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EXAMINING AN INFORMATION SYSTEM TO SUPPORT MARITIME TRAFFIC AND COMMERCE: RESEARCH OPPORTUNITIES FOR THE IS DISCIPLINE

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ABSTRACT

This paper introduces a comprehensive information system for supporting maritime traffic and commerce and explores the information systems related research opportunities associated with this system. The paper begins by reviewing the existing dominant technologies deployed in the maritime environment: VHF Radio, Radar and GPS. Next, the paper describes a comprehensive system called the Automated Identification Systems (AIS) that is being proposed by the maritime industry, military, government, and The International Maritime Organization. A deployment scenario highlights how such a system could have unintended consequences if not carefully designed and deployed. The paper concludes by briefly examining several information systems related research opportunities surrounding the design and deployment of the AIS. Given that little research is leading the design and deployment of the AIS, and given the critical role the worldwide maritime industry plays in commerce, this paper provides a foundation for others to begin the examination of this important area.

KEYWORDS: IS research, information systems, marine, SDLC, acceptance, utilization, opportunities, capacity, scalability

I. INTRODUCTION

Every year, 95% of all goods and materials that enter or exit the United States do so via the various ports distributed up and down the East and West coasts of North America. Since the time that humans first took to the oceans with the desire to trade, the basics of the marine environment (vessels, navigation, wind, and waves) stayed relatively the same. Of course, many advances occurred in ship design, capacity, speed, and electronics. However, one area where innovations did not keep pace is the real-time ship identification and tracking. This problem is considerable, given that shipping and vessel traffic is growing every year, and the vessels plying the coastal waterways and oceans are becoming more numerous and bigger. In addition to the hundreds of commercial vessels, thousands of recreational vessels can be intermingled within the busier harbors. Consequently, the stage is set for potentially catastrophic accidents, loss of life, and severe detrimental impact on the environment.

This problem is made even timelier by the events of September 11, 2001. Many countries that routinely move goods in and out via the maritime port system are now closely examining their security precautions for shipping and vessel traffic. Some countries are almost completely dependent on the maritime commerce infrastructure system to keep their economies operating. They must seriously consider and plan for the security of their ports to prevent possible de-stabilization in the event of an attack.

In this paper we introduce a comprehensive information system for supporting maritime traffic and commerce and explore the information-systems- related research opportunities associated with such a system. The paper begins by reviewing the existing dominant technologies deployed in the maritime environment (Section II). In Section III, the paper describes a comprehensive system called the Automated Identification Systems (AIS) being proposed by the maritime industry, military, government, and The International Maritime Organization. A deployment scenario, in Section IV, highlights how such a system could have unintended consequences if not carefully designed and deployed. The paper concludes (Section V) by briefly examining several information-systems-related research opportunities surrounding the design and deployment of the AIS.

Given that little research is leading the design and deployment of the AIS, and given the critical role the worldwide maritime industry plays in commerce, this paper provides a foundation for others to begin the examination of this important area.

II. WATER UNDER THE BRIDGE

Three core technologies underlie the new Automated Identification System discussed in this paper:

- Very High Frequency (VHF) Radio,
- Radar and
- GPS technologies.

Each of these technologies was developed and used in turn throughout the past 50 years. However, it is by combining these technologies that an automated identification system is created and the problems and issues discussed in this paper are observed. In this section we provide a brief history of each of these technologies to illustrate their individual strengths and weaknesses.

VHF RADIO

Prior to 1941, telegraph stations were the norm on all commercial marine vessels. These devices were cumbersome and unwieldy, but were minimally capable enough to transmit weather reports from shore stations and, with intermittent success, ship-to-ship communications. In the early 1940's, marine radio became the backbone of the maritime information system. It was in the late 1930's that the Federal Communications Commission in the United States released the Very High Frequency (VHF) spectrum for commercial use. Mainly in response to the needs from the commercial airlines, the first VHF radio was delivered to a commercial airline in 1941. Ironically, later that year, the attack on Pearl Harbor occurred and sparked the U.S. military's and the maritime communities' interest in VHF [Anonymous, 2001].

The marine radios were used specifically for voice traffic and their use was tightly managed by the FCC and, for maritime use, the U.S. Coast Guard. These radios greatly advanced the capabilities of communication; however, there were still drawbacks to these devices. For example, range was always an issue. Many of the smaller, less powerful radios could only send and receive from short ranges (5 - 7 km). The range of the more powerful versions, and subsequently better designs later in the 1950's and 1960's was 30 – 40 km. While on the open sea the added range was useful to be able to hail passing vessels when in trouble. It started to become troublesome because of too much voice traffic on the radio. This overload was especially problematic when the vessels were headed into port where a large number of vessels were present. With every cargo ship, tug boat, commercial vessel and now recreational yacht calling on the radio to everyone else (i.e., "chatter"), it can be understood why the radio, in and of itself, was not the "silver bullet" for marine communication systems.

RADAR

Beginning in the late 1940's, *RAD*io *D*etection *A*nd *R*anging (RADAR) began to be developed maritime industry use. Radar by definition is a system that uses reflected electromagnetic radiation to determine the velocity and location of a targeted object [Academic Press, 1996]. With radar, it became possible to "see" other vessels, in real time, even at night and in inclement weather conditions such as fog, rough seas, or rain). Shipboard radar was also used to identify geographical points, land masses, and approaching weather systems. The range on these systems varied historically with size and power, but now can be as far as 150 km.

However, there are drawbacks to radar's method of identification. Unless the vessel assigns a person to work full-time tracking the radar "contacts", the ship is not able to discern the heading (direction) in which the contact is going, nor will they be able, without significant calculations, know how fast the contact is moving. Heading and speed are obtained by plotting information about where the other vessels are. Ships are never able, without very sophisticated and classified military systems, to determine from the radar image alone just what type of vessel that "contact" is. So, with radar, it is possible to know something is out there, and roughly where it is, but it is not possible to know exactly what it is or where it is going. Further, as with radio "chatter", as more and more marine traffic came into operation, the radar "contacts" increased in number and frequency; causing many radar screens to be almost painted white when coming into a busy port. The many different "contacts" render them virtually useless.

GPS

More recently, the advent of the Global Positioning System (GPS) became one of the most significant advances in maritime navigation and safety. The U.S. Military released GPS technologies for commercial use starting in late 1980's; it was then brought to much wider public attention after its very successful use in the Persian Gulf War. The European Union is considering building its own GPS system, currently called *Galileo*. In a GPS system a receiver unit (currently down to the size of a deck of playing cards) receives a signal from, at a minimum, 3 geo-stationary GPS satellites. Upon receiving these signals, the GPS calculates its own position through a geometric process called Trilateration (using known distances from other known points to determine the receiver location). This data is presented in the form of latitude and longitude values. The accuracy of commercially available devices (ones) is now down to a margin of error +/- 6 feet.

Prior to the development and use of GPS, mariners were forced to use a system of estimation to determine their locations; and even then those estimations could be off by several miles. In the open ocean, all the water looks the same. While the GPS solution helps the individual vessel know where it actually is at all times (a major benefit from a navigation standpoint) it really does not do anything to address issues related to other vessels and objects in and around the water. The crew of a vessel still cannot "know" who or what the other vessels are around them, even though they precisely know their own vessel's location.

III. THE NEXT WAVE

In 2000, efforts began to combine these disparate systems and create, in some form or fashion, a consolidated and efficient Maritime Identification and Information System. This prototype environment is called the Automated Identification System (AIS). Figure 1 is a schematic of this system[1]. The AIS is a combined effort of the maritime industry, military, government and The International Maritime Organization (IMO - the governing body that sets Maritime policies and regulation standards) to come together and develop a standard information

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[1] This image was provided by TransPonder Tech, a division of SAAB, and presented at the first international workshop for AIS, Seattle, WA USA October 2001.

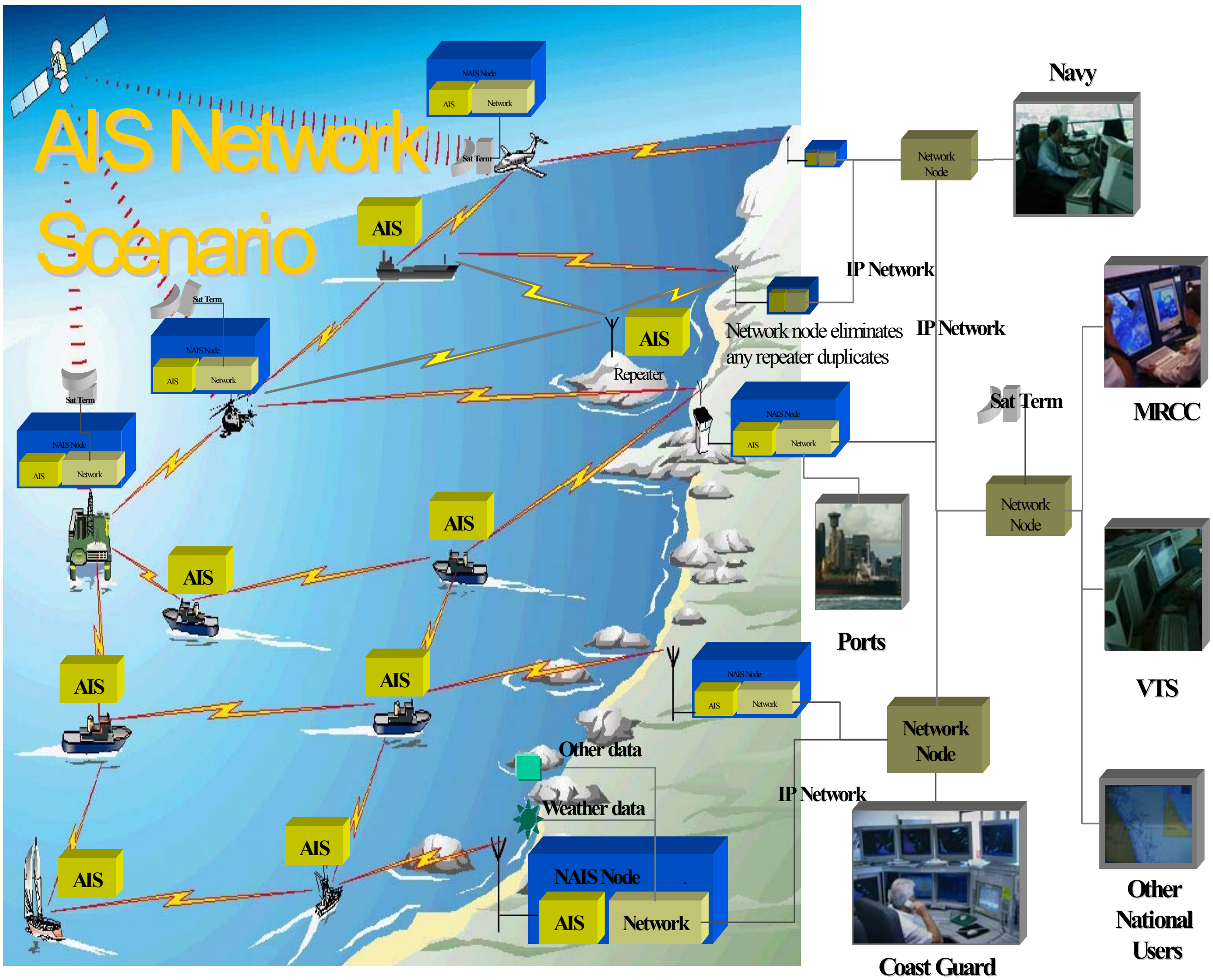

Figure 1. IS Scenario

system by which all relevant marine traffic data can be identified, and that also makes pertinent details about a vessel available to all other vessels in the area, and vice versa.

The three core components to the AIS system are:

1. A device for communications (on vessels and other points that might be necessary to identify).
2. A system that is integrated into the existing vessel's other information systems (such as radar, navigation, and autopilot).
3. An infrastructure and standards environment to support the data generated.

The device currently under development to meet the communications goals is called a Marine Transponder System (MTS), which is essentially the ears and mouth of a vessel's AIS system. This communications device, using the principles of ad-hoc networking (roaming network "nodes" form networks for communication when they are within range of each other), use two different VHF communications channels on two separate but integrated VHF radios (one for sending data and one for receiving). The MTS will automatically broadcast the core information set for the vessel at predetermined intervals while the vessel is underway. When other vessels or locations similarly equipped come within a preset range for each for a given MTS (ranges can extend to almost 30 km), then data is exchanged and a peer-to-peer network for data exchange is formed.

Since the MTS is integrated into the various ship systems (such as GPS, radar, and navigation.), the data from these systems (such as course, heading, speed, vessel weight, call sign, GPS location), can be sent automatically to other ships and ground- based AIS receivers within range. Each vessel can then take the data broadcast from other vessels in the area (and/or from fixed location stations such as channel markers or lighthouse beacons) and combine it with their own radar display images (as an overlay) to obtain a complete informational representation of their surroundings of all vessels within range.

The benefits of this combined technological system are enormous. With previous tracking and navigation methods, radio communications and manual note taking were required to keep track of vessels in the vicinity (i.e., everyone radioed their current locations back and forth). With an AIS display, all the transponders within range can be tracked automatically. Radar images that were complete mysteries (i.e., is that smudge of green on the screen a vessel coming towards you, going away from you, a finger of an island jutting out into the ocean, a fog cloud, or something else?) can now be verified automatically when the radar image is overlaid with the AIS data being obtained from the other transponders within range.

These AIS systems, while quite good, are not a perfect solution. Thus, opportunities exist for further research (Section VI).

Figure 2 shows an actual Radar/AIS image from a Vancouver, British Columbia, Canadian Coast Guard Vessel Traffic System (VTS) monitoring the harbor area approaching Vancouver, BC.

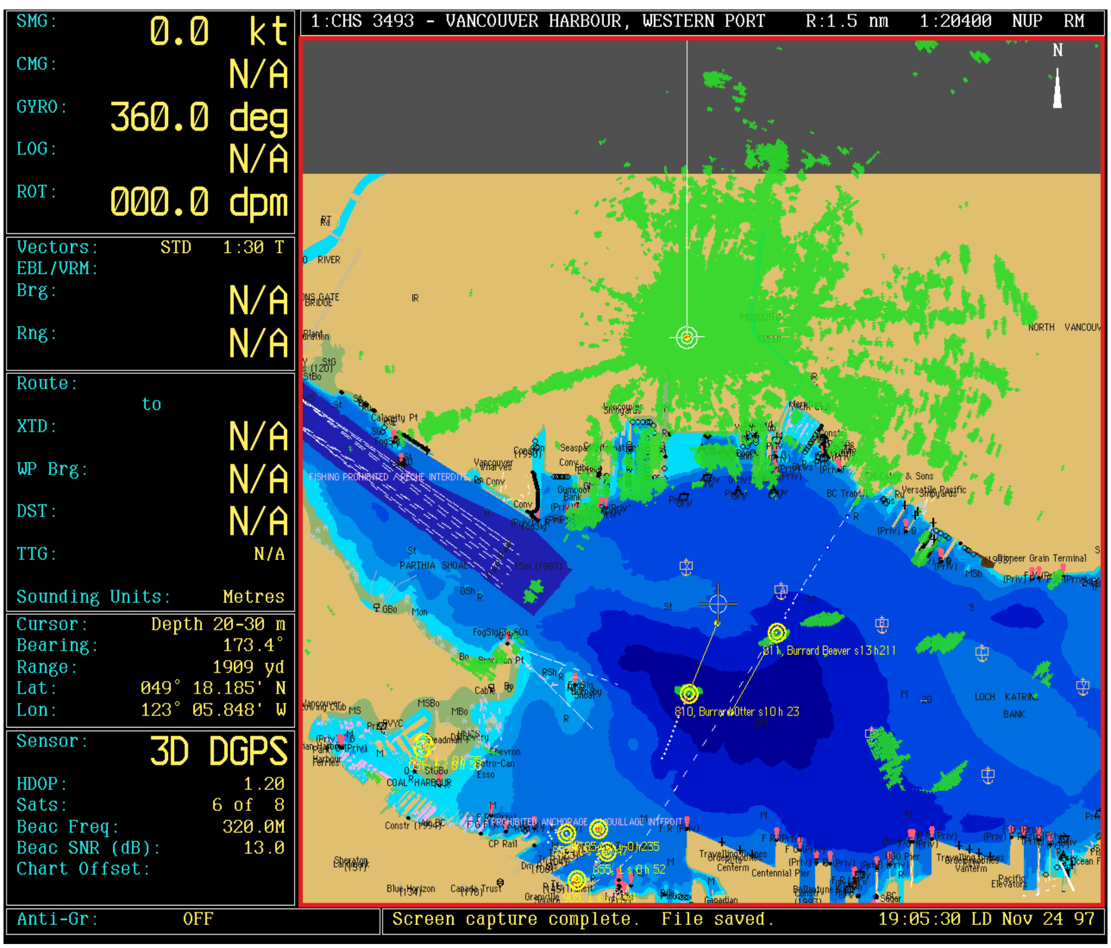

Figure 2. Radar Image

In Figure 2, the smaller green icons with the yellow rings (use ZOOM IN in .pdf and expand to 300% or larger) in the middle lower section of the image are actually ship icons. Associated text is displayed, on screen, showing course, speed, and other parameters. The other green 'smudges" around these two ships could potentially be other vessels, land masses, or mist banks. However, there is no real way of knowing that precisely. This data/image was gathered from a prototype AIS system developed for the Asia Pacific Economic Conference in November 1997. This system was used to track and manage the Coast Guard vessels available on the water to reinforce security for the AIS conference.

This type of system came under intense scrutiny in 2002 by many security organizations around the world, most significantly the newly formed Office of Homeland Defense in the United States. The Office (slated to become a Department) is investigating the use of AIS systems for the protection of harbor cities and shipping channels against terrorist operations, smuggling, and illegal immigration coming in from the oceans.

IV. WATER, WATER, EVERYWHERE

If the AIS design was specific to one country, or one company for that matter, the issues facing this effort would hardly appear daunting. However, since the goal is to create an industry-wide, global consortium and agreement around the standards of information type, transmission and design for AIS, issues both large and small are yet to be investigated. To understand the broader range of challenges facing this effort better, a scenario of how the systems are supposed to operate versus how they might actually operate, highlighting areas for further exploration, was created by the first author of this paper. The scenario is a description of how such a system might be operationalized.

SCENARIO: THE HMV "*LEAKY BUCKET*"

Capt. John Whetts headed down to his fishing trawler the "Leaky Bucket" to head out for his six week stint in the Kenai Peninsula fishing grounds. He started early in the month of July from the port of Seattle and headed up into the inside passage, and via Canada, on up to Alaska. The fishing season isn't very long and he had to maximize his time on the ocean.

He'd just refitted the Bucket with new electronics and installed a new AIS system that the local Coast Guard had said he'd need in order to pass inspection. He wasn't certain how it was supposed to work, given that he had been provided with only a user's manual and no hands on training before he headed out but the gist of it was that he would be able to "see" other ships that were around him and they would be able to see him and know who and where he was at all times. The system was supposed to keep him and other vessels from running into one another around the ports and on the open ocean. He thought to mention to the "coast guard fella" that he hadn't "run" into anybody in thirty years of fishing, but he didn't want to make any trouble and, who knew, the system might be useful down the line.

As all the ship systems were finally powered up and the first mate, who went by the nickname of "Dipper", gave him the "all clear" signal, Capt. Whetts pressed the throttle. As the engines thundered to life, he pointed the trawler out into the Puget Sound from the Shillshole docks. The radio crackled with chatter from the other shipping traffic in the area. Whetts hailed the Coast Guard "…this is Capt. John Whetts in the Leaky Bucket, headed out of Shillshole docks for Alaska, over…" The Coast Guard responded "… Leaky Bucket, Leaky Bucket, we have you on our screens. No other commercial vessel traffic in your area. Weather indicates fair winds and following seas. Good luck Whetts, stay dry in the Bucket, over and out…"

Whetts then took some time to look at his radar and navigation system that now boasted the latest in AIS and high resolution graphics. When the screen came up, Whetts called Dipper to the bridge with a yell. "What do you *see on the screen, Dipper?" asked Whetts. Dipper peered at the screen and said, "Looks like we have clear waters for the next 25 miles, Capt." Then Whetts looked out the forward bridge windows and said, "Now what do you see out there?" Dipper looked out and exclaimed in surprise.*

Hundreds of different types of watercraft, of all shapes and sizes, as far as the eye could see, dotted the waters around the trawler. Being July in Seattle, the numbers of recreational watercraft (e.g., powerboats, sailboats, jet skis, water skiers, kayakers) out in the sound was amazing. But not a single one of them showed up on the AIS screen. This seemed strange because the AIS systems was supposed to be able to provide accurate GPS coordinates, speed, heading and other pertinent info, on other vessels, into his navigation systems automatically. Whetts thought back to a previous conversation with one of the Coast Guard officials and recalled that he had mentioned that the recreational watercraft were not yet required to participate in the AIS system. "Seems to me," Whetts said to no one in particular, "that these are the exact vessels that need to be carrying some kind of device like the AIS system. I'm a lot more likely to run over one of them than another vessel my own size. Wonder what bureaucrat made that brilliant decision?"

Whetts steered the ship out of the crowds of recreational boaters and headed north, past the San Juan Islands towards Alaska. Over the course of the next few days, every now and then he would get an image on his AIS system of a ship in the vicinity, and could actually see who they were and where they were headed, whereas before he would have seen a radar paint of something, and then had to rely on radio communications and binoculars to determine who and what the radar image was. This came in very useful early one morning when Whetts identified a massive oil tanker, The Gusher, bearing down on them in the pre-dawn light. While he could not see the vessel physically, as soon as the tanker came into range of the AIS system, all the relevant data for the Gusher became instantly available. Whetts saw the speed and direction the Gusher was headed, and was able to steer to avoid the tanker on the portside and also the rocky outcropping 100 meters off the starboard bow, which also showed up via the AIS system. That rocky outcropping had an AIS Transponder system installed for just this kind of situation, but interestingly enough, the outcropping hadn't been picked up by the ship's radar system, so without the AIS system, he would have never known it was there… The system certainly showed some value that foggy morning.

Two weeks later, Whetts and Dipper were a day away from their secret fishing area and Whetts remarked on how strange the trip had been with these new electronics. Aside from not seeing any recreational boaters on his screens (apparently they did not have to carry the devices) and having to dodge them all visually, he'd nearly been run down by an aircraft carrier that he saw on the radar, but couldn't tell what ship it was and where it was headed until it was almost on top of him. For some reason, the military didn't seem to have to use a transponder system either.

And then finally, just two days ago, another unidentifiable blip had come upon them in the early morning and he'd awoken to shouts and jeers from an activist group's vessel out protesting the harm to the environment that the commercial fishing industry was causing. Again Whetts looked at the radar/transponder system and saw that the vessel image was totally without information.

"Well, that's OK", he said with a sigh, "We're here, finally, and can start casting lines in the morning." They rounded the last stretch of rocky coastline to the deep, secluded cove that the Whetts' fishermen had been fishing for over 60 years. They anchored and prepared the lines for the morning and got to their bunks early. It would be a long day tomorrow.

When Whetts came onto the deck of the Bucket the next morning and looked around, he dropped his coffee mug right over the side. Where normally there would be nothing but wind and waves, he counted 22 other fishing vessels, all currently casting lines and nets in his secret spot! He sputtered and ran onto the bridge and yelled at Dipper, "Did you see them come in? Why didn't you wake me?" Dipper shrugged and said, "I thought maybe you had shared the location with them, so I didn't think to mention it." Whetts sputtered, "But how did they find us? I never told anybody where this place is!" Dipper looked out and said casually, "Well, if I was them, I'd probably just be following our AIS transponder signal. Since they knew you had a secret spot you fished, and they could know which vessel was yours because most of them carry one of these AIS systems, all they had to do was wait till you came through the area and then follow us in."

That afternoon, as they pulled in the lines with far fewer fish than they normally would have, Whetts was determined to better understand this new technology he was being forced to use. He had seen firsthand how it could work for him and also, unfortunately, how it could work against him.

V. RESEARCH OPPORTUNITIES

To understand and best develop and manage the AIS system fully for people like Capt. Whetts and others, this effort should be guided by IS research. This area provides an opportunity to engage in research that is both rigorous and relevant. This emerging area provides researchers with both a relevant context within which to work and exposure to a dynamic and undetermined technology [Benbasat and Zmud, 1999]. For those whose research takes them even closer to the practitioner side, such as Action Researchers, this area is ripe for investigation. Using the research categories of Organizational, Behavioral, Systems Development, and Technical, we briefly discuss

- the relevant research issues and implications
- IS theoretical frameworks that could be used to investigate and guide this initiative

These research opportunities are summarized in Table 1.

ORGANIZATIONAL

Given the scale and complexity of this initiative, a number of questions are open for investigation. Our colleagues in the management discipline investigated strategic partnerships and value creation intra-organizationally [Porter, 1979, 1985, 2001] extensively. For example, how is such an infrastructure created and organized? What strategic partnerships will and should be created to maximize the effectiveness of such a broad-reaching technology infrastructure? What group of, governmental and commercial entities can and will manage such a vast infrastructure?

This infrastructure potentially touches every country on earth, each with its associated government, defense, and business interests. Perhaps Pfeffer's resource dependency theory [Pfeffer, 1978] could be a framework for investigating the ramifications and interrelationships that will be necessary for such a convoluted meta-organization to be successful. Given that various government agencies, defense departments, business organizations, and vessel crews will be involved, in what way will their dependencies on each other dictate their relationships and exchanges with each other? What effect, if any, will that have on the success or failure of the AIS environment? Further, will AIS become an infrastructure like the Internet, built for one purpose, but opened up and suborned by the commercial masses or will it become like air traffic control?

Table 1. Possible IS Research Opportunities In the Design, Implementation, and Deployment of the Automatic Identification System

Level of Analysis	Opportunities and/or Topics	Possible Approach
Organizational	1. Strategic Partnership impact 2. Resource Dependency 3. Ethical issues	Case Study examining relationships between different countries. Value Chain analysis of various entities and their interrelationships and interdependencies. Interviews of end users to determine relevant ethical dilemmas and how they are managed.
Behavioral	1. Validation of Technology Acceptance Model 2. Critical Mass and User Acceptance	Survey of end users and survey of instigating organizations Ethnographic exploration of end users in situ.
Systems Development	1. Stakeholder involvement in development of system 2. Variations on SDLC	Survey of stakeholders and/or communication pattern analysis. Case Study of development approach used and apparent critical success factors.
Technical	1. Capacity and scalability for full implementation 2. User Interface Design and validation	Simulations such as of single port, vessel, to determine needs. Delphi Group of key users and then experiment with control for different features.

Mason's "ethical issues of the information age", the PAPA framework (Privacy, Accuracy, Property and Accessibility), [Mason, 1986] can be investigated within the context of these issues as they relate to this system and its infrastructure. Questions of interest might include who owns the data transmitted by the participant vessels through the network? Will every activist or terrorist cell be able to look on the Coast Guard or public access websites and view where any vessel is at anytime and where they are heading?

How are the various navies and defense organizations around the world going to participate in this system? Surely they will want to be able to "see" other vessels, but will they want to be "seen". If they are not "seen", then does that not work counter to the original intent for this infrastructure? Will each military/government control the spectrum on which this infrastructure depends for communications? Will cargo manifests be broadcast for commercial and governmental oversight and use? Can anyone access this data that has the correct equipment? If AIS s is required for all types of vessels, how should it be installed and supported? What are the carriage requirements (what vessels must carry these devices) and how soon will AIS be required? If a vessel does not carry the device, then what are the penalties? Who enforces them? Who pays for that enforcement?

If none of these organizational issues are decided when the first systems are deployed, does that mean that it is doomed to failure from competing standards, lack of commitment, or lack of interest? We can at least say that working with these groups to help them understand more fully the issues they face is likely to have positive effects on the design and implementation of the next generation of AIS systems.

BEHAVIORAL

In the scenario in Section IV, Whetts was told that he needed to implement this new system. Never mind that he did not know the true nature or supposed purpose of this system. Never mind that no training was in place to allow him to understand the abilities and limits of this new technology. He was mandated to carry it. Then in his encounter with the recreational boaters, even though he carried it, the system did not in fact do what Whetts had been expecting it to do. His and other end users' perceptions and acceptance of the technology could be quite appropriately measured by using a Technology Acceptance Model (TAM) instrument. This context could in fact provide a valuable extension to the TAM framework [Davis, 1989; Venkatesh, 2000]. Given that TAM has been used primarily for cases where the technology under investigation was not mandated, it could be the case that unique issues, related to requiring technology, could adversely affect user acceptance and utilization. AIS could, perhaps, be a context in which constructs other than the ones of ease of use and usefulness are important in determining acceptance and use. One could look at variables such as the effects of forced compliance, substitutability, faked usage, and/or agreement with the policy for forced use in this context.

Could an investigation of the technologies involved and the related user communities, grounded in Markus's work with Critical Mass theory [Markus, 1987], provide some explanation as to the reasons behind the users' potential lack of acceptance and utilization? One could argue that the odds are low that this community will broadly adopt these technologies of their own accord. (Remember that most of these users would not be considered technology early adopters). It is foreseeable, even though the technologies are mandated, that there would be so much apathy from this user community that technological inertia would fail to push the systems fully into acceptance and utilization. Could Critical Mass Theory provide an understanding for why and how this technology would have difficulty being accepted?

Would Hartwick and Barki's roles of user participation in information systems' use still apply when the system/technology is mandated and the users are basically ignorant of the system's value and are not stakeholders in the direct sense [Hartwick and Barki, 1994]? As users did not participate in the systems development or implementation, they could be believed to have no vested interest in the technology, even though it proposes to save lives and property on their behalf. Would apathy or outright hostility result in a lack of user acceptance? It is possible, but further investigation would be necessary to show it either way.

SYSTEM DEVELOPMENT

The development process for the AIS system, even in its initial prototype phase, followed anything but the traditional systems development life cycle approach. The idea for the AIS system was originally brought up for discussions in the mid-1990's between the International Maritime Organization and the International Convention governing Safety of Life at Sea (SOLAS). Its original intent was to support mariner safety and reduce collisions between vessels at sea and also assist in emergencies. A group of international maritime equipment providers, in conjunction with the Coast Guard, proposed AIS implementation for all SOLAS governed vessels on the oceans.

This consortium started several different projects in countries around the world. Over the following few years, as the research progressed, the IMO decided to re-investigate the AIS efforts and attempt some standardization so implementation could occur. However, many countries had invested in competing technology paths while awaiting the decisions from the IMO, and so would not be compatible with the new standards that have recently been released. In approximately 1998, a carriage requirement schedule for AIS systems was adopted as part of the most recent SOLAS Convention.

Given that thus far in the development of this infrastructure, the end users (vessel captains and maritime community at large) were not consulted nor involved in the development cycle of this technology/infrastructure, what ramifications will that have on the usefulness of the technology? If this development project was looked at through the lens of the traditional SDLC, it might be found to have been conducted completely without the feedback loop from the vessel captains and maritime community that the technology and infrastructure were meant to serve.

The research would look at whether running, counter user-centered design approaches affects the quality of the design.

TECHNICAL

Many technical issues still need to be resolved; for example, user interface design for AIS data representation, data management and storage for vessel traffic, and data transmission and capacity planning for the ad-hoc VHF networks. These examples are merely representative of the broader technical issues in user interface design, network analysis, and implementation. Figure A1 (in the Appendix) shows two vessels labeled and two potential vessels (radar images) in the screen. Imagine now that regular traffic patterns were in effect and there were over 60 radar images, representing vessels, displayed on the screen. How can an operator, navigator, or vessel traffic management specialist be expected to deal with all the vessels that would appear on a screen image? What size should the radar images be, once they are corroborated with the AIS data? Should imminent collision warnings systems, similar to IFF systems in commercial and military aircraft, be added to alert pilots and captains? If not, why not?

Using the example of the networks being investigated, what kind of capacity can be attributed to these randomly occuring, ad-hoc systems? With the proposed additions of email support and possibly streaming media for these networks, can enough bandwidth be present to support current and future needs, or is there an imminent network change coming that will necessitate a hardware change and extra costs?

VI. CONCLUSION

The field of maritime information systems is little studied by the IS discipline. While this industry that has been almost invisible for most MIS researchers, its value and impact on the commercial, governmental, and military organizations is high. As the maritime industry goes through a period of transformation in its creation and utilization of information technology, as in the development of the AIS system, opportunities exist for IS researchers for investigation and participation. Not only are the opportunities great for rigorous investigation and subsequent scholarly publication, but the issues to be dealt with are immediately relevant and highly important.

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REFERENCES

EDITOR'S NOTE: The following reference list contains hyperlinks to World Wide Web pages. Readers who have the ability to access the Web directly from their word processor or are reading the paper on the Web, can gain direct access to these linked references. Readers are warned, however, that

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