Tactical Environmental Processor
At-Sea Demonstration

Tom McNellis, Program Manager
Lockheed Martin Government Electronic Systems
199 Borton Landing Road
Moorestown, NJ 08057
Phone: 856-722-6090; Fax 856-722-7209
EMAIL: thomas.j.mcnellis@lmco.com

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LONG-TERM GOALS

The long-term goal of this program is to develop radar-based remote environmental sensing to support safe and effective naval operations in the littoral region. This includes accurate spectral measurements of the environment, including land, sea and environmental "clutter", and timely volumetric measurements of radar propagation conditions.

With the application of advanced signal processing techniques, a tactical Navy radar such as the AN/SPY-1 radar can provide accurate, real time weather information to benefit a variety of units in the battle group. SPY-1 provides the sensitivity and flexibility to integrate a secondary capability of weather surveillance, with minimal impact on the primary role of tactical surveillance. This can be accomplished through an auxiliary environmental signal processor that operates in parallel with the tactical radar. Such a processor could provide real-time performance improvements to the SPY-1 radar as well as valuable environmental information to be disseminated for the support of fleet operations.

OBJECTIVES

The goal of the TEP As-Sea Demonstration is to demonstrate the results of technology developed in the previous land-based SPY-1 Weather Experiment as applied to a shipboard environment using a near-real-time Tactical Environmental Processor (TEP). The accuracy of the radar meteorological data collected aboard ship will be characterized, and the data will be disseminated to enable studies of the benefits of a real-time environmental sensing capability.

Specific objectives of this program are as follows:

- to further investigate the discrimination of sea clutter, volume clutter and land clutter in the littoral environment and over open ocean;
- to make available radar environmental data that could support future post mission analysis with a goal of reducing false track initiations, enhanced weapon system performance through clutter environment characterization and improved waveform selection, and improved clutter lock loop performance;
- to demonstrate the feasibility of a COTS-based scaleable signal processor to perform near-real time environmental processing on a ship without interfering with normal radar operations;

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- to apply advanced signal processing algorithms, incorporating pulse compression and doppler tolerant sidelobe suppression, in an operational environment;
- to make meteorological surveillance data available to shipboard personnel in an operational environment; and
- to collect and make available radar environmental data that could be used for future or concurrent research into meteorological techniques and modeling.

APPROACH

The Tactical Environmental Processor system is illustrated in figure 1. It consists of a data tap from a tactical radar (the SPY-1 B/D radar), an Auxiliary Environmental Signal Processor (AESP), a Display and Control Subsystem, and a data archiving capability. It collects data from the SPY-1 signal processor via a passive data tap, processes the data in near-real time, and displays the resulting measurements of reflectivity (intensity), radial velocity, and spectrum spread (an indicator of turbulence and shear).

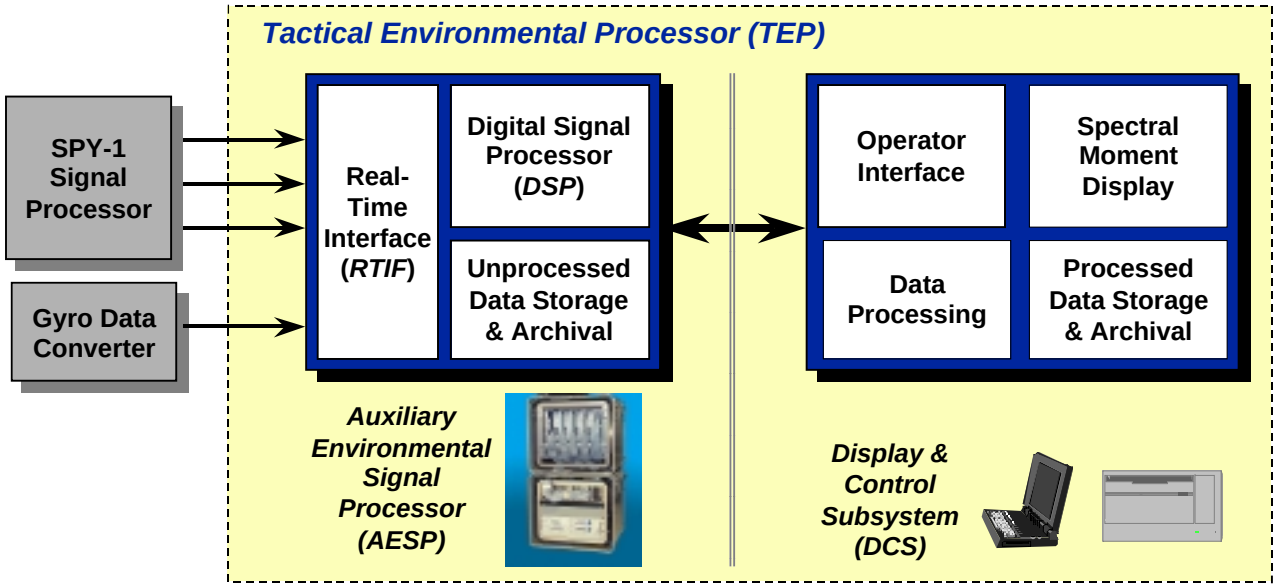


Figure 1: Tactical Environmental Processor Block Diagram

The AESP is contained within an enclosure within the radar equipment room, next to the SPY-1 B/D signal processor. The Display and Control Subsystem (DCS) is hosted in the AESP workstation in the radar equipment room which produces displays and acts as an interface to the AESP. The DCS also contains a remote monitor to allow for display of the processed data in CIC. AESP operator interface is conducted at the AESP workstation. This workstation is used for demonstration purposes only. For final product operation, the display and control features required for the AESP will be incorporated in existing SPY-1 B/D consoles. Operation of an end-item AESP system will not require any additional consoles or personnel.

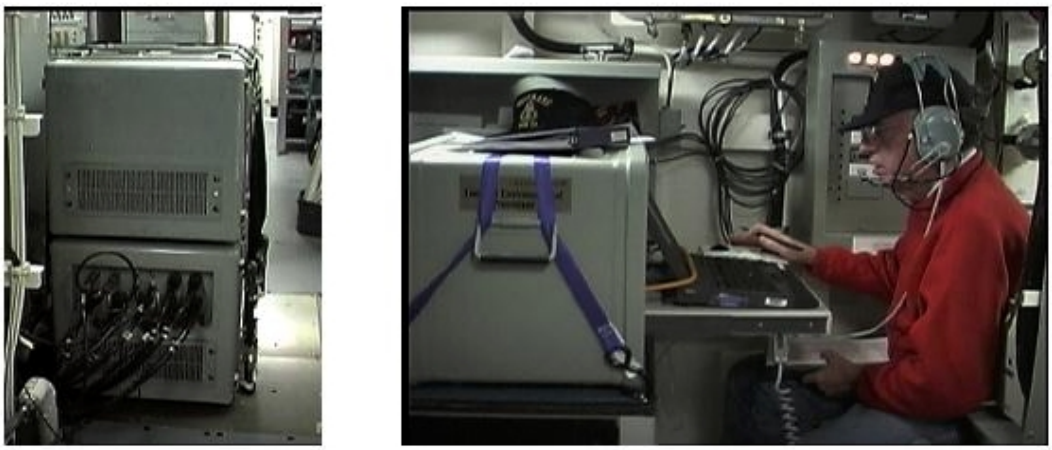


Figure 2: Tactical Environmental Processor Installation Aboard USS O'Kane

The at-sea demonstration is in progress onboard USS O'Kane (DDG-77). Several data sets are being collected during the at-sea demonstration, planned through December 1999. Included in this demonstration are validation data sets conducted in coastal regions within the coverage of a NEXRAD radar. Extracted spectral moments will be compared to NEXRAD Level II data for processing validation. The at-sea demonstration team consists of LM/GES engineers and Pennsylvania State University meteorological consultants.

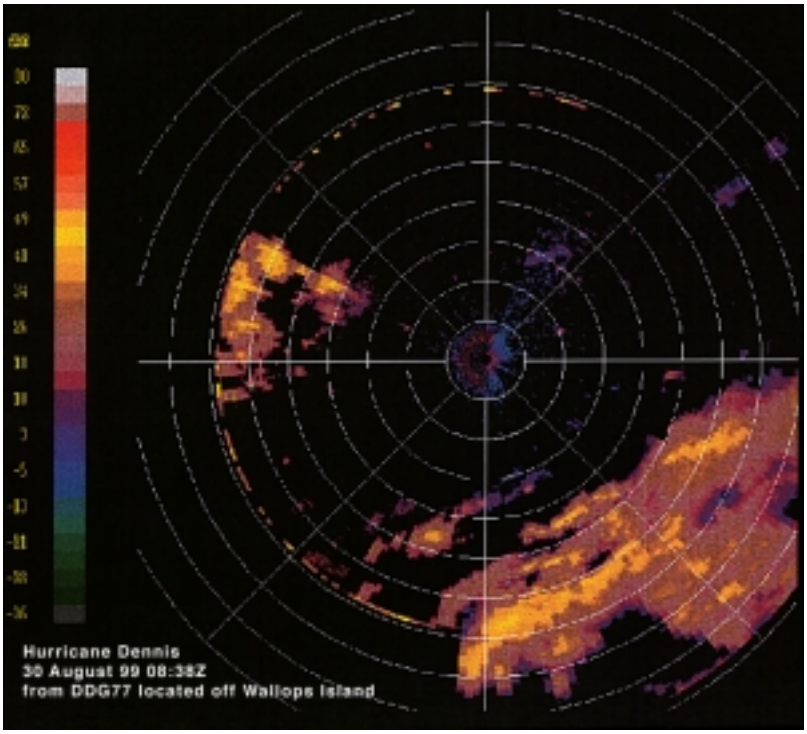
WORK COMPLETED

The program was authorized in February 1998. During FY98, the system requirements were established and an architecture design completed. During FY99, the following tasks were completed:

- The Display and Control System (DCS) and the Auxiliary Environmental Signal Processor (AESP) were successfully built, tested and integrated.
- The SPY-1 software modifications were designed, coded and tested on the SPY-1B radar at the Navy's CSED test site in Moorestown.
- The TEP system was integrated with the SPY-1B radar at the CSED site, completed system test in July. An Engineering Assessment was successfully held, consisting of a series of system-level tests witnessed by the Navy.
- The TEP system was installed on the USS O'Kane in August and thoroughly tested in the shipyard in preparation for Sailaway on August 26.
- A series of at-sea operations were conducted in the period from August 26 through October 4. During that period, data was collected by TEP on a variety of meteorological conditions including precipitation, clear air, ducted clutter, and marine boundary layer.
- An extensive set of data was collected in cooperation with several NEXRAD sites, including Grey, Jacksonville, and Melbourne. This data will be used for detailed comparison and validation of TEP data quality.
- The TEP team provided support for the SPAWAR Refractivity from Clutter program, including a direct link to the RFC laptop computer for immediate access to TEP clutter data.

RESULTS

Analysis is underway to validate the data collected to date on the TEP at-sea operations. An example of data collected to date is shown in Figure 3, which shows the northern rain bands of Hurricane Dennis as the O'Kane approached the Norfolk area on August 30. Initial results and conclusions will be available in November. Additional data will be collected in December during CSSQT events. Final results will be documented in a final report available in February 2000. Specific goals completed to date include the demonstration of shipboard environmental radar sensing with near-real-time data provided aboard ship. Another critical goal completed was the proof-of-concept for a viable COTS-based architecture capable of performing the signal processing necessary for the environmental sensing function that can operate in a not-to-interfere basis with the tactical radar. This architecture establishes the viability of this technology for transition to a fleet installation aboard ship.



Northern Rain Bands of Hurricane Dennis Observed by TEP on August 30, 1999

IMPACT/APPLICATIONS

Local real-time weather surveillance offers many benefits to the U.S. Navy. With local forecasting using TEP data, the forecast lag time can be decreased from as much as 12 hours to as little as 2 hours. Knowledge of precipitation and winds in the vicinity of air operations can significantly increase the efficiency and safety of those operations. The ability to detect cloud layers would also be of benefit to the coordination of air operations, which are affected by varying visibility conditions. The ability to monitor real time weather conditions can also provide improvements in the performance of tactical sensors through effective waveform and pulse repetition frequency (PRF) selection, and by aiding in the removal of undesirable clutter tracks which correlate to weather return. This could increase radar sensitivity by as much as 10dB, and decrease the utilization of radar resources dedicated to clutter management by as much as 50%.

The detailed clutter maps produced by TEP also directly enable the near-real-time generation of refractivity profiles.

This project provides several significant commercial (non-DoD) benefits. Several technological advancements demonstrated in this project are directly applicable to the NEXRAD radar system as upgrades. They include advanced surface clutter filtering techniques (such as the Matrix Clutter Filtering technique that will be used in this project), application of coded waveforms to boost system sensitivity, and implementation of spectral processing techniques (instead of pulse-pair processing) to offer more robust spectral characterization of weather events.

The combination of phased array technology and rapid scan processing techniques used with the SPY-1 B/D have direct benefit to both National Weather Service and Federal Aviation Administration research in preparation for future meteorological radar systems. Although these concepts have been discussed in the research environment, this project provides a full operational demonstration of advanced concepts, providing measures of real performance for this type of system to support future NWS & FAA efforts.

The third major benefit is the extension of NWS meteorological surveillance to the large expanses of ocean that are currently not observed with NWS radars. With the Tactical Environmental Processor technology, other existing maritime and Navy radars can be used to provide currently unavailable meteorological radar data for improving of forecast lead time and accuracy. Although satellites, aircraft, ships, and buoys provide some data over the oceans, the detailed lower altitude data provided by NEXRAD radars is missing.

TRANSITIONS

The TEP At-Sea Demonstration program will establish the basis for transition of the advanced clutter mapping capability into the SPY-1 radar and other Naval radars. We will also continue to work with Navy Labs and academia, including Penn State University and MIT Lincoln Labs, to provide over-ocean radar data suitable for incorporation into meteorological models. This data will provide a basis for through-the-sensor measurements that can enable local Nowcasts and Forecasts, and can help advance research into areas such as radar assimilation, dual-doppler wind retrieval, and propagation assessment.

RELATED PROJECTS

Although not directly addressed within the scope of the current project, there exist a number of closely related projects within the Navy and academia which can benefit from the radar-based environmental data generated to date, and the data soon to be generated as part of the At-Sea Demonstration. We are in contact with Dr. Qin Xu at NRL regarding their on-going efforts to retrieve full wind field information from radial velocity measurements and to assimilate radar data with numeric models. Other related efforts include the Remote Refractivity Sensing Project led by Ted Rogers at NRaD, the NRL Onboard Model Development efforts, and the Penn State University initiatives in radar assimilation for Mesoscale models and LES models.

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