

Innovation

SBIR Topic Number:
AF06-207

SBIR Title:
Ground-Based Radar Performance Improvements

Contract Number:
FA8718-07-C-0050

SBIR Company Name:
NorthWest Research Associates, Inc.,
Monterey, CA

Technical Project Office:
AFRL Sensors Directorate,
Wright-Patterson AFB, OH

This Air Force SBIR/STTR Innovation Story is an example of Air Force supported SBIR/STTR technology that met topic requirements and has outstanding potential for Air Force and DoD.

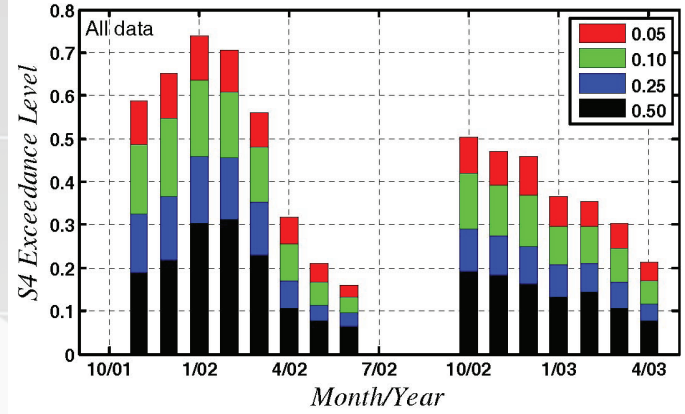
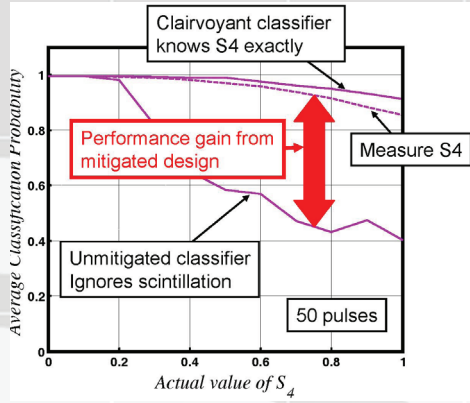


Figure 1: Performance of a multiple-hypothesis Bayesian maximum likelihood classification technique.
Figure 2: Exceedance (level of scintillation) experienced at various probabilities.

Ground-Based Radar Performance Improvements

- Small-scale variations in electron-density in the natural ionosphere can disturb propagating radar signals, with such irregularities potentially causing rapid variation in the amplitude, phase, and other signal properties, referred to as scintillation
- NorthWest Research Associates, Inc., (NWRA) developed signal processing techniques to mitigate the effects of the perturbed polar region ionosphere on radar classification functions for Air Force radar systems
- The algorithms developed under this work are directly useful for application to the Thule, Greenland, Upgraded Early Warning Radar (UEWR)

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Air Force Requirement

Ultra High Frequency (UHF) radars at high latitude can observe significant perturbations in measurements of amplitude, phase, range, and Doppler, caused by ionospheric disturbances. Without mitigation of these effects, the natural ionosphere is a major issue for the important radar functions of tracking and classification at the Thule, Greenland, Upgraded Early Warning Radar (UEWR).

SBIR Technology

Small-scale variations in electron-density in the natural ionosphere can disturb propagating radar signals. Such irregularities can cause rapid variation in the amplitude, phase, and other signal properties, referred to as scintillation.

UHF radars that operate in the polar region can experience scintillation anytime of the day or night, particularly in the winter of the five years centered around the maximum of the 11-year solar cycle. Under this SBIR project, NorthWest Research Associates, Inc., (NWRA) showed that if the radar signal processor is aware in real-time of the severity of the scintillation, it is possible to mitigate the effects of scintillation.

NWRA developed signal processing techniques to mitigate the effects of the perturbed polar region ionosphere on radar classification functions for Air Force radar systems. Mitigation techniques are needed for the Thule UEWR object classification (OC) and target track functions. OC is the process whereby the radar separates threatening targets (those carrying warheads) from non-threatening targets.

Typical radar performance criteria that were analyzed include the classification performance as a function of the number of pulses used to classify and the accuracy of the scintillation (S4) index measurement. These analyses were performed for a representative set of threat objects over the complete range of ionospheric disturbances to fully measure and document the performance of the NWRA mitigation algorithms.

Disturbances from the natural ionosphere are a substantial impediment to successfully track and discriminate targets using early warning radar systems. Hence, the subject matter of this proposed work is significant to the national defense and instrumental to the future successful performance of a critical radar resource.

Figure 1 (see page 1) summarizes the performance of a multiple-hypothesis Bayesian maximum likelihood

classification technique. NWRA considers a simple object classification problem wherein a Bayesian classifier attempts to decide which of three objects (a balloon, a re-entry vehicle, or debris, each with a different radar cross section (RCS) distribution) is being tracked. The results for average probability of classification show that the effect of total ignorance of the channel is a catastrophic loss in classifier performance with increasing value of the scintillation index (the bottom curve).

As shown in Figure 2, NWRA developed a maximum likelihood estimator to estimate S4 from calibration targets tracked from the Thule UEWR. Five thousand horizon-to-horizon tracks of large calibration satellites during the three-year period after solar maximum in May 2000 are analyzed to quantify the exceedance, or the level of scintillation, experienced at various probabilities. The results show that there is a significant probability of severe scintillation for several winters following solar maximum.

Potential Application

The algorithms developed under this work are directly useful to the UEWR prime contractor for application to the Thule UEWR.

Company Impact

"This SBIR effort has enabled NWRA to expand its expertise in mitigating the effects of ionospheric disturbances on radar performance and to develop specific mitigation algorithms," states Dr. Dennis Knepp, NWRA Senior Research Scientist. "Expertise in this area of scientific research should enable NWRA to develop mitigation algorithms for other radio wave communications or radar systems where scintillation is an issue."

NWRA is a small scientific research group whose goal is to solve important problems of interest to the United States in the areas of electromagnetic propagation, radar, communications, oceanography, and atmospheric physics. NWRA is owned and operated by the Principal Investigators of the company and has over 95 employees in three office locations (Seattle, Washington; Boulder, Colorado; and Monterey, California).



SBIR/STTR

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