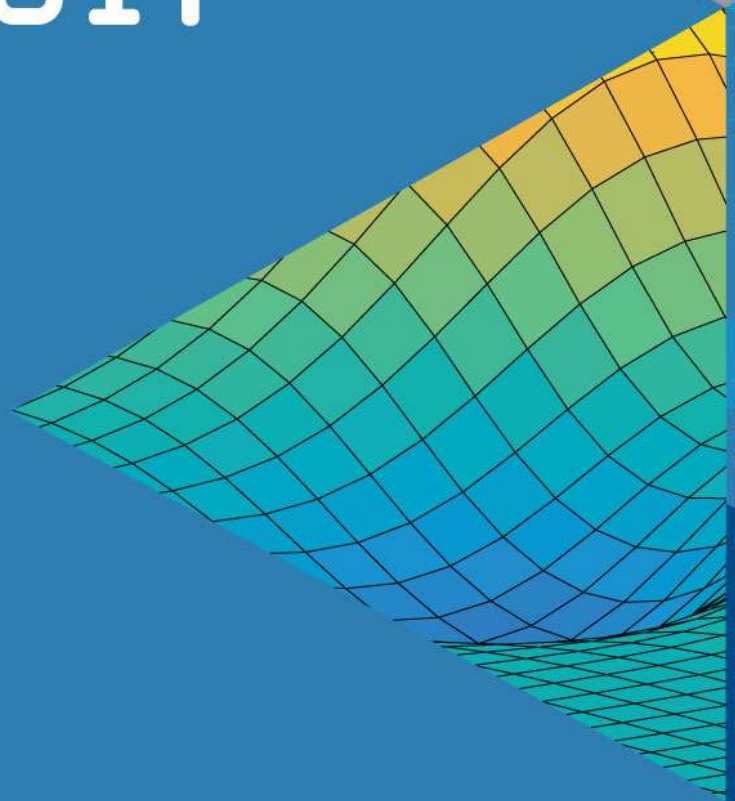
MATLAB EXPO 2017 KOREA

4월 27일, 서울

등록 하기 matlabexpo.co.kr



5G 무선통신 시스템 설계
: WLAN/LTE/5G

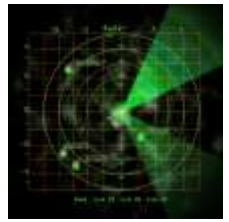
김종남
Application Engineer

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



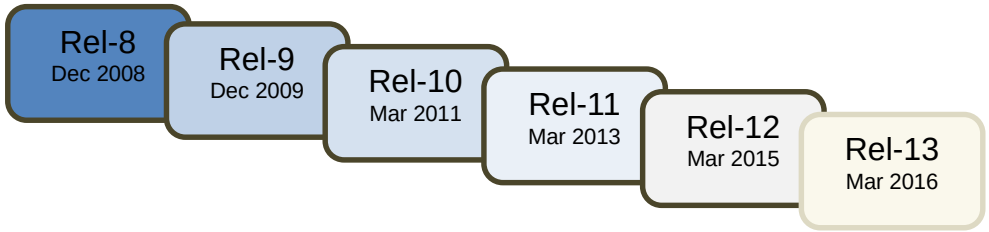


Evolution of Air Interface Technologies

4G **5G ?**

3GPP
LTE, LTE-A

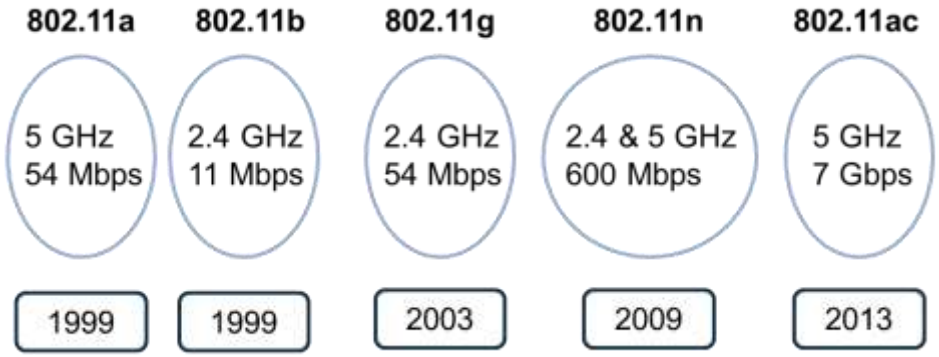


5G standardization

Requirements
- **Higher data rates**
- **More flexible spectrum use**
- **Spatial resource**
- **Low delay & link adaptability**
- **Reliable service everywhere**

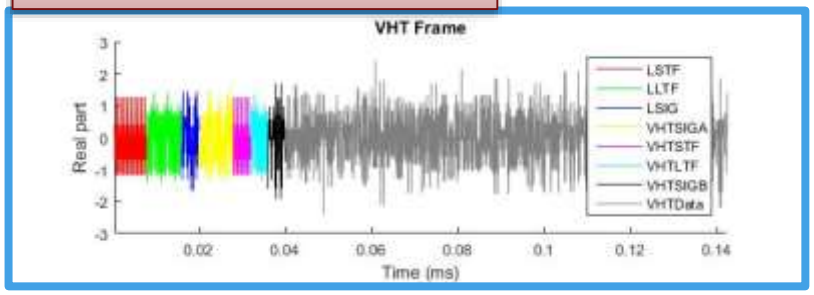
Proposed enabling technologies
- **Massive MIMO**
- **Small Cell, HetNet**
- **New Modulations**
- **New Frequency bands**

IEEE 802.11 WLAN standards

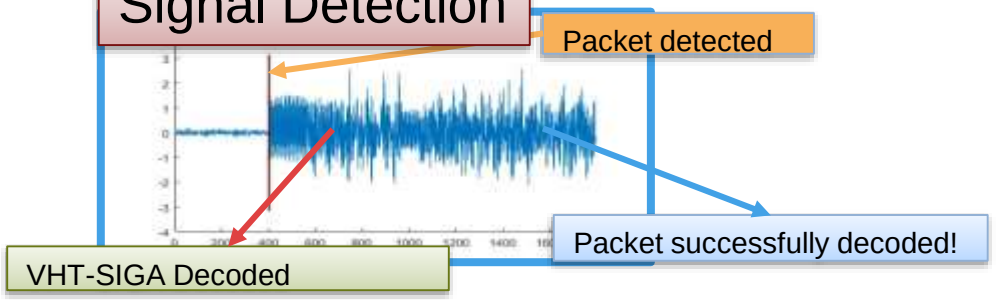


Workflow/Use-cases of wireless designers

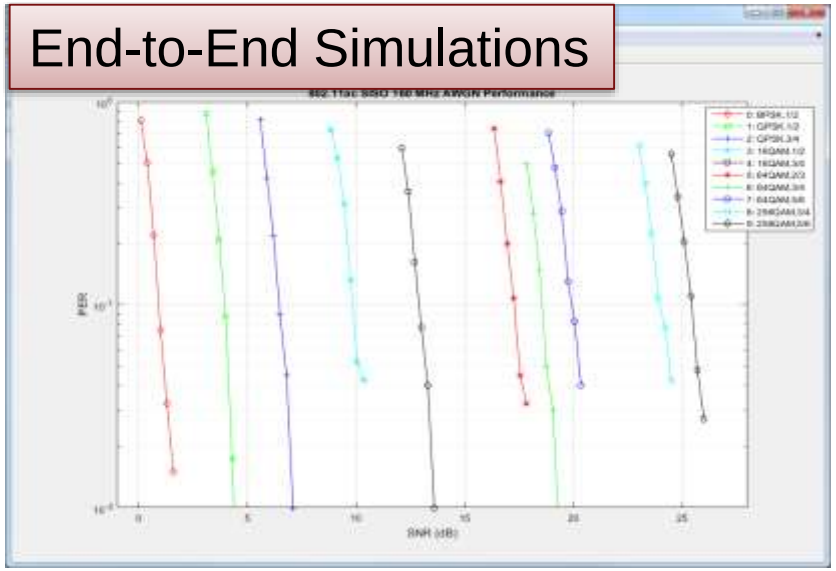
Signal Generation



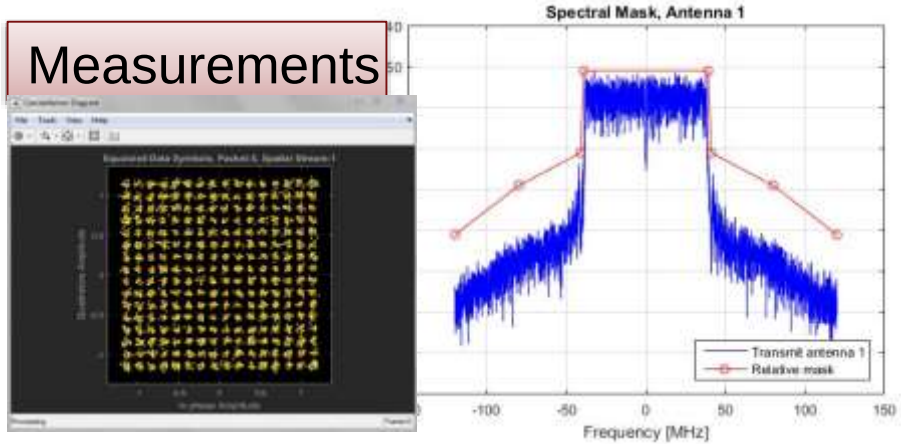
Signal Detection



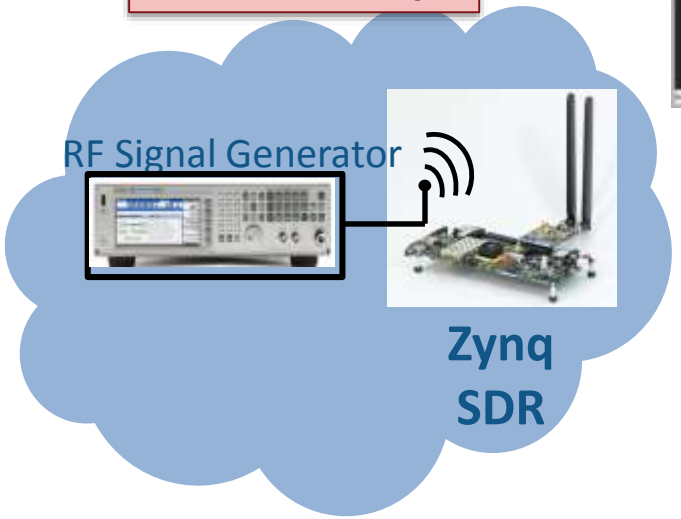
End-to-End Simulations



Measurements



HW & Radio Connectivity



Did you know MATLAB/Simulink can help you with …

Design and Verification

Simulate baseband and RF systems
Including LTE & WLAN standards

Over-the-air testing

Validate models with SDR and RF instruments

Prototyping and Implementation

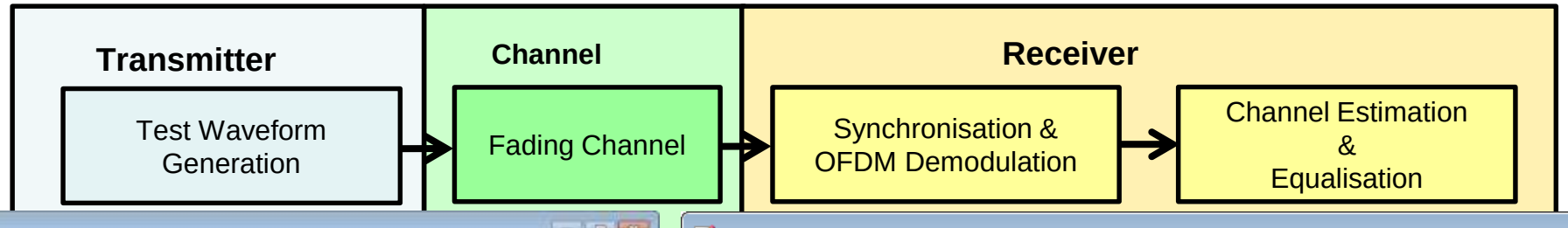
Deploy algorithms onto target system

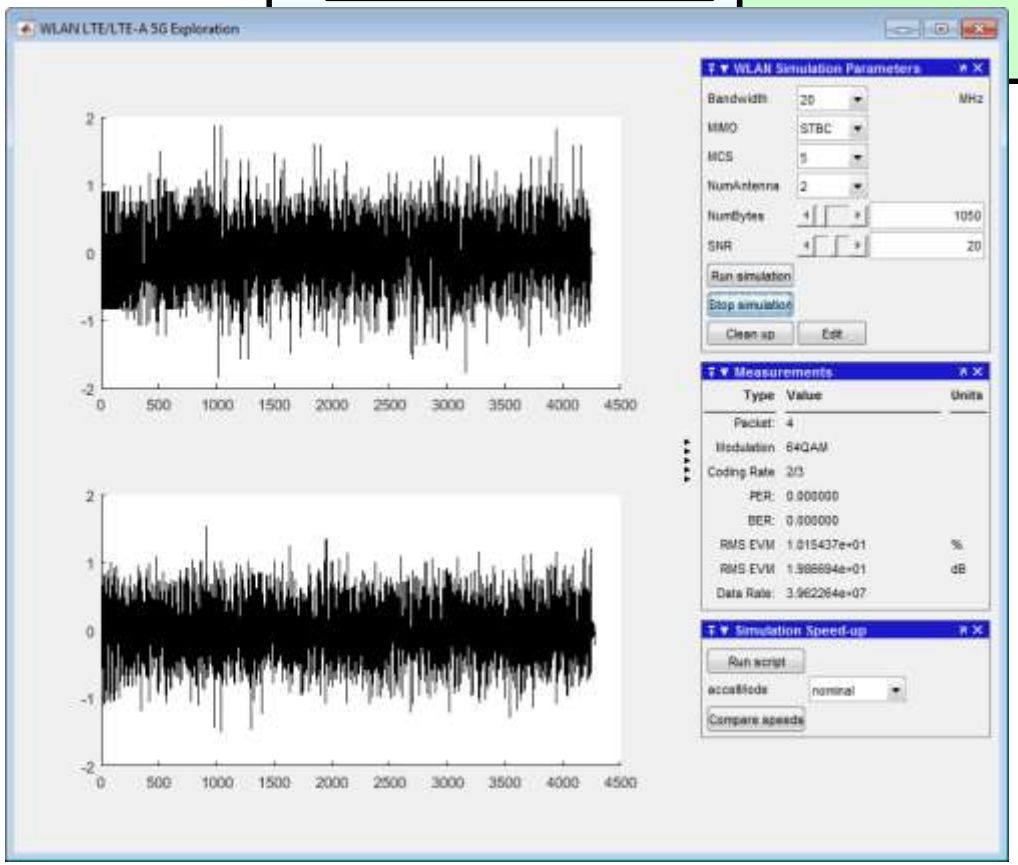
WLAN systems

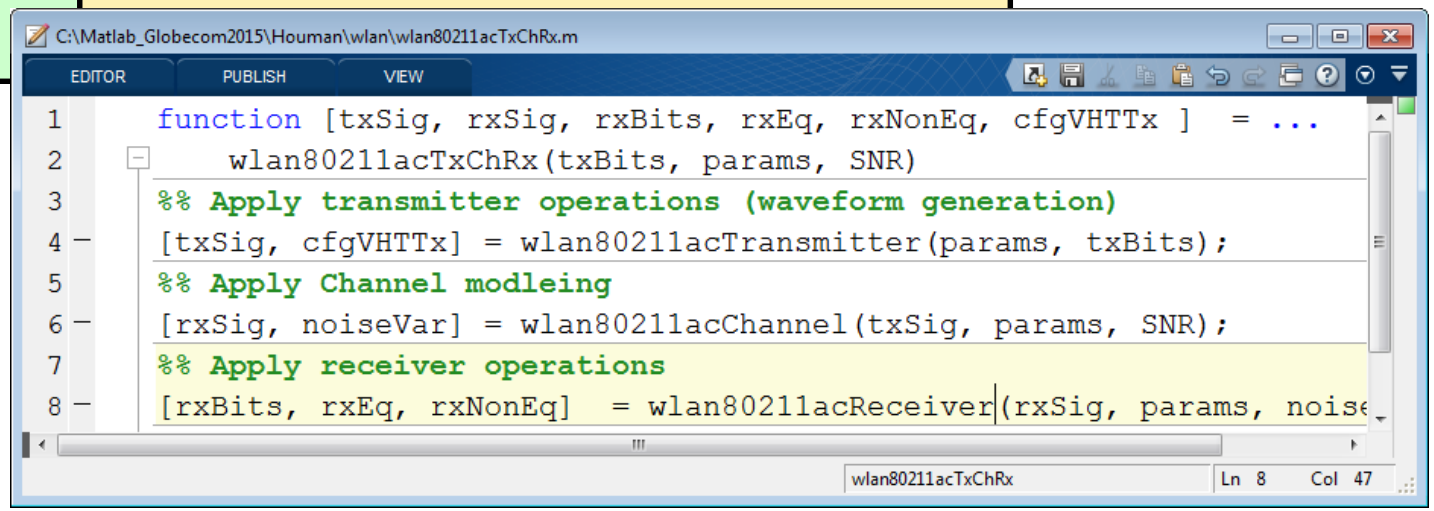
:Waveform Generation & End-to-end Simulation

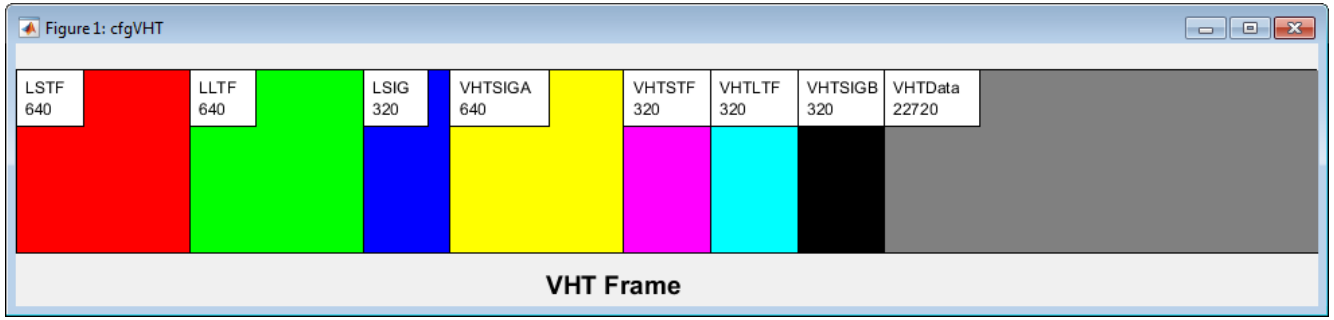
WLAN 802.11ac Transceiver

Demo









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

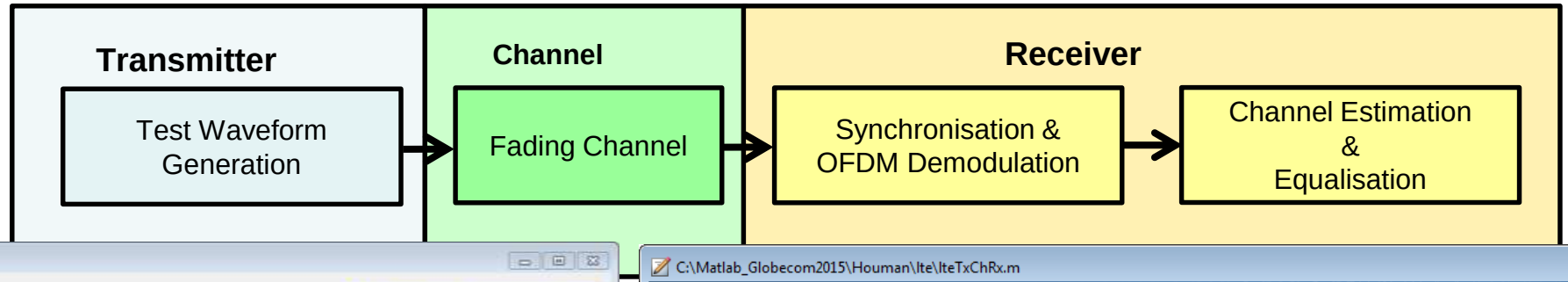
Open, customizable MATLAB code
C-code generation with MATLAB Coder

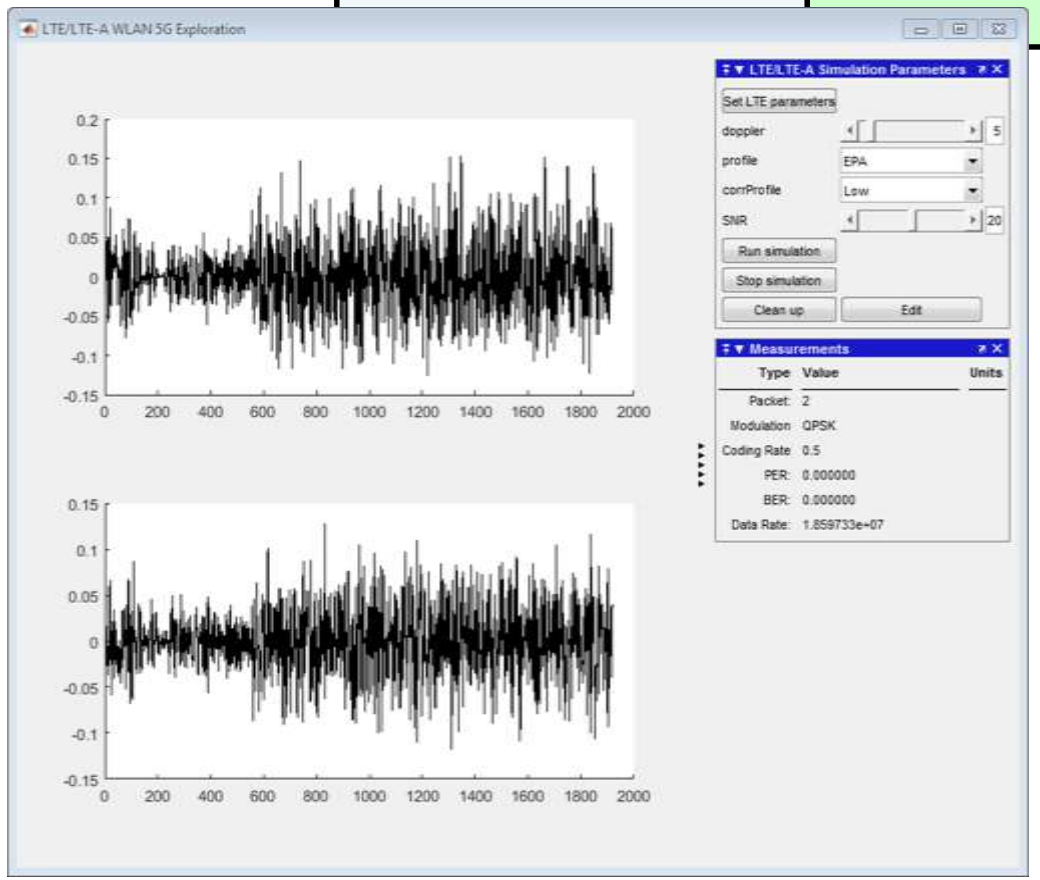
LTE/LTE-A system

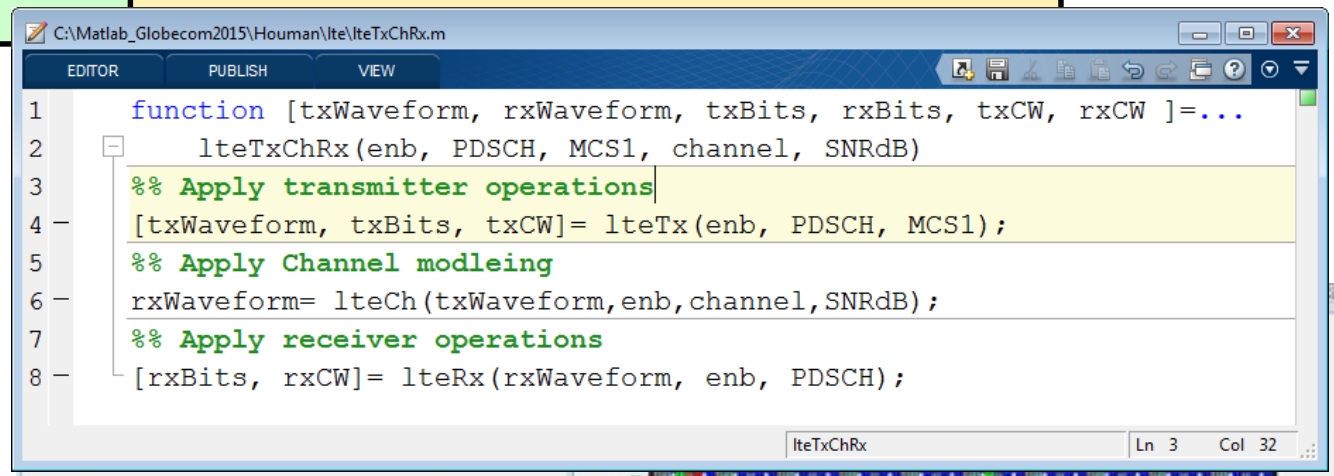
:Waveform Generation & End-to-end Simulation

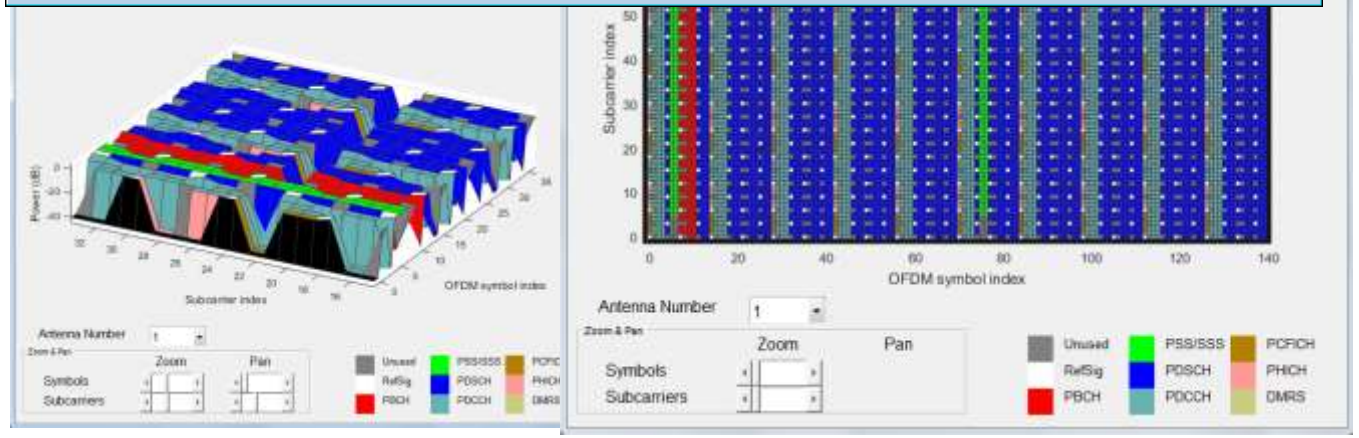
LTE/LTE-A Transceiver

Demo



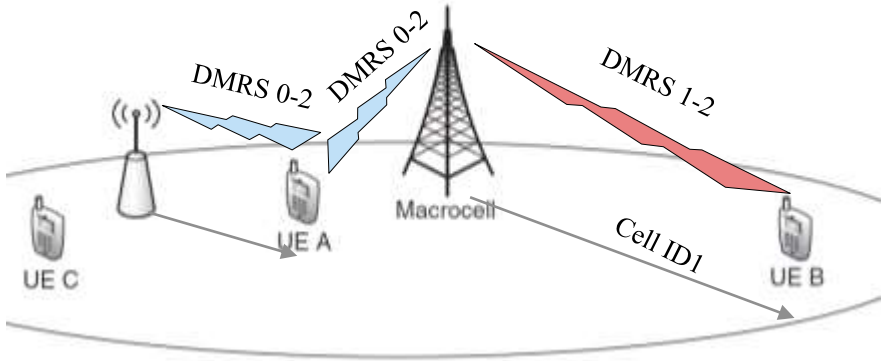




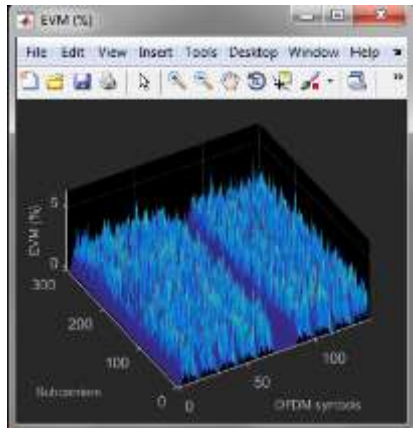


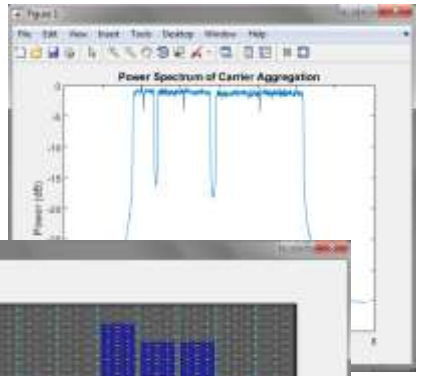
LTE System Toolbox

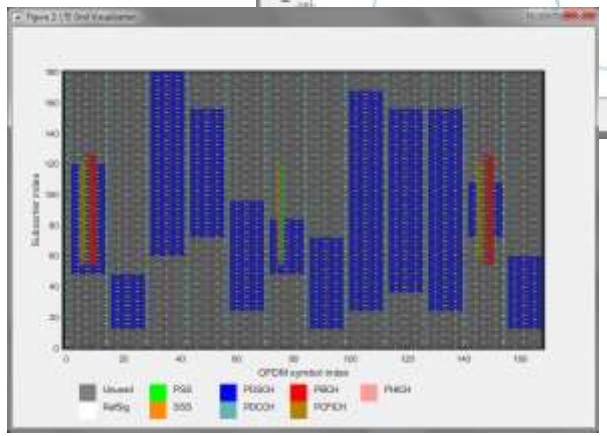
- LTE and LTE-Advanced (Rel-8 through Rel-12)
- Scope
  - FDD/TDD
  - Uplink/Downlink
  - Transmitter/Receiver



- ~200 functions for physical layer (PHY) modeling
- Signal generation for LTE & UMTS
- ACLR/EVM measurement
- Conformance Tests





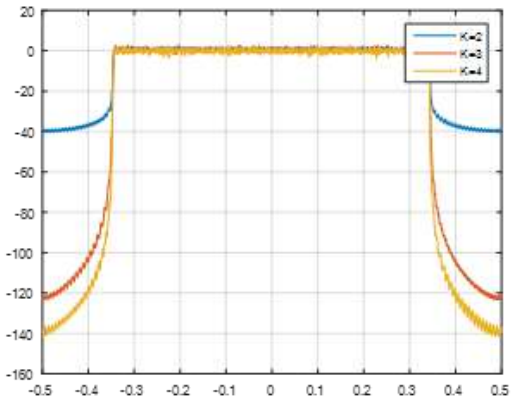


5G New Modulations: FBMC, UFMC

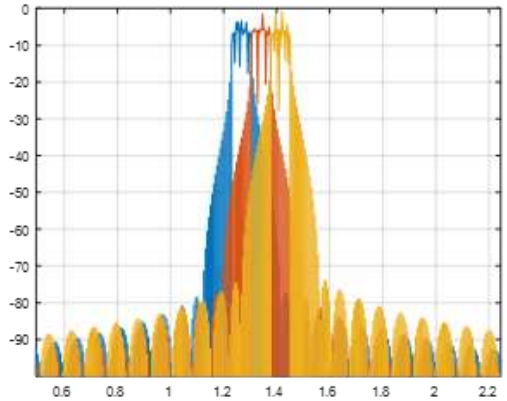
:Waveform Generation & End-to-end Simulation

5G Waveforms: New Modulation Schemes

- For 5G system both efficiency a nd robust synchronization are p aramount
- Majority of candidates: Non-Orth ogonal waveforms
- Members of “filtered” OFDM des igns:
  1. FBMC: Filter-Bank Multi-Carrier
  2. UFMC: Universal Filtered Multi-C arrier
  3. GFDM: Generalized Frequency Di vision Multiplexing



FBMC

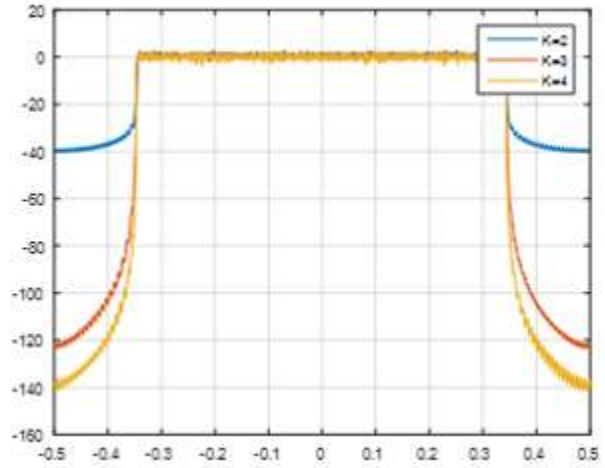


UFMC

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)



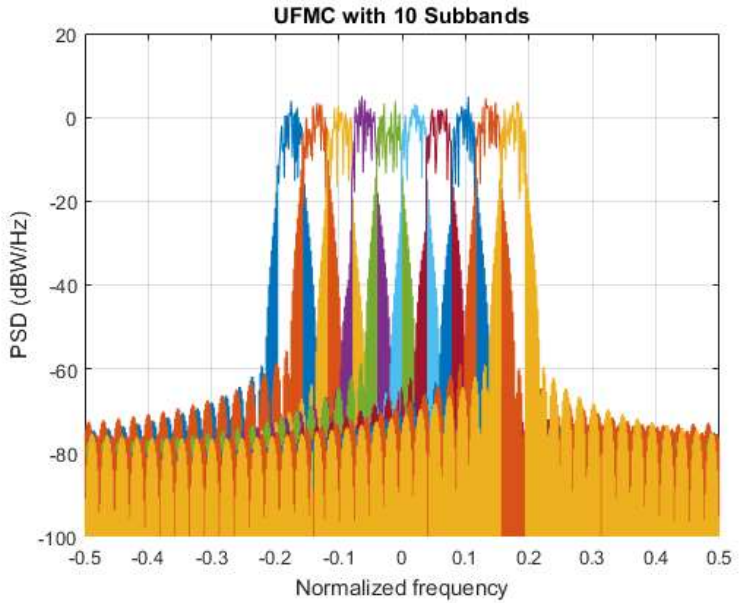
Disadvantages:

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

Universal Filtered Multi-carrier (UFMC)

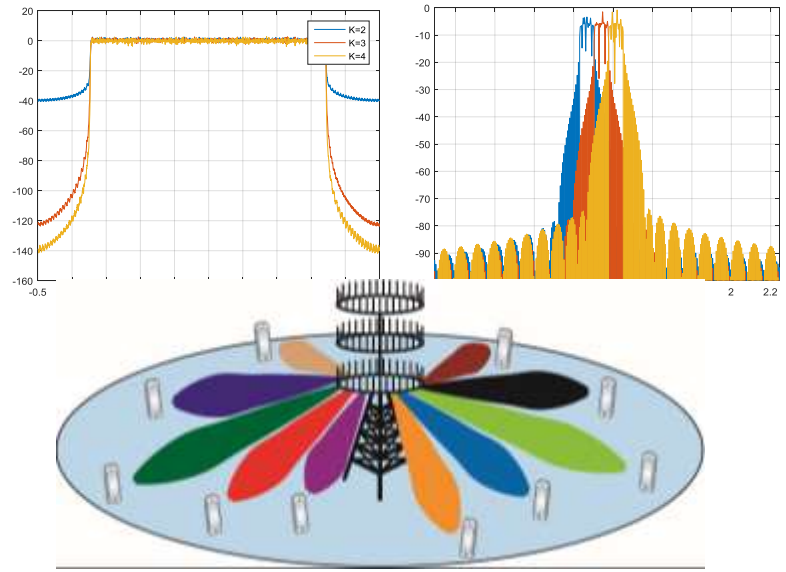
Demo

- 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

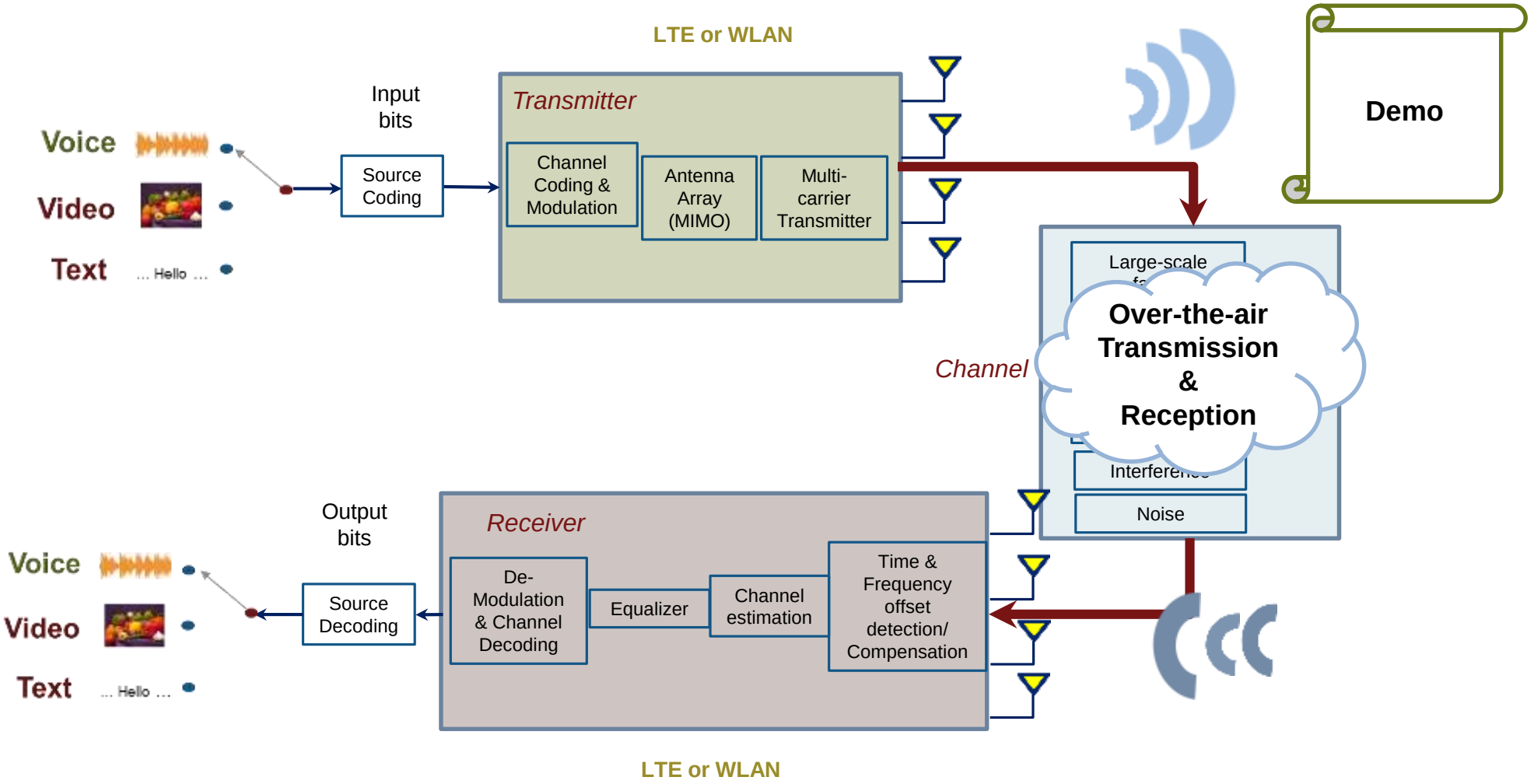
- **New Modulation Schemes**
  - Performance characteristics of FBMC, UFMC, etc.
- **More Antennas**
  - Beamforming and precoding algorithms
  - Antenna arrays and Massive MIMO
- **New Frequency Bands**
  - RF system architectures design in mmWave frequencies
  - Advanced Antenna, RF and DSP Co-Design
  - 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 stand ard compliant signals such as LTE and Wi-Fi
  - Quick prototyping on FPGA



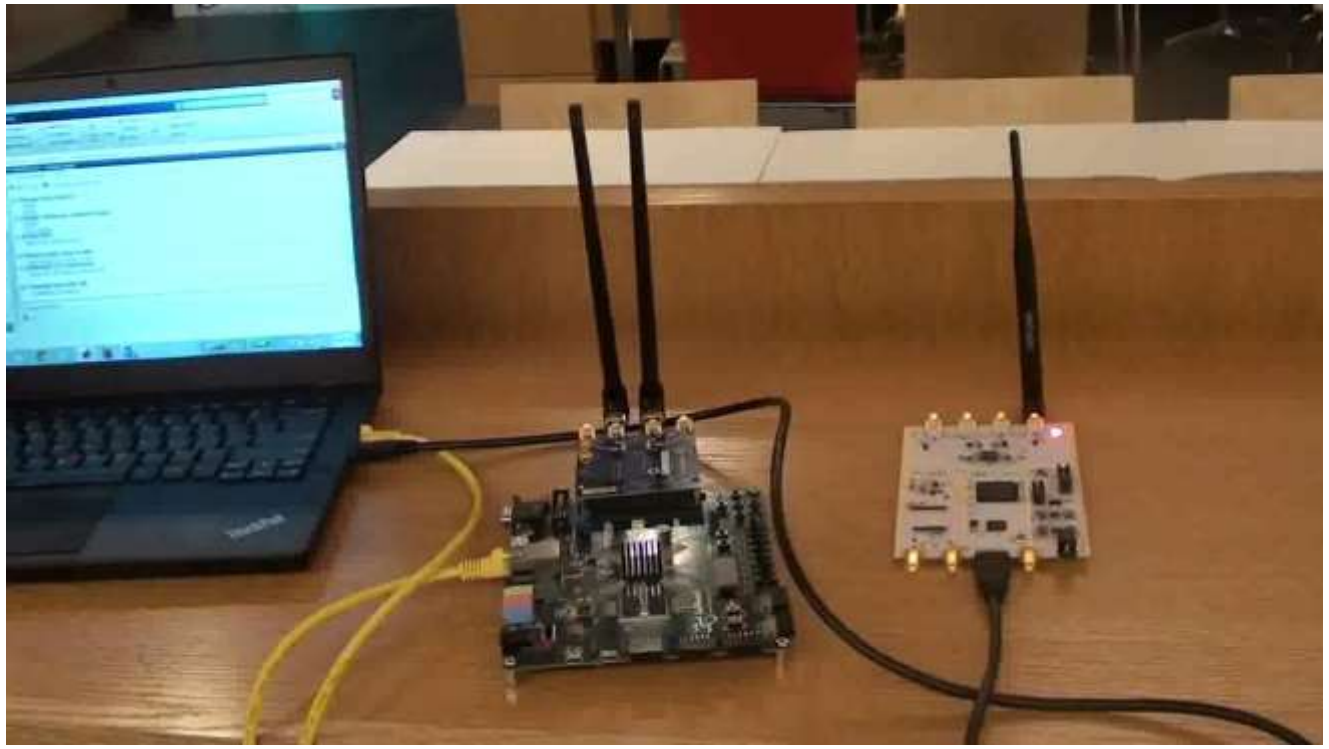
Connectivity to RF instruments & SDR

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

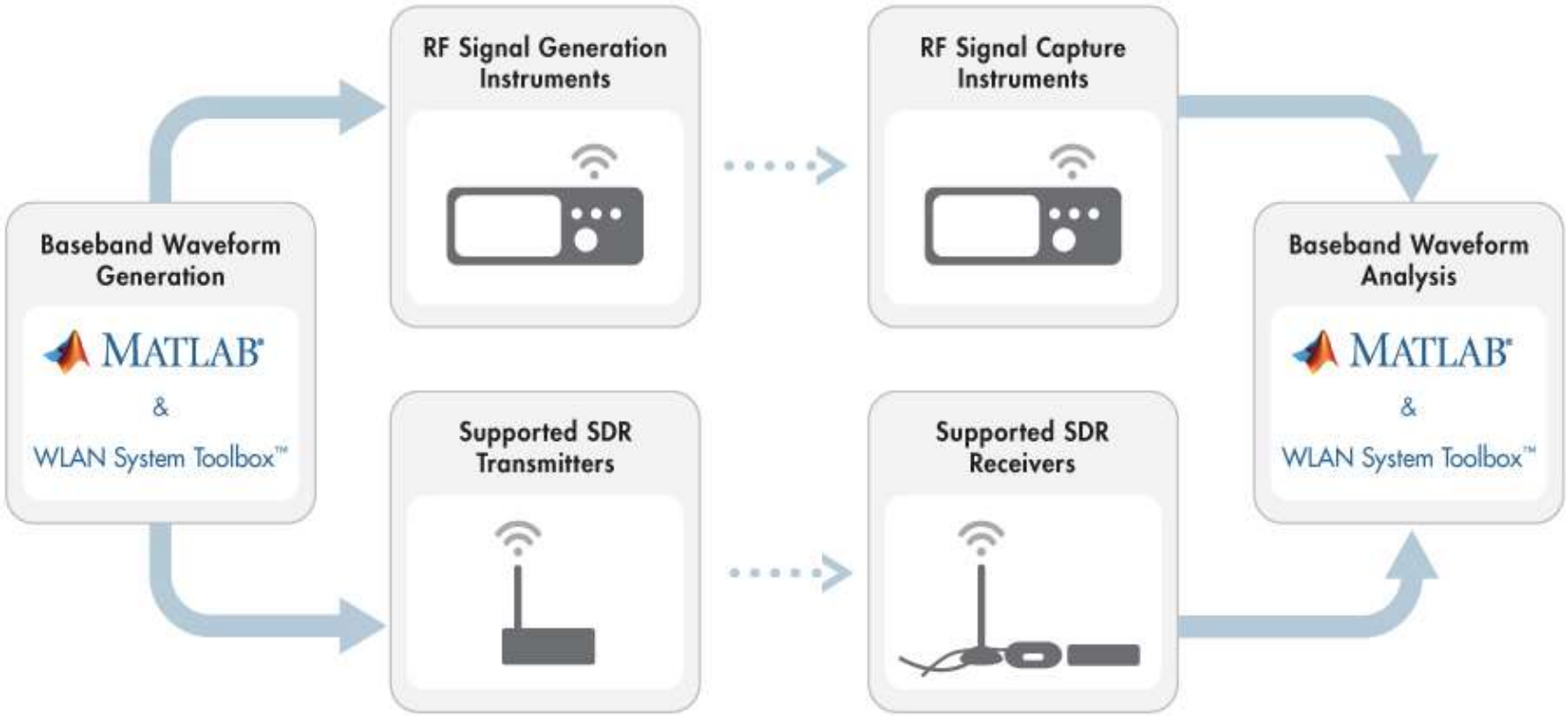
Over-the-air testing



Physical connectivity to radio hardware



Hardware & Radio Connectivity



Generate custom waveforms

Transmit with SDR devices or RF instruments

Capture signals with SDR or instruments

Recover original data

Range of supported hardware

RF Signal Generator

Spectrum Analyzer

Zynq Radio SDR

USRP SDR

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*