Appendix A
Adjacent Channel Test Procedures and Recorded Data

Adjacent Channel Bench Tests

The marine VHF radios (both 25 and 12.5 kHz channelized units) were tested for susceptibility to adjacent channel interference by using either 25 or 12.5 kHz channelized marine radios as interfering transmitters. A diagram of the test set-up used to test the 25 kHz radios is shown below in Figure A-1. The frequencies selected for the desired signal channel and interferer radio for the tests are described in Appendix F.

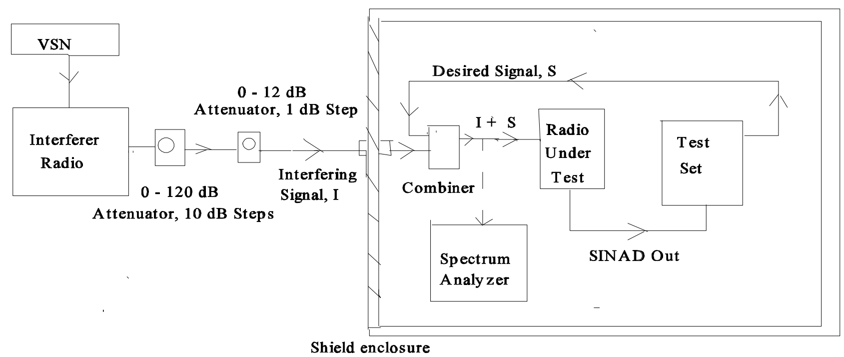

Figure A-1
25 kHz Receiver Bench Test Set-up

The following steps were taken to perform the tests on the 25 kHz radio receivers:

1. The receiver of the 25 kHz radio under test was tuned to the desired marine channel. The test set which was used as the 25 kHz desired signal transmitter was also tuned to that same channel and was modulated by an internal 1 kHz tone adjusted in amplitude for a 3 kHz signal deviation.

2. The power of the desired signal, S, from the RF output of the test set was adjusted and its value recorded in dBm when the SINAD of the radio receiver under test was 15 dB.

3. The interferer radio was set to the proper adjacent frequency. The frequencies used by the interferer radio and the desired signal radio for the testing are described in Appendix A.

4. The interferer radios were modulated by voice-shaped noise (VSN) played from a tape in a cassette player. The peak amplitude of the VSN signal from the cassette tape was matched as closely as possible

to the amplitude of a 1 kHz tone that would produce a 2.5 kHz signal deviation for a 25 kHz interferer radio. For the 12.5 kHz interferer, the peak amplitude of the VSN signal from the cassette tape was matched as closely as possible to the amplitude of a 1 kHz tone that would produce a 1.5 kHz signal deviation.

5. The RF output of the interferer radio, I, was fed through the step attenuators and then through the shielded enclosure. This signal was then combined with the desired signal, S, from the test set and connected to the RF input of the radio being tested.

6. The interferer radio was keyed so that it would transmit. The step attenuators were set to their maximum values and then adjusted till the interference power reduced the SINAD of the radio being tested from 15 to 12 dB.

7. The combiner at the RF input to the radio being tested was then connected to the spectrum analyzer and the RF power of the interfering signal, I, was measured in dBm. In some instances, the power of the interferer was below the noise floor of the spectrum analyzer. For those cases a 20 dB RF amplifier was connected to the output of the combiner before the measurement was made.

8. The interferer radio was tuned to the next adjacent frequency from the desired channel and the above steps were repeated till all adjacent frequencies were tested for that particular radio under test.

For testing 12.5 kHz radio receivers, the test set was used as the interferer radio and the 12.5 kHz radio located outside the shield room functioned as the desired signal radio. In this case, the desired signal radio was externally modulated by a 1 kHz tone for a 2.0 kHz signal deviation and its RF power adjusted by the step attenuators. The RF power of the test set acting as the 25 kHz interferer was adjusted from a front panel control and externally modulated by the VSN played from the cassette player. The peak amplitude of the VSN signal from the cassette tape was matched as closely as possible to the amplitude of a 1 kHz tone that would produce a 2.5 kHz signal deviation from the test set acting as the interferer radio. The test procedures were then repeated for the 12.5 kHz radio tests as in the 25 kHz radio tests, which was to reduce the SINAD of the 12.5 kHz radio receiver from 15 to 12 dB.

A diagram of this test set-up is shown below in Figure A-2. The frequencies used during these tests are described in section Appendix F.

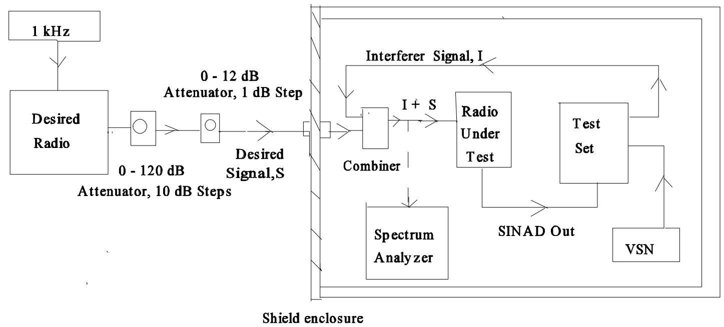

Figure A-2
12.5 kHz Receiver Test Set-up

Adjacent Signal Bench Test Results

The results of the adjacent interference susceptibility tests are contained in the following tables. Each table lists the desired signal power of each radio along with the power of the adjacent interferer needed to reduce the SINAD of the radio being tested from 15 to 12 dB (for each adjacent interference frequency).

Table A-1 contains the results of 25 kHz radio receivers versus a 25 kHz interferer on a simplex channel.

Table A-1
25 kHz receiver vs. 25 kHz Transmitter

Radio under test	Desired Signal Power (dBm)	Power of Adjacent Interferer (dBm)			
		-50 kHz	-25 kHz	25 kHz	50 kHz
Receiver A	-114	-48	-59	-58	-50
Receiver B	-119	-53	-63	-61	-51
Receiver E	-115	-48	-58	-59	-48
Receiver F	-116	-48	-58	-59	-48
Receiver G	-115	-55	-64	-62	-53
Receiver H	-115	-49	-61	-58	-47
Receiver I	-117	-51	-61	-60	-51
Receiver K	-118	-51	-60	-60	-51

Table A-2 contains the results of 25 kHz radio receivers versus a 12.5 kHz interferer on a simplex channel.

Table A-2
25 kHz receiver vs. 12.5 kHz Transmitter

Radio under test	Desired Signal Power (dBm)	Power of Adjacent Interferer (dBm)							
		-50.0 kHz	-37.5 kHz	-25.0 kHz	-12.5 kHz	12.5 kHz	25.0 kHz	37.5 kHz	50.0 kHz
Receiver A	-114	-46	-51	-55	-97	-99	-54	-54	-51
Receiver B	-119	-53	-55	-59	-99	-90	-59	-53	-52
Receiver E	-115	-48	-51	-56	-92	-95	-56	-52	-49
Receiver F	-116	-48	-50	-55	-95	-95	-55	-50	-48
Receiver G	-115	-55	-58	-63	-101	-99	-60	-59	-55
Receiver H	-115	-49	-55	-55	-103	-92	-54	-51	-49
Receiver I	-117	-50	-53	-57	-97	-101	-56	-52	-50
Receiver K	-118	-49	-52	-55	-105	-71	-54	-50	-48

Table A-3 contains the results of 25 kHz radio receivers versus a 25 kHz interferer on a duplex channel testing the mobile receiver.

Table A-3
25 kHz receiver vs. 25 kHz Transmitter

Radio under test	Desired Signal Power (dBm)	Power of Adjacent Interferer (dBm)			
		-50 kHz	-25 kHz	25 kHz	50 kHz
Receiver A	-114	-51	-60	-61	*
Receiver E	-115	-48	-58	-60	*

Table A-4 contains the results of 25 kHz radio receivers versus a 12.5 kHz interferer on a duplex channel testing the mobile receiver.

Table A-4
25 kHz receiver vs. 12.5 kHz Transmitter

Radio under test	Desired Signal Power (dBm)	Power of Adjacent Interferer (dBm)							
		-50.0 kHz	-37.5 kHz	-25.0 kHz	-12.5 kHz	12.5 kHz	25.0 kHz	37.5 kHz	50.0 kHz
Receiver A	-114	-46	-49	-54	-129	-113	-56	-53	*
Receiver E	-115	-42	-48	-52	-110	-115	-54	-50	*

Duplex communications requires that one radio be configured as a base unit and the other as a mobile. Most recreational boaters do not use base station radios in regular operations on duplex channels. For the most part base station marine radios on duplex channels in the United States are only used by those selling public correspondence services from coast stations to commercial shipping operators.

Table A-5 contains the results of a 25 kHz radio receiver versus a 25 kHz interferer on a duplex channel testing the base receiver.

Table A-5
25 kHz receiver vs. 25 kHz Transmitter

Radio under test	Desired Signal Power (dBm)	Power of Adjacent Interferer (dBm)			
		-50 kHz	-25 kHz	25 kHz	50 kHz
Receiver D	-119	-51	-59	-58	-51

Table A-6 contains the results of a 25 kHz radio receiver versus a 12.5 kHz interferer on a duplex channel testing the base receiver.

Table A-6
25 kHz receiver vs. 12.5 kHz Transmitter

Radio under test	Desired Signal Power (dBm)	Power of Adjacent Interferer (dBm)							
		-50.0 kHz	-37.5 kHz	-25.0 kHz	-12.5 kHz	12.5 kHz	25.0 kHz	37.5 kHz	50.0 kHz
Receiver D	-119	-56	-58	-61	-96	-88	-61	-56	-54

The 12.5 kHz channelized radios were tested for susceptibility to interference from a 25 kHz interferer. The results of adjacent signal interference tests for the 12.5 kHz mobile unit on a simplex channel versus a 25 kHz interferer are contained in Table A-7.

Table A-7
12.5 kHz Receiver vs. 25 kHz Transmitter

Radio under test	Desired Signal Power (dBm)	Power of Adjacent Interferer (dBm)			
		-37.5 kHz	-12.5 kHz	12.5 kHz	37.5 kHz
Receiver C	-117	-65	-86	-82	-64

The results of adjacent signal interference tests for the 12.5 kHz mobile unit on a duplex channel versus a 25 kHz interferer are contained in Table A-8.

Table A-8
12.5 kHz Receiver vs. 25 kHz Transmitter

Radio under test	Desired Signal Power (dBm)	Power of Adjacent Interferer (dBm)			
		-37.5 kHz	-12.5 kHz	12.5 kHz	37.5 kHz
Receiver C	-117	-78	-89	-82	-73

The results of adjacent signal interference tests for the 12.5 kHz base unit on a duplex channel versus a 25 kHz interferer are contained in Table A-9.

Table A-9
12.5 kHz Receiver vs. 25 kHz Transmitter

Radio under test	Desired Signal Power (dBm)	Power of Adjacent Interferer (dBm)			
		-37.5 kHz	-12.5 kHz	12.5 kHz	37.5 kHz
Receiver J	-114	-58	-67	-65	-60

Adjacent Channel Radiated Tests

The marine VHF radios (both 25 and 12.5 kHz channelized units) were tested for susceptibility to adjacent channel interference for the radiated tests by using either 25 or 12.5 kHz channelized marine radios as interfering transmitters. The frequencies of the channels used in these tests are shown in Table A-2 of Appendix A.

A diagram of the test set-up used to test the 25 kHz radios is shown below in Figure A-3.

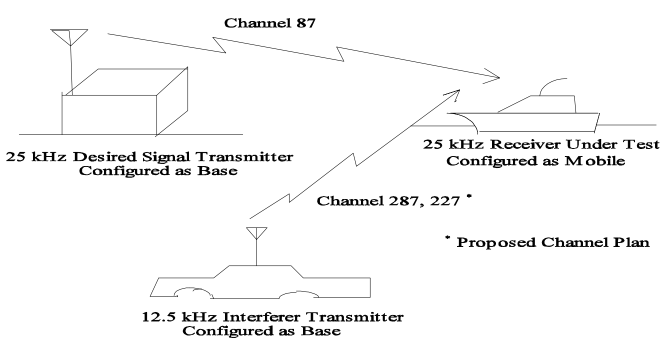

Figure A-3
25 kHz Receiver Radiated Test Set-up

The following steps were taken to perform the interference susceptibility tests on the 25 kHz radio receivers:

1. The receiver of the 25 kHz radio (configured as a mobile) being tested on board the boat was tuned to marine channel 87 and connected to a whip antenna. The 25 kHz desired signal transmitter (configured as a base) was also tuned to channel 87 and modulated by an 1 kHz tone adjusted in amplitude for a 3 kHz signal deviation. The RF output of the desired signal transmitter was connected to an antenna located on the roof of Ross Engineering.

2. The desired signal transmitter at the test facility was keyed. The boat moved out from the dock (located approximately 4.5 nautical miles from the test facility) into Clearwater Harbor and stopped when the SINAD of the radio being tested measured 15 dB with the communications test set. At that location, the level of the desired signal power was measured (at the receiver input) in dBm with the spectrum analyzer and its value recorded. The location of the boat was determined in latitude and longitude with a GPS receiver.

3. The 12.5 kHz interferer radio (configured as a base) was located in a car on the boat dock (approximately 2 miles from the boat) and was tuned to either adjacent interstitial channel 287 or 227. The carrier of these channels are +12.5 and -12.5 kHz from the carrier of channel 87. The RF output of the radio was connected to a 3 dB attenuator and then into adjustable RF step attenuators. The output of the adjustable attenuators was then connected to a whip antenna mounted on the roof of the car.

4. The interferer radio was modulated by voice-shaped noise (VSN) played from a tape in a cassette player. The peak amplitude of the VSN signal from the cassette tape was matched as closely as possible to the amplitude of a 1 kHz tone that would produce a 1.5 kHz signal deviation.

5. The interferer radio was keyed so that it would transmit on either adjacent interstitial channel. The RF power output of the interferer radio (located in the car) was adjusted with the step attenuators until the SINAD of the 25 kHz radio being tested (located in the boat) measured 12 dB with the test set. The location of the car was determined in latitude and longitude with a GPS receiver.

6. The cable to the RF input to the radio being tested on-board the boat was then connected to the spectrum analyzer, and the received RF power of the interferer radio was measured in dBm with the spectrum analyzer and its value recorded.

7. Steps one through six were repeated for each 25 kHz radio being tested.

A diagram of the test set-up used to test the 12.5 kHz radio's susceptibility to an adjacently tuned 25 kHz transmitter is shown below in Figure A-4.

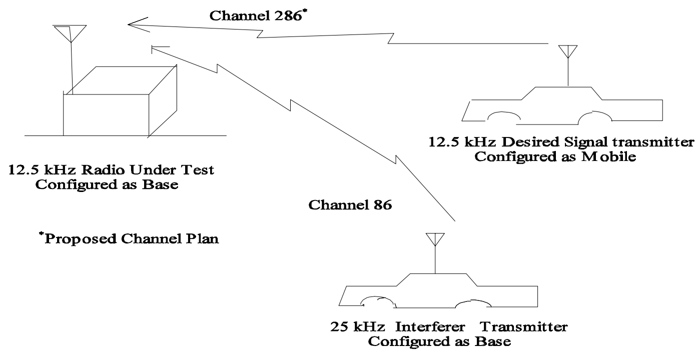

Figure A-4
12.5 kHz Receiver Radiated Test Set-up

The following steps were taken to perform the interference susceptibility tests on the 12.5 kHz radio receiver:

1. The receiver of the 12.5 kHz radio (configured as a base) being tested was located at a test facility in Tampa and was tuned to marine channel 286. The RF input to the radio was connected to adjustable RF attenuators and then to an antenna mounted on the roof the building. The 12.5 kHz desired signal transmitter (configured as a mobile) was also tuned to channel 286 and modulated by an 1 kHz tone adjusted in amplitude for a 2 kHz signal deviation. The RF output of the desired signal transmitter was connected to a whip antenna mounted on the roof of the car.

2. The desired signal transmitter in the car was keyed up and moved to a point approximately 1 mile north of test facility and stopped. The received desired signal power in the lab was adjusted with the attenuators until the test set measured a 15 dB SINAD for the 12.5 kHz radio being tested. The level of the desired signal power at the receiver input was then measured in dBm with the spectrum analyzer and its value recorded. The location of the car containing the desired signal transmitter was determined in latitude and longitude with a GPS receiver.

3. The 25 kHz interferer radio (configured as a mobile) was located in another car and was tuned to channel 86. The interferer radio was modulated by voice-shaped noise (VSN) played from a tape in a cassette player. The peak amplitude of the VSN signal from the cassette tape was matched as closely as possible to the amplitude of a 1 kHz tone that would produce a 2.5 kHz signal deviation.

4.The RF output of the 25 kHz interferer radio was connected to a 3 dB attenuator and then into adjustable RF attenuators. The output of the adjustable attenuators was then connected to a whip antenna mounted on the roof of the car.

5. The interferer radio was keyed so that it would transmit on channel 86. The car then moved south of the test facility and stopped when the SINAD of the 12.5 kHz radio being tested measured 12 dB with the communications test set. The location of the car containing the interferer transmitter was determined in latitude and longitude with a GPS receiver.

6. The received power of the 25 kHz interferer radio at the input to the 12.5 kHz radio (located at the test facility) was then measured in dBm with the spectrum analyzer and its value recorded.

7. As an additional test, the car containing the interferer radio moved closer to the test facility and stopped when the SINAD of the radio being measured in the lab was further reduced by 2-3 dB and the 1 kHz tone could no longer be heard.

8. The received power of the interferer radio at the input to the 12.5 kHz radio being tested was then measured in dBm with the spectrum analyzer and its value recorded. The GPS position of the car containing the interferer radio was also determined.

Adjacent Channel Radiated Test Data

The results of the adjacent signal interference susceptibility tests on the 25 kHz receivers are contained in the following paragraphs.

Column one in Table A-10 lists the radio receiver being tested. Column two lists the desired signal power required by each 25 kHz radio to produce a 15 dB SINAD as measured with the communications test set. Column three lists the received signal power of the adjacent narrowband transmitter at the receiver input which reduced SINAD of the 25 kHz radio receiver from 15 to 12 dB. The narrowband transmitter was operating on channel 227 which is -12.5 kHz off-tuned from the desired signal carrier of channel 87. Column four lists the received signal power of the narrowband transmitter at the receiver input which reduced the SINAD from 15 to 12 dB. In this case the interferer transmitter was operating on channel 287, which is 12.5 kHz off-tuned from channel 87.

Table A-10
25 kHz Receiver Radiated Test Data Vs 12.5 kHz Transmitter

25 kHz Radio	**Desired Signal Power,S (dBm)**	**Interferer power, I (dBm)**	
		-12.5 kHz off-tuned Channel 227	**12.5 kHz off-tuned Channel 287**
Receiver A	-107	-100	-109
Receiver B	-126	-116	-116
Receiver E	-108	-94	-112
Receiver F	-105	-95	-106
Receiver G	-111	-112	-123
Receiver H	-113	-114	-115
Receiver I	-124	-114	-120
Receiver K	-112	-107	-109

The signal-to-interference ratio (S/I) in dB for each radio was calculated by subtracting the interference power, I, from the desired signal power S. The results are shown below in Table A-11.

Table A-11
25 kHz Receiver S/I Values

25 kHz Radio	**Signal-to-Interference, S/I (dBm)**	
	-12.5 kHz off-tuned Channel 227	**12.5 kHz off-tuned Channel 287**
Receiver A	-7	2
Receiver B	-10	-10
Receiver E	-14	4
Receiver F	-10	1
Receiver G	1	12
Receiver H	1	2
Receiver I	-10	4
Receiver K	-5	-3

The location of the desired 25 kHz signal transmitter, the 12.5 kHz interferer transmitter, and the 25 kHz the radio for these tests are shown below in Table A-12.

Table A-12
25 kHz Receiver Test Locations

	Latitude	Longitude
Desired Transmitter	27E 53.147' N	82E 45.679' W
Interferer Transmitter	25E 55.066' N	82E 49.950' W
Radio under test	27E 56.597' N	82E 49.520' W

The results of the adjacent signal interference susceptibility tests on the 12.5 kHz receiver are contained in the following paragraphs.

The desired signal transmitter and the radio being tested were operating on duplex channel 286. The desired signal transmitter was configured as a mobile and the radio being tested was configured as a base. The 12.5 kHz receiver required a desired signal power, S, of -117 dBm from a 12.5 kHz transmitter to produce a 15 dB SINAD as measured with the communications test set without interference present in the link.

The 25 kHz interferer was operating on duplex channel 86 and configured as a mobile. It was 12.5 kHz off-tuned from the 12.5 kHz desired signal carrier. The SINAD of the radio being tested was reduced from 15 dB to 12 dB when the interferer power, I, at the input to the radio was -82 dBm. The resulting signal-to-interference ratio (S/I) is -35 dB. Due to frequency licensing restrictions the 12.5 kHz radio was not tested with a 25 kHz interferer off-tuned by -12.5 kHz.

The locations of the desired 12.5 kHz signal transmitter, the 25 kHz interferer transmitter, and the 12.5 kHz radio for these tests are shown below in Table A-13.

Table A-13
12.5 kHz Receiver Test Locations

	Latitude	Longitude
Desired Transmitter	27E 54.120' N	82E 45.720' W
Interferer Transmitter	27E 52.794' N	82E 45.701' W
Radio under test	27E 53.147' N	82E 45.679' W

In the second part of this test, the interferer moved closer to the radio under test and stopped when the 1 kHz desired signal tone was unintelligible. At this point, the power of the interferer at the input to the radio under test was measured to be -78 dBm. The location of the interferer was 27E 53.447' N latitude and 82E 45.731' W longitude.

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Appendix B
Interoperability Test Procedures and Recorded Data

Bench Tests Procedures

The interoperability of 25 and 12.5 kHz channelized marine VHF radios was bench tested by measuring the sensitivity of 25 kHz receivers with a 12.5 transmitter and the sensitivity of 12.5 kHz receivers with a 25 kHz transmitter. The sensitivity of 25 kHz receivers to a 12.5 kHz transmitter was performed using the test set-up below in Figure B-1. The frequencies selected for these tests are described in Appendix F.

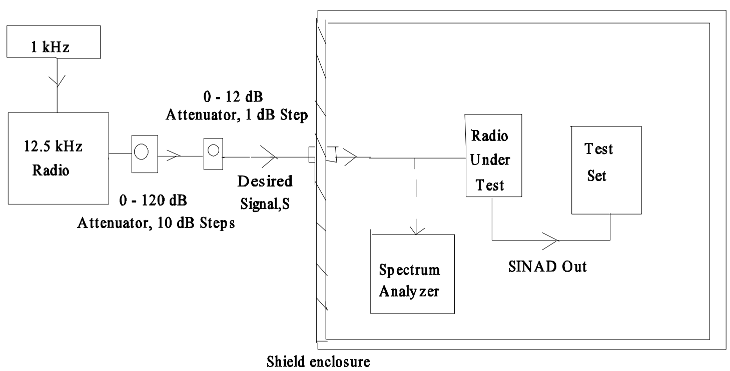

Figure B-1
25 kHz Receiver Interoperability Bench Test Set-up

The following steps were taken to perform the tests on the 25 kHz radio receivers:

1. The 12.5 kHz radio was set to the same channel as the 25 kHz radio being tested.

2. The 12.5 kHz radio was modulated by a 1 kHz tone adjusted in amplitude to produce a 2 kHz signal deviation.

3. The RF output of the 12.5 kHz radio, S, was fed through the step attenuators and then through the shielded enclosure. This signal was then connected to the RF input of the 25 kHz radio being tested.

4. The 12.5 kHz radio was keyed so that it would transmit. The step attenuators were set to their maximum values and then adjusted till the output power of the 12.5 kHz radio produced a 15 dB SINAD for the 25 kHz radio being tested.

5. The power of the desired signal, S, was measured in dBm with the spectrum analyzer and its value recorded.

For testing the interoperability of 12.5 kHz radio receivers with 25 kHz transmitters, the test set was used as the desired signal transmitter. The amplitude of the internal 1 kHz tone generator in the test set was set to a value that would produce a 3 kHz signal deviation. The RF power output of the test set was connected to the RF input of the 12.5 kHz radio and its level adjusted through a front panel control. The RF power of the test set was increased from -139 dBm to a value that would produce a 15 dB SINAD on the 12.5 kHz radio. A diagram of this test set-up is shown below in Figure B-2.

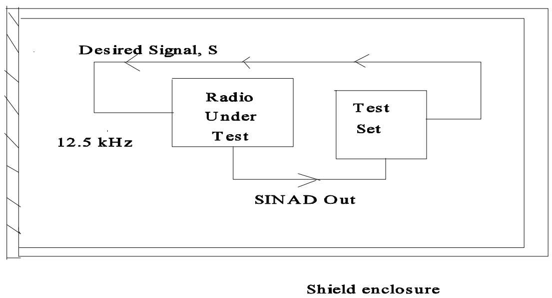

Figure B-2
12.5 kHz Receiver Interoperability Bench Test Set-up

The value of the RF power of the test set was recorded from the front panel in dBm when the SINAD measured 15 dB.

Bench Test Results

The results of the bench interoperability tests between a 12.5 kHz transmitter and the 25 kHz receivers are contained in the following paragraphs.

Simplex marine channel 22A was used as the desired signal channel for testing the interoperability of a 12.5 kHz transmitter with 25 kHz receivers. Column one in Table B-1 lists the receiver model and column two lists the amount of power in dBm for the 12.5 kHz transmitter to produce a 15 dB SINAD in the 25 kHz receiver. Column three lists the desired signal power in dBm from a 25 kHz transmitter required to produce the 15 dB SINAD.

Table B-1
25 kHz Receivers Interoperability Bench Data

Receiver	12.5 kHz Desired Signal, S (dBm)	25 kHz Desired Signal, S (dBm)
Receiver A	-111	-114
Receiver B	-117	-119
Receiver E	-114	-115
Receiver F	-116	-116
Receiver G	-110	-115
Receiver H	-111	-115
Receiver I	-113	-117
Receiver K	-118	-118

The results of the bench interoperability tests between a 25 kHz transmitter and the 12.5 kHz receivers are contained in the following paragraphs.

Simplex marine channel 22A and duplex marine channel 85 were used as the desired signal channels for testing the interoperability of a 12.5 kHz receiver with a 25 kHz transmitter. Column one in Table B-2 contains the receiver type or category and column two lists the amount of power in dBm required for the 25 kHz transmitter to produce a 15 dB SINAD in the 12.5 kHz receiver. Column three lists the desired signal power in dBm from a 12.5 kHz transmitter required to produce the 15 dB SINAD. Radio C was used as the 12.5 kHz receiver in both cases.

Table B-2
12.5 kHz Receiver Interoperability Bench Data

Receiver	25 kHz Desired Signal, S (dBm)	12.5 kHz Desired Signal, S (dBm)
Simplex	-119	-117
Duplex	-118	-117

Radiated Test Procedures

The interoperability of 25 and 12.5 kHz channelized marine VHF radios was tested in a maritime environment by measuring the sensitivity of 25 kHz receivers with a 12.5 transmitter. The sensitivity of the 25 kHz receivers with a 25 kHz transmitter was previously measured during the interference susceptibility tests described in section 4.0 of this report. The sensitivity of 25 kHz receivers to a 12.5 kHz transmitter was performed using the test set-up below in Figure B-3.

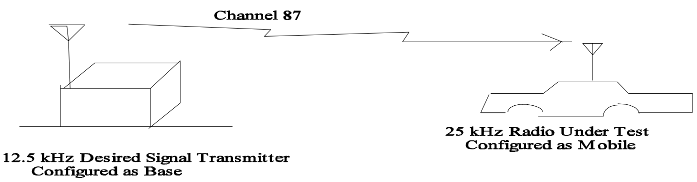

Figure B-3
25 kHz Receiver Interoperability Radiated Test Set-up

The following steps were taken to perform the tests on the 25 kHz radio receivers:

1. The 12.5 kHz radio and the 25 kHz radio being tested were both set to channel 87.

2. The 12.5 kHz radio was modulated by a 1 kHz tone adjusted in amplitude to produce a 2 kHz signal deviation.

3. The RF output of the 12.5 kHz radio was connected to an antenna located on the roof of the test facility.

4. The 25 kHz receiver was located in a car. The RF input to the radio was connected to adjustable RF attenuators and then to a whip antenna mounted on the roof of the car. The 12.5 kHz radio was keyed so that it would transmit.

5. The car then moved 2 miles north of the test facility and stopped. The level of the received desired signal power was then adjusted with the step attenuators till the SINAD of the radio being tested measured 15 dB with the communications test set. At that point the power of the desired signal at the receiver input was measured in dBm with the spectrum analyzer and its value recorded. The location of the car was determined in latitude and longitude with a GPS receiver.

6. Steps one through five were repeated for each radio being tested.

Radiated Test Results

The results of the interoperability tests with a 12.5 kHz transmitter and the 25 kHz receivers are contained below in Table B-3. Column one lists the 25 kHz receiver being tested, column two shows the desired signal power at the 25 kHz receiver input required to produce a 15 dB SINAD from a 12.5 kHz transmitter. Column three shows the desired signal power from a 25 kHz transmitter required to produce the 15 dB SINAD.

Table B-3
25 kHz Receivers Interoperability Radiated Data

25 kHz Radio	12.5 kHz Desired Signal, S (dBm)	25 kHz Desired Signal, S (dBm)
Receiver A	-115	-107
Receiver B	-119	-126
Receiver E	-113	-108
Receiver F	-115	-105
Receiver G	-116	-111
Receiver H	-115	-113
Receiver I	-116	-124
Receiver K	-116	-112

The locations of the desired signal transmitter and the radio under test are shown below in Table B-4.

Table B-4
Transmitter and Receiver Locations

	Latitude	Longitude
Desired Transmitter	27E 53.147' N	82E 45.679' W
Radio under test	27E 54.943' N	82E 45.976' W

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Appendix C
Intermodulation Test Procedures and Recorded Data

The marine VHF radios were tested for susceptibility to 3rd and 5th order intermodulation products by using two signal generators as interfering transmitters that could possibly generate intermodulation products on channel 67 within the receiver of the radio being tested. A diagram of the test set-up is shown below in Figure C-1.

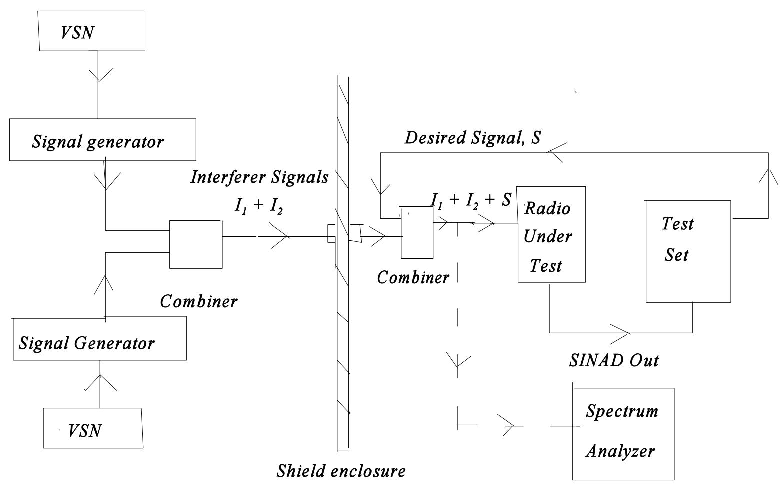

Figure C-1
Intermodulation Susceptibility Test Set-up

The following steps which were taken to perform the intermodulation tests.

1. The receiver of the radio under test was tuned to marine channel 67. The test set which was used as the desired signal transmitter was also tuned to channel 67 and was modulated by an internal 1 kHz tone adjusted in amplitude for a 3 kHz signal deviation.

2. The power of the desired signal, S, from the RF output of the test set was adjusted and its value recorded in dBm when the SINAD of the radio receiver under test was 15 dB.

3. The frequencies of the signal generators were set to values that could generate the 3rd or 5th order intermodulation products on channel 67 within the radio's receiver. Two pairs of frequencies were chosen so that both frequencies of each pair were either in the marine band (156-174 MHz) or both out of the marine band.

4. The RF outputs of the signal generators were FM modulated by voice-shaped noise (VSN) played from tapes in cassette players. The peak amplitudes of the VSN signals from the cassette tapes were

matched as closely as possible to the amplitude of a 1 kHz tone that would produce a 2.5 kHz signal deviation.

5. The RF outputs of the signal generators, I_1 and I_2, were combined and fed through the shielded enclosure. This composite signal was then combined with the desired signal, S, from the test set and connected to the RF input of the radio.

6. The RF power of each signal generator was increased from -139 dBm in equal increments (i.e. , the signal generator RF output levels were kept approximately equal) until the SINAD of the radio being tested dropped from 15 to 12 dB.

7. The SINAD reduction due to intermodulation products was verified by turning each of the signal generators off and observing the SINAD meter on the test set. If the SINAD did not recover to 15 dB with only one signal generator present, then receiver saturation was presumed to be the dominant interference mechanism rather than intermodulation.

7. Once the SINAD reduction due to the intermodulation product was verified, the RF power of each signal generator, I_1 and I_2 , at the RF input to the radio was measured in dBm with a spectrum analyzer and recorded.

8. If receiver saturation occurred, then it was so noted and the tests continued.

The CCIT audio weighting filter in the test set was not activated during these tests.

Setting Frequency Generators

Using equation C-1, two frequencies were selected to generate the 3rd order in-band intermodulation product on channel 67. Note: F1 is tuned below F2.

In band frequencies: F1=158.700 MHz, F2=161.025 MHz

(Eq. C-1) $F_{IM3} = 2F1 - F2$

$F_{IM3} = 2*158.700 - 161.025$

$F_{IM3} = 156.375$ MHz, which is the carrier frequency of marine channel 67

Equation C-2 was used to select frequencies to generate the 3rd order out-of-band intermodulation products on channel 67.

Out-of-band frequencies: F1=151.725 MHz, F2=154.050 MHz

(Eq. C-2) $F_{IM3} = 2F2 - F1$

$F_{IM3} = 2*154.050 - 151.725$

$F_{IM3} = 156.375$ MHz, which is the carrier frequency of marine channel 67

Using equation C-3, two frequencies were selected to generate the 5th order in-band intermodulation product on channel 67. Note: F1 is tuned below F2.

In band frequencies: F1=158.700 MHz, F2=159.8625 MHz

(Eq. C-3) $F_{IM5} = 3F1 - 2F2$

$F_{IM5} = 3*158.700 - 2*159.8625$

F_{IM5} = 156.375 MHz, which is the carrier frequency of marine channel 67

Equation C-4 was used to select frequencies to generate the 5th order out-of-band intermodulation product on channel 67.

Out-of-band frequencies: F1=152.8875 MHz, F2=154.050 MHz

(Eq. C-4) $F_{IM5} = 3F2 - 2F1$

$F_{IM5} = 3*154.050 - 2*152.8875$

F_{IM5} = 156.375 MHz, which is the carrier frequency of marine channel 67

Calculating Intermodulation Rejection Ratio

The intermodulation rejection ratio (IMR) of the victim receiver was calculated using equation C-5:

(Eq. C-5)
$$IMR = S - I$$

where:

IMR= Intermodulation rejection ratio of victim receiver, in dB

S = Desired signal power for 15 dB SINAD, in dBm

I = Power of interferer, in dBm

The IMR, S, and I for each receiver is shown below in Tables C-1 through C-4. Table C-1 contains the data for the out-of-band response and Table C-2 contains data for the in-band response for 3rd order IMR. The powers of each interferer are almost equal, therefore the S/I was calculated using the nominal value.

Table C-1
In-Band 3rd Order IMR Response

Radio	Desired Signal, S (dBm)	F1= 158.700 MHz F2= 161.025 MHz		
		IMR (dB)	I_1 (dBm)	I_2 (dBm)
Receiver A	-114	-63	-50.8	-50.5
Receiver B	-119	-81	-38.7	-38.2
Receiver C	-117	-77	-40.0	-39.6
Receiver D	-119	-80	-40.6	-40.2
Receiver E	-115	-62	-53.5	-53.2
Receiver F	-116	-78	-38.7	-38.2
Receiver G	-115	-61	-54.2	-53.8
Receiver G	-115	-72	-43.5	-43.2
Receiver I	-117	-67	-50.5	-49.8
Receiver K	-118	-66	-52	-52

Table C-2
Out-of-Band 3rd Order IMR Response

Radio	Desired Signal, S (dBm)	F1= 151.725 MHz F2= 154.050 MHz		
		IMR (dB)	I_1 (dBm)	I_2 (dBm)
Receiver A	-114	-68	-46.0	-46.3
Receiver B	-119	saturation	*	*
Receiver C	-117	-84	-33..5	-32.8
Receiver D	-119	saturation	*	*
Receiver E	-115	-71	-44.3	-42.3
Receiver F	-116	-83	-33.2	-32.6
Receiver G	-115	-71	-44.8	-44.2
Receiver H	-115	saturation	*	*
Receiver I	-117	-71	-46.6	-46.2
Receiver K	-118	-69	-49	-49

Table C-3 contains the data for the out-of-band response and Table C-4 contains data for the in-band response for 5th order IMR.

Table C-3
In-Band 5th Order IMR Response

Radio	Desired Signal, S (dBm)	F1= 158.700 MHz F2= 159.8625 MHz		
		IMR (dB)	I_1 (dBm)	I_2 (dBm)
Receiver A	-114	-73	-41.3	-41.0
Receiver B	-119	saturation	*	*
Receiver D	-119	-86	-33	-33
Receiver E	-115	-76	-39	-39
Receiver F	-116	saturation	*	*
Receiver G	-115	saturation	*	*
Receiver H	-115	saturation	*	*
Receiver I	-117	saturation	*	*
Receiver K	-118	-80	-38	-38

Table C-4
Out-of-Band 5th Order IMR Response

Radio	Desired Signal, S (dBm)	F1= 152.8875 MHz F2= 154.050 MHz		
		IMR (dB)	I_1 (dBm)	I_2 (dBm)
Receiver A	-114	-77	-37	-37
Receiver B	-119	saturation	*	*
Receiver D	-119	saturation	*	*
Receiver E	-115	-81	-34	-34
Receiver F	-116	saturation	*	*
Receiver G	-115	saturation	*	*
Receiver H	-115	saturation	*	*
Receiver I	-117	-83	-35	-34
Receiver K	-118	-82	-36	-36

The saturation values were not recorded but generally occurred at higher powers than the intermodulation products.

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Appendix D
Transponder Test Procedures

The following steps were used to test the susceptibility of a VTS-like transponder system to a 12.5 kHz interferer tuned 12.5 kHz from the transponder channel carrier. The transponder system operates according to the procedures outlined in ITU-R M.825 with some enhancements. The system is able to update the status information of a participating vessel by interrogating the ship's transponder every 10 seconds. The ship's transponder responds to the interrogations by sending the ship's information (i.e., ship's ID, heading, speed, location, draft, cargo) back to the system controller. This information is then sent by the controller to the other vessels participating in the system. The transponder is considered to be in failure mode if it is not able to reply to the system controller's interrogations for information.

The objective of this test was to inject sufficient adjacent channel interference into the transponder receiver so that it could no longer receive the system controller's interrogations and be put in a failure mode.

The transponder was tested using the set-up shown below in Figure D-1.

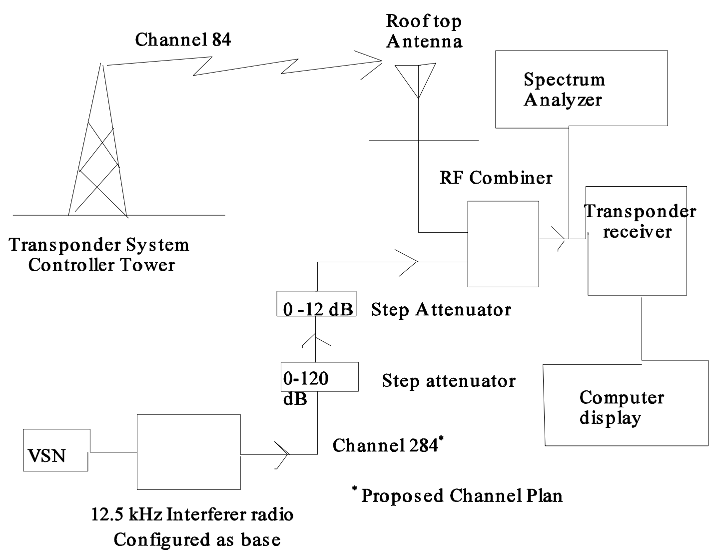

Figure D-1
VTS-Like Transponder Test Set-up

The following steps were taken to perform the transponder tests.

1. The transponder being tested was operating as a stationary unit in the laboratory of the test facility. The transponder was connected to a rooftop antenna and was communicating with the system controller at the test facility via a tower located 3 miles from the building.

2. Since the transponder had already been "acquired" by the system on channel 70, it was now communicating with the system controller on duplex channel 84 as a mobile unit. The 12.5 kHz interferer radio was tuned to channel 284 (the interstitial 12.5 kHz offset from the carrier of channel 84) and was modulated by VSN matched in amplitude to a 1 kHz tone that would produce a 1.5 kHz signal deviation. The interferer was configured as a base unit operating on the interstitial channel.

3. The RF output of the interferer radio was connected to a 3 dB attenuator and then to adjustable RF step attenuators. The output of the attenuators was then connected to one input of a 2-to-1 RF combiner. The other input to the combiner was connected to the cable of the rooftop antenna. The output of the combiner was then connected to the RF input of the transponder receiver.

4. The attenuators were set to their maximum value and the interferer radio was keyed up so that it would inject interference into the transponder.

5. The power of the adjacent channel interference was increased by decreasing the value of the step attenuators so that the interferer would disrupt the transponder operations. The power of the interferer was increased till the transponder could no longer respond to the system controller's interrogations. When the transponder was in failure mode, the power of the interferer at the input to the transponder was measured in dBm with the spectrum analyzer and its value recorded.

Transponder Test Results

The transponder was able to respond to the controller's polls and reach a 50% reply rate with an interference power of -26 dBm injected into its RF input on an adjacent interstitial channel. The transponder was unable to receive interrogations with an interference power of -25 dBm injected into its RF input and was considered to be in failure mode. These tests were performed while the transponder was in "distance mode". By switching to "local mode" the transponder could withstand an additional 2-3 dB of interference power before failure occurred.

The desired transponder signal measured at the input to the transponder receiver was approximately -60 dBm. The Signal-to-Interference (S/I) ratio for the 50% reply rate for the transponder receiver was -34 dB and the S/I ratio for failure mode was -35 dB.

Appendix E

Calculating Adjacent Channel Separation and Interoperability Distances

Calculating Required Path Loss and Corresponding Distance

Adjacent channel separation and interoperability distances were calculated for the 25 kHz and 12.5 kHz receivers by first determining the required path loss by using the following equations and assumptions:

(Eq. E-1) $P_R = P_T + G_T + G_R - L_S - L_P$

where:

P_R = Power at receiver input (defined below), dBm
P_T = Transmitter Power, dBm
G_T = Transmitter Antenna Gain Towards Receiver, dBi
G_R = Receiver Antenna gain Towards Transmitter, dBi
L_S = System Loss, dB
L_P = Required Path Loss, dB

with:

P_T = 44, 37, and 30 dBm
G_T = 3 dBi
G_R = 3 dBi
L_S = 2 dB

Rearranging equation E-1 to solve for the required path loss, L_P, results in equation E-2.

(Eq. E-2) $L_P = P_T + G_T + G_R - L_S - P_R$

For the adjacent channel separation distances, the required path loss was calculated by using the above assumptions and setting the received power, P_R, equal to the received interference power values in Tables A-1, A-2, and A-7 of Appendix A.

For the interoperability distances, the required path loss was calculated by using the above assumptions and setting the received power, P_R, equal to the received desired signal power values in Tables B-1 and B-2 of Appendix B.

Once the required path loss values were calculated, the adjacent channel separation and interoperability distances were determined by reading the appropriate value of distance that corresponds to the required path loss on Figures E-1, E-2, and E-3. These figures were created using the NTIA nlambda propagation model for smooth earth at 157.1 MHz over seawater with vertical polarization at the 50 percentile. Three cases of transmit and receive antenna heights were considered: 3 m, 3 and 10 m, and 10 m. These cases were done to model communications between recreational boaters, recreational and commercial boaters, and commercial boaters. Higher antenna heights increase the radio line-of-sight distance and alter the path loss values.

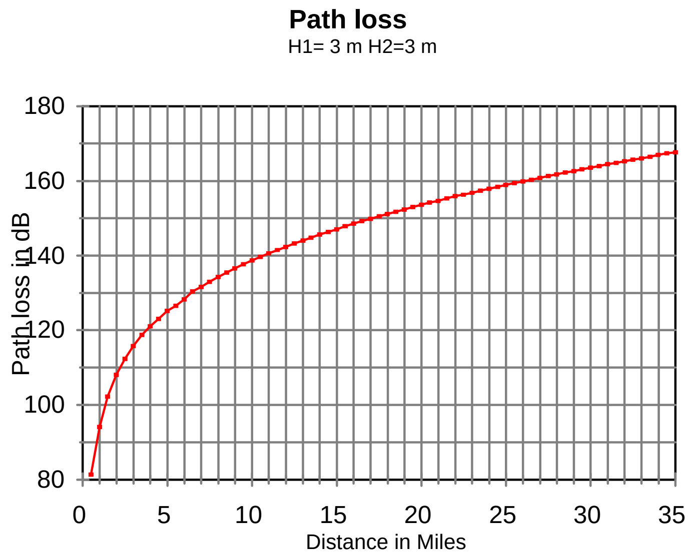

Figure E-1
Path Loss Distance Curve, 3 m and 3 m

Figure E-2
Path Loss Distance Curve, 3 m and 10 m

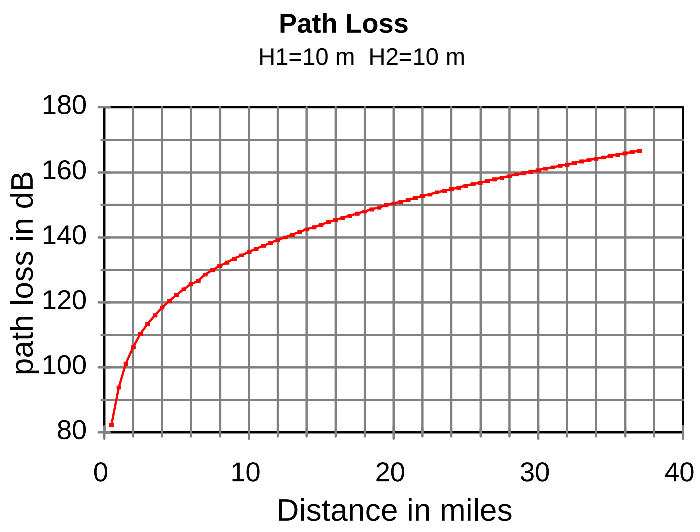

Figure E-3
Path Loss Distance Curve, 10 m and 10 m

Sample Calculations

The following paragraphs contain sample calculations for determining the adjacent channel separation and interoperability distances for receiver A, a 25 kHz radio. The same methodology applies to all other 25 and 12.5 kHz radios.

Adjacent Channel Separation Distance

The received interference power for Receiver A in column four of Table A-1 is -59 dBm for a 25 kHz interferer off-tuned by -25 kHz from the desired signal. The received interference power for receiver A from a 12.5 kHz interferer off-tuned by 12.5 kHz is -97 dBm (column 6 of Table A-2).

Setting P_R in equation E-2 equal to -59 and -97 dBm and using the other assumptions, the required path loss can be calculated for receiver A versus the 25 kHz and 12.5 kHz interferers at each level of interferer transmitter power. The results are 107, 100 and 93 dB, and 145, 138 and 131 dB, respectively.

The corresponding distance for each required path loss can then be determined by using the appropriate figure for the selected antenna heights. For example, for a required path loss of 107 dB the corresponding distance for antenna heights of 3 meters can be determined from Figure E-1 to be approximately 1.5 miles. For a required path loss of 145 dB, the corresponding distance for antenna heights of 3 meters can be determined from Figure E-1 to be approximately 13.5 miles. Figure E-2 can be used to determine the adjacent separation distances for antenna heights of 3 and 10 meters. Figure E-3 can be used to determine the adjacent channel separation distances for antenna heights of 10 meters.

Adjacent channel separation distances for different scenarios/situations can be determined from the figures by changing the assumptions for antenna gain and system loss in equation E-2.

Interoperability Distance

The desired signal power for Receiver A in column two of Table B-1 is -111 dBm for a 12.5 kHz transmitter and in column three is -114 dBm for a 25 kHz transmitter.

Setting P_R in equation E-2 equal to -111 and -114 dBm and using the other assumptions, the required path loss can be calculated for receiver A communicating with the 12.5 kHz and 25 kHz transmitters. The results are 159, 152 and 145 dB, and 162, 155 and 148 dB, respectively.

The corresponding distance for each required path loss can then be determined by using the appropriate figure for the selected antenna heights. For example, for a required path loss of 159 dB, the corresponding distance for antenna heights of 3 meters can be determined from Figure E-1 to be approximately 25 miles. For a required path loss of 162 dB, the corresponding distance for antenna heights of 3 meters can be determined from Figure E-1 to be approximately 28 miles. Figure E-2 can be used to determine the interoperability distances for antenna heights of 3 and 10 meters. Figure E-3 can be used to determine the interoperability distances for antenna heights of 10 meters.

Interoperability distances for different scenarios/situations can be determined from the figures by changing the assumptions for antenna gain and system loss in equation E-2.

Conversion To Nautical Miles

The distances chosen from the figures are in statute miles. They were converted to nautical miles in the main report by multiplying by .87.

Appendix F
Test Frequencies

Bench Test Frequencies

The following paragraphs describe the frequencies\channels used during the adjacent channel interference susceptibility and interoperability bench tests.

Adjacent Channel Interference Tests

The 25 kHz radios were tested for susceptibility to adjacent channel interference on simplex and duplex channels. The 25 kHz radios were tested with both 25 and 12.5 kHz channelized radios acting as the interferers. The 25 kHz interferers were tuned ±25 and ±50 kHz (two channels) from the desired signal carrier frequency and the 12.5 kHz interferers were tuned ±12.5, ±25, ±37.5, and ±50 kHz from the carrier frequency. Using this method a “baseline” measurement of the current operating 25 kHz environment could be simulated and those results compared to the proposed 25 and 12.5 kHz environment.

The frequencies that were used by the desired signal and interferer radio during the simplex interference susceptibility testing are shown below in Table F-1. The desired signal was transmitted on channel 22A. On-tune interferers were not tested. The interstitial channel designations for the interferers in Tables F-1 and F-2 are identified by adding a prefix of “2” to the previous 25 kHz channel. For example, the interstitial channel 12.5 kHz above channel 21 is labeled 221. This channel plan designation has been submitted to ITU-R study group 8B but has not yet been internationally adopted.

Table F-1
25 kHz Simplex Test Channels

Simplex Channel Designation	Interferer Frequency (MHz)	offset value kHz
21A	157.0500	-50.0
221*	157.0625	-37.5
81A	157.0750	-25.0
281*	157.0875	-12.5
22 A	**157.1000**	**0**
222*	157.1125	+12.5
82A	157.1250	+25.0
282*	157.1375	+37.5
23A	157.1500	+50.0
* proposed designator		

The frequencies that were used by the desired signal and interferer radio during the duplex interference susceptibility testing are shown below in Table A-2. Channel 87 was the desired signal channel.

Table F-2
25 kHz Duplex Test Frequencies

Duplex Channel Designation	Transmit Mobile Stations (MHz)	Transmit Base Stations (MHz)	Offset value (kHz)
86	157.3250	161.9250	-50.0
286*	157.3375	161.9375	-37.5
27	157.3500	161.9500	-25.0
227*	157.3625	161.9625	-12.5
87	**157.3750**	**161.9750**	**0**
287*	157.3875	161.9875	+12.5
28	157.4000	162.0000	+25.0
228*	157.4125	162.0125	+37.5
88	157.4250	162.0250	+50.0
* proposed designator			

When testing the 25 kHz mobile receiver on the duplex channel, the test set functioned as the desired base station transmitter and the interferer radio located outside the shield room acted as the adjacently tuned base station 25 or 12.5 kHz transmitter. Conversely, when testing the 25 kHz base station receiver on the duplex channel the test set functioned as the desired mobile transmitter and the interferer radios acted as the adjacently tuned mobile transmitter.

The radios were configured as either a base station or mobile unit. Therefore, the tests were completed by merely selecting the proper channel for each test set-up. Internal programming in the radios selected the proper frequency for that particular desired and interferer channel for each test. Most marine VHF radios are sold either as a base station radio or as a mobile radio. Although, some manufacturers sell radios that can be configured by the user as either one.

Note: In Tables F-1 and F-2 the 25 kHz interferers transmitted only on the assigned marine channels. The 12.5 kHz interferers transmitted on the assigned marine channels and the interstitial channels between them.

The 12.5 kHz radios were tested for susceptibility to adjacent channel interference on simplex and duplex channels. The 12.5 kHz radios were only tested with 25 kHz channelized radios acting as the interferers. The 25 kHz interferer radios were off-tuned ±12.5 and ±37.5 kHz from the carrier frequency of the desired 12.5 kHz signal. Table F-3 lists the frequencies of the simplex desired and interferer channels tested. The interstitial channel 222A was the desired signal channel. Obviously, due to the channel plan an on-tune 25 kHz interferer could not be tested.

Table F-3
12.5 kHz Simplex Test Frequencies

Simplex Channel Designation	Interferer Frequency (MHz)	offset value (kHz)
81A	157.0750	-37.5
22A	157.1000	-12.5
222A*	**157.1125**	**0**
82A	157.1250	+12.5
23A	157.1500	+37.5
* proposed designator		

Table F-4 lists the frequencies of the duplex desired and interferer channels. The interstitial channel 285 was the desired signal channel.

Table F-4
12.5 kHz Duplex Test Frequencies

Duplex Channel Designation	Transmit Mobile Stations (MHz)	Transmit Base Stations (MHz)	Offset value (kHz)
25	157.2500	161.8500	-37.5
85	157.2750	161.8750	-12.5
285*	**157.2875**	**161.8875**	**0**
26	157.3000	161.9000	+12.5
86	157.3250	161.9250	+37.5
* proposed designator			

When testing the 12.5 kHz mobile and base receiver on the duplex and simplex channel the test set functioned as the adjacently tuned 25 kHz interferer radio. This was accomplished by adjusting the carrier frequency of the RF output of the test set to the values shown in Table F-4.

Interoperability Tests

Simplex channel 22A was used as the desired signal channel for testing the interoperability of a 12.5 kHz transmitter with the 25 kHz receivers. Channel 22A was also used to test the interoperability of a 25 kHz transmitter with a 12.5 kHz receiver on a simplex channel. Channel 85 was used to test the interoperability of a 25 kHz transmitter and 12.5 kHz receiver on a duplex channel. The frequencies of these channels are shown above in Tables F-1 and F-2.

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Appendix G
Spectrum Emission Figures

The emission spectra of the test set, a 25 kHz radio, and a 12.5 kHz radio were measured with a spectrum analyzer and recorded with a computer. The results are shown in figures on the following pages. The type of modulating signal and the amount of signal deviation is included in the title of each figure.

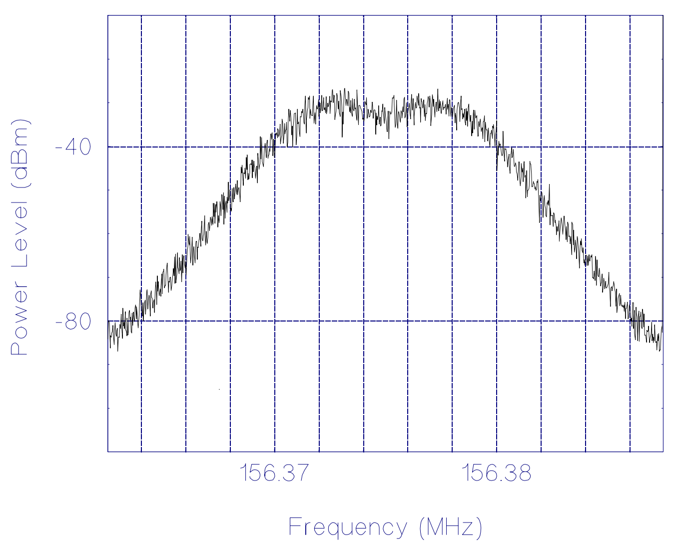

Figure G-1
Test Set with VSN modulation and 3 kHz Deviation

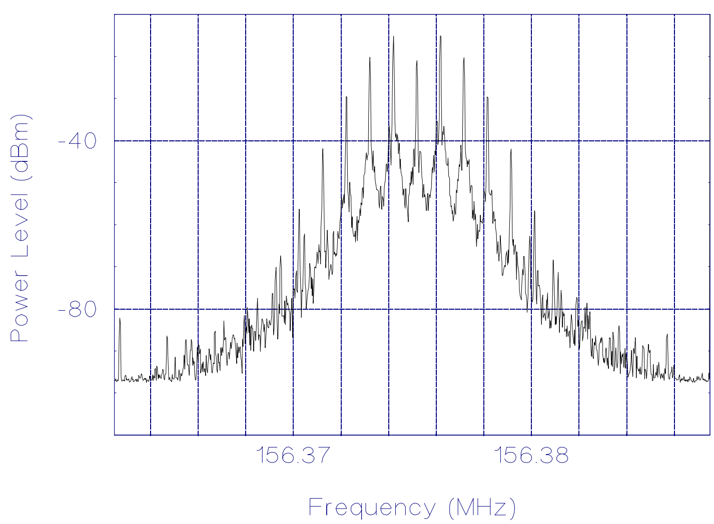

Figure G-2
Test Set with 1 kHz modulation and 3 kHz Deviation, High Output

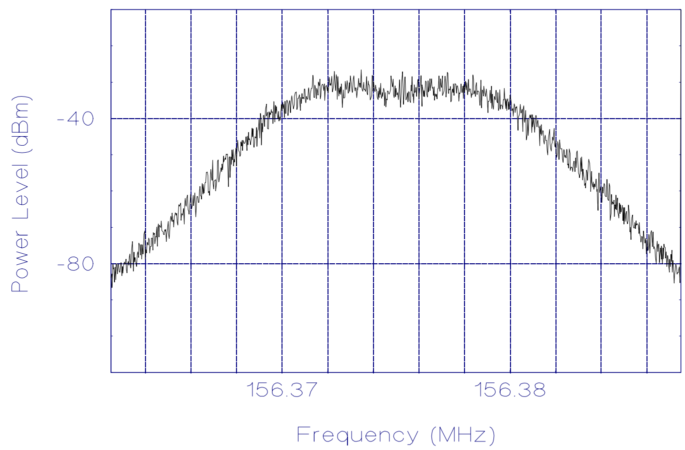

Figure G-3
Test Set with VSN modulation and 2.5 kHz Deviation

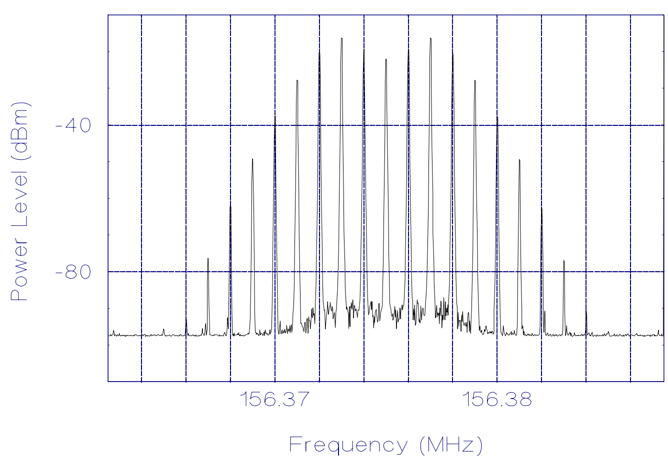

Figure G-4
Test Set with 1 kHz modulation and 2.5 kHz Deviation, High Output

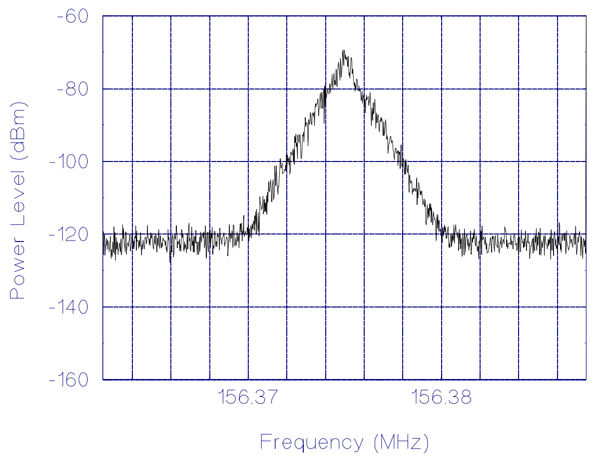

Figure G-5
25 kHz radio with VSN modulation and 3 kHz Deviation

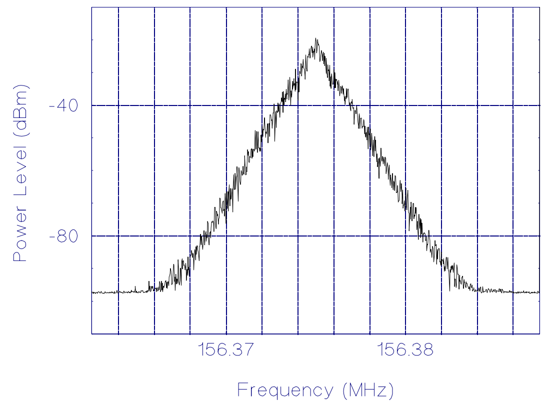

Figure G-6
25 kHz radio with VSN modulation and 2.5 kHz Deviation

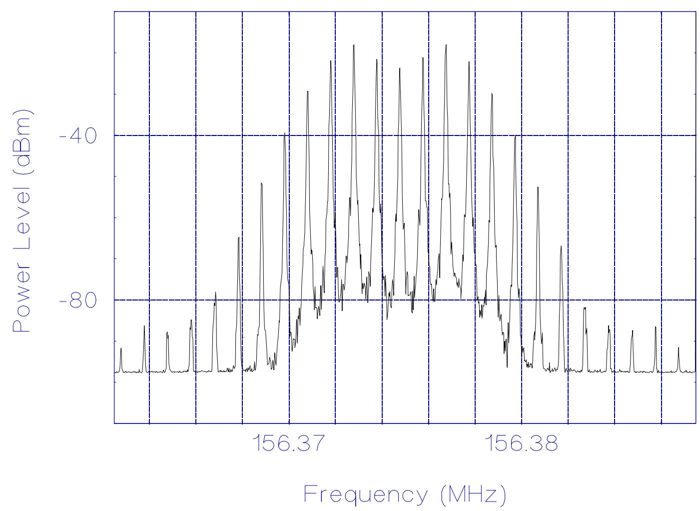

Figure G-7
25 kHz radio with 1kHz modulation and 3 kHz Deviation, High Output

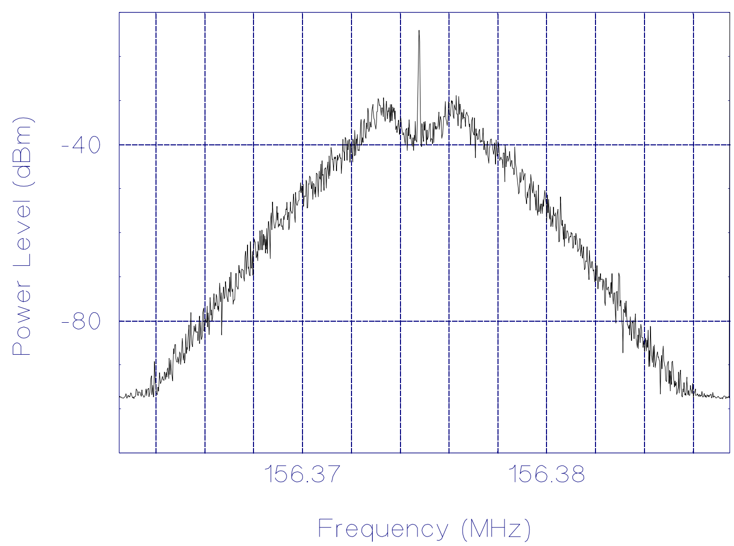

Figure G-8
25 kHz radio with VSN modulation and 2.5 kHz Deviation, High Output

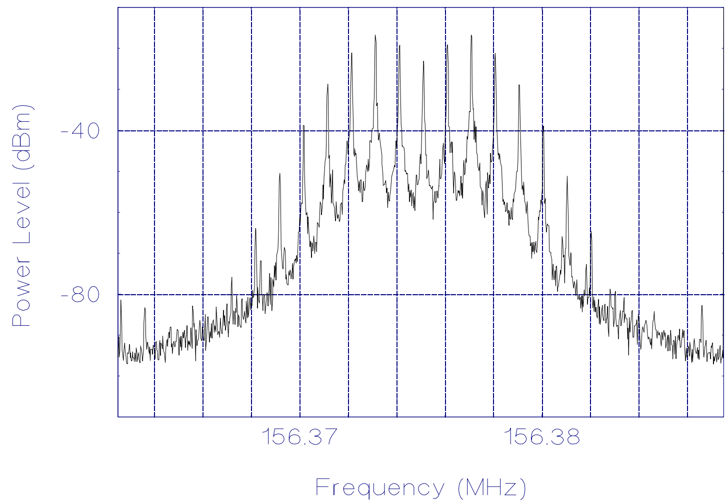

Figure G-9
12.5 kHz radio with 1kHz modulation and 2 kHz Deviation, High Output

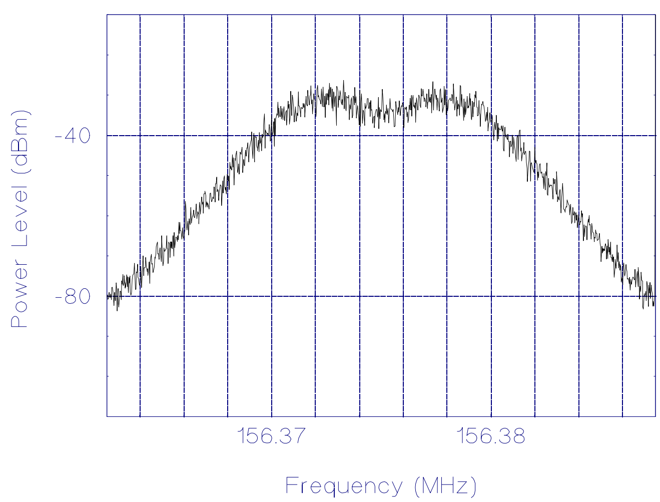

Figure G-10
12.5 kHz radio with VSN modulation and 1.5 kHz Deviation

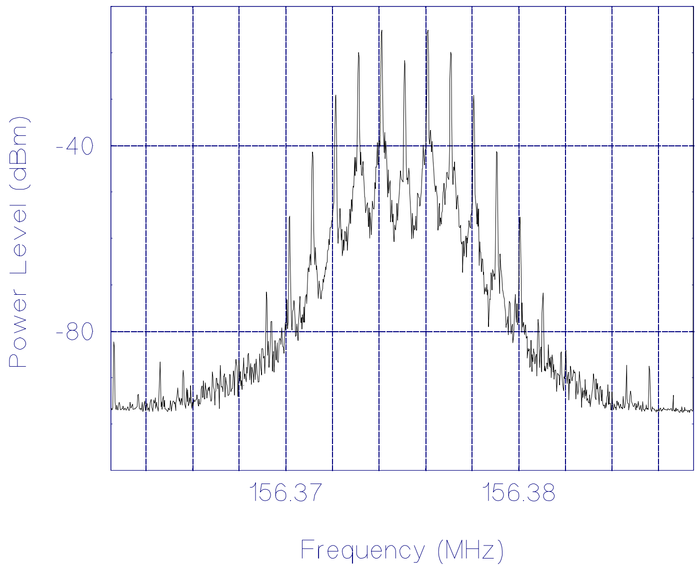

Figure G-11
12.5 kHz radio with 1kHz modulation and 1.5 kHz Deviation, High Output