System level Radar Simulation using Model based Design

Dr. Dyana A
Scientist ‘D’
Center for Adaptive Sensing Technology (CFAST)
LRDE, DRDO
Bangalore
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
Model based design

Radar System model

- Antenna model
- Waveform model
- RF model
- Processing model
- Environment 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:**
  - 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

Ambiguity diagram
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

<table>
<thead>
<tr>
<th>Target</th>
<th>Clutter</th>
<th>Jammer</th>
<th>Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Point scatters</td>
<td>• Constant gamma</td>
<td>• Barrage jammer</td>
<td>• Temperature</td>
</tr>
<tr>
<td>• RCS</td>
<td>• Different terrain models</td>
<td>• Platform motion</td>
<td>• Pressure</td>
</tr>
<tr>
<td>• Swerling Model</td>
<td></td>
<td></td>
<td>• Vapour density</td>
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<tr>
<td>• Position (Geographical and Cartesian)</td>
<td></td>
<td></td>
<td>• Rain rate</td>
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<tr>
<td>• Velocity</td>
<td></td>
<td></td>
<td>• Target and jammer channel</td>
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<tr>
<td>• Acceleration</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>• Trajectory</td>
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</tbody>
</table>
Target modelled with multiple point scatters

Range Doppler Image

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System simulation

- System specifications
- Graphical user interface
  - Simulink model parameters
  - Simulation
  - Results
    (Detection, Range Doppler Images)

Matched Filter output

Detection
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