NTIA REPORT 00-374

Lower Mississippi River Ports and Waterways Safety System (PAWSS) RF Coverage Test Results

technical report

U.S. DEPARTMENT OF COMMERCE Ž National Telecommunications and Information Administration

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Lower Mississippi River Ports and Waterways Safety System (PAWSS) RF Coverage Test Results

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Executive Summary

The Coast Guard plans to operate an Automatic Identification System (AIS) Digital Selective Calling (DSC) based transponder system as part of the Ports and Waterways Safety System (PAWSS) in the lower Mississippi River. The AIS uses two duplex channels for ship-to-shore and shore-to-ship digital data transmissions and a simplex channel for channel management. The duplex channels are identified as AIS working channels.

The PAWSS relies on a combination of voice and AIS working channels in the VHF maritime mobile band to provide signal coverage in the Vessel Traffic Service Area (VTSA). The proposed coverage area for the VTSA encompasses the Mississippi river starting at river mile 255 to the sea buoy located at Southwest Pass and also includes an area in the Gulf of Mexico for ships approaching the sea buoy. Other waterways such as the Mississippi River Gulf Outlet and the Industrial Canal are also included in the proposed VTSA. A contractor has installed government owned equipment at five tower sites along the river to provide the coverage for both the voice and data channels. Each tower provides coverage for part of the VTSA. Before the system can reach operational status, the coverage of the RF portion of the system must be measured and documented.

The Coast Guard funded NTIA to perform coverage tests on the system to examine and evaluate the adequacy of the RF coverage of the channels used for voice and AIS data transmissions. The tests were performed August 4-10, 1999 by NTIA ,Coast Guard, and SETA personnel with vans carrying the necessary test equipment. Two vans were used to make measurements on top of the river levee every three miles. One van went upriver on top of the levee and the other van went down river on top of the levee. For measurements taken in the southern part of the area covered by the tower located at Venice, a ship was used to take measurements down to the sea buoy and out into the Gulf of Mexico.

The objective of these tests was to verify the signal coverage in the VTSA. This was accomplished using quantitative and qualitative methods.

For the quantitative methods, the strength of the signal that was received from each of the five towers on simplex voice channels 11 and 14 was measured. The signal strength of the shore-to-ship side of the duplex AIS working channels 90 and 94 was also measured.

For the qualitative methods, Channel 70 functions were measured by noting the time it took for the transponders to switch to the AIS working channel. For qualitative voice measurements, hand held and fixed mount radios were used to establish communications with personnel at the Vessel Traffic Center (VTC) for each tower on channels 11 and 14 via land lines. The communications were qualitatively rated as good, poor, or bad. To prevent emissions from adjacent towers affecting the tests, each tower was tested with the other four turned off.

During the tests, it was observed that other authorized users were present on the voice channels, the ship-to-shore side of the AIS working channels, and possibly channel 70. These other users could degrade the quality of the voice measurements and effect the transponder's ability to switch to the AIS working channel. In addition, loading on channel 70 due to the test configuration may have affected the transponders ability to switch to the working channel.

The results of the tests for each of the five towers are represented by signal strength graphs of the voice and AIS working channels, AIS observations, and voice communication observations. The test results show that there are RF coverage gaps for the voice and AIS data services that require corrective measures to ensure that the Coast Guard PAWSS can operate in the proposed VTSA. These corrective measures may include adding base stations at additional tower locations, moving existing base stations to other tower locations, and/or changing the orientation/height of the antennas on towers at existing at base stations.

The results and conclusions of this report can also be used by the Coast Guard to develop coordination procedures with Public Correspondence System operators, so that both of their systems can operate in the VHF maritime mobile band with a minimal amount of mutual interference.

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SECTION 1
INTRODUCTION

1.1 Background

The Coast Guard plans to operate an Automatic Identification System (AIS) Digital Selective Calling (DSC) based transponder system as part of the Ports and Waterways Safety System (PAWSS) in the lower Mississippi River. The AIS uses two duplex channels for ship-to-shore and shore-to-ship digital data transmissions and a simplex channel for channel management. The duplex channels are identified as AIS working channels.

The PAWSS relies on a combination of voice and AIS working channels in the VHF maritime mobile band to provide signal coverage in the vessel traffic service area (VTSA). The proposed coverage area for the VTSA encompasses the Mississippi river starting at river mile 255 to the sea buoy located at Southwest Pass and also includes an area in the Gulf of Mexico for ships approaching the sea buoy. Other waterways such as the Mississippi River Gulf Outlet and the Industrial Canal are also included in the proposed VTSA. A contractor has installed government owned equipment at five tower sites along the river to provide the coverage for both the voice and AIS working channels. Each tower provides coverage for part of the VTSA. Before the system can reach operational status, the coverage of the RF portion of the system must be measured and documented.

The Coast Guard funded NTIA to perform coverage tests on the system to examine and evaluate the adequacy of the RF coverage of the channels used for voice and AIS data transmissions. The tests were performed August 4-10, 1999. The results of these tests are given in the following sections of this report.

1.2 Test Objectives

The objective of these tests was to verify signal coverage in the VTSA, including:

- Voice communications on channels 11 and 14 in ship-to-shore and shore-to-ship mode.
- Channel 70 DSC functions for transponder VTS system login and channel management.
- Communications on channels 90 and 94, which are used for transponder-to-shore and shore-to-transponder data transfer and text messaging.

Each function was tested for each of the five communication tower sites one at a time with the other four towers turned off. Testing the coverage of each site for the above functions in that manner ensured that data collected for each tower was not affected by emissions from adjacent sites.

During the tests, it was observed that other authorized users were present on the voice channels, the ship-to-shore side of the AIS working channels, and possibly channel 70. These other users could degrade the quality of the voice measurements and effect the transponder's ability to switch to the AIS working channel.

1.3 Test Procedures

The following steps were taken to perform the tests on the voice and AIS working channels.

1. Two vans were equipped with the following equipment: a Differential (DGPS) receiver, a 12 volt power supply, a spectrum analyzer, a cellular phone, two AIS transponders, a fixed mount VHF radio with a whip antenna and collapsible roof mount stand, and a hand held VHF radio.

2. Personnel at the VTC set the transponder report rate to five seconds and set the size of the zone for the tower being tested to encompass the entire proposed VTSA (see Note 1). The measurement range for the tower being tested was up to 1 mile beyond the next adjacent tower (see Note 2). A transponder was turned on and placed outside the tower that was being tested. This transponder was used as an integrity monitor so that the tower would always be in contact with a transponder and therefore would always re-broadcast its position data to personnel on the levee. This ensured that the signal strength of the transponder working channel from that tower could always be measured on the levee in case the transponders in the vans could not communicate with it, due to interference or adverse propagation effects.

3. The vans were driven onto the river levee at a point that was close to the tower being tested. A transponder was turned on and placed on the roof of each van. The transponder display was used to note the location of the van on the levee in river miles. This transponder was left on for the duration of the day's test.

4. Another transponder was placed outside each van and turned on at each test point. Its operation was observed by personnel on the levee and VTC to verify that it had changed to the working channel. This transponder was given up to 15 minutes to switch to the AIS working channel (see Note 3). If the transponder did not change to the AIS working channel in that amount of time it was noted in the test log and the tests continued.

5. Personnel on the levee used the fixed mount and hand held radios to establish voice contact with the personnel at the VTC on the voice channels in ship-to-shore and shore-to-ship mode for qualitative measurements. Radios on the levee were operated in low and high power (see table 2). Cellular phones and text messaging via the transponders were used to coordinate the activities.

Note: If contact was not made with the VTC on a channel at that location, then personnel on the levee moved about 100 feet above or below their position and this step was repeated.

6. Personnel at the VTC keyed the microphone and signal strength measurements of the voice channels were made on the levee using a spectrum analyzer. The results were noted and recorded.

7. The signal strength of the AIS working channel from the tower was measured on the levee in dBm with the spectrum analyzer and its value was recorded into the test log.

Note 1: This does not affect the RF power output of any the tower's voice or data transmissions.
Note 2: This does not correspond to any system specification and was for test purposes only.
Note 3: The transponder 15 minute timeout for switching to the working channel was for test purposes only and does not correspond to any system specification or requirement

8. The second transponder was logged out of the system and it was turned off by personnel on the levee.

9. One van moved 3 miles along the top of the levee upriver and steps 3 through 8 were repeated. The other van moved 3 miles along the top of the levee down river and steps 3 through 8 were repeated.

10. Steps 1 through 9 were repeated for each communications tower.

Although the northern boundary for the proposed VTSA is river mile 255, the measurements were conducted up to river mile 299. The proposed southern service area encompasses a region for ships approaching the sea buoy at Southwest Pass. A small ship (equipped with the test equipment and personnel) was used to perform tests past Venice into the Gulf of Mexico and around Southwest Pass. Measurements were taken southwest and south of the sea buoy. Additional testing was not done in the Gulf due to vessel master time constraints. In addition, the Mississippi River Gulf outlet and Industrial Canal were not tested.

1.4 Tower Locations

The towers for each zone are placed at the following locations:

Zone 1: Venice, Louisiana	N29-18-00/W89-22-29	Antenna height 110 m
Zone 2: Point Ala Hache, Louisiana	N29-34-50/W89-49-40	Antenna height 111 m
Zone 3: Algiers, Louisiana	N29-56-45/W90-01-17	Antenna height 113 m
Zone 4: Vacherie, Louisiana	N29-57-13/W90-43-25	Antenna height 112 m
Zone 5: Baton Rouge, Louisiana	N30-36-51/W91-14-02	Antenna height 115 m

The antenna heights are referenced from sea level.

SECTION 2
TEST RESULTS

2. Test Results

Test results for each of the five towers are represented by signal strength graphs, AIS observations, and voice communications observations. They are presented in the following sections.

The signal strength graphs show the received power on the levee in river miles of the shore-to-ship side of the AIS working channel and voice channels 11 and 14 for each tower. River miles are counted as either Below Head of Passes (BHP) or Above Head of Passes (AHP) and are noted as mile markers (MM). The distance from Head of Passes to the Sea buoy is about 21 miles. The signal strength graphs also include 6 dBi of gain for the VHF whip antenna that was mounted on top of each van.

The minimum required signal strength for the AIS working channel was based on the sensitivity of the transponder receiver, which was specified by the Coast Guard to be -107 dBm. Assuming a zero dBi antenna gain for the transportable transponder with one dB of system loss and correcting the graphs for the whip antenna gain, a signal level of -100 dBm will be used as the reference point on the graphs for the minimum transponder working channel signal strength. The AIS observations note the length of time and position in river miles that the transponder was able to switch from channel 70 to the zone's AIS working channel. The switching time does not necessarily indicate the transponders functional capability because of interference on channel 70 and the loading of the channel due to the test configuration.

The voice communication observations note if personnel using the hand held and fixed mount radios could establish communications with personnel at the VTC via the tower using channels 11 and 14. The whip antenna that was mounted on the roof of the van was used with the fixed mount radio. The hand held radio used a small stub antenna. The quality of the communications was rated as good, poor, or bad. A description of the voice quality ratings is shown below in Table 1.

Table 1
Voice Quality

Rating	Description
Good	The listener was able to hear the talker on the radio speaker clearly without repetition.
Poor	The listener was able to hear the talker on the radio speaker, but had to pay close attention and would occasionally miss words or phrases.
Bad	The listener was barely able to hear the talker on the radio speaker, communications were difficult and not reliable.

Most marine VHF radios have a sensitivity of about .25 to.35 FV for a 12 dB SINAD ratio. For a 50 Ohm load this equates to a power level of -119 to -116 dBm. However this specification does not consider the degradation of the receiver’s performance due to operating in an intense electromagnetic environment such as the lower Mississippi River.

The area of the lower Mississippi River has been the subject of an investigation by the U.S. Coast Guard and the FCC because of reports by pilots of radio frequency interference, especially in the New Orleans area. In order to improve and preserve the viability of marine radio services in the Mississippi River and other inland ports and waterways that are experiencing interference, the Radio Technical Commission for Maritime Services (RTCM) established a special committee, RTCM SC-117, to prepare a voluntary receiver standard for VHF marine radios, taking into account the "Intense Electromagnetic Environment" in these waterways. To date, only one manufacturer's radio has been designed and tested to meet this new recommended standard, the same standard which calls for a minimum receiver sensitivity of -107 dBm in the presence of three high-level in-band interfering signals using a local/distance mode switched attenuator and a high dynamic range receiver. Therefore, it should be understood that not all mariners transiting the VTSA would use such a radio, but instead may use radios that require a much higher desired signal strength for good voice communications. Actual test results indicated that signals as high as -90 dBm were needed to facilitate good communications in some areas for fixed mounted radios and as high as -80 dBm for handheld radios.

The RF characteristics of the equipment that was used in these tests is shown below in Table 2.

Table 2
RF Characteristics

Equipment	Output Power (dBm)	Antenna Gain (dBi)	Antenna Height (m) Above Ground
AIS Transponder	High 41 Low 30	0	1.5
AIS Base Station	nominal 39	11	100 (typical)
Hand Held Radio	High 37 Low 30	-5	2
Fixed Mount Radio	High 44 Low 30	6	3
Spectrum Analyzer	------	6	3
Tower Radio	Nominal 39	11	100

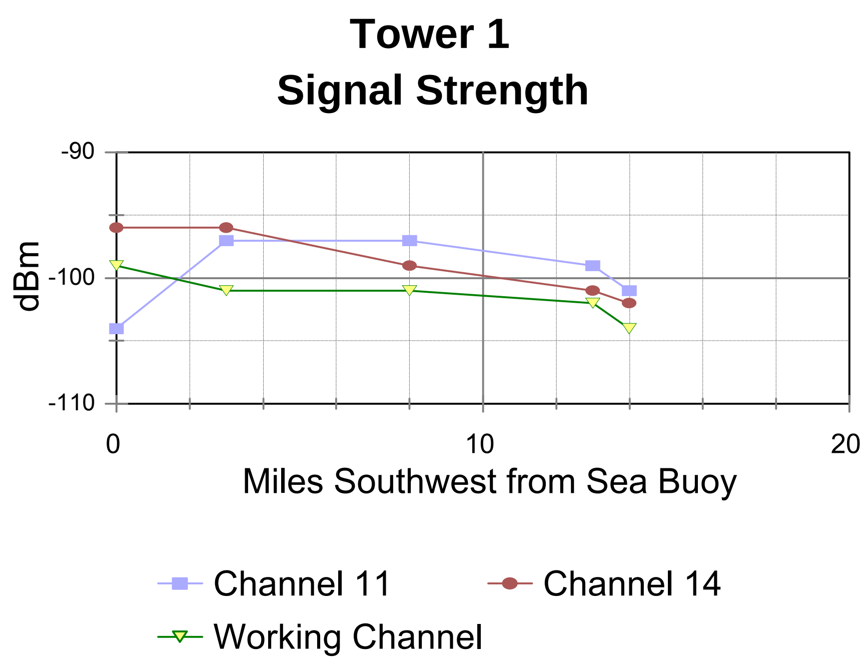
The path loss from the levee to the tower was not measured, however by reciprocity it should be the same as the path loss from tower to the levee if the antenna heights do not change.

It is important to note that the weak link in communications to/from the VTC and the levee is in the levee to VTC path, especially with the hand held radio.

2. 1 Tower 1 Test Results

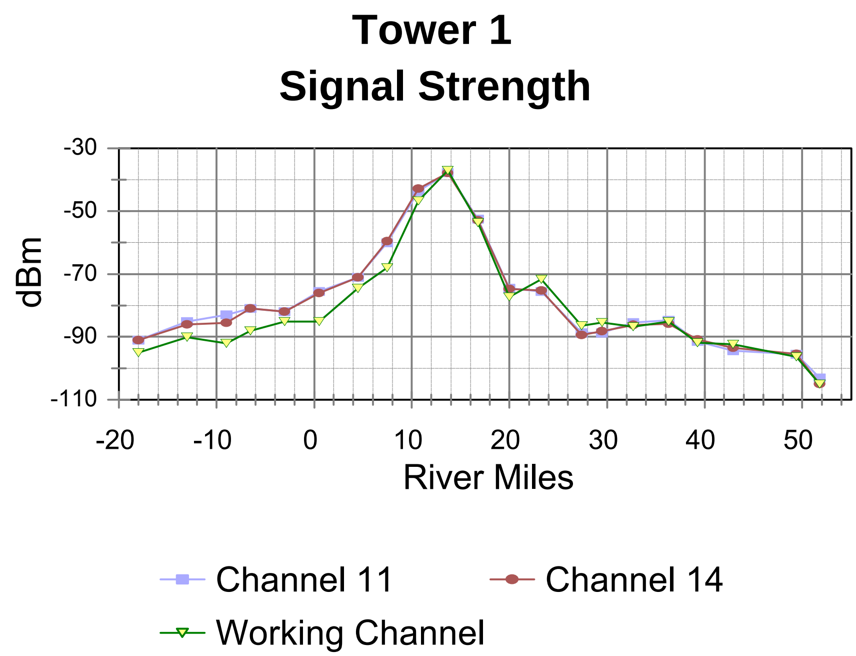
2.1.1 Tower 1 Signal Strength Graphs

The length of the river that encompassed the measurement locations for tower 1 was 15 miles southwest of the sea buoy to MM 52 AHP. Two signal strength graphs are presented for zone 1. Graph 1A is referenced in straight line distance southwest from the sea buoy and Graph 1B is referenced in river miles. Graph 1B has a zero point in river miles which indicates the location of Head of Passes. The distance between first data point in Graph1A and the first data point in Graph 1B is about 3.5 miles.



Graph 1A
Tower 1 Signal Strengths Referenced from Sea Buoy

Graph 1A shows that the signal strength of the AIS working channel fell below -100 dBm about 22 miles BHP. This indicates that there is not sufficient signal strength for the working channel from the tower located at Venice from 22 miles BHP and southwest from that location out into the Gulf of Mexico.



Graph 1B
Tower 1 Signal Strengths

Graph 1B shows that the maximum received power for the AIS working channel and the voice channels occurred at MM 14 AHP and was about -37 dBm. At the northern end of the zone, the power of the working channel fell below -100 dBm at MM 52 AHP.

2.1.2 Tower 1 AIS Observations

At the south end of the measurement zone for tower 1, the last location that the transponder switched to the working channel was MM 18 BHP. The transponder took 1 minute and 45 seconds to switch from channel 70 to 90. After switching to the working channel, the transponder transmitted and received position reports according to the reporting schedule set by personnel at the VTC. The measured signal power of the AIS working channel at that location was -95 dBm For all measurements taken south of that location the transponder stayed on channel 70.

At the north end of the measurement zone for tower 1, the last location that the transponder switched to the working channel was MM 49 AHP. The transponder took 3 minutes to switch from channel 70 to 90. After switching to the working channel, the transponder transmitted and received position reports according to the reporting schedule set by personnel at the VTC. The measured signal power of the AIS working channel at that location was -96 dBm. One additional measurement point was taken for this zone at MM 51.8, however the transponder did not switch to the working channel at that location.

Between the southern last location (MM 18 BHP) and northern last location (MM 49 AHP) that the transponder switched to the AIS working channel, the transponder did not switch to the AIS working channel at mile markers 23 and 42 AHP.

<u>2.1.3 Tower 1 Voice Observations</u>

For tower 1, the length of river for good voice communications for personnel on the levee using the hand held radio to personnel at the VTC was MM 10 BHP to 20 AHP. For good communications from the VTC to personnel using the hand held radio on the levee, the range was MM 22 BHP to 43 AHP. Past those locations, communications to/from the VTC and personnel on the levee using the hand held radio was either poor or bad.

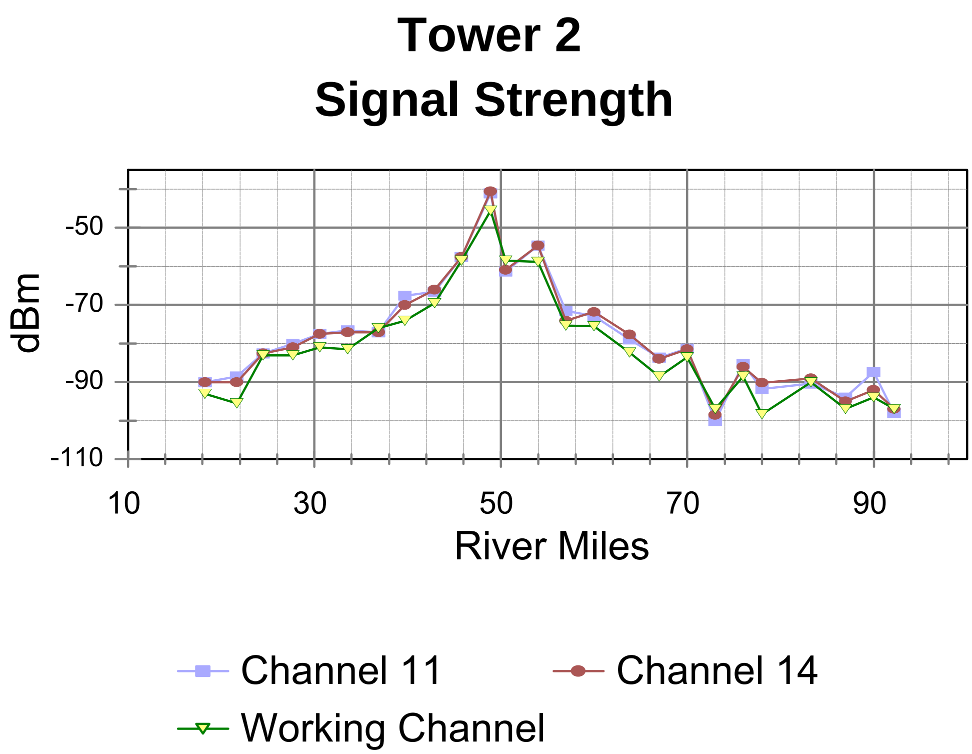
For tower 1, the length of river for good voice communications for personnel on the levee using the fixed mount radio to personnel at the VTC was 8 miles southwest of the sea buoy to MM 39 AHP. For good communications from the VTC to personnel using the fixed mount radio on the levee, the range was 8 miles southwest oft the sea buoy to MM 49 AHP. Past those locations, communications to/from the VTC and personnel on the levee using the fixed mount radio was either poor or bad.

A summary of the data collected for tower 1 voice and AIS observations is contained in Table 3 of section 2.7 of this report

2. 2 Tower 2 Test Results

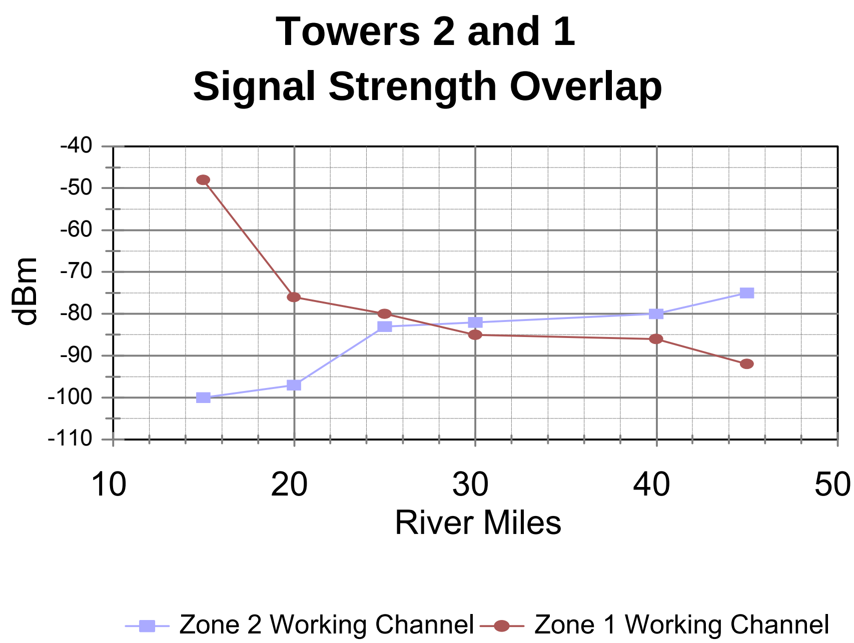
2.2.1 Tower 2 Signal Strength Graph

The length of the river that encompassed the measurement locations for tower 2 was MM 17 to 92 AHP. Graph 2A shows that the peak received power for the AIS working channel and voice channels was about -40 dBm and it occurred at MM 46 AHP. The signal power of the AIS working channel did not fall below -100 dBm at the last test locations for the northern and southern measurement locations.



Graph 2A
Tower 2 Signal Strengths

Using -100 dBm as the reference point for overlapping signal strength between towers 1 and 2, Graph 2B shows that there should be sufficient signal strength for the AIS working channel from tower 1 located at MM 14 to tower 2 located at MM 49.



Graph 2B
Towers 2 and 1 Signal Overlap

Graphs 2B also shows that the crossover point for the AIS working channel signal strength measurements between towers 1 and 2 occurred at MM 27 AHP. At that location, the signal power of the working channel was -82 dBm.

2.2.2 Tower 2 AIS Observations

At the south end of the measurement zone for tower 2, the last time the transponder switched to the AIS working channel was at MM 30 AHP. The transponder took 1 minute to switch from channel 70 to 94. After switching to the working channel, the transponder transmitted and received position reports according to the reporting schedule set by personnel at the VTC. The measured signal power of the AIS working channel at that location was -81 dBm For all measurements taken south of that location the transponder stayed on channel 70.

At the north end of the measurement zone for tower 2, the last location that the transponder switched to the AIS working channel was MM 70 AHP. The transponder took 4 minutes to switch from channel 70 to 94. After switching to the working channel, the transponder transmitted and received position reports according to the reporting schedule set by personnel at the VTC. The measured signal power of the AIS working channel at that location was -84 dBm. For all measurements taken north of that location the transponder stayed on channel 70.

Between the southern last location (MM 30 AHP) and northern last location (MM 70 AHP) that the transponder switched to the AIS working channel, the transponder did not switch to the AIS working channel at mile markers 43 and 57 AHP.

2.2.3 Tower 2 Voice Observations

For tower 2, the length of river for good voice communications for personnel on the levee using the hand held radio to personnel at the VTC was MM 27 to 70 AHP. For good communications from the VTC to personnel using the hand held radio on the levee, the range was MM 27 to 87 AHP. Past those locations, communications to/from the VTC and personnel on the levee using the hand held radio was either poor or bad.

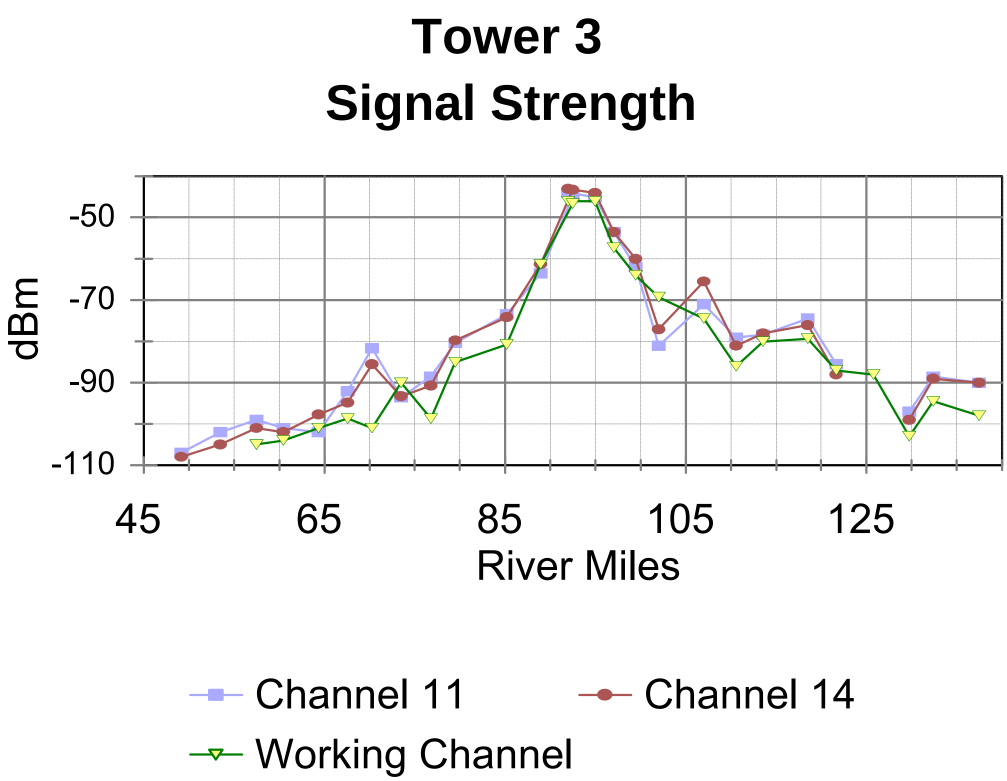
For tower 2, the length of river for good voice communications for personnel on the levee using the fixed mount radio to personnel at the VTC was MM 24 to 92 AHP. For good communications from the VTC to personnel using the fixed mount radio on the levee, the range was also MM 24 to 92 AHP. Past those locations, communications to/from the VTC and personnel on the levee using the fixed mount radio was either poor or bad.

A summary of the data collected for tower 2 voice and AIS observations is contained in Table 3 of section 2.7 of this report

2. 3 Tower 3 Test Results

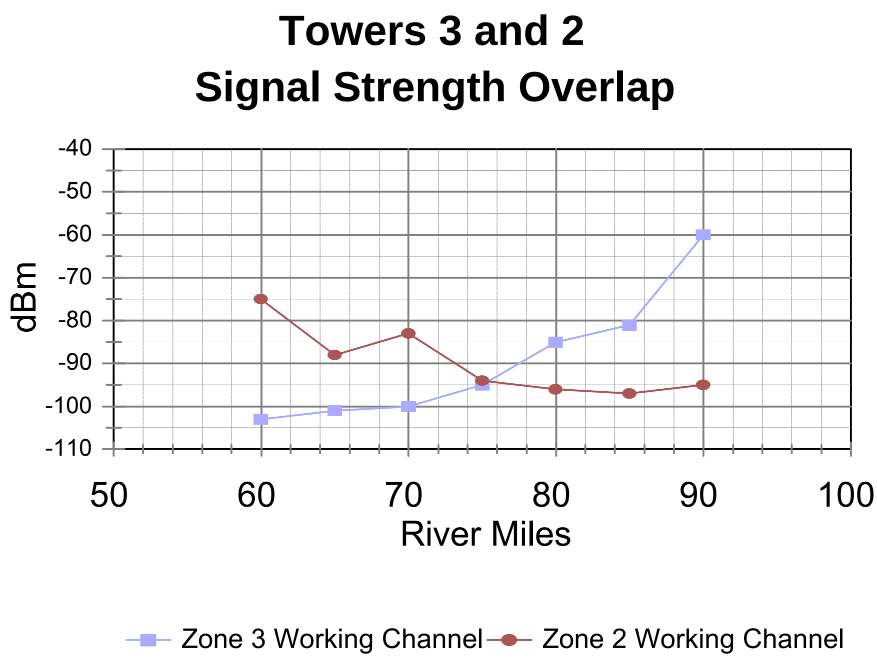
2.3.1 Tower 3 Signal Strength Graph

The length of the river that encompassed the measurement locations for tower 3 was MM 49 to137 AHP. Graph 3A shows that the peak received power for the AIS working channel and voice channels was about -45 dBm and it occurred at MM 93. The signal power of the AIS working channel fell below -100 dBm at about MM 70 at the south end of the measurement range, and at about MM 127 at the northern end.



Graph 3A
Tower 3 Signal Strengths

Using -100 dBm as the reference point for overlapping signal strength between towers 2 and 3, Graph 3B shows that there should be sufficient signal strength for the AIS working channel from tower 2 located at MM 49 to tower 3 located at MM 93.



Graph 3B
Towers 3 and 2 Signal Overlap

Graphs 3B also shows that the crossover point for the AIS working channel signal strength measurements between towers 2 and 3 occurred at MM 75. At that location, the signal power of the AIS working channel was -92 dBm.

2.3.2 Tower 3 AIS Observations

At the south end of the measurement zone for tower 3, the last location that the transponder switched to the AIS working channel was at MM 67 AHP. The transponder took 4 minutes and 15 seconds to switch from channel 70 to 90. After switching to the working channel, the transponder transmitted and received position reports according to the reporting schedule set by personnel at the VTC. The measured signal power of the working channel at that location was -99 dBm. For all measurements taken south of that location the transponder stayed on channel 70.

At the north end of the measurement zone for tower 3, the last location that the transponder switched to the AIS working channel was at MM 126 AHP. The transponder took 1 minute to switch from channel 70 to 94. After switching to the working channel, the transponder transmitted and received position reports according to the reporting schedule set by personnel at the VTC. The measured signal power of the working channel at that location was -88 dBm. For all measurements taken north of that location the transponder stayed on channel 70.

2.3.3 Tower 3 Voice Observations

For tower 3, the length of river for good voice communications for personnel on the levee using the hand held radio to personnel at the VTC was MM 85 to 122 AHP. For good communications from the VTC to personnel using the hand held radio on the levee, the range was MM 67 to 137 AHP. Past those locations, communications to/from the VTC and personnel on the levee using the hand held radio was either poor or bad.

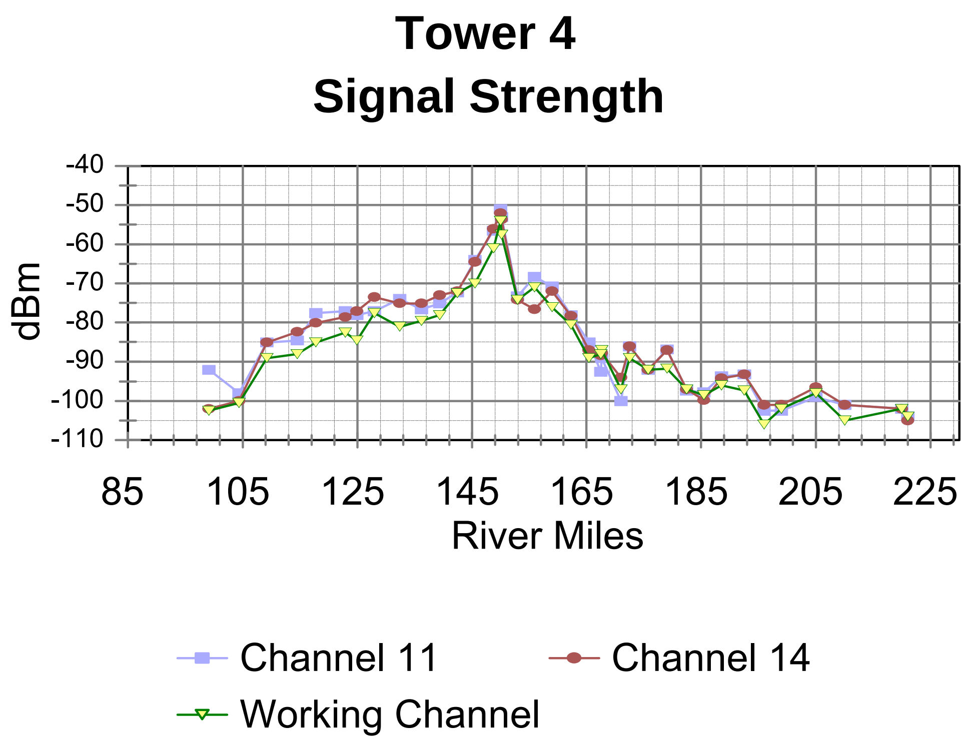
For tower 3, the length of river for good voice communications for personnel on the levee using the fixed mount radio to personnel at the VTC was MM 64 to 118 AHP. For good communications from the VTC to personnel using the fixed mount radio on the levee, the range was MM 57 to 137 AHP. Past those locations, communications to/from the VTC and personnel on the levee using the fixed mount radio was either poor or bad.

A summary of the data collected for tower 3 voice and AIS observations is contained in Table 3 of section 2.7 of this report

2.4 Tower 4 Test Results

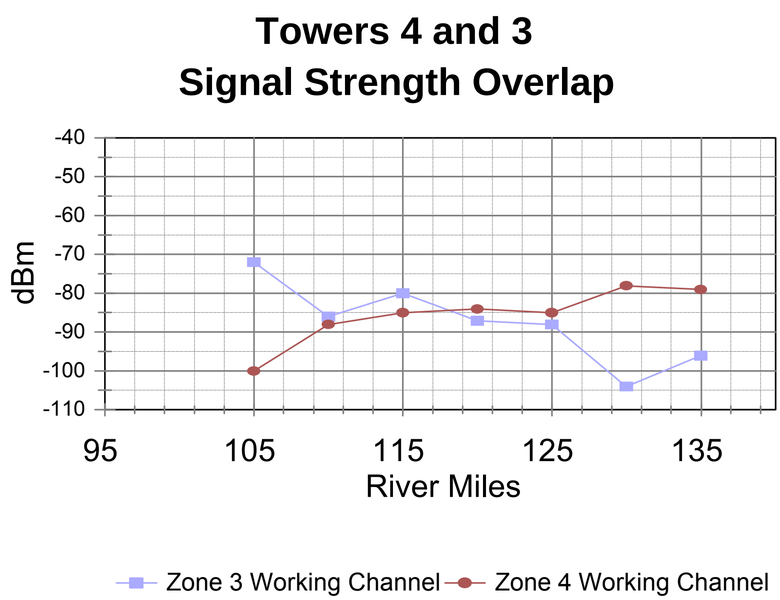
2.4.1 Tower 4 Signal Strength Graph

The length of the river that encompassed the measurement locations for tower 4 was MM 99 to 221 AHP. Graph 4A shows that the peak received power for the AIS working channel and voice channels was about -50 dBm and it occurred at MM 150. The signal power of the AIS working channel fell below -100 dBm at about MM 105 at the south end of the measurement range, and at about MM 195 at the northern end.



Graph 4A
Tower 4 Signal Strengths

Using -100 dBm as the reference point for overlapping signal strength between towers 3 and 4, Graph 4B shows that there should be sufficient signal strength for the AIS working channel from tower 3 located at MM 93 to tower 4 located at MM 150. Note that the signal strength graph for tower 4 is not symmetrical and that the measured signal strength for all three channels at the upper end (higher mile markers) is much weaker than the lower end (lower mile markes). This indicates that the optimal antenna azimuth position on the tower may be oriented to the south of tower 4, which results in a greater signal strength in that direction. During other tests, the Coast Guard has tracked transponders well out into the Gulf of Mexico and as far east as Pascagoula, Mississippi from tower four.



Graph 4B
Towers 4 and 3 Signal Overlap

Graphs 4B also shows that the crossover point for the AIS working channel signal strength measurements between towers 3 and 4 occurred at MM 118. At that location, the signal power of the working channel was -85 dBm.

2.4.2 Tower 4 AIS Observations

The transponder was erratic in the southern part of the tower 4 measurement zone in switching to the working channel. The transponder switched to the AIS working channel at MM 125 in one minute with a measured signal power of -85 dBm. After switching to the working channel, the transponder transmitted and received position reports according to the reporting schedule set by personnel at the VTC. However at other locations with a greater signal power the transponder did not switch to the working channel. Interference on channel 70 or the working channel may have caused this problem to occur.

At the north end of the measurement zone for tower 4, the last location that the transponder switched to the AIS working channel was at MM 172 AHP. The transponder took 5 minutes to switch from channel 70 to 94. After switching to the working channel, the transponder transmitted and received position reports according to the reporting schedule set by personnel at the VTC. The measured signal power of the working channel at that location was -89 dBm. For all measurements taken north of that location the transponder stayed on channel 70.

Between the southern last location (MM 125 BHP) and northern last location (MM 172 AHP) that the transponder switched to the AIS working channel, the transponder did not switch to the AIS working channel at the following mile markers: 128, 132, 142,145,148, 150, 153, and 167 AHP.

2.4.3 Tower 4 Voice Observations

For tower 4, the length of river for good voice communications for personnel on the levee using the hand held radio to personnel at the VTC was MM 109 to 172 AHP. For good communications from the VTC to personnel using the hand held radio on the levee, the range was MM 109 to 179 AHP. Past those locations, communications to/from the VTC and personnel on the levee using the hand held radio was either poor or bad.

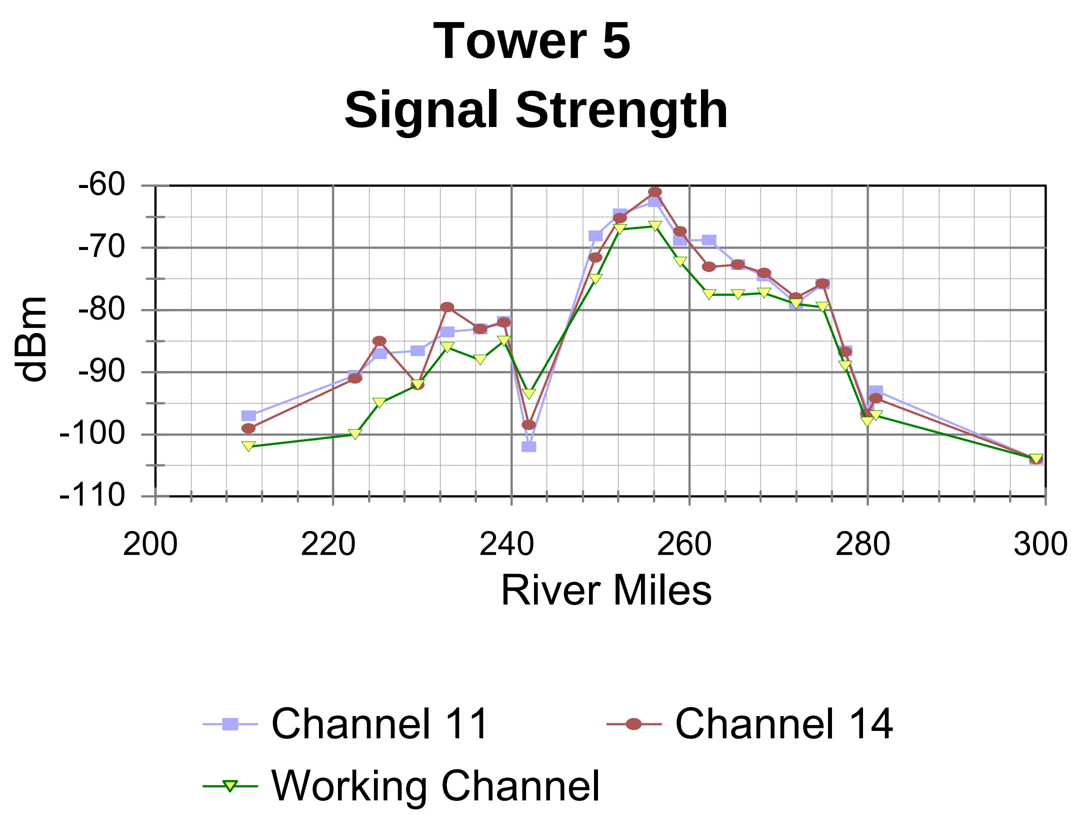
For tower 4, the length of river for good voice communications for personnel on the levee using the fixed mount radio to personnel at the VTC was MM 109 to 192 AHP. For good communications from the VTC to personnel using the fixed mount radio on the levee, the range was MM 109 to 205 AHP. Past those locations, communications to/from the VTC and personnel on the levee using the hand held radio was either poor or bad.

A summary of the data collected for tower 4 voice and AIS observations is contained in Table 3 of section 2.7 of this report

2. 5 Tower 5 Test Results

2.5.1 Tower 5 Signal Strength Graph

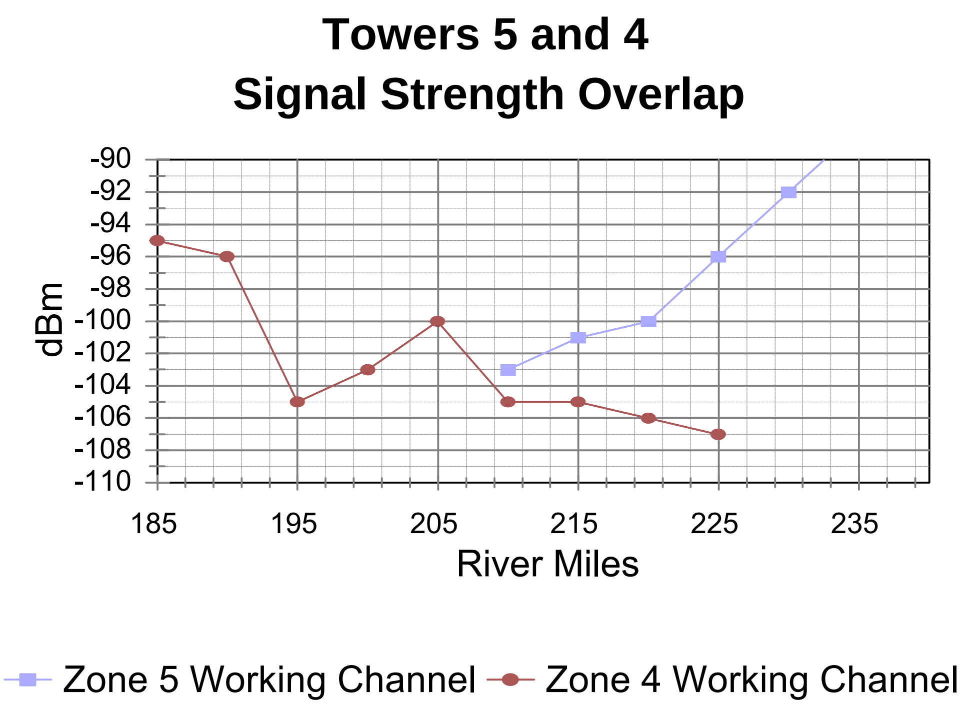
The length of the river that encompassed the measurement locations for tower 5 was MM 210 to 299 AHP. Graph 5A shows that the peak received power for the AIS working channel was about -66 dBm and for the voice channels is about -62 dBm. The peak values occurred at MM 256, which is 1 mile beyond the northern limit of the proposed VTSA. The signal strength was -95 dBm at MM 244 and then rose back to -80 dBm at MM 248. The signal power of the AIS working channel fell below -100 dBm at MM 220 at the south end of the measurement range, and at MM 285 at the northern end.



Graph 5A
Tower 5 Signal Strengths

Note that the signal strength graph for tower 5 is not symmetrical and that the measured signal strength for all three channels at the lower end (lower mile markers) is much weaker than the upper end (upper mile markers). This indicates that the optimal antenna azimuth position on the tower may be oriented to the north of tower 5, which results in a greater signal strength in that direction.

Tower 4 has similar problem. However, the optimal antenna position for tower 4 is oriented to the south which may compound the lack of signal strength between towers 4 and 5.



Graph 5B
Towers 5 and 4 Signal Overlap

Using -100 dBm as the reference point for overlapping signal strength between towers 4 and 5, Graph 5B shows that there is not sufficient signal strength for the AIS working channel from MM 195 to 220 AHP.

2.5.2 Tower 5 AIS Observations

The transponder was erratic in the southern part the measurement zone for tower 5 in switching to the AIS working channel. The transponder switched to the AIS working channel at MM 232 AHP in 7 minutes with a measured signal power of -86 dBm. After switching to the working channel, the transponder transmitted and received position reports according to the reporting schedule set by personnel at the VTC. For all measurements taken south of that location the transponder stayed on channel 70. At MM 249 AHP with a measured signal power of -75 dBm, the transponder took 13 minutes to switch from the working channel to channel 90. Interference on channel 70 or the working channel may have caused this problem to occur.

At the north end of the measurement zone for tower 5, the last location that the transponder switched to the AIS working channel was at MM 275AHP. The transponder took 1 minute and 45 seconds to switch from channel 70 to 90. After switching to the working channel, the transponder transmitted and received position reports according to the reporting schedule set by personnel at the VTC. The measured signal power of the AIS working channel at that location was -80 dBm. For all measurements taken north of that location the transponder stayed on channel 70.

Between the southern last location (MM 232) and northern last location (MM 275) that the transponder switched to the AIS working channel, the transponder did not switch to the AIS working channel at mile markers 242 and 259 AHP.

2.5.3 Tower 5 Voice Observations

For tower 5, the length of river for good voice communications for personnel on the levee using the hand held radio to personnel at the VTC was MM 249 to 262 AHP. For good communications from the VTC to personnel using the hand held radio on the levee, the range was MM 249 to 277 AHP. Past those locations, communications to/from the VTC and personnel on the levee using the hand held radio was either poor or bad.

For tower 5, the length of river for good voice communications for personnel on the levee using the fixed mount radio to personnel at the VTC was MM 249 to 268 AHP. For good communications from the VTC to personnel using the fixed mount radio on the levee, the range was also MM 249 to 281 AHP. Past those locations, communications to/from the VTC and personnel on the levee using the fixed mount radio was either poor or bad.

A summary of the data collected for tower 5 voice and AIS observations is contained in Table 3 of section 2.7 of this report

2.6 Channel 70 Observations

The test for channel 70 was based on the amount of time that it took for a transponder to switch to the transponder working channel. In some cases the transponder promptly switched to the working channel with a signal level as low as -99 dBm, but in some cases it took up to 15 minutes to switch with a signal level of -70 dBm. The signal strength of channel 70 was not directly measured because it was difficult to determine if the transmission came from the towers or transponders themselves. Due to the test configuration, basing the coverage for channel 70 on the amount of time that the transponder took to switch to the working channel is not a true indication of coverage for channel 70.

In the test configuration, the coverage zone for each tower being tested was set to be the entire proposed VTSA so that the coverage range was far beyond the radio range of the tower. Using this method the test teams were able to find the limits of the tower radio range. However, in setting the coverage zone so large all the transponders on the river were operating in a ship-to-ship mode and the tower being tested was attempting to switch those that it could hear to ship-to-shore-to-ship mode. This intense switching process on channel 70 with so many transponders may have overwhelmed the system and caused the times for switching from channel 70 to the working channel to vary so much. In addition voice traffic on channel 70 from mariners using old radios may have caused interference to the transponder as well.

A better indication for channel 70 coverage should be based on the received RF power for the AIS working channels. The signal strength graphs show that the signal strength for channel 70 should be close to those measured for the AIS working channel because they are close in frequency and use the same antenna. At times, the transponder switched to the AIS working channel within 1 dB of the reference level of -100 dBm so it did perform to its design specification.

2.7 Summary Table

A summary of the test results for each tower's voice and data observations is shown below in Table 3.

Table 3
Voice and AIS Results and Summary Observations

Tower	AIS Working Channel $ -100 dBm	Transponder switch to AIS working Channel	Levee to VTC Good Communications Hand Held Radio	VTC to Levee Good Communications Hand Held Radio	Levee to VTC Good Communications Fixed Mount Radio	VTC to Levee Good Communications Fixed Mount Radio
Tower 1 Tower Location: MM 14 AHP Measurement Range: 15 SWSB* - MM 52 AHP	MM 22 BHP to 52 AHP	MM 18 BHP to 49 AHP	MM 10 BHP to MM 20 AHP	MM 22 BHP - 43 AHP SS at MM22: -76 dBm SS at MM 43: -94 dBm	8 SWSB - 39 AHP	8 miles SWSB to MM 49 AHP SS at SWSB: -99 dBm SS at MM 49: -95 dBm
Tower 2 Tower Location: MM 49 AHP Measurement Range: MM 17 - 92 AHP	MM 17 - 92 AHP	MM 30 - 70 AHP	MM 27 - 70 AHP	MM 27 - 87 AHP SS at MM 27: -81 dBm SS at MM 87: -95 dBm	MM 24 - 92 AHP	MM 24 - 92 AHP SS at MM 24 -83 dBm SS at MM 92: -98 dBm
Tower 3 Tower Location: MM 93 AHP Measurement Range: MM 49 - 137 AHP	MM 70 - 127 AHP	MM 67 - 126 AHP	MM 85 - 122 AHP	MM 67 - 137 AHP SS at MM 67: -93 dBm SS at MM 137: -90 dBm	MM 64 - 118 AHP	MM 57 - 137 AHP SS at MM 57: -102 dBm SS at MM 137: -90 dBm
Tower 4 Tower Location: MM150 AHP Measurement Range: MM 99 - 221 AHP	MM 105 - 195 AHP	MM 125 - 172 AHP	MM 109 - 172 AHP	MM 109 - 179 AHP SS at MM 109: -85 dBm SS at MM 179: -87 dBm	MM 109 - 192 AHP	MM 109 - 205 AHP SS at MM 109: -85 dBm SS at MM 205: -99 dBm
Tower 5 Tower Location: MM 256 AHP Measurement Range: MM 210 - 299 AHP	MM 220 - 285 AHP	MM 232 - 275 AHP	MM 249 - 262 AHP	MM 249 - 277 AHP SS at MM 249: -68 dBm SS at MM 277: -87 dBm	MM 249 - 268 AHP	MM 249 - 281AHP SS at MM 249: -76 dBm SS at MM 281: -94 dBm

* SWSB Southwest from Sea Buoy

SS: Signal Strength measured with spectrum analyzer using a 6 dBi gain VHF whip antenna.

AHP: Above Head of Passes, BHP: Below Head of Passes

Good Communications: The listener was able to hear the talker on the radio speaker clearly without repetition.

2.8 Impact on Test Results Using New ITU AIS Standard and Safety Margin.

The Coast Guard intends to change the configuration of the PAWSS AIS system from the current standard, ITU-R. M825-3, to a new universal standard, ITU-R. M1371. The new standard has a much higher data rate to allow more vessels to participate in its local operating area and have higher position reporting rates as well. In addition, systems similar to PAWSS like those used for tracking and navigating commercial aircraft usually have a safety margin of 6-10 dB designed into their RF link budget. This margin is designed into the RF link budget of the system to take into account the effects of equipment variation, multi-path, and antenna shielding and installation.

Therefore, an additional 6dB of margin in the AIS shore-to-ship link would help account for those effects as well as ITU-R. M 1371's higher data rate. The signal strength graphs show that with a margin of 6 dB, the new reference level for the AIS received power would be -94 dBm. The graphs also show that the only areas affected by this new reference level would be those that are already lacking sufficient signal strength, which are below tower 1 and between towers 4 and 5.

SECTION 3
CONCLUSIONS and RECOMMENDATIONS

3.1 Transponder Working Channel Conclusions

The following conclusions for the working channel are based on the results of these tests and a signal level of -100 dBm:

1. There is not sufficient signal strength for the working channel from 1 mile south of the sea buoy and out from the sea buoy into the Gulf of Mexico from tower 1 located at Venice.

2. There is sufficient signal strength for the working channel from MM 22 BHP to195 AHP and from MM 220 to 285 AHP.

3. There is not sufficient signal strength for the working channel from MM 195 to 220 AHP.

3.2 Voice Channel Conclusions

Table 4 summarizes the quality ranking of the voice communications by mile markers.

Table 4
Voice Coverage Summary

Mode	Good Communications	Poor or Bad Communications
Mobile to VTC		
Hand Held Radio	10 miles BHP - MM 20 AHP MM 27 - 70 AHP MM 85-171 AHP MM 249 -262 AHP	MM 23 - 25 AHP MM 73 - 80 AHP MM 175 - 242 AHP
Fixed Mount Radio	8 Miles SWSB - MM192 AHP MM 249 - 272 AHP	MM 199 - 242 AHP
VTC to Mobile		
Hand Held Radio	22 miles BHP - MM179 AHP MM 249-277 AHP	MM182 - 242 AHP
Fixed Mount Radio	8 miles SWSB - MM 205 AHP MM 249 -281 AHP	MM 210 - 242

As Table 4 shows, the weak link in voice communications is in the levee-to-VTC direction. The range for good communications in the VTC-to-levee direction is greater than the levee-to-VTC direction.

3.3 Recommendations

To improve PAWSS AIS and voice operations, it is recommended that the Coast Guard:

1. Institute corrective measures to provide sufficient signal strength for the AIS working and voice channels in the proposed VTSA which may include: adding additional tower locations, moving existing base stations to other tower locations, and/or changing the antenna orientation/height of base stations on existing towers. The orientation of the receive antenna at the base station should also be adjusted to maximize the coverage of the transponder ship-to-shore link.

2. Determine by system analysis and potential testing in normal operations why the transponders amount of time to switch from channel 70 to the AIS working channel varied extensively. Note that this is not a coverage issue and will depend on many factors such as channel usage, system protocol for channel switching, and RF interference.

3. Determine how much coverage is required for good voice communications for various types of voice radios (fixed mount of hand held) and modes (high or low power) for operations in the VTSA.