End-to-end Radar System and Signal Processor Design strategy using MATLAB

Honeywell Technology Solutions Lab

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Agenda

1. Introduction
2. Problem Statement
3. Current Pain Areas
4. Why MATLAB?
5. Generic Architecture and Design work flow
6. Results
7. Benefits
8. Future Scope of Improvement to design flow
9. Summary and Conclusion

Introduction

- IntuVue RDR-4000 3D Weather Radar System

- Capable of detecting and displaying Wx hazards
- Gimballed System
- Mounted in the nose of the aircraft
- Intercepts hazardous precipitation in flight path

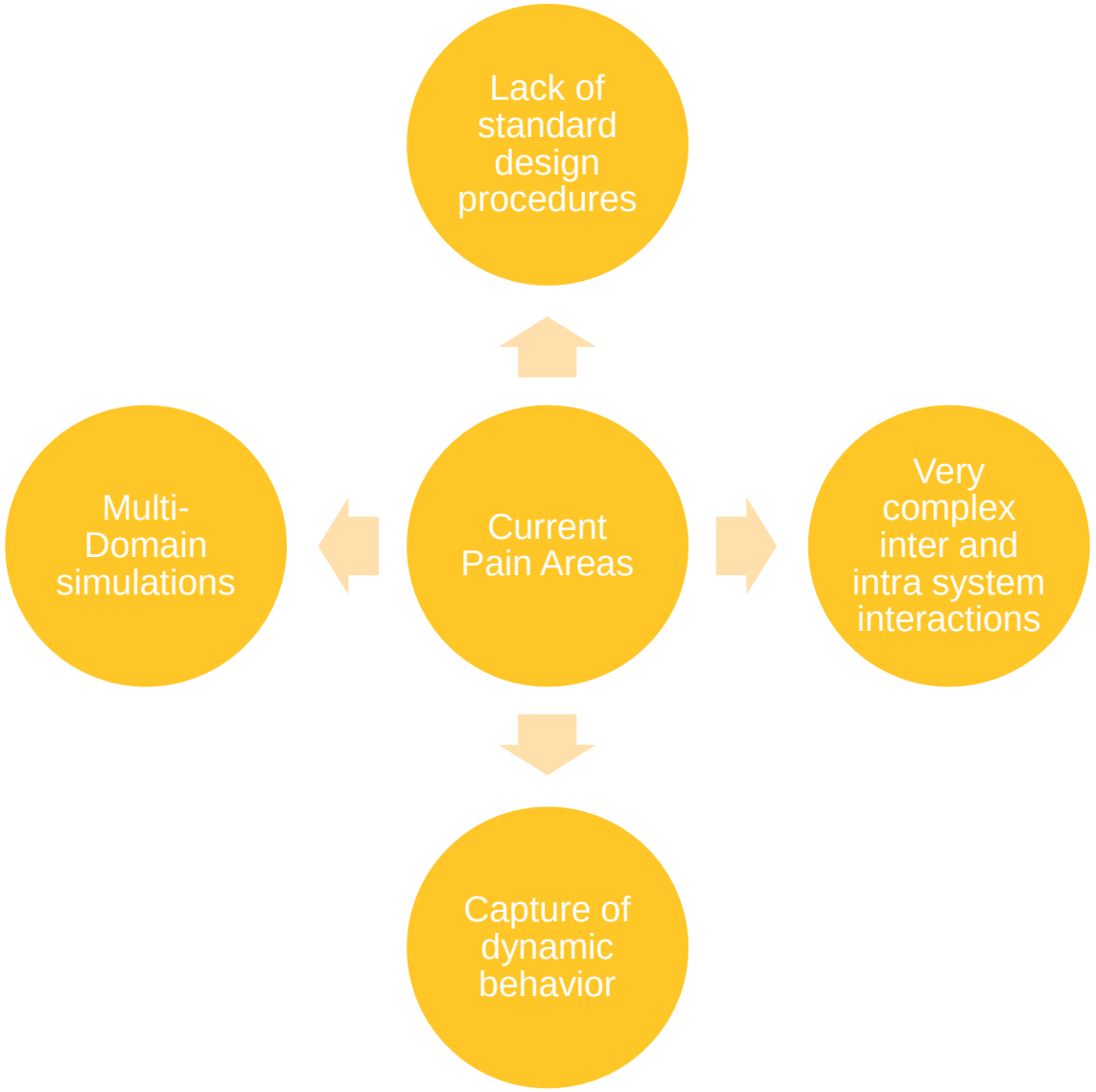
Problem Statement(s) :
How to model Radar System Parameters?
How to quantify radar performance through simulations alone?
What-if analysis……

- The radar is mounted in the nose of the aircraft
- The aircraft flight plan trajectories (purpose/intent)
- The object of interest can be a cloud, land, sea, moving targets in space
- The situation is dynamically changing
- Presence of interfering sources
- Complexities in the medium through which the EM wave travels

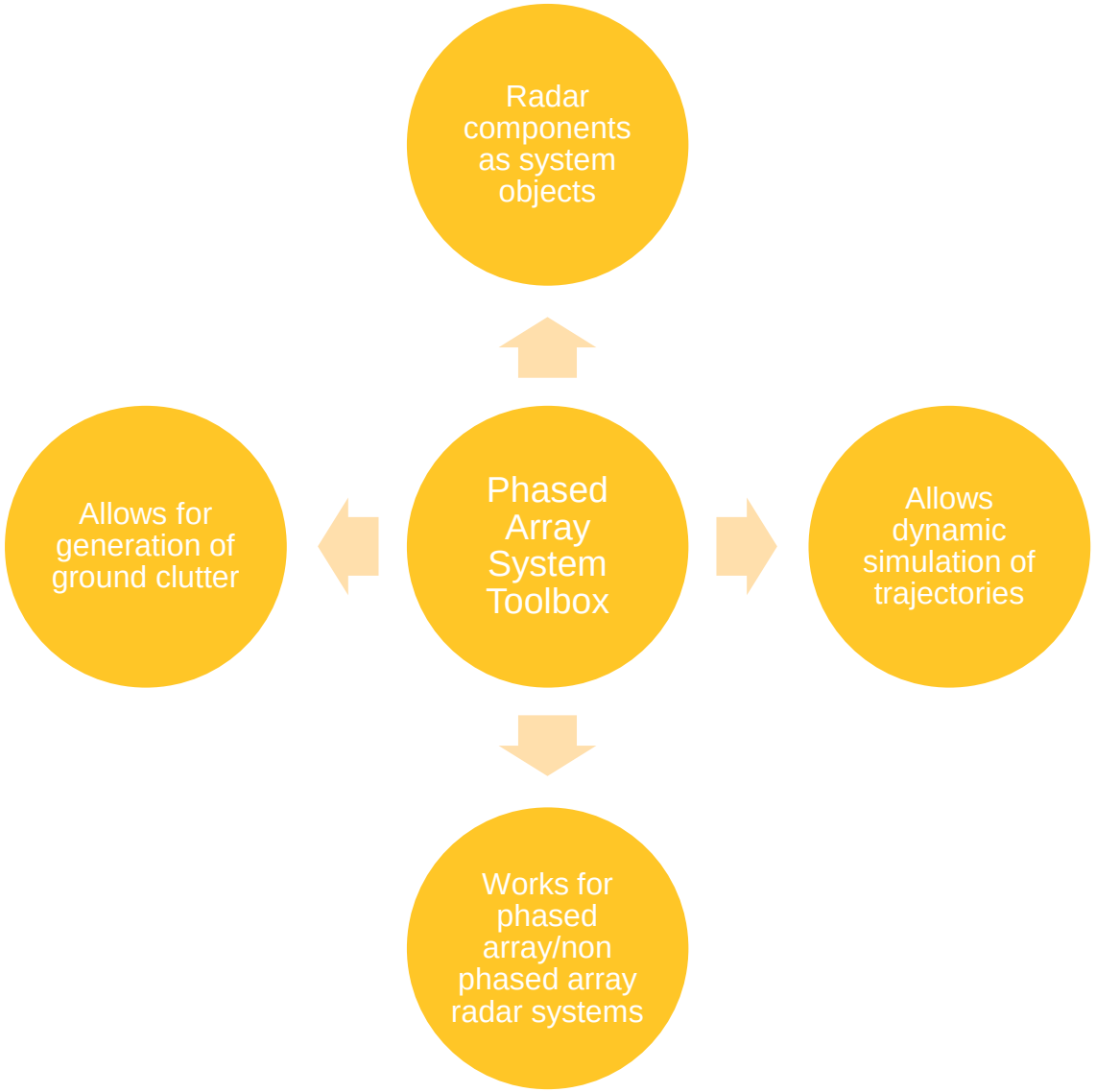
Why do you need to verify airborne radar performance through simulations?

- Actual Flight sorties are very costly
- You need to build a prototype radar system through calculations alone (static…)
- Reduction in cost and time for scratch pad to flight testing
- Very easy to change system parameters on the fly and perform what..if analysis
- Ability to generate hazardous situations without flying through them!
- Ample time afforded to make any system parameter changes based on the simulation outputs

Current Pain Areas



Why MATLAB (Phased Array System Toolbox)?



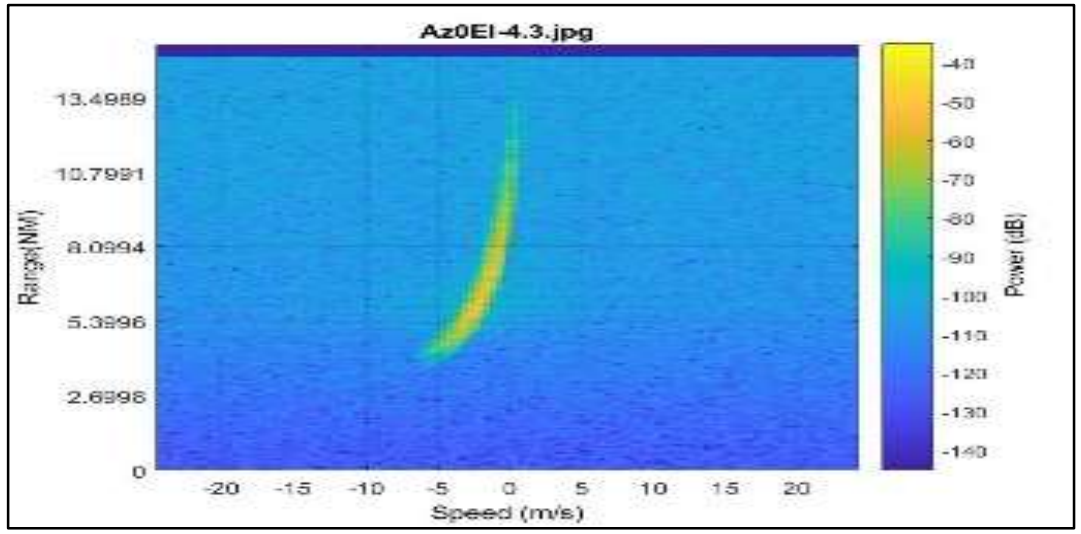
Dependencies of interest:

- MATLAB
- Phased Array System Toolbox
- Signal Processing Toolbox
- DSP System Toolbox
- Communications System Toolbox
- MATLAB Coder
- Parallel Computing Toolbox
- RF Toolbox

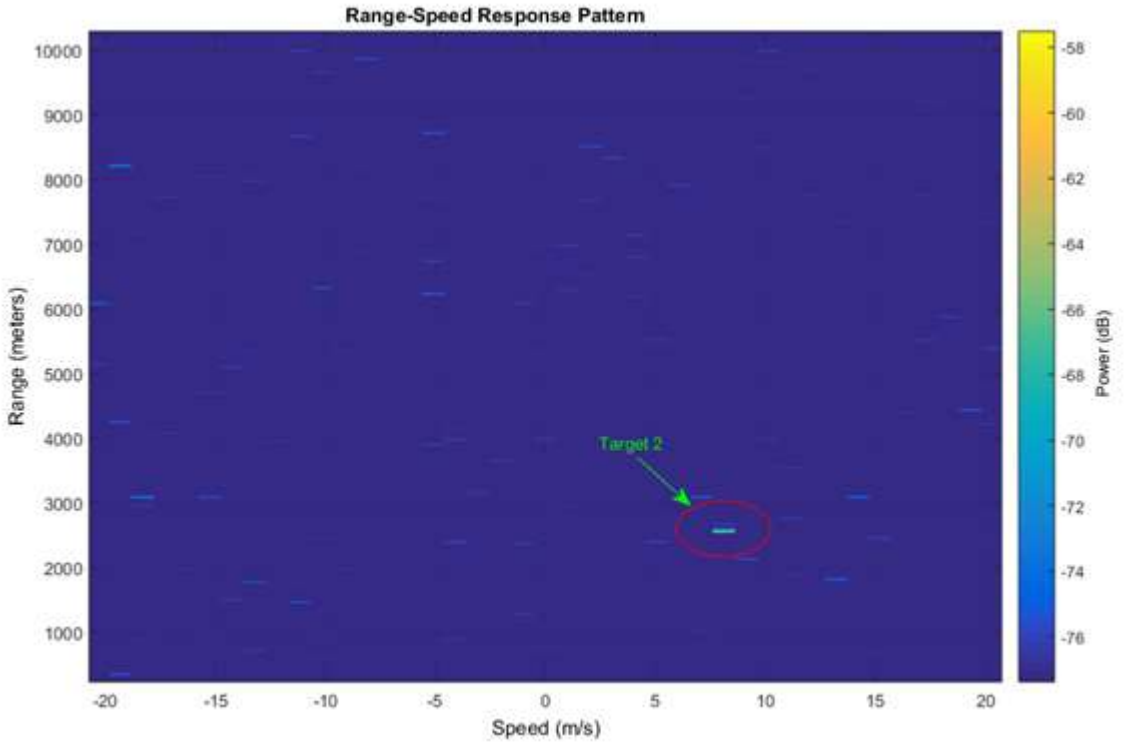
Suggested Generic Design Flow

- Generic Design flow can be in 2 parts:
  a. Data generation based on physical scenario
  b. Signal Processing on the data generated in Step 1 above
- Data Generation:
  a. An actual model of airborne radar is built with phased array system toolbox in MATLAB
  b. Desired aircraft-target (if any) scenario is deployed
  c. The radar is airborne with typical A/c motion parameters
  d. Digital baseband radar data is generated with designed waveforms for the given physical scenario (geometry)
  e. The model is dynamic and changes its state at every time instant (granularity of time is decided based on simulation fidelity and simulation time requirements)
- Signal Processing:
  a. The generated radar data (3 dimensional radar data cube) is processed with the designed signal processor to verify the theoretical results with the simulated ones
  b. Signal processor can be fine tuned to get the desired results
  c. Interactive iteration between radar system parameters and signal processing to reach design goals

So what is expected after all … some examples

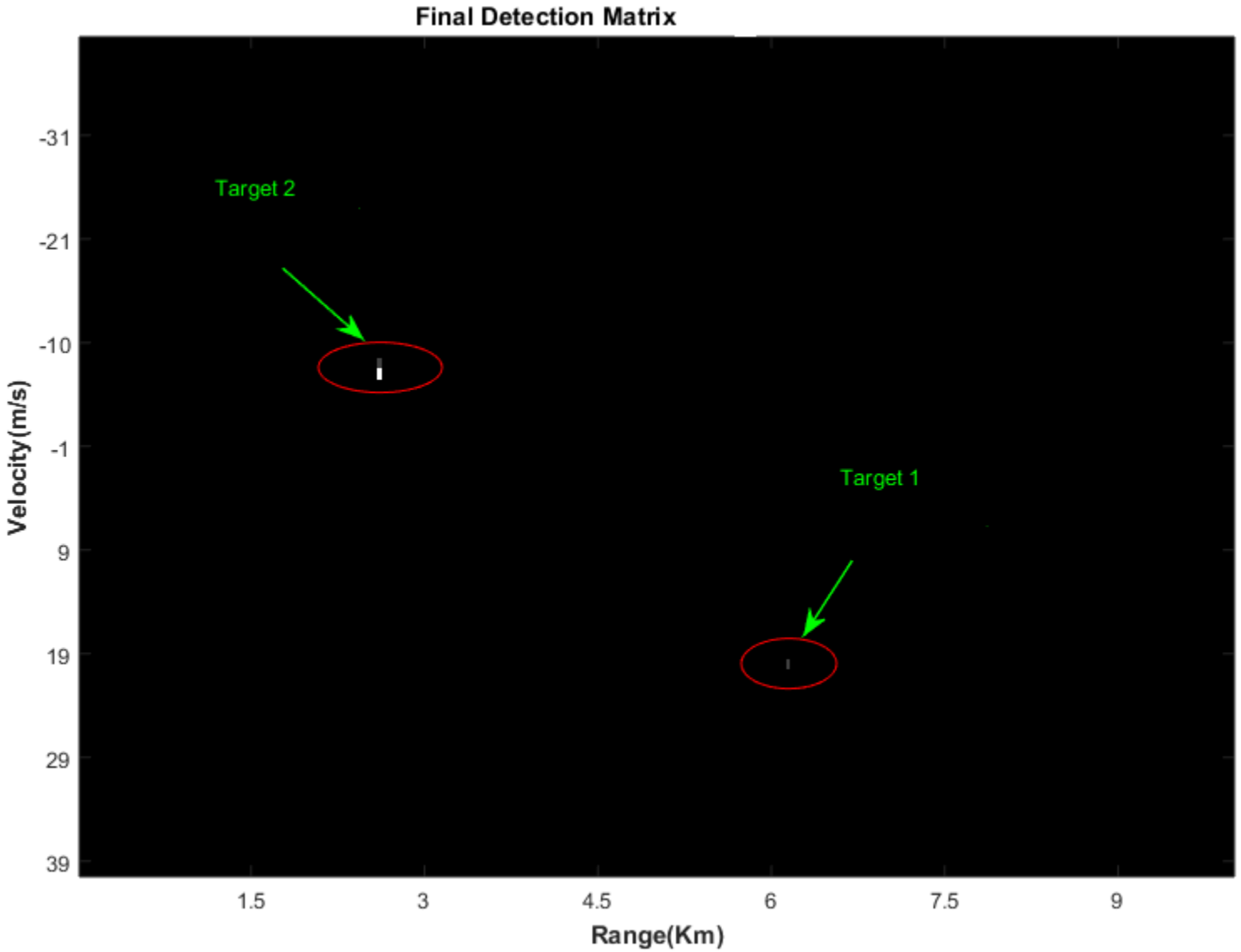


Example airborne ground clutter



A typical Range-Speed Response Pattern

… some more examples (A sample detection matrix)



Benefits

- Multi Domain simulations – easy to pass between teams
- Object Oriented Approach- easy to maintain models and reuse
- Iterative approach to radar system design
- Saves cost and time before actual flight sorties
- Plethora of options to accelerate simulation
- Traditional user friendliness and ease of use by Non SMEs

Further scope of improvement to design flow

- Possibility to integrate legacy codes to models built using phased array system toolbox
- Possibility to inject actual flight data into the models and quantify performance
- Extension to original system objects possible with user defined system objects built for specific needs
- Fully dynamic simulation not only for radar system but also for the host platform
- Addition of RF related impurities to base band data
- Possibility of user defined clutter model definitions

Summary and Conclusion

- Phased Array System Toolbox, a desirable tool for a Radar System designer
- Augments the capability of a radar system designer in making suggestions for a design revamp
- Offers a very convenient way of visualizing the output from a complex device like radar
- Offers a way to iteratively design a radar waveform and signal processing depending on the mode of operation
- The extension to more complicated scenarios/ radar systems is easy as the models are easily scalable
- Offers a convenient method to study design trade-offs
- Ability to improve fidelity be incorporating more details through use of other toolboxes like RF toolbox, Communications System toolbox etc

THANK YOU

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