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Pre-Phase I Final Report

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N O T I C E

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Technical Report Documentation Page

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16. Abstract (MAXIMUM 200 WORDS)

Automatic Identification System (AIS) is an autonomous broadcast that exchanges maritime safety/security information between participating vessels and shore stations. In addition to providing a means for maritime administrations to track the movement of vessels in coastal waters, AIS can be used to transmit information to ships while inport or underway to ensure safety-of-navigation and protection of the marine environment. In the USA, it is intended that this capability will enhance the Vessel Traffic Services (VTS) provided by the U.S. Coast Guard (USCG).

A study was conducted by *Alion Science and Technology* for the USCG Research and Development Center to develop requirements for marine information that could be broadcast by USCG VTS Centers. The study focused on gathering stakeholder requirements and determining the capabilities of: information providers, disseminators, and shipboard equipment manufacturers, and users (mariners). The goal was to identify and prioritize the types of information that should be broadcast using AIS binary messages.

In the analysis, information items were scored based upon perceived mariner need, suitability for AIS transmit, and suitability for use by manufacturers to present to the mariner. Based on the results of this study, there is interest on the part of providers, disseminators, and users in having AIS binary messages be used as a part of expanded VTS services. Also clear, that there is a need to have more information flow from the VTS to the mariners as digital data capable of being displayed rather than by increased voice communications.

17. Key Words Automatic Identification System, AIS, Vessel Traffic Services, VTS, Transmit, Broadcast, Functional Requirements, United States Coast Guard, USCG, Mariner, Electronic Chart Systems, ECS, Vessel Operators, National Oceanic Atmospheric Administration, NOAA, US Army Corp of Engineers, USACE, ECDIS	18. Distribution Statement This document is available to the U.S. public through the National Technical Information Service, Springfield, VA 22161.		
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List of Abbreviations

ADCP	Acoustic Doppler Current Profiler
AIS	Automatic Identification System
ARPA	Automatic Radar Plotting Aid
ATON	Aids to Navigation
BNTM	Broadcast Notice to Mariners
CCG	Canadian Coast Guard
CHRIS	Coastal and River Information Service
COPT	Captain of the Port
DGPS	Differential Global Positioning System
ECDIS	Electronic Chart Display Information System
ECS	Electronic Chart System
FM	Frequency Modulation
GPS	Global Positioning System
LT	Lieutenant
LTJG	Lieutenant Junior Grade
LTCDR	Lieutenant Commander
MCTS	Marine Communications and Traffic Services
MIB	Marine Information Broadcast
MIO	Marine Information Overlay
MKD	Minimum Key Display
NACC	North American Controls Corporation
NMEA	National Marine Electronics Association
NOAA	National Oceanic and Atmospheric Administration
NOTM	Notice to Mariners
OOW	Officer of the Watch
PAWSS	Ports and Waterways Surveillance System
POC	Point of Contact
PORTS®	Physical Oceanographic Real-Time System
RACON	Radar Beacon
R&D Center	USCG Research and Development Center
RR	Railroad
RTCM	Radio Technical Committee for Maritime Services
RTCV	Real Time Current Velocity
SLW	Saint Lawrence River Waterway
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
VDL	Very-High Frequency Digital Link
VHF	Very High Frequency
VTS	Vessel Traffic Services
WASS	Wide Area Surveillance System

EXECUTIVE SUMMARY

Automatic Identification System (AIS) is an autonomous broadcast that exchanges maritime safety/security information between participating vessels and shore stations. In addition to providing a means for maritime administrations to track the movement of vessels in coastal waters, AIS can be used to transmit information to ships while in port or underway to ensure safety-of-navigation and protection of the marine environment. This includes meteorological and hydrographic information, carriage of dangerous cargos, safety and security zones, status of aids-to-navigation, and other waterway management information. In the USA, there are plans to transmit this information from shore-based AIS broadcast stations using both previously defined and proposed binary messages. It is intended that this capability will enhance the Vessel Traffic Services (VTS) provided by the U.S. Coast Guard (USCG).

A study was conducted by *Alion Science and Technology* for the USCG R&D Center to develop requirements for marine information that could be broadcast by USCG VTS Centers. The study focused on gathering stakeholder requirements and determining the capabilities of information providers and disseminators, shipboard equipment manufacturers, and users (mariners). The goal was to identify and prioritize the types of information that should be broadcast using AIS binary messages.

There were three major concerns as to what would be considered to be relevant message information:

1) Important (i.e., useful → crucial) to the mariner for decision support,
2) Reliably available and without interruption, and
3) Provided in a timely fashion in a usable format.

The three main **Providers** for navigation/waterway–related information to mariners in US ports/harbors and VTS areas are:

- United States Coast Guard (USCG),
- National Oceanic and Atmospheric Administration (NOAA), and
- U.S. Army Corps of Engineers (USACE).

USCG operates VTS Centers in 11 of the busiest U.S. ports. They primarily use Very High Frequency (VHF) voice communications to provide mariners with information concerning, vessel transits, severe weather, closings, low visibility, security zones, safety zones, buoy changes, special operating conditions, dredge locations, and other information related to the safety of navigation.

NOAA operates a system of sensors called the Physical Oceanographic Real-Time System (*PORTS*®). It provides real-time environmental observations, forecasts, and other geospatial information related to water level, current flow, salinity, wind speed/direction, atmospheric pressure, and air/water temperature. *PORTS*® is installed in 13 ports, eight of these ports have USCG VTS Centers.

USACE is responsible for 186 locks and 200+ chambers on the inland waterway system in the USA. The information that USACE provides is primarily current flow and water level. The USACE has two programs, RTCV and CRIS, associated with AIS binary messages. RTCV (Real Time Current and Velocity) is an initiative that provides real-time current flow information to towboats using Acoustic

Doppler Current Profiler (ADCP) technology. CRIS is the proposed Coastal and River Information Service.

The primary **Disseminators** of maritime information in North America are the Vessel Traffic Service (VTS) Centers operated by USCG, and Marine Communications and Traffic Services (MCTS) Centers operated by the Canadian Coast Guard (CCG). During this study the following VTS Centers in the U.S. were contacted: New York, Louisville, San Francisco, Sault Ste. Marie, Puget Sound, and Houston/Galveston. Also, centers contacted in Canada were the MCTS at Sarnia and VTS St. Lawrence River in Quebec City. In general, all VTS and MCTS Centers were in favor of anything that reduced workload, and made operations more efficient.

The primary study focus was to survey marine **Users** of VTS services in VTS areas of operation. Survey respondents included primarily ferries, tugs, and marine pilots, and to a lesser extent, commercial shipping companies. Others included USCG VTS operators, charter boats (fishing, diving), law enforcement vessels, commercial fishing, water taxis, and commercial tow boats. In general, users want more information, but are concerned about information overload. They are also concerned about too much information being sent, and having some control over what is displayed and when. They also believe that the presentation and display of AIS information is crucial. Specifically, respondents wanted information to be presented in multiple ways:

- symbols (or icons) on a chart,
- text in a message on the chart, and
- text on a separate display.

This study's findings were supported by the results of two previous studies related to supplemental information being provided using AIS:

- Marine Management Consulting report: "2002 Test of AIS – A Step on the path to AIS-aided Navigation," and
- Canadian Shipowners Association survey report of 2006 on users of the Detroit – St. Clair Rivers.

Eleven AIS **Manufacturers** were contacted regarding their capability, experience and views about the use of AIS binary messages. In addition to a review of AIS-compatible electronic charting software listings on the internet, survey respondents (i.e. marine users surveyed) were asked what type of AIS and electronic charting equipment they use onboard their vessels. Information about the types of AIS equipment being used aboard vessels was also provided by VTS Center Sault Ste Marie and the Canadian Shipowners Association. Several of the AIS equipment manufacturers (including ICAN, Transas Marine, Furuno, RosePoint, and Raven) were contacted by telephone and e-mail to gain additional information about their products. Most expressed an interest in working with the USCG in developing both the AIS binary message standards and the appropriate portrayal of the information aboard ship. They were also willing to participate in any AIS binary message test bed efforts.

In order to use AIS binary messages to transmit supplemental VTS information, providers, disseminators, users, and manufacturers will have different **Roles**. While Providers (e.g., USCG USACE, NOAA) are the source, it is the Disseminators (i.e., USCG VTS centers) who will be responsible for transmitting this information as the data portion of AIS binary messages. At this stage, it has not been decided who will be responsible for conversion of the information into its binary data format. Once received and output by the

AIS transponder, it will be the responsibility of the Shipboard system manufacturer to appropriately display the data (as an overlay of additional information) on an electronic chart. However, it will be the Users who will ultimately determine the suitability of the data transmission (e.g., amount and timeliness) and judge the appropriateness of the portrayal/display in terms of decision support.

An **Analysis** was made of the preferences of VTS Centers and Users with regard to the overall importance of various types of information that could be provided via AIS binary message. There was agreement on 11 of the 19 items, including the need for tides/water levels, security zones, visibility, emergency messages, dredging operations, and ATON outages.
There was less agreement regarding anchorage management, GPS performance, and Broadcast NOTM.
There was general agreement regarding the limitations of "text messages" and the benefits of having AIS binary message information being supplemental layers on an electronic chart (e.g., Marine Information Overlay or MIO).

The report also provides a brief description of the seven IMO AIS binary messages that were established as a basis for initial testing. They were issued in SN/Circ.236 on 28 May 2004 as "Guidance on the Application of AIS Binary Messages." Also presented is a brief explanation of the proposed AIS binary message that is under development by RTCM SC 121 Working Group Working Group on Expanded Use of AIS within VTS. SC 121 has proposed that three "general" AIS binary messages can be used:

1) Zone Information (security zones, dredging, anchorage, fog, etc),
2) Waterways Management (lock order, bridge open/close, etc), and
3) Environmental (tides, currents, water levels, and weather).

These three categories are capable of addressing nearly all of the information requirements contained in SN/Circ.236, as well as future requirements. However, this needs to be confirmed by testing/test bed activities.

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1 INTRODUCTION

Automatic Identification System (AIS) is an autonomous maritime broadcast system that exchanges maritime safety/security information between participating vessels and shore stations. In addition to providing a means for maritime administrations to effectively track the movement of vessels in coastal waters, AIS can be used on a continuous basis to transmit information to ships while in port or underway to ensure safety-of-navigation and protection of the marine environment. This includes meteorological and hydrographic information, carriage of dangerous cargos, safety and security zones, status of aids-to-navigation, and other port/waterway management information. In the USA, there are plans to transmit this information from shore-based AIS broadcast stations using both previously defined and proposed binary messages. It is intended that this capability will enhance the Vessel Traffic Services (VTS) provided by the U.S. Coast Guard (USCG).

The Waterways Management Directorate, Office of Navigation Systems (Vessel Traffic Services) requested that the USCG Research and Development Center (R&D Center) conduct a study to identify and develop requirements for marine information that could be broadcast by USCG VTS Centers via AIS binary messages and other telecommand capabilities. The basic premise is that an AIS binary message can improve the safety and efficiency of vessel navigation, especially within VTS areas of operation.

This study focused on gathering requirements and determining the capabilities of a number of stakeholder segments, including: information providers, disseminators, and shipboard equipment manufacturers, and users (mariners). The goal was to identify and prioritize the types of information that could be broadcast using AIS binary messages.

As it relates to presently conducted VTS operations or any future use of AIS as a component of expanded VTS, the term “information” refers to any type communication that is conveyed from a provider to a user. This can include voice, text, fax, graphical, geo-spatial (map or chart), etc. When this “information” is converted (coded) into a numerical form for digital transmission, it becomes “data” (e.g., NMEA 0183 or AIS binary message). In order to be relevant to a mariner, this data must eventually be converted (decoded) back into a display (or portrayal) of “information” that is used for situational awareness or decision support.

2 PROCESS

Alion Science & Technology was contracted by the USCG R&D Center to perform the research. During August – November 2007, Alion Science personnel conducted interviews and site visits with the various entities that use AIS. This included “Providers” and “Disseminators” such as the USCG, NOAA, St. Laurence Seaway, and other government organizations. Other participants included “Information Users” such as tug and barge operators, ferry operators, Harbor Pilots, commercial vessels, fishing vessels, and charter boats. Discussions were also held with AIS equipment manufacturers such as ICAN and Transas Marine.

For each category (e.g., information provider, disseminator, equipment manufacturer, and user) a uniform list of questions was used to guide the interviews. The interview questions were usually sent to participants ahead of time so that they would know the scope of the study. Interviews were conducted over the phone or in person.

To facilitate the exchange between the Project Team members and study participants, Alion established a website (called *SharePoint*). Copies of all interview questions were posted as well as all of the responses from study participants.

Based on an initial list of potential data types that could be transmitted (see Table 1), these were used as discussion points with each person interviewed. Respondents were also asked to identify additional data types as well.

Table 1. Potential data types.

Fog	Dredging locations / information
Captain Of The Port (COTP) Orders	ATON outages / changes
Water levels	Chart updates
Tides and currents	Marine info (regattas, events)
Broadcast Notice To Mariners (BNTMs)	Weather
Marine Information Broadcasts (MIBs)	Meteorological data
Emergency Messages	Lock order
GPS trouble/outage reports	Anchorage management
Security zone locations / information	Government only encrypted messages

There were three major concerns as to what would be considered to be relevant information. Specifically, it should be:

1) important to the mariner for decision support,
2) reliably available and without interruption, and
3) provided in a timely fashion in a usable format.

3 PROVIDERS OF MARITIME INFORMATION

There are three main providers of data/information of interest to mariners in US ports/harbors and VTS areas:

- United States Coast Guard (USCG),
- National Oceanic and Atmospheric Administration (NOAA), and
- U.S. Army Corps of Engineers (USACE).

3.1 United States Coast Guard (USCG)

USCG VTS Centers are mandatory vessel movement reporting systems established under the authority of the Ports and Waterways Safety Act of 1972. USCG operates VTS Centers in 11 of the busiest U.S. ports. The purpose of the VTS is to facilitate safe, efficient waterborne commerce. Specifically, VTS exists so that it may prevent groundings, rammings, and collisions by sharing information and implementing appropriate traffic management measures. Coast Guard military and civilian personnel operate a Very High Frequency - Frequency Modulation (VHF-FM) communications network 24 hours a day, 365 days a year at most VTS Centers. These centers provide mariners with information concerning, vessel transits, severe weather, closings, low visibility, security zones, safety zones, buoy changes, special operating conditions, dredge locations, and other information related to the safety of navigation. The center may also include

radar, closed circuit television, and AIS to monitor the VTS area. Some VTS Centers also have the capability to communicate using the AIS.

3.2 National Oceanic and Atmospheric Administration (NOAA)

NOAA operates a system of sensors called the Physical Oceanographic Real-Time System (*PORTS*®). It is a decision-support tool that improves the safety and efficiency of maritime commerce and coastal resource management through the integration of real-time environmental observations, forecasts and other geospatial information. *PORTS*® measures and disseminates observations and predictions of water levels, currents, salinity, and meteorological parameters (e.g., winds, atmospheric pressure, air and water temperatures) that mariners need to navigate safely (see Figure 1). Table 2 indicates some of the types of information that are provided.

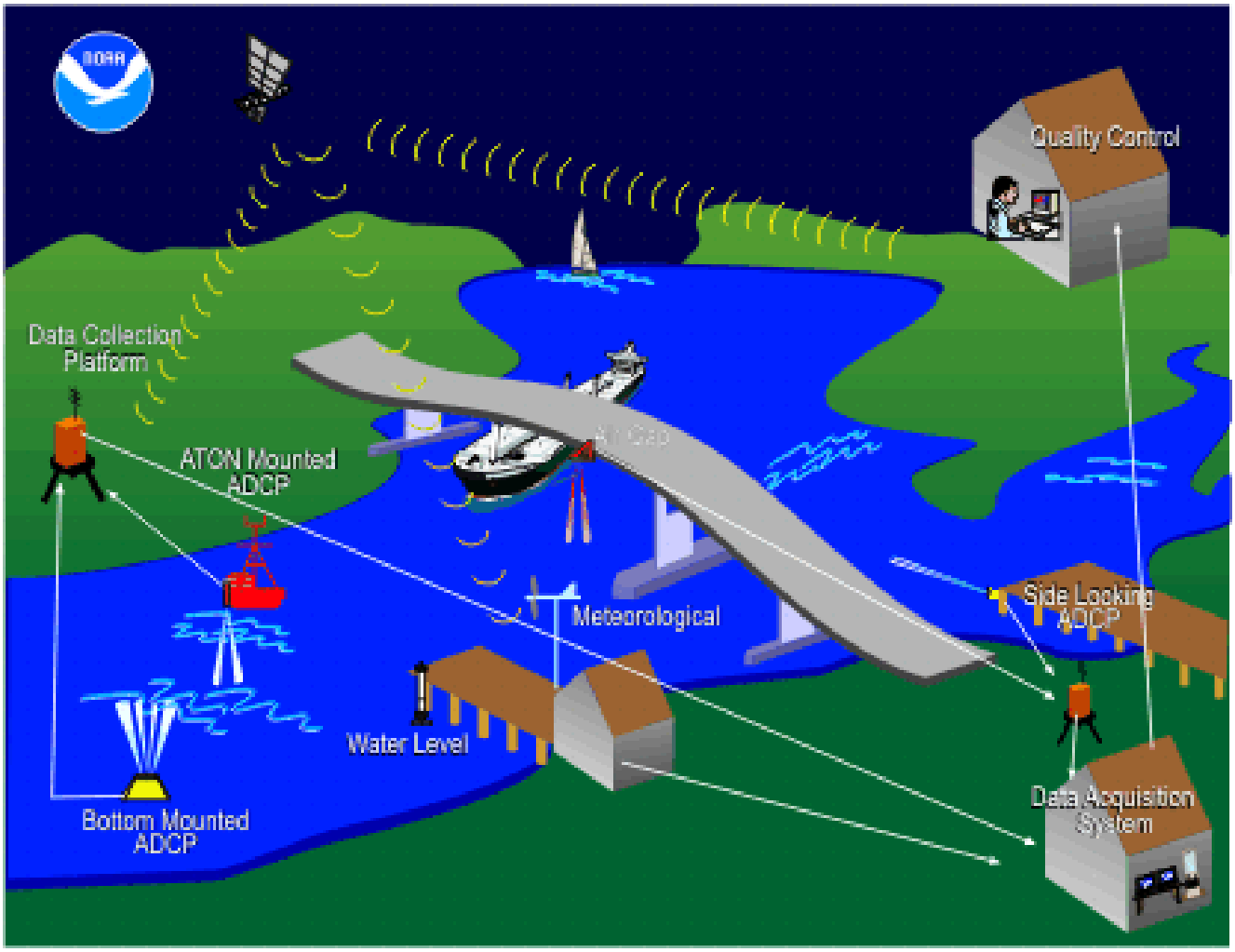

Figure 1. NOAA *PORTS*® diagram.

Table 2. NOAA *PORTS*® data types.

Information	Real time	Prediction
Tides	X	
Tide predictions		X
Currents	X	
Current nowcast/forecast		X
Water levels	X	
Water level nowcast/forecast		X
Bridge air gap	X	
Water temperature	X	
Salinity	X	
Air pressure	X	
Air temperature	X	
Wind	X	
Wind nowcast/forecast		X

PORTS® data is currently available in the locations listed in Table 3. Figure 2 indicates how this corresponds with Coast Guard VTS locations. Currently, Sault St. Marie (Michigan) is the only location where *PORTS*® data is being broadcast via AIS. Otherwise, *PORTS*® is currently available to users over the internet, and through the use of a telephone voice system. The *PORTS*® internet service allows a user to retrieve data in several formats. NOAA has sample queries on their internet site, and they offer to assist anyone who needs help getting data. The internet site was developed as an Integrated Ocean Observation Service (IOOS) portal. It is designed to make retrieving data easy.

Table 3. *PORTS*® data locations.

Chesapeake Bay	Delaware Bay
Houston/Galveston	Los Angeles/Long Beach
Lower Columbia River	Narragansett Bay
New Haven	New York/New Jersey Harbor
Port of Anchorage	San Francisco Bay
Sault St. Marie Locks	Tacoma
Tampa Bay	

Eventually, NOAA intends to provide real-time data to mariners through the use of AIS binary messages. In particular, this includes prediction and nowcast/forecast data. In the future, NOAA plans to use the USCG Nationwide AIS infrastructure to broadcast *PORTS*® information. The format of the *PORTS*® information will need to comply with the AIS standards for such broadcasts. An objective of this study is to make recommendations concerning the format of the broadcasts.

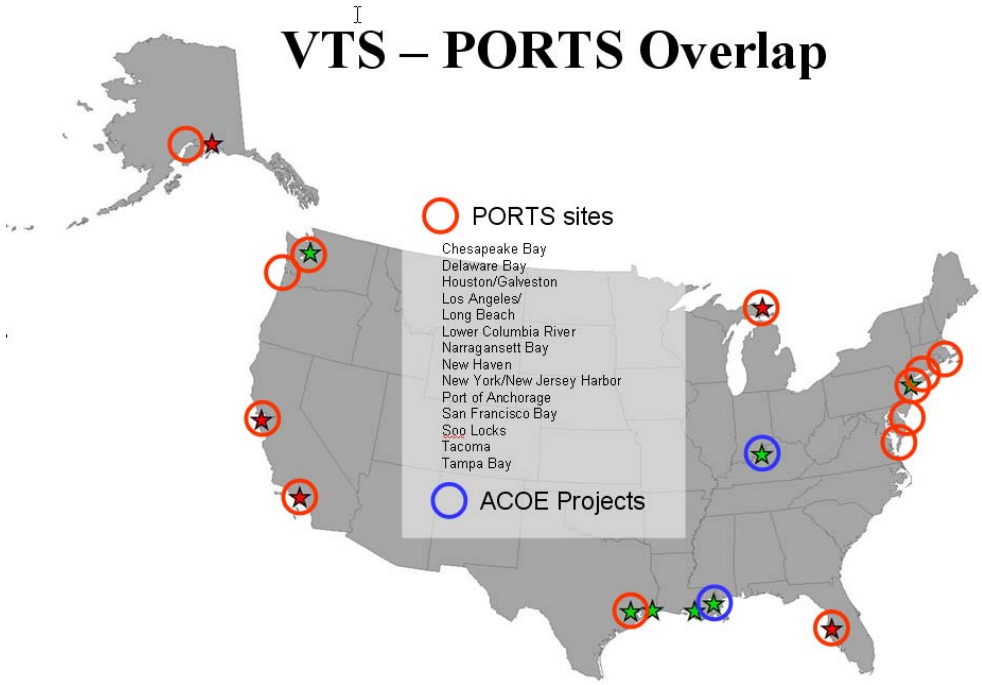

Figure 2. VTS - *PORTS*® overlap.

3.3 U.S. Army Corps of Engineers (USACE)

The navigation mission of the USACE is to provide safe, reliable, efficient, effective and environmentally-sustainable waterborne transportation systems for movement of commerce, national security needs, and recreation. At the present time, the USACE has two programs associated with AIS binary messages, RTCV and CRIS. RTCV (Real Time Current and Velocity) is an initiative that provides real-time current flow information to towboats. RTCV uses Acoustic Doppler Current Profiler (ADCP) technology to obtain the real-time current flow information. CRIS is the proposed Coastal and River Information Service. As stated in the draft Project Plan: (dated 29 October 2007):

> *The Coastal and River Information Service (CRIS) will be designed to be the central source for domestic transportation and related information on U.S. coastal and inland waterways. It will serve a wide range of safety, operational, security, and statistical needs. Some of the major requirements include real time operational, hydrological, and climate data for tactical operation purposes, and commercial shipping and transportation statistics for planning and analysis. CRIS is not a system, but rather a service. The service will be developed through a public-private partnership and will support "one stop shopping" for Federal Agencies and the industry. It will leverage successful information systems already in place, using Geographic Information System (GIS) and electronic charting technology to provide a complete information picture on the inland and coastal waterways. The system will also enhance communication among Federal Agencies, and between the public and private sectors through the use of nationally and internationally accepted standards. CRIS will support the Corps 'mission of being a Ready, Relevant, Reliable, and Responsive agency. Additionally, the concept of CRIS is consistent with the recommendation established in IT09, Appendix C of the National Performance Review of 1993. The recommendation specifically states that the federal government should "Consolidate and modernize government data processing centers."1*

[1] National Performance Review 1993, Appendix C, IT09: Establish an Information Infrastructure

The USACE is responsible for 186 locks and more than 200 chambers on the inland waterway system in the USA. The waterways/navigation related information that USACE provides is primarily current flow and water level. Currently, there are current flow meters and pool level sensors at only one site. The ADCP sensor installed at the Tom Bevel Lock on the Ohio River near Louisville, KY measures the current at 100, 200, and 300 foot distances from the entrance of the lock. ADCP sensor data is continually broadcast to towboat operators using AIS (see Figure 3). At the Lock, an AIS transmitter (Kongsberg Seatex 110) converts the sensor information into an ICAN-defined format that is then broadcast as an AIS binary message. After being received by the onboard AIS equipment, the binary message is converted for display on the ICAN Aldebaron II electronic chart system (See Figure 3).

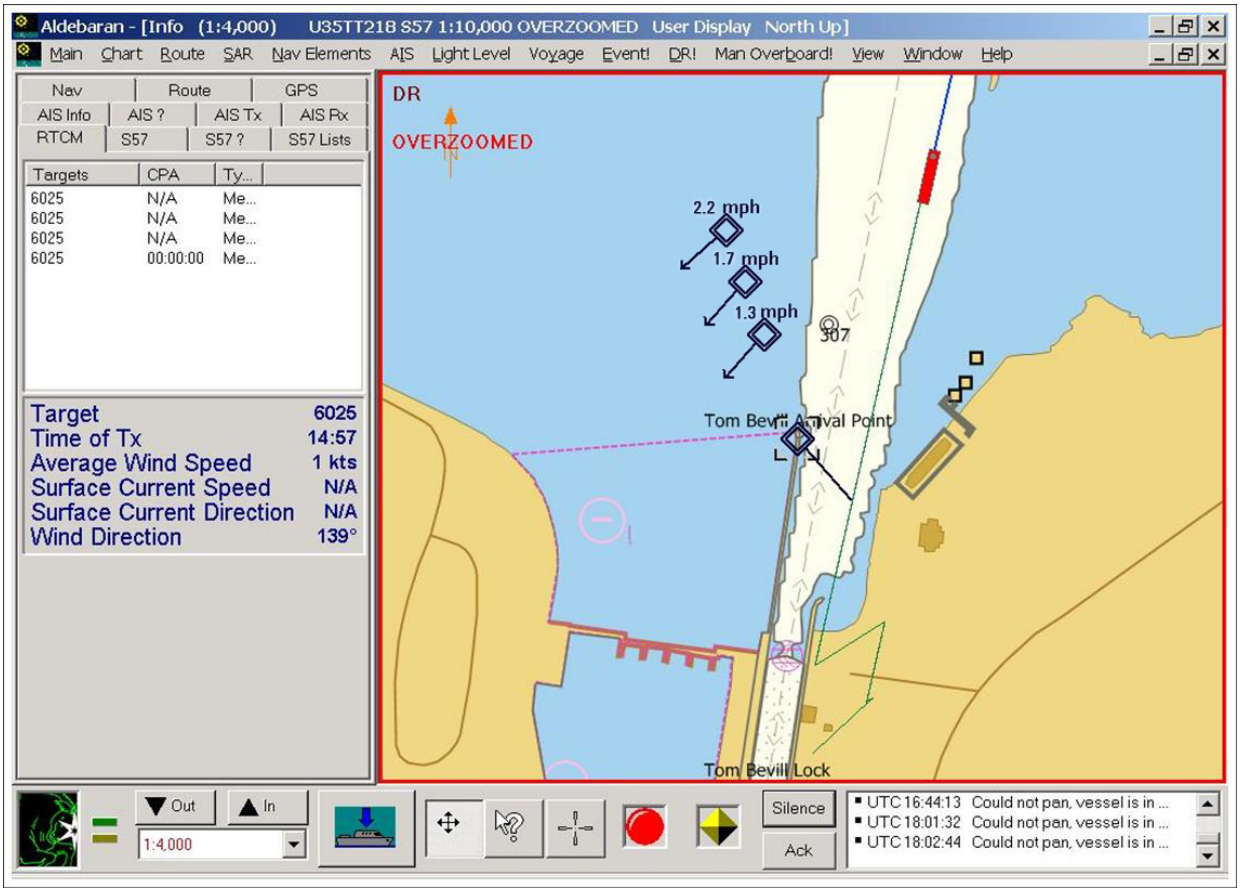

Figure 3. Tom Bevel lock current flow data as displayed on ICAN software.

In the near future the USACE intends to provide to mariners information such as: vessel assist available, projected traffic, lock delay time, lock available, gate openings, wind, ice, debris, channel condition (i.e., highly-dynamic river channels), and lock sequence order. In turn, the USACE would like to receive from the ships such information as: tow length, width, number of barges (currently limited to 9 in the international standard), loaded/unloaded, commodity codes, and whether the vessel made the lockage. Working with the USCG, USACE has plans to put AIS at other lock control sites. A proof-of-concept demonstration is being planned for the McAlpine Lock near Louisville, KY.

4 DISSEMINATORS OF MARITIME INFORMATION

The primary disseminators of maritime information are the Vessel Traffic Service (VTS) Centers in the US and Marine Communications and Traffic Services (MCTS) Centers in Canada. Personnel at a number of USCG VTS Centers were interviewed and some general comments for each VTS are described in the following subsections. Further information on each VTS is contained in Appendix A. In addition, the MCTS operated by the Canadian Coast Guard at Sarnia, ON, provided information on the Saint Lawrence River Waterway. The summary results of the data items for all of the VTS Centers are contained in Table 4. In general, all VTS and MCTS Centers were in favor of anything that reduced workload, and made operations more efficient.

Table 4. VTS center interest in VTS-related information sent via AIS broadcast.

	VTS NY	VTS Louisville	VTS San Francisco	VTS Sault St Marie	MCTS Sarnia	VTS Houston	VTS Puget Sound	SLS	Yes to No Ratio	Score	Summary
Fog		Yes	Yes	Yes	Yes	No	Maybe	Yes	5 to 1	5.0	Yes
COTP Orders		No	Yes	Yes	Yes	No	No	N/A	3 to 3	1.0	No
Water levels	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8 to 0	8.0	Yes
Tides and currents	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8 to 0	8.0	Yes
BNTMs		No	Maybe	Yes	Yes	Maybe	Yes	Yes	4 to 1	4.0	Yes
MIBs		No	Maybe	Yes	Yes	Yes	Yes	Yes	5 to 1	5.0	Yes
Emergency Messages		Yes	Yes	Yes	Yes	Yes	Yes	Yes	7 to 0	7.0	Yes
GPS trouble reports		No	Yes	Yes	Yes	No	Maybe	No	3 to 3	1.0	No
Security zones	Yes	Yes	Yes	Yes	Yes	No	Yes	No	6 to 2	3.0	Yes
Dredging information	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8 to 0	8.0	Yes
ATON outages	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8 to 0	8.0	Yes
Chart updates	Yes	No	No	Yes	Yes	No	Maybe	No	3 to 4	0.8	No
Marine information	Yes	Yes	Yes	Yes	Yes	No	Yes	No	6 to 2	3.0	Yes
Weather	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	7 to 1	7.0	Yes
Meteorological data		Maybe	Yes	Yes	Yes	No	Yes	Yes	5 to 1	5.0	Yes
Lock order		Yes	Yes	Yes	Yes	No	Maybe	N/A	4 to 1	4.0	Yes
Anchorage management	Yes	No	Yes	Yes	Yes	No	Maybe	Yes	5 to 5	2.5	Yes
Government messages		No	Yes	Yes	Yes	No	Yes	No	4 to 3	1.3	Maybe
Ice Advisory				Yes	Yes	No	Yes	Yes	4 to 1	4.0	Yes

4.1 VTS New York

Information presently provided by VTS NY includes: vessel transits, severe weather, waterway closings, and low visibility. In addition to VHF voice, the National Notification Network (NNN) is used to send out messages to a distribution list (360-380 subscribers). Depending on user preference, the information is sent by e-mail, telephone, or text message. A key part of this NNN is the acknowledgement (ACK) back confirming that the users received the message. At present, no information is sent using AIS.

VTS NY is reluctant to rely on AIS. A main reason is that there have been cases where the AIS position differed from the radar and/or video. If a position offset is observed, the standard practice is for the VTS center to notify the vessel via voice to recycle the power on their AIS unit. A related issue is the need to win the mariner's confidence. Currently, they are more likely to trust either voice radio or radar than AIS. VTS NY is also concerned about AIS binary messages being "hacked." That is the false broadcast of navigation safety related information. Another issue is that most vessels have only the text display of their AIS equipment (i.e., MKD) to view information the VTS might broadcast. Information display and processing is also important – the information needs to show up on the chart. Finally, tugs currently do not have AIS installed in the upper house. As such, AIS information is not available when pushing ahead.

In the future, VTS NY would like to be able to transmit (in addition to those items listed in the table): hot work around bridges, bridge work (often reducing the clearance "air gap" by 10 to 15 feet), bridge openings (AMTRACK railroad bridge affects all traffic), VTS measures, and boarding points. The biggest benefit of AIS Transmit would be to provide information to newcomers to the VTS area. This includes: security and safety zones, buoy changes, special operating conditions, dredge locations, etc. Having an ACK back from the AIS transmit would be helpful. Dynamic information is the priority.

4.2 VTS Louisville

Information presently provided by VTS Louisville includes: water level, visibility, limited weather information, water level predictions from ACOE internet web site, anticipated wait time for lock opening, transit order (only 3 vessels at a time are allowed though the channel), and anything else the VTS Center is asked. Currently, all information is sent using voice VHF radio communications. The operators report that this is very frustrating because of: the time and resources it ties up; and the dialect and language barriers. As in Sault Ste. Marie (See below.), there are serious issues with accents of the vessel operators. The operators for New Orleans are almost impossible to understand, especially when the vessel distance is at the threshold of VHF communications. The opportunity to communicate using AIS text messages would be a big help.

In the future, VTS Louisville would like to be able to transmit (in addition to those items listed in the table): water height trend (going up or down) and projected water height (low or high and when), scheduled lock down times (maintenance), air draft information for bridges, hazardous material vessels in vicinity, and outflow (overflow) information from locks (see Figure 4).

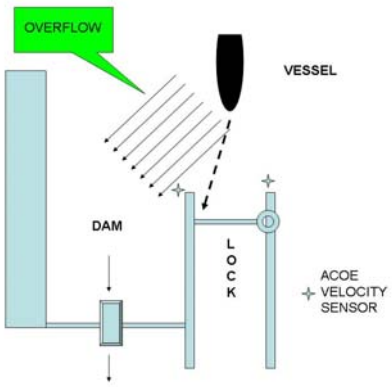

Figure 4. Lock chamber overflow currents.

4.3 VTS San Francisco

VTS San Francisco transmits the typical VTS information as specified in their Operations Manual. All information is sent using voice radio communications, mostly VHF-FM with a small amount by telephone. Some of the tug companies have the *Transview* AIS display system for checking AIS reports in their office; this reduces the number of telephone calls.

VTS San Francisco would like to begin using binary messages to streamline communications. The two issues mentioned include:

1) selective retransmission[2] of vessel position reports (due to the geographic masking) and,
2) including more information about towed vessels (currently there is nothing in the AIS message to describe the length of tow and size of barge).

VTS San Francisco has seven encounter zones that vessels should not be in a meeting situation.

In the future, VTS San Francisco would like to be able to selectively rebroadcast vessel positions (to counteract the geographic masking vessels experience), send safety zone information, and sail plans. Anything that helps to streamline radio communications is good – including voyage facts, dynamic information like engine failure, etc. Also, ferries prefer not to transmit passenger counts over voice so currently only report to their companies – making it difficult for the VTS to get when needed. Also needed is an efficient means for barge dimensions to be added to the vessel reports.

4.4 VTS Sault Ste Marie

Information presently provided by VTS Sault Ste. Marie includes: water levels, water-flow/current speed, high and low water, other ships traffic (opposing traffic), VTS directives/measures, and Hazards to Navigation (NTMs). This information is written on a paper card and is read by the operator to anyone that requests it; and to ships one hour prior to entering the St. Mary's River. Voice communications using VHF-FM is the sole method of communication for daily VTS operation.

[2] This is different from "repeater" function – a very important distinction.

Sault Ste. Marie AIS binary messaging is handled by the Ports and Waterways Surveillance System (PAWSS) software developed by Lockheed Martin. PAWSS automatically pulls water levels and visibility information from the NOAA web site via an Internet connection and transmits it over AIS. There are four weather stations that constantly report information to VTS – one of those weather stations is used to automatically transmit AIS binary weather messages that contain: air temperature, barometric pressure, water temperature, wind speed, wind direction and wind gusts. In addition, PAWSS has the capability to send out ship's processing order and dredging advisories. PAWSS also implemented text messaging, but it cannot guarantee reception of messages, and is not widely used. Furthermore, decoders are not standardized and some ships receive scrambled text.

4.5 VTS Puget Sound

Information presently provided by VTS Puget Sound includes:

- Hazardous conditions or circumstances,
- Vessel congestion,
- Traffic Density reports,
- Environmental conditions,
- Aids to navigation status,
- Anticipated traffic encounters (e.g., overtaking, meeting, crossing situations),
- Another vessel's name, type, position, hazardous vessel operating conditions (if applicable), and intended navigation movements,
- Temporary measures in effect,
- A description of local harbor operations and conditions (e.g., ferry routes, dredging),
- Anchorage availability, and
- Other information or special circumstances.

The typical means of transmission is voice communications using VHF-FM from the VTS Sector Operator to the Master/Mate or Pilot. The alternative is cellular telephone or Satellite relay via the ship's agent.

Information could be pushed to a great extent via AIS and would be much more reliable and less intrusive to the VTS user than current voice communications. However, caution is needed so as not to push too much information – just because technology allows. Instead, verify that the user truly needs the information for navigation safety purposes. The user must also have the means/tools to display AIS information in a format that is intuitive (text alone might not be the answer) and have the means to acknowledge receipt of AIS to the VTS. Vessel Traffic Advisories, Recommendations and Directions would still need to be transmitted via voice communications.

In the future, the VTS Center would like to provide reliable VTS weather sensor data (i.e., existing weather sensor locations are not optimal). Additional AIS information such as vessel flag state, persons onboard, and defects/deficiencies/DG/CDC information would be helpful. In addition, Class B AIS for fishing vessels would greatly enhance navigational safety in the Puget Sound region. Even if the AIS transmitted only their name, voice radio communication frequency of choice, and relevant information on their fishing operation would greatly enhance Traffic Separation Scheme safety.

4.6 VTS Houston/Galveston

VTS Houston sends all the usual information expected from a VTS. The information is transmitted primarily by voice. The VTS Center has the ability to send AIS text messages, but it is not a preferred method. They would like to have more control over where the AIS transmission is sent from, and sometimes the PAWSS software is not configurable enough to control certain broadcasts (like all ships meeting a certain criteria).

In the future they would like to provide to VTS users bridge air gap information. There has been an attempt to incorporate a laser "trip wire" at the entrance of the channel for the I-610 bridge air gap. The idea being if the mast on a ship breaks the laser at the entrance, then it is going to hit the I-610 bridge. The goal is for both the vessel and the VTS to be notified. There is a current effort (first one failed) with North American Controls Corp. (NACC, Jim Robinson POC). This seems to be an area of concern. There have been two allisions the past two years causing great damage and millions of dollars of lost commerce as the river had to be shut down. Also, announcement of ATON "knock downs" and discrepancies are a must for any future improvements. Another need is the broadcast of all the NOAA data, ATON information, and other data to specific areas. A system of "trigger points" along the canal/rivers would help reduce the amount of redundant information being sent out (see Figure 5). As a ship transited the river, it would trigger AIS messages with updated pertinent information for that vessel.

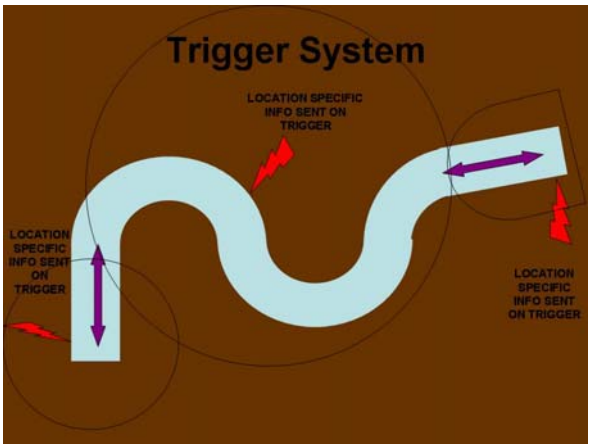

Figure 5. Trigger system diagram.

4.7 Marine Communications and Traffic Services (MCTS) Sarnia[3]

MCTS Sarnia is operated by the Canadian Coast Guard (CCG). They provide a purely informational service to their customers along the 90 mile stretch of the Detroit River and in western Lake Erie (~30 ships/day). Some areas of the Detroit River have alternating one-way traffic. In this situation, Maritime Pilots resolve procession order among themselves without the involvement of MCTS. During the spring, summer, and fall, MCTS Sarnia has two operators on duty at all times. During the winter, there is one operator. They have several VHF antennas along Detroit River and western Lake Erie. One VHF antenna is equipped with an AIS transceiver.

[3] Based on interviews with Bruce Mair (Officer in Charge) and John North (VTS Opertor)

MCTS Sarnia uses *INNAV* software developed by the CCG for vessel traffic tracking. Each ship tracked by *INNAV* software has an Electronic Transit Card that contains extensive information about the ship and the cargo. This Electronic Transit Card information is managed by an external Canadian Coast Guard database. The *INNAV* Shore Positioning system uses information from AIS, Radar and dead reckoning to track ships' movements. The INNAV system is in the infancy stage of AIS capabilities; currently it is running on Windows NT with a new version being developed for Windows XP that will add AIS text messaging capabilities.

MCTS Sarnia transmits AIS binary information messages using Horizon software developed by ICAN. The Horizon software transmits water level via AIS text messages at a preset time interval. The text message with water level information is entered manually, with water level information looked up from the NOAA Gibraltar gauge – available via the Internet. Also, Notice to Mariners and weather broadcasts, as prerecorded messages, are repeated every seven minutes on VHF-FM voice.

4.8 Canadian Coast Guard VTS - Saint Lawrence River[4]

Currently, water level is the only AIS binary data being sent by the CCG VTS Centre in Quebec City. They have 20 gauges which are maintained by the Canadian Hydrographic Service and Oceans Canada that are connected using VHF data links and phone lines. The data is broadcast every five seconds in blocks of two sets. As a result, every 60 seconds 12 messages are sent that include the data from all 20 gauges and the four AIS broadcast stations between Montréal and Les Escoumins (150 miles east of Québec city). Three out of these 20 gauges are seasonal and are removed during the winter season due to ice. They are generally operating from April to November. CCG is currently looking at adding Water Level Forecast for specific "Strategic Points" in the Saint Lawrence River Waterway (SLW). The goal is for vessel operators to be able to look at these strategic points and see where the water level is predicted to be at a certain time. "Strategic Points" are defined as potentially dangerous areas due to the depth of the water. When a vessel is depending on the depth of the water being a certain level during high tide, it would be advantageous for planning purposes to be able to know when it is safe to pass though these points. Also, it should take into account seasonal effects in addition to just tide information. The average daily delta for the water level on the SLW varies from a few centimeters (Montreal area) up to 4 to 6 meters in Quebec City.

The CCG also uses an Internet-based information dissemination solution for some of its information. Regional Marine Information Portal Quebec Region[5] is the web site used to propagate the data. Ice information, including that from ice cameras, is available. Figure 6 shows an example of a daily ice chart. On the St. Lawrence River most floating buoys are seasonal. Due to the intense ice conditions they are either removed from the river, or replaced by smaller winter buoys during the winter periods. The data for these buoys is located on this Internet web site. Before debarking for their ship, users, such as pilots, can log onto this site and download the information they want. In addition to the ice and buoy data, the site also provides links to CCG and other agencies which may be important to mariners. The site also has important notices to mariners and provides a means for the mariner to report issues they encounter. The site also contains other links and information.

[4] Gilles Ringuette, CCG Project Engineer – St. Lawrence River e-Navigation Project was the primary point-of-contact. Also interviewed was Giles Parent, Lifecycle Manager for eNav for the CCG and John Bertorelli.

[5] http://www.marinfo.gc.ca/en/general/accueil.asp

One useful function is a "vessel passage restriction window" that provides information calculated by the VTS officer for a specific period of time. The calculation determines when a vessel cannot pass at a specific point in the waterway (e.g., low tide and under-keel clearance). When requested, this is sent via fax to the vessel. This computed information (based on tide forecast at different points along the vessel's route) is also sent by fax to the pilot's corporation.

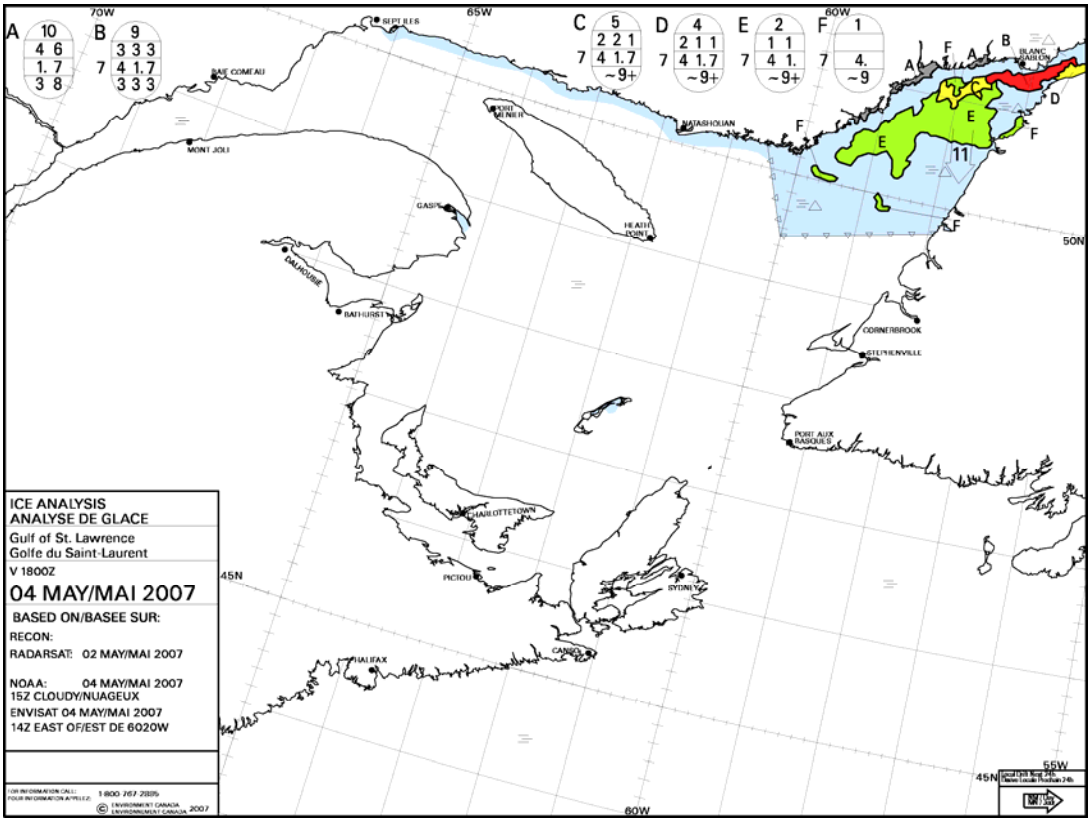

Figure 6. Daily ice chart provided by the Canadian Ice Service.

In the future they would like to provide environmental data (wind, temp, etc.) and Notice to Navigators. Canada is in the process of upgrading its AIS system. At the time of the interview, award of a contract for Canada's AIS infrastructure was pending and persons in the CCG were somewhat limited in what they could discuss regarding future plans for AIS. The contract has since been awarded.

5 USERS OF MARITIME INFORMATION

The primary study focus was to survey regular users of VTS services in the various VTS areas of operation. Survey respondents included primarily operators of ferries and tugs, and marine pilots, and to a lesser extent, commercial shipping companies. Other users surveyed included Coast Guard VTS operators, charter boats (fishing and diving), law enforcement vessels, commercial fishing, water taxis, and commercial tow boats. It was not intended to be a comprehensive survey of all users, but a representative sampling. Participants were contacted and interviewed via telephone and/or e-mail.

User responses are summarized in Table 5. A more comprehensive listing of all responses can be found in Appendix B.

Table 5. Summary of user interest in VTS-related Information sent via AIS broadcast.

	Overseas Shipping Group Inc.	Bouchard Towing	Moran Towing	Sandy Hook Pilot	Interport Pilots	NY DOT	Horizon Lines	Roehrig Maritime	Roehrig Maritime	Ingrahm Barge	American Commercial Lines	Houston Pilots	Florida Marine Transportation	Kirby Towing	WA State Ferry	SF Marine Exchange	Yes to No Ratio	Score	Summary
Fog	Yes	No	Very	Very	No	Yes	Yes (9)	Yes	Yes	Yes	No	No	No	Yes	Yes	No	18 to 6	3.0	Yes
COTP Orders	No	Very	Very	No	Yes	Yes	Yes (9)	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	19 to 5	3.8	Yes
Water levels	No	Yes	Yes	Yes	Yes	Yes	Yes (2)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	13 to 4	3.3	Yes
Tides and currents	Yes	Yes	Yes	Yes	No	Yes	Yes (4)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	16 to 3	5.3	Yes
BNTMs	No	No	No	Yes	No	No	Yes (1)	No	No	Yes	No	No	No	Yes	Yes	Yes	6 to 10	0.6	No
MIBs	No	No	Yes	Yes	Yes	No	Yes (1)	No	Yes	Yes	No	No	No	Yes	Yes	Yes	9 to 7	1.3	Maybe
Emergency Messages	Yes	Yes	Very	Very	Yes	Yes	Yes (9)	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	21 to 3	7.0	Yes
GPS outage reports	Yes	No	No	No	Yes	Yes	Yes (7)	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	17 to 5	3.4	Yes
Security zones	Yes	Very	No	Yes	Yes	No	Yes (8)	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	20 to 3	6.7	Yes
Dredging information	Yes	No	No	Yes	Yes	No	Yes (6)	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	16 to 5	3.2	Yes
ATON outages	Yes	Very	Very	Very	Yes	Yes	N/A	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No	12 to 3	4.0	Yes
Chart updates	Yes	No	No	No	Yes	No	Yes (3)	Yes	No	Yes	No	No	No	No	Yes	Yes	9 to 9	1.0	No
Marine information	Yes	No	Yes	No	Yes	Yes	Yes (7)	No	No	Yes	No	No	Yes	No	Yes	Yes	15 to 7	2.1	Yes
Weather	No	Very	Yes	No	No	No	Yes (3)	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	11 to 7	1.6	Maybe
Meteorological data	No	N/A	No	No	No	No	Yes (2)	Yes	No	Yes	No	No	No	Yes	Yes	No	6 to 10	0.6	No
Lock order	Yes	Very	Very	Very	N/A	N/A	Yes (2)	No	No	Yes	Yes	N/A	No	Yes	N/A	N/A	9 to 3	3.0	Yes
Anchorage management	Yes	No	N/A	Very	Yes	N/A	Yes (3)	No	No	Yes	N/A	No	N/A	No	N/A	N/A	7 to 5	1.4	Maybe
Government only	No	N/A	No	N/A	No	No	N/A	No	No	N/A	No	No	No	No	Yes	No	1 to 11	0.1	No
Ice Advisory	N/A	Very	Very	Very	N/A	N/A	N/A	N/A	N/A	Yes	N/A	N/A	N/A	Yes	N/A	N/A	5 to 0	5.0	Yes

In general, users want more information, but they are concerned about information overload. The users are also concerned about too much information being received and having some control over what is displayed and when. The users believe that the presentation and display of AIS information will be important. When asked, most respondents want the information presented in multiple ways:

- symbols (or icons) on a chart,
- text in a message on the chart, and
- text on a separate display.

Some specific user comments included:

- AIS data must be user-selectable. The pilot must have the ability to turn information off/on. In addition, the pilot must be able to configure the unit to receive and display other vessels data. Also, to be able to view vessels by type, size and nature of business. This will help to not clutter the display with too much information.
- Keep AIS as a collision avoidance tool. Do not clutter the system with information which can be easily obtained by other means (e.g., the Internet). "Rules of the Road" should be used to determine who has right-of-way. In general though, dredging platforms should be required to have AIS and report safe passage side and standard information.
- No more vessels than those presently required should carry AIS. Benefit is minimal from anyone else other than the present complement of vessels. This information would just complicate the system with unneeded information that would not be used effectively. In congested areas, AIS positions from numerous small boats would be too hard to absorb.

- Operationally, we would like any navigational information we can get our hands on (everything listed under potential data). Boats receiving information directly from the USCG or USACE would be very beneficial. Direct communication prohibits several opportunities for error. However, it is very important to the folks on the vessels that there is no information overload. That being said, we are interested on how this information would be distributed and accessed. Would a vessel only receive information on the segment of river in which they are located? Or would the updates be system wide. Several items (virtual aids, buoys, wrecks, dredge operations, etc.) could be placed directly onto our electronic charts. A technical issue would be how our software could toggle what virtual aids are displayed on the chart to accommodate each pilot. Every pilot is unique. If there was a way for our vessels to effectively receive all available information, but access only the information each individual pilot is interested in would be great. However, in certain conditions, automatic warnings/alerts would be beneficial.
- All information can be used in a positive way. The presentation is our biggest concern or hurdle so to speak. Like any other profession, each pilot uses different tools, at different times, to achieve the same end. If there were constant pop-ups on the electronic chart regarding information from weather or out-drafts or buoys, the pilots would be disturbed. If this all can be presented in a user-friendly manner, I believe this project will be very successful.
- I like the concept of a symbol on EC that if you hit with the pointer it shows all the pertinent data. Text-only on an AIS receiver is useless. Text on an ECS is too much information that may clutter up the screen.
- ECDIS with AIS is an augmentation to other navigation systems, including radar and visual. Generally, piloting is a continuous process of determining vessel's position by all means appropriate. We are always double-checking ourselves with multiple systems.
- Most of the time the only thing that we have time for as far as operation of any computer based system is a few mouse clicks. There is more and more discussion about Bridge Team Management with more people involved with the piloting of a vessel. It still seems to fall on one person to analyze a lot of data. That is why I push for just the important data. We just don't have the time to go through a lot of steps and read through a lot of text messages.
- What they do in the Port of San Francisco is useful. Much like airports, they have a system that assigns a unique number or designator to all major infrastructure points. This greatly reduces confusion.

Some specific user comments relating to others who should have AIS included:

- Law enforcement – No; Towing vessels while towing - Yes; Fishing vessels, sport fishermen, draggers, lobster boats while in the act of fishing - Yes; Harbor taxis - No.
- Dredging platforms should be required to have AIS[6]; Lobster boats, draggers, commercial fisherman while in the act of fishing should be required to have AIS; all law enforcement; and, all towing platforms.
- Fishing draggers - Yes, especially as they are going to and coming from fishing grounds. Sport Fishing vessels only if they are carrying passengers for hire. Small towing vessels – Yes (i.e., *Seatow* and *Boat US*). USCG and Law enforcement vessels – Yes, I've had some close calls with all of these. The flashing blue light guys think they can go anywhere and do anything.

[6] This is required in some VTS areas, but not all.

- Harbor taxis may be too much information to be valuable. For example, placing AIS units aboard water taxis in the vicinity of the Battery would cause a tremendous amount of information to be displayed on the ECDIS. I would need to see whether this would be something that we could toggle-off based on size. If not, this might be a case of too much information being displayed at one time.
- Fishing draggers.
- All vessels over 20 feet in length, preferably with some kind of filter so that smaller vessels could be filtered out if necessary to reduce clutter.
- Sport Fishing Vessels, Vessel Assist Boats, and any small passenger vessels.
- Any and all small craft that can afford it. It is a great benefit to augment radar reception, especially in rough sea conditions.
- Pilot boats, USCG, dredges. Need to exercise caution about having too many boats cluttering the radar screen.
- Law enforcement, Passenger Vessels, Fishing Draggers, Coast Guard Vessels.
- Any and all commercial vessels and any vessel >30' in length needs some type of AIS.
- Unmarked participating vessels (i.e. military) not engaged in security operations are a huge concern. Passenger vessel carrying 6 or more passengers for hire would be a better limitation as too large of a target group gets excluded in the current standards. All enforcement fire and security vessels not engaged in stealth operations should participate.

The user groups were also queried about RACONs and what they thought about replacing those with AIS transmitters. Uniformly, the user groups were against this idea. Some specific user comments included:

- I like the idea of separate systems. In this case we would be relying on basically one system (GPS) that if it ever fails or goes down, even for a very short time, will really have some serious safety implications. AIS augmenting RACON would be OK.
- Add the AIS and keep the RACON. What if the AIS fails? In some locations RACON is the only method of distinguishing between buoys and other targets on the radar; i.e. sport fishing vessels and other small vessel traffic (non-AIS targets).
- RACONs are very beneficial approaching busy harbors.
- RACON signals are invaluable in identifying buoys in congested areas.
- Strongly recommend that RACONs be left as-is. They are an important navigational tool that is used regularly and relied upon to distinguish important aids from the clutter of targets on radar.
- Do not get rid of RACONs. They can be seen in bad weather in the middle of a cluster of boats. Only if this trait can be preserved will AIS be useful.
- RACONs should never be removed because of the real-time information that is crucial during low visibility, close quarter, and radar-assist operations.
- RACON should continue to be a RADAR activated device; which helps distinguish ATONS on a cluttered radar.
- The difficulty is that vessels may congregate near a buoy location in inland waters to fish. If so, it becomes difficult to identify the buoy from the vessels. If the RACON is present it allows the operator to discriminate the buoy from other return. An AIS aid would not show on radar and the current ENC display requirements do not indicate that the radar image has to be displayed on the ENC. Also, buoys on chains do drift and a fixed charted position for a RACON may conflict with the AIS transmitter position, unless that AIS transmitter were always a virtual aid there could be confusion.

5.1 Cruise Ship Report

In 2002, Marine Management Consulting prepared a report entitled "2002 Test of AIS - A step on the path to AIS-Aided Navigation." This report described the results of a test of AIS conducted on three cruise ships during the summer of 2002 while in British Columbian and southeast Alaskan waters. The Bridge Team recommendations for improvement of AIS were: (quoted from the report):

- All ships >20 m should display as AIS targets.
- VTS should broadcast its ARPA targets.
- AIS information should be displayed on radar and ECDIS.
- AIS-equipped ships should not have to report to VTS.
- Disallow AIS-aided VHF hailing of ships except for safety messages.
- Publish transit sequence schedules for narrow channels, lock entrances, bridges and capes.
- Broadcast RACON buoys as AIS targets.
- Broadcast real-time environmental conditions.
- Eliminate the addressed ship-to-ship message feature.
- Confirm receipt of ship-to-shore messages.
- Make verification of own ship broadcasts user friendly.
- Allow the OOW to save his/her preferred navigation information display settings in a user profile.
- Consolidate ARPA and AIS icons of the same ship.
- Suppress icons for ships less than 20m.
- Use icon colors to distinguish between ship types.
- Allow flexibility in sorting targets in the target table.
- Eliminate the feature of graphically displaying AIS target's [planned] routes.
- Show AIS targets' predicted path as a curved vector.

5.2 Sault Ste Marie Survey

In 2006 the Canadian Shipowner Association conducted a survey of users of the Detroit – St Clair Rivers. Twenty-five completed surveys were received and summarized and the results sent to the Canadian Coast Guard. The following is quoted from the summary letter:

> *Results from the survey show that the mariners would like some environmental information available through the AIS format. Input provided by the mariners shows a diversity of opinions. This diversity can be distilled into defined areas within the Detroit and St. Clair River system.*
> *Input on water levels and visibility show that both entrances to the river systems and a median point are most desirable. Wind speed in the Lower River and Lake St. Clair areas were most requested. Weather Station data was not universally required, and no common areas were identified. Current flow was most important for the mariners in the Amherstburg area.*

6 MANUFACTURERS OF SHIPBOARD DISPLAY EQUIPMENT

Table 6 provides a listing of the 11 AIS manufacturers that were surveyed.

Table 6. AIS manufacturers.

Company	Model	Website
Gatehouse		https://gad.gatehouse.dk
Kongsberg		http://www.kongsberg.com
SAAB		http://www.saabgroup.com
Euronav, UK	AI3000 receiver	http://www.euronav.co.uk
Comar Systems, UK	CSB200, Class B AIS Transponder	http://www.comarsystems.com
Nobeltec, US	AIS 100 receiver	http://www.nobeltec.com
Shine Micro, US	RadarPlus AIS BX transponder	http://www.shinemicro.com
Weatherdock, Germany	EasyAIS AIS Receiver	http://www.easyais.com
Milltech Marine (distributor), US / Smart Radio (Shenzhen Yuantong Telecom), China	SR161 AIS Receiver	http://www.milltechmarine.com
Nasa Marine, UK	AIS Radar	http://www.nasamarine.com
Seacas	SafePassage AIS	http://www.seacas.com

Most type-approved shipboard AIS transceivers support AIS messages 1 to 22 (Messages 23-26 were added to ITU-R M.1371 more recently. The current Class A standard has still to be updated for those units to properly recognize and apply information in messages 23-26). At present most stand-alone AIS equipment function primarily as a transceiver with minimal display capabilities, i.e., they meet the requirements for a Minimum Keyboard and Display (MKD). However, AIS equipment can be interfaced to another shipboard device (e.g., ECDIS, ECS, or radar) for display. The interfaces between AIS units and ECDIS/ECS and radar systems are defined in IEC 61162-1 Ed 3.0 (NMEA 0183 version 3). AIS-compatible ECS software are listed in Table 7. AIS-compatible ECDIS systems are listed in Table 8.

Table 7. AIS-compatible ECS software (as reported Seacas and Milltech).

Company	Software	Website	Seacas	Milltech
Rose Point	Coastal Explorer	http://www.rosepointnav.com	X	X
Nobeltec	Admiral	http://www.nobeltec.com	X	X
MapTech	Capn 8.0	http://www.thecapn.com	X	X
ICAN	Regulus Aldebaran	http://www.icanmarine.com	X	X
Global Navigation	NavPak	http://www.globenav.com	X	X
DigiBOAT	Software On Board	http://www.digiboat.com.au	X	X
Nobeltec	Visual Navigation Suite	http://www.nobeltec.com	X	X
Euronav	seaPro UAIS	http://www.euronav.co.uk	X	X
MaxSea	Navigator	http://www.maxsea.com	X	X
NavSim	Boatcruiser	http://www.navsim.com	X	X
GPSNavX	MacENC	http://www.gpsnavx.com	X	X
Seaclear		http://www.sping.com/seaclear	X	X
Maptech	Chart Navigator Pro	http://www.maptech.com	X	
Transas Marine	Navi-Sailor	http://www.transas.com	X	
Fugawi Marine	ENC	http://www.fugawi.com	X	
Chartworx	TheMap Yachting	http://www.chartworx.com	X	
P-Sea	WindPlot II	http://www.p-sea.com	X	
Tridentnav	ECS Standard	http://www.tridentnav.se	X	
TIKI	Navigator	http://www.tiki-navigator.com	X	
Xanatos	Titan	http://xanatosholdings.com/tais.html		X
Y-tronic	Yacht-AIS	http://www.y-tronic.com		X
Navicon	AIS Navigator	http://www.navicon.dk		X
COAA	Ship Plotter	http://www.coaa.co.uk/shipplotter.htm		X
Memory-Map	Memory-Map Professional	http://www.memory-map.com		X

Table 8. AIS-compatible chart-plotters (as reported by Seacas).

Company	Software	Website
Furuno	NavNet vx2	http://www.furuno.com/
Si-Tex	ColorMax	http://www.si-tex.com/
Lorenz Electronics	Excalibur World Map	http://www.lorenz-electronics.com
Seiwa	Barracuda Nautilus Barramundi	http://www.seiwa-marine.com
VDO	Map Chart Plotters	http://www.vdo.com
JRC	JMA 5300	http://www.jrcamerica.com
Raymarine	E Series & C Series	http://www.raymarine.com
Garmin	GPSMAP 392, 398, 492, 498, 2206, 2210, 3205, 3206, 3210 and all 2007 models	http://www.garmin.com
Furuno	Chart Plotter GP7000/NT and Chart Plotter & Fish Finder GP7000F/NT	http://www.furuno.com
Standard Horizon	CPV350, CP180, CP180i, CP155C, CP175C, CP1000C, CP500 all with software V. 11.06	http://www.standardhorizon.com
Navman	8120, 8084, 5607 & 5507	http://www.navman.com
Northstar	M121 and M84	http://www.northstar.com

Table 9 provides a sampling of the AIS and electronic charting equipment that was being used by survey respondents.

Table 9. A sampling of AIS and electronic charting equipment being used.

	AIS Equipment	Charting Equipment
Overseas Shipping Group Inc.	Makes and models vary but generally it is Furuno and JRC.	Fitting Furuno ECDIS on the APSI ships and looking at Navmaster ECDIS for existing ships.
Bouchard Towing	Fleet-wide utilize FURUNO FA-100 and more recently FURUNO FA-150.	The Capn Ver. 8.3.20a with AIS overlay.
Moran Towing	None.	Handheld GPS used sometimes when docking.
Sandy Hook Pilot	Varies – depends upon the ship being ridden. AIS data is accessed via the pilot plug.	We are using the Raven/Starlink developed specialized charting program for pilots called Wheelhouse II.
Interport Pilots	AIS data from the ship via the pilot plug (ships GPS data as well as compass heading, etc). There are various brands that ships use but Furuno and Simrad seem to be the most popular.	For software, I am using Coastal Explorer that is published by Rose Point Navigation. For charts I download ENCs (Electronic Navigational Charts) from NOAAs web site and they are excellent. They are very good at keeping then up to date with corrections.
NY DOT	Currently, the AIS units aboard the ferries are JRC.	Custom made chart system that is installed on JRC radars. I expect that we will be going to ECDIS within the next year (maybe Transas).
Horizon Lines	Furuno FA-100 (5 ships), JRC JHS-180 AIS (16 ships).	Furuno FEA-2107 (5 ships), no ECDIS or ECS on the 16 ships.
Roehrig Maritime	Not reported.	Not reported.
Ingrahm Barge	JRC JHS-182.	CEACT.
American Commercial Lines	Varies.	Varies.

Table 9. A sampling of AIS and electronic charting equipment being used (Cont.).

Houston Pilots	Varies – depends upon the ship being ridden. AIS data is accessed via the pilot plug.	Raven Industries Wheelhouse II
Florida Marine Transportation	JRC JHS-182 hardware.	RiverPro software but the software is real bad; waiting for the Work Boat Show in Nov in NOLA before deciding what to switch to.
Kirby Towing	Furuno FA-100 and FA-150 units, 265 total.	Currently using Capn software but switching to ICAN; would be interested in supporting the Test Bed work
WA State Ferry	Furuno FA-100.	AIS Enhanced Radar Displays FAR-2127 and FR-2125.

Further information about what AIS equipment is in use was provided by USCG VTS, Sault Ste Marie. Table 10 provides a listing of the companies and the AIS equipment onboard the vessels transiting in their area-of-responsibility.

Table 10. AIS make/model number installed on Lake Carrier Association member vessels.

Company	AIS Equipment	Vessels
Algoma Central Corp / Seaway Marine (Contract)	Sailor KDU1805 Unit Interfaced With a Transas 3000 ECDIS	17
Algoma Tankers	Sailor KDU 1805	4
American Steamship	Furuno, model FA-100	11
Canadian Steamship Line	Sailor KDU 1805	16
Central Marine	AIS Simrad, model A170	3
Cleveland Tankers	JRC Model JHS-180	2
GLF Great Lakes Corp	Saab (SPERRY), model R4	1
Grand River	JRC. Model JHS-180	3
Great Lakes Associates / Oglebay Norton (Contract)	Tbd	1
Great Lakes Fleet	Saab, Model R4	7
HMC Ship Management	Furuno, model FA100	1
Great Lakes Marine Leasing / Vanekenvort (Contract)	Tbd	1
Inland Lakes Management	MDS MODEL AIMS M IV and AIMS K1 display	3
Interlake Steamship & Lake Shipping	Furuno, model FA-100 UAIS	9
ISG Burns Harbor	Saab (Sperry), model R4	2
Soo Marine	Tbd	?
Oglebay Norton	Saab (SPERRY), model R4	12
Pierre Marquette	Tbd – AIS yet to be installed	1
Upper Lakes Towing	Tbd – AIS yet to be installed	1
Upper Lakes Group Inc	Sailor KDU-1805	15
Vanenkevort Tug & Barge Inc	Tbd	1
Great Lakes Transport	Sailor KDU 1805	1
Keystone Great Lakes Inc	Tbd	1
Interlake Transport	Furuno FA-100	1
Lower Lakes Ltd	JRC Model JHS-180	4
Mckeil BROS Ltd	Tbd	4
Navigation Desgagnes Inc	Tbd	4
Purvis Marine	Furuno, model FA-100 UAIS	5

Several of the AIS equipment manufacturers were contacted by telephone and e-mail. Summaries of the interviews are contained in the following subsections.

6.1 ICAN[7]

ICAN develops chart plotting solutions for ships navigation. ICAN is also a system integrator, providing turnkey ship navigation solutions that incorporate its Regulus II and Aldebaran II software with hardware AIS transponders from SAAB, True Heading, CNS Systems, L-3 Communications, Kongsberg Seatex and Zeni Light. A major part of ICAN's business involves shore infrastructure development for ship tracking, ship data routing, communication and AIS.

Regulus II Workboat Features:

- Barge Builder Creation
- Configurable Guard Zones
- S-57 Electronic Chart Format (free in the US)
- Route Planning and Monitoring
- Complete AIS integration with existing AIS hardware

Figure 7. ICAN Regulus II.

ICAN products currently support AIS binary messages that are standardized and are in use. ICAN worked with Army Corps and USCG Command and Control Engineering Center (C2Cen) on implementing "Blue Force Tracking" with selective hiding capability that allows only select group of ships to be able to see each other. Blue Force Tracking was implemented using binary messaging and required changes in AIS transceivers firmware - now most AIS transceivers are shipping with firmware that accommodates this standard. ICAN was also involved in the St. Lawrence Seaway Development Corporation AIS project and implemented support for binary messages in its software that includes water levels, weather data and lockage order-of-turn for each lock within the Seaway. Furthermore, ICAN worked with the US Coast Guard on implementing lock order messages.

ICAN supports display of binary messages defined by the IMO Met-Hydro standard.[8] Support for new binary messages could be added by software upgrades. ICAN ship ECDIS/chart plotting solutions run on standard Windows platforms. Upgrades can be handled by end-users. ICAN chart plotting products support

[7] POC was Joel Box, ICAN Inc. - USA.
[8] IMO NAVCirc.236

serial, TCP/UDP (via Ethernet), and Kongsberg Seatex buses. The serial bus uses the standard NMEA 0183 protocol. TCP/UDP protocols use NMEA 0183 messages over Ethernet. ICAN also offers data routing solutions for device integration using TCP/IP interface. All communication between ECDIS and AIS transponders can be carried out via the standard NMEA 0183 serial bus. ICAN is committed to implementing the display of new AIS messages as they become available. ICAN is interested in working with the Coast Guard R&D Center on providing input on defining messaging standards. They are also willing to provide recommendations on appropriate means of portrayal.

6.2 Transas[9]

The Transas *NaviSailor* Electronic Chart System (ECS) supports binary messages that were defined and used on the Great Lakes. Transas could add support for additional informational messages when they become defined and available. Transas ECS is a software application that runs on a Windows platform – upgrades are possible and could be handled by the end-user running an update CD. Transas ECS uses a NMEA 183 interface via the serial bus as well as TCP/IP. Support for the NMEA 2000 interface is currently in development. All communication between ECDIS and the AIS transceiver is done via the NMEA interface.

Transas USA has engineering resources available to formulate the messages and forward specification to a software development team based in Russia. If there is a AIS Binary message test bed project, Transas is willing to become involved in prototype testing and provide input on binary format.

Transas Navi-Sailor Electronic Chart System Features:

- Automated keeping of the ship logbook.
- Obtaining information on navigational objects.
- Passage planning.
- Taking into account currents and weather conditions.
- Alarms.
- Generation of SAR operation patterns.
- Work with AIS equipment in compliance with IEC 61993/2 standard.

Figure 8. Transas Navi-Sailor ECS.

[9] POC: Henry Nil, Transas USA

6.3 Furuno[10]

Furuno is a developer/manufacturer of ECDIS, AIS, chart-plotters, ECS and radar systems for commercial and recreational ship navigation. Furuno's main R&D facilities are in Japan but the Furuno U.S. division has local engineering resources to formulate development requirements for support of binary messages and can then work with R&D on implementing them. In addition, Furuno U.S. has capabilities and could participate in system implementation and testing.

Furuno FEA-2107 ECDIS Features:

- Display - Color 21" LCD
- Cartography - C-Map, ARCS, S57
- Navigational data includes: AIS and ARPA targets
- Variety of other navigation information such as position, course, and speed.
- Voyage route / planning

Figure 9. Furuno FEA-2107 ECDIS.

Furuno FA150 - AIS Transponder Features:

- Display - Mono LCD
- Receiver Type - GPS/VHF
- Meets all IMO regulations
- FCC type approved
- Multiple interfaces for Radar, ECDIS and PC
- Short safety-related messages and free messages

Figure 10. Furuno FA150 - AIS transponder.

[10] POC: Eric Kunz, USA Product Manager

Furuno worked with the USCG on implementing "Blue Force Tracking" with selective hiding capability that allows only select group of ships to be able to see each other. Blue Force Tracking was implemented using binary messaging. New binary messaging capabilities can be implemented as they become defined and available. Support for new binary messages could be added by software upgrades. Furuno ECDIS/chart plotters/ECS/Radars can be upgraded by end-users; upgrades can be loaded from SD cards, or using the Ethernet interface. Furuno navigation products support the serial bus and TCP/IP (UDP) via Ethernet (except ECDIS that is serial only). The serial bus uses standard NMEA 183 protocol while the TCP/UDP protocols use NMEA 183 messages encapsulated for transmission over Ethernet. Furuno is developing devices with support for NMEA 2000. All communication between ECDIS and the AIS transceiver can be carried out via the standard NMEA 0183 serial bus.

Furuno is committed to incorporating support for display of new AIS messages as they become available. Furuno is interested in working with Coast Guard R&D Center on testing this functionality and providing input on defining messaging standard. In particular, Furuno is interested in passing the water current information to plotters and radar systems for Western River navigation.

6.4 RosePoint[11]

Rose Point Navigation Systems produces PC-based navigation software for recreational boaters and commercial shipping. Rose Point's main customers are companies operating fleets of light commercial vessels. Rose Point produces Coastal Explorer software targeted for the recreational market and Explorer ECS for commercial users. Explorer ECS software follows ECDIS specifications for display of information. Coastal Explorer can use an AIS transponder or receiver to display other vessels on the chart and track their progress in real-time. It can calculate whether or not those vessels are on a collision course and tell how much time you have to change course. Other AIS features include: graphical display of AIS vessel orientation and past track, dynamic storable list of all known AIS vessels including their MMSI number, name, position, closest point of approach (CPA) and the time to CPA, speed, course, heading, range, bearing, destination, ETA, and navigational status. Each vessel may be assigned its own icon and track colors. The software can also search for other vessels by name.

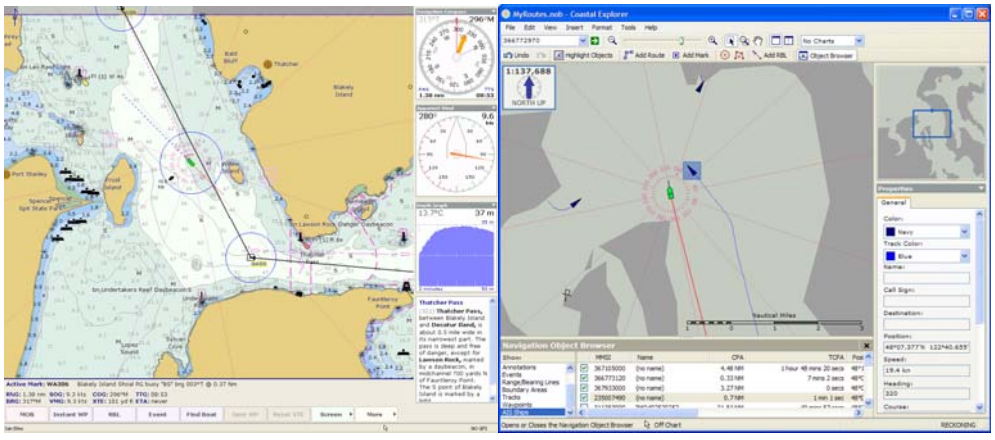

Figure 11. Rose Point Coastal Explorer (navigation on left and AIS on right).

[11] POC: Jeff Hummel

Rose Point worked with Shine Micro (AIS receiver manufacturer) to implement text messaging and vessel tracking features for use by the U.S. military. New binary messaging capabilities can be implemented as they become defined and available for reception. Rose Point can easily add support for new messages. Rose Point provides software-only solutions - updates/installations are handled by end-users. Incremental updates are free to customers; there is a charge for major upgrades. Rose Point software supports the NMEA 0183 serial bus interface via either built-in serial port or a USB to serial adapter. Proprietary buses were developed mainly to support exchange of images and video. All AIS information is available through the serial/NMEA 0183 interface. When a protocol for new messages becomes available, Rose Point can readily add support for new messages and test the software against pre-recorded data provided by the Coast Guard.

6.5 Maptech[12]

Maptech is based in Amesbury, MA. It's a producer of marine, land and air navigation products including PC and Handheld software, books, charts, and touch-screen command systems. Maptech marine PC Software includes: Chart Navigator Pro, Chart Navigator, The Cap'n, U.S. Boating Charts DVD, and International Chart CDs. Maptech also offers marine touchscreen command systems: i3 and Sea Ray Navigator. The Cap'n software interfaces with AIS, NMEA autopilot, GPS/DGPS/WASS, compass, and depth sounders. The Cap'n features include on-chart tide and current display; celestial navigation module; full-fledged log-keeping and vessel management. The Cap'n supports vector charts, raster charts and photos, 3D bathy charts and tides and currents. The Cap'n is AIS ready – it can plot the position, course, speed, type, size and identity of commercial traffic near the vessel.

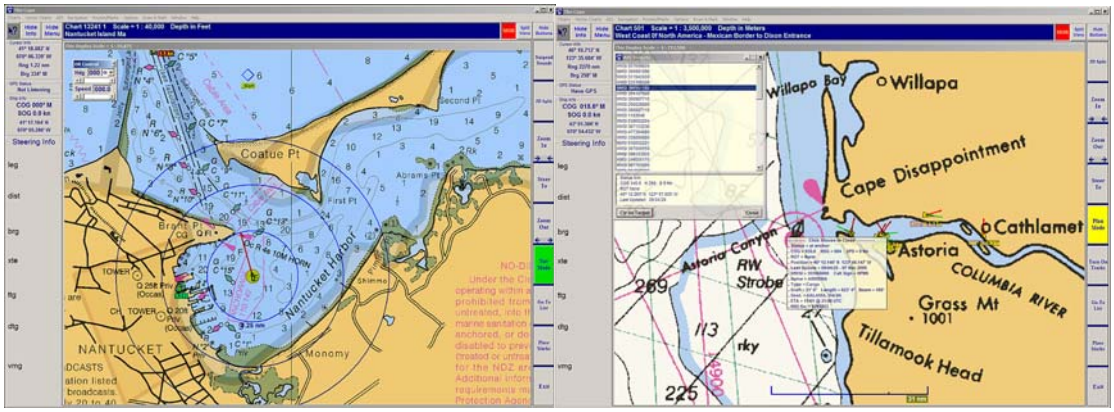

Figure 12. Maptech the Cap'n (left navigation, right AIS).

6.6 Raven[13]

Raven was founded in 1956 and is based out of Sioux Falls, South Dakota with offices across the country. Its Austin Technology Center (formerly known as Starlink Inc.) located in Austin, Texas, focuses on the design, manufacture, and distribution of high-performance differential global position system (DGPS) products and other leading technologies. Raven has over 10 years of experience in developing navigation

[12] Unable to arrange an interview with a Maptech representative.
[13] POC: Chuck Parker, Program Manager, Marine Division

solutions for professional marine pilots. The Raven Wireless Portable Pilot System and Wheelhouse II Navigation System feature: Wireless Sub-meter DGPS to the laptop, AIS targets display, S57 Charts, Customizable remote vessel, Wireless internet connectivity, Remote vessel, DGPS integrity monitor, Intercept feature and User-friendly interface.

Raven is aware of the new development in shore to ships AIS binary messages and is interested in supporting them. Raven's Wheelhouse II system (Figure 13) is currently using NOOA web interface to display weather information. Currently, weather data is downloaded using wireless internet card – Raven would be interested in using AIS data channel for downloading weather information. Raven Wheelhouse II is an integrated system, that uses matched components, including receivers/ navigation sensors, computer hardware, and ECS software. AIS information is exchanged using standard NMEA 0183 interface. For GPS - communication interface is proprietary, implemented to support Raven's custom data types, such as GPS operating conditions and alarms.

Raven is interested in working with the Coast Guard on testing and providing feedback on AIS binary messages - particularly in New York and Houston VTS areas, because Raven has physical presence/offices in those areas.

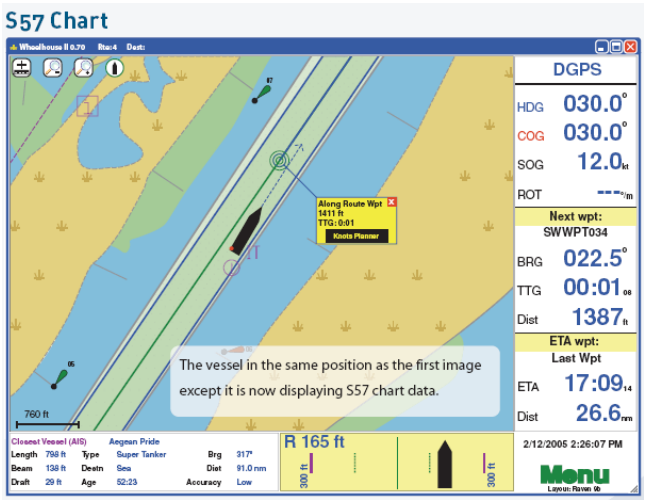

Figure 13. Raven Wheelhouse II.

7 ROLES

In regard to using AIS binary messages to transmit supplemental VTS information, providers, disseminators, users, and manufacturers will have different roles.

7.1 Information Providers

The information providers (e.g., USCG VTS Centers, USACE, and NOAA) have information (data) that can be transmitted. As such, it is up to each information provider to verify and validate the data being supplied for transmission. It may also be the responsibility of the provider to convert the data into a binary message format.

7.2 Information Disseminators

The information disseminators (i.e., USCG NAIS/VTS Centers) will be responsible for transmitting the data as AIS binary messages. If not already done so, they will need to reformat the data into binary message format. The VTS Centers will also need to manage the binary message queue. Of primary importance is ensuring that the AIS channel (i.e., AIS VHF Data Link (VDL)) is not overloaded due to the broadcast of binary messages. A separate broadcast management process is needed to apply intelligence to the message broadcasting process to ensure order on the VDL. This process can also manage message ordering and arrange the messages in priority order. Another important aspect brought up by many VTS Centers is the need for an acknowledgment back from the vessels. AIS provides a limited capability for meeting this need, and more efficient methods need to be developed for widespread implementation of a capability that meets this need.

7.3 Display Manufacturers

Each data type to be transmitted must have its binary message representation defined. In addition, there must be a portrayal scheme developed so that the data's information can be displayed with the electronic chart. A goal is to have the information displayed as an overlay and not just as text to increase the usability to the user while minimizing information overload. Manufacturers must be part of the AIS binary message development process so that new message types can be properly defined, implemented, and portrayed.

7.4 Users

The users are the most important part of this process. If the data to be transmitted is of little/no use to a mariner, then there is no point in transmitting it. As such, it is important to engage some users in order to keep the AIS binary message development process grounded in reality. It will also be important to demonstrate concepts to potential users, and educate them to the possibilities and capabilities that AIS binary messages provide. The appropriate portrayal of the information is critical, and key display concepts will need to be tested during the proof-of-concept.

8 ANALYSIS

Table 11 indicates the preferences of VTS Centers and Users in regard to the overall importance of various types of information that could be provided via AIS binary message. For the majority of items listed, there is general agreement (both Yes or No). However, for some items, the "Maybe" indicates some uncertainty. There are 11 items that are of importance to both the VTS and to the Users (i.e., Yes by both). Anchorage management is included as well since it was very important to the VTS, while a "Maybe" for the Users. Other items of interest appeared to be variations on the categories; bridge air gap (related to water level), bridge work/obstruction (related to security zone), narrow channel procession order (similar to lock order), etc. A key item of interest was the retransmission of vessel position reports – not a repeater function but a retransmission of selected VTS track data to selected areas. This capability is already covered by an existing AIS binary message. Many VTS's also wanted a better description of the towed vessel/barge.

Table 11. Comparison of VTS center and user preferences for AIS binary message information.

	VTS	User
Fog	Yes	Yes
COTP Orders	No	Yes
Water levels	Yes	Yes
Tides and currents	Yes	Yes
BNTMs	Yes	No
MIBs	Yes	Maybe
Emergency Messages	Yes	Yes
GPS trouble/outage reports	No	Yes
Security zone locations / information	Yes	Yes
Dredging locations / information	Yes	Yes
ATON outages / changes	Yes	Yes
Chart updates	No	No
Marine info (regattas, events)	Yes	Yes
Weather	Yes	Maybe
Meteorological data	Yes	No
Lock order	Yes	Yes
Anchorage management	Yes	Maybe
Government only encrypted messages	Maybe	No
Ice Advisory	Yes	Yes

The 11 items were then scored based upon perceived mariner need, suitability for AIS transmit, and suitability for use by manufacturers to present to the mariner. These were then sorted by priority, from high to low (see Table 12). Perceived Mariner Need is the User Raw score scaled to a range of 1-10. Perceived VTS Need is the VTS Raw Score scaled to a range of 1-10. Suitability for AIS transmit is 10 if a message is already in existence and 5 if it can be developed. Ease of implementation by manufactures is a "10" if already implemented in software, while a "5" if it needs to be developed.

Table 12. Prioritized preferences for AIS binary message information.

	VTS	User	User Raw Score	Perceived Mariner Need (1 - 10)	VTS Raw Score	Perceived VTS Need	Suitability for AIS transmit (1 - 10)	Ease of implementation by manufacturers (1-10)	Total
Tides and currents	Yes	Yes	5.3	7.6	8.0	10.0	10	10	37.6
Water levels	Yes	Yes	3.3	4.7	8.0	10.0	10	10	34.7
Emergency Messages	Yes	Yes	7	10.0	7.0	8.8	10	5	33.8
ATON outages / changes	Yes	Yes	4	5.7	8.0	10.0	10	5	30.7
Lock order	Yes	Yes	3	4.3	4.0	5.0	10	10	29.3
Ice Advisory	Yes	Yes	5	7.1	4.0	5.0	10	5	27.1
Dredging locations / information	Yes	Yes	3.2	4.6	8.0	10.0	5	5	24.6
Security zone locations / information	Yes	Yes	6.7	9.6	3.0	3.8	5	5	23.3
Fog	Yes	Yes	3	4.3	5.0	6.3	5	5	20.5
Marine info (regattas, events)	Yes	Yes	2.1	3.0	3.0	3.8	5	5	16.8
Anchorage management	Yes	Maybe	1.4	2.0	2.5	3.1	5	5	15.1

8.1 Text Messages

There has been discussion by some VTS Centers about using the "text messaging" capability of the AIS system as a means of communication. This could provide a simple mechanism for transmitting some information by using preformatted or "canned" messages. One concern is that vessels need to be monitoring for text messages. Another concern is that there also needs to be a mechanism for acknowledgment. Text messages can be received and displayed by all AIS equipment (works with the MKD). This is an advantage over binary messages that need to have an ECS system to process and display the information. At present, the only requirement for vessels to display AIS information is a Minimum Keyboard Display (MKD). In order for information to be displayed as symbols on an electronic chart, it needs to be sent as binary data. Text would be very inefficient for this. Text messages are a capability that can be investigated as part of the test bed, but will not meet all information transfer needs.

8.2 Existing AIS Binary Messages[14]

Seven AIS binary messages have been established by IMO as a basis for initial testing. They were issued in SN/Circ.236 on 28 May 2004 as "Guidance on the Application of AIS Binary Messages." The intent was to use this set of seven messages (applications) for a trial period of four years with no change. Although extensive testing of these trial messages has not occurred, a number of comments/concerns regarding the limitations of each have been made. The following is a brief description of each of the seven applications:

8.2.1 Application 1 – Meteorological and Hydrological Data

The purpose of this message is to allow the distribution of meteorological and hydrological information. Not all of the information specified in the tables will be available at all stations. It should only be transmitted if time of measurement and position are known. If there is no data available, the default value to be transmitted is the highest available binary value for that particular data field. This message takes 2 slots. The interval between the broadcasting of this message should not exceed 12 minutes. The message attributes are: broadcast, shore station transmitting, no acknowledgement required.

Some drawbacks of this message are that the existing message will only send data for multiple parameters at one location. If additional readings of a similar parameter (e.g., current profile) need to be disseminated, multiple binary messages must be sent, increasing VDL loading. Also, even if only one parameter is available, the entire two-slot message must be sent, rather than a smaller message containing the available data. Finally, some parameters do not allow for the required level of accuracy (e.g., water level only to 0.1m).

8.2.2 Application 2 - Dangerous cargo indication

This message should be used as a response to a request for Dangerous Cargo Indication from a competent authority. The message content is essential to identify the harbor where the necessary documents for the dangerous goods cargo can be found (e.g., last and next port of call). The indication of main dangerous goods and its quantity gives at least an estimation of a potential danger. The message attributes are:

[14] Ccomments in this section originate from output generated by the IALA VTS 26 meeting (Output 09) and RTCM Expanded use of AIS within VTS working group discussions.

addressed, ship transmitting, no acknowledgement. One problem with this message is the inability to report multiple dangerous cargoes in one message.

8.2.3 Application 3 - Fairway closed

The purpose of this message is to inform ships, in particular to give guidance to large vessels, about temporary closed fairways or sections in ports. The message attributes are: broadcast, shore station transmitting, and no acknowledgement. One problem with this message is that the ability to indicate a polygon or other complex area is required. Also, the application should be considered for use for broader application beyond simply a closed fairway. For instance, there would be a benefit of using this message for other purposes (e.g., as specified in the reason field) for the designation of a SAR operation area.

8.2.4 Application 4 - Tidal window

This message is used to inform vessels about tidal windows which allow a vessel the safe passage through a fairway. It includes predictions of current speed, current direction, and time. The message attributes are: addressed, shore station transmitting, acknowledgement required. Similar to the Fairway Closed message, this message could be made more general, in that, many maritime operations can be defined with a "window" such as passage of drawbridges or entry into one-way channels.

8.2.5 Application 5 - Extended ship static and voyage related data

The purpose of this message is for a ship to report height over keel. The message attributes are: broadcast, ship transmitting, no acknowledgement. One problem with this message is that the use of an entire binary message solely for air draft is inefficient.

8.2.6 Application 6 - Number of persons on board

This message is used by a ship to report the number of persons on board (e.g., on request by a competent authority). The message attributes are: addressed, acknowledgement required. Although the persons on board data is useful, it would be made more valuable through addition of information on number of infants or disabled persons on board, for the benefit of SAR and security services.

8.2.7 Application 7 - Pseudo-AIS targets

The purpose of this message is to transmit VTS targets. The message is variable in length, based upon the number of VTS targets. The maximum of VTS Targets transmitted in one International FM 16 should be seven. Because of the resulting effects of VDL channel loading, the transmission of International FM 16 should be no more than necessary to provide the necessary level of safety. A VTS target should only be used, when the position of the target is known. However, the target identity and/or course and/or time stamp and/or speed over ground may be unknown. The message attributes are: broadcast, VTS transmitting, no acknowledgement. This is a valuable message for VTS operations; however, it could be made more valuable through further enhancements, such as allowing VTS to highlight targets or add amplifying information to the target and other enhancements based on an evaluation of VTS operational procedures and requirements.

8.3 New Binary Messages

The desired data types listed in Table 12 have been discussed by the Working Group (RTCM SC121 Working Group on Expanded Use of AIS within VTS). Some additional desired data elements were

reviewed as well: intended routes, floating hazards, fishing areas, traffic advisories, VTS measures, and man overboard. In addition, it was pointed out that the Lock Order item should be more generic in order to handle additional similar cases such as procession order through narrows, non-passing zones, bridge openings/closings, etc.

These desired data elements cannot be handled efficiently by the existing binary messages. Although, the AtoN outages can possibly be done with the existing AtoN message (Message ID 21) and Emergency Messages via standard Safety Related Text Messages (Message IDs 12 or 14), the rest will need to be covered with new binary messages. In this regard, the RTCM AIS Working Group has proposed that three "general" AIS binary messages can be used:

1) Zone Information (security zones, dredging, anchorage, fog, etc.),
2) Waterways Management (lock order, bridge open/close, etc), and
3) Environmental (for tides, currents, water levels, and weather).

Table 13. Assignment of information categories to AIS binary message type.

Information	AIS Binary Message
Tides and currents	Environmental
Water levels	Environmental
Emergency Messages	Existing Message 12/14
AtoN outages / changes	Existing Message 21 or Zone Information
Lock order	Waterways Management
Ice Advisory	Zone Information
Dredging locations / information	Zone Information
Security zone locations / information	Zone Information
Fog	Environmental or Zone Information
Marine info (regattas, events)	Zone Information
Anchorage management	Zone Information

9 CONCLUSIONS/RECOMMENDATIONS

Based on the results of this study, there is interest on the part of providers, disseminators, and users in having AIS binary messages used as a part of expanded VTS services. It is also clear that there is a need to have automatic information flow from the VTS to the mariners as digital data capable of being displayed rather than by increased use of voice communications. While there is a large amount of data available that can potentially be used to improve the safety and efficiency of navigation within the VTS area of operation, both mariners and VTS operators can become overloaded by too much information.

Users are a diverse group. Different user communities (tugs, ferries, pilots, etc.) all have different information needs. Each VTS area of operation also has different needs for information flow due to geographic area and customer base. Thus, flexibility is important, to be able to send the data that is needed to the people who want it based on area of operation. The one commonality to all users is that the information must be displayed in a way that is user-friendly, clear, uncluttered, and does not overwhelm the mariner with too much or useless information. An appropriate means to portray AIS information – including the possibly of allowing the user to filter the information -- needs to be tested and evaluated.

The existing capabilities of AIS were reviewed to see if the currently established AIS message types are suitable for meeting existing requirements. Keeping in mind the need for flexibility to handle the varied

users communities and geographic differences, three new generic binary messages have been proposed. These three messages along with existing AtoN and Safety Related Text messages should be able to handle all of the desired information transfer.

Some of the manufacturers appear more willing than others to participate in a test bed – ICAN and Transas seem to be the most interested with RosePoint also willing to make changes to their software. Having manufacturers onboard is critical since it will be necessary for them to modify their software to decode the binary messages and display the information. Exactly how the information is displayed to the mariner is also very important and will need to be studied.

APPENDIX A. USCG VTS INFORMATION

A.1 VTS Areas Overview

Figure A-1 shows where the current USCG VTS Centers are located. Missing from the map is the new VTS in Tampa, FL. The VTS Centers surveyed are each described in the following sections.

Figure A-1. Overview of USCG VTS locations.

A.2 VTS New York

VTS New York has the responsibility of coordinating vessel traffic movements in the busy ports of New York and New Jersey. The VTS New York area includes the entrance to the harbor via Ambrose and Sandy Hook Channels, through the Verrazano Narrows Bridge to the Throgs Neck Bridge in the East River, to the Holland Tunnel in the Hudson River, the Kill Van Kull including Newark Bay and all of Arthur Kill, and Raritan Bay (see Figure A-2).

The VTS Supervisor, Mr. Patrick Mannion was interviewed along with CWO Ramon Pagan (Electronics Material Officer), Mr. William Barry (watchstander), and Mr. Matt Holliday (training officer). VTS NY has the highest density of traffic per mile of channel of any harbor. Tugs and barges and ferries cause the most work for the VTS. Large ships are actually less work. They noted that bad weather and low visibility increase the demands on the VTS.

Initially they were not very PRO AIS, but after 2 hours of discussion, I don't think that is an accurate sentiment. NY seems to have problems with RF interference (spectrum issues) as well as poor AIS coverage, installation issues, and issues with the PAWSS software. They are very interested in AIS transmit and the improved capability that it can offer. VTS NY currently uses AIS broadcast occasionally (text messages) but has not been able to get the addressed mode to work using the PAWSS software – it only works with broadcast mode.

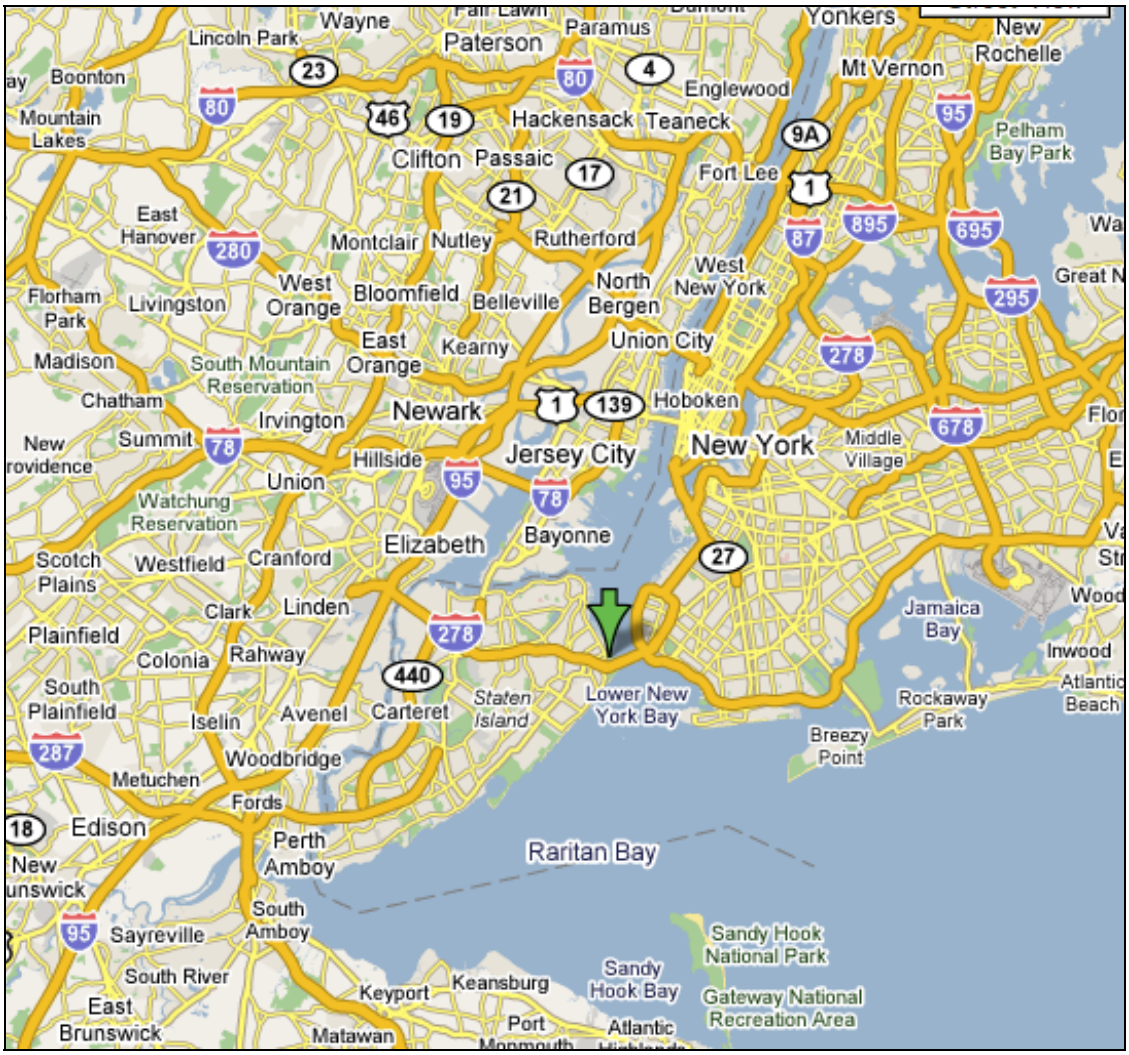

Figure A-2. VTS NY AOR.

A.3 VTS Louisville

VTS Louisville covers the Ohio River between miles 592 and 606 (see Figure A-3).

We met with CDR Gregory Howard, Dep. Commander and watchstanders YN2 James Templeton, YNC Matt Kristofferson, SK2 Anthony Lore, and SK2 John Kissel. VTS Louisville is not a 24/7/365 VTS. It only stands up when the water level reaches a high of around 11-13 ft. (above mean sea level). It is manned by the OS rating a little, but most of the personnel are out-of-rate for the watch (YN and SK rates). They are also severely short on personnel when they man the VTS. VTS Louisville currently does not have AIS installed, although they are scheduled to have it installed within the next month according to CDR Tetreault. They use voice for all their communications and have cameras for the tracking of the vessels. They are very reliant on the vessels providing their accurate positions to the VTS. The majority of the vessels in VTS AOR are push tugs; they have as many as 20 barges for each tug.

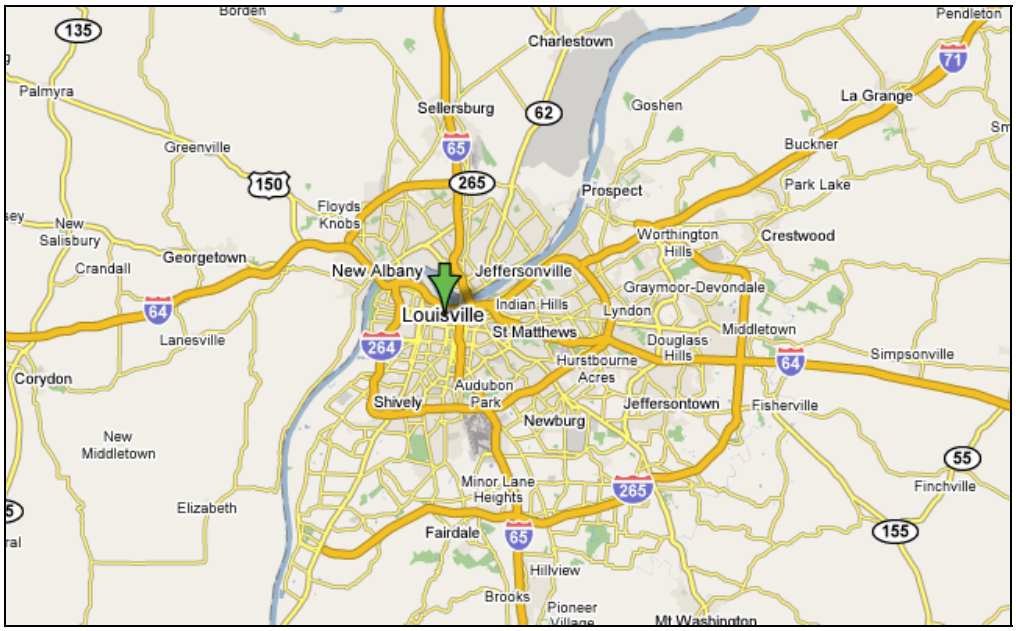

Figure A-3. VTS Louisville AOR.

A.4 VTS San Francisco

VTS San Francisco is responsible for the safety of vessel movements along approximately 133 miles of waterway from offshore to the ports of Stockton and Sacramento (see Figure).

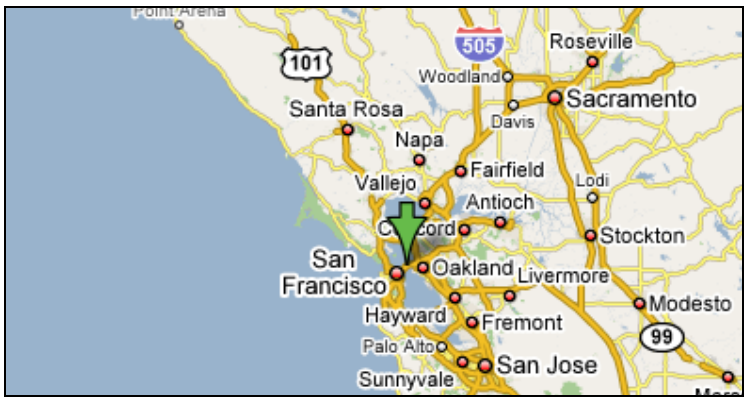

Figure A-4. VTS San Francisco AOR.

The Training Director, Mr. Scott Humphrey was interviewed along with LTJG Matt Zolnierek. VTS San Francisco has 5 AIS sites (2 very high) which provide coverage of the entire area – all the way to Sacramento. Geography masks transmission/reception for vessels though so reception of AIS reports by the vessels is very limited. The majority of their traffic is ferries (80,000/yr), with the 2nd largest being tugs and then piloted vessels (10,000/yr). Of the vessels not required to use AIS (small towing and small ferries) most are not using it, though some tugs (not required) are using it and some yachts. Most users are NOT using ECS – they have the MKD although the Ferry companies just went to a Furuno chart display system. SF uses CGVTS and has no plan to switch to PAWSS – they use PAWSS just to control the AIS transmitters.

A.5 VTS Sault Ste Marie

VTS Sault Ste Marie's area of responsibility is along the entire length of the St. Mary's River (approx. 80 miles, see Figure A-5)

Figure A-5. VTS Sault Ste Marie AOR.

The VTS Director of VTS, Mr. Mark Gill and VTS operators Jack Crumbaugh and Rick Birch were interviewed. Sault Ste Marie VTS has the following personnel on duty around the clock: 2 VTS operators, 2 SAR operators, and 4 COMMS operators. VTS personnel coordinate ship traffic along the St. Marie River, especially around locks, and have the authority to close the river for navigation in case of fog. The width of the channel in some places along the St. Marie River is restricted to one ship – it is the VTS's responsibility to generate procession order and forward it to the ships. In wintertime, the locks close and VTS Sault Ste Marie switches its area of operation to northern Lake Michigan and northern Lake Huron.

Sault Ste Marie VTS has 4 video cameras around its area of operation and 11 VHF antennas. Out of 11 antennas, 2 are equipped with SAAB AIS transceivers – they are linked to VTS operation center via T1 phone lines. In addition, there are 2 NAIS sites.

In 2006, 22 Great Lakes shipping companies were surveyed regarding their desires for the growth of AIS/electronic navigation enhancements for the Great Lakes Navigation System. Unanimously they wanted to see WX and Water level information made readily available through AIS broadcasts. (At present, our Ports and Waterways Safety System samples NOAA/*PORTS*® websites and rebroadcasts select data. The St. Lawrence Seaway Development Corporation (SLSDC) and MCTS Sarnia sites will soon do the same). To a one, each of the responders commented on the need for information to be broadcast unobtrusively; many users still are limited to MKD displays which become bogged down with "nice to know" information.

A.6 VTS Puget Sound

VTS Puget Sound is located at Pier 36 in Seattle and monitors the Strait of Juan de Fuca, Rosario Strait, Admiralty Inlet, and Puget Sound south as far as Olympia (see Figure A-6). Mark Ashley (Operations Director) and Vic Zboralski (training director) were interviewed.

Information sent to a VTS user must be scalable to the user, tailored for the area the user needs, and user friendly/simple to understand. This would likely require VTS intervention to ensure a user got what they needed when they needed it so that the vessel operator could focus on safe navigation. Checking verifying by the VTS would be necessary. Not only that, but 'tweaking' what is relevant as well. We do not need our VTS Users inundated or distracted with messaging and not looking out the window. Currently we share information with the Canadian MCTS' Tofino and Victoria. Handling information outside of our AOR would have responsibility drift into Canadian procedure agreement.

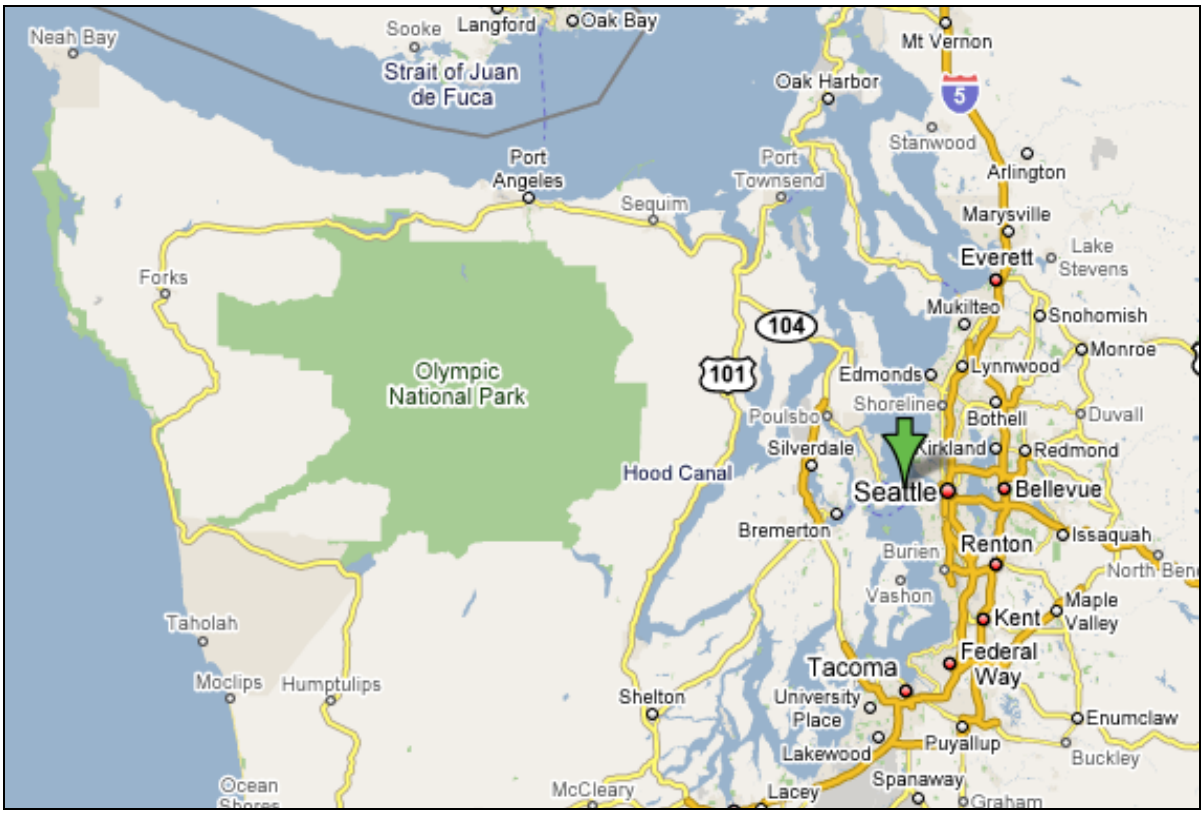

Figure A-6. VTS Puget Sound AOR.

A.7 VTS Houston-Galveston

The VTS operating area is the Houston Ship Channel from the sea buoy to the turning basin (a distance of 53 miles) and the side channels to Galveston, Texas City, Bayport, and the Intracoastal Waterway (see Figure A-7)).

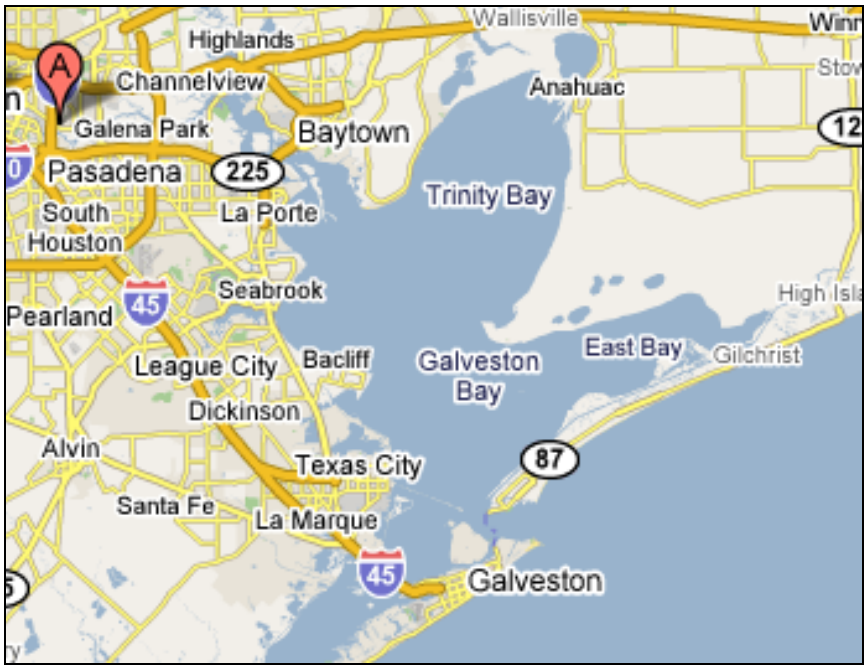

Figure A-7. VTS Houston-Galveston AOR.

The following personnel were interviewed at VTS Houston-Galveston: Steve Nerheim, CWO Johnny O'Rourke, and CDR Hal R. Pitts. Houston's AOR is very large and busy; they have between 400-600 vessel transits every day. There are up to 6 VTS personnel on watch, each with their own distinct AOR. They transmit the requested data such as weather, traffic conditions, ATON issues and dredging information. They have 16 video feeds and 3 radar sites. Also, they pass on NOAA information such as the data provided by buoy 18 at the channel entrance. They use *PORTS*® to obtain this information. Although end users can access this information if they have web access underway, VTS Houston has monitors with the appropriate *PORTS*® page open so that VTS personnel can glance at it and give the information requested. As mentioned before, LLB 18 is the most popular data set requested.

The VTS used the PAWSS software fed GMDSS data from 3 sites on oil platforms. The farthest one is 120 miles out. They use Shine Micro equipment on the rigs; this is part of the Coastal Zone Awareness initiative.

APPENDIX B. USER INFORMATION

Table B-1. Summary of user responses to prospective data items - Part I.

	Overseas Shipping Group Inc (NY)	Bouchard Towing (NY)	Moran Towing (NY)	Sandy Hook Pilot (NJ)	Interports (NY)	NY DOT	Horizon Lines (NY)	Roehrig Maritime (NY)
Category	Commercial Shipping	Tug	Tug	Pilot	Pilots	Ferry	Commercial Shipping	Tug
Fog	Yes	No	Yes	Yes	No	Yes	Yes (9)	Yes (2)
COTP Orders	No	Yes	Yes	No	Yes	Yes	Yes (9)	No(1) Yes (1)
Water levels	No	Yes[15]	Yes	Yes[16]	Yes[17]	Yes[18]	Yes (2)	No (2)
Tides / currents	Yes	Yes[19]	Yes	Yes[20]	No	Yes[21]	Yes (4)	No (2)
BNTMs/MIBs	No	No	No / Yes	Yes[22]	No / Yes	No	Yes (1)	No (2) / No (2) Yes (1)
Emergency Messages	Yes[23]	Yes[24]	Yes	Yes	Yes	Yes	Yes (9)	Yes (2)
GPS trouble reports	Yes	No	No	No	Yes.	Yes	Yes (7)	Yes (2)
Security zone information	Yes	Yes	No	Yes	Yes.	No	Yes (8)	Yes (2)
Dredging information	Yes	No	No	Yes	Yes	No	Yes (6)	Yes (2)
ATON outages / changes	Yes	Yes	Yes	Yes	Yes.	Yes for outages.		Yes (1) No (1)
Chart updates	Yes	No	No	No	Yes if it involves a ship channel.	No	Yes (3)	Yes (1) No (1)
Marine regattas and events	Yes	No	Yes	No	Yes if it involves a main channel.	Yes	Yes (7)	No (2)
Weather	No	Yes[25]	Yes	No	No	No	Yes (3)	Yes (1) No (1)

[15] Very important on major rivers only (i.e. Mississippi, Ohio and Columbia Rivers)
[16] Very important but must indicate predicted and measured.
[17] Only if more than a 1 ft over/under predicted.
[18] , abnormal.
[19] Very important on major rivers only (i.e. Mississippi, Ohio and Columbia Rivers)
[20] Very important but must indicate predicted and measured.
[21] , abnormal.
[22] Very important as part of an Emergency Message only this could also include any important information which is less than 1 hour old.
[23] important with an audible alarm.
[24] Very important as part of a Captain Of The Port (COTP) Message
[25] Very important for severe changes only (i.e. lightning storms, tornados, hail etc.)

Table B-1. Summary of user responses to prospective data items - Part I (Con't).

	Overseas Shipping Group Inc (NY)	Bouchard Towing (NY)	Moran Towing (NY)	Sandy Hook Pilot (NJ)	Interports (NY)	NY DOT	Horizon Lines (NY)	Roehrig Maritime (NY)
Category	Commercial Shipping	Tug	Tug	Pilot	Pilots	Ferry	Commercial Shipping	Tug
Meteorological data	No		No	No	No.	No	Yes (2)	Yes (1) No (1)
Lock order	Yes	Yes	Yes	Yes	Don't know	No	Yes (2)	No (2)
Anchorage management	Yes	N/A	Unsure	Yes	Yes	No	Yes (3)	N/A
Government only encrypted messages	No	Not sure	Not sure	Not sure	No	No		No (2)
Ice Advisory		Very Important, Hudson River	Yes	Very Important, Hudson River.				

Table B-2. Summary of user responses to prospective data items - Part II.

	Ingrahm Barge (Louisville)	American Commercial Lines (Houston)	Houston Pilots	Florida Marine Transportation (Houston)	Kirby Towing (Houston)	WA State Ferry	SF Marine Exchange	SF Pilots
Category	Tug, Barge	Tug/Barge	Pilot	Tugs	Tug/Barge	Ferry	Other	Pilot
Fog	Yes	No	No	No	Yes	Yes	No	
COTP Orders	Yes	No	No	Yes	Yes	Yes	Yes	
Water levels	Yes	Yes[26]	Yes	Yes[27]	Yes!	Yes	No	
Tides / currents	Yes	Yes	Yes	Yes currents, no tides	Yes!	Yes	Yes	
BNTMs/ MIBs	Yes	No	No	No – too long. Maybe if they could be shortened.	Yes, text msg alerts only, new msgs	Yes	Yes	
Emergency Messages	Yes	No	No	No	Yes	Yes	Yes	
GPS trouble reports	Yes	Yes	Yes	No	Yes	Yes	No	

[26] Draft equals $$$. The need 9 feet to break even. Every inch past 9 ft is profit. So, if they know the exact water depth at all times, they can max out the barges. Also, if they are approaching a spot where is has become to shallow, they can save time by off loading ahead in the optimal area, no at the last second.

[27] Rivers use "gauges" not really water levels. The problem is that gauges mean different things at different locations. It is the local knowledge of the captains which gives meaning to the gauge levels; this may be difficult to translate into data.

Table B-2. Summary of user responses to prospective data items - Part II (Con't).

	Ingrahm Barge (Louisville)	American Commercial Lines (Houston)	Houston Pilots	Florida Marine Transportation (Houston)	Kirby Towing (Houston)	WA State Ferry	SF Marine Exchange	SF Pilots
Security zone information	Yes	No except for MARSEC escorts	No	Yes	Yes	Yes	Yes	
Dredging information	Yes	Yes	No	Yes	Yes	Yes	No	
ATON outages / changes	Yes	Yes: outages less important, wrong location more important	No	Yes	Yes	Yes	No	
Chart updates	Yes	No	No	No	No	No	Yes	
Marine regattas and events	Yes	No	No	Only if they affect local operations	No, included in NTMs	Yes	Yes	
Weather	Yes	No	No	Yes	Yes, linked to tide	Yes	Yes	
Meteorological data	Yes	No	No	No	Yes, linked to tide	Yes	No	
Category	Tug, Barge	Tug/Barge	Pilot	Tugs	Tug/Barge	Ferry	Other	Pilot
Lock order	Yes	Yes, as data, down, up, broke, maintenance, queue	N/A	No[28]	Yes	N/A	N/A	
Anchorage management	Yes	N/A	No	N/A	N/A	N/A	N/A	
Government only encrypted messages		No	No	No	No	Yes	No	
Ice Advisory	Yes	N/A	N/A	N/A	Yes		N/A	

[28] Their main office uses BoatTracs to send this info, they would probably rely on their own data before AIS data.

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