Trends in AESA Radar Systems

- Phased Array technology is pervasive
- Array structures are complex – conformal arrays are required
- Predicting system performance most valuable early in the project
- Requirements for robust operations in the presence of interference
- Wideband applications are expanding rapidly
- Multi-function, multi-domain systems are complex (radar, EW, comms)
Full Coverage of Radar Design Process

- Testing
- System architecture
- Documentation Generation
- Requirements management
- C and HDL Code Generation
- Radar design & simulation
Radar System Design: From Antenna to Algorithms

Antenna, Antenna arrays
- type of element, # elements, configuration
  - Antenna Toolbox
  - Phased Array System Toolbox

Channel - interference, clutter, noise
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Mixed-Signal
Continuous & discrete time
- Simulink
- DSP System Toolbox
- Control System Toolbox

Algorithms
beamforming, beamsteering, MIMO
- Phased Array System Toolbox
- Communications System Toolbox
- DSP System Toolbox

Signal Processing
- Phased Array System Toolbox
- Signal Processing Toolbox
- SimEvents
- Instrument Control Toolbox

RF Impairments
frequency dependency, non-linearity, noise, mismatches
- RF Blockset
- RF Toolbox

Waveforms & Resource Scheduling
Automotive Radar Modeling

- What kinds of parameters can we determine from a model?
  - Detection
  - Angle of arrival
  - Distance
  - Direction

- How can we use a radar to see this region of interest?
Modeling ADAS Features in Simulink

Integrate sensing (radar, vision, etc…) and control algorithms
Multifunction Space-Time Adaptive Processing (STAP) Radar Model

- What is needed to model radar systems?
  - Phased array antenna
  - Receiver/Transmitter
  - Propagation channel
  - Target(s)
  - Interference
  - Clutter
  - Signal processing algorithms
Objectives for MathWorks Radar Simulation Architecture

- Extensible modeling tools for phased array radar design
  - Reduce risk of complex system development
  - Signal level simulation to ensure understanding before system is designed and built

- Multi-domain system modeling for radar systems
  - RF, signal processing, data processing, etc.

- Path to higher fidelity and customization
  - Model should match closely with end system

- Live specification for model-based design
  - Encourage re-use through project phases and across projects
  - Provide early model of system to your customers
Simulation Framework Overview

- Functions for calculations and analysis
- Apps for common workflows
- Parameterized components for system modeling
- Code generation for deployment
Array Modeling

- Design an array
- Design subarrays
- Model imperfections
- Import antenna patterns

- Taper/thin arrays
- Synthesize arrays
- Model failures
- Model mutual coupling

Similar capabilities for other radar components
System Level Validation

Wideband Radar with One Target in a Separable Multipath Environment
Supporting Capabilities for Radar Systems

Data cube processing

Scenario visualization

Polarization

Wideband

Spatial signal processing

Environment

CFAR

Code generation

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Path to Higher Fidelity

- Extend model fidelity over project evolution

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- Simple interface to replace off-the-shelf components with custom ones
Case Studies: Staggered PRF Radar

Dynamic PRF/Waveform selection based radar detections
Closed loop between radar model and scheduler
Case Studies: Modeling a Radar Scheduler

Dynamic & static events
Case Studies: Model-Based Design of an MTI Radar

Develop and test with synthesized data

Verification with measured data

8 channel Rx array
Workflow

- Model-based simulation for algorithm development and validation
  - Scenario synthesis
  - Detection thresholds, CFAR, Beamforming, DOA

- Moving Target Indication
  - Pulse canceller

- Range-Doppler processing

- Antenna effects
  - Mutual coupling
  - Model fidelity

```matlab
>> myURA = phased.URA;
>> myURA.Element = customAntenna;
```
Summary

- Building phased array radar systems is easier with MathWorks tools
  - Phased Array System Toolbox
  - Antenna Toolbox
  - RF Blockset

- Many examples to get started with

- Thank you for attending and please visit our demo station

Explore these examples and more online:
mathworks.com/phased-array-examples

- Antenna Array Analysis with Custom Radiation Pattern
- Array Pattern Synthesis
- Mutual Coupling in Large Arrays
- Space-Time Adaptive Processing
- Designing a Monostatic Pulse Radar
- Ground Clutter Mitigation with MTI Radar
- Simulating a Bistatic Polarimetric Radar

Radar System Design: mathworks.com/radar
What You Can Do to Learn More

Design and simulate phased array signal processing systems

Phased Array System Toolbox™ provides algorithms and apps for the design, simulation, and analysis of sensor array systems in radar, sonar, wireless communications, and medical imaging applications. The system toolbox includes pulsed and continuous waveforms and signal processing algorithms for beamforming, matched filtering, direction of arrival (DOA) estimation, and target detection. It also includes models for transmitters and receivers, propagation, targets, jammers, and clutter.

The system toolbox lets you model the dynamics of ground-based, airborne, or ship-borne multifunction radar systems with moving