

Experience With VTS/AIS as A Systems Integrator

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Abstract

Lockheed Martin has integrated and installed numerous AIS systems around the world as part of several VTS installation contracts and technology demonstrations for customers. Each of these systems incorporates specific customer requirements addressing differing objectives. This paper describes the capabilities and features of Lockheed Martin's current implementation of the Universal AIS system, and the experiences Lockheed Martin has had with earlier AIS and ADS (automated dependent surveillance) system installations. Specific examples are provided for an amphibious landing exercise with the US Army; installations at a Middle-East Oil port; technology demonstrations in New York Harbor, USA; river systems in New Orleans, Louisiana, USA; and coastal applications in the Gulf of Suez. The paper closes a brief overview of the most recent activity, the Turkish Straits VTMS project that requires Universal AIS installations. The evolution of the technology and lessons learned will be discussed in the context of these examples. The perspective will be on Lockheed Martin's experience working with different customers to integrate AIS technology into a larger VTS or Port Information System. It will also discuss, from the practical side, how AIS information is used by a variety of maritime organizations with differing needs and information objectives.

Lockheed Martin System Description

Lockheed Martin's Marine Traffic Management Business in Syracuse, NY, has developed and now includes in our basic ports and waterways systems a Universal AIS option. Our integrated Vessel Traffic Management Service (VTMS) solution for AIS is compliant with the ITU requirements of the Universal Automatic Identification System program as it is defined in finalized form today. This option features ship based transponders and shore based transponder base stations integrated with Lockheed Martin's proven MTM100 software, along with optional Lockheed Martin Carry Aboard Packages (CAPs). This combination of technologies – hardware and integrated software -- provides a comprehensive, flexible, and modular design to satisfy a range of applications. It also offers a tremendous advantage over existing Automated Dependent Surveillance/Digital Selective Calling systems (ADS/DSC).

Lockheed Martin's MTM100 software for ports and waterways also integrates Universal AIS vessel movement data with other information including radar tracks and text messages; environmental information such as weather, currents, and tides; and vessel safety information such as underkeel or overhead clearance data. Lockheed Martin's Universal AIS approach is now being implemented in waterways in several locations, with other technology demonstrations being de-

veloped either under current contracts or in conjunction with our internal research and development programs.

Lockheed Martin Univesal AIS Functional Overview

The Lockheed Martin Universal AIS combination complies with the approved Maritime Standard ITU-R M.1371 "Technical Characteristics for a Universal Shipborne Automatic Identification System". This solution efficiently integrates all AIS transponder-equipped ships and Lockheed Martin shore based MTM100 VTS or VTMS workstations into an advanced capability network supporting present and future traffic projections.

Additional interfaces with external information systems are provided by the modularity inherent in Lockheed Martin's system design, which uses standard network protocols. Both text and data messages can be passed from either ships or from the shore-based centers over the Universal AIS VHF radio link. This function has been implemented in several of the examples described below.

The international standard requires a technique known as Self-Organized Time Division Multiple Access (STDMA) which provides for up to 2,000 vessel reports per minute, easily handled in the MTM100 workstation. In a crowded harbor with vessels requiring additional information such as radar track reports, environmental (weather, marine data, etc.) information, and text messages, this capability provides vessel traffic control centers the best approach to managing safety.

The automated alert and advisory capability in the integrated design also means the system does not have to be manned continuously, saving operating costs.

Applications

The Lockheed Martin integrated MTM100 Universal AIS solution can be used in several applications to support waterways safety and efficiency including:

- Vessel Traffic Services (VTS) system enhancement
- Tug boat location monitoring, scheduling, and emergency dispatching
- Ferry service location monitoring, scheduling, and navigational control
- Work boat location monitoring, scheduling, and navigational control
- Pilot or marine police boat location monitoring, vessel vectoring, and navigational control
- Commercial cargo vessel location monitoring and navigational control
- Remote monitoring, control, and data acquisition of buoys and other offshore sensors
- Bridge air gap and under-keel clearance warning messages

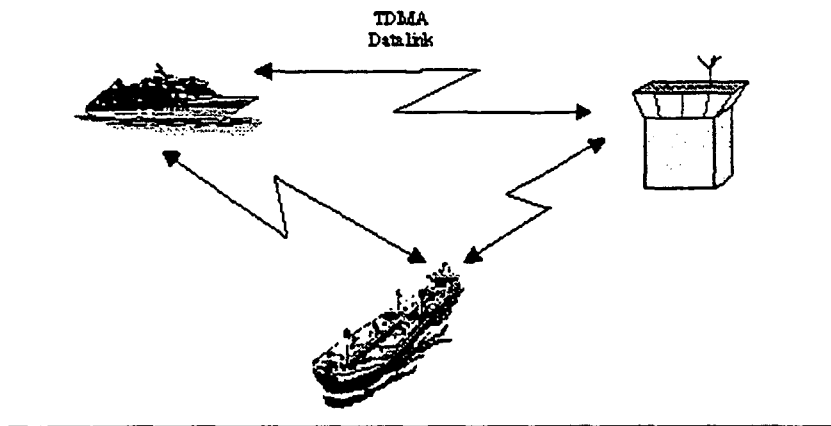
Certainly, the list above is not exhaustive. Additional applications can be identified that will contribute to the usefulness of an integrated UAIS and VTMS situation.

Examples of several of these applications are given in the details that follow.

Transponder Functions

As implemented by Lockheed Martin, the AIS transponders communicate in both ship-to-ship and ship-to-shore operation using STDMA communications over VHF radio links. Ship position

reports provided by the Universal AIS transponders are passed to the Lockheed Martin MTM100 workstation through the Universal AIS Basestation transponder. Likewise, ship-to-ship reports are implemented using the same STDMA communications.



The result is a tightly coupled yet extremely flexible maritime network based on full compliance with current international standards for Universal AIS and the capability to easily support field software upgrades to accommodate any future standards modifications.

AIS and the MTM100 Workstation – Central Hub

AIS reports from the ship-based transponders are received and processed by Lockheed Martin's MTM100 rule-based software. This software helps to ensure that all safety and regulatory rules of the waterways are enforced. Interface with the MTM100 workstation is via the Lockheed Martin Interface Adapter Unit (IAU) PC, and the shore-based Universal AIS base station transponder typically co-located at the VTMS control center. Additional Universal AIS base station transponders may also be installed at remote sites to increase surveillance area coverage. Interface to the LM VTMS system is through additional Interface Adapter Units that are also typically at the remote sensor sites.

The vessel transponder sends a unique AIS-based identification number to the VTMS, where it is received and used by the MTM100 workstation. The MTM100 software then can link the AIS tracks displayed on the electronic chart display with information in the MTM100 database. This automatic linking with the MTM100 database removes the need for operator voice communication with the vessel to associate ships data with the AIS track thereby providing "Silent VTS" operation.

The Lockheed Martin MTM100 workstation software also provides complete integration of other sensor systems including meteorological, hydrological, and VHF Direction Finding systems. The MTM100-based VTMS system broadcasts real-time information to all Universal AIS transponder equipped vessels. In addition, the MTM100 workstation allows data from the Universal AIS system to be provided directly to other systems external to the vessel traffic control center.

The MTM100 workstation at the control center also correlates all radar tracks in the area of interest with AIS position reports for display to the operator. Correlated track reports are also

broadcast over the AIS network to all Universal AIS equipped vessels. Those vessels equipped with the Lockheed Martin CAP can display these tracks giving the Pilot and Master the most comprehensive graphical view of the waterway possible. The operator at the workstation has the option of selecting (1) only AIS tracks for display; (2) selecting only radar tracks or plots; or (3) selecting a correlated combination of both AIS and radar tracks for display.

AIS and the Carry Aboard Package (CAP)

The Lockheed Martin CAP is available for rapid integration with the shipboard Universal AIS transponder to provide a shipboard user graphical and text display interface to the MTM100 system. The compact, self-contained package contains all equipment for setup and use. Lockheed Martin has developed the CAP through a combination of internal resources, technology demonstrations, and performance on contracts. Continuing feedback from users has shown that the integration of this component into a larger maritime traffic system (i.e. VTMIS) has definite advantages for both the shore-based control centers and the vessel-based users.

Sophisticated software developed by Lockheed Martin is configured on each CAP to provide advanced navigational assistance and optional display of important environmental data such as wind speed and direction, current data, and tidal information. The CAP displays an electronic chart to plot own-ship position and course as well as the position, course and speed information from all vessels tracked by the MTM100 system (via radar or Universal AIS).

The CAP is brought on board the ship as a single unit containing all necessary equipment including a laptop PC and the transponder. The transponder has external VHF and GPS antennas that are connected to the transponder via simple plug and play cables and placed outside the bridge at a clear view position. Differential corrections are received from the base station transponder avoiding the need to add beacon receivers to the Pilot Carry Aboard package. The entire package may also be used in a fixed shipboard installation with the same basic equipment setup.

AIS EXPERIENCE

Lockheed Martin experiences with integrating AIS technology and our proven VTMS system solutions stem from several years of demonstrations, system installations, participation in worldwide organizations such as IALA's AIS subcommittee, and customer feedback over six years.

Lockheed Martin's first "AIS" system involved an amphibious offloading exercise with the US Army in 1994. In 1995 Lockheed Martin began installation of its first ADS/DSC system and in 1998 demonstrated its first Universal AIS system. Today, Lockheed Martin is integrating and plans to install the Universal AIS subsystem in the Turkish Straits VTMIS – a high visibility project that is being carefully watch by the IMO.

A short review of just six of the systems Lockheed Martin has installed, demonstrated, or is currently integrating is necessary on order to put the current efforts into perspective.

1994 US ARMY JLOTS EXERCISE

This two-day demonstration involved early transponder and AIS technology in an exercise aimed at expediting offloading military cargo during a US Army amphibious exercise. A command post was located on shore with a VTS surveillance system and one radar. Onboard the main cargo vessel a CAP was positioned. As cargo was offloaded to lighters each item was scanned with a barcode reader and cargo transfer information was sent to shore where it was integrated with the VTS information. In this manner not only could the shorebased operator station monitor all vessel traffic (including almost 1000 lighters) but cargo offloading progress and cargo location on shore could be easily monitored. Bottlenecks in traffic flow could easily be seen. Army officials responsible for the correct positioning of vessels coming to and going from the shore could direct movements better. Moreover, as certain supplies were determined to be required in order, cargo-offloading priorities were transmitted to the cargo ship. Communications were accomplished via cell phones using a proprietary message structure optimized for this exercise.

As a result of the application of this AIS technology the 7th Transportation Group of the US Army set a record for fastest cargo offloading.

MIDDLE EAST OIL PORT INSTALLATION

This oil port VTMS has two AIS systems: (1) an ADS/DSC system using the ITU-R M.825 communications protocol and (2) a transponder based system using a proprietary communications protocol designed for rapid transfer of large amounts of port data from the shorebased operations center to participating vessels. Approximately 40 port vessels are equipped with DSC radios to allow precise tracking of these vessels. The purpose of this AIS system is to allow efficient utilization of port vessels by scheduling them for multiple tasks based on the more precise knowledge of their positions and intended routes. Twenty-five additional CAP units, which communicate with shore via a proprietary communications interface, are carried-aboard vessels when they enter the waterway. These devices are used primarily as docking aids for the final approach and berthing. The following types of information is sent from the shorebased operations center to the vessels:

- Approach Speed Monitor read-out,
- Mooring strain sensor read-out when docked,
- Other vessel tracks (Radar, DSC, CAP),
- Underkeel Clearance information along intended route (including forecasts for up to 24 hours in the future),
- Meteorological/hydrological/oceanographic information
- Other general administrative information.

The installation at this port preceded the development of the Universal AIS standard, and has given Lockheed Martin extensive additional experience integrating AIS type packages with land-based vessel traffic systems.

NEW YORK CITY

A two-month AIS demonstration was held in New York Harbor during the fall of 1998 as a cooperative effort involving Lockheed Martin, the State of New York, the local pilots organizations, and the existing US Coast Guard VTS station. In this exercise, a shore-based Lockheed Martin workstation monitored the movement of twenty CAPs and provided additional information back to the CAPs being used by pilots. The shore basestation received real time environmental inputs from US Government sources (National Oceanographic and Atmospheric Administration sensors) and an installed Bridge Clearance system that measured the air gap between the water level and the bridge structure. The combined information was sent to all CAPs along with tracks from all vessels equipped with CAPs. Text messaging between CAP equipped vessels and with the shore station was also available and exercised. Users could select from either formatted text messages or could input their own short messages to exchange with other users or with the shore station. In this manner mariners could receive real time graphical environmental information and bridge clearance information, tracks of all participating vessels, and could send text messages to each other. The communication was achieved with spread spectrum technology using proprietary message structures optimized for this information transfer.

NEW ORLEANS, LOUISIANA, USA

The US Coast Guard has conducted extensive AIS tests along the Mississippi River since September of 1998. As the system integrator for the overall US national Ports and Waterways Safety Systems for the US Coast Guard, Lockheed Martin has been involved with these tests on three levels: (1) as the master VTMS system integrator; (2) as an integrator of some government-furnished components of the system; and (3) as a contributor to the final technical solutions. Currently, the Louisiana system consists of a shore based operator station near New Orleans that monitors vessel traffic from Baton Rouge, Louisiana to the Gulf of Mexico, over 270 river miles. The Coast Guard has provided approximately 50 CAPs to mariners and continually monitors their location on the river from the Vessel Traffic Center in New Orleans. Track data originating from the transponders associated with the CAPs is available at the main control station where it can be merged with or compared to radar tracks (selectable by the operator). Five remote stations provide complete coverage along the surveillance area of the river where traffic is dense, requiring the additional coverage of vessels without the transponders. The AIS system originally used the ITU-R M. 825 DSC protocol but in the spring of 2000 a test using the Universal AIS protocol was run. The purpose of this test was to determine the state of the AIS suppliers capability to perform in a ship board mode. Final results of the exercise have not been incorporated into the existing VTMS system in New Orleans yet. As those decisions are made and the technology adopted into the overall system, it is highly likely that Lockheed Martin will be participating as the system integrator for the installed VTS.

EGYPT'S GULF OF SUEZ

Lockheed Martin is currently installing a VTMS to provide continuous coverage throughout the Gulf of Suez. The area to be covered is the 250-mile length of the gulf from just below the Suez Canal and extending around the Sinai Peninsula to the Gulf of Aqaba. This system will include two shore based operator centers and multiple radars (11) for surveillance of all targets vessels. Included in this system is the capability at the vessel traffic centers to track any vessels equipped with ITU-R M.825 DSC and/or GMDSS radios using 5 remote communications sites to cover the entire Gulf. Currently the system will be used in a ship to shore mode only for vessel tracking. As with earlier implementations, the operators at the center will be able to choose from the radar track, the AIS track, or the correlated combination of both. The system today is awaiting full installation in Egypt, therefore customer feedback from regular day to day operational use is still somewhat in the future.

TURKISH STRAITS

In late 1999, Lockheed Martin was selected to install a VTMS system in the Turkish Straits. A major part of this system is the integration of a Universal AIS subsystem. This project is the culmination of the efforts to field an integrated Universal AIS system with the standard that has now been finalized. The VTMS system itself is an extensive implementation of several technologies following several years of efforts by the Turkish government to define, finalize, and procure a system that embraces international standards to the extent possible. The VTMS system consists of two Vessel Traffic Centers (VTCs), thirteen remote radars with triple polarized antennae, and multiple meteorological sensor suites, Doppler current and hydrological sensors, VHF direction finders, dGPS reference stations, CCTV/LLTV/IR camera sites, and 50 sets of portable Universal AIS transponders in a carry-aboard package configuration.

Each of the remote sensor sites is designed and located to provide overlapping coverage of the entire Bosphorous and Canakkale Straits. Integrated into a Wide Area Network (WAN), all sensors, including the Universal AIS packages, are utilized by multiple VTC operators at the Istanbul and Canakkale VTCs. Land-based sensor data, including radar and camera video, is transferred to the VTCs via phone line where advanced data fusion techniques are employed to provide each operator with a complete and comprehensive picture of the existing and developing traffic situation supported with real time meteorological and hydrological readings. This data will then be available for further transmission to the carry aboard packages to implement the best-correlated overall picture of the traffic situation.

It is expected that the Universal AIS implementation being delivered by Lockheed Martin will bring the following benefits to shipping in the Straits:

- Real time monitoring and assessment of the waterway by participants carrying the package
- Presentation of an AIS common traffic image to show vessel movements, environmental conditions, and movements of hazardous cargo (identified by the VTMS)
- Broadcast and notification of timely safety advisories and decision making

- Reduced reliance on voice communications
- More effective vessel scheduling and utilization of the straits by relating vessel movements to the integrated VTMIS database
- Better positive control of emergency response assets because locations will be based on real-time situations, with vessels positively identified in the Universal AIS scheme.

Because of the status of the international AIS standard, Lockheed Martin reserved the right at the beginning of this contract to determine which supplier would be providing the Universal AIS transponder component of the Turkish Straits VTMIS project. Recently, several companies responded to Lockheed Martin's issuance of a set of technical requirements and a set of demonstrations was arranged to help determine the suitability of systems on the market. As the integrator, Lockheed Martin was able to draw on its experience with the previous projects to publish an overall technical document governing the scope of work and the expectations for delivery of the AIS subsystem. Final decisions are yet to be published, as the evaluation of the supplier of choice is still underway.

SUMMARY OBSERVATIONS

From the various systems that Lockheed Martin has installed over the years the primary observation is that in most applications a recognized international communications standard must be utilized. Even though the purpose of some of the above AIS systems is tracking of vessels that never leave the port it is always important to include international vessels that periodically enter the waterway. Vessels that call on many ports demand a single, internationally recognized standard. IMO and other international maritime organizations have been working to address this issue with the new Universal AIS standard, and have made some progress over the past year. Currently this standard – now finalized and subject to ratification - is defined by an IMO performance standard and an ITU technical standard (ITU-R M.1371).

Another important observation is the utility of AIS as a stand-alone surveillance system. While it will be many years before all vessels of interest will be equipped with AIS transponders in a port or waterway, many vessels that remain in that waterway or transit the region can be equipped with portable or permanently mounted AIS systems. A single shore facility with several communications repeater sites can cover an extremely large body of water as evidenced by the Mississippi River and Gulf of Suez systems. The result is an extremely cost-effective surveillance or tracking system that can be installed at a fraction of the cost of a radar only VTS with comparable coverage. However, a few strategically placed radars can be included to add coverage for vessels not equipped with transponders while still keeping overall system cost much lower than a radar only system. Systems such as these – combining the two technologies - are ideal for maritime organizations that are mainly interested in communicating with and tracking their assets. The ability of the Universal AIS communications protocol to allow text messaging and the exchange of other valuable information such as weather, vessel tracks, and clearance data (both underkeel and bridge) makes the system useful as a waterways information management system.

Experience in several ports around the world has shown the AIS systems significantly reduce VHF voice traffic as advertised. Data is transferred digitally with more precise position localization and vessel identification than ever before. This information can be entered directly into a VTMS system database for display to the operator, thus greatly reducing the need to constantly call vessels to verify identification and location.

On a final note, designers and end-users of maritime traffic management systems must consider the capabilities and experience of the systems integrator when specifying and procuring any overall vessel traffic solution that includes evolving standards. Whereas the Universal AIS transponder may eventually be "type approved", customers must be careful about integrating everything together in a single, working, package that comprehensively addresses all facets of marine traffic: VTS, AIS, and all other systems and subsystems. Experience, though, is a good indicator and on that basis, Lockheed Martin would be pleased to offer itself as a participant in any further efforts to define and implement a solution for tomorrow's vessel traffic management situation.