Introduction

Currently the Coast Guard is undergoing a communications systems (COMMSYS) transformation to unify communications service-wide. HF communications in the Coast Guard, particularly at Sectors, are unreliable and difficult to maintain because of a lack of coverage and a complicated protocol. Many members of the Coast Guard express frustration with HF communications. [1,2] One portion of the COMMSYS transformation is to improve HF communications. The Telecommunications and Information Systems Command (TISCOM) is sponsoring the testing of COTHEN, operated by the Customs and Border Patrol, as a possible solution.

COTHEN is an HF network that consists of land transmission/reception sites across the country that are connected by telephone and internet lines. The landlines serve as a backbone, connecting the network sites to one another to provide seamless communications coverage. For example, a call made from a unit in the Pacific Ocean may to a unit on the Atlantic, may be received by a COTHEN site in New Mexico and sent along the land line to another site located in Florida for transmission to the unit. The COTHEN network itself selects the most optimal transmission sites through software. This way the most optimal site manages the radio call. There is a Technical Service Center (TSC) that ensures the optimal sites are used for communications and continuously provides technical support.

COTHEN uses the Automatic Link Establishment (ALE) protocol to select the best transmission frequency from the unit to a COTHEN site and vice versa. ALE is a software based communications protocol that establishes radio links and eliminates human error. This ensures maximum connectivity between assets. The ALE radio frequently sends and receives signals (known as soundings) in order to determine the optimal operating frequencies for that particular

radio and location. Based on these soundings, the radio is able to automatically connect or "handshake" with other radios without requiring the user to manage the frequencies. Through the use of ALE techniques and the COTHEN network, the Coast Guard will optimize its HF communications capabilities. This system is intended to improve high frequency communications specifically between Sectors and their assets, such as aircrafts and cutters.

The purpose of this project is to improve HF communications across the Coast Guard. The Coast Guard's communications needs were defined within the expectations of the COMMSYS transformation. This includes standardizing Coast Guard communications and reducing the load at the Communications Area Master Station (CAMS). Additionally the Coast Guard will update its legacy, or outdated, communications systems while improving interoperability within the Department of Homeland Security (DHS). Maintenance costs will be reduced because the Coast Guard will no longer need to invest in expensive and rare replacement parts for the outdated systems.

This paper provides the basic background of HF communications in the Coast Guard and pinpoints where they can be improved. It also will introduce the concepts of ALE and how it functions with COTHEN. Operation of the COTHEN network itself will also be described. Then the needs and requirements of the Coast Guard will be identified and discussed as well as how COTHEN can satisfy those needs. Next, a test plan will be presented along with an analysis of the results. Last, a final recommendation will be made as to the effectiveness of the communications system based on the results from the test plan.

Background

High Frequency Communications

There are five different propagation paths for radio communications: ground reflected wave, surface wave, direct wave, refracted wave, and sky wave. HF transmitters typically utilize sky waves because of the long wavelength associated with HF. HF is designed for use in long range, over the horizon communications. Transmission sites radiate the HF signal upward and outward, forming the sky wave, so that communications are possible beyond the line of sight. Sky wave propagation depends on the ionosphere to reflect the waves back to earth, so the quality of the signal can be affected by many different natural factors, such as time of day and solar sunspot activity. Because of the differences in the ionosphere, different transmitting frequencies are optimal for communications at various times in the day. [3]

HF Communications in the Coast Guard

Currently the Coast Guard uses point-to-point HF communication. This means that each transmission/reception site has its own coverage area, and assets communicate directly with a particular site. The user must pick the frequency in which to communicate and the transmission goes to a land site then is sent out to the receiving unit. In order to do this properly, the user needs an understanding of HF wave propagation. The variations in optimal frequency as a result of differences in the ionosphere can be both challenging and confusing for users. Some users do not understand how to best manage these frequencies, and communications are often lost in one location and need to be picked up by another unit [1, 2].

In addition to the factors affecting HF wave propagation, there are also issues with coverage under typical point-to-point communications. As seen below in Figure 1, each site has its own individual coverage area. Between each coverage area are gaps where there is no

communications coverage. Under this system design, calls cannot be transferred from one site to another because there is no land line connectivity. [4]

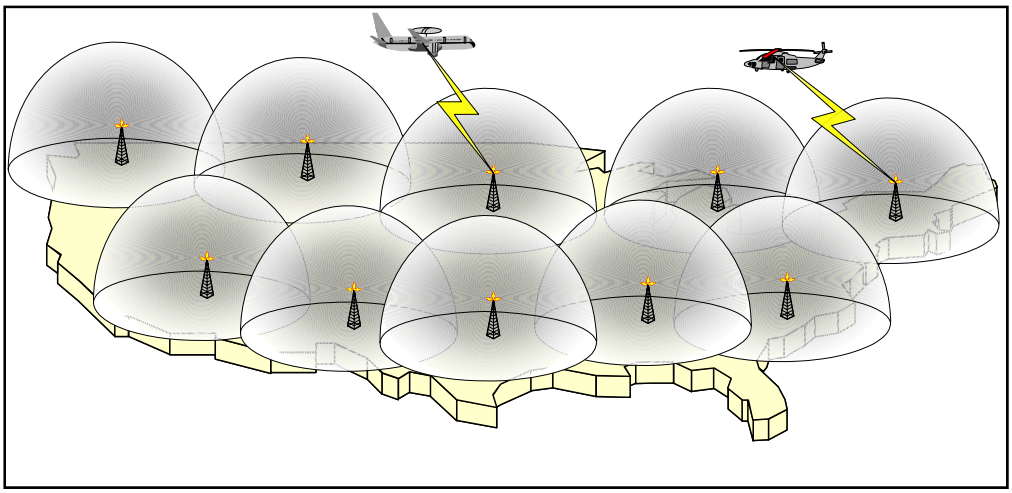

Figure 1: Current HF Communications Network
Adapted from Powerpoint Presented by Jim Coffman [4]

HF communications are very valuable for the Coast Guard though they are not typically used for primary communications at sea because of the slow data rate. Currently, HF communications serve the Coast Guard afloat units as a secondary system to VHF.

However, HF communications are very important for aircrafts making position reports. Position reports are required every fifteen minutes from rotary aircraft pilots and every thirty minutes from fixed wing pilots. If two consecutive position reports fail to be acknowledged, the radio guard must be transferred to another unit or the mission must be aborted. Aircraft are typically well beyond the range of VHF communications. Satellite communications are not a viable alternative because of an aircraft's high speeds and significant relative motion in reference to the satellite. This relative motion causes Doppler error.

For long range communications aboard ship, the Coast Guard uses satellite communications. [1, 2] However, this method of communication is expensive and is becoming increasingly vulnerable. HF communications are much cheaper to maintain and less vulnerable

to international threats as the transmission sites are located on the US soil versus in space where technology exists to remove satellites from orbit. It is important to maintain HF communications so the Commandant of the Coast Guard has mandated the COMMSYS transformation as a part of the Coast Guard transformation. [5]

This transformation has defined the need for an overall improvement of HF communications. If the Coast Guard is going to continue providing funds for HF communications they need to be more reliable and cost effective.

Automatic Link Establishment

ALE is a software based communications protocol that makes radio linkage automatic and transparent to the user. On standard HF radios, the operator manually scans through each frequency for optimal communications. ALE scans these same HF frequencies automatically. Each ALE radio is given a specific address designation, or callsign, which serves the same purpose as a phone number. To reach a specific station, the operator simply dials the callsign on the radio. [3] ALE not only removes the operator from managing frequencies but also the complex communications protocol that coincides with manually establishing radio links.

An ALE station that is not yet linked (engaged in communication with another station) continuously scans a pre-determined set of frequencies listening for its ALE callsign. This constant scanning maximizes the probability that an incoming call will be received. When the scanning station detects the first characters of its address designation, it stops scanning and tunes in to that particular frequency. The radios then systematically confirm the establishment of the link, which is called a “handshake”. When the call is completed, one of the stations transmits a disconnect signal and both radios resume scanning. [3]

ALE radios measure the quality of the channels available for propagation via periodic soundings. These brief, self-identifying broadcasts are transmitted and then received by other stations in the system. Each station in the system records the identity of the sounding station and evaluates the quality of the signal received. The quality of the signal is quantified and stored internally as a number in each radio. This number is referred to as the Link Quality Analysis (LQA). An LQA is a parameter based on the signal to noise ratio (SNR) and the bit error ratio (BER) of a given signal. [3]

An ALE radio will consistently update its stored LQA data for all stations with each new sounding received. Since the channel conditions are time variable, each data entry is coupled with a time to facilitate an age bias of stored LQA data. In other words, older LQA measurements are less favored than more recent measurements. Data collected from the soundings permit the scanning station to select the optimal working channel when calling a particular station. [3] Figure 2 below is diagrams ALE operation.

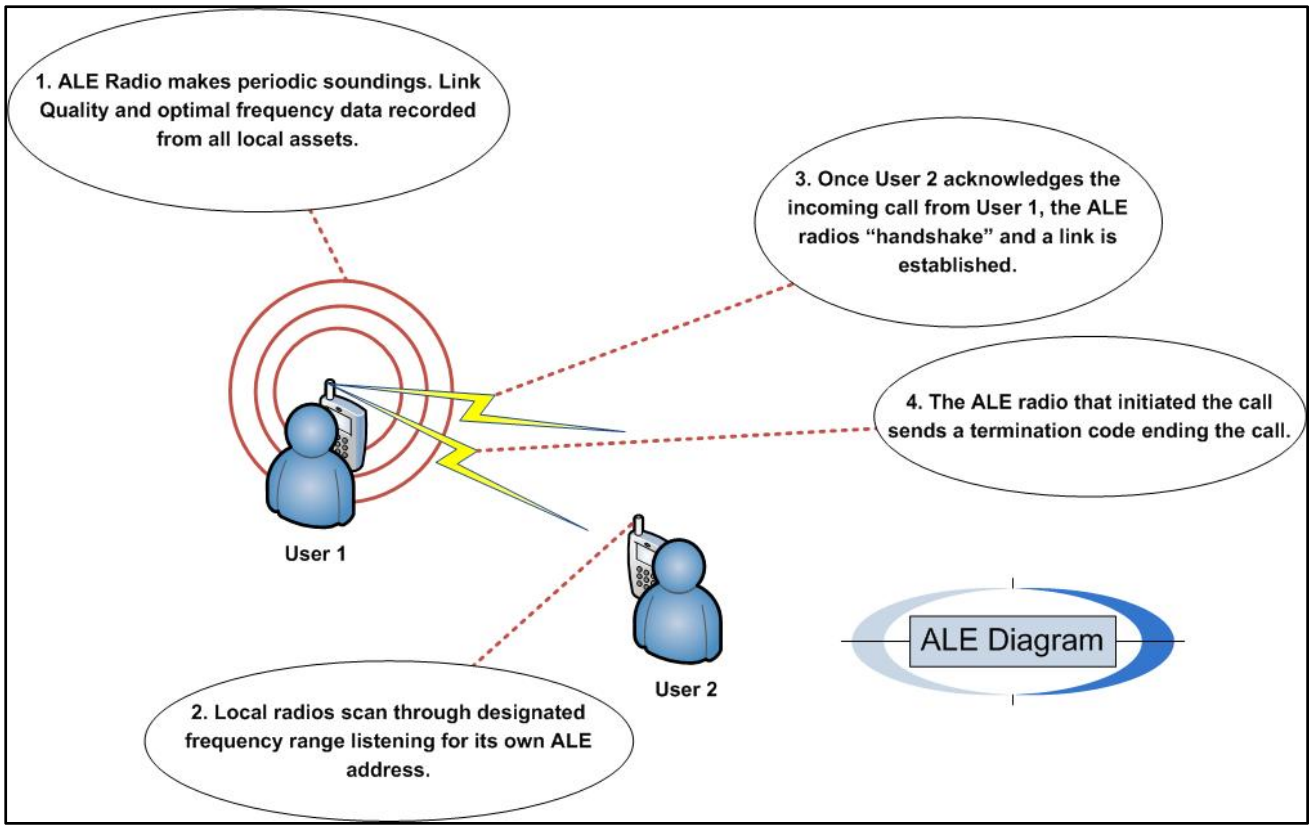

Figure 2: ALE Operation

Cellular Over the Horizon Enforcement Network (COTHEN)

COTHEN is an HF ALE network that uses landlines to connect nineteen transmission sites spanning the nation in order to form one unified coverage area. An illustration of this coverage area is depicted in figure 3.

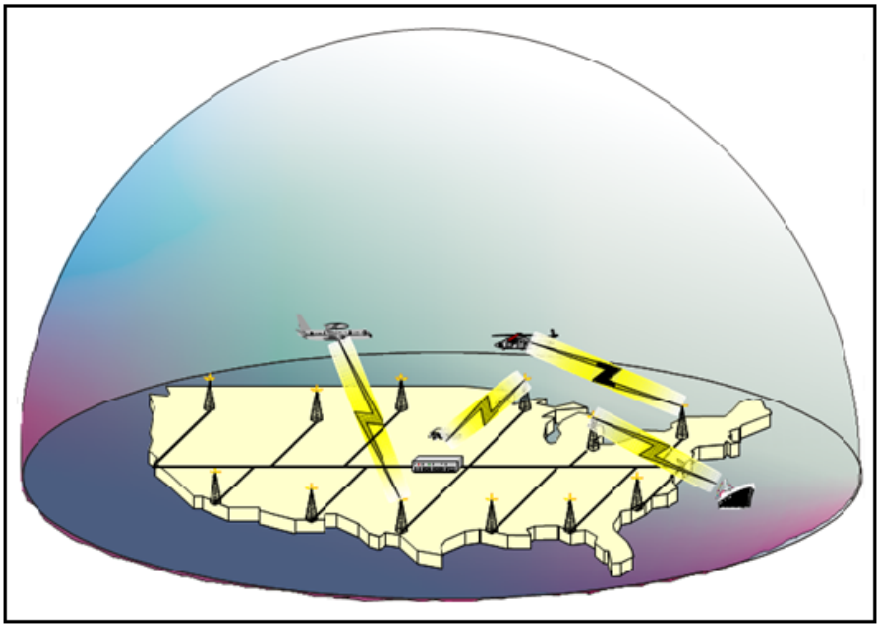

Figure 3: COTHEN Coverage Area Example [4]
[Adapted from Powerpoint Presented by Jim Coffman]

This network has satisfied the communications needs of Customs in terms of reliability and nation-wide coverage [4]. Currently, the network has 19 sites, 89 remote communications consoles (RCC's), and a TSC in Orlando, FL.

The TSC constantly monitors all communications using the network by tracking the radio calls of all assets. The TSC operators ensure that communications are established and that links are optimal. This is done by observing which land site a radio call is using to establish the link. If the link is not the best one possible, the TSC operator can remotely change the site without the users knowing, improving the quality of the communications.

Additionally, the TSC can communicate with the users in order to answer questions, provide training, and walk the user through troubleshooting. Watch standers at the TSC have the ability to let the user know that the unit they are trying to call is busy with another call, or is not available. This assures the users that their radios are functioning and that communications will be established as soon as possible.

Another capability of the TSC is the ability to make telephone patches, which allows COTHEN to maintain communications regardless of external conditions. The TSC is an important aspect of COTHEN because it provides a central hub for the network and because it is staffed by highly experienced operators. There is a back-up control site for the TSC in Cedar Rapids, Iowa. Having a secondary control site protects COTHEN against any terrorist attack or natural disaster, such as a hurricane. [4]

COTHEN is an all purpose communications network. COTHEN can receive calls from air, sea, or shore and maintain seamless communications regardless of the origin of the call. Once an asset is connected to the network, the TSC monitors the call and the communications. The signals travel across landlines in order to use a combination of transmission sites to optimize the signal for both the receiver and the sender.

At the sectors, RCCs provide a graphical interface for watch standers that depicts the assets online within the network. The operator can see what assets are engaged in communications within the network and the quality of the links with each asset. Figure 4 is a screen shot taken from an RCC.

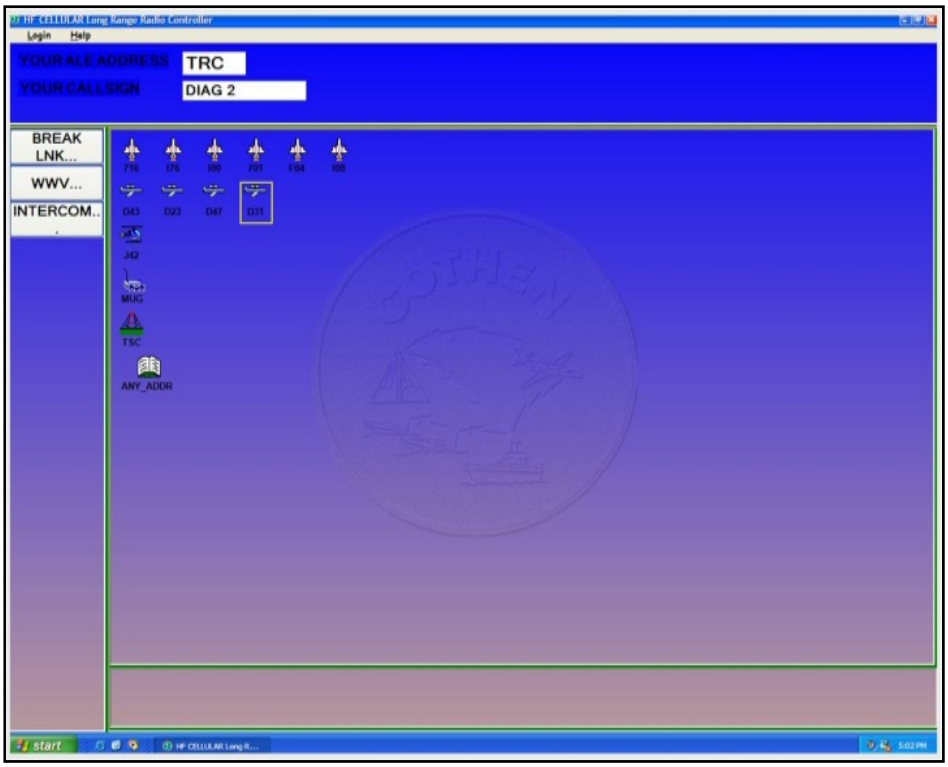

Figure: 4 RCC Screen Shot [4]
[Adapted from Powerpoint Presented by Jim Coffman]

The Coast Guard has been using COTHEN since 2003 for the purpose of flight following. Currently, the majority of the Coast Guard COTHEN operations falls on CAMS (Communications Area Master Station) as they are the designated entity for flight following and position report logging. The Coast Guard represents approximately 85 % of COTHEN's daily communications activities. The system has the potential to expand with Coast Guard assistance, if the Coast Guard decides to use COTHEN full time. The Coast Guard currently only uses COTHEN for flight following purposes, but under the COMSYS transform plan, all HF communications need to be standardized. [5]

Objectives

Needs and Requirements

The Coast Guard is implementing plans to improve HF communications as part of the COMMSYS transformation. This will include centralizing Coast Guard communications and

reducing the load at the CAMS. This is important because the Commandant has ordered a three phase transformation to include consolidation, specifically of CAMSLANT and CAMSPAC into one Communications Command, COMCOM [6]. Additionally the Coast Guard needs to update communication systems in order to reduce maintenance costs and improve interoperability within the Department of Homeland Security (DHS). Currently, 90% communications resources support legacy, or outdated, systems [7]. Lastly, the Coast Guard is in need of more communications support in terms of watch standing and technical expertise regarding system maintenance and operation [8, 9]. Based on these needs, it is the goal of this project possible to evaluate the implementation of COTHEN service-wide as a possible solution to the needs of the Coast Guard. A table of detailed system requirements to satisfy the previously stated needs can be found in the Functional Requirements Document in Appendix A.

The specific functional requirements that meet these needs are the following: 1. There must be one standard HF communications protocol, as mandated by the Commandant in the COMMSYS transform; 2. Position reports from aircraft need to be made every 15 minutes for helicopters and every 30 minutes for fixed wing aircraft 95% of the time. If this requirement can be met at the Sector level, then the Sectors will be able to maintain flight following, and remove work-load from CAMS.

Constraints

The primary constraint in this project is the limited scope of the solution. The proposed solution to this project is strictly confined to the use COTHEN and ALE as mandated by the Coast Guard [10]. Within COTHEN there may exist other constraints or limitations. The first of which is COTHEN's operating capacity. If the Coast Guard joins COTHEN, over 1000 Coast Guard assets will be added to the system. Too many assets calling at once could overload the

system. This system limitation must be considered throughout the project as it could possibly limit the effectiveness of COTHEN integration. The other limitation is the Coast Guard's budget and the high yearly premium that COTHEN charges the Coast Guard to use the network. This is estimated to cost as much as $375,000 per year. Other considerations and constraints are outlined in the Business Case found in Appendix B and the Support Plan in Appendix C. Further outlining the timeline and project objectives is the Project Management Plan found in Appendix D.

System Design

Overview

The design solution that will be considered to improve HF communications is to implement COTHEN at selected Sectors across the country. A detailed test plan was developed to test the quality and efficiency of the new HF communications system, and verify that it meets Coast Guard requirements. The results of these tests were analyzed and evaluated and a recommendation was made to as to whether the communications system shall remain.

COTHEN as a Solution

COTHEN consists of 19 unmanned transmission sites across the country. Table 1 lists those sites, the three digit identification used within the network, latitude, longitude, and town location.

Table 1: Transmission Site Summary

Site I.D	**Latitude**	**Longitude**	**Town**
ATL	32 55’ 18” N	84 39” 33” W	Warm Springs, GA (S. of Atlanta)
MEM	34 36”59” N	090 04 53" W	Senatobia, TN (S. of Memphis)
OKO/OKD	34 51' 46" N	097 51' 47" W	Chichasha, OK (SW of Oklahoma City)
LUV	40 05' 21" N	118 31' 57" W	Lovelock, NV (NE of Reno)
RSH	34 49' 02" N	078 07 55" W	Concord, NC (E of Fayetteville)
KCM	38 36' 96" N	093 36' 35" W	Raleigh, NC
DEN	39 26' 26" N	103 57' 31" W	Agate, CO (SE of Denver)
ABQ	35 08' 39" N	105 54' 31" W	Stanley , NM (E of Albuquerque)
CDI	34 57' 30" N	076 16' 36" W	Cedar Island, NC (SE of Raleigh, E of Jacksonville)
VGS	36 35' 44" N	114 29' 27" W	Longandale, NV (NE of Vegas)
RNO	38 52' 00" N	119 24' 38" W	Simpson, NV (SE of Reno)
SEA	34 58' 07" N	078 23' 32" W	Clinton, NC (E of Fayetteville)
CDR	42 00' 26" N	091 29' 43" W	Marion, IA (E of Cedar Rapids)
SAR	27 21' 15" N	081 52' 25" W	Limestone, FL (E of Sarasota)
FTM	26 33’ 38” N	081 25” 00” W	Sarasota, FL
PR1	18 29’ 08" N	066 37' 59" W	Islote, PR (W of San Juan)
CR1-CR8	42 03’ 18” N	091 63’ 75” W	Omaha, NE
SS1	42 00’ 26” N	0 91 29’ 43” W	Cedar Rapids, IA

These site locations were selected by Customs to give optimum coverage of the area of operation (AOR).

The characteristics of HF wave propagation affect the location of the transmission sites. HF waves radiate upward and bounce off of the ionosphere back down to the Earth’s surface. The distance between the transmission site and where the wave is received is a dead zone, called the skip zone. In order to account for this and avoid dead spots in the coverage area, the sites are located at least one skip zone from the operating area. The sites are located just south of the center of the country in order to provide the best coverage on the southern border of the United States, where Customs and Boarder Protection is most active. This can be seen in figure 5.

Figure 5: Location of Transmission Sites

Each site location was first surveyed to in order to find low noise platforms. In avoiding undesired interference, it is important that the sites are clear from physical obstructions and not near any power lines or electrical power systems that will generate electrical noise. As a result, all of the transmission site locations are outside major cities, in rural areas.

Each transmission site has two antennas; Omni TSI 530 and a Directional TS 540. The omni-directional antenna radiates power uniformly in one plane. These antennas are generally used for air support. Directional antennas radiate more power in one direction then in any other. These antennas are particularly useful for marine support.

Each site transmits 1 KW of power and is connected to one another with 56 K bit phone lines. The connection of the sites by phone line unifies the each site's coverage area so that the network provides one large coverage area rather than 19 individual ones. This is illustrated in figure 6.

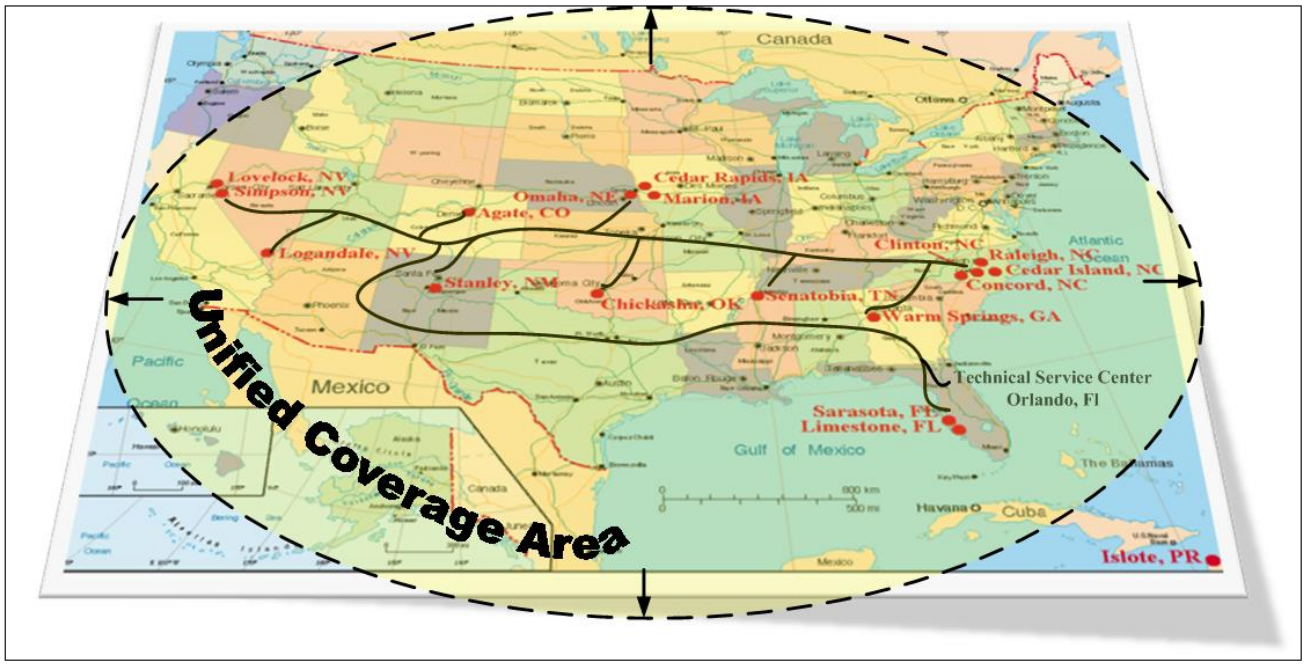

Figure 6: Phone Line Connect Transmission Sites, Unifying Coverage Areas

This eliminates dead spots resulting from the skip zones of each site. The propagation map and coverage area of COTHEN is depicted in figure 5. Further detail about the equipment and design of the system can be found in the Design Specification in Appendix E.

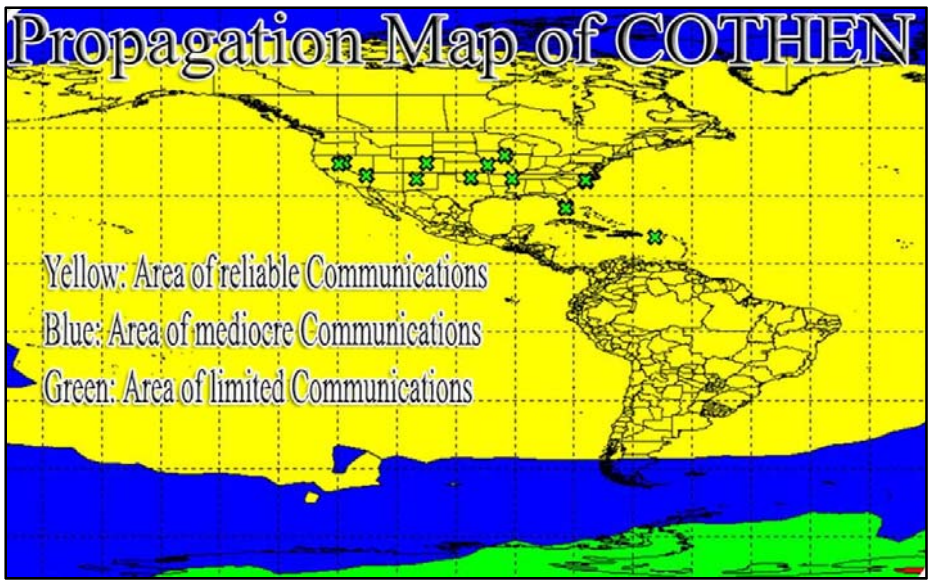

Figure 5: Actual Coverage Area of COTHEN
[Adapted from Powerpoint Presented by Jim Coffman] [4]

COTHEN has the potential to be a very useful system for the Coast Guard. It is already an established and successful network that has been proven reliable by the Customs and Border Patrol [2, 4, 5]. COTHEN will meet the HF coverage needs because of its vast area of reliable communications.

Test Plan

As detailed in the Support Plan Document, Appendix C, two weeks of HF communications data from Sector Key West and Sector San Diego were planned on being gathered before and after ALE and COTHEN are implemented. However, the test plan that was actually implemented involved gathering two weeks of data from CAMSLANT. This change in test plan was due to the fact that the same watch stander can monitor flight following data on HF as well as COTHEN at CAMSLANT. The data collected at CAMSLANT includes: the number of calls attempted using HF, the number of successful calls using HF, the number of calls attempted using COTHEN, the number of successful calls using COTHEN, and finally whether or not the call was clear or

broken. The type of unit making the transmission was also recorded. For the purposes of this project, a successful call is defined as one made within a five minute threshold of the required time for each aviation platform. All data with the exception of the clarity of calls and the number of dropped calls was procured from the communications data log at CAMSLANT. The quality of transmission and percentage of dropped calls were determined from a separate data log provided to the watch standers. Appendix F contains this data collection log.

In the analysis of COTHEN, data will also be gathered from the TSC. Such data will include the LQA data of each call made and most used transmission site. The results were analyzed to determine the value of implementing COTHEN. The original test plans are found in Appendix G.

Along with determining the effectiveness of COTHEN, this system design will identify potential weaknesses of the system. These weaknesses may include: compatibility between radios, the maintaining a link with weak signals, and coverage gaps. Once identified, a recommendation will be made as to whether or not they can be mitigated and if not, a cost-benefit analysis will be performed to further ascertain the effectiveness and worth of the system.

There are other possible solutions to the Coast Guard's HF communications problems. One such solution is to develop our own, similar, network, as was done in Alaska. A second possibility would be implementing ALE without COTHEN, or merely increasing the number of transmission sites used across the country. These solutions were not tested as they were beyond the scope of the project.

Results

In order to determine whether COTHEN is an improvement over traditional HF communications we intended to test the quality of HF communications prior to the installation of COTHEN and the quality of communications using COTHEN at Sector Key West, Sector San

Diego, and CAMSLANT. This test is outlined in Test 1 and Test 2 of the Test Plan, enclosed in Appendix G. These test plans use the data sheet previously discussed to gather qualitative data in both environments over a two week period. The intention was to paint a picture of the current state of Coast Guard Communications in an operational setting in order to compare the COTHEN communications. The post-COTHEN data at each Sector was supposed to provide qualitative measure of communications using COTHEN. This test, however, was only implemented at CAMSLANT. The Sectors were unresponsive in providing feedback for the tests. The CAMS data was used to compare HF to COTHEN, but the data is much less robust as a result of the missing Sector data.

CAMSLANT LOGS

In the place of data from the Sectors, CAMSLANT submitted their communications logs for a two week period. These logs were used to determine if Coast Guard aircrafts could make their position reports more reliably when using COTHEN than HF. The expectation is that rotary wing aircrafts make position reports every fifteen minutes, and fixed wing make them every thirty. It was decided that a five minute grace period would be appropriate to allow the operators to not interfere with their mission and allow for CAMSLANT to respond even when radio traffic was heavy. The communications logs for the days provided by CAMSLANT were examined. This analysis included documenting the aircraft that made the call and the time interval between successive calls. Special observation was also made to the “OPNOTES” as they generally provided information about the quality of communications, missions, or any other concerns. The data for each of the days is summarized in Table 2.

Table 2: Total Number of Calls and Successful Calls Made To CAMSLANT

Table 2	COTHEN				HF			
Date	Rotary Calls	Rotary < 20min	Fixed Calls	Fixed < 35m	Rotary Calls	Rotary < 20min	Fixed Calls	Fixed < 35min
3-Mar	71	63	29	27	0	0	21	21
10-Mar	92	89	45	43	0	0	27	25
13-Mar	86	85	31	30	0	0	57	57
14-Mar	140	115	32	31	0	0	39	37
16-Mar	35	35	3	3	0	0	25	22
17-Mar	55	52	13	13	0	0	75	70
18-Mar	62	57	37	35	2	2	50	44
19-Mar	112	110	17	13	10	10	43	39
20-Mar	122	114	34	33	0	0	43	42
21-Mar	35	33	26	25	0	0	47	46
22-Mar	22	20	26	25	21	19	11	11
23-Mar	16	16	13	13	0	0	22	20
24-Mar	82	74	31	27	4	4	55	50
25-Mar	93	84	57	53	0	0	43	41
Total	**1023**	**947**	**394**	**371**	**37**	**35**	**558**	**525**

This table was then used to calculate the percentage of the time that position reports were made on time or within the five minute threshold using both COTHEN and HF. This percentage was calculated for both fixed wing and rotary aircraft. The results are summarized below in Table 3.

Table 3: CAMSLANT Percentage of Successful Calls (clear and within 5 min threshold)

Table 3				
Type	**COTHEN**		**HF**	
Platform	Rotary	Fixed	Rotary	Fixed
Total Calls Made	1023	394	37	558
Percentage of Successful Calls	92.57087%	94.1624365%	94.59459%	94.0860215%

As observed in Table 2, 92.57% of the calls made from rotary aircraft to CAMSLANT were successful using COTHEN whereas 94.59% were successful using HF. For fixed wing aircraft, 94.16% of the calls made using COTHEN were successful and 94.08% of the calls made using standard Coast Guard HF frequencies were successful. An example of a daily communications log is enclosed as Appendix H

These results were not expected. It was originally thought that communications were poor using standard HF working frequencies and much improved using COTHEN. The data does not reflect this conjecture as a higher percentage of calls were successful to rotary aircraft using HF. It is suspected that these results were the product of a number of variables. First, the data analyzed was for two week span and gathered at one single location. As seen in Table 1, 37 calls were made from rotary aircraft using standard HF whereas 1,023 calls were made from rotary aircraft using COTHEN. There were not enough data points from rotary wing aircraft to generate accurate results from this portion of the test. It is suspected that if more calls were made such that the difference between the number of calls using both systems was minimized, the data would more strongly favor COTHEN. It appears that COTHEN is the preferred method of communication since it was used for 70% of the total amount of calls.

The degree to which the data will favor COTHEN may be ascertained in the analysis of the fixed wing communications. For the fixed wing aircraft analysis, it is important to note that from Table 1, 394 calls were made using COTHEN and 558 calls were made using traditional HF radios. Because the difference between the calls made for HF and COTHEN is much smaller, it is suspected that these results are more accurate than were the rotary wing communications results. As noted in Table 2, the percentage of successful calls using COTHEN is higher than the percentage of successful call using traditional HF. These results suggest that if more calls were made from rotary aircraft using traditional HF, the number of successful calls using COTHEN would be slightly greater.

This test data shows that the percentage of successful position reports on both HF and COTHEN did not meet the functional requirement that timely position reports will be made for 95% of total calls. However, what this data fails to show is the excessive communications load at

CAMSLANT. Many calls were delayed beyond the five minute threshold due to the watch stander being in constant communications with other aircrafts. For example, on any given day at CAMSLANT calls were coming in that were recorded at the same time or a minute apart. This makes it very difficult for the watch stander to respond to all users on time. This could account for many of the delayed position reports as they were generally only off by a few minutes. Additionally, the data represents a limited sample of Coast Guard operations. There are many other aircrafts and Coast Guard missions around the world. Possible further research could include other units as well as a longer time frame, to provide more robust data. This quantitative data was coupled with qualitative data from CAMSLANT to provide a better view of both HF and COTHEN communications.

The last analysis of the data logs involved the documentation of all HF calls dropped or transferred to COTHEN and vice versa. For the two week test period, 20 HF calls were noted as faint or lost by the watch stander whereas seven were noted when COTHEN was used. Three calls were switched to COTHEN from HF whereas one was switched to HF from COTHEN. A total of four calls were successful due to aid from the TSC.

CAMSLANT Qualitative Data

In addition to the analysis of the CAMS data logs, qualitative data was gathered by the watch stander using the data sheet previously discussed. Data entered into this log included: the date the call was made, from whom it was made, whether the call was clear or broken, whether communications were lost, and whether radio guard had to be kept by another unit. This was done for both COTHEN and HF calls. Appendix I is the completed log. Table 4 is a summary of the findings.

Table 4: Qualitative Data from CAMSLANT

Table 4			
COTHEN		HF	
% Calls Made	59.2%	% Calls Made	40.8%
Broken	6.4%	Broken	10.5%
Dropped	0.8%	Dropped	5.8%

This data confirms the belief that COTHEN communications are of a better quality than typical HF. CAMSLANT had 5.0% fewer calls dropped when using COTHEN and 4.1% more of the calls were clear. This also aligns with the opinions of the watch standers at CAMSLANT, who stated in interviews that they preferred using COTHEN. [1]

The findings of better quality with COTHEN were substantiated by many of the "OPNOTES" found in the CAMSLANT communications logs. Often times the watch stander at CAMSLANT logged poor quality communications when using HF. On several occasions the HF frequency was shifted in order to establish more clear communications. These were all indications that the quality of HF is relatively low when compared to COTHEN.

Technical Service Center Data

The data gathered from the TSC included the total number of links made, the LQA's of each link, the channel used, and the transmitter site used. The data was used as a quantitative means to ascertain how reliable COTHEN is. Communications are reliable when the LQA is above 30. For this test, LQA data of each site for every call made over a seven week period was analyzed. Appendix J is the spreadsheet of LQAs greater than 30. There is at minimum one site

that has a LQA over 30 for 99.9% of total communications using COTHEN. In the instances when none of the sites had a LQA over 30, the network automatically selected the site with the highest value. The lowest value for this seven week span is 27. This proves that even though the quality LQA cutoff is 30, effective communications can still be established at an LQA of 27.

This data also demonstrates that COTHEN is an intelligent system. In all cases, COTHEN choose the most optimal transmission site to use based on the LQA from the ALE soundings. The internal ALE protocol in the asset's own radio chooses the best frequency. Thus, communications were optimized in each situation COTHEN was used.

The next analysis was performed on the frequency of channel usage for each channel. This was in response to the possibility of the Coast Guard adding it's frequencies to the network. Table 5 shows the distribution of how frequently channels were used.

Table 5: Summary of Channel Usage

Date	Feb 14-20	Feb 21-27	Mar6-12	Mar13-19	Mar20-26	Mar27-Apr2	Apr3-9
Total Link	1467	1501	1845	1435	1771	1804	1637
Channel							
1	415	502	437	406	516	441	378
2	263	181	318	233	273	371	284
3	274	204	287	284	236	279	226
4	115	150	238	131	149	197	150
5	139	127	175	96	197	221	200
6	109	102	132	132	156	108	173
7	73	93	107	86	110	93	111
8	50	78	72	34	58	49	56
9	18	28	51	26	49	24	31
10	2	21	19	3	15	14	21
11	6	15	9	4	12	7	7

Table 5 shows that the first six channels are used much more frequently that the later six. This could be due to the lack of sunspot activity during the time of testing which makes HF communications difficult to maintain.

Recommendations

The first recommendations address the manner in which COTHEN was evaluated. In order to have more robust data, the tests should be run for a year in more than one location. A full year's data will account for varying solar conditions. Currently there is low solar activity, therefore the ionosphere is less energized and HF waves are expected to have poor reflection back to earth. This could not only affect the quality of the calls, but also the strength of the signals received, and therefore the likeliness of the receipt of a call. This would affect not only the HF data but also the COTHEN data as COTHEN operates in the HF spectrum and is thus susceptible to the same external variables.

A second test factor that could be further examined is the how location affects the quality of each transmission site. It was observed that the sites most used in calls to CAMSLANT were the ones located in North Carolina with calls signs: RSH, SEA, and CDI. It is logical that the site in North Carolina are used most frequently for calls on the eastern seaboard, it would be interesting to note whether or not they are still used so frequently from other parts of the country. If so, should the Coast Guard choose to join COTHEN, Coast Guard transmission sites already located near those areas could be added to provide addition support for the increased traffic.

Based on the results gathered from this study, we recommend that the fully Coast Guard joins the COTHEN network. The Coast Guard already uses COTHEN for 70% of the calls made through CAMSLANT. This affirms the belief that the operators prefer COTHEN over typical HF. Also, the results suggest that COTHEN communications are of a higher quality and similar reliability. It is our belief that if the system was tested over a longer period of time, we would find that COTHEN is in fact more reliable. The sample of data represented only a fraction of Coast Guard operations and was centered on a specific AOR.

COTHEN is capable of providing the Coast Guard an increased level of technical support and expertise. The TSC can trouble shoot the system and provide users with over the air assistance. This would satisfy many of the Coast Guards communications requirements, particularly the requirement calling for an increased HF communications expertise in the Coast Guard. COTHEN and the TSC would vastly increase the communications capabilities of the Coast Guard and make it more interoperable within the Department of Homeland Security.

If the Coast Guard was to implement COTHEN service wide, the load at CAMSLANT would be greatly decreased. As mentioned previously, the CAMSLANT watch standers are not capable of maintaining all flight following calls on time especially during the busier portions of the radio day. With COTHEN, watch standers at individual sectors could maintain flight following for the entirety of the flight mission and position reports would be more likely to be on time due to a lessoned communications load at one location. Additionally, the Coast Guard should consider installing RCCs at air stations as well. It was observed in analyzing the CAMSLANT communications logs that most calls were transferred from air stations rather than sectors.

Conclusion

Currently, HF communications in the Coast Guard is complex and unreliable. Calls are often dropped and radio guard needs to be transferred to units in the operating area to maintain a shore-side communications link. Many users have expressed frustration with HF communications and tend to avoid using it whenever possible. For these reasons, the Commandant has mandated a communications system transformation. This transformation will include a consolidation of CAMS into one central Communications Command, COMCOM. Also, legacy Coast Guard communications systems will be phased out due to the high price of

maintenance and spare parts. In doing so, a new HF communications framework needs to be established. This project focuses on one possible solution to the HF communications problem- the implementation of ALE and COTHEN. COTHEN will alleviate many of the communications problems that exist. With COTHEN, the sectors will have the ability to follow flights and, with the larger coverage area, there will be fewer cancelled operations due to communications loss. It is important to the Coast Guard that HF communications are maintained because of the vulnerability and cost of satellite communications.

An additional benefit to shifting to COTHEN is increased expertise through the TSC. The TSC is available to all COTHEN users who need real-time technical assistance with call linking and radio operation. However, this does come at a yearly fee to the Coast Guard. Finally, the operating capacity of COTHEN must be sufficient to support all Coast Guard HF communications. The testing of these limitations was beyond the scope of this project.

For the testing phase of the project, the quantity of dropped or transferred calls were recorded for both traditional HF communications and for communications using ALE/COTHEN. Qualitative data was collected by the watch standers at CAMSLANT. This data was used to calculate the percentage of broken calls and percentage of calls dropped. Link quality data was collected at the TSC to quantify the effectiveness and operation of the COTHEN system. The results were analyzed to find that COTHEN reduces the percentage of dropped calls from 5.8% to 0.8% of calls made. There was little difference percentage of timely position report calls made from aircraft to CAMSLANT. However, this position report data was subject to a number of variables such an influx of communications during the busier parts of the day, solar activity, and the frequencies used. COTHEN is a network of antennas that operates with a select group of working frequencies. It is plausible that one of the two Coast Guard frequencies provides better

communications than do one of the COTHEN frequencies. An important attribute of the COTHEN network is that it automatically selects the best operating frequency and transmitting station for the particular contact. If Coast Guard transmission sites and frequencies were integrated into COTHEN, then the network could utilize these in its determination of the best working frequency and transmission site to use. COTHEN has been proven to be more reliable in terms of the frequency of dropped calls and is preferred by the watch standers. Perhaps the most relevant benefit that COTHEN offers is its ease of use and interoperability across different government agencies. It is for these reasons that COTHEN recommended for implementation and use in the Coast Guard.

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Appendices

Appendix A: Functional Requirements Documents
Appendix B: Business Case
Appendix C: Support Plan
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Appendix A

COTHEN ALE

Functional Requirements Documents

1/c Jennifer Sullivan

1/c Christopher Rogers

19 October 2007

1. INTRODUCTION

1.1 Project Description

The goal of this project is to implement Customs and Boarder Protection Cellular Over the Horizon Enforcement Network (COTHEN) at select units in the Coast Guard. The units include Sector Key West, Florida, Sector Southeastern New England, Sector San Diego and Air station Sacramento. Once COTHEN is established in these locations the quality and effectiveness of HF communications will be tested and analyzed to see if this is the best solution for Coast Guard HF communications. Ultimately, we will provide a recommendation to TISCOM about the use of COTHEN in the Coast Guard.

1.1.1 Background

The Coast Guard is currently undergoing a communications systems transform in order to better unify systems service wide. One portion of this project is the Shore-side Automatic Link Establishment (ALE) Network Expansion. This is intended to improve high frequency communications specifically between sectors and their assets. Currently, the Coast Guard fosters a culture that opposes HF communications because HF point to point communications leave gaps in the coverage area. Additionally, with the current

system, the user needs to manage frequencies manually. This requires a great deal of knowledge about how weather, time of day, and season effect the quality of a specific frequency channel. Some users do not understand how to best manage these frequencies, and communications are often lost in one location and need to be picked up by another unit.

Automatic Link Establishment is one solution to this HF communications dilemma that TISCOM is considering. ALE is a software based communications protocol that establishes radio links and eliminates human error. The ALE radio frequently sends and receives signals (known as soundings) in order to determine the optimal operating frequencies for that particular radio and location. Based on these soundings, the radio is able to automatically connect, or "handshake" with the other radio without requiring the user to manage the frequencies. In this way, ALE ensures better communications and a greater connectivity between assets

TISCOM plans on integrating an ALE based communications system through the Customs Over the Horizon Enforcement Network (COTHEN). COTHEN is an already proven nationwide HF ALE network that is connected by a backbone of land lines. This network has 19 sites, 89 remote command consoles (RCC's), and a Technical Service Center (TSC) in Orlando, FL. The Coast Guard has been using COTHEN since 2003 for the purpose of flight following. Currently most of the use falls on CAMS as they are the only units with full RCC consoles, but some sectors have had the opportunity to use the mini RCC's temporarily. Currently the Coast Guard is 85 % of COTHEN's daily activities. It has the potential to expand with Coast Guard assistance if the Coast Guard decides to use COTHEN full time.

COTHEN provides many benefits which will benefit the Coast Guard in addition to the greater coverage area. For example, the TSC constantly monitors communications using the network by tracking assets' radio calls. They ensure that communications are established and the link is optimal. This is done by monitoring which land site a radio call is using to establish the link, and if it is not the best one the TSC can remotely change the site without the users knowing, improving the quality of the communications. Additionally, they can communicate with the users in order to answer questions, provide training, and walk the user through solutions to problems. They also have the ability to let the user know that the person they are trying to call is not available. This reinsures the user that their radio is functional and that communications will be established as soon as possible. Another capability of the TSC is to perform telephone patches and over the air rekeying, which allows COTHEN to maintain communications regardless of external conditions.

1.1.2 Purpose

The purpose of our project is to improve HF communications service wide. This will include centralizing Coast Guard communications and reducing the load at the Communications Area Master Station (CAMS). Additionally the Coast Guard has a need to update systems in order to reduce maintenance costs and improve interoperability within the Department of Homeland Security (DHS). Lastly, the Coast Guard is in need of more communications support and expertise.

A solution that will be investigated is to implement ALE radios using COTHEN at select sector sites across the country. Once in place, the scope of the project shifts to the development of a detailed test plan to test the quality and efficiency of the new HF

communications system. The results of this test will be analyzed and based on the data, a final recommendation will be made to TISCOM ascertaining whether or not this system should be made permanent.

1.2 Assumptions and Constraints

The success of this project is based primarily on a three assumptions. First of which, the Radio Control Consols (RCC's) must be installed properly installed at select sectors in a timely manner so that testing can be performed on them within the next year. Next, ALE radios must also be properly installed and used by operational Coast Guard units. This way data can be recorded and a final recommendation can be made. Last, we are assuming that Customs can provide Coast Guard operators at sectors the training and support they need to be able to effectively operate the new equipment.

There are three primary constraints this project. First, the solution to this project is strictly focused on COTHEN and ALE. This constraint exists because this solution is what TISCOM is currently researching and beginning to implement at the sector level. The second constraint is the operating capacity of COTHEN itself. If the Coast Guard takes on COTHEN, over 1000 assets will be added onto the system. This constraint must be kept in mind throughout the project as it could possibly limit the usage and efficiency of COTHEN. The other constraint is vulnerability of TSC and the antennas themselves. The TSC is located in Florida, but is protected for up to a category 5 hurricane. Still, there is no guarantee against natural disaster. Since it is the central hub of COTHEN, it must remain functional. To mitigate the risk involved in one centralized hub location, Customs did create a backup TSC location in Ohio. The antenna locations must also be intact and properly maintained by customs. Losing antenna assets due to natural disasters

could severely cripple the communications systems. Thus, the Coast Guard would be almost exclusively dependant of Customs for HF communications.

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2. SPONSOR NEEDS / OPERATIONAL REQUIREMENTS

1. Improve HF Communications
2. Centralize CG Communications

3. Lessen the Load on CAMS
4. Updated Systems to reduce maintenance costs
5. Increased Communications Expertise
6. Improve Interoperability within DHS

3. REQUIREMENTS TRACEABILITY MATRIX

Level	Need	Functional Requirement	Justification
	1	Communications between aircrafts and shore stations need to be made every 15 minutes 95% of the time	If two consecutive position reports fail to be transmitted on HF the flight following needs to be transferred to another unit or the mission needs to be canceled. Currently this happens for over half of the missions, not all are cancelled, but transferring responsibility causes a disconnect in communications and a limitation on asset control by sectors
	2	One standard HF communications protocol	Mandated by the Commandant of the CG in the COMMSYS Transform
	3	Operational commanders do all the flight following	Currently CAMS picks up a lot of flight following when Sectors lose communications because they are currently subscribing to ALE and have RCC consoles. They have many other jobs

			including routine broadcasting that flight following is an additional load that causes unnecessary stress on the system.
	4	Provide all sectors with RCC consoles	It is with RCC consoles that Sectors will monitor link establishments to ensure effective communication
	4	All CG assets have ALE compatible radios	In order for an asset to communicate using COTHEN they will have to have ALE radios
	5	Semi-Annual training schedule for all OS's that stand watch at Sectors	Many operators in the CG do not have the knowledge base to fully understand HF comms. The Technical Support Center of COTHEN provides highly trained personnel that can provide on the spot training to those who need it over the radio, but they will also need a proper training on the equipment and processes. If it is only yearly, then the new operators may go for quite some time without training. Semiannual ensures all users are up to date on the technology
	6	Operational Commands have at least 3 mini-RCC's	In can not be ensured that other agencies are using COTHEN and it

		available to provide to other Agencies in the event of joint missions or emergencies.	is necessary to still communicate with them

Appendix B

Automatic Link Establishment and COTHEN for HF communications

Business Case

1/c Christopher Rogers

1/c Jennifer Sullivan

Project Advisor: Dr. McKaughan

Project Sponsor: Telecommunications and Information Systems Command

1. Needs Statement

Currently the Coast Guard is undergoing a communication systems (COMMSYS) transform to unify communications service wide. Within this COMMSYS transform the Coast Guard has a very specific set of needs in relation to high frequency (HF) communications: improve the fidelity of HF communications, centralize them under one command, lessen the communications load on Communications Area Master Stations (CAMS), update current systems, increase expertise in the area of HF communications, and improve interoperability between both Coast Guard assets and other government agencies.

2. System Description and Justification

One possible solution to be investigated is to transfer current Coast Guard HF communications into the Cellular Over the Horizon Enforcement Network (COTHEN).

COTHEN is a HF communications network that has transmission/reception sites all across the country that are connected, essentially, by telephone lines. These sites use automatic link establishment (ALE) protocol to communicate to the user. This protocol internally searches out the best frequency for transmission, calls the other radio using a callsign, and the two radios establish communications on that optimal frequency. ALE takes out the requirement of the user managing frequencies to find the best one, reducing human error.

The present state of HF communications, particularly at sectors, is that they are unreliable, and difficult to maintain. This has created a culture in the Coast Guard that is opposed to using HF communications. Many of these problems are solved by using ALE techniques and the COTHEN network. ALE requires less knowledge, at the user level, of the physics behind HF communications and frequency selection. Additionally, COTHEN provides a large coverage area extending well beyond the bounds of the United States and the Carribean. The Coast Guard currently maintains multiple transmission sites which have individual coverage areas. This has caused problems with HF communications in the Coast Guard; particularly gaps where the coverage areas do not over lap where communications are weak or non-existent. COTHEN is a proven network of transmission sites that works well consistently, and should be considered as a possible solution to HF communications challenges.

3. Objectives

The ultimate goal of this project is to provide Telecommunications and Information System Command (TISCOM), the project sponsor, with a recommendation of whether or not the Coast Guard should transfer HF communications to COTHEN. This involves developing test plan to measure the effectiveness and feasibility of implementing Automatic Link Establishment

(ALE) HF communications, specifically through COTHEN at the sector level in the Coast Guard. The test results will serve as the basis of a Coast Guard-wide implementation plan.

COTHEN will provide be implemented at Sector Key West, FL, Sector Southeast New England in Woods Hole, MA, Sector San Diego, CA, and Air station Sacramento, CA in order to monitor how it will work for the Coast Guard. Through the COTHEN Technical Support Center (TSC), data about the quality of a link and consistency of link establishment can be recorded. This data can be analyzed to determine how effectively COTHEN works in establishing Coast Guard communications. Comparing the results of COTHEN to the current effectiveness of Coast Guard HF communications will demonstrate how COTHEN could improve communications if implemented. This will also help in determining how to implement the system and observe any challenges that the implementation could face. In addition, observing how effective the system at different regions across the country will provide insight on COTHEN's consistency across different areas of operation around the Coast Guard.

4. Benefit Analysis

ALE will be beneficial to the needs of the service for its ease of use, link quality, and reliability. Implementing ALE through COTHEN will allow the Coast Guard use of an established communications network. Currently the Coast Guard pays to maintain many transmissions sites for a communications system that many Coast Guard operators do not use because of its lack of dependability. Through COTHEN, the Coast Guard will no longer need to maintain these sites and can focus more resources on training, so that operators at sectors can benefit from HF communications.

There are some possible risks associated with using COTHEN as a solution to HF communication challenges including the possibility of overwhelming the network. The Coast Guard would add approximately 1200 assets to a system that currently supports less than 300. Therefore, it will be important to accurately indentify how many assets COTHEN can support. Another potential risk is that Coast Guard radios may not be compatible with the COTHEN system. This risk will be addressed during the testing phase of our project. A third risk is the Coast Guard's inherent dependability on another agency if the Coast Guard moves toward a COTHEN backed ALE system. Customs and Boarder Protection may at some point decide to stop supporting the COTHEN program. The Coast Guard would then have to reevaluate its HF communications network entirely. Finally, there may be challenges associated with implementing COTHEN in both Alaska and Hawaii as a result of their remote locations.

Appendix C

COTHEN ALE

Support Plan

1/c Jennifer Sullivan

1/c Christopher Rogers

29 November 2007

Purpose:

The purpose of our project is to improve high frequency (HF) communications across the Coast Guard. This will include standardizing Coast Guard communications and reducing the load at the Communications Area Master Station (CAMS). Additionally the Coast Guard has a need to update systems in order to reduce maintenance costs and improve interoperability within the Department of Homeland Security (DHS). Lastly, the Coast Guard is in need of more communications support and expertise.

A solution that will be investigated is to implement ALE radios using COTHEN at select sector sites across the country. Once in place, the scope of the project shifts to the development of a detailed test plan to test the quality and efficiency of the new HF communications system. The results of this test will be analyzed and based on the data, a final recommendation will be made to TISCOM ascertaining whether or not this system should be made permanent.

Proposed Design Solution:

TISCOM plans on integrating an ALE based communications system through the Customs Over the Horizon Enforcement Network (COTHEN). COTHEN is an already proven nationwide HF ALE network that is connected by a backbone of land lines. This network has 19 sites, 89 remote communications consoles (RCC's), and a Technical Service Center (TSC) in Orlando, FL. The Coast Guard has been using COTHEN since 2003 for the purpose of flight following. Currently most of the use falls on CAMS as they are the only units with full RCC consoles, but some sectors have had the opportunity to use the mini RCC's temporarily. Currently the Coast Guard is 85 % of COTHEN's daily activities. It has the potential to expand with Coast Guard assistance if the Coast Guard decides to use COTHEN full time.

COTHEN provides many benefits which will benefit the Coast Guard in addition to the greater coverage area. For example, the TSC constantly monitors communications using the network by tracking assets' radio calls. They ensure that communications are established and the link is optimal. This is done by monitoring which land site a radio call is using to establish the link, and if it is not the best one the TSC can remotely change the site without the users knowing, improving the quality of the communications. Additionally, they can communicate with the users in order to answer questions, provide training, and walk the user through solutions to problems. They also have the ability to let the user know that the person they are trying to call is not available. This reinsures the user that their radio is functional and that communications will be established as soon as possible. Another capability of the TSC is to perform telephone patches and over the air rekeying, which allows COTHEN to maintain communications regardless of external conditions.

COTHEN as a Solution

COTHEN may be a very useful system for the Coast Guard. It is already an established and successful network that has been proven reliable by the Customs and Border Patrol [2, 4, 5]. COTHEN will meet the HF coverage needs because of its vast coverage area. The actual talk area for COTHEN is illustrated in Figure 3. The yellow areas represent reliable communications, while the blue and green areas are locations in which there is limited or no coverage.

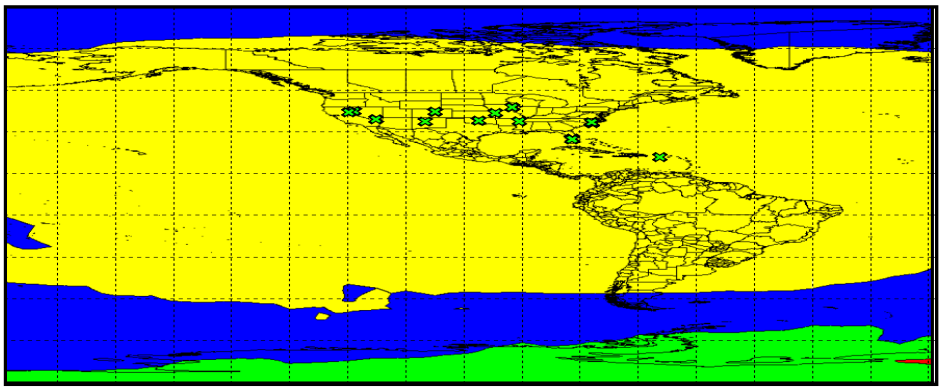


Figure 3: COTHEN Talk Area

Adapted from Powerpoint Presented by Jim Coffman

<u>Support Considerations:</u>

- **Economic**
  - The project's funding source is TISCOM.
  - This project has an initial installation cost for the ALE systems and an annual maintenance/ lease cost. The initial installation cost is estimated to be $3,737,278.00. This covers the testing and engineering, the first year's maintenance and circuit lease from COTHEN, and the cost to purchase and install the ALE radios themselves. However, this initial cost does not cover the

following: ALE installation aboard mobile units, the cost to upgrade COTHEN to level 1 encryption as required by the Coast Guard, cost to manage the configuration of ALE radios, cost for additional personnel, and finally, the cost for a backup technical service center. The recurring annual cost for leasing the circuits and maintaining the systems after the initial installation is $1,195,276.00.

  - This project does not have to compete for funding. It is an included portion of the COMSYS transform and is set to be implemented Coast Guard wide.

- **Manufacturability**
  - Technicians from COTHEN and TISCOM will be installing the remote command consoles (RCC) at the sector level.
  - Initially 4 systems will be built and implemented. Eventually, all 39 sectors will have an RCC and ALE/COTHEN capabilities.
  - The primary concern in manufacturability is the compatibility of different radios and ensuring that all Coast Guard units have updated equipment and software.
- **Sustainability and Reliability**
  - All spare parts for the RCCs can be procured from the commercial sector.
- **Life Cycle Costs**
  - The costs during the life cycle of the design include:
    - Maintenance and Support
      - COTHEN is responsible for all maintenance, support, and additional man power. This service comes at a yearly premium, $375,000.00. The maintenance and support is estimated to cost $820,276.00.

- Training
    - The number and cost of the increased number of billets needed to manage the new ALE/COTHEN system is unknown. The cost of training personnel is also unknown at this point in project.
- Initial Installation
    - The cost to purchase and install the RCC hardware for the sectors Coast Guard wide is $2,062,002.40. The estimated cost to engineer and test the newly installed system is $250,000.00.
- Upgrades
    - The cost to increase the level of encryption required of COTHEN by the Coast Guard in unknown. Also unknown is the cost to uninstall the current HF radio network that will be phased out with the onset of the COTHEN based system.

External Considerations:

- **Environmental:**
    - There are no environmental issues associated with installing new radios. Since the antennas are already installed and networked, there are no external concerns beyond the radio installation.
- **Health and Safety:**
    - There is less static noise on ALE radios than on traditional HF radios. This should help the hearing of the OS's standing the watch as they do not have to continuously listen to loud static noise.
    - There are no known negative impacts of our design solution.

- **Ethical, Political & Social**
    - This design comes as a result of the communications systems transform that is being mandated by the commandant of the Coast Guard. CAMSPAC and CAMSLANT are merging and the Coast Guard is adopting more of a command and control philosophy which requires a uniform communications network, such as COTHEN.

<u>Software Considerations:</u>

- **Privacy:**
    - The user data that will be collected is the ALE radio addresses for nearby units.
    - The ALE radio addresses are used to identify other units nearby and to initiate communications if desired. Also stored is the LQA data for each channel and unit. This data will be used to determine the best operating frequency for each specific unit.
- **Security:**
    - The system will store ALE radio addresses for nearby units as well as the LQA data associated with each address. This data will be stored internally in each radio.
    - Transmissions will be protected from unauthorized listening through the use of an encryption box which both has the ability to encrypt and decrypt messages used in transmission. This is accomplished through the use of a security key which is classified.

Future Testing:

We plan on gathering two weeks of HF communications data from Sector Key West and Sector Southeastern New England before and after ALE and COTHEN are implemented. This data will include: the number of calls attempted using HF and from which platform, the number of successful calls, the number of flight following missions completed, the number of flight following missions that needed to be transferred to other units, and the number of calls lost completely and from which platforms. Once ALE is implemented at the sectors, this data will be gathered again in addition to the following: the average time it takes to establish a link, how often the TSC needs to be contacted for communications assistance, and number times a weaker call is overridden by a stronger incoming call. While using ALE, data will also be gathered from the TSC with regards to the LQA, ineffective transmission sites, and coverage gaps. These two sets of data will be analyzed and then compared to ascertain the degree of effectiveness of the use of COTHEN in the Coast Guard.

Appendix D

ALE COTHEN
PROJECT PLAN

1. INTRODUCTION

The purpose of this Project Management Plan is to provide a synopsis of the project background, organization, and schedule.

1.1 Project Description

The Coast Guard depends largely on high frequency (HF) communications for aircraft position reports and long range communications. Unfortunately, current HF communications are unreliable and difficult to use. Often times Coast Guard operators do not have the knowledge of HF wave propagation to optimize the signal, and so the calls are broken or lost. This results in a decreased mission capability, as the communications have to be transferred to a different unit. Currently the Coast Guard is undergoing a communications systems (COMMSYS) transformation to unify communications service-wide. One portion of the COMMSYS transform is to solve problems with HF communications. The Coast Guard is in need of standardized communications, reduced load on the Communications Area Master Stations (CAMS), updated systems to reduce maintenance costs, improved interoperability with in the Department of Homeland security, and increased support and expertise in the area of HF communications. The goal of this project is to prove that Customs and Boarder Protection's Cellular Over the Horizon Enforcement Network (COTHEN) is the best solution to satisfy all of these needs. It will be implemented at Sector Key West, Florida, Sector Southeastern New England, Sector San Diego and Sector Seattle, Washington.

Once COTHEN is established in these locations the quality and effectiveness of HF communications will be tested and analyzed to see if this is the best solution for Coast Guard HF communications. Ultimately, we will provide a recommendation to TISCOM about the use of COTHEN in the Coast Guard.

1.2 Project Background

1.2.1 COMMSYS Transform

The Coast Guard is currently undergoing a communications systems transform in order to better unify systems service wide. One portion of this project is the Shore-side Automatic Link Establishment (ALE) Network Expansion. This is intended to improve high frequency communications specifically between sectors and their assets.

1.2.2 CG HF Communications

There tends to be a culture opposing HF communications in the Coast Guard. Typical HF point to point communications leave gaps in the coverage area in which communications are weak. Additionally, the user needs to manage frequencies. This requires a great deal of knowledge about how weather, time of day, and season effect the quality of a specific frequency channel. Most users do not understand how to best manage these frequencies, and communications are often lost in one location and need to be picked up by another unit, causing a discontinuity of command.

1.2.3 ALE

Automatic Link Establishment is a software based communications protocol that establishes radio links and reduces human error. The ALE radio frequently sends and

receives signals (known as soundings) in order to determine the optimal operating frequencies for that particular radio and location. Based on these soundings, the radio is able to automatically connect, or "handshake" with the other radio without requiring the user to manage the frequencies. In this way, ALE ensures better communications and a greater connectivity between assets

1.2.4 COTHEN

COTHEN is a nationwide HF ALE network that is connected by a backbone of land lines. This network has 19 sites, 89 remote command consoles (RCC's), and a Technical Support Center (TSC) in Orlando, FL. The Coast Guard has been using COTHEN since 2003 for the purpose of flight following. Currently most of the use falls on CAMS as they are the only units with full RCC consoles, but some sectors have had the opportunity to use the mini RCC's temporarily. Currently the Coast Guard is 85 % of COTHEN's daily activities. It has the potential to expand with Coast Guard assistance if the Coast Guard decides to use COTHEN full time.

COTHEN provides many benefits in addition to a greater coverage area. For example, the TSC constantly monitors communications using the network by tracking assets' radio calls. They ensure that communications are established and the link is optimal. This is done by monitoring which land site a radio call is using to establish the link, and if it is not the best one the TSC can remotely change the site without the users knowing, improving the quality of the communications. Additionally, they can communicate with the users in order to answer questions, provide training, and walk the user through solutions to problems. They also have the ability to let the user know that

the person they are trying to call is not available. This reassures the user that their radio is functional and that communications will be established as soon as possible. Another capability of the TSC is to perform telephone patches and over the air rekeying, which allows COTHEN to maintain communications regardless of external conditions.

1.2.5 Past Work and Current Status

As of Jan 2008, COTHEN had not yet been established at any of the planned Sectors. The work of last semester consisted of researching ALE and COTHEN and developing an understanding of what benefits COTHEN provides aside from improved communications. These benefits will be integral in proving that COTHEN meets all of the Coast Guards needs; specifically that it increases support and expertise as well as improved interoperability.

The test plan was also developed last semester, so that testing could be performed before COTHEN was installed and as soon as the RCCs were installed. Sector Key West began testing their current HF communications on the 19 Dec, 2008. They were asked to collect two weeks of data. This pre-COTHEN testing is necessary to paint a picture of the current HF communications and how COTHEN improves them.

Currently, Sector Key West has received COTHEN capabilities and the operators are familiarizing themselves with the system. Testing will hopefully start 10 February 2008. Sector San Diego is currently gathering pre-COTHEN data and will be receiving the RCC on 04 February. The dates of the RCC installation are still to be determined. If these dates fall after March first, it is not guaranteed that data from these locations will be included in the final report.

1.3 References

N/A.

2. ROLES AND RESPONSIBILITIES

2.1 Project Sponsor

The project sponsor is TISCOM. The project sponsor is supporting a large communications systems transformation in which they have asked us to do a part. LTJG McCann and CWO Mills are the contacts at TISCOM providing us with the support we need and overseeing the project.

2.2 Project Advisor

The project Advisor is Dr. McKaughan.

2.3 Team Members

1/c Jennifer Sullivan and 1/c Christopher Rogers

2.4 Stakeholders

Sector Key West, FL

Sector South Eastern New England

Sector San Diego, California

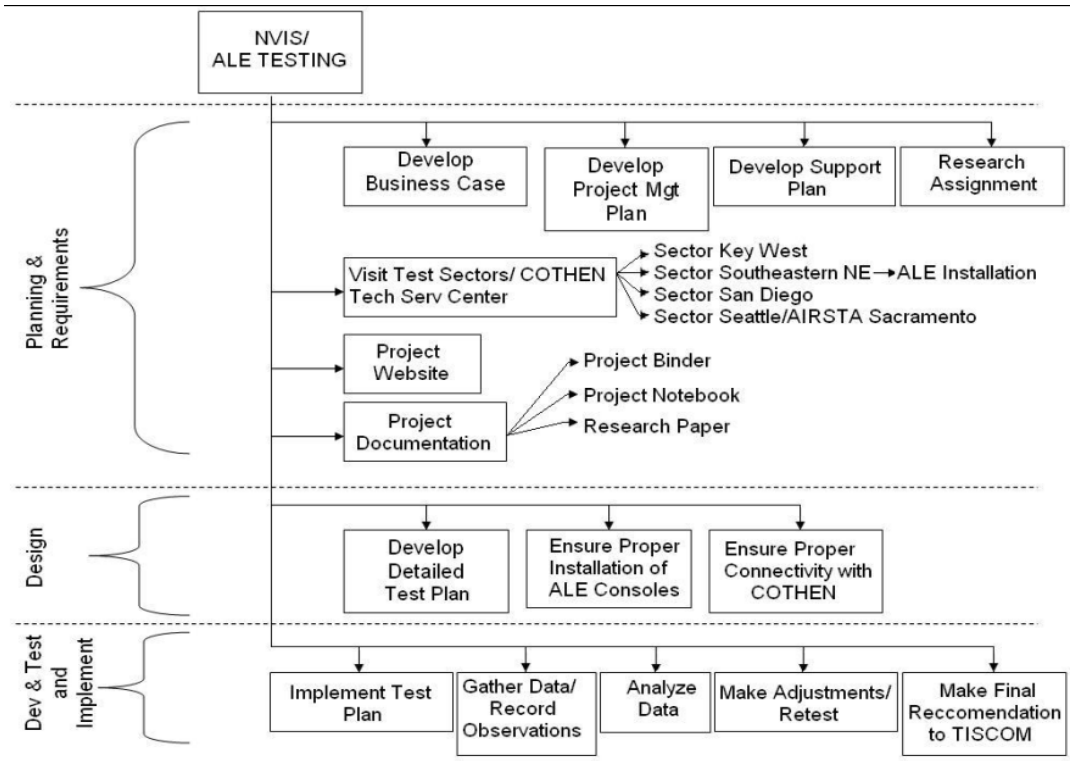
Sector Seattle, Washington

Eventually the Coast Guard

Customs and Boarder Protection

3. PROJECT DESCRIPTION, SCHEDULE, AND RESOURCES

3.1 Project Work Breakdown Structure (WBS)



3.2 Resource Estimates

N/A.

3.3 Schedule

Oct 9: PMP Presentation

Oct 19: Requirements Specification

Nov 6: Objectives and Outline II

Nov 9: Project Notebook Review II

Nov 20: Support Plan

Nov 27: Paper: System Design

Dec 7: Semester Paper

Dec 12: Presentation Practice

Dec 18: Begin Pre-COTHEN testing at Sector Key West

Dec 17: Formal Presentations

Dec 17: Project Notebooks and Binder

Jan 9: Conclude Pre-COTHEN testing at Sector Key West

Jan 20: Begin Pre-COTHEN testing at Sector San Diego

Jan 22: RCC installed in Sector Key West

Jan 25: Interim Design Paper

Feb 1: Receive Pre-COTHEN data from Sector Key West

Feb 1: Conclude Pre-COTHEN testing at Sector San Diego

Feb 4: RCC installed in Sector San Diego

Feb 4: Receive Pre-COTHEN data from Sector San Diego

Feb 6: Presentation

Feb 8: Draft Poster

Feb 8-9: Testing at TISCOM

Feb 10: Begin COTHEN testing at Sector Key West

TBD (FEB): RCC Installed in Sector Seattle, Washington

Feb 15: Final Poster

Feb 18: Begin COTHEN testing at Sector San Diego

Feb 24: Conclude COTHEN testing at Sector Key West

Mar 03: Conclude COTHEN testing at Sector San Diego

Mar 21: Draft Test Plan

TBD (MAR): Testing at CAMSLANT

TBD (MAR): RCC Installed in Sector Southeastern New England

March 31: Compile Data

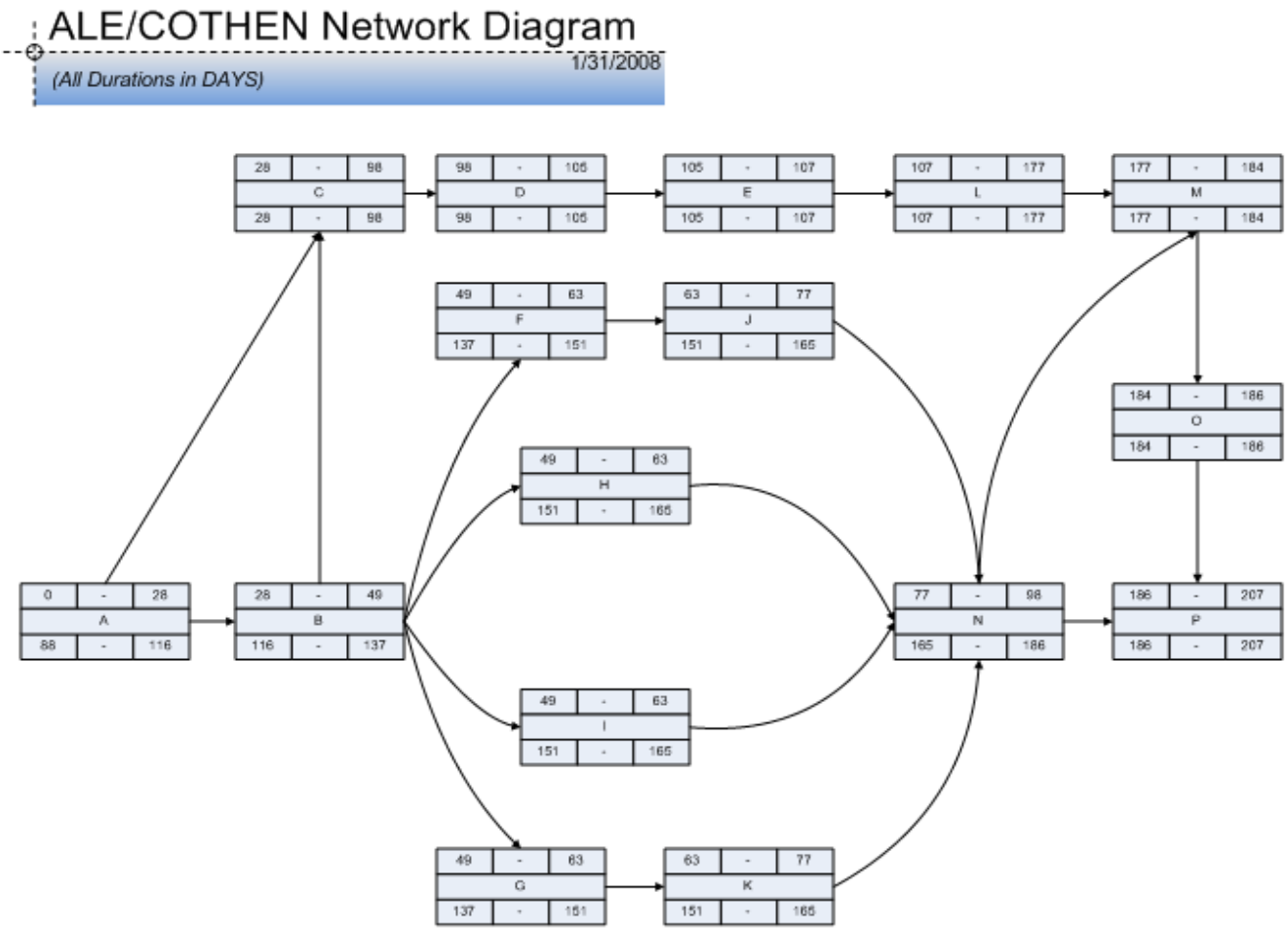
April 4: Draft Design Specification

April 18: Draft Project Paper

April 25: Project Paper

3.4 Network Diagram

Network Diagram Table			
Ltr	Task	Duration	Pre-Req's
A	Develop understanding of ALE/COTHEN	28 d	-
B	Understand components of COTHEN	21 d	A
C	Interim Documentation (Fall Semester)	70 d	A,B
D	Interim Presentation (Fall Semester)	7 d	C
E	Interim Project Binder (Fall Semester)	2 d	D
F	Pre-COTHEN Testing: Sec Key West	14 d	B
G	Pre-COTHEN Testing: Sec San Diego	14 d	B
H	TISCOM RCC Familiarization/ Testing	14 d	B
I	CAMS Testing: Pre/Post COTHEN	14 d	B
J	COTHEN Testing: Sec Key West	14 d	F
K	COTHEN Testing: Sec San Diego	14 d	G
L	Full Project Documentation (Spring Semester)	70 d	E
M	Final Presentation (Spring Semester)	7 d	L
N	Analyze Results	21 d	H, I, J, K
O	Final Project Binder (Spring Semester)	2 d	M, N
P	Final Project Paper and Recommendation	21 d	N, O



Appendix E

ALE COTHEN

Design Specification

Purpose: The purpose of our project is to improve high frequency (HF) communications across the Coast Guard. This will include standardizing Coast Guard communications and reducing the load at the Communications Area Master Station (CAMS). Additionally the Coast Guard has a need to update systems in order to reduce maintenance costs and improve interoperability within the Department of Homeland Security (DHS). Lastly, the Coast Guard is in need of more communications support and expertise. Testing will provide data about the effectiveness of communications when using the Cellular Over the Horizon Enforcement Network (COTHEN) as a solution to Coast Guard HF communications. Based on the data, a final recommendation will be made to TISCOM ascertaining whether or not this system should be made permanent.

Design Solution:

COTHEN is a land based communications network that implements ALE technology to ensure the most effective communications possible. The network is comprised of multiple components which will each be discussed in turn.

Automatic Link Establishment Technology

ALE is a software based communications protocol that makes establishment of radio links automatic and transparent to the user. On standard HF radios, the operator manually scans through each frequency for an optimal transmission. ALE scans the same HF frequencies automatically. Each ALE radio is given a specific address designation, or callsign, which serves the same purpose as a phone number. To reach a specific station, the operator simply dials the Callsign on the radio.

An ALE station that is not yet linked (engaged in communication with another station) continuously scans a pre-determined set of frequencies listening for its ALE Callsign. This constant scanning maximizes the probability that an incoming call will be received. When the scanning station detects the first characters of its address designation, it stops scanning and tunes in to that particular frequency. The radios then systematically confirm the establishment of the link, which is called a “handshake”. When the call is completed, one of the stations transmits a disconnect signal and both radios resume scanning. The following block diagram depicts the procedure for making a call on ALE radios.

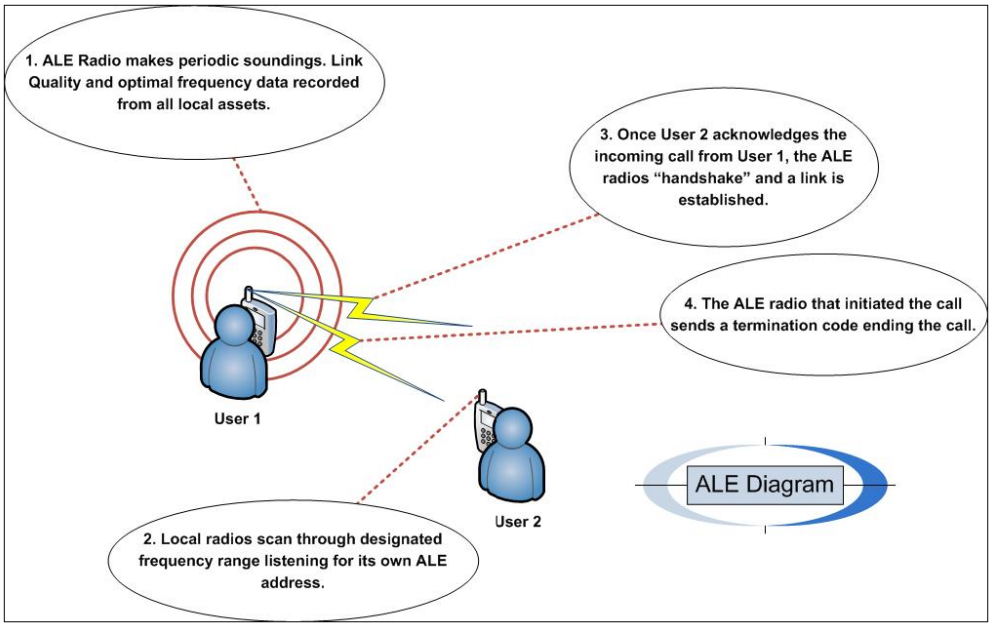


Figure 1: Block Diagram of ALE Radio communications

ALE radios measure the quality of the channels available for propagation via periodic soundings. These brief, self-identifying broadcasts are transmitted and then received by other stations in the system. Each station in the system records the identity of the sounding station and evaluates the quality of the signal received. The quality of the signal is quantified and stored internally. This number is referred to as the Link Quality Analysis (LQA). An LQA is a parameter based on the signal to noise ratio (SNR) and the bit error ratio (BER) of a given signal.

An ALE radio will consistently update its stored data for all stations with each new sounding received. Since the channel conditions are time variable, each data entry is coupled with a time to facilitate an age bias of stored LQA data. In other words, older LQA measurements are less favored than more recent measurements. Data collected from the unilateral soundings permit the scanning station to select the optimal working channel when calling a particular station.

All ALE equipment used within the network is commercial off the shelf (COTS) radios by Rockwell Collins. The assets that communicate using the network must have ALE capable radios. It is important that the radios have the same scanning frequency at the network, it must have a tune time of 10 sec. This can be programmed into the radio easily, but most radios already operate this way and are therefore compatible with the network.

Within COTHEN the scanning frequencies are on eleven different channels. All ALE radios and the transmission sites have these channels programmed to scan. Table 1 lists the channels and their frequencies.

Table 1: COTHEN Channels and Frequencies

Channel	Frequency (MHz)
1	5.732
2	7.527
3	8.912
4	10.242
5	11.494
6	13.907
7	15.867
8	18.594
9	20.890
10	23.214
11	25.350

Transmission Sites

- **Locations:**

  There are 18 unmanned transmission site locations across the country, and some locations have multiple sites. The following table lists those sites, the three digit identification used within the network, latitude, longitude, and town location.

Table 2: Transmission Site Summary

Site I.D	**Latitude**	**Longitude**	**Town**
ATL	32 55’ 18” N	84 39” 33” W	Warm Springs, GA (S. of Atlanta)
MEM	34 36”59” N	090 04 53" W	Senatobia, TN (S. of Memphis)
OKO/OKD	34 51' 46" N	097 51' 47" W	Chichasha, OK (SW of Oklahoma City)
LUV	40 05' 21" N	118 31' 57" W	Lovelock, NV (NE of Reno)
RSH	34 49' 02" N	078 07 55" W	Concord, NC (E of Fayetteville)
KCM	38 36' 96" N	093 36' 35" W	Raleigh, NC
DEN	39 26' 26" N	103 57' 31" W	Agate, CO (SE of Denver)
ABQ	35 08' 39" N	105 54' 31" W	Stanley , NM (E of Albuquerque)
CDI	34 57' 30" N	076 16' 36" W	Cedar Island, NC (SE of Raleigh, E of Jacksonville)
VGS	36 35' 44" N	114 29' 27" W	Longandale, NV (NE of Vegas)
RNO	38 52' 00" N	119 24' 38" W	Simpson, NV (SE of Reno)
SEA	34 58' 07" N	078 23' 32" W	Clinton, NC (E of Fayetteville)
CDR	42 00' 26" N	091 29' 43" W	Marion, IA (E of Cedar Rapids)
SAR	27 21' 15" N	081 52' 25" W	Limestone, FL (E of Sarasota)
FTM	26 33’ 38” N	081 25” 00” W	Sarasota, FL
PR1	18 29’ 08" N	066 37' 59" W	Islote, PR (W of San Juan)
CR1-CR8	42 03’ 18” N	091 63’ 75” W	Omaha, NE
SS1	42 00’ 26” N	0 91 29’ 43” W	Cedar Rapids, IA

These site locations were picked to give optimum coverage of the area of operation (AOR). The characteristics of HF wave propagation affect the location of the transmission sites. HF waves radiate up and bounce off of the ionosphere back to Earth. The distance between the transmission site and where the wave is received is a dead zone, called the skip zone. In order to account for this and avoid dead spots in the coverage area, the sites are located at least one skip zone from the AOR. In this case, the sites are located just south of the center of the country in order to provide the best coverage on the southern board of the United States, where Customs and Boarder Protection is most active. This can be seen in figure 2.

Figure 2: Location of Transmission Sites

Each site location was first surveyed to in order to find low noise platforms. Particularly, it is important that the sites are not near any power lines or electrical power systems that will generate electrical noise. This is important because HF antennas operate using electrical fields and being near electrical noise would interfere with the transmissions. As a result, all of the transmission site locations are outside major cities, in rural areas.

- **Site Equipment**

Each site has two antennas, an Omni TSI 530 and a Directional TS 540. An omni-directional antenna radiates power uniformly in one plane. These antennas are generally used for air

support. Directional antennas radiate more power in one direction then in any other. These antennas are particularly useful for marine support.

Each site transmits 1 k watt of power and are connected to one another with 56 k bit phone lines. The connection of the sites by phone line unifies the sited coverage areas so that the network provides one large coverage area rather than 18 individual. This is illustrated in figure 3.

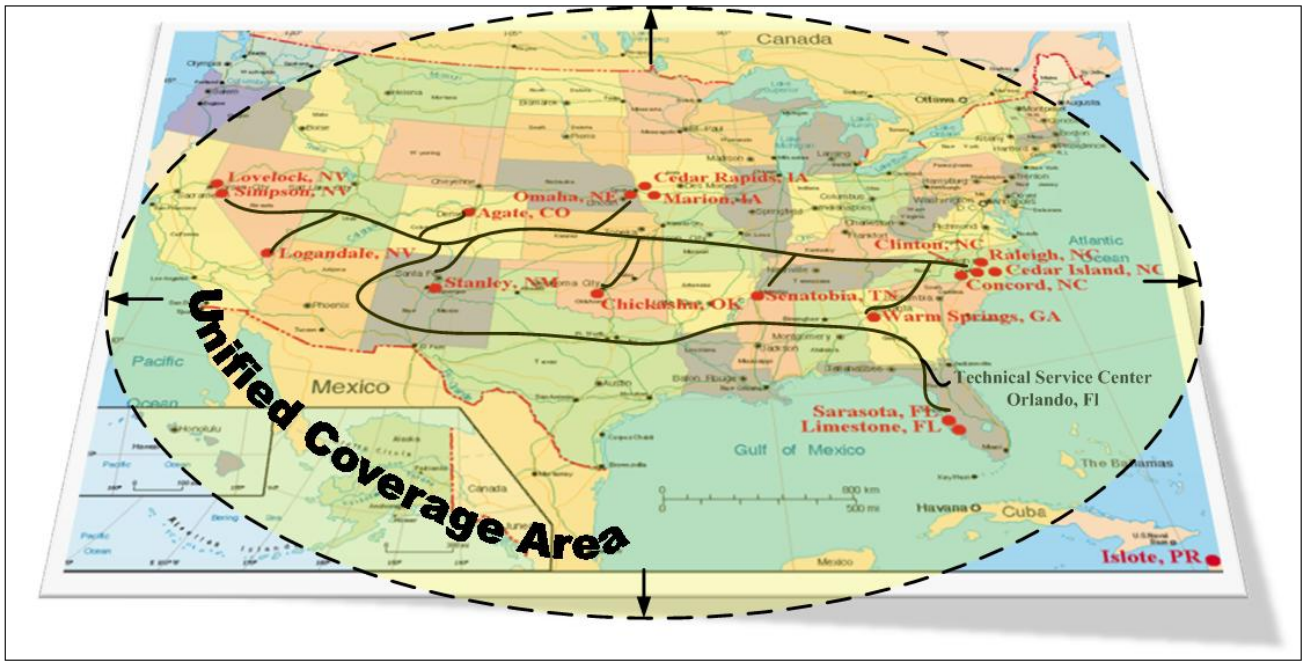


Figure 3:Phone Line Connect Transmission Sites, Unifying Coverage Areas

This eliminates dead spots resulting from the skip zones of each site. The unified coverage area can be seen in figure 4.

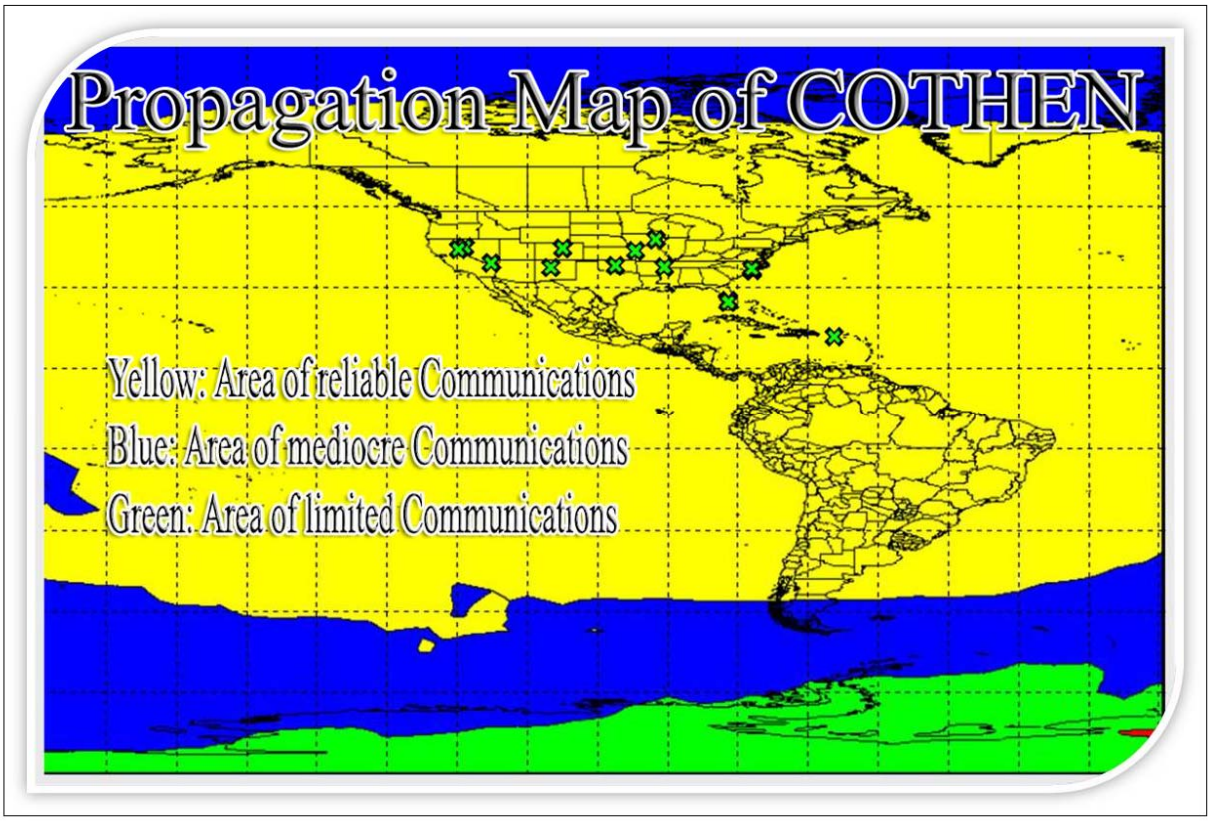


Figure 4: Actual Coverage Area of COTHEN

The radios are Rockwell Collins RT 2200. There are two racks of equipment that can be remotely switched if there is a failure in one. The monitoring equipment gathers information about the temperature in the building, the equipment, and the weather or not the doors are open. When there is a change in conditions the monitoring equipment at the sites calls the Technical Service center.

- **Technical Service Center**

The Technical Service Center is the central hub of the network. All phone lines are connected through the TSC and all data is compiled there. The TSC not only monitors the status of all the network equipment, but also monitors all calls made within the network to ensure optimal calling. The following is a list of the capabilities of the TSC:

- Best Station Linking
- Network Analysis at a Glance
- Active Platforms ICON Display
- Alternate Station Routing
- Detect and Avoid Faulted Radios
- No Null Areas
- Redundant Capacity
- Generic User Interface (HyperTerminal & Audio)
- Contingency Comms Capable for Emergency Response
- Simultaneous Calling (Collision Avoidance)
- Busy Channel Avoidance
- Intercom Call Routing
- Call Forwarding

These capabilities are achieved using the cellular program. The data is gathered using software and transferred across the phone lines to the TSC where it is compiled to be presented to the watch stander in a user interface. The software and all components of the cellular program were developed by Rockwell Collins contractors.

- **Remote Command Consoles**

The RCCs are the units that would be located a land sites to allow the users to monitor their assets. Sectors will need to have RCCs in order to communicate with their assets in the COTHEN network. Also in this manner they can graphically monitor their assets usage. The RCCs consist of Rockwell Collins RT 2200 radios, same as the transmission site, and computer

systems for the user display. They also require a phone line connection into the network. COTHEN also has portable RCCs that lack the computer display but still allows the user into the network. The only requirement for the mini RCC is that it has a direct phone line to connect into.

Design Decisions:

Support Considerations:

- **Economic**
  - The project's funding source is TISCOM.
  - This project has an initial installation cost for the ALE systems and an annual maintenance/ lease cost. The initial installation cost is estimated to be $3,737,278.00. This covers the testing and engineering, the first year's maintenance and circuit lease from COTHEN, and the cost to purchase and install the ALE radios themselves. However, this initial cost does not cover the following: ALE installation aboard mobile units, the cost to upgrade COTHEN to level 1 encryption as required by the Coast Guard, cost to manage the configuration of ALE radios, cost for additional personnel, and finally, the cost for a backup technical service center. The recurring annual cost for leasing the circuits and maintaining the systems after the initial installation is $1,195,276.00.
  - This project does not have to compete for funding. It is an included portion of the COMSYS transform and is set to be implemented Coast Guard wide.
- **Manufacturability**
  - Technicians from COTHEN and TISCOM will be installing the remote command consoles (RCC) at the sector level.

- Initially 4 systems will be built and implemented. Eventually, all 39 sectors will have an RCC and ALE/COTHEN capabilities.
- The primary concern in manufacturability is the compatibility of different radios and ensuring that all Coast Guard units have updated equipment and software.

- **Sustainability and Reliability**
  - All spare parts for the RCCs can be procured from the commercial sector.
- **Life Cycle Costs**
  - The costs during the life cycle of the design include:
    - Maintenance and Support
      - COTHEN is responsible for all maintenance, support, and additional man power. This service comes at a yearly premium, $375,000.00. The maintenance and support is estimated to cost $820,276.00.
    - Training
      - The number and cost of the increased number of billets needed to manage the new ALE/COTHEN system is unknown. The cost of training personnel is also unknown at this point in project.
    - Initial Installation
      - The cost to purchase and install the RCC hardware for the sectors Coast Guard wide is $2,062,002.40. The estimated cost to engineer and test the newly installed system is $250,000.00.
    - Upgrades

- The cost to increase the level of encryption required of COTHEN by the Coast Guard in unknown. Also unknown is the cost to uninstall the current HF radio network that will be phased out with the onset of the COTHEN based system.

External Considerations:

- **Environmental:**
  - There are no environmental issues associated with installing new radios. Since the antennas are already installed and networked, there are no external concerns beyond the radio installation.
- **Health and Safety:**
  - There is less static noise on ALE radios than on traditional HF radios. This should help the hearing of the OS's standing the watch as they do not have to continuously listen to loud static noise.
  - There are no known negative impacts of our design solution.
- **Ethical, Political & Social**
  - This design comes as a result of the communications systems transform that is being mandated by the commandant of the Coast Guard. CAMSPAC and CAMSLANT are merging and the Coast Guard is adopting more of a command and control philosophy which requires a uniform communications network, such as COTHEN.

Software Considerations:

- **Privacy:**
  - The user data that will be collected is the ALE radio addresses for nearby units.
  - The ALE radio addresses are used to identify other units nearby and to initiate communications if desired. Also stored is the LQA data for each channel and unit. This data will be used to determine the best operating frequency for each specific unit.
- **Security:**
  - The system will store ALE radio addresses for nearby units as well as the LQA data associated with each address. This data will be stored internally in each radio.
  - Transmissions will be protected from unauthorized listening through the use of an encryption box which both has the ability to encrypt and decrypt messages used in transmission. This is accomplished through the use of a security key which is classified.

Requirements: *Provide a description on how your design meets all of your requirements specifications (updated based upon any changes from your sponsor). If specific requirements have not been met, say why they have not been met. It is acceptable that this is a bulleted list/*

- **Communications between aircrafts and shore stations need to be made every 15 minutes 95% of the time:** This was not met, however it was determined that due to radio traffic and mission completion.

- **One standard HF communications protocol:** COTHEN maintains the communications protocol without the user involvement. In this way it ensures that all radio calls are being performed in the same manner.
- **Operational commanders do all the flight following, reducing the load at CAMS:** Data is still being analyzed to determine if the Sectors can maintain the air guard for their assets.
- **Provide all sectors with RCC consoles**
- **All CG assets have ALE compatible radios**
- **Semi-Annual training schedule for all OS's that stand watch at Sectors:** This would be required in the implementation policy
- **Operational Commands have at least 3 mini-RCC's available to provide to other Agencies in the event of joint missions or emergencies:**

Appendix F

Data Log

DATE	UNIT	CLEAR	BROKEN	NO JOY / LOST COMMS	GUARD KEPT W/ OTHER UNIT / WHO?

Appendix G

ALE/COTHEN

Projects Members: 1/c Jennifer Sullivan and 1/c Chris Rogers

Project Advisor: Dr. McKaughan

Project Sponsor: TISCOM

Test Plans 1 & 2: Pre and Post COTHEN Qualitative Test

25 March 2008

Synopsis: *The purpose of this test is to provide a qualitative comparison of current HF communications and HF communications using ALE/COTHEN. This is broken into two separate tests: A pre-COTHEN and post-COTHEN analysis. These are acceptance tests.*

Personnel: *Qualitative data will be collected in a data log provided to the Sector Command Center watchstander for testing at SEC Key West and SEC San Diego. Data will be collected from CAMS by the HF watchstander. This test requires Coast Guard assets to communicate with Sector Command Centers using both standard HF and ALE/COTHEN technology.*

Procedure: *This test will be performed at SEC Key West, SEC San Diego, and CAMSLANT. The Remote Command Console's (RCC) have been installed at these sites by TISCOM. On-site Operator training has been completed at these locations. The testing at CAMS will last 2 weeks. Each phase at sectors (Pre and Post-*

COTHEN) will last 2 weeks. At each site the designated watchstander will record the appropriate data in a special data log provided by the project members. After 2 weeks, the group members will analyze the data to evaluate HF communications with and without COTHEN.

Equipment Required:

1. *An RCC is required at the Sector and CAMS level.*
2. *HF radios that use ALE technology are required on Coast Guard units participating in the test so that they can operate within COTHEN.*
3. *Special data log sheets provided to the participating sectors and CAMSLANT by the project members.*

Initial Set-up:

The RCC's have been installed by TISCOM and implemented into the daily watches at SEC Key West, SEC San Diego, and CAMSLANT. Radio operators have been trained on how to properly operate the RCC. This will be done on-site by COTHEN personnel.

Test # 1 – Pre- COTHEN *Qualitative Communications Test*

Objective: *This test will assess the qualitative audibility of communications before the installment of the RCC and implementation of COTHEN. This test is a subjective test that will be performed at SEC San Diego and SEC Key West. At CAMSLANT, this data will be collected simultaneously as both COTHEN and standard HF communications are used in normal operations. The purpose of this test is to gather base line information about the current state of HF communications in order to compare to the COTHEN Network.*

Requirements: *All of the requirements are located in the Functional Requirements Document. The requirements that this test specifically addresses are:*

Requirement 2. Communications between aircraft and shore stations need to be made every 15 minutes 95% of the time.

Requirement 4. Operational commanders maintain all flight following.

Test Overview: *Watchstanders will evaluate the quality of communications based on whether the radio transmissions are clear or broken and whether or not radioguard had to be transferred from the sector or CAMS to another unit. The test period is 2 weeks. The standard radio communications quality scale will be used to rate the quality of each communication.*

Test Procedure:

1. *A) Each watchstander at the sectors will have the attached sector data log.*

B) Each watchstander at CAMSLANT will have the attached CAMS data log.

2. *A) Watchstanders at sectors will record the unit with whom communications are attempted, and whether or not the communications are clear or broken. If the communications were broken, the watchstander will indicate with whom radioguard was transferred. Each phase of testing will last two weeks.*

   B) Watchstanders at CAMS will record the same data as the watchstanders at sectors, but will keep the logs simultaneously. There will be one 2 week test conducted at CAMSLANT.

3. *Analyze the Data*

   A) Percentage of communications that are clear

   B) Percentage of communications that are broken

   C) Percentage of communications that are transferred

   D) Percentage of communications transferred to CAMSLANT

4. *HF communications are expected to be unreliable.*

Results:

Test # 2 – Post- COTHEN *Qualitative Communications Test*

Objective: *This test will assess the qualitative audibility of communications after the installment of the RCC and implementation of COTHEN. This test is a subjective test that will be performed at SEC San Diego and SEC Key West. At CAMSLANT, this data will be collected simultaneously as both COTHEN and standard HF communications are used in normal operations.*

Requirements: *All of the requirements are located in the Functional Requirements Document. The requirements that this test specifically addresses are:*

Requirement 2. Communications between aircraft and shore stations need to be made every 15 minutes 95% of the time.

Requirement 4. Operational commanders maintain all flight following.

Requirement 6. Coast Guard assets have COTHEN compatible ALE radios.

Test Overview: *Watchstanders will evaluate the quality of communications based on whether the radio transmissions are clear or broken and whether or not radio guard had to be transferred from the sector or CAMS to another unit. The test period is 2-weeks. The standard radio communications quality scale will be used to rate the quality of each communication.*

Test Procedure:

1. *A) Each watchstander at the sectors will have the attached sector data log.*

   B) Each watchstander at CAMSLANT will have the attached CAMS data log.

2. *A) Watchstanders at sectors will record the unit with whom communications are attempted, and whether or not the communications are clear or broken. If the communications were broken, the watchstander will indicate with whom radioguard was transferred. Each phase of testing will last two weeks.*

   B) Watchstanders at CAMS will record the same data as the watchstanders at sectors, but will keep the logs simultaneously. There will only be one two- week phase of CAMS testing.

3. *Analyze the Data*

   E) Percentage of communications that are clear

   F) Percentage of communications that are broken

   G) Percentage of communications that are transferred

   H) Percentage of communications transferred to CAMSLANT

4. *COTHEN is expected to provide a higher percentage of clear and unbroken radio transmissions.*

Results:

ALE/COTHEN

Test Plan 3: TSC COTHEN LQA Analysis

25 March 2008

Synopsis: *The purpose of this test is to provide quantitative data about the quality of calls made within the COTHEN network. This is an acceptance test to present evidence that COTHEN provides high quality communications to satisfy the Coast Guard's needs.*

Personnel: *This test requires the COTHEN Technical Service Center to gather data from the network itself.*

During this test, COTHEN equipped sectors will use COTHEN exclusively.

Procedure: *The Technical Service Center routinely records data on all radio communications through the network. These data are periodically gathered and reviewed by TSC personnel for quality assurance and maintenance purposes. The TSC will provide periodic data files to the project members for analysis to determine the quality of the communications through COTHEN.*

Equipment Required:

1. *The COTHEN Network.*
2. *The Remote Command Console (RCC) at select Coast Guard Units.*
3. *ALE radios on all Coast Guard Assets under the control of Sector Key West, Sector*

San Diego and CAMSLANT.

<u>Initial Set-up</u>:

The RCC's have been installed by TISCOM and implemented into the daily watches at SEC Key West, SEC San Diego, and CAMSLANT. Radio operators have been trained on how to properly operate the RCC. This will be done on-site by COTHEN personnel.

Test # 3 – *TSC COTHEN LQA Analysis*

Objective: *The goal of this test is to quantitatively analyze COTHEN through the Link Quality Analysis (LQA) number for SEC San Diego, SEC Key West, and CAMSLANT calls. Another analysis that will be performed on the test data is an evaluation of the effectiveness of COTHEN transmission sites and which sites are most often used.*

Requirements: *All of the requirements are located in the Functional Requirements Document. The requirements that this test particularly addresses are below:*

Requirement 2. Communications between aircraft and shore stations need to be made every 15 minutes 95% of the time.

Requirement 4. Operational commanders maintain all flight following.

Requirement 6. Coast Guard assets have COTHEN compatible ALE radios.

Test Overview: *The LQA data will be collected on calls made by SEC Key West, SEC San Diego, and CAMSLANT for a two week period. In addition to the LQA data for each call, the COTHEN transmission site used will be included in the data sheet.*

The LQA's are expected to be between 40-50(best) for each call made. LQA's below 30 represent unclear communications. Certain transmission sites are expected to be used more than others because of the limited testing locations

and HF propagation conditions during the test period.

Test Procedure:

1 *The TSC in Orlando, Fl automatically collects the LQA data for all calls made.*

2 *The logs submitted will be limited to transmissions from Sector Key West, Sector San Diego and CAMSLANT.*

3 *Analyze the Data*

A) LQA range for successful calls

B) Frequencies most commonly used

C) Transmission sites most commonly used

D) Percentage of Successful communications

E) LQA data compared to date and time

Results:

Appendix H

FOR OFFICIAL USE ONLY
Public availability to be determined under 5 U.S.C. and 552

PRIATG
LOG-01 Modified
10 Mar 2008

ENTRIES	FREQ	SITE	TIME
BEGIN NEW RADIO DAY: OS3 P. EL ATON ON WATCH. OPNOTES: 1. SOURCES CANNOT BE CHANGED ON RADRACS DUE TO AIKEN BEING DOWN. SOURCES CAN BE PATCHED MANUALLY TO THE XMTRS FOR EQP CHECKS AND NML OPERATIONS BY TECH CONTROL 2. ALL AIR GUARDS NO MATTER THE AMOUNT MUST BE ENTERED INTO GCCS (AS PER OSC CASEY) 3. AIRCRAFT STARTING WITH TAIL NUMBER 23 ARE NEW AIRCRAFT STATIONED OUT OF ATC MOBILE AND AIRSTA ELIZABETH CITY (NTFD BY MR. PAINTER) 4. P/P IS NOT HARDWIRED TO RCVR NMN 24, TECH HAS TO MANUALLY PATCH P/P TO A NMN RCVR IN ORDER TO GET BACK TO BACKS (NTFD BY TECH)			0000Z
OPNOTE: EQP CHECKS COMPLETED ON PREV RDO DAY	ZUB		0001Z
ASSUMED GUARD: 1719 (FW), W/07 POB, (P) COTHEN >>, (S) 8983 AA, H/P: AIRSTA CLEARWATER, ENR: H/P, FM SEARCH AREA, ETA: 0000Z, NEXTCOMMS: 0128Z	COTHEN		0058Z
FLIGHT OPS: 1719 FON, POSN: 2711N 08150W, NEXTCOMMS: 0159Z	COTHEN		0129Z
SECURED AIRGUARD: 1719 ON FINAL, PLACE: HOME PLATE, GUARD TIME: 40 MIN(S), SORTIES: 1	COTHEN		0138Z
SIGN OFF: WATCH RELIEVED BY OS3 EVERETTE. OPNOTES: 1. SOURCES CANNOT BE CHANGED ON RADRACS DUE TO AIKEN BEING DOWN. SOURCES CAN BE PATCHED MANUALLY TO THE XMTRS FOR EQP CHECKS AND NML OPERATIONS BY TECH CONTROL 2. ALL AIR GUARDS NO MATTER THE AMOUNT MUST BE ENTERED INTO GCCS (AS PER OSC CASEY) 3. AIRCRAFT STARTING WITH TAIL NUMBER 23 ARE NEW AIRCRAFT STATIONED OUT OF ATC MOBILE AND AIRSTA ELIZABETH CITY (NTFD BY MR. PAINTER) 4. P/P IS NOT HARDWIRED TO RCVR NMN 24, TECH HAS TO MANUALLY PATCH P/P TO A NMN RCVR IN ORDER TO GET BACK TO BACKS (NTFD BY TECH) CASREP: AIKEN AUDIO SWITCH MATRIX			0207Z

OS3 P. EL ATON

FOR OFFICIAL USE ONLY
Public availability to be determined under 5 U.S.C. and 552

PRIATG
LOG-02 Modified
10 Mar 2008

ENTRIES	FREQ	SITE	TIME
SIGN ON: OS3 K. EVERETTE ON WATCH, PREV SIGN OFF NOTED.			0207Z
OPNOTE: EQUIP CHECKS COMPLETED, OPS NML	ZUB		0226Z
ASSUMED GUARD: J33 (RW), W/04 POB, (P) COTHEN >>, (S) 8983 AA, H/P: AIRSTA CLEARWATER, ENR: NAPLES, FM AIRSTA CLEARWATER, ETA: 0000Z, MISSION: SAR, NEXTCOMMS: 0346Z	COTHEN		0331Z
FLIGHT OPS: J33 FON, NEXTCOMMS: 0358Z	COTHEN		0343Z
FLIGHT OPS: J33 FON, POSN: 2701N 08213W, NEXTCOMMS: 0409Z	COTHEN		0354Z
FLIGHT OPS: J33 FON, NEXTCOMMS: 0419Z	COTHEN		0404Z
FLIGHT OPS: J33 FON, POSN: 2614N 08155W, NEXTCOMMS: 0430Z	COTHEN		0415Z
FLIGHT OPS: J33 FON, NEXTCOMMS: 0441Z	COTHEN		0426Z
FLIGHT OPS: J33 FON, POSN: 2535N 08143W, NEXTCOMMS: 0455Z	COTHEN		0440Z
FLIGHT OPS: J33 FON, NEXTCOMMS: 0508Z	COTHEN		0453Z
FLIGHT OPS: J33 FON, POSN: 2546N 08144W, NEXTCOMMS: 0518Z	COTHEN		0503Z
FLIGHT OPS: J33 FON, NEXTCOMMS: 0532Z	COTHEN		0517Z
FLIGHT OPS: J33 FON, POSN: 2541N 08142W, NEXTCOMMS: 0545Z	COTHEN		0530Z
FLIGHT OPS: J33 FON, NEXTCOMMS: 0556Z	COTHEN		0541Z
FLIGHT OPS: J33 FON, POSN: 2611N 08159W, NEXTCOMMS: 0609Z	COTHEN		0554Z
FLIGHT OPS: J33 FON, NEXTCOMMS: 0623Z	COTHEN		0608Z
SIGN OFF: WATCH RELIEVED BY OS3 HARDICK. AIR: 1. J33 OPNOTES: 1. SOURCES CANNOT BE CHANGED ON RADRACS DUE TO AIKEN BEING DOWN. SOURCES CAN BE PATCHED MANUALLY TO THE XMTRS FOR EQP CHECKS AND NML OPERATIONS BY TECH CONTROL 2. ALL AIR GUARDS NO MATTER THE AMOUNT MUST BE ENTERED INTO GCCS (AS PER OSC CASEY) 3. AIRCRAFT STARTING WITH TAIL NUMBER 23 ARE NEW AIRCRAFT STATIONED OUT OF ATC MOBILE AND AIRSTA ELIZABETH CITY (NTFD BY MR. PAINTER) 4. P/P IS NOT HARDWIRED TO RCVR NMN 24, TECH HAS TO MANUALLY PATCH P/P TO A NMN RCVR IN ORDER TO GET BACK TO BACKS (NTFD BY TECH) CASREP: AIKEN AUDIO SWITCH MATRIX			0610Z

OS3 K. EVERETTE

Appendix I

HF

DATE	UNIT	Clear (C)/Broken (B)	COMMS LOST?	GUARD W/ WHOM?
10 MAR	1719	C / B	Y / N	CAMSLANT
	2131	C / B	Y / N	CAMSLANT
	2117	C / B	Y / N	CAMSLANT
	2121	C / B	Y / N	CAMSLANT
	2129	C / B	Y / N	CAMSLANT
	1500	C / B	Y / N	CAMSLANT
	2135	C / B	Y / N	CAMSLANT
	2117	C / B	Y / N	CAMSLANT
	2112	C / B	Y / N	SECTOR BOSTON
	1500	C / B	Y / N	NMN
	2128	C / B	Y / N	NMN
11 MAR	2128	C / B	Y / N	NMN
	2112	C / B	Y / N	CAMSLANT
	~~6034~~	~~C / B~~	~~Y / N~~	~~CAMSLANT~~
	2114	C / B	Y / N	CAMSLANT
	1500	C / B	Y / N	NMN
	1701	C / B	Y / N	NMN
	1500	C / B	Y / N	NMN
	2112	C / B	Y / N	NMN
	2134	C / B	Y / N	NMN
	2121	C / B	Y / N	NMN
	2135	C / B	Y / N	NMN
12 MAR	2121	C / B	Y / N	NMN
12 MAR	STINGRAY 17	C / B	Y / N	NMN
12 MAR	2113	C / B	Y / N	NMN
~~12 MAR~~	~~73~~	C / B	Y / N	
12 MAR 08	2129	C / B	Y / N	NMN
" "	2120	C / B	Y / N	NMN
" "	SWORDFISH 17	C / B	Y / N	NMN
13 MAR 08	SWORDFISH 13	C / B	Y / N	NMN
13 MAR	2129	C / B	Y / N	NMN

ALE

DATE	UNIT	LQA	CLEAR (C)/ BROKEN (B)	COMMS LC
10 MAR	6027	N/A	C / B	Y / N
	2129	N/A	C / B	Y / N
	6033	N/A	C / B	Y / N
	6041	N/A	C / B	Y / N
	1501	N/A	C / B	Y / N
	6031	N/A	C / B	Y / N
	1500	N/A	C / B	Y / N
	6019	N/A	C / B	Y / N
	2303	N/A	C / B	Y / N
	6018	N/A	C / B	Y / N
	2129	N/A	C / B	Y / N
	6034	N/A	C / B	Y / N
	6033	N/A	C / B	Y / N
	6001	N/A	C / B	Y / N
	6014	N/A	C / B	Y / N
	6027	N/A	C / B	Y / N
	2140	N/A	C / B	Y / N
	6018	N/A	C / B	Y / N
	1701	N/A	C / B	Y / N
	6001	N/A	C / B	Y / N
	6038	N/A	C / B	Y / N
	6033	N/A	C / B	Y / N
	1701	N/A	C / B	Y / N
	R6001	N/A	C / B	Y / N
11 MAR	1711	N/A	C / B	Y / N
	6027	N/A	C / B	Y / N
	6001	N/A	C / B	Y / N
	2140	N/A	C / B	Y / N
	1719	N/A	C / B	Y / N
	2140	N/A	C / B	Y / N
	6034	N/A	C / B	Y / N

HF DATE	UNIT	Clear (C)/Broken (B)	COMMS LOST?	GUARD W/ WHOM?	ALE DATE	UNIT	LQA	CLEAR (C)/ BROKEN (B)	COMMS LOST?
13MAR	2104	C / B	Y / N	NMN	11MAR08	6041	N/A	C / B	Y / N
		C / B	Y / N			2140	N/A	C / B	Y / N
		C / B	Y / N			6012	N/A	C / B	Y / N
		C / B	Y / N			6003	N/A	C / B	Y / N
		C / B	Y / N			6001	N/A	C / B	Y / N
		C / B	Y / N			6014	N/A	C / B	Y / N
		C / B	Y / N			1711	N/A	C / B	Y / N
		C / B	Y / N			6012	N/A	C / B	Y / N
		C / B	Y / N			6041	N/A	C / B	Y / N
		C / B	Y / N			6034	N/A	C / B	Y / N
		C / B	Y / N			6012	N/A	C / B	Y / N
		C / B	Y / N			6018	N/A	C / B	Y / N
		C / B	Y / N			2140	N/A	C / B	Y / N
		C / B	Y / N			6001	N/A	C / B	Y / N
		C / B	Y / N			6014	N/A	C / B	Y / N
		C / B	Y / N			1501	N/A	C / B	Y / N
		C / B	Y / N		11MAR08	h01	N/A	C / B	Y / N
		C / B	Y / N		12MAR08	6001	N/A	C / B	Y / N
		C / B	Y / N		12MAR08	1500	N/A	C / B	Y / N
		C / B	Y / N		12MAR08	J33	N/A	C / B	Y / N
		C / B	Y / N		12MAR08	J12	N/A	C / B	Y / N
		C / B	Y / N		12Mar08	2140	N/A	C / B	Y / N
		C / B	Y / N		12Mar08	1701	N/A	C / B	Y / N
		C / B	Y / N		" "	6042	N/A	C / B	Y / N
		C / B	Y / N		" "	6003	N/A	C / B	Y / N
		C / B	Y / N		12Mar08	1502	N/A	C / B	Y / N
		C / B	Y / N		13MAR08	2104	N/A	C / B	Y / N
		C / B	Y / N		13MAR08	1701	N/A	C / B	Y / N
		C / B	Y / N		13MAR08	6019	N/A	C / B	Y / N
		C / B	Y / N		↓	6033	N/A	C / B	Y / N
		C / B	Y / N			2140	N/A	C / B	Y / N

HF DATE	UNIT	Clear (C)/Broken (B)	COMMS LOST?	GUARD W/ WHOM?
[illegible]	2120	C / B	Y / N	NMN
13MAR08	2112	C / B	Y / N	NMN
~~[illegible]~~	~~[illegible]~~	~~C / B~~	~~Y / N~~	
~~[illegible]~~	~~1701~~	~~C / B~~	~~Y / N~~	~~NMN~~
14MAR08	2112	C / B	Y / N	NMN
[illegible]	2113	C / B	Y / N	NMN
[illegible]	2131	C / B	Y / N	NMN
~~14MAR~~	~~6031~~	~~C / B~~	~~Y / N~~	~~NMN RA~~
14MAR	1711	C / B	Y / N	NMN
14MAR	2301	C / B	Y / N	NMN
14MAR	2120	C / B	Y / N	NMN
14MAR	2101	C / B	Y / N	NMN
14 MAR	2107	C / B	Y / N	NMN
15MAR	2113	C / B	Y / N	NMN
15MAR	2102	C / B	Y / N	NMN
15MAR	2121	C / B	Y / N	NMN
15MAR	1711	C / B	Y / N	NMN
15MAR	2121	C / B	Y / N	NMN
16MAR	2121	C / B	Y / N	NMN
17MAR	2113	C / B	Y / N	NMN
17MAR	2102	C / B	Y / N	Shifted TO FLIP NMN / A1C McBride
	2112	C / B	Y / N	CAMSLANT
	1708	C / B	Y / N	CAMSLANT
	2117	C / B	Y / N	CAMSLANT
	2140	C / B	Y / N	CAMSLANT
	1711	C / B	Y / N	CAMSLANT
	2301	C / B	Y / N	CAMSLANT
	2121	C / B	Y / N	CAMSLANT
	2313	C / B	Y / N	CAMSLANT
	2102	C / B	Y / N	CAMSLANT
	2121	C / B	Y / N	CAMSLANT

ALE DATE	UNIT	LQA	CLEAR (C)/ BROKEN (B)	COMMS LOST?
13MAR08	6039	N/A	C / B	Y / N
	6031	N/A	C / B	Y / N
13MAR08	6033	N/A	C / B	Y / N
13MAR08	6042	N/A	C / B	Y / N
13MAR08	1716	N/A	C / B	Y / N
14MAR08	6033	N/A	C / B	Y / N
14MAR08	6034	N/A	C / B	Y / N
14MAR08	2140	N/A	C / B	Y / N
14MAR08	1701	N/A	C / B	Y / N
14MAR08	6003	N/A	C / B	Y / N
14MAR08	6033	N/A	C / B Both	Y / N
14MAR	6034	N/A	C / B	Y / N
14MAR	6032	N/A	C / B	Y / N
15MAR	6010	N/A	C / B	Y / N
15MAR	6033	N/A	C / B	Y / N
15MAR	1708	N/A	C / B	Y / N
15MAR	6001	N/A	C / B	Y / N
17MAR	1701	N/A	C / B	Y / N
17MAR	6042	N/A	C / B	Y / N
	6003	N/A	C / B	Y / N
	6010	N/A	C / B	Y / N
	6033	N/A	C / B	Y / N
	6014	N/A	C / B	Y / N
	1708	N/A	C / B	Y / N
17MAR08	1502	N/A	C / B	Y / N
18MAR	6042	N/A	C / B	Y / N
~~[illegible]~~	~~[illegible]~~ 6003	N/A	C / B	Y / N
19MAR08	6039	N/A	C / B	Y / N
19MAR08	6019	N/A	C / B	Y / N
19MAR08	6010	N/A	C / B	Y / N
[illegible]	[illegible]	N/A	C / B	Y / N

HF

DATE	UNIT	Clear (C)/Broken (B)	COMMS LOST?	GUARD W/ WHOM?
3/13/08	2117	C / B	Y / N	NMN
"	2129	C / B	Y / N	NMN
"	2113	C / B	Y / N	NMN
"	2127	C / B	Y / N	NMN
19MAR	1701	C / B	Y / N	NMN
19MAR	2113	C / B	Y / N	NMN
19MAR	2129	C / B	Y / N	NMN
19MAR	2134	C / B	Y / N	NMN
19MAR	1711	C / B	Y / N	NMN
19MAR	2121	C / B	Y / N	
19MAR	6012	C / B	Y / N	
19MAR	2114	C / B	Y / N	
19MAR	2102	C / B	Y / N	
21MAR	6554	C / B	Y / N	
22MAR	2127	C / B	Y / N	NMN
~~22MAR~~	~~1720~~	~~C / B~~	~~Y / N~~	~~NMN~~ KH
22MAR	2140	C / B	Y / N	NMN
22MAR	6556	C / B	Y / N	NMN
22MAR	6012	C / B	Y / N	NMN
23MAR	1705	C / B	Y / N	NMN
23MAR	1701	C / B	Y / N	NMN
23MAR	J39	C / B	Y / N	NMN
23MAR	F29	C / B	Y / N	NMN
23MAR	1711	C / B	Y / N	NMN
23MAR	SWORDFISH 05	C / B	Y / N	NMN
23MAR	2134	C / B	Y / N	NMN
25MAR	2127	C / B	Y / N	NMN
25MAR	2133	C / B	Y / N	NMN
25MAR	2121	C / B	Y / N	NMN
		C / B	Y / N	
		C / B	Y / N	

ALE

DATE	UNIT	LQA	CLEAR (C)/ BROKEN (B)	COMMS LOST?
19MAR08	6019	N/A	C / B	Y / N
19MAR08	6039	N/A	C / B	Y / N
19MAR08	6003	N/A	C / B	Y / N
19MAR08	1707	N/A	C / B	Y / N
19MAR08	1500	N/A	C / B	Y / N
19MAR08	6024	N/A	C / B	Y / N
19MAR	6010	N/A	C / B	Y / N
19MAR	6039	N/A	C / B	Y / N
19MAR	1720	N/A	C / B	Y / N
19MAR	6019	N/A	C / B BOTH	Y / N
20MAR	6010	N/A	C / B	Y / N
20MAR08	J41	N/A	C / B	Y / N
20MAR08	F04	N/A	C / B	Y / N
20MAR08	J24	N/A	C / B	Y / N
20MAR08	J27	N/A	C / B	Y / N
20MAR08	J34	N/A	C / B	Y / N
20MAR08	J10	N/A	C / B	Y / N
20MAR08	F04	N/A	C / B	Y / N
21MAR08	1720	N/A	C / B	Y / N
22MAR08	J03	N/A	C / B	Y / N
~~22MAR~~ ~~1720~~	1720	N/A	C / B	Y / N
22MAR	J03	N/A	C / B BOTH	Y / N
22MAR	7001	N/A	C / B	Y / N
22MAR	F29	N/A	C / B	Y / N
22MAR08	2134	N/A	C / B	Y / N
~~" "~~	~~6558~~	~~N/A~~	~~C / B~~	~~Y / N~~ KH
23MAR	J03	N/A	C / B BOTH	Y / N
25MAR	6003	N/A	C / B	Y / N
25MAR	6001	N/A	C / B	Y / N
25MAR	1716	N/A	C / B	Y / N
25MAR	1500	N/A	C / B	Y / N

HF DATE	UNIT	Clear (C)/Broken (B)	COMMS LOST?	GUARD W/ WHOM?
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
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		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	
		C / B	Y / N	

ALE DATE	UNIT	LQA	CLEAR (C)/ BROKEN (B)	COMMS LOST?
25mAR	6048	N/A	C / B	Y / N
25mAR	6037	N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N
		N/A	C / B	Y / N

Appendix J

Date	Feb 14-20	Feb 21-27	Mar6-12	Mar13-19	Mar20-26	Mar27-Apr2	Apr3-9	Total LQA >30	% of calls w/ LQA >30
Total Links	1467	1501	1845	1435	1771	1804	1637	11460	
>30 LQA									
VGS	50	154	74	113	103	88	108	690	6.020942408
SS1 XMT	0	0						0	0
SS1 RCV	193	233						426	3.717277487
SEA	428	503	396	387	433	376	300	2823	24.63350785
SAR	129	205	127	134	162	132	146	1035	9.031413613
RSH	194	274	159	188	252	171	176	1414	12.33856894
RNO	23	91	25	24	33	47	45	288	2.513089005
PR1	165	257	173	191	214	192	128	1320	11.51832461
OKO	146	210	167	127	177	194	143	1164	10.15706806
OKD	93	122	80	62	127	105	91	680	5.933682373
MEM	165	246	178	155	212	199	150	1305	11.38743455
LUV	69	133	57	50	95	87	87	578	5.043630017
KCM	136	230	135	135	193	186	132	1147	10.008726
FTM	162	254	125	137	188	134	151	1151	10.04363002
DEN	23	87	46	37	51	80	73	397	3.464223386
CR8_330	57	77	61	76	79	109	83	542	4.729493892
CR7_270	48	100	69	56	84	92	104	553	4.82547993
CR6_210	87	136	96	85	140	151	129	824	7.190226876
CR5_150	109	196	178	175	226	242	169	1295	11.30017452
CR4_90	96	163	138	152	192	199	147	1087	9.485165794
CR3_30	84	81	81	64	96	121	99	626	5.462478185
CR2_NW	140	208	184	163	195	205	154	1249	10.89877836
CDI	196	257	158	208	251	180	176	1426	12.44328098
ATL	153	230	147	148	177	196	139	1190	10.38394415
ABQ	37		34	9	46	67	54	247	2.155322862
CR1_NE			104	75	124	119	83	505	4.406631763
CDR			150	144	231	203	139	867	7.565445026