AUTOMATIC IDENTIFICATION SYSTEM/ BLUE FORCE TRACKING AFFECTS ON THE VHF DATA LINK

A Project Report

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Abstract

The United States Coast Guard's (USCG) Blue Force Tracking (BFT) system is a part of the Hawkeye project, and initiative aimed at integrating the technology supplying a large scale Common Operating Picture to all Coast Guard and friendly forces assets. The Automatic Identification System (AIS) is a communication system required by law to be equipped on most commercial and Coast Guard vessels. Using an existing software simulation program at the CG R&D Center and available real-world AIS data collected in New York and Seattle, this project's goal is to determine the conditions under which the presence of vessels equipeed with BFT version 2 will cause significant communications disruptions on the AIS Very High Frequency (VHF) Data Link

Table of Contents

Introduction	page 1
Background	page 3
Objective	page 7
System Design	page 8
Results	page 16
Conclusions	page 24
References	page 25
Appendices	page 27
Appendix A: Project Requirement Specification Document	page A-1
Appendix B: Project Support Plan	page B-1
Appendix C: Detailed list of Inputs and Outputs	page C-1
Appendix D: Blue Force Tracker Implementation from R&D Center	page D-1
Appendix E: Project Plan	page E-1
Appendix F: E-mail Correspondence between 1/c McNeil and Mr. S…	page F-1
Appendix G: Results Graphs for Todt Hill	page G-1
Appendix H: Results Graphs for Pier 36	page H-1
Appendix I: Design Specifications	page I-1

Introduction

In a busy port, it is vital that the U.S. Coast Guard (USCG) and its port partners (the Drug Enforcement Agency, local Police units, etc.) maintain awareness of the maritime domain they operate in. As a premier maritime service, the USCG has a vested interest in the safety of all those who use the nation's ports and waterways. The Hawkeye project was created in an effort to develop an integrated port and coastal security system which would supply a Common Operating Picture (COP) to Coast Guard assets. Now the radar, camera, Global Information System (GIS), Automatic Identification System (AIS), and components of the existing Vessel Traffic Service (VTS) and Ports and Waterways Safety & Security (PAWSS) services have been combined and expanded upon to include friendly-forces tracking and encrypted communication capabilities. All of these components fall under the umbrella of the Hawkeye project with the goal of increasing Maritime Domain Awareness

In addition to a maritime safety mission, the USCG must act in a law enforcement role. The USCG often relies on the high visibility and distinctive markings of its vessels to deter illegal activities. However, units must also be prepared to apprehend criminals and investigate potential threats in their Area of Responsibility (AOR). Hawkeye aims at increasing awareness and reducing reaction time to maritime domain threats by supplying a COP, but enhanced awareness is no more critical to unit preparedness than effective communication is.

The USCG has recognized the need to engineer a way to disguise AIS identification of a cutter or aircraft acting in its law enforcement role. This solution is called Blue Force Tracking (BFT) and shares the goal of making unit positions available only to other friendly force assets, like U.S. Navy vessels and port partners. AIS equipment has already been installed on USCG vessels,

so the AIS BFT v2 solution allows a CG unit to communicate over the AIS network with a minimal amount of new equipment installation and crew training. BFT-equipped vessels transmit an encrypted message decipherable only by other AIS-equipped units in possession of the decryption key.

The Coast Guard's Command and Control Center (C2CEN), the engineering command which developed AIS BFT v2, has sponsored this senior design project. The goal of this project is to determine the conditions under which a VHF Data Link (VDL) communications disruption will occur due to transmissions by BFT-equipped vessels on AIS frequencies, and the severity of these disruptions. Theoretical analysis was conducted through software modeling of the VDL, and real-world data is collected from several AIS coverage areas.

Background

AIS is a communication system required by law on commercial and Coast Guard vessels. The AIS network is currently operating at only a fraction of its total communications capacity; New York Harbor experiences a maximum of roughly 400 vessels per diem within AIS receiver range of the shore, yet the theoretical capacity of the AIS VDL numbers in the thousands. The potential exists that an overcrowded VDL could result in the loss or garbling of a vital transmission, with the possible consequence of a vessel collision. Such garbling often occurs when two vessels are trying to transmit their position reports simultaneously on the AIS network. A nationwide VHF radio-based Automatic Identification System (NAIS) has been in development since July of 2005 [2]. As the U.S. government presses to have Nationwide AIS implementation and requires all vessels of certain characteristics to be AIS equipped, and as the USCG expands its use of AIS

BFT v2 within the fleet, VDL interference by BFT equipment may become a serious safety issue.

Modern AIS provides both ship-to-shore communications and ship-to-ship communications within self-organizing cells (Fig. 1). Similar cellular radio and satellite communication systems have been in use commercially and by the military since 1996 [3]. Early researchers examined the use of VHF-radio networks for commercial communications. In 1988, researchers compared Random Access Time Division Multiple Access (RA/TDMA) and Spread Spectrum Code Division Multiple Access (SS/CDMA) network access techniques for VHF radio-based communications [4]. In 1993, the effect of system architecture and channel assignment methods on microcellular radio system capacity was examined [5]. The results of both of these tests indicated that RA/TDMA access techniques and cellular radio networks were a good foundation for a nationwide network like AIS.

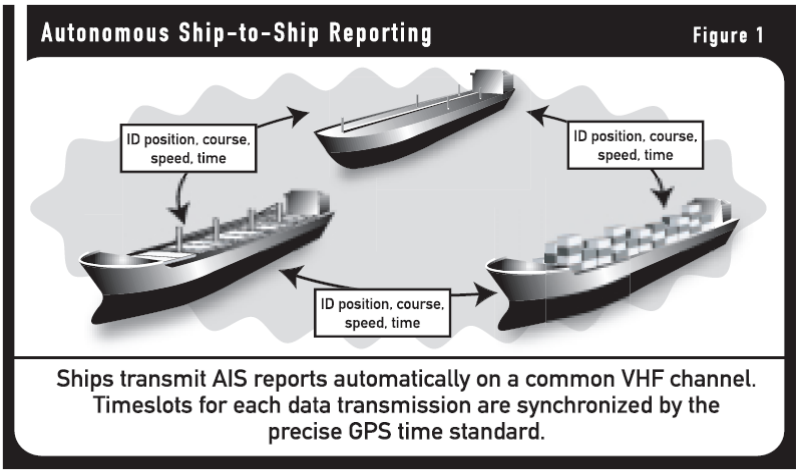

Figure 1: AIS provides ship-to-ship communications [1]

Before large scale systems like AIS were developed, cellular radio communications researchers struggled to test their theories on a real, complex network. Engineers today have recognized that software simulation/modeling methods can provide insight and some control over variables affecting highly complex TDMA systems [6]. This continues to be the standard in VHF communication system research, but requires a thorough examination of relevant parameters, and

careful choices of key term definitions, like ‘capacity’ and ‘saturation’ [7]. It is this type of simulation analysis that has driven most of the research on the Coast Guard’s AIS BFT.

The Coast Guard R&D Center has created a software simulation model of the VDL that can be used to analyze the effects of AIS BFT v2 on the AIS network’s performance. The simulation “permits [these] assessments for conditions that would otherwise be cost prohibitive or hazardous if attempted using actual vessels”[8]. The simulation program, called Universal AIS (UAIS), “is based upon a complex radio protocol, and overall performance is sensitive to variables ranging from signal propagation to number of vessels in an operating area, to UAIS equipment specifications”[8]. The software was originally developed in 2005 in order to assess the impact of the Carrier Sense TDMA standards being considered at that time as “alternative Class B methods for use with the existing Class A AIS technology”[8] . More specifically the simulation was designed “to represent the UAIS activities (broadcast and receive) of platforms whose movements and speeds are defined by vessel position reports (VPR) in a ship-history file”[8]. Blue Force Tracking version 1 devices were implemented in this simulation, but will need to be modified to more accurately represent the rules for AIS BFT v2.

The Coast Guard’s AIS BFT system is an offshoot of the Hawkeye project, a Department of Homeland Security initiative aimed at improving the technology supplying a large scale Common Operating Picture to all Coast Guard and friendly forces assets. Hawkeye will provide:

> “[I]mmediate coastal surveillance capability in a high priority area; offer the Coast Guard and its DHS and local and state partners the means to develop operational concepts; and implement and test the interoperability among Homeland Security and Department of Defense systems and networks”[9]

The sub-system ‘Rescue 21’ was initially contracted with the intent to develop a Search and Rescue voice communication system[]. This contract grew to include a 6-frequency VHF BFT requirement, but there was a change in system requirements. The responsibility of developing a different BFT system for the Coast Guard was given to C2CEN. By using existing standards for AIS, C2CEN was able to engineer BFT that was not just for sector-oriented response, but could also be equipped on any non-Deepwater vessel above 65 feet in length, with a minimal amount of new equipment or training required.

In order for C2CEN’s AIS BFT equipment to be operationally compatible with the standards for all international AIS systems, the design had to be in accordance with IALA’s Recommendation ITU-R M.1371.1. This document defines important technical terms and establishes the rules by which standard AIS electronic equipment shall operate. It describes the twenty-two message types which can be transmitted across two AIS VHF radio frequencies (AIS1: channel 87B, and AIS2: 88B) in ‘dual-channel operation’ over a Time Division Multiple Access (TDMA) network. The AIS equipment is referred to as either a mobile or stationary unit[].

There are two classes of AIS mobile, A and B, and a base station unit, that operate in following with the IALA standards document, ITU 1371.1. The ITU standards document does not define the Coast Guard’s BFT equipment’s technical characteristics; it was up to C2CEN to determine the manner in which AIS BFT v2 would make use of these existing AIS standards. Working within the existing international standards for AIS equipment, C2CEN was able to create and deploy a Coast Guard-specific BFT solution.

The AIS mobile equipment equipmenton CG vessels is neither a Class A nor Class B mobile, and its behavior on the VDL depends on which mode of operation it is in (normal, encrypted, or hybrid).

In encrypted mode, the AIS mobile transmits 128-bit encrypted messages of type 6 and 8 (general and addressed binary broadcast messages, respectively) over AIS 1 using a Random Access TDMA scheme (RATDMA). RATDMA communications do not reserve a time slot on the frequency, but instead transmit at what was an unused slot last frame. The data contained in these encrypted transmissions includes a dynamic vessel position report, a static and voyage related data report, and Target of Interest (TOI) identification information. Each type of data has a variable update rate, as this AIS mobile is not bound by the strict update rates outlined in ITU1371.1. TOI information is usually transmitted every 45 seconds, static position data every 60 seconds, and dynamic position data every 15 seconds.

Working in parallel with the design and development ongoing at C2CEN, the Coast Guard R&D Center created a software simulation model of the AIS VDL. This model was used to test the performance of existing AIS mobile and stationary units, and eventually BFT equipment was incorporated into the model. This simulation has not yet been used to analyze the effect that BFT traffic will have on AIS system performance and loading. The R&D Center's simulation model needs to be updated with current AIS BFT v2 specifications before it can be used in current research.

The basic background of the AIS BFT v2 technology and an understanding of the progression of cellular/AIS network analysis that has been done to date is vital to this project and future research. AIS BFT v2 is a product of the Hawkeye project, and is designed to be operationally compatible with the standards for all international AIS systems. The Coast Guard R&D Center's software simulation model of the AIS VDL will be used to analyze the effects of AIS BFT v2 on the AIS network's performance without interrupting its operation.

Objective

This project determines the conditions under which the presence of vessels equipped with AIS BFT v2 could cause significant communications disruptions on the AIS VDL. The Coast Guard engineering community will be able to apply the results of this project to define the operational limits of the current AIS BFT v2 implementation and system capacity. C2CEN, the project sponsor, has a documented theoretical analysis based on current operational data which can be provided to policymakers and lawyers as a guide to the capacity limitations of the system. As the use of Blue Force Tracking equipment expands in the Coast Guard and other national maritime assets at the federal, state, and local level, it is critical that both operators and engineers understand the limitations of the technology, and the conditions which affect its performance. In order to find the most operationally appropriate results, it is critical to first define important, subjective terms and then perform theoretical testing in order to reach valuable conclusions.

The requirements of this project focus on determining the length of time between a garbled Class A vessel transmission and its next update, as well as the range of this vessel away from the central mobile unit. This project also evaluates communications in a self-organized cell containing a combination of AIS BFT v2 equipped vessels and Class A vessels (see Appendix A, the Requirement Specifications document). The significance of the range/transmission interruption time factors are not to be determined by this project. The length of time before a vessel's next received transmission as a function of its distance from the center of the cell will act as a gauge of the severity of VDL disruption. Theoretical analyses and testing were conducted using a software model of the VDL uplink. The controlled environment of a software model allows for more precise parameter control, including the ability to dictate the number and characteristics of vessels in the self-organizing cell.

System Design

This project's goal was to determine the number and mix of AIS BFT-equipped vessels commercial AIS-equipped vessels that, when operating in the same VHF area of coverage, would negatively impact the VHF Data Link. The project quantified the severity of those disruptions over time.

The design component of this project was encapsulated in the testing phase. Under specific constraints, theoretical analysis accomplished by computer simulation determined the statistics needed to meet this project's goal. This was the best approach because it made use of an existing VDL software simulation developed by the R&D Center. The software has inputs from three text files, which come from "an application which provides tools to filter and format actual AIS reports to create 'scenario' files as the main inputs to the simulation"[8]. The application also provides the capability to modify transmit and receive characteristics of individual units, control a set of simulation variables, and initiate the simulation runtime. Once the scenario begins,

> "The simulation reads filtered data continuously throughout the duration of a scenario run. Each time an AIS unit is 'updated' by a VPR, it is updated in the simulation. During the time between updates, the simulation assumes that a unit has no changes in speed, reporting interval, or rate of turn. The simulation provides dead-reckoning track inputs after an interval defined by the user. Any ship that is not updated by an input file VPR line (not a DR value) within a user-selected time-out interval is removed from the simulation."[8]

Input for the simulation can be either manually entered, or, by selecting a port of interest, recent real AIS vessel tracks and position reports can be collected and merged to create extremely high-density vessel traffic scenarios.

The parameters of the software simulation may be divided into several major element categories: type of AIS unit, location and motion of each AIS unit, installation characteristics of each AIS

unit, and transmitted signal attenuation between any two AIS units [8]. A more detailed list of the input and output parameters is provided in Appendix C. The simulation does not include algorithms to model bit stuffing, synchronization analysis tools, or adjustments to account for propagation delay – all of which the real AIS system includes. The software simulation's output log file distinguishes between the several reasons that cause a broadcast message to not be received. These reasons are:

- two or more transmissions were received simultaneously,
- the reference ship was transmitting at the time the broadcast arrived,
- the broadcast was below the detection sensitivity of the unit (due to range, blocking, or other signal corruption),
- receiver was awaiting a two-slot transmission, such as used by AIS BFT v2 equipped vessels [8].

The R&D Center's software simulation was precisely the tool to properly conduct a theoretical analysis of AIS BFT v2's affects on the VHF Data Link. However, since the existing BFT representation had been implemented prior to the release of AIS BFT v2 in the CG fleet, the representation needs to be updated to most accurately represent the AIS BFT v2 system. This is accomplished by revising the R&D Center's BFT implementation document (see Appendix D). Theoretical testing was done on a laptop provided by the USCGA ECE section and one of the R&D Center's more powerful P.C. platforms for batch processing.

Unit and Integration testing of the UAIS simulation software had already been conducted in past years by the Research and Development Center. Acceptance testing, designed in this project, determined the VHF Data Link loading conditions under which a class A AIS-equipped vessel's position reports were interrupted due to BFT-equipped vessel presence, the duration of the

interruption, and the range of the vessel whose report was missed from an arbitrary reference ship. Ultimately these statistics determined the severity of the impact that BFT-equipped vessels have on normal communications between class A vessels over the VHF Data Link.

Three people were involved in implementing this design solution. The Test Lead provided the direction for testing by using their understanding of the requirement specifications, carried out the actual testing scenarios, and validated results. Two Data Analysts set up and manipulated the data and the simulation prior to testing, and demonstrated how to analyze the results obtained.

Testing took place at the USCG Research and Development Center at Avery Point. The simulation software and raw data had previously been collected there. For the basic testing to be completed, 86 simulation scenarios were run in order to meet the requirement specifications. A brief description of all the test runs completed is provided in the table below (Table 1). Note that each phase will be run once for Todt Hill data and once for data from Pier 36.

Test Phase	**Description**
1 Establish a maximum Class A capacity	Start with 0000 data and add additional hours up to 2300
2 Establish Baseline Data Set 1	Examine statistics for the single hour of most vessel traffic
3 Add extra vessels to Data Set 1	Add Class A vessels in increments of 50
	Start over with the Baseline Data Set, then add BFT vessels in increments of 50

Table 1: The Three Testing Phases

The tests listed above take real AIS vessel track information from July 25th, 2006 at the Todt Hill receiver in New York and from December 7th, 2006 at the Pier 36 receiver in Seattle. Both of these 24-hour data streams were selected because they are representative of the highest daily

vessel traffic levels for each area. New York harbor experiences a maximum of about 400 vessel tracks per diem, and Seattle harbor ranges from 200-250 maximum tracks. For high traffic density simulations, these 24-hour data streams were compressed into one-hour scenarios. For lower traffic density scenarios, specific hours were used from the 24-hour data stream. For all scenarios, additional vessel traffic was imposed on to the original data set from December 14th, 2006 at both Todt Hill and Pier 36 receivers. This is done in order to maintain separation between the variable tracks (the ones which act as BFT-equipped vessels or BFT stand-in class A type vessel) and the original data sets (all set to act as Class A type vessels).

The decision process which led from the project's requirement specifications as ordered by C2CEN to this Test Plan design is outlined in the System Design flowchart in Diagram 1, which comes from the Design Specifications document found in Appendix I.

REQUIREMENTS:

UNDER WHAT CONIDITIONS || WOULD A SHIP'S || REPORTS BE INTERRUPTED

TRANSLATION TO SIM:

- Power conditions
- Traffic conditions
- not weather or environmental conditions

- single vessel-centric simulations are a possibility
- or reports can be generated for a whole local traffic focus

We also want to see a worst case scenario in which the system is overloaded. It would never be overloaded with BFT unless it is implemented on a nationwide scale, which negates any benefit of encrypted communications.

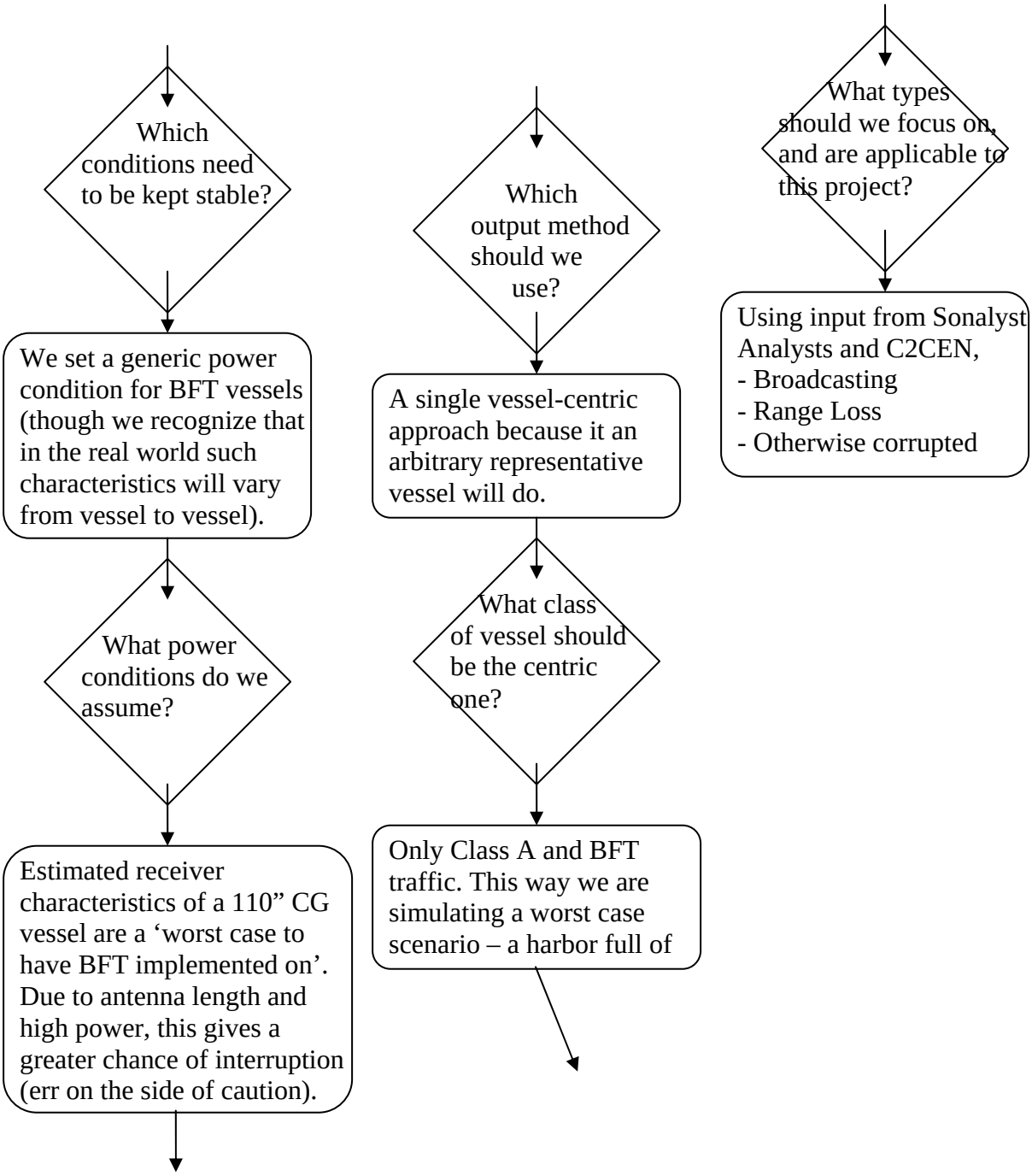

Diagram 1: Test Plan Decision Process Flowchart (Part II)

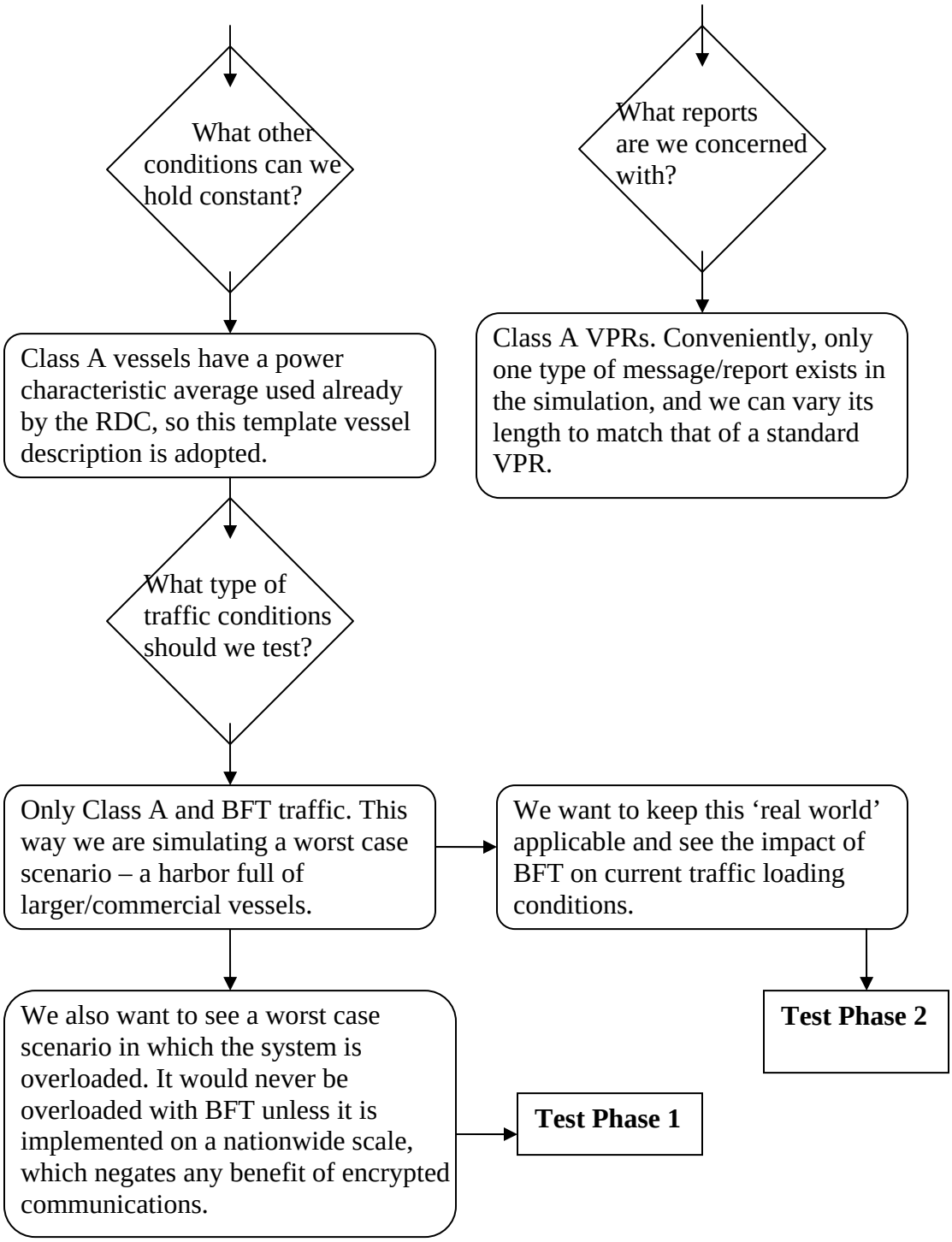

Diagram 1: Test Plan Decision Process Flowchart (Part III)

The criteria which factored most into the decision to use this system design solution were Economic and Sustainability considerations (see Support Plan, Appendix B). Economic concerns included achieving the project's goals on the budget available to the ECE Section and C2CEN. Sustainability considerations encompass keeping track of the methods used, to be expanded upon and revised in a way that will assist in answering similar future questions.

The economic considerations of the project included a minimal budget. As the need for funds arose, requests for those funds were addressed to one of the two main sources of funding: either the project sponsor (C2CEN) or the Electrical and Computer Engineering (ECE) section. The specific expenditures were the cost of contractor support (40 hours between two Sonalyst, Inc. Analysts) and the cost of travel to and from C2CEN in Norfolk, VA for two people. Both expenditures were covered by the project sponsor, C2CEN (see Support Plan, Appendix B).

The sustainability issue for this project is the repeatability of results and the ability of the project's methods to be adapted to later modifications/extensions of the AIS BFT equipment. Documentation on this project will be stored at the USCGA and submitted on Compact Disk to C2CEN. The age of the modeling software is also an issue; if it is to be used for any prolonged period beyond the scope of this project, the need exists to update the program to enable it to run on faster machines (improving efficiency) and to add a graphical user interface. This is not a requirement for the project, but a consideration for future expansions on this theme.

As a project that will determine numbers used by Coast Guard lawyers and policymakers to justify the extensive use of the AIS BFT v2 technology, system design considerations for this project included ethical, social, political, and privacy factors. The political considerations are the interest of the developers and command at C2CEN that ordered the development and deployment

of the AIS BFT v2 resource, for whom the safe use of the system is a valid concern. Information Privacy is not an issue for this project as all of the information for the 'real track' simulations will be data that has already been broadcast for use by AIS. The exact types of data that are collected to create these 'real track' simulations are simply vessel course and speed. All other data is electronically generated and is subject to the Freedom of Information Act (FOIA). The simulation model is government owned software and not proprietary.

Results

The results for this project are broken up into three testing phases. Full results charts for all simulation scenarios run can be found in the Results Graphs for Todt Hill (Appendix G) and the Results Graphs for Pier 36 (Appendix H) . The Microsoft Excel data files which used the UAIS simulation output to generate these results charts are provided on the Compact Disk accompanying this project paper.

<u>Test Phase 1</u>

Although determining the maximum capacity of the AIS VDL is not directly part of this project's requirement specifications, it makes sense during testing to look at a worst-case scenario for VDL loading. Phase 1 sought to do this, since in no previous research has the upper boundary of a vessel-to-vessel communications network been reached.

Since AIS VHF radio operates on two channels, each with 2250 slots per minute, the simple answer to the question of maximum capacity would seem to be that 4500 slots would be available each minute. Class A AIS mobiles transmit for one slot once every 3 minutes at least

(faster reporting rates are required with an according increase in vessel activity), so the maximum number of vessels that should theoretically be able to communicate over AIS in any given minute within a single VHF radio cell would be 135,000.

However, as with any radio communications system, there are transmission losses due to range, time delays, and other common network activity which cause communications to act in a less than ideal manner. As communications traffic increases, these losses compound exponentially as the result of congestion. Therefore, we could not assume that 135,000 vessels is the true maximum capacity of the AIS VDL – we had have to test it. Since Todt Hill simply had ever experienced vessel traffic conditions like those we were looking to examine, we made use of the UAIS Simulation's ability to compress multiple hours of traffic into a single hour. Using this process, Phase 1 of the test plan compresses 24 hours of traffic data into one hour, generating artificially high traffic density scenarios.

Results are presented using two basic graphics. The bar chart in Figure 1 shows total transmission losses broken down into their respective range away from an arbitrary Class A reference vessel. This shows the range at which transmissions from any of the other vessels in

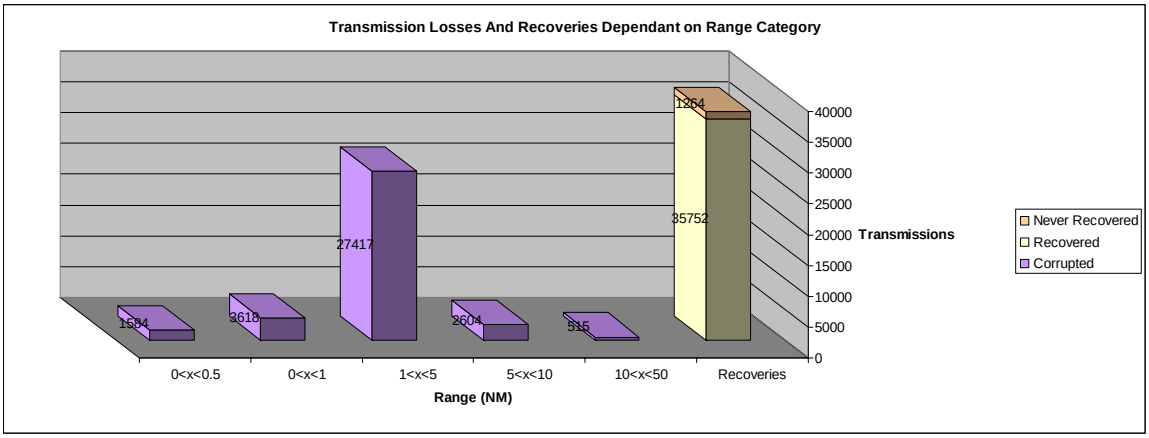

Figure 1 : Transmission Losses for the 0000-2400 Todt Hill Test Phase 1 Data

the area were lost due to the type of interference (corruption) which the presence of a BFT mobile unit would cause. Figure 1 also includes a bar showing the total number of transmissions which were recovered and those which were permanently lost. Permanent loss of a transmission might be due to the reporting vessel going outside of the range of the simulation, turning off their AIS equipment, or the scenario ending before their loss is recovered.

The star chart in Figure 2 shows the maximum duration of transmission loss in seconds, and is divided up unto the same range categories as the bar chart in Figure 1.

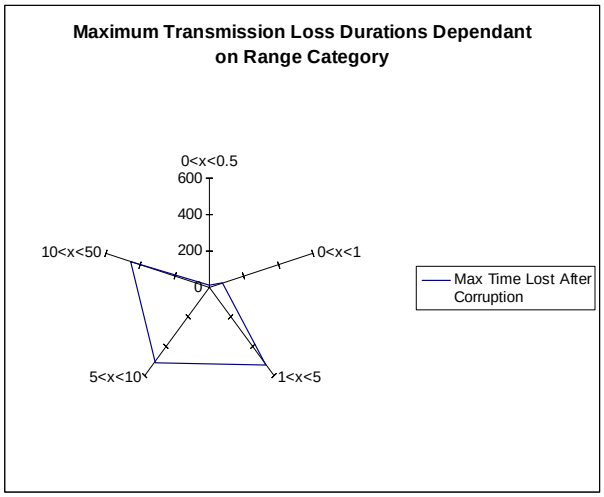

Figure 2: Maximum Transmission Loss Durations for the 0000-2400 Todt Hill Phase 1 Data

Since we are concerned with the range between vessels at which loss of communications would risk a safety of life issue, results for the less than 5 NM range are most likely to be critical.

Thus, for the full twenty-four hours of the Todt Hill Phase 1 test data, the total transmission losses due to corruption in the 1-5 NM range(as observed in Figure 1) is 27,417 losses, 4,202 of which were occurring in less than 1 NM range from the reference vessel. In the 1-5 NM range, maximum transmission loss duration in was 530 seconds (about 8.8 minutes), and was up to one minute within the less than 1 NM range.

This shows that although the estimate had been that about 135,000 vessels should be able to communicate over the AIS network at a given moment, the effects of congestion and less than ideal circumstances have already become apparent at just over 9,000 vessels. Even though we still can push the AIS network further, this test phase has sufficiently established a reasonable upper boundary for safe communications.

Due to the eccentricities of the UAIS Simulation, the Pier 36 data for Phase 1 Testing only has generated results with up to 10 hours of data compressed together into one hour. These results are included in Appendix H but are not analyzed in this report because they have little direct relevance to the purpose of this testing phase They may be used to extrapolate results, but due to their nature a good extrapolation is unlikely.

Test Phase 2

In phase two, a baseline data set was established which more closely represents realistic vessel traffic conditions in a busy port. Establishing this baseline data set allows observation of the effect on transmission loss which adding additional BFT vessels to the simulation makes. To ensure that any transmission loss was really due to the unique two-slot message type of a BFT vessel and not just the presence of more vessels, the same simulation scenarios were run with an

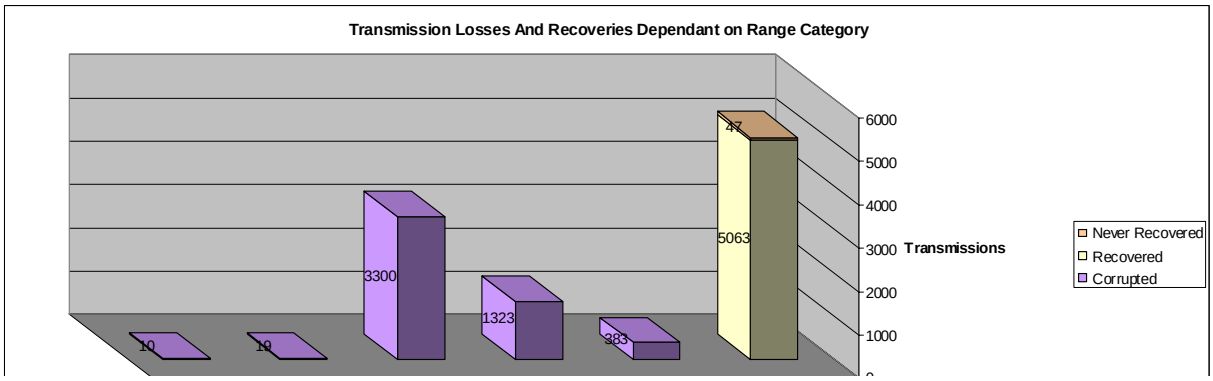

Figure 3: Transmission Losses for the Todt Hill Test Phase 2 Baseline Data Set

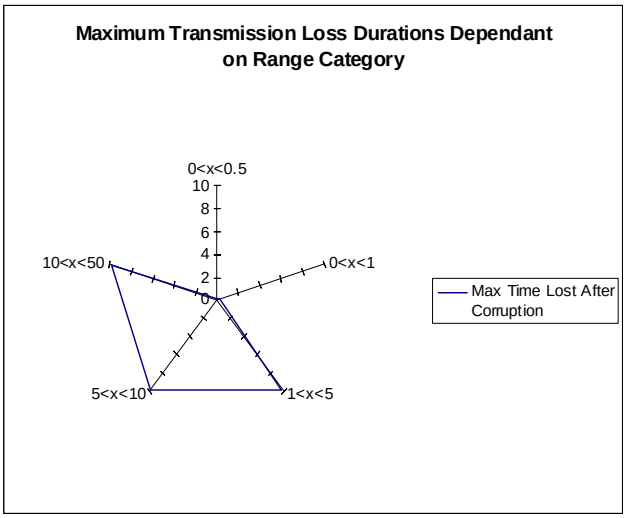

Figure 4: Maximum Transmission Loss Durations for the Todt Hill Phase 2 Baseline Data Set

For the second phase of testing, a baseline for Todt Hill was established with total transmission losses due to corruption in the 1-5 NM range of 3,300 transmission losses (see Figure 3), and a maximum duration of loss of 9.84 seconds (see Figure 4).

Test Phase 3

In this phase, vessels are added in increments of 50 (up to 250 additional vessels) to the baseline data set from Phase 2. The resulting bar and star charts from adding 250 Class A type vessels versus 250 Blue Force Tracking vessels are Figures 5&6 and 7&8, respectively.

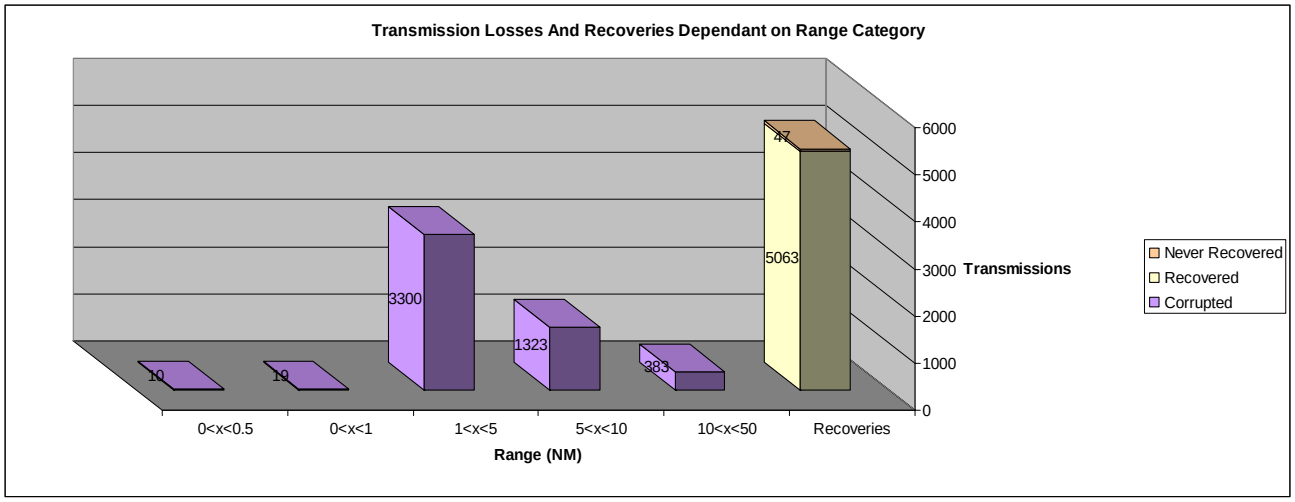

Figure 5: Transmission Losses for the Todt Hill Test Phase 3 Data (250 Class A vessels added to the baseline)

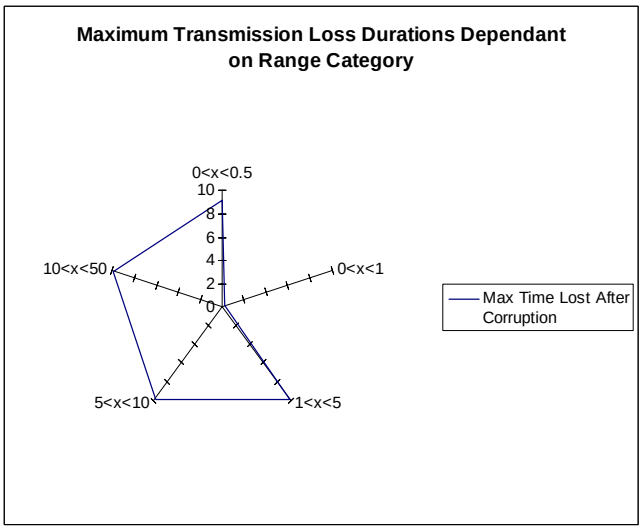

Figure 6: Maximum Transmission Loss Durations for the Todt Hill Phase 3 Data with 250 additional Class A Vessels

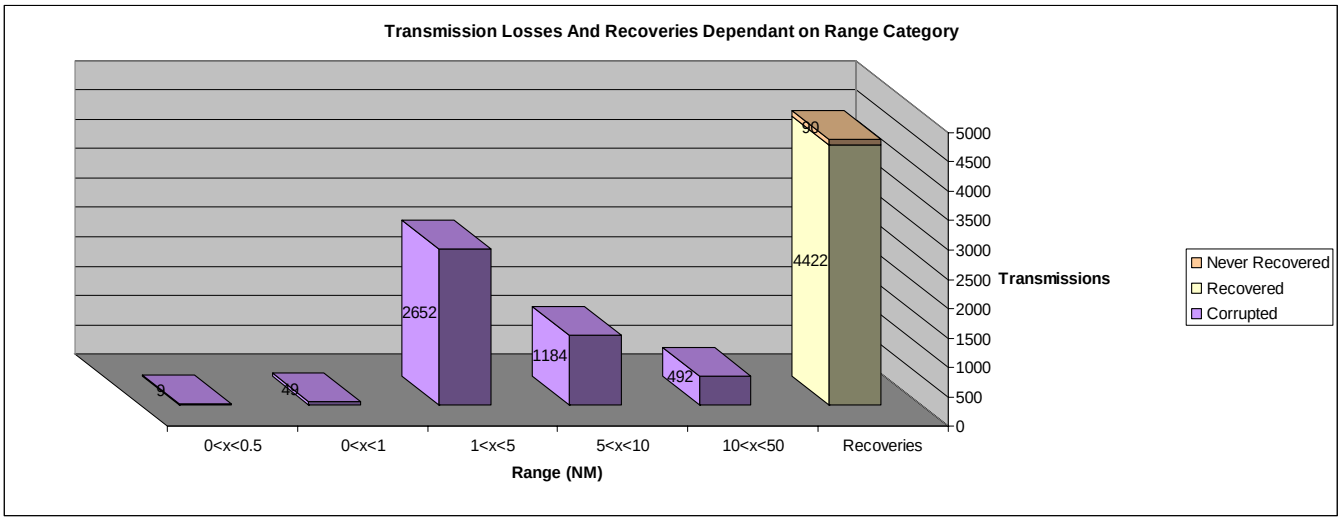

Figure 7: Transmission Losses for the Todt Hill Test Phase 3 Data (250 BFT vessels added to the baseline)

Within the 0 to 5 NM range, Class A vessels maintain same number of transmission losses even when more BFT vessels are added.

Transmission losses decrease when BFT vessels are added, although they begin to increase again after 150 are added

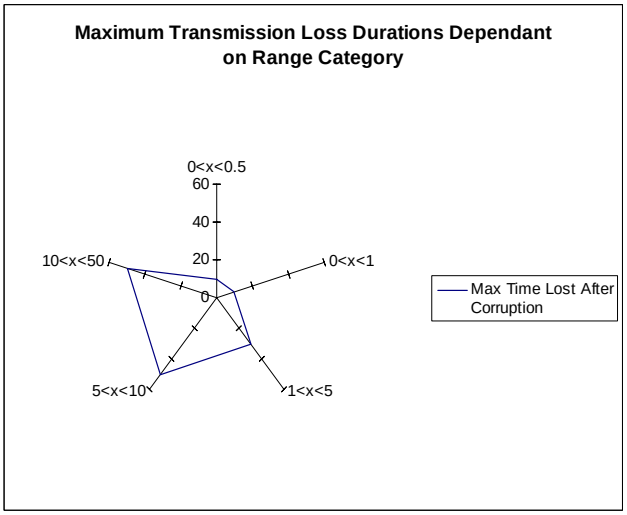

Figure 8: Maximum Transmission Loss Durations for the Todt Hill Phase 3 Data with 250 additional BT Vessels

Within the 0 to 5 NM range, Class A vessels maintain transmission loss duration when more vessels are added. However, transmission loss duration increases when BFT vessels are added, decreasing after 150 are added. The maximum duration of loss at this range is still 70 seconds, just over a minute. This may not seem like a lot, but could be critical to safety of life. Figures 9 and 10 show the respective trends for AIS Class A vessel additions and their affect on AIS VDL transmission losses and duration of loss, as well

as the same affects when BFT vessels are present. These next plots are intended to summarize data and to demonstrate the observed trends within the third phase of testing.

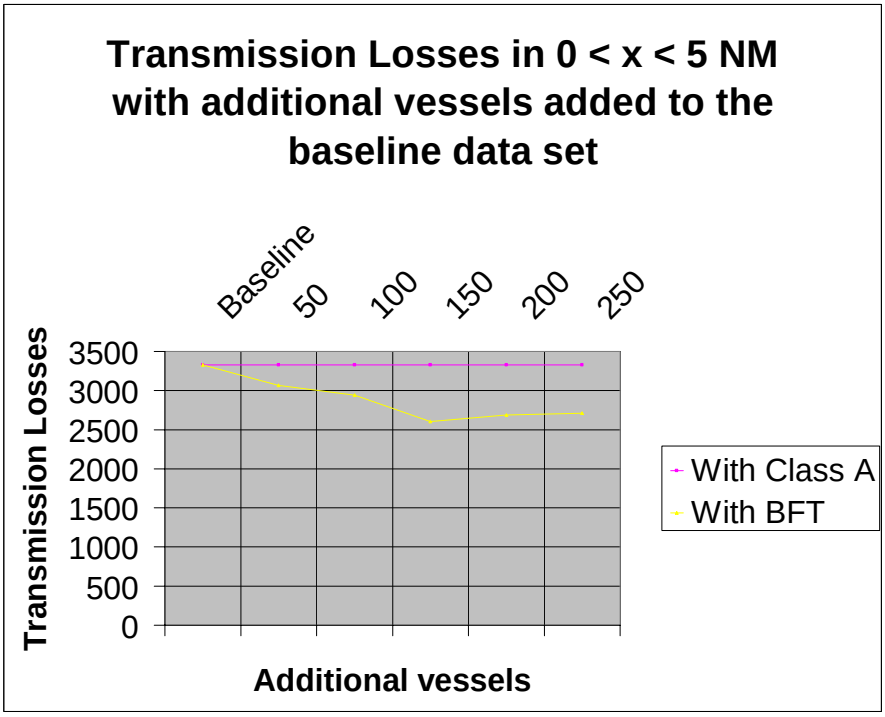

Figure 9: Overall Trends for the Todt Hill Reciever Transmission Losses in Phase 3 Testing

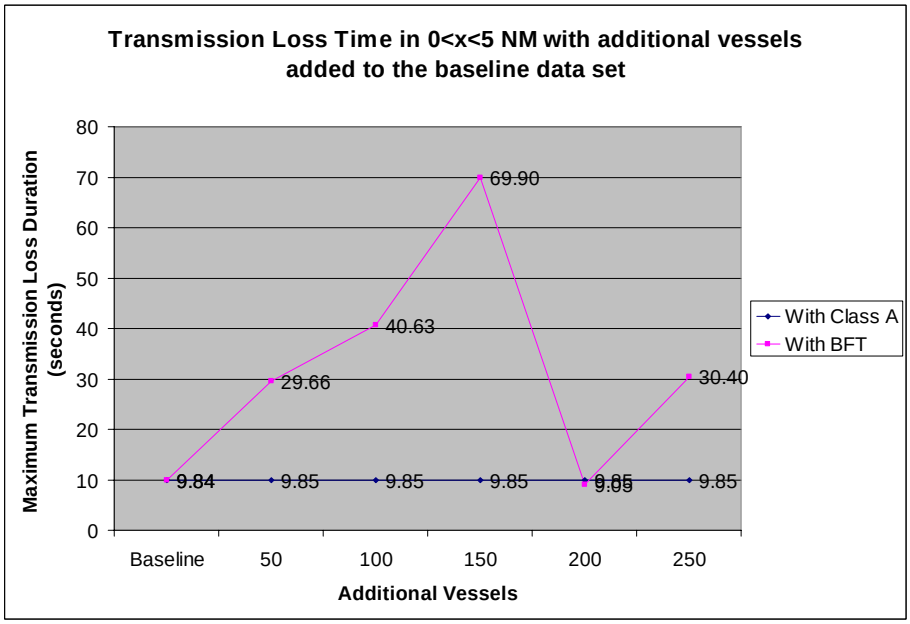

Figure 10: Overall Trendline for the Todt Hill Reciever Transmission Loss Durations in Phase 3 Testing

Conclusions

These final results overall may seem counter-intuitive and possibly erroneous, but it is critical to remember that the charts shown in the results section of this paper only represent a small slice of the transmission losses going on in the simulation, and only focus on one range. Depending on the range of the additional vessels relative to the reference vessel, it is possible that by narrowing the results focus on a specific range, we may not even be seeing the additional vessels because they do not affect the 0 to 5 NM range statistics. This is a problem of data selection and is compounded by the complexity of the simulation and the number of design decisions that have to be made on the spot to keep the project moving towards results. From here, the results and data of this project will be turned over to the project sponsor at C2CEN. They will be used to determine what is a significant disruption and what is not. This data will include all available

information received from the Pier 36 AIS receiver analysis, though due to time constraints and difficulties with the simulation it was not fully completed.

The Coast Guard's AIS BFT system is a part of the Hawkeye project, a Deepwater initiative aimed at improving the technology supplying a large scale Common Operating Picture to all Coast Guard and friendly forces' assets. As with any 'special features' implemented on an existing system (like AIS), there is an associated cost. The Coast Guard's Command and Control Center (C2CEN) has sponsored this project, with the objective of determining the number and impact of AIS BFT v2 equipped vessels that on the VHF Data Link.

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Appendices

Appendix A – Project Requirement Specifications Document

Appendix B – Project Support Plan

Appendix C – Detailed list of Inputs and Outputs

Appendix D – Blue Force Tracker Implementation from R & D Center

Appendix E – Project Plan

Appendix F – E-mail correspondence between 1/c McNeil and Mr. Steve Farthing at C2CEN

Appendix G – Results Graphs for Todt Hill

Appendix H – Results Graphs for Pier 36

Appendix I – Design Specifications