DBF System Engineering Study

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Motivation

- **Air Force is considering a variety of low-band air moving target indication (AMTI) options for future wide area surveillance platforms**
- **Initial systems engineering needs to be performed to explore the technical feasibility of using Digital Beamforming (DBF)**

Idealized depiction of aperture real estate on typical platform.

Technical Approach

- **Contractual Effort – Prime Contractor**
  - Perform unclassified system engineering on use of DBF for "representative" AMTI mission requirements.
  - Examine the validity of perceived DBF advantages over conventional electronically steered phased array (ESA)
  - Examine the potential for reducing size, weight, and power (SWaP) by digital implementation of a DBF array.
- **In-house Effort – David S. Choi (Vistronix Inc.)**
  - Work with prime contractor to ensure soundness in technical approach and merits
  - Concurrent in-house effort to perform similar radar system engineering

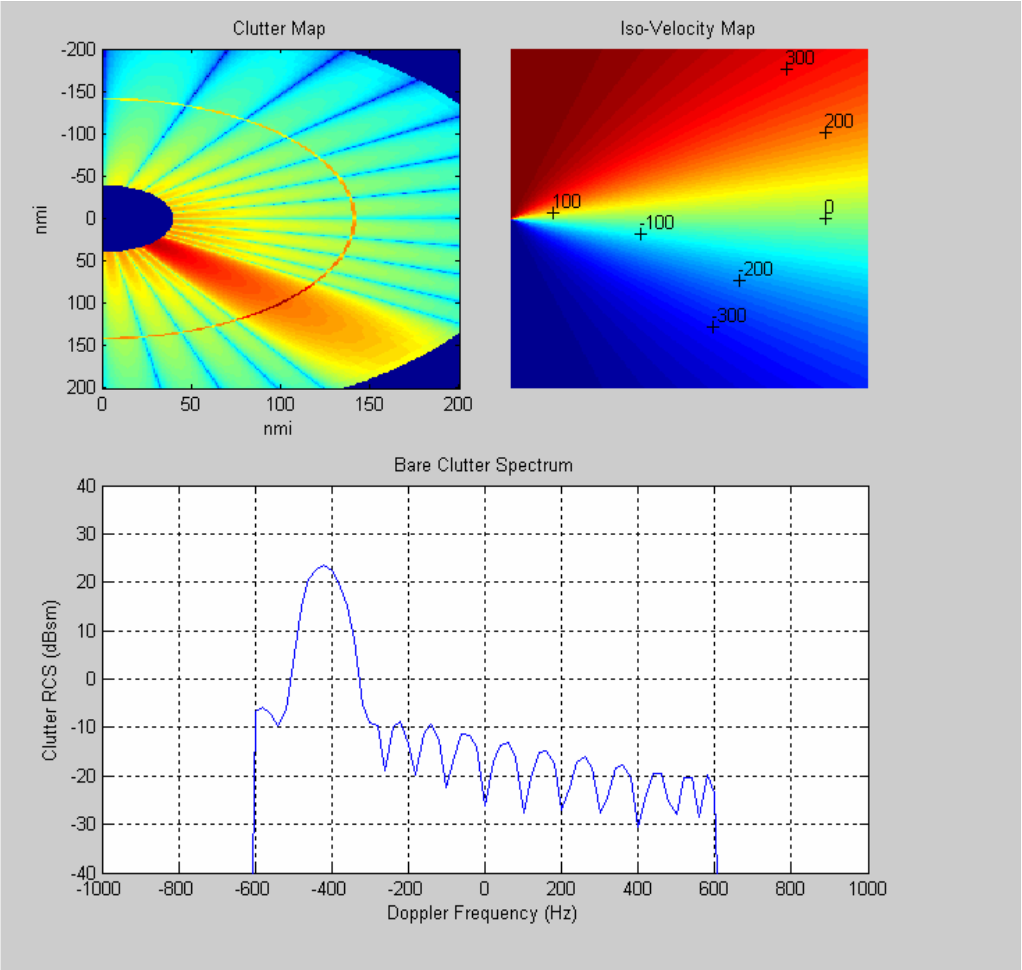
Technical Accomplishments

- **Determined radar performance parameters**
  - Operating frequency
  - Bandwidth – sets range resolution
  - Number of antenna elements – determined by the available aperture
  - Average power – sets maximum detectable range
  - Low PRF – sets maximum unambiguous range

- **Developed an in-house airborne radar simulation software to estimate the extent of the radar clutter**
  - Sidelobe clutter is of limited concern - adaptive nulling can reject clutter
  - Mainlobe clutter is a major issue - limits detection of slow moving targets. Displaced phase center antenna (DPCA) is required.

Technical Accomplishments

- **Example of radar simulation output**



Technical Accomplishments

- **Identified core capabilities afforded by DBF**
  - Multiple simultaneous beams: multiple concurrent search and tracking mode possible
  - Improved performance of interference/clutter rejection and other digital signal processing algorithms
  - Waveform diversity: possible use of multiple pulse repetition frequencies (PRFs) or non-conventional radar waveforms
  - Run-time calibration and compensation: it can enhance performance at a decreased production cost

Technical Accomplishments

- **Performed hardware implementation trades**
  - Butler matrix vs. DBF trade
  - Digital signal processing (DSP) vs. FPGA-based processing
  - Node distributed processing vs. central processing
- **Considered SWaP trade**
  - SWaP parameters are typically estimated from a set of parametric equation using radar's average power as the only parameter – not a very good trade method.
  - Very difficult to quantitatively determine SWaP using conventional approach. However, qualitative trades are possible.

Technical Summary

- **Some perceived DBF advantages are not always applicable**
  - Multiple beams are useful for simultaneous search and track. For given aperture size, beamwidth can be too wide for tracking.
  - To fully benefit from DBF, the antenna aperture should be large enough to meet tracking requirements
- **DBF can improve clutter rejection algorithms**
  - Improved displaced phase center antenna (DCPA) performance : For ESA, the phase centers are fixed in space. With DBF, we can place the phase centers anywhere along the array.
- **DBF SWaP trades – qualitative reasons why DBF wins**
  - DBF does not require heavily shielded wires and should significantly reduce SWaP
  - FPGA-based implementation provides for highly compact and efficient design – should result in reduction in power consumption and in aircraft integration footprint
  - Run-time calibration capability allows less strict array specifications.