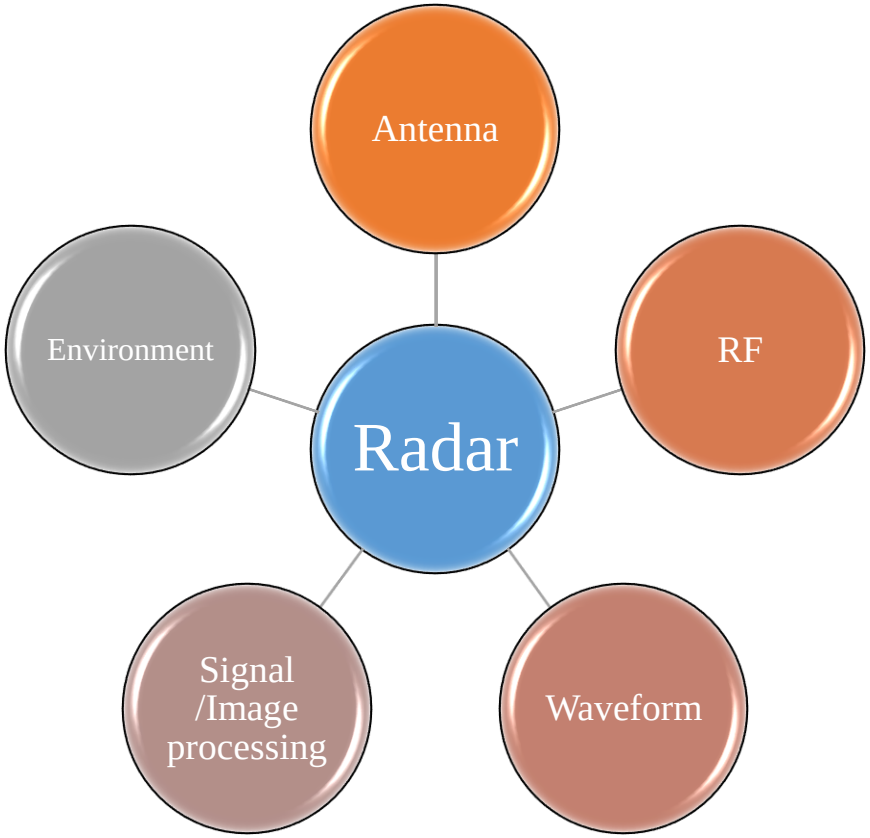
System level Radar Simulation using Model based Design

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

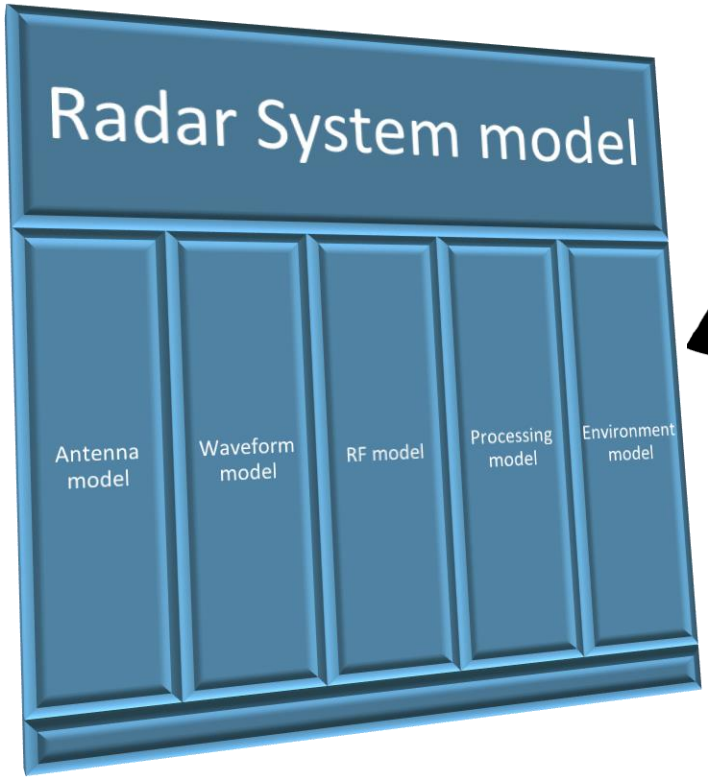
Frequent interactions

Time and effort

System Design

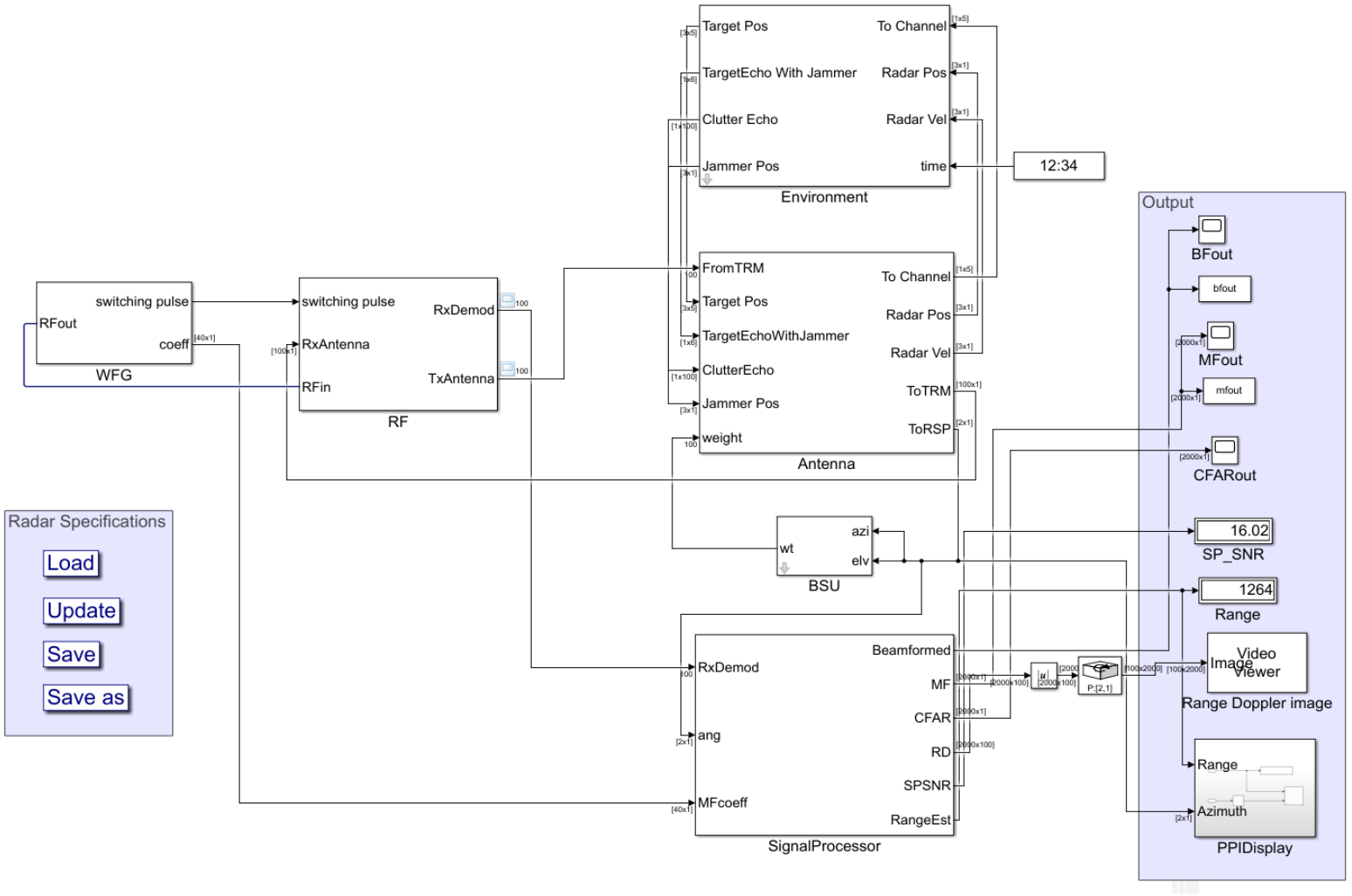
Multiple platforms and simulations

Model based design



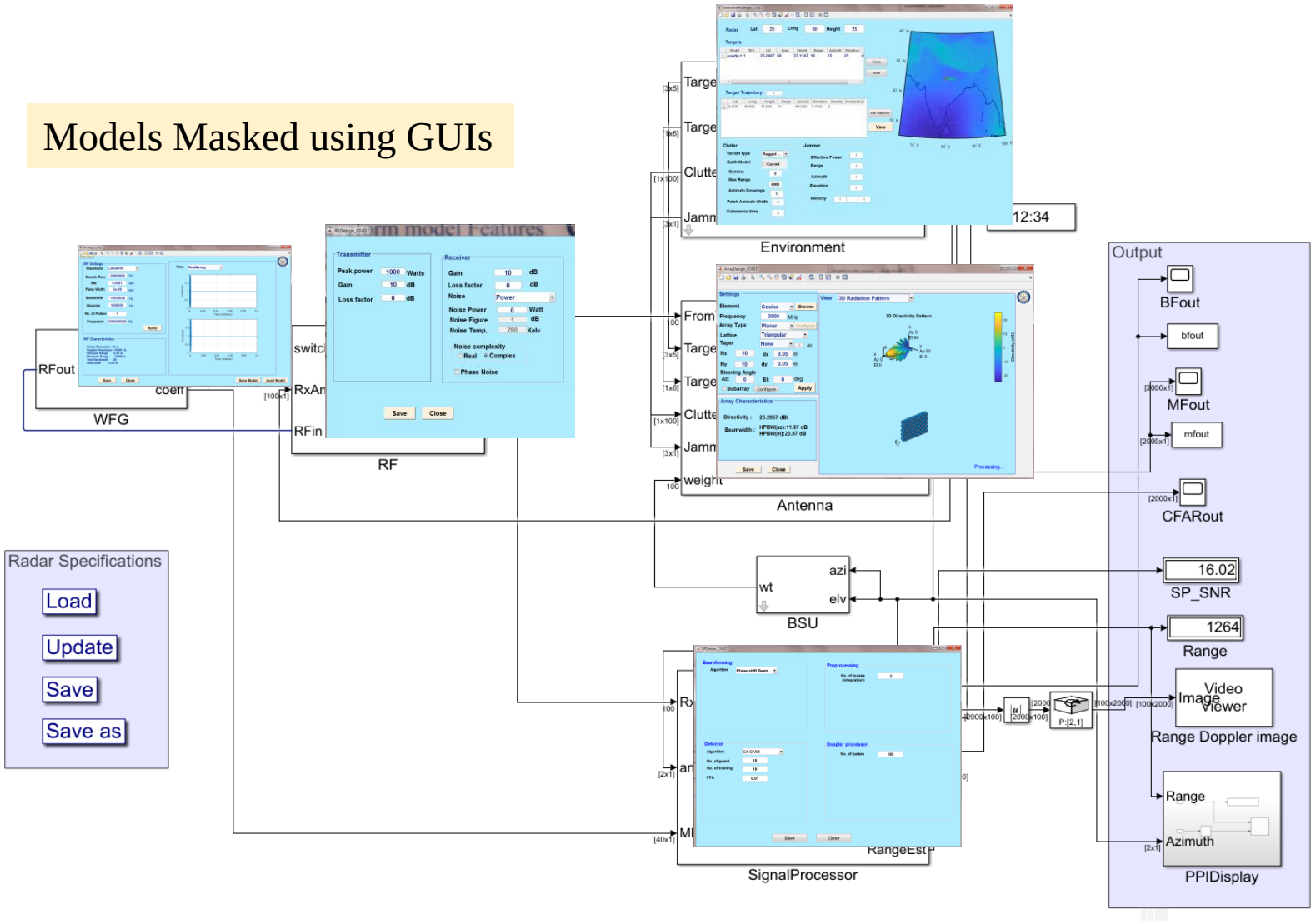
- System Designers
- Subsystem Designers
- Developers
- Researchers

Model based design using Simulink



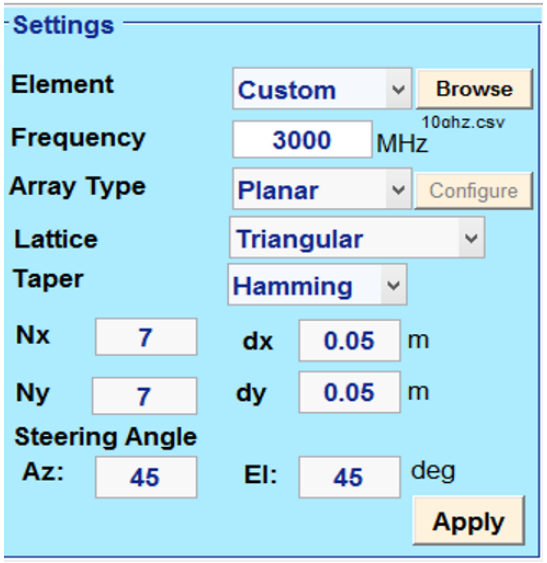
Model based design using Simulink

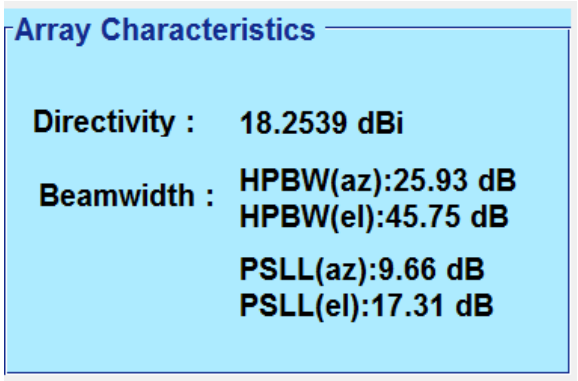
Models Masked using GUIs

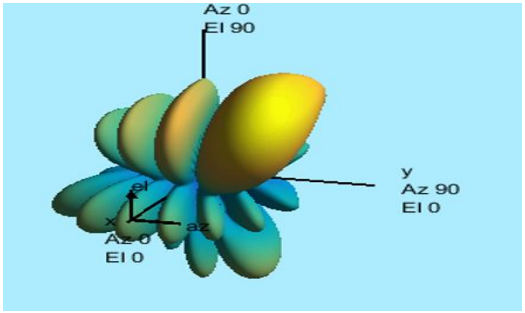


Antenna array model Features

- 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





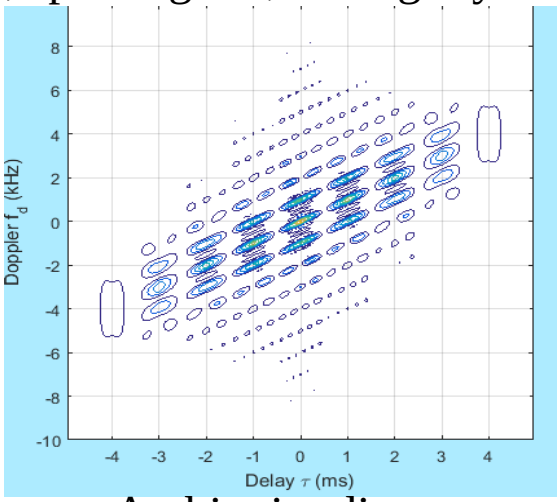


Waveform model Features

- 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.

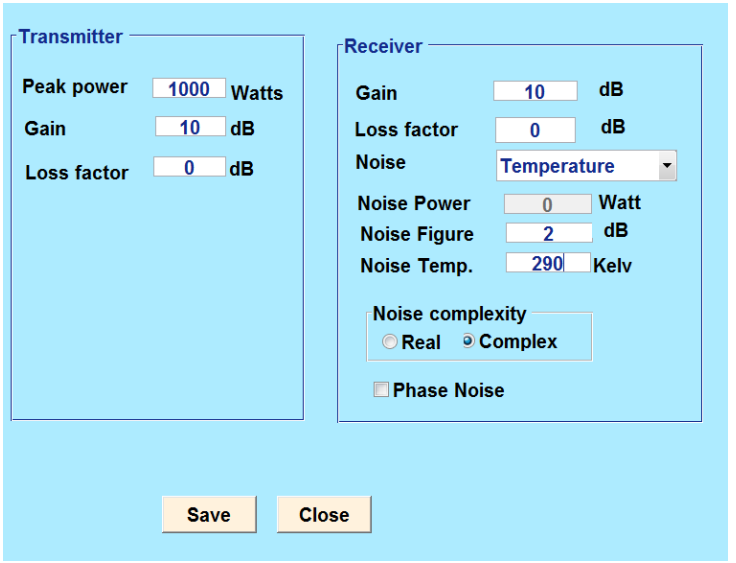
- Analysis using spectrum, spectrogram, Ambiguity diagrams

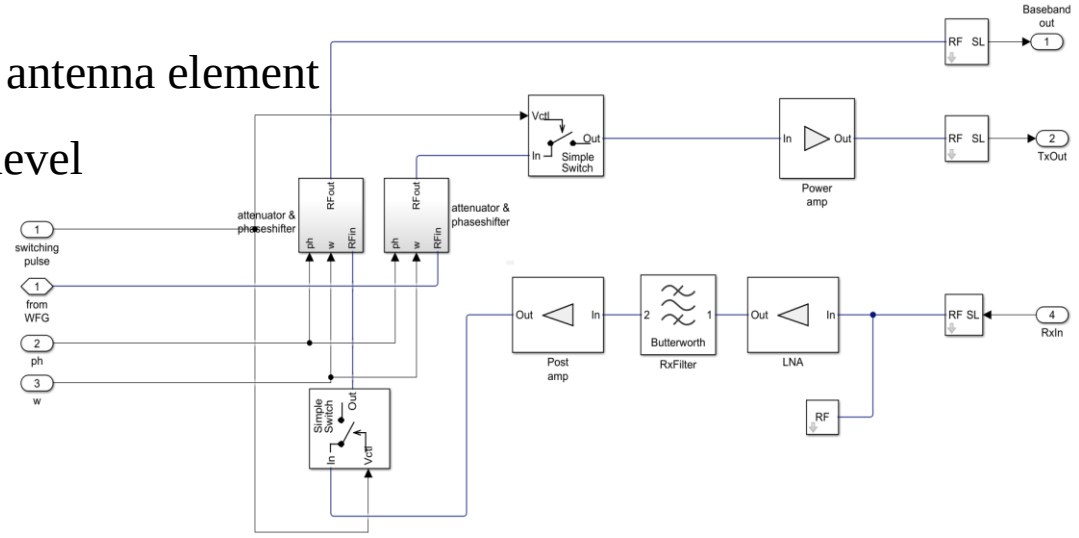


Ambiguity diagram

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

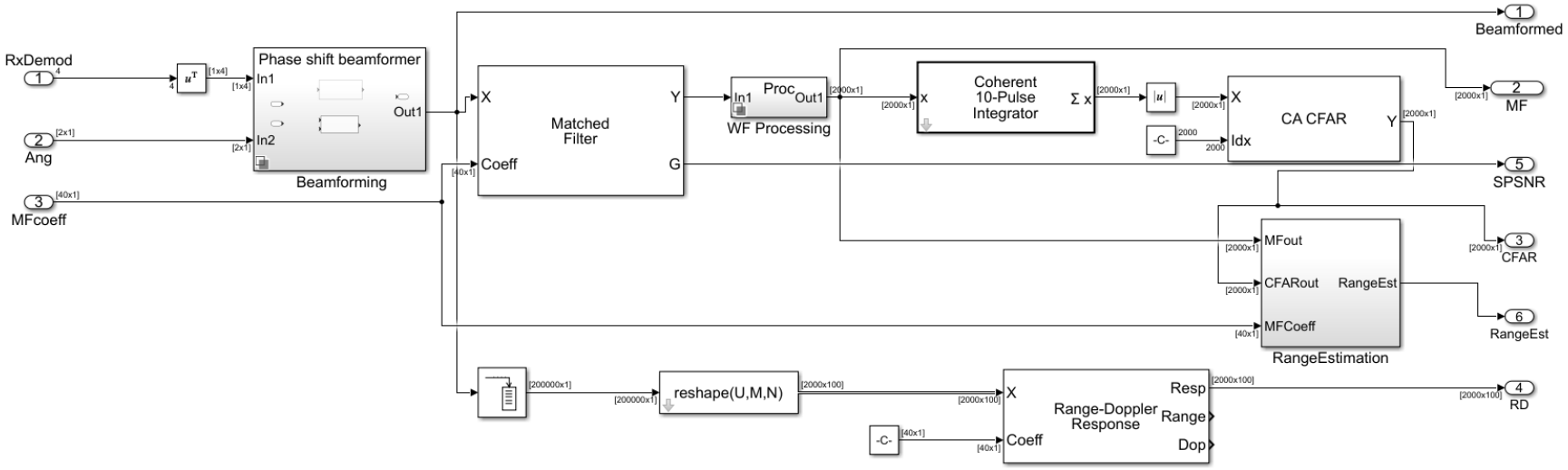




Signal processing model

- 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

Beamforming → **Matched filtering** → **Pulse integrator** → **CFAR** → **Doppler processing**

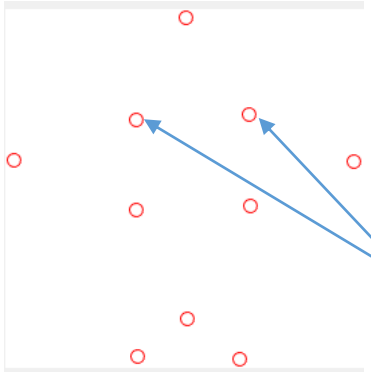


Environment model

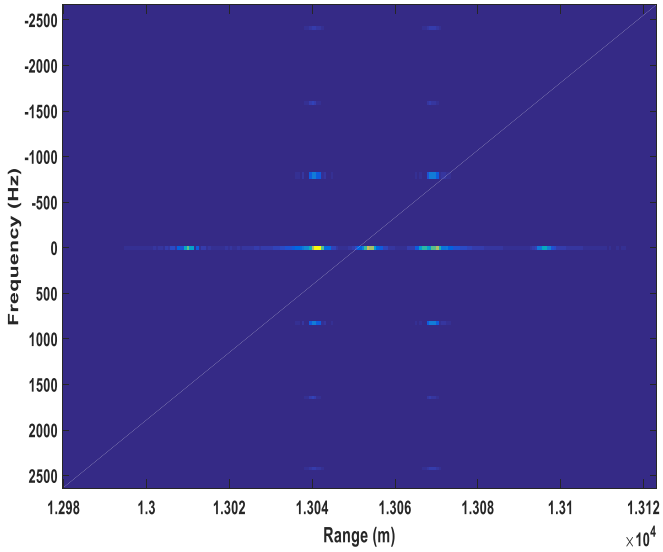
Target	Clutter	Jammer	Channel
• Point scatters • RCS • Swerling Model • Position (Geographical and Cartesian) • Velocity • Acceleration • Trajectory	• Constant gamma • Different terrain models	• Barrage jammer • Platform motion	• Temperature • Pressure • Vapour density • Rain rate • Target and jammer channel

Target modelled with multiple point scatters

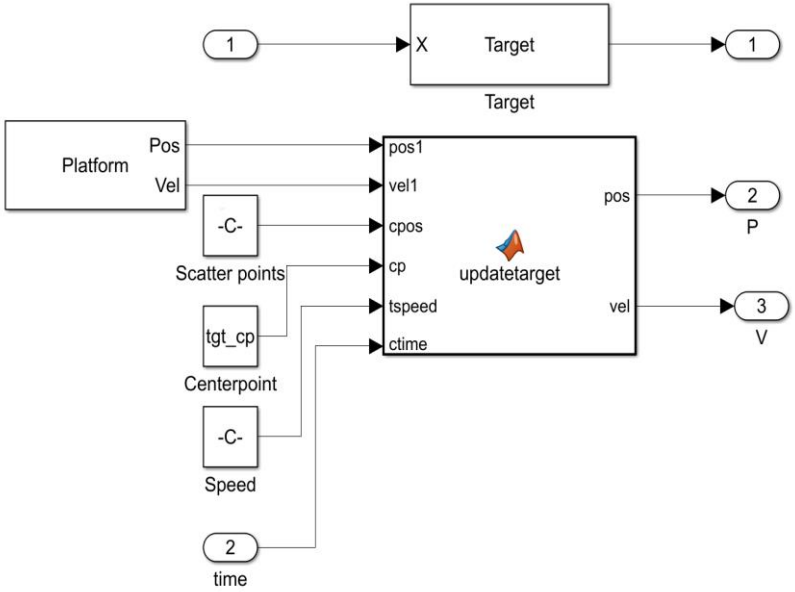
Target



Rotating points



Range Doppler Image



System simulation

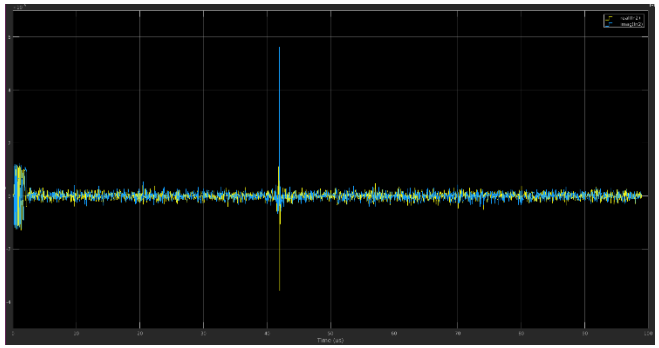
System specifications

Graphical user interface

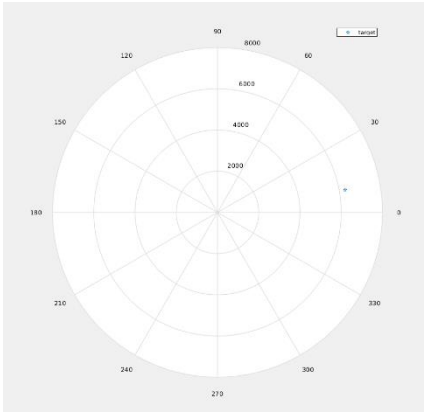
Simulink model parameters

Simulation

Results
(Detection, Range Doppler Images)

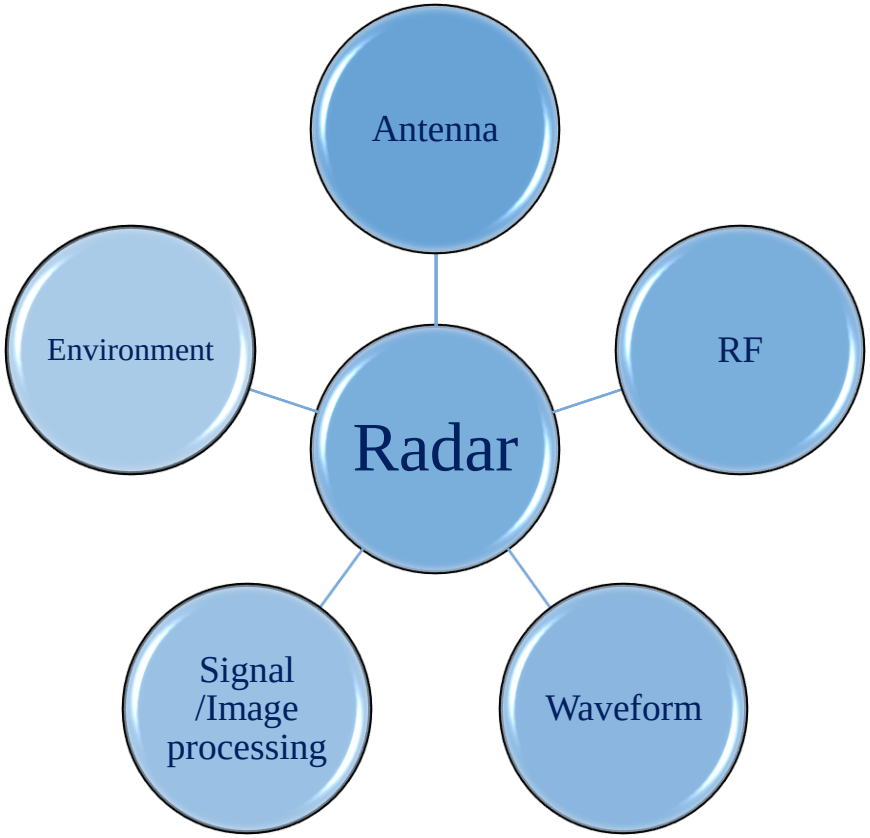


Matched Filter output



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