System level Radar Simulation using Model based Design

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Introduction

❖ Phased Array Radar System consists of different subsystems such as Antenna, Waveform, RF, Signal and Data Processing.

❖ The system is also dependent upon external entities such as target, clutter, jammer and channels.

❖ The system requires a model based design approach for end to end radar design, analysis and simulation.
Challenges

- Multi Domain
- Multiple Teams
- Interdependency among subsystems
- Duplication of work in multiple projects
Challenges

Frequent interactions

Time and effort

Multiple platforms and simulations

System Design
Model based design

Radar System model

System Designers
Subsystem Designers
Developers
Researchers
Model based design using Simulink
Model based design using Simulink

Models Masked using GUIs
Antenna array model Features

- Antenna element type (standard and custom)
- Antenna array arrangement (including conformal)
- Derivation of Directivity, Beamwidth, Side lobe levels
- Analysis using Radiation patterns (2D & 3D), Grating lobe diagram

Array Characteristics

Directivity: 18.2539 dBi
Beamwidth:
- HPBW(az): 25.93 dB
- HPBW(el): 45.75 dB
- PSLL(az): 9.66 dB
- PSLL(el): 17.31 dB
Waveform model Features

- Design of different waveforms:
  - Rectangular
  - Linear FM
  - Stepped FM
  - Stepped Chirp (Custom)

- Derivation of range resolution, Doppler resolution, Time Bandwidth product, unambiguous range, duty cycle etc.

- Analysis using spectrum, spectrogram, Ambiguity diagrams
RF model Features

➢ Design of Transmit and Receive modules
➢ Design of RF units using SimRF
  ➢ Power amplifiers
  ➢ LNA
  ➢ Bandpass filters
  ➢ Attenuators
  ➢ Phase shifters
➢ Each TR module connected to each antenna element
➢ Simulation at abstract and detailed level
Signal processing model

- Choice of different algorithms (inbuilt and customized)
- Ease of adding novel algorithms
- Tunable parameters for simulation
- Data export for analysis
- Signal and Image Scopes for visualization
# Environment model

## Target
- Point scatters
- RCS
- Swerling Model
- Position (Geographical and Cartesian)
- Velocity
- Acceleration
- Trajectory

## Clutter
- Constant gamma
- Different terrain models

## Jammer
- Barrage jammer
- Platform motion

## Channel
- Temperature
- Pressure
- Vapour density
- Rain rate
- Target and jammer channel
Target modelled with multiple point scatters

Range Doppler Image

Rotating points
System simulation

1. System specifications
2. Graphical user interface
3. Simulink model parameters
4. Simulation
5. Results
   - Detection
   - Range Doppler Images

Matched Filter output

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Benefits

- Multi-domain system in a single simulation using Simulink
- Reduces dependency on human expertise
- Eases subsystem dependency by using system objects
- Reusability in multiple projects using model based design and user friendly means of changing specifications and design
Future Scope

• Modelling of scheduler with simEvents
• Modelling of tracker
• Report generation
Thank You