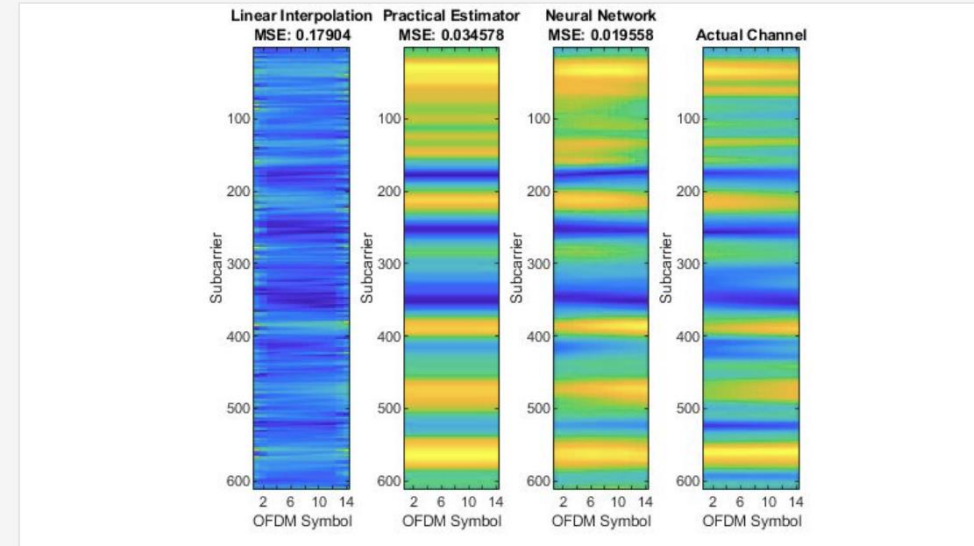
Examples: How to Use AI for Wireless with MATLAB



Digital Pre-Distortion

Apply neural network-based digital predistortion (DPD) to offset the effects of nonlinearities in a power amplifier (PA).

💡 [Neural Network for Digital Predistortion Design - Offline Training](#)



Beam Management and Channel Estimation

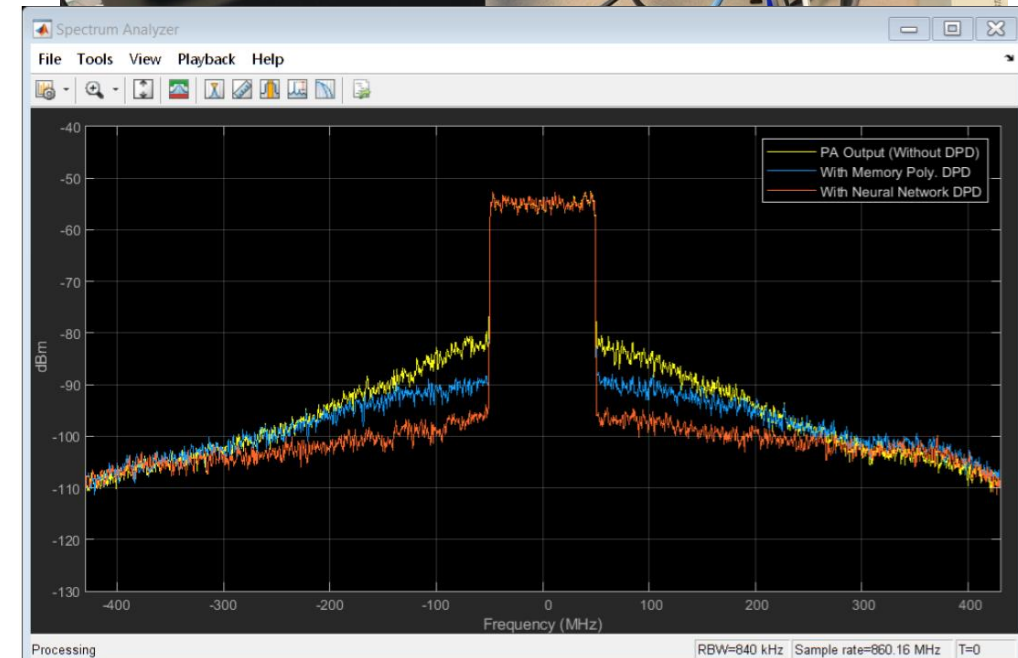
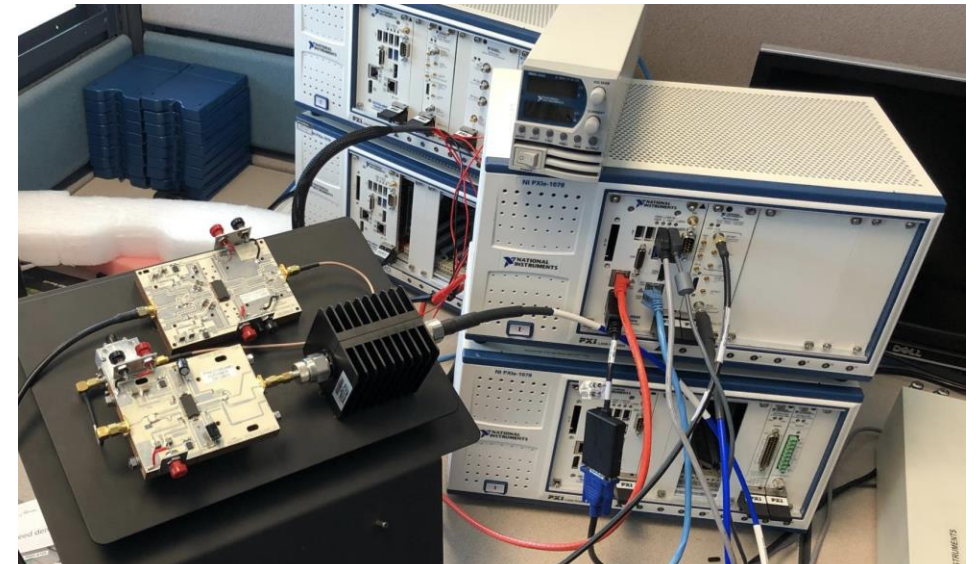
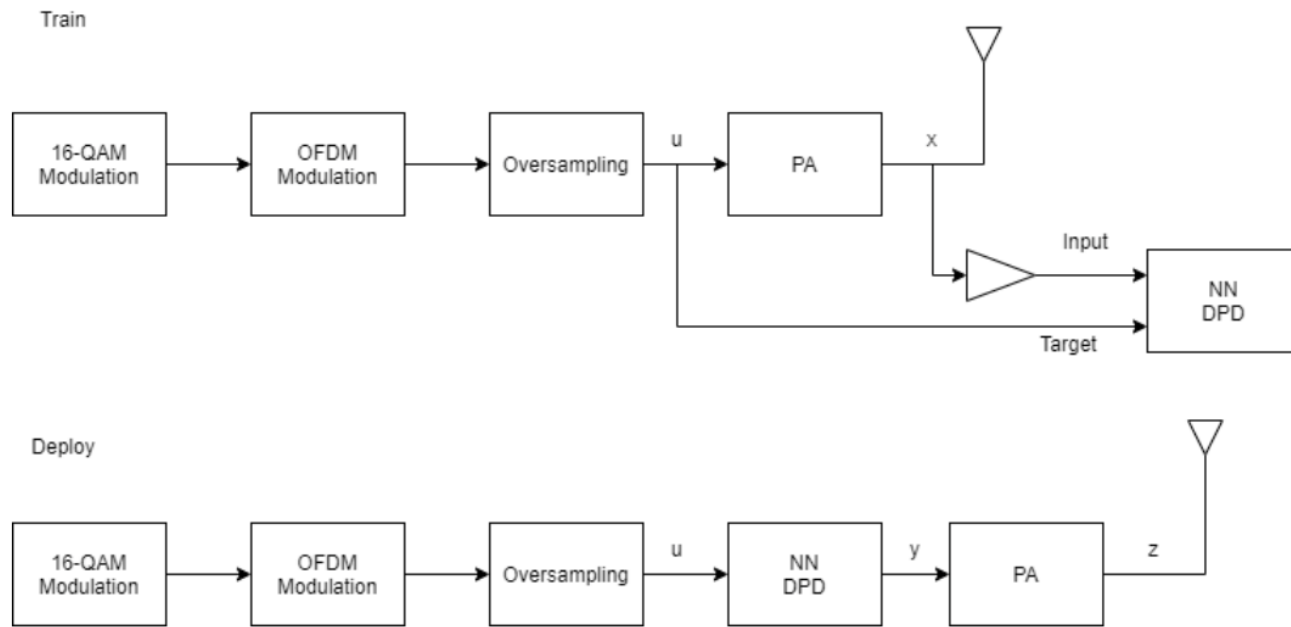
Use a neural network to reduce the computational complexity in the 5G NR beam selection task. Train a CNN for 5G NR channel estimation.

💡 [Neural Network for Beam Selection](#)

💡 [Deep Learning Data Synthesis for 5G Channel Estimation](#)

<https://www.mathworks.com/solutions/wireless-communications/ai.html>

AI for Digital Pre-Distortion with training and deployment



Workflow

- Collect data from a real PA using test instrument hardware or characterize the PA and use the model for simulation
- Train a neural network using real PA data or simulation data
- Test the network with real data using the hardware
- Once satisfied, prune and quantize the network
- Target an FPGA and deploy the algorithm with HDL

AI for Channel Estimation

Data Preparation

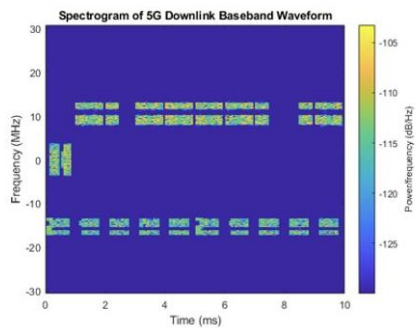
AI Modeling

Simulation & Test

Deployment

Data Synthesis

Generate 5G Standard-compliant Waveforms



Algorithm Design

Deep Learning Design & Training

Simulate 5G Transmission

Visualization and Performance Comparison

Automate

Hardware Deployment

Generate and Deploy FPGA HDL Code



Deploy to any processor with best-in-class performance

AI models in MATLAB and Simulink can be deployed on embedded devices, edge devices, enterprise systems, the cloud, or the desktop.

Deployment



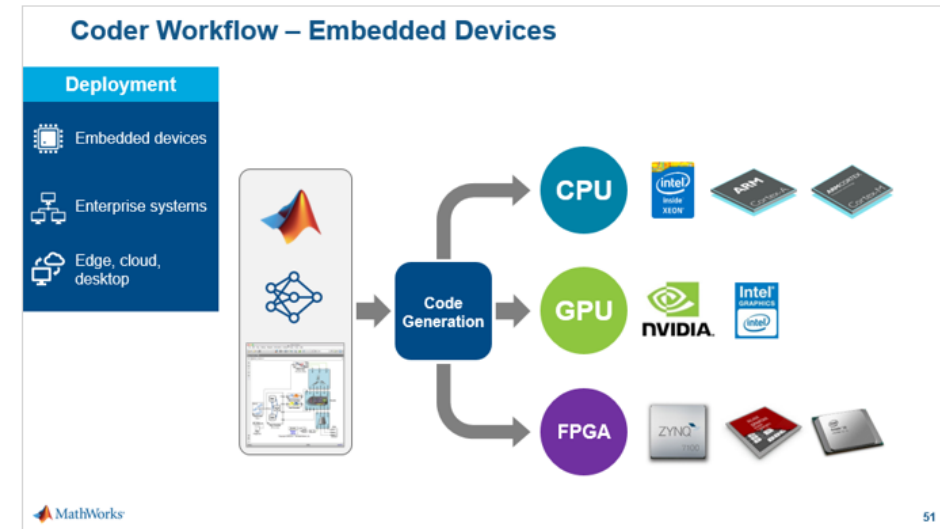
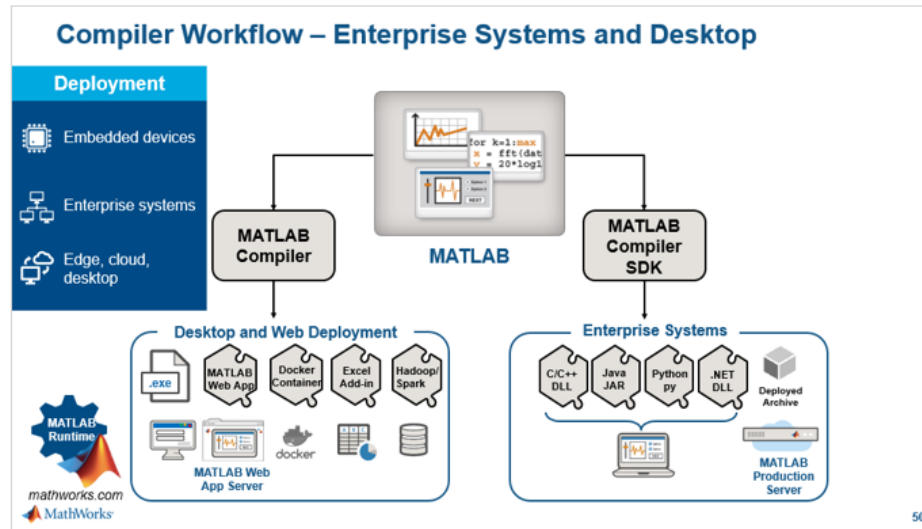
Embedded devices



Enterprise systems



Edge, cloud,
desktop



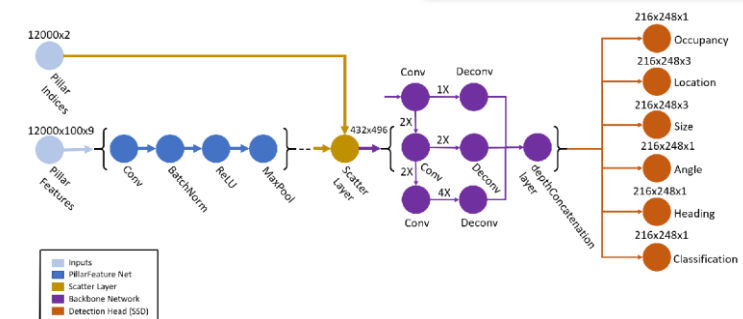
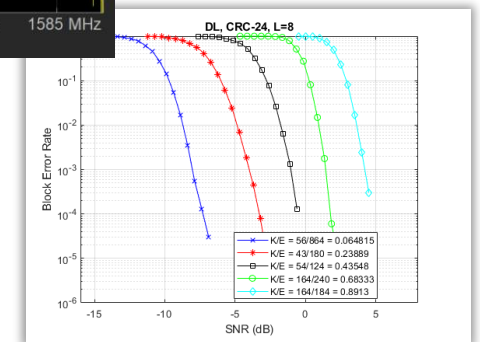
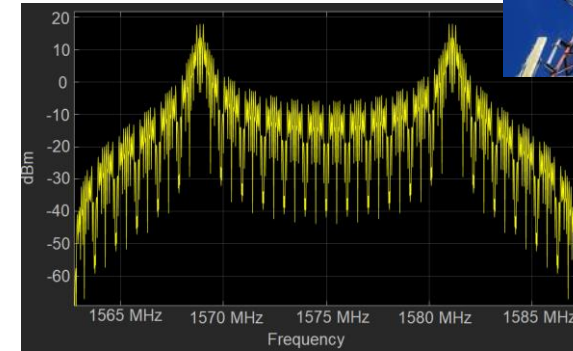
Agenda

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4 Summary



How to Learn More

Wireless Communications product pages

5G

LTE

WLAN

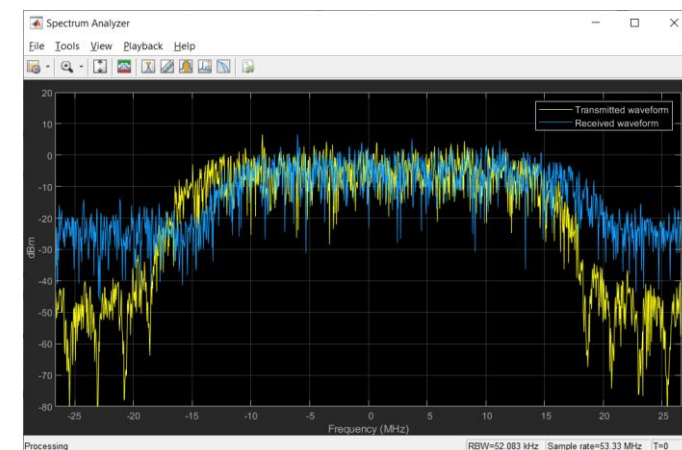
Satellite-communications

Bluetooth

Wireless Testbench

Wireless communications solution page

mathworks.com/solutions/wireless-communications.html



Summary

MATLAB and Simulink enable efficient design of end-to-end wireless communications systems. They enable you to handle complexity of wireless design with standards-based tools, to ensure reliability with enhanced testing and verification tools, and to optimize your designs with AI models and tools.

These capabilities include:

- New Standards-based 5G, Wi-Fi, satellite communications and Bluetooth
- Testing and verify your design with hardware connectivity and assess performance and coexistence in the presence of interfering signals
- New applications of AI for wireless design

MATLAB EXPO

Thank you



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