VESSEL TRAFFIC MANAGEMENT SYSTEM

A Test Technology Development and Demonstration Project

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ABSTRACT

The Vessel Traffic Management System is a cooperative effort of the Naval Undersea Warfare Center and the Naval Air Warfare Center Aircraft Division, funded by the OSD's Test Technology Development and Demonstration Program. The project is establishing the capability to acquire ship tracking information from numerous sources (GPS and radar target extractors), and combine them into a comprehensive, integrated view of the range safety target area. The consolidated tracking information will be transmitted to range safety vessel personnel and presented on portable display systems to aid in clearing the surveillance area of unauthorized vessels. The communications module is media independent in that positional and image data can be routed via RF modem, cellular phone, Intranet or Internet, singly or in any combination. The software systems for data acquisition, display and control are also platform independent, with the system under development operating under WindowsNT and Windows95. Additionally, the use of Java and VRML tools permits a user to display data (including three dimensional presentations of the data) without requiring the applications software. This system has numerous applications including range safety, commercial vessel traffic management, port authority and services monitoring, and oceanographic data gathering.

KEYWORDS

Radar, Radar Processing, Range Safety, Tracking

INTRODUCTION

The Naval Air Warfare Center - Aircraft Division, Patuxent River, Maryland, and the Naval Undersea Warfare Center Division, Newport, Rhode Island, have teamed to develop the Vessel Traffic Management System (VTMS). This system, while developed to satisfy a need for enhanced Test & Evaluation (T&E) range safety, is also suitable for use in the monitoring and advising of commercial ship movements. This joint effort has taken

advantage of two different and distinct vessel tracking system technologies independently developed by the two commands. Features of both technologies were combined, and added to, in order to create a surveillance system to monitor vessel traffic in and around the waterways utilized by the DOD for T&E missions. While the VTMS was specifically developed to increase the efficiency of range safety, an effort was made to consider Coast Guard requirements and commercial applications of the system in the design.

THE PROBLEM

There are two types of related problems which are addressed in the design of the VTMS: range safety and commercial marine traffic management.

Range Safety A specific example of a T&E range that faces this challenge is the Atlantic Test Range (ATR) within the NAWCAD, Patuxent River, Maryland. Here the Navy conducts in-air tests of naval aircraft weapon and sensor systems. In particular, aerial delivery of ordnance is typically carried out in the ATR over the Chesapeake Bay. The number of commercial ships transiting this area year-round creates a potentially dangerous situation; however, the number of small pleasure craft in the summer months sometimes results in a nightmarish situation for range safety officers at the ATR operations center.

Commercial Marine Traffic The need for keeping track of ship traffic in navigation areas leading to and within the congested area of deep draft ports is of concern to environmentalists, port authorities, and ship captains and owners, especially since the Exxon Valdez disaster of 1989. One of the US Coast Guard's missions is to provide vessel traffic management in the nation's most congested ports through the Coast Guard Vessel Traffic Service (CGVTS) and has installed monitoring systems in eight ports. Recently with support from NAWCAD they have completed a twenty-five million dollar investment program to upgrade the facilities in New York, Seattle, and San Francisco. A Ports Needs Study completed by the Department of Transportation in August 1991 identified 23 ports throughout the country which would benefit from installation of some form of VTS. The VTS, as it exists today, relies on radar imagery and closed circuit cameras, in conjunction with radio communications, to maintain knowledge of vessel movement in ports. Because of the high cost of these systems, Congress has severely curtailed funding of planned VTS installations; only recently approving funding of a system for New Orleans. At the projected rate of installation, it is anticipated that not all 23 installations will be possible before major renovation of the oldest systems is required.

BACKGROUND

The existing systems which currently support the ATR range safety and Coast Guard VTS operations have some limitations of effectiveness which brought about the development of the VTMS.

Range Safety The existing surface surveillance radar system in use at the Atlantic Test Range relies on Raytheon and Furuno surface scan radars located along the shores of Chesapeake Bay. The locations of the shore sites ensure sufficient overlap in coverage over the identified range areas. The radar images are viewed in the Range Operations Center and monitored by a range safety officer. Range safety vessels are stationed near the range target areas. If it appears that a vessel will enter the target area unless it changes course, the range safety officer will vector the range safety vessel to warn the intruder off. In the confusing environment of summer pleasure craft mixed with commercial traffic, it is often difficult to identify the radar return of the range safety vessel among the others. The misidentification of the range vessel sometimes results in erroneous directions being given to the pilot of the craft, wasting time before the error is detected and corrective action taken.

Commercial Marine Traffic. The VTS systems installed by the Coast Guard in the ports of NYC, Seattle, and San Francisco were state-of-the-art, open systems based architecture. They were also predominantly commercial off the shelf (COTS) equipment items. Key to this system's architecture was the leveraging of the common operating environment and core software applications (a small subset) of the Joint Maritime Common Information System (JMCIS) products of what was then the Navy's tactical command and control community. This leveraged Navy investment was then augmented by several VTS specific applications, most notably a radar imagery segment, to produce the final VTS Upgrade product.

This improvement program brought many advances to the existing Coast Guard operations including: the integration of multiple radar returns onto a single watchstander display, fusing of electronic maps, tracked vessel symbology, and radar imagery into a single presentation, improvements in vessel tracking by embedded radar processors, automation of vessel transit reporting, removal of system single points of failure, and increased system reliability.

EXPERIENCE

Both NAWC-AD, Pax River, and NUWC Division, Newport, have considerable experience in developing tracking systems. In addition to its surface surveillance expertise such as that employed to support the Coast Guard's VTS improvements, NAWCAD's ATR is the organization responsible for precision tracking of test aircraft and external

ordnance. This tracking includes the use of radar, global positioning system (GPS), cinetheodelite cameras, and telemetered inertial navigation systems data. NUWC Division, Newport, develops undersea and above-water tracking systems for test and training of submarine and antisubmarine warfare combat systems, and has investigated the dual-use application of tracking technology to solve vessel traffic management problems in consultation with the Coast R&D Center and the Volpe National Transportation Service Center.

APPPROACH

The completion of the VTS support to the Coast Guard by the Navy resulted in a fielded waterway surveillance system that has greatly surpassed the capabilities of many T&E range systems of similar function such as range safety systems as described previously. This is especially true with respect to the fusing of electronic charts, mutiple radar images, and tracked vessel symbology onto a single display. In proposing this test technology project the approach was to leverage the twenty-five million dollar Coast Guard VTS investment (adapted to the range safety mission), integrate it with GPS technology proven out for this mission by NUWC, and accomplish this with only COTS equipment items. Furthermore, with the advances in both performance and functionality in the personal computer class hardware, this program was also to attempt to reduce the recurring costs for the sensor data, database, and display processing computer hardware components.

RADARs Referred to in the VTMS documentation as Remote Sensor Systems, the radar instrumentation includes the radar processor, radar control unit, radar transmitter/receiver, and radar antenna.

Vessel Traffic Control Subsystem This subsystem consists of all the hardware and software required of the operator console(s), and provides the functions of setup and control of VTMS, display of data including radar tracks, radar images, and GPS tracks, at a minimum, and the display of vessel data and status. Additional capabilities will include weather updates (local weather instrumentation and Internet sources), hazards to navigation text, other position data, and other data.

The Vessel Traffic Control Subsystem will consolidate all tracks and images in separate “layers” which allows the operator to selectively change the information displayed as desired. The system will also be able to transmit in a broadcast mode the consolidated data to remote displays by a number of communication means including telephone or cellular modem, RF modem, Internet, Intranet, or other local network.

Remote Displays The capability for the range safety vessels to view the same information which the range safety officer sees on the operator’s display will reduce the ambiguity

sometime experienced in the current system. A portable display subsystem is designed and includes a PCMCIA card GPS receiver to determine the position of the vessel, a laptop PC to display that position on a chart of the area, and a RF modem to pass positional information to the Vessel Traffic Control Subsystem. The RF modem will also be able to receive the broadcast tracking information and display radar tracks, radar images, and other GPS tracks. Other data such as weather information and navigation advisories may also be transmitted to the portable display if desired. The portable display system may be updated in the future to include a heading sensor which will provide a ship's heading in cases where GPS vector data is not available, such as when the ship is at anchor.

COMMUNICATIONS

Main features of the VTMS include the distribution of remote sensor subsystems, the ability for vessels instrumented with GPS receivers to transmit their position to the Vessel Traffic Control Subsystem, and for remote display subsystems to receive consolidated tracking data and radar images from the Vessel Traffic Control Subsystem.

The remote sensor subsystem consists of a radar antenna, radar processor, radar control unit, and GPS time receiver. A remote site processor communicates with the Vessel Traffic Control Subsystem via a wide area network (DATAWAN) using 10-Base T Ethernet; the operator can control and monitor all of the functions of the remote sensor system. Other remote sensor elements which may be collocated with the radar system include video, RF modems, RF transceivers, and weather instrumentation.

The remote displays use a "client downloadable" technology via the programming language Java, and a Java Compatible Browser such as Netscape Navigator or MS Internet Explorer. The notion is that a user can input a Uniform Resource Locator (URL) into the browser and request an HTML document that has a Java Applet embedded in the document. The Java Applet is executed and makes a socket connection to the data server from which the document and Applet originated. The Applet then can display data from the server including the charts, tracks, radar images, weather, and other data. Control over screen attributes is available at the remote display including zoom, size, location, area, colors, layers displayed, etc. No special software is required on the remote display, allowing any user to view the tracking data from any computer with a compatible browser, the URL, and the password (if access controlled). The software thus becomes platform independent by being compatible with any computer or workstation which has a Java compatible browser installed. In this way, not only can the range safety officer see the displayed tracks and radar images, but the base commander, design engineer, or sponsor will be able to view the entire picture at his/her computer by accessing the URL.

The communication controller resides as a separate software module which is also platform independent, and facilitates the integration of different communication techniques. Communication channels which have demonstrated include standard telephone modes operating at 14.4 Kbit or 28.8 Kbit, high speed Internet connection, and cellular phone modem. To accommodate the high data rate and expected volume of data, a 115 Kbit spread spectrum radio modem manufactured by Freewave is used between the Vessel Traffic Control Subsystem and the portable display systems. The radio modems operate with TCP/IP over Point to Point Protocol (PPP) using the standard software provided with Windows95 which is installed on the portable display laptop PCs.

RESULTS

Viability of a migration to personal computer class hardware has not only been proven, but proven in many cases to outperform the workstation class platforms from which it was leveraged. The radar technology of the Coast Guard VTS system has successfully been integrated with the GPS technology of the NUWC system. Recurring equipment costs have been reduced by seventy-five percent with the ability to increase system horsepower by only a few hundred dollars vice the previous system figure of several thousand dollars! In addition many elements of this system have been designed to provide direct access to its surveillance information over the internet without need of any specialized equipment or software beyond a web browser.

The Vessel Traffic Control Subsystem is near completion and is operating at the NAWCAD, Patuxent River, MD. It is currently supporting the F-18E/F test program. Radar processors (target extractors) have been installed on the NAWC-AD radars and integrated into a single display console which are located next to the old radar displays for comparison and performance analysis. Display performance of the Vessel Traffic Control Subsystem far exceeds that of the VTS systems installed by NAWCAD for the Coast Guard. . Table 1 indicates the performance gains accomplished with the VTMS architecture over the VTS system, and lists the test conditions under which performance was compared. While the VTS is able to refresh the radar image display every third scan or once every nine seconds, the VTMS update the image every scan, a three to one increase in performance. Test of the VTMS hardware and software have been conducted with a combination of 2000 real and simulated targets which are updated at a rate of five times per second, far faster than would be required in actual use which was not achievable with the previous system.

Table 1. System Performance Comparison

Parameter	Vessel Traffic Service System	Vessel Traffic Management System
Radar Image Update Rate	9 seconds	3 seconds
Track Icon Update	6 seconds	3 seconds
Radar Image Latency (remote site to display screen)	15 seconds	< 7 seconds
System Responsiveness to Operator Input	Marginal (with failures)	Acceptable (with no failures)
Computer Platforms Required	Three Workstations (HP-755 and Modcomp)	One Personal Computer (Pentium Pro)

Test Conditions:
Six Chart Windows Open (three per screen)
Ten Radar Images Distributed Among the Chart Windows
Total of 100 Tracks in System
Track Icons Display Course Vector
Radar Images Received from Remote Sites at Three Second Intervals
(recorded data from VTS New York; images unmasked)
Track Reports Received from Remote Sites at Three Second Rate (simulated tracks)

FUTURE APPLICATIONS

The Vessel Traffic Management System has demonstrated the capabilities to track radar generated targets as well as GPS instrument vessels in a range safety application; NUWC Division Keyport, WA, and Vandenberg AFB are reviewing proposals and cost estimates for similar installations. Features of the VTMS are also applicable to the monitoring of ports and harbors as currently provided by the Coast Guard. The Coast Guard is soliciting to acquire hardware and software to provide Vessel Traffic Services for the Port of New Orleans. In addition to this application, VTMS is also suited for other similar use such as the Panama Canal where a mix of instrumented vessels which shuttle pilots from ship to ship, uninstrumented ships at anchor, and portable display instrumented ships are tracked.