

MATLAB EXPO 2017

KOREA

4월 27일, 서울

등록 하기 matlabexpo.co.kr

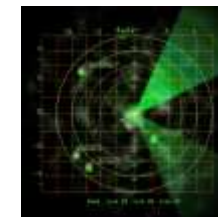
5G 무선통신 시스템 설계 : WLAN/LTE/5G

김종남

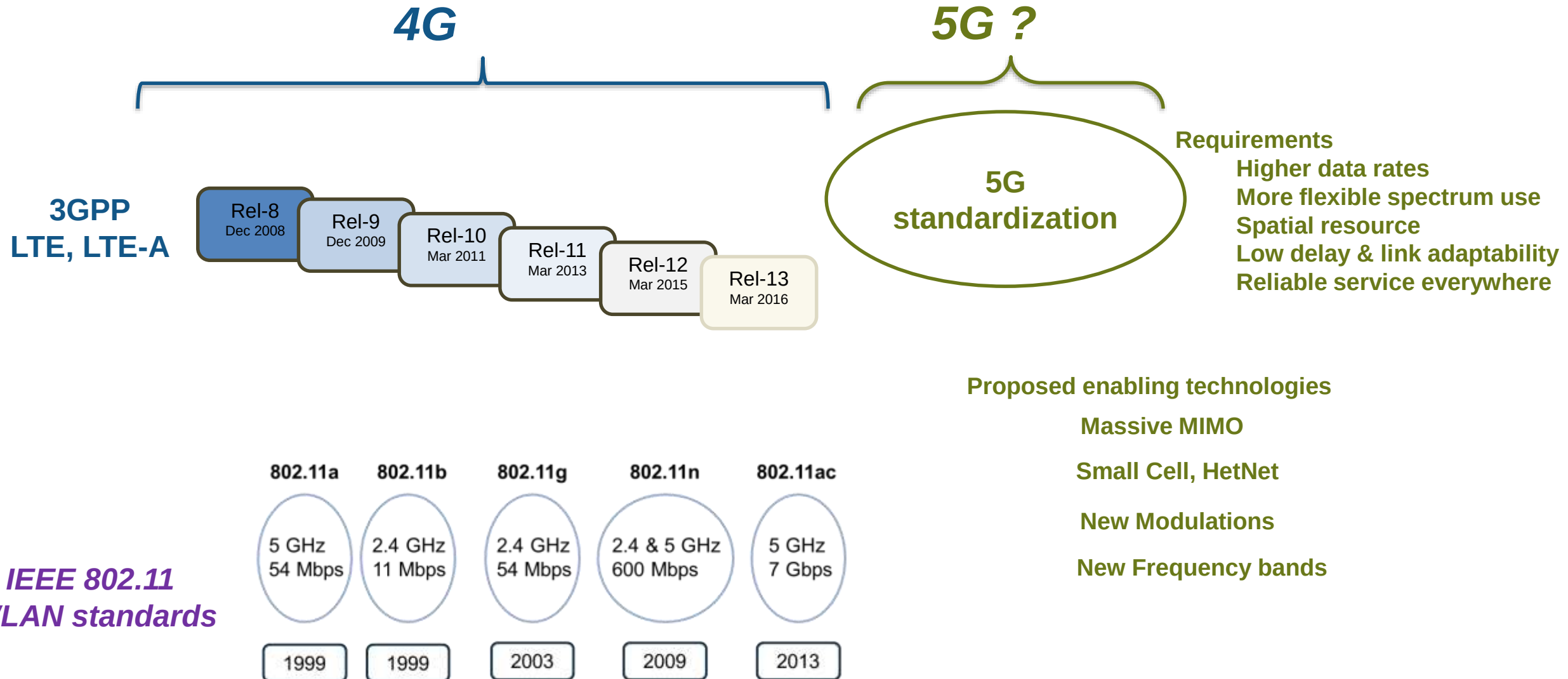
Application Engineer

Agenda

- Innovations in Mobile Communications
- Waveform Generation and End-to-end Simulation
 - WLAN, LTE, 5G (FBMC, UFMC)
- RF Instrument & Software-Defined Radio Connectivity
 - Transmission/Reception of LTE/WLAN Signals with SDRs
- Summary

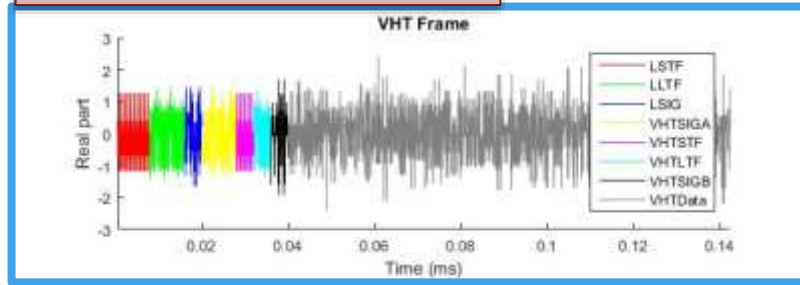


Evolution of Air Interface Technologies

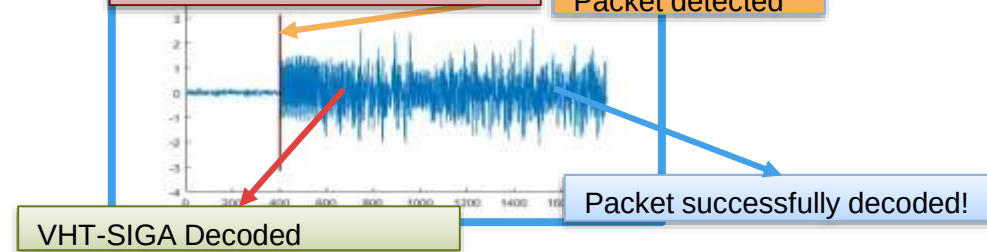


Workflow/Use-cases of wireless designers

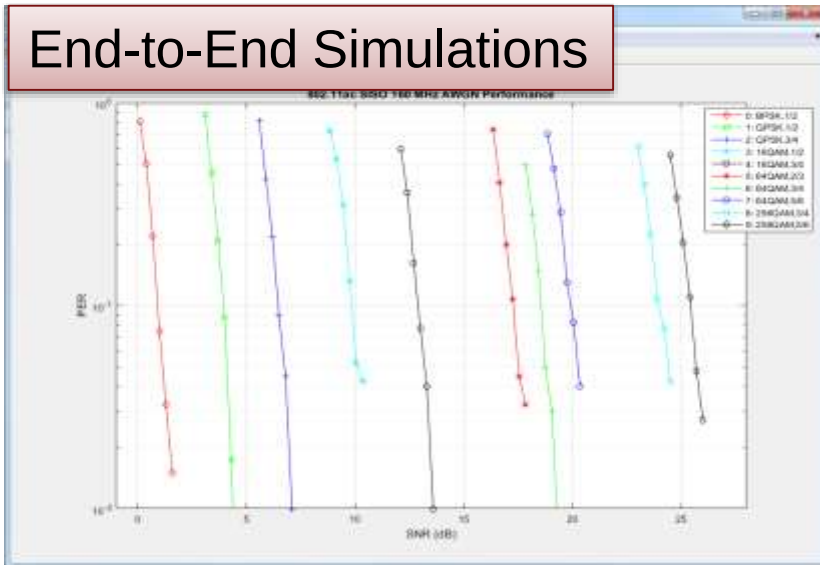
Signal Generation



Signal Detection



End-to-End Simulations



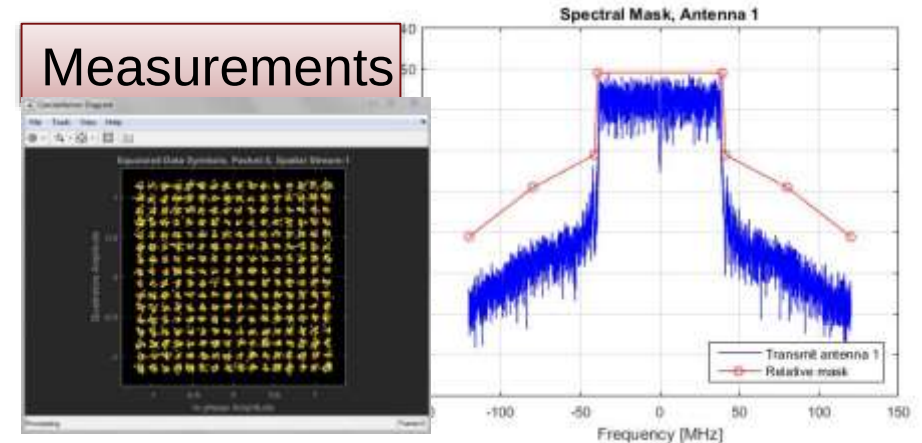
HW & Radio Connectivity

RF Signal Generator



Zynq
SDR

Measurements



Did you know MATLAB/Simulink can help you with ...

Simulation



Design and Verification

*Simulate baseband and RF systems
Including LTE & WLAN standards*

Testing



Over-the-air testing

Validate models with SDR and RF instruments

Production



Prototyping and Implementation

Deploy algorithms onto target system

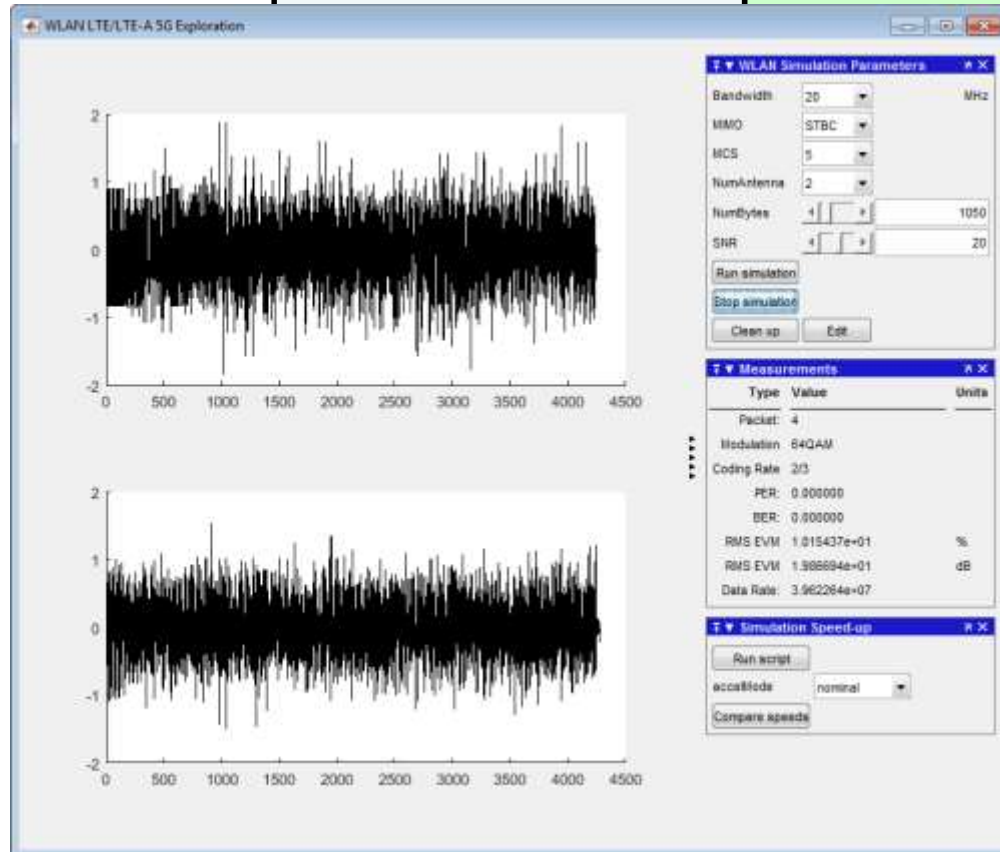
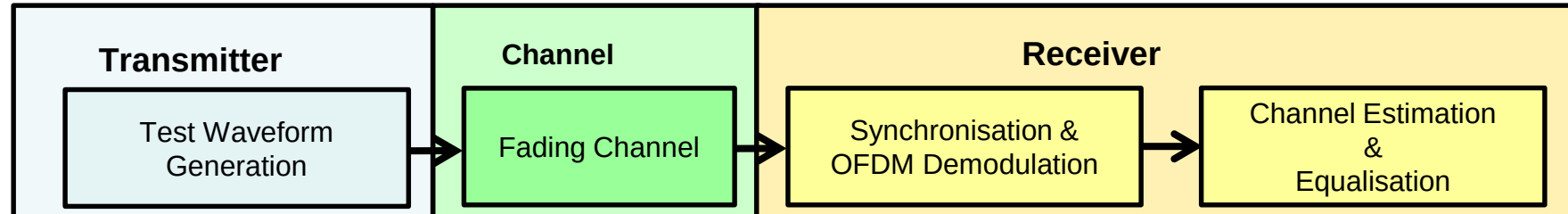


WLAN systems

:Waveform Generation & End-to-end Simulation

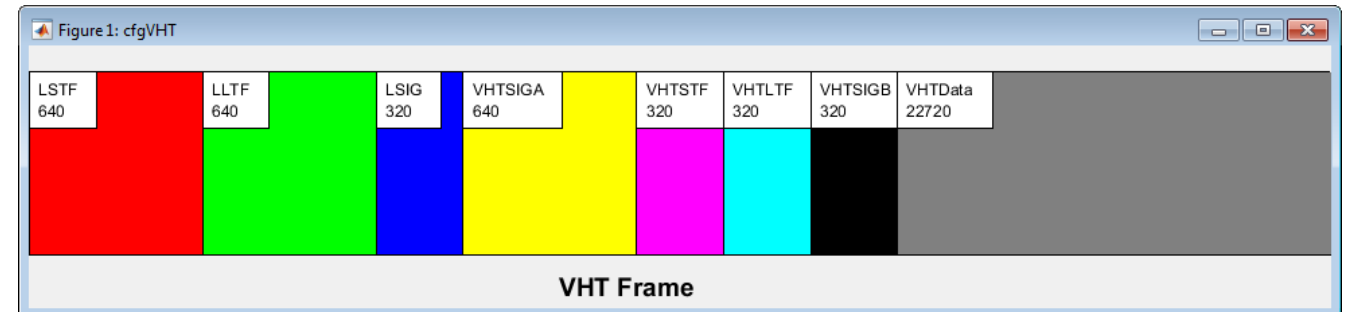
WLAN 802.11ac Transceiver

Demo



```

C:\Matlab_Globecom2015\Houman\wlan\wlan80211acTxChRx.m
EDITOR PUBLISH VIEW
1 function [txSig, rxSig, rxBits, rxEq, rxNonEq, cfgVHTTx] = ...
2     wlan80211acTxChRx(txBits, params, SNR)
3     %% Apply transmitter operations (waveform generation)
4     [txSig, cfgVHTTx] = wlan80211acTransmitter(params, txBits);
5     %% Apply Channel modeling
6     [rxSig, noiseVar] = wlan80211acChannel(txSig, params, SNR);
7     %% Apply receiver operations
8     [rxBits, rxEq, rxNonEq] = wlan80211acReceiver(rxSig, params, noiseVar);
  
```



What is WLAN System Toolbox?

Physical layer (PHY) modeling

Standard-compliant functions for the design, simulation, analysis, and testing of wireless LAN communications systems

Transmitter & Receiver

L-SIG, HT-SIG, VHT-SIG-A, VHT-SIG-B
OFDM, MIMO Equalization, STBC Combining
Packet detection, symbol timing correction
Coarse and fine frequency offset estimation
Preamble signal decoders for L-SIG, HT-SIG, VHT-SIG-A, VHT-SIG-B fields

Propagation Channel

TGn

TGac



Measurements

Packet Error Rate

EVM

Spectral Emissions

Features

Open, customizable MATLAB code

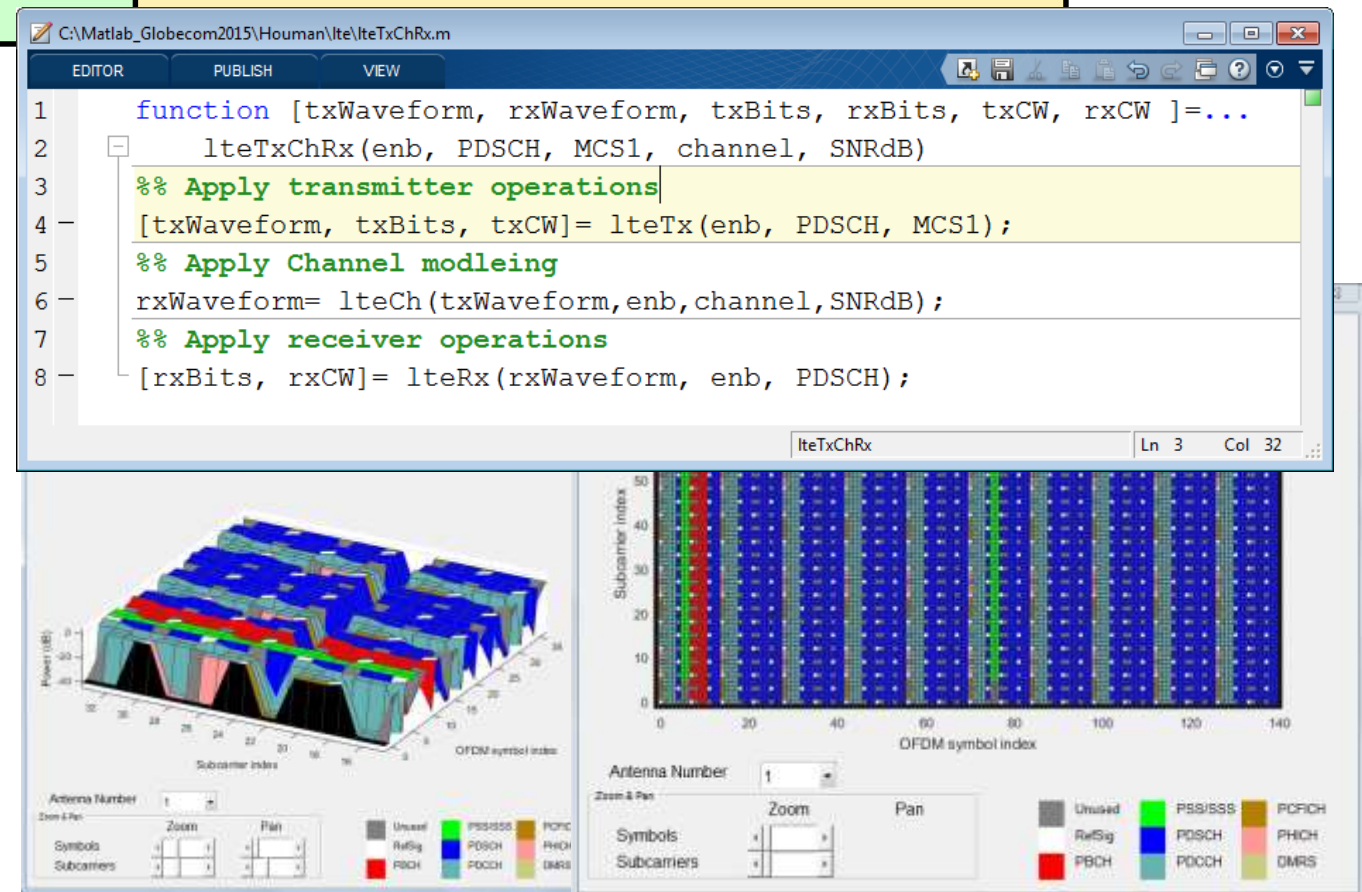
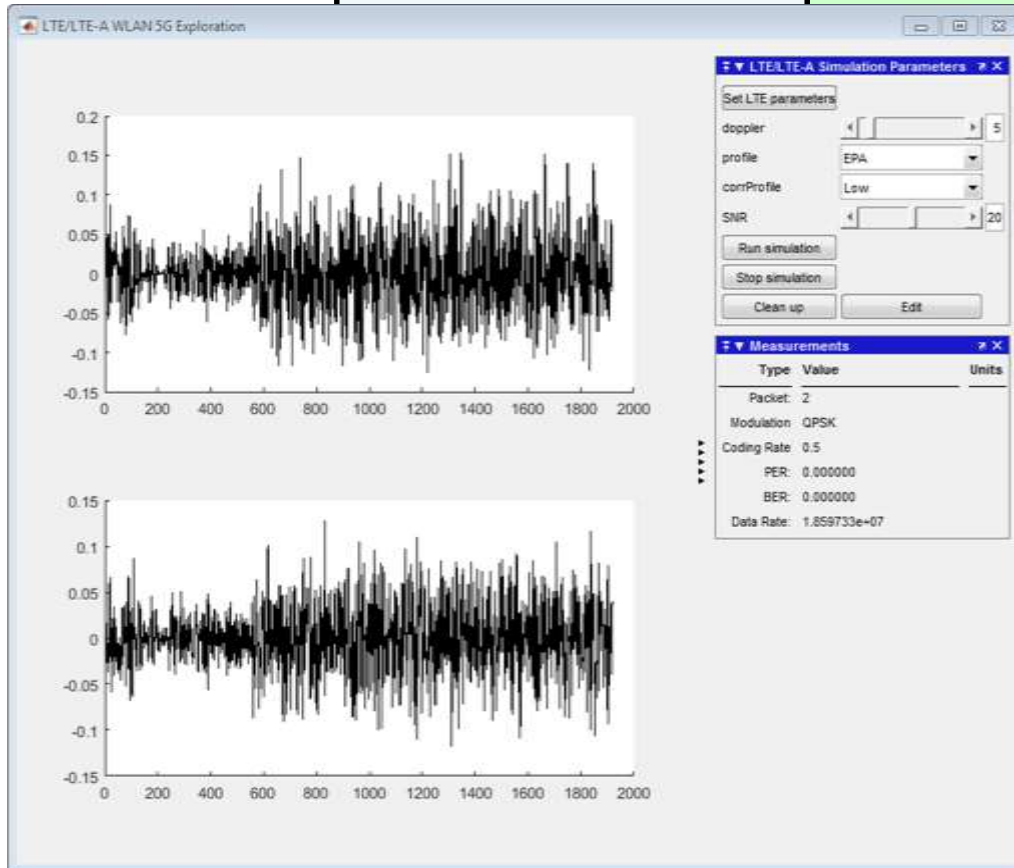
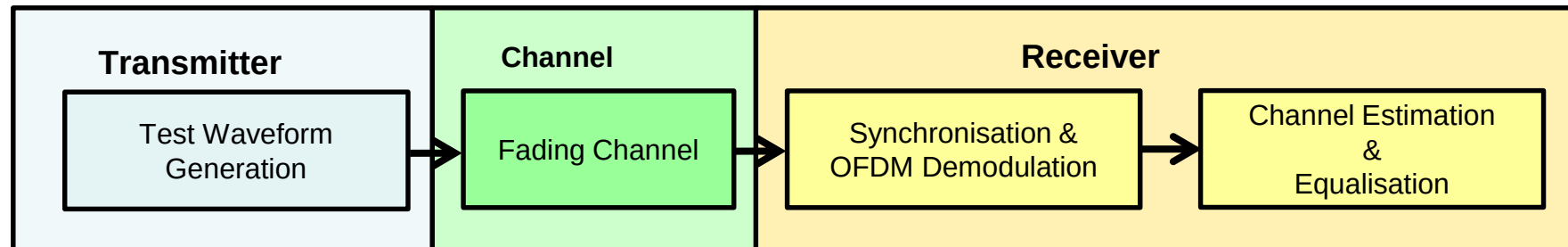
C-code generation with MATLAB Coder

LTE/LTE-A system

:Waveform Generation & End-to-end Simulation

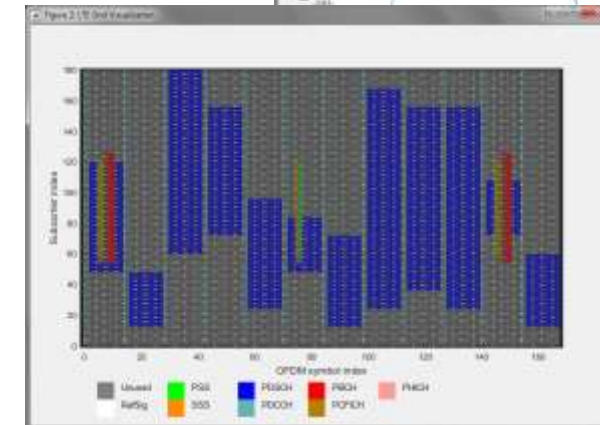
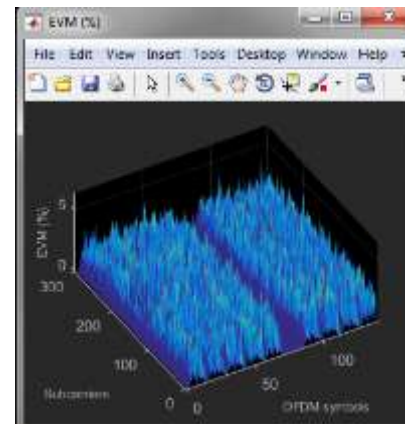
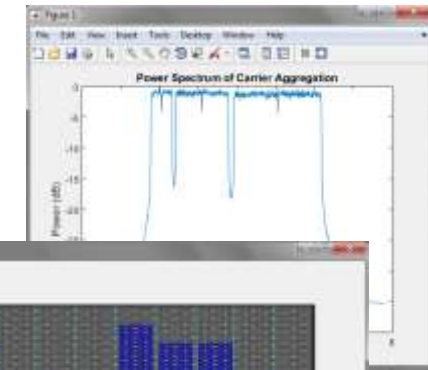
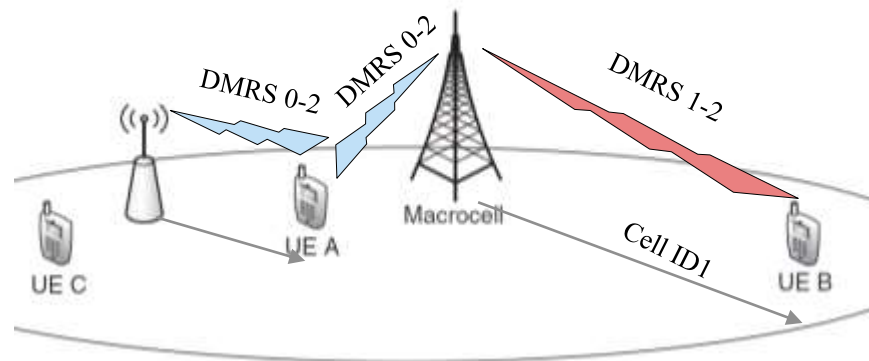
LTE/LTE-A Transceiver

Demo



LTE System Toolbox

- LTE and LTE-Advanced (Rel-8 through Rel-12)
- Scope
 - FDD/TDD
 - Uplink/Downlink
 - Transmitter/Receiver
- ~200 functions for physical layer (PHY) modeling
- Signal generation for LTE & UMTS
- ACLR/EVM measurement
- Conformance Tests

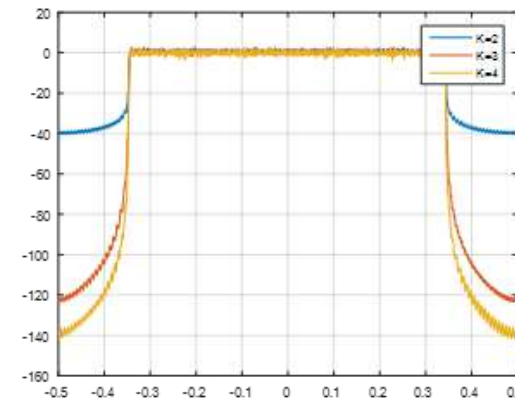


5G New Modulations: FBMC, UFMC

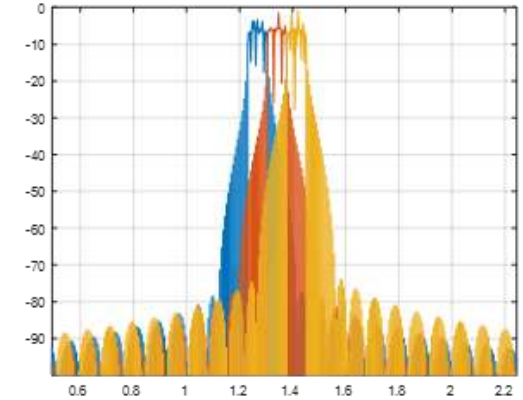
:Waveform Generation & End-to-end Simulation

5G Waveforms: New Modulation Schemes

- For 5G system both efficiency and robust synchronization are paramount
- Majority of candidates: Non-Orthogonal waveforms
- Members of “filtered” OFDM designs:
 1. FBMC: Filter-Bank Multi-Carrier
 2. UFMC: Universal Filtered Multi-Carrier
 3. GFDM: Generalized Frequency Division Multiplexing



FBMC



UFMC



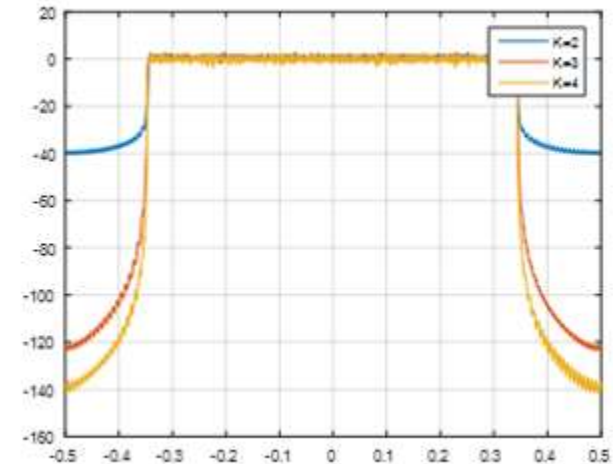
Filter-Bank Multi-Carrier (FBMC)

Demo

- Introduce per-subcarrier filtering to reduce the side-lobes
- Arises from the staggered-multi-tone modulation (SMT) framework
- Couple of implementation options:
 - Frequency spreading (extended iFFT/FFT)
 - Poly-phase network (more efficient, commonly employed)

Disadvantages:

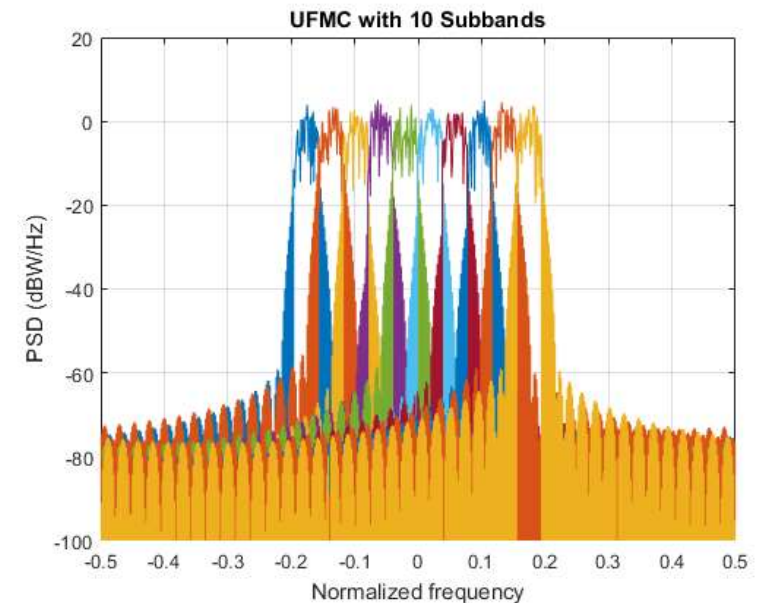
- Non-orthogonal, overlapped symbols
- A more complicated receiver structure, esp. for MIMO



Universal Filtered Multi-carrier (UFMC)

Demo

- Filtering applied per sub-bands (not per sub-carrier as in FBMC)
 - Filtering parameterized by side-lobe attenuation
 - Reduced filter length (compared to FBMC)
 - Good for short bursts, suited for uplink with multiple users
- Orthogonal in the complex plane
 - use complex QAM symbols, reapply MIMO schemes
- Receive complexity
 - Similar to OFDM, use per subcarrier equalization



5G Challenges and Our solutions

- **New Modulation Schemes**

- Performance characteristics of FBMC, UFMC, etc.

- **More Antennas**

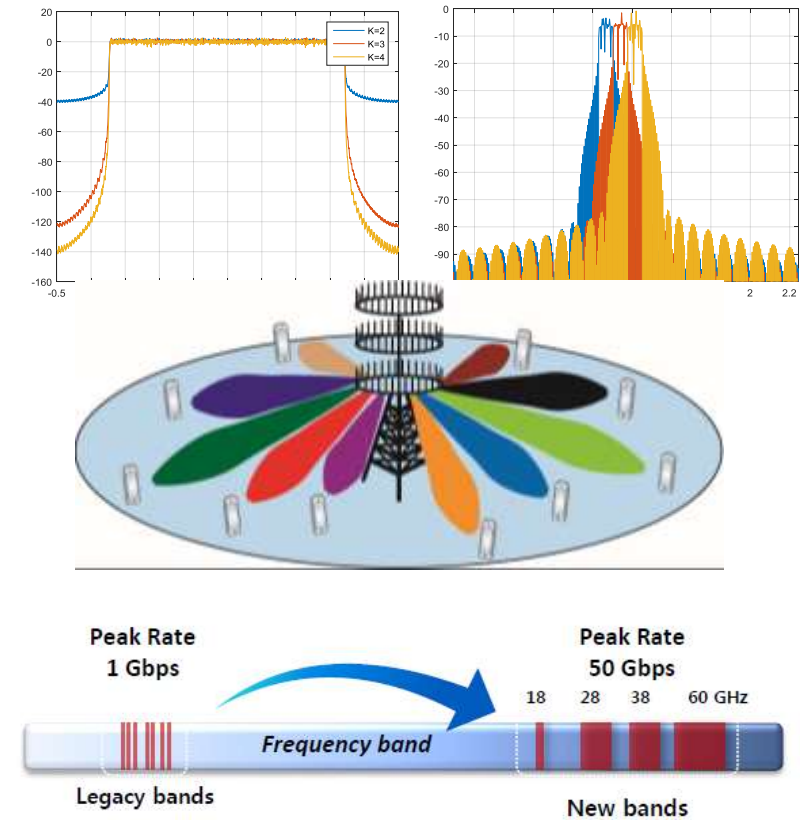
- Beamforming and precoding algorithms
- Antenna arrays and Massive MIMO

- **New Frequency Bands**

- RF system architectures design in mmWave frequencies
- Advanced Antenna, RF and DSP Co-Design
- Channel modeling from real-world measurement data

- **Real Hardware Verification and Prototyping**

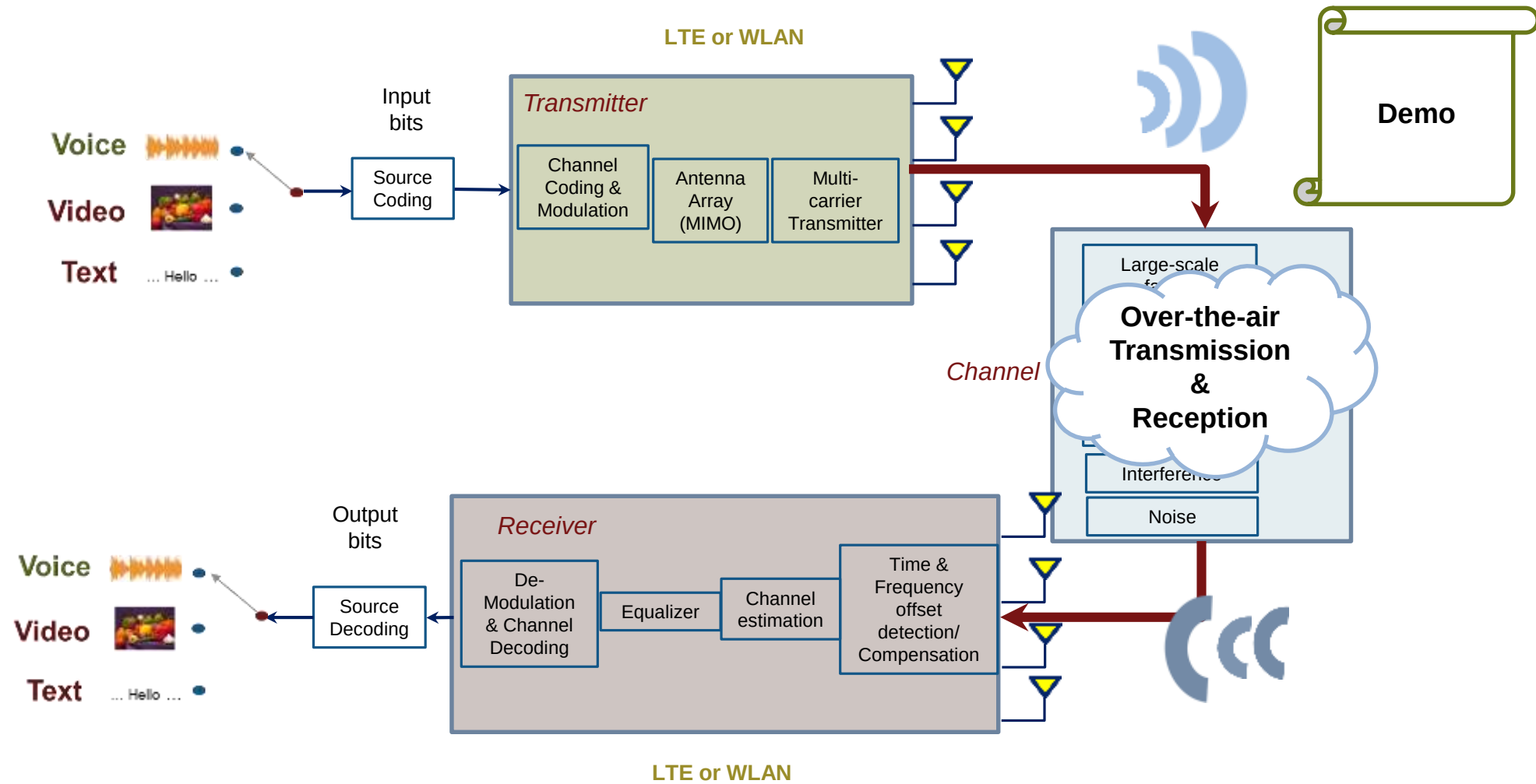
- Hardware testbed to verify designs with live radio signals in realistic scenarios with standard compliant signals such as LTE and Wi-Fi
- Quick prototyping on FPGA



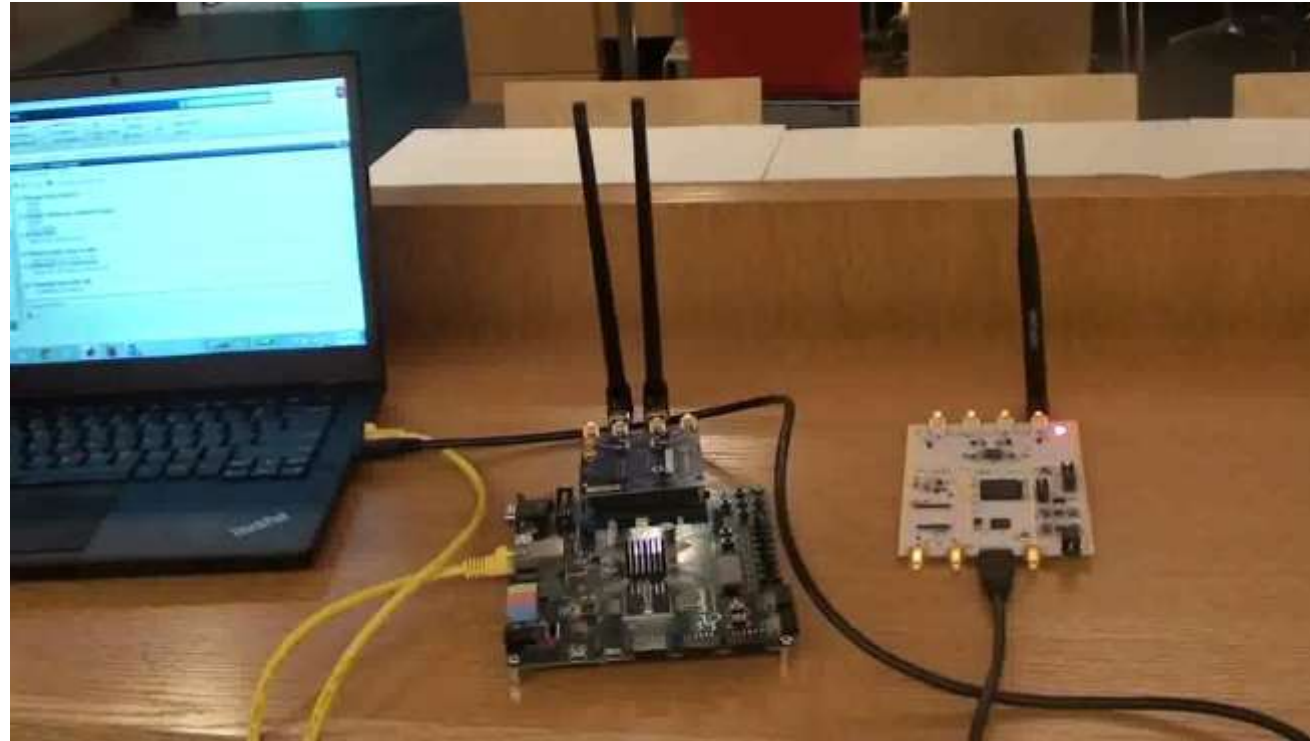
Connectivity to RF instruments & SDR

: Over-the-air testing and Verification with Radio/Hardware

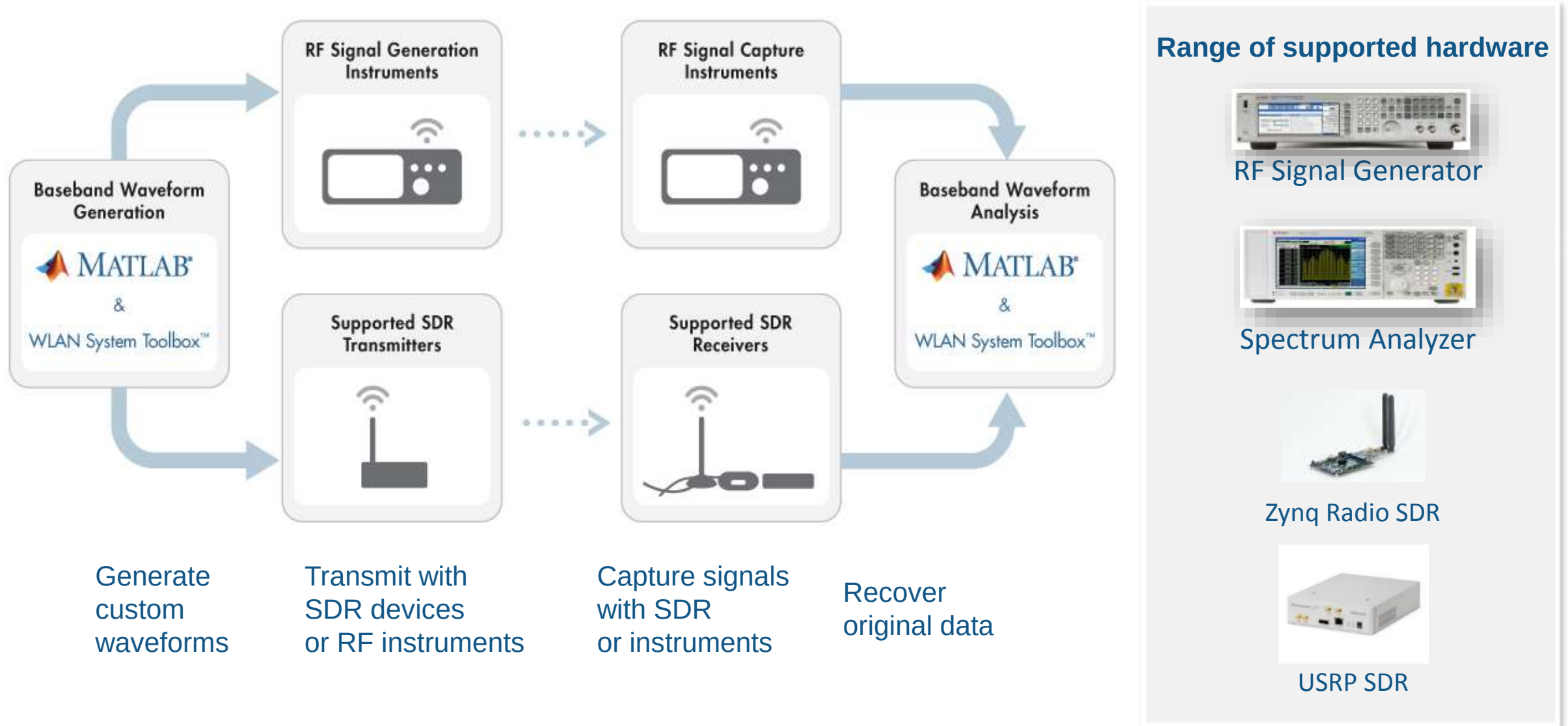
Over-the-air testing



Physical connectivity to radio hardware



Hardware & Radio Connectivity



Supported SDRs & RF instruments

RF Signal Generator



Zynq Radio SDR



USRP SDR



RF Spectrum Analyzer



Zynq Radio SDR



USRP SDR



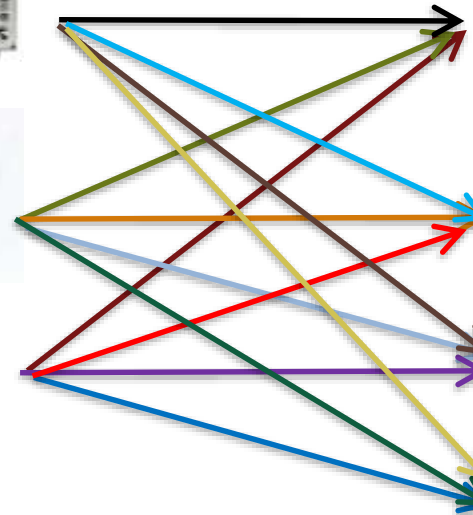
RTL SDR



Transmitter



Receiver



Summary:

With Today's MATLAB you can ...

Design and Verification

Simulate baseband and RF systems

- 5G, WLAN, LTE and custom waveform generation
- Measurements (EVM, BER, PER, ...) & analysis of received waveforms
- Transmitter-Channel-Receiver end-to-end simulation



Over-the-air testing

Validate models with SDR and RF instruments

- Connect LTE/WLAN signals to USRP or Zync Radio
- Live experiments with Video/music/audio as input signals
- Measurements (EVM, BER, PER, ...) & analysis of over-the-air received waveforms

