Radar Clutter

Challenge for Radar Signal Processing Methods

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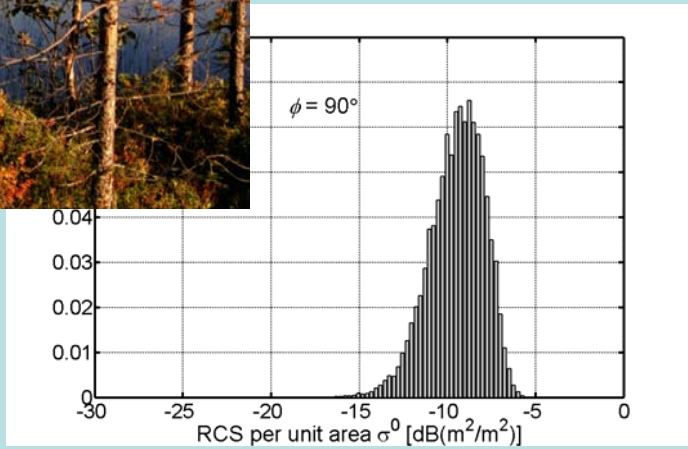
Puolustusvoimien Teknillinen Tutkimuslaitos
Elektroniikka- ja informaatiotekniikkaosasto



Outline

- Introduction
- Radar reflectivity definitions
- Clutter environment
- Signal processing
- Measurement campaigns
  - In general
  - Examples of recorded data

Introduction

- Targets and clutter
  - Terms are defined by the operational purpose of the radar
- Target detection is degraded by
  - Clutter
  - Changes in propagation of radio waves
  - Intentional/unintentional jamming
- In order to optimize radar signal processing methods the effects the surface and volume clutter have on radar detection capabilities have to be known

Radar reflectivity definitions

- Radar cross section (RCS), a measure of a size of a target with a given radar frequency. Depends on
  - polarization
  - material parameters
  - complexity (surface, overall)
  - Position of the target

Radar reflectivity definitions

- Object with a specific radar cross section is a point target from the viewpoint of the observing radar
  - Therefore it is not practical to use RCS when dealing with surface or volume clutter
    - in most operational situations the radar instantaneously illuminates the vast clutter sources in such a way, that the radar range cell (volume) or the cross section of the antenna beam is completely filled with e.g. rain or land.
- Use σ^0 = backscattered RCS per illuminated area

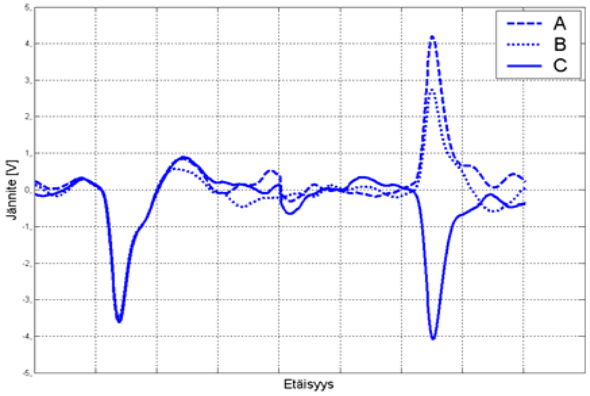
Clutter environment

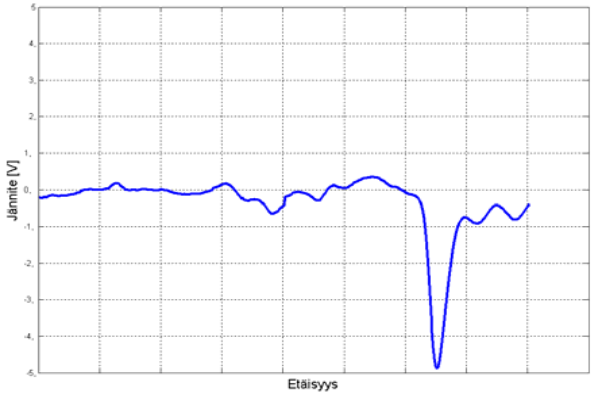
- Target detection in radar systems is based on the amplitude and phase characteristics of the return echo signal
- Doppler effect provides means for detecting a moving target in the presence of clutter whose amplitude exceeds that of the target
- Methods are MTI- (moving target indication) and Doppler processing

Clutter environment

- In case of volume clutter the backscattered echo depends on
  - The depth of the scattering layer
  - The shapes and sizes of the scattering particles
  - The orientation of the scattering particles
  - The dielectric properties of the scattering particles
  - The density of particles in the air

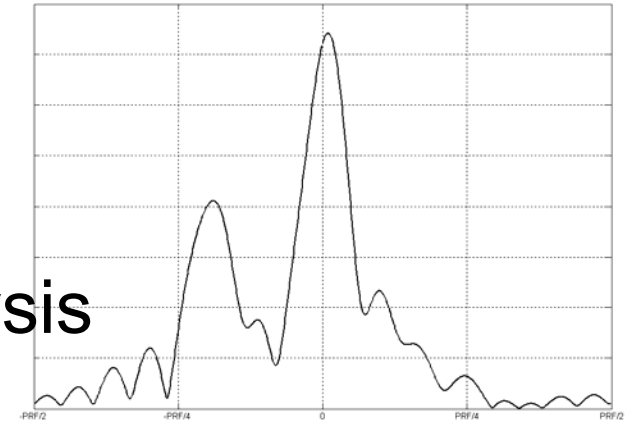
Signal processing





MTI-processing eliminates echoes from the vicinity of zero frequency in the Doppler spectrum

Doppler processing is based on spectral analysis (FFT) of the return echoes



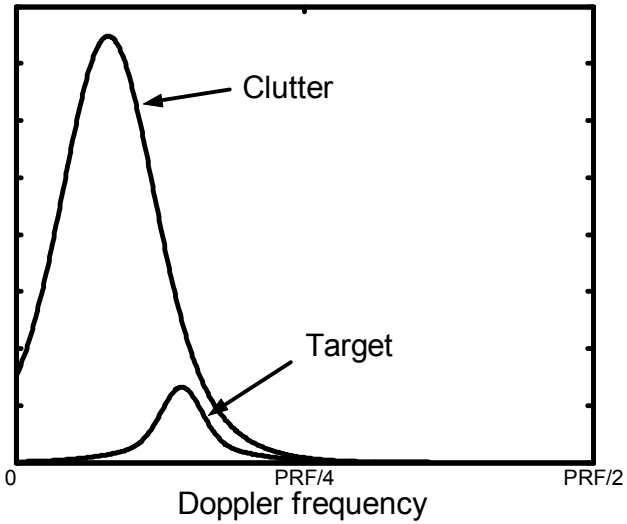
Measurement campaigns

- Mobility is a requirement for a modern radar
- If there's an intention to utilize a radar on the ground, extremely small and perfectly perpendicular illumination directions at various frequency bands must be considered
- The focus of experimental radar clutter measurement campaigns has been at moderate grazing angles (10°- 70°)
  - Very low grazing angle values have also been studied in the past, but only for sea clutter
- The most interesting results are not available and may not be directly translated from one environment to another

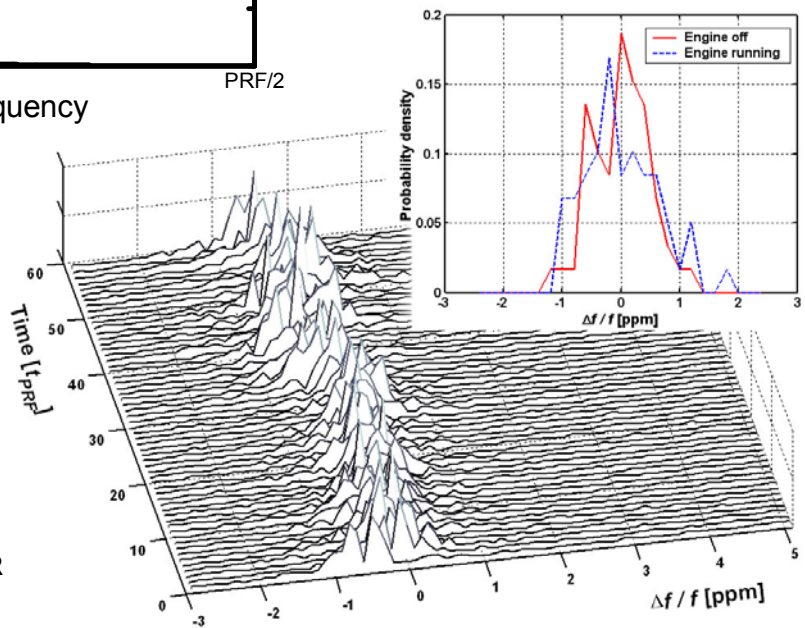
Measurement campaigns

- A mobile platform causes effects on the radar oscillator performance, which can not be reliably modeled with computer simulations
- Laboratory instruments and indoor test platforms are everyday facilities used in oscillator work. Computer simulation tools enabling circuit development and mechanical vibration analysis have been available for a couple of decades
- Despite these advances, oscillator performance evaluations continuously require extensive and well-prepared experimenting out in the field, in the particular foreseen operating environment

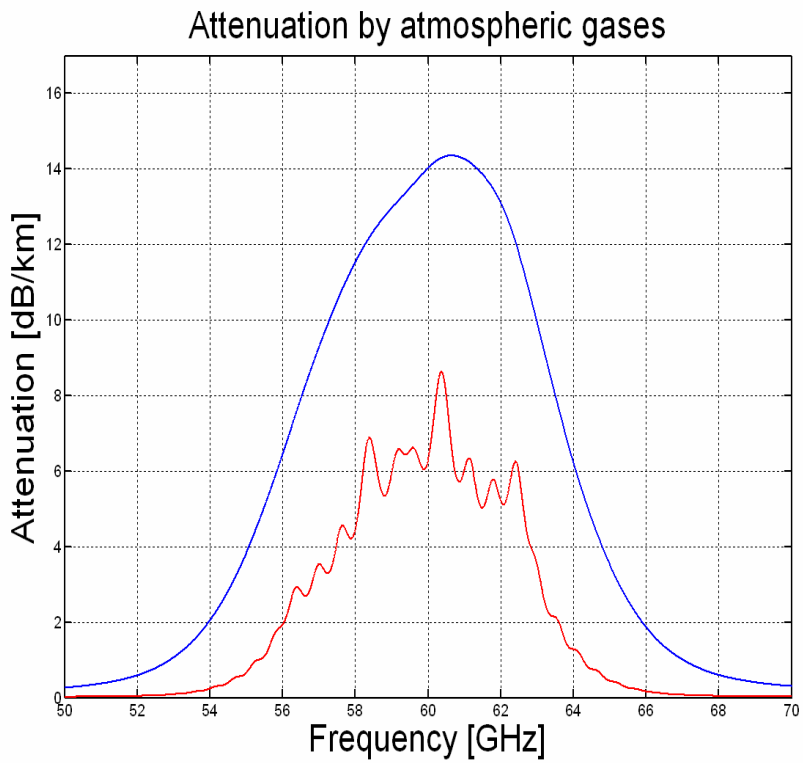
Measurement campaigns



- In Doppler processing technique the spreading of target and clutter echoes in frequency domain results in power leakage to the adjacent Doppler bins
  - deteriorates the velocity resolution
  - may prevent target detection



Measurement campaigns
- things to consider



- At mmw frequencies the atmospheric attenuation due to oxygen and water vapor is significant
- At the V-band there the numerous oxygen absorption lines merge together to form a broad absorption band
- The specific attenuation of atmospheric gases is a function of temperature, pressure and humidity of the air (ITU-R)

Measurement campaigns
- things to consider

- Before the start of the clutter measurements a careful internal calibration of the measurement system was performed in laboratory conditions.
- Calibrations with
  - passive targets with well defined RCS
  - active calibration methods

  at far field test range have been conducted to monitor the system status before each measurement occasion
- The far field test range calibrations allowed to determine antenna beamwidths in order to be able to calculate the illuminated area with high precision

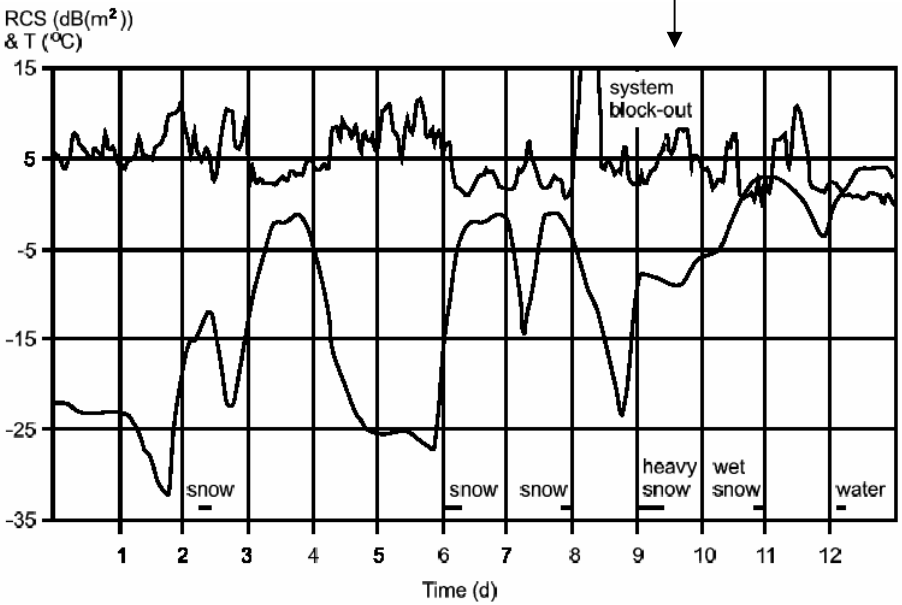
Measurement campaigns

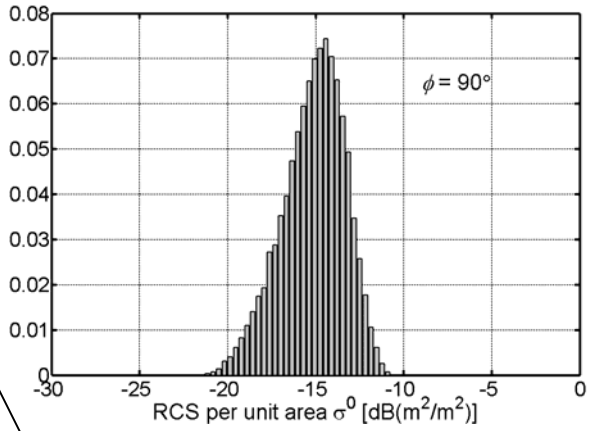
- examples of some results

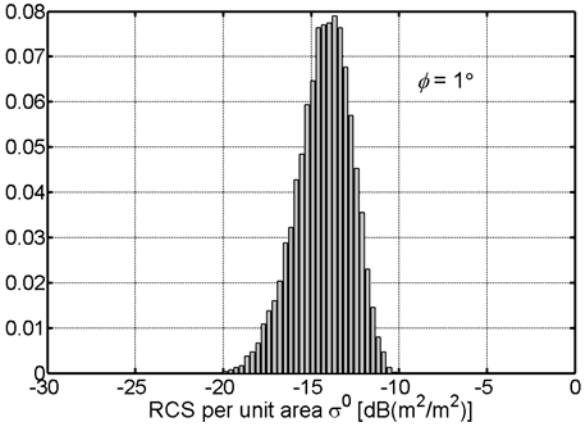
Pine forest, summertime

Refrozen snow

Backscattering of the sky at wintertime







Thank you!
Questions...?