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# CLUTTER FILTER DESIGN CONSIDERATIONS FOR AIRBORNE DOPPLER RADAR DETECTION OF WINDSHEAR

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Clemson, SC 29634-0915

## ABSTRACT

The problem of clutter rejection when processing down-looking Doppler radar returns from a low altitude airborne platform is a paramount problem. With radar as a remote sensor for detecting and predicting windshear in the vicinity of an urban airport, dynamic range requirements can exceed 50 dB because of high clutter to signal ratios. This presentation describes signal processing considerations in the presence of distributed and/or discrete clutter interference. Previous analyses have considered conventional range cell processing of radar returns from a rigidly mounted radar platform using either the Fourier or the pulse-pair method to estimate average windspeed and windspeed variation within a cell. Clutter rejection has been based largely upon analyzing a particular environment in the vicinity of the radar and employing a variety of techniques to reduce interference effects including notch filtering, Fourier domain line editing, and use of clutter maps. For the airborne environment the clutter characteristics may be somewhat different. Conventional clutter rejection methods may have to be changed and new methods will probably be required to provide useful signal to noise ratios. Various considerations are described. A major thrust has been to evaluate the effect of clutter rejection filtering upon the ability to derive useful information from the post filter radar data. This analysis software is briefly described. Finally, some ideas for future analysis are considered including the use of adaptive filtering for clutter rejection and the estimation of windspeed spatial gradient directly from radar returns as a means of reducing the effects of clutter on the determination of a windshear hazard.

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FOR
AIRBORNE DOPPLER RADAR DETECTION OF WINDSHEAR

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OUTLINE

I. The Clutter Problem
   A. Radar antenna sidelobes causes high clutter levels
   B. Moving radar platform influences spectrum widths
   C. Discrete clutter sources in the urban environment

II. Review of Past Clutter Rejection Research
   A. Notch filtering at zero Doppler
   B. Fourier line editing
   C. Geographical clutter maps

III. Clutter Rejection for Airbourne Radar
   A. Notch filter requirements
      1. zero gain at zero Doppler
      2. transient response short
      3. notch width considerations
      4. dynamic range requirements
      5. non-stationarity
   B. Fourier line editing
      1. mid-band discrete clutter
      2. computational load
   C. Geographical clutter maps
      1. poor repeatability
   D. Antenna Steering
   E. Adaptive Filters
   F. Non-conventional Signal Processing
      1. estimating windspeed gradient directly
      2. hazard detection and estimation

IV. Effects of Clutter Rejection On Signal Parameter Estimation
   A. Computer software development
      1. filtering in time or frequency domain
      2. repeated trials
      3. simulated or real data
   B. Pulse-pair estimation of spectral parameters
      1. ideal notch filter
      2. simple IIR filters
      3. phase response constraints
      4. the pulse canceller

V. Summary and Conclusions

# Clutter Filter Design Considerations For Airborne Doppler Radar Detection of Windshear
October 19, 1988

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by

E.G. Baxa, Jr.
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## OUTLINE

- The Clutter Problem
- Review of Past Clutter Rejection Research
- Clutter Rejection for Airborne Radar
- Effects of Clutter Rejection On Signal Parameter Estimation
- Summary and Conclusions

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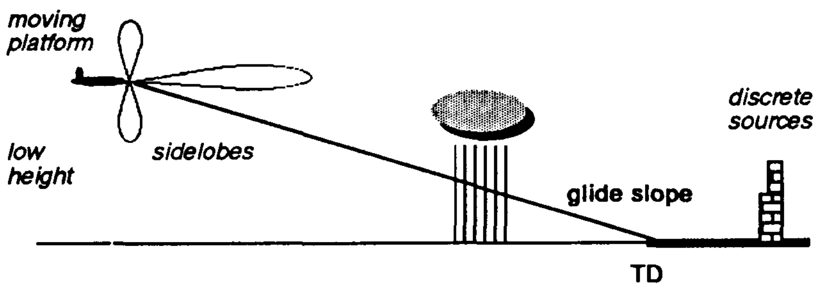
## The Clutter Problem

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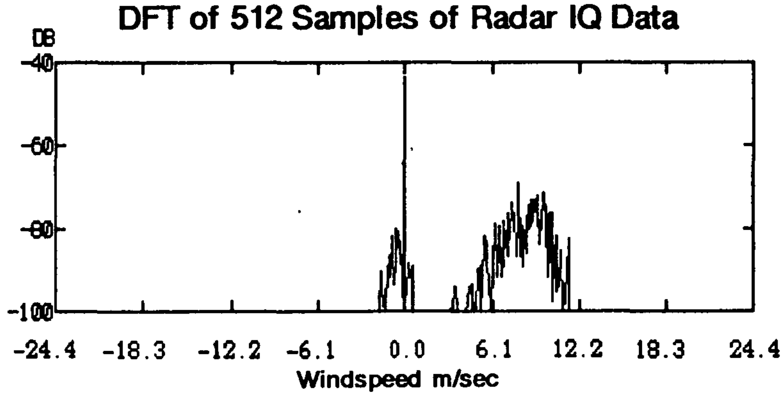
## Simulated Spectra

### DFT of 512 Samples of Radar IQ Data

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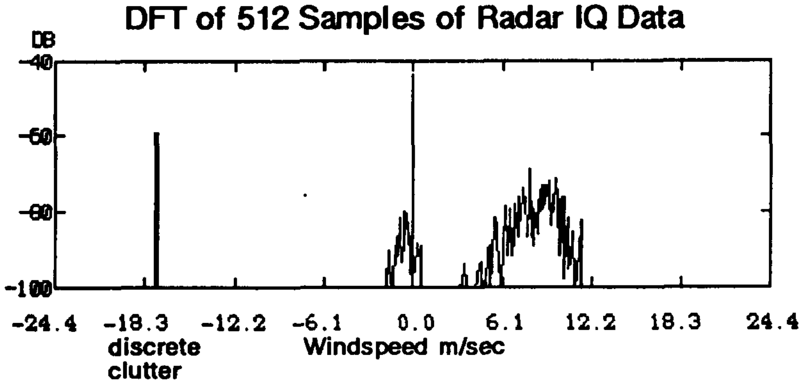
## DISCRETE CLUTTER

DFT of 512 Samples of Radar IQ Data

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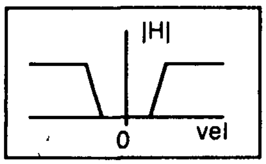
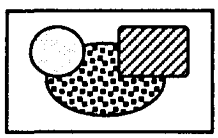
## Conventional Clutter Rejection

Notch Filter




Fourier Line Editing


Clutter Maps



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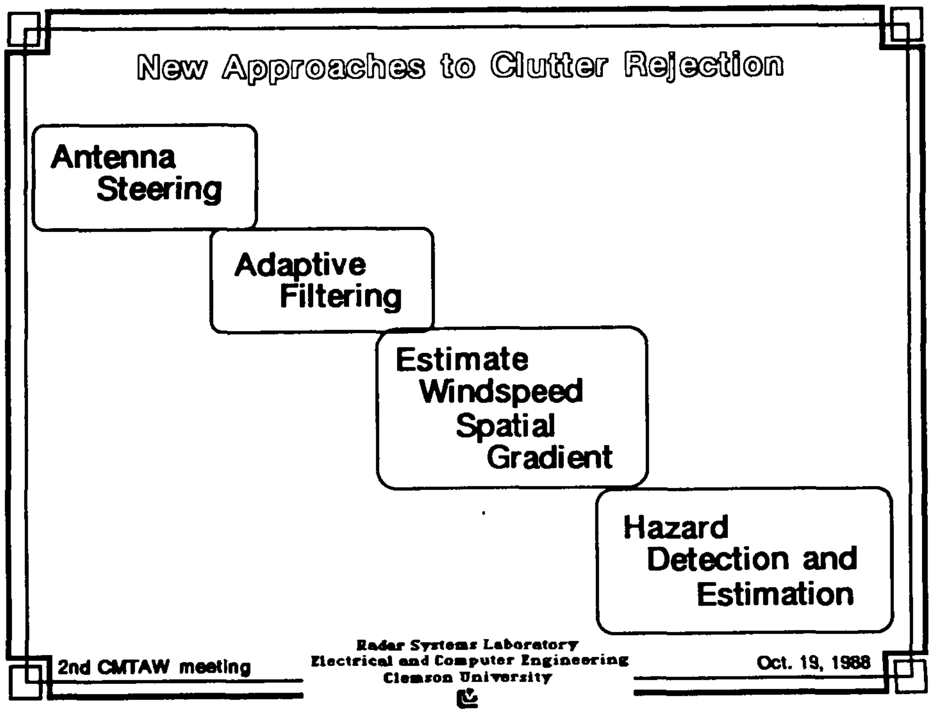
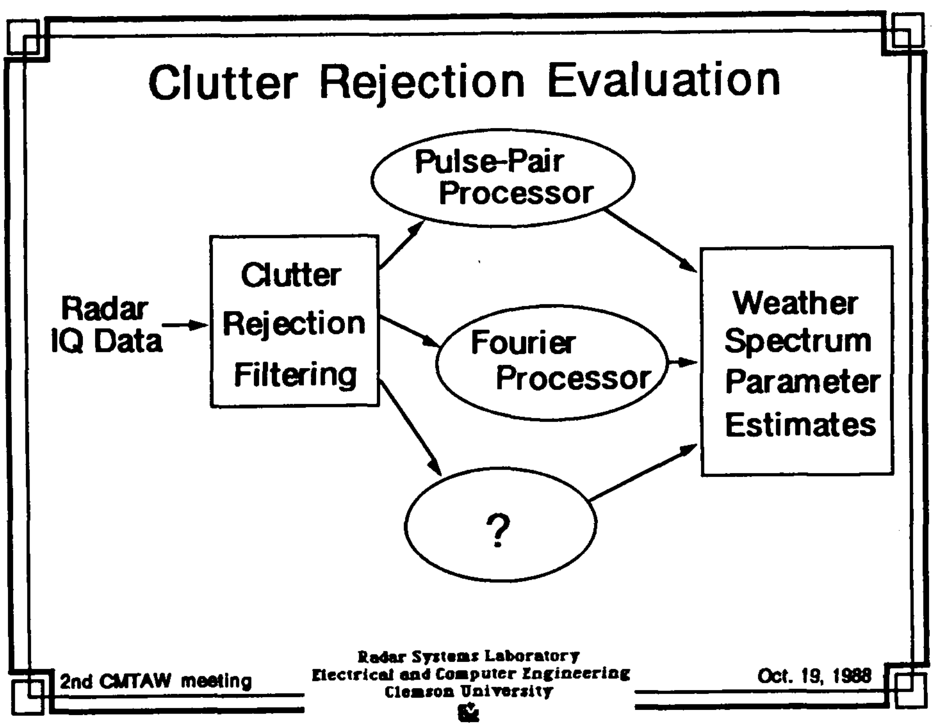
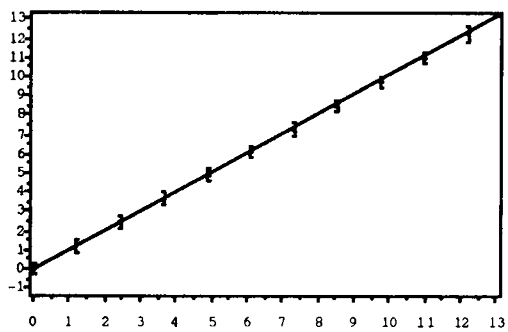


## PULSE-PAIR MEAN ESTIMATE

**Mean Estimate versus True Mean**




NYQUIST BW = ± 24.4 m/s
TRUE WIDTH SIGMA = 2.0333 m/s

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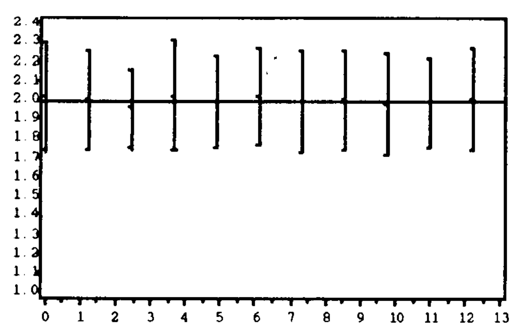
## PULSE-PAIR WIDTH ESTIMATE

**Width Estimate versus True Mean**




NYQUIST BW = ± 24.4 m/s
TRUE WIDTH SIGMA = 2.0333 m/s

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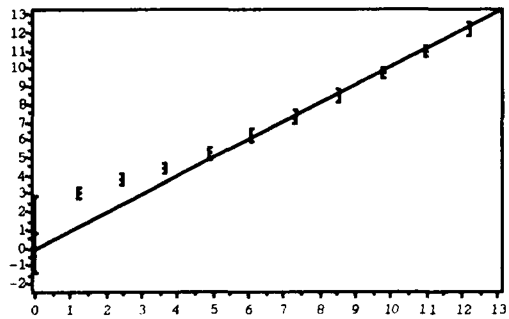
## PULSE-PAIR MEAN WITH IDEAL NOTCH FILTER

**Mean Estimate versus True Mean**




NYQUIST BW = ± 24.4 m/s
TRUE WIDTH SIGMA = 2.0333 m/s
IDEAL FILTER NOTCH BW = 2.44 m/s

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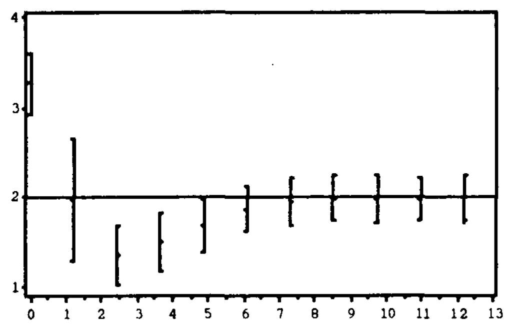
## PULSE-PAIR WIDTH WITH IDEAL NOTCH FILTER

**Width Estimate versus True Mean**




NYQUIST BW = ± 24.4 m/s
TRUE WIDTH SIGMA = 2.0333 m/s
IDEAL FILTER NOTCH BW = 2.44 m/s

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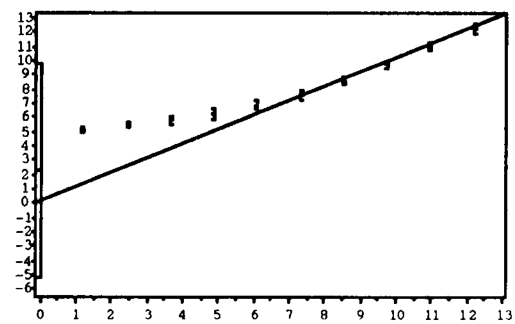
# Clutter Filter Design Considerations For Airborne Doppler Radar Detection of Windshear October 19, 1988

## PULSE PAIR MEAN WITH 4 m/s IDEAL NOTCH

**Mean Estimate versus True Mean**




NYQUIST BW = ±24.4 m/s
TRUE WIDTH SIGMA = 2.0333 m/s
IDEAL FILTER NOTCH BW = 4.88 m/s

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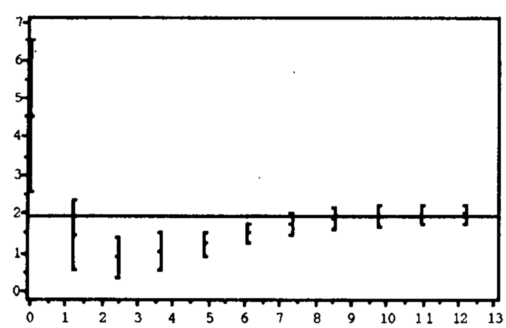
## PULSE PAIR WIDTH WITH 4 m/s IDEAL NOTCH

**Width Estimate versus True Mean**




NYQUIST BW = ± 24.4 m/s
TRUE WIDTH SIGMA = 2.0333 m/s
IDEAL FILTER NOTCH BW = 4.88 m/s

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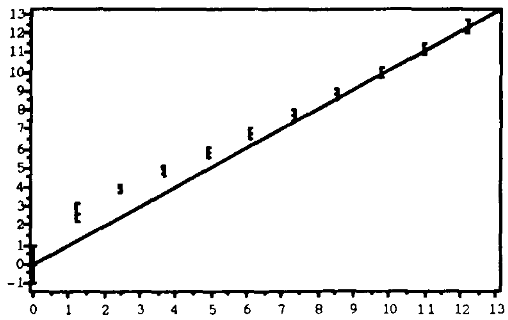
## PULSE-PAIR MEAN WITH BUTTERWORTH NOTCH FILTER

**Mean Estimate versus True Mean**




NYQUIST BW = ± 24.4 m/s
TRUE WIDTH SIGMA = 2.0333 m/s
$y(n) = 0.5 * y(n-1) + x(n) - x(n-1)$

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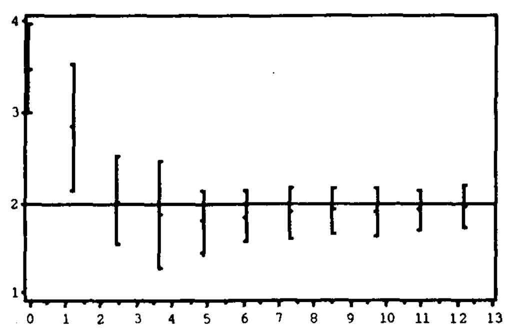
## PULSE-PAIR WIDTH WITH BUTTERWORTH NOTCH FILTER

**Width Estimate versus True Mean**




NYQUIST BW = 24.4 m/s
TRUE WIDTH SIGMA = 2.0333 m/s
$y(n) = 0.5 * y(n-1) + x(n) - x(n-1)$

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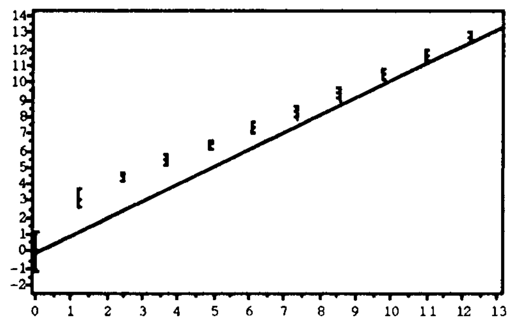
## PULSE-PAIR MEAN WITH PULSE CANCELLER

**Mean Estimate versus True Mean**




NYQUIST BW = ± 24.4 m/s
TRUE WIDTH SIGMA = 2.0333 m/s
y(n) = x(n) - x(n - 1)

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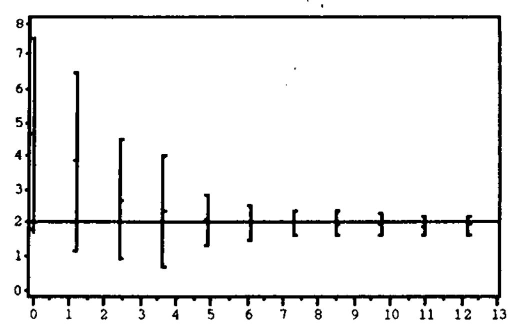
## PULSE-PAIR WIDTH WITH PULSE CANCELLER

**Width Estimate versus True Mean**




NYQUIST BW = ± 24.4 m/s
TRUE WIDTH SIGMA = 2.0333 m/s
y(n) = x(n) - x(n - 1)

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## *SUMMARY*

- **Airborne Environment Has Unique Problems**

  large clutter to signal ratios

  dynamic range requirements

  non-stationarities

  lack of repeatability

- **Optimized Signal Processing Schemes are Needed and are Feasible**

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