FINAL
(VERSION 4)

COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS JOINT MILITARY TRAINING

UTILITIES STUDY VOLUME V: INFORMATION TECHNOLOGY/COMMUNICATIONS

Department of the Navy
Naval Facilities Engineering Command, Pacific
258 Makalapa Drive, Suite 100
JBPHH HI 96860-3134

September 2014

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N62742-11-D-1801 Amd 01 Contract Task Order 02

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LIST OF ACRONYMS AND ABBREVIATIONS

ADN	Area Distribution Node
CJMT	Commonwealth of the Northern Mariana Islands Joint Military Training
CLF	Cable Landing Facility
CNMI	Commonwealth of the Northern Mariana Islands
DoN	Department of the Navy
EIS/OEIS	Environmental Impact Statement/Overseas Environmental Impact Statement
EMI	Electromagnetic Interference
IT/COMM	information technology/ communications
MLA	Military Lease Area
POTS	plain old telephone service
RFI	radio frequency interference
RTA	Range and Training Area
TRCRD	Training Range Communication Requirements Document
TV	television
U.S.	United States

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CHAPTER 1. INTRODUCTION

1.1 OVERVIEW

The purpose of this report is to provide information regarding the information technology/communications (IT/COMM) requirements associated with a proposed action to establish a series of live-fire and maneuver ranges, training areas, and supporting facilities within the Commonwealth of the Northern Mariana Islands (CNMI) to address the United States (U.S.) Pacific Command Service Components' unfilled training requirements in the Western Pacific. These live-fire ranges, training courses, and maneuver areas collectively constitute a Range and Training Area (RTA). Under the proposed action, a unit level RTA is proposed for Tinian and a combined level RTA is proposed on Pagan. The proposed action includes construction, range management, expanded training and operations (to include combined-arms, live-fire, and maneuver training at the unit and combined levels), establishment of danger zones, designation of special use airspace, and acquisition and/or lease of land to support simultaneous and integrated training. The CNMI Joint Military Training (CJMT) Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) is being prepared to assess the proposed action. This report focuses on existing ground, air, and marine infrastructure capacity and facility requirements, proposed projects, and methodology to meet the proposed action. Figure 1.1-1 provides an overview of the CNMI, and Figure 1.1-2 and Figure 1.1-3 provide overviews of Tinian and Pagan, respectively.

There are two different training tempos proposed for both Tinian and Pagan. The first training tempo is the proposed action presented in the CJMT EIS/OEIS, consisting of 20 weeks per year on Tinian and 16 weeks per year on Pagan. In the future, the training tempo might be increased to 45 weeks per year on Tinian and 40 weeks per year on Pagan and is addressed by the CJMT EIS/OEIS as a potential future action. This study addresses both training tempos.

1.1.1 Goals and Objectives

The goal of this study is to make recommendations for the proposed improvements to provide the required IT/COMM connectivity and to evaluate the overall IT/COMM impact associated with the proposed action. This study provides sufficient and detailed information to support the CJMT EIS/OEIS. The objectives of Volume V, *IT/COMM*, of the *Utilities Study* are as follows:

- Analyze and describe the existing telecommunications and supporting infrastructure on Tinian. (Although analysis of Pagan is not included in the scope of work, IT/COMM infrastructure on Pagan is briefly addressed in this volume for context.)
- Provide sufficient details to support the CJMT EIS/OEIS and provide planning information including conceptual development plans to support the design of IT/COMM infrastructure on Tinian.

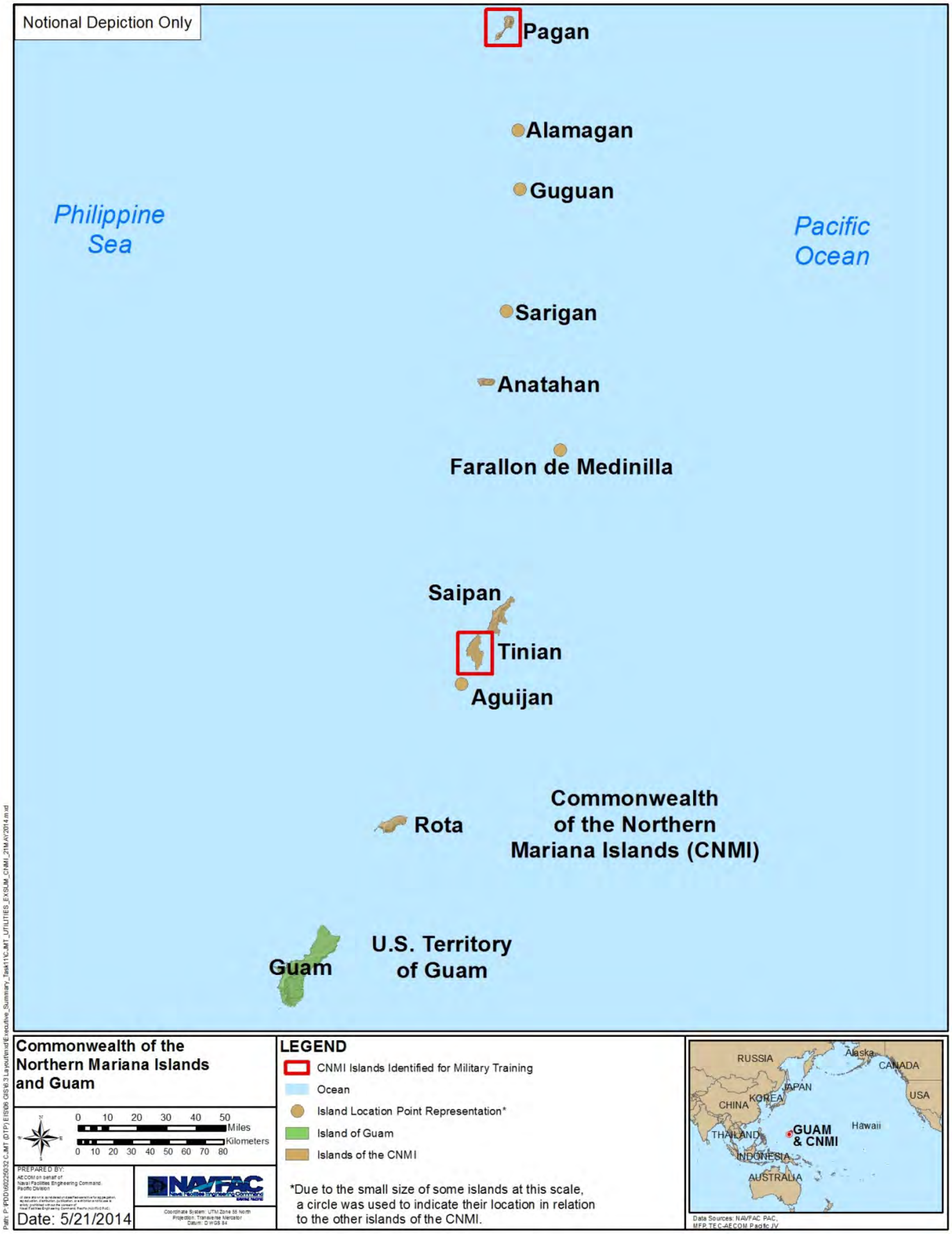

Figure 1.1-1. Commonwealth of the Northern Mariana Islands and Guam
Source: DoN 2014.

Figure 1.1-2. Island of Tinian and the Military Lease Area
Source: DoN 2014.

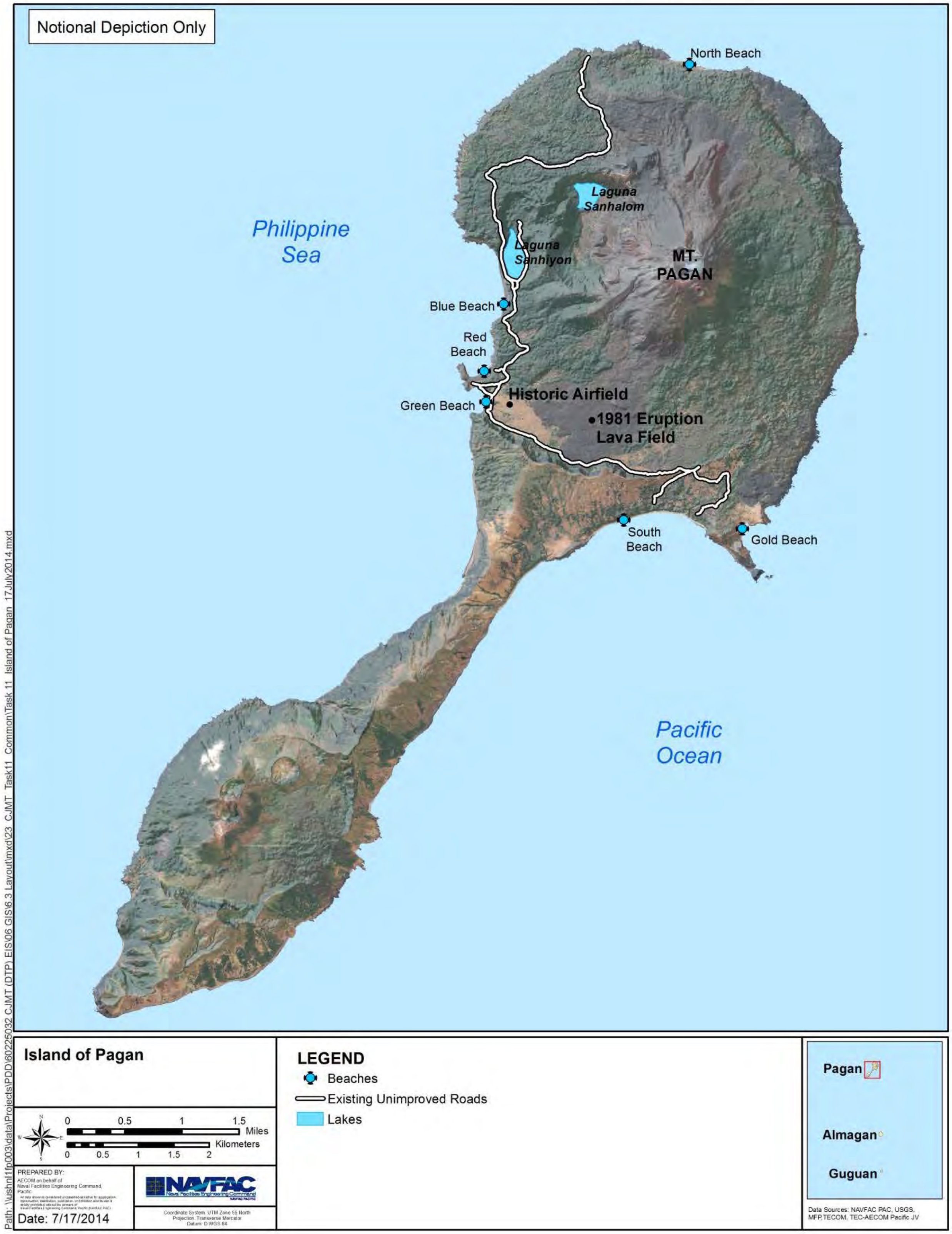

Figure 1.1-3. Island of Pagan
Source: DoN 2014.

The proposed improvements and modifications included in this study support the CJMT requirements on Tinian. The assumptions used for this study are consistent with the *Unconstrained Training Concept* (DoN 2014) and proposed action as defined in the master planning documents available at the time this study was performed. This planning report provides information on the infrastructure needed to support the three proposed alternatives for Tinian. The main areas in the Tinian alternatives include the base camp, the Munitions Storage Area, the port facilities, the ranges and their facilities, and the Tinian International Airport. Use of Tinian International Airport has two scenarios: proposed plan for expeditionary use without any permanent improvements for IT/COMM infrastructure, and potential future end state with permanent facilities being considered in the CJMT EIS/OEIS for cumulative impacts.

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CHAPTER 2.
CURRENT IT/COMM INFRASTRUCTURE

2.1 UNITED STATES MILITARY AND COMMERCIAL IT/COMM INFRASTRUCTURE

Tinian currently does not have any U.S. military IT/COMM infrastructure. Local government agencies use radio frequency communications. Emergency services utilize Land Mobile Radio, and the Port Authority utilizes radio communications in the Very High Frequency spectrum. Commercial IT/COMM services on Tinian are provided by IT&E, including phone, internet, and cellular phone services through overhead distribution and cell phone towers. Marianas Cable Vision Broadband provides cable television (TV) service on Tinian. There is no IT/COMM infrastructure in the Military Lease Area (MLA).

An undersea fiber optic cable links Tinian and other islands in the CNMI to the Trans-Pacific Cable hub on Guam. In addition to the undersea fiber optic cable, a microwave system between Saipan, Tinian, and Rota provides alternative connectivity and provides diverse and redundant capability for IT&E commercial communications to Tinian in the event the undersea fiber optic cable is disabled (IT&E n.d.). The IT&E Cable Landing Facility (CLF) is located on Tinian near Broadway and Canal Street in San Jose. Photo 2.1-1 shows the IT&E CLF. Figure 2.1-1 shows the locations of Guam, Saipan, Tinian, and Rota.

Pagan has no existing U.S. military or commercial IT/COMM services or infrastructure.

Photo 2.1-1. Existing IT&E Cable Landing Facility on Tinian

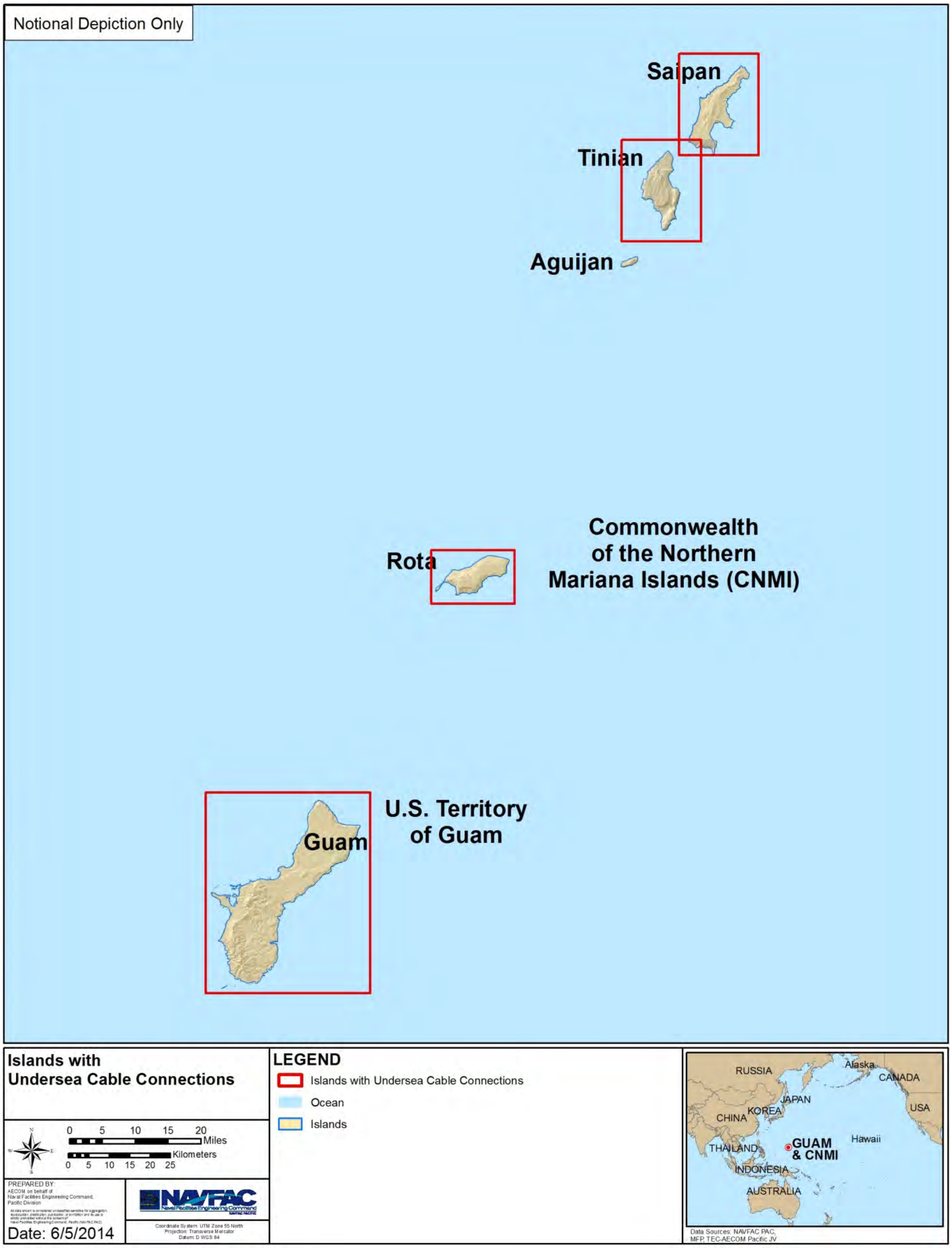

Figure 2.1-1. Islands with Undersea Cable Connections
Source: DoN 2014.

CHAPTER 3. CJMT IT/COMM TECHNICAL REQUIREMENTS

3.1 UNITED STATES MILITARY IT/COMM REQUIREMENTS

Training range communication requirements are provided in the Training Range Communication Requirements Document (TRCRD) developed in support of the CJMT EIS/OEIS by the Marine Corps Forces Pacific with Naval Surface Warfare Center Corona Division (DoN 2013). The proposed alternatives described in the TRCRD were based on the alternatives previously considered, which were somewhat different than the current proposed alternatives. This study adjusts the details of those requirements to the revised alternatives currently being considered. The TRCRD identifies and describes the communication systems, fiber and copper requirements, and backbone architecture required to develop training range capabilities for the Marine Corps. These systems would provide voice, video, and data communications that support the ranges and support facilities proposed for Tinian. The TRCRD describes the following specific operational capabilities required within the Tinian Range and Training Area:

- Public address
- Target control
- Scoring
- Simulation
- Radio
- Video
- Telephone
- Utility monitoring and control system
- Instrumentation tactical engagement simulation system

Instrumentation for range-specific capabilities would be located within the specific ranges. Some of the range-specific capabilities would require links to Range Control in the base camp through a cable connection.

The following supporting capabilities would generally provide administrative and safety functions that are essential to the training mission:

- Radio
- Wide area network
- Mass notification system
- Position location information - Air
- Position location information - Surface
- Integrated range status system
- Radio systems, including the Enterprise Land Mobile Radio system

The TRCRD also describes sample layouts and connection methods for the various ranges. These connection methods include outside plant infrastructure including underground, aerial, and microwave connections. Options are presented using each method or a combination of methods.

Area Distribution Nodes (ADNs) at the base camp and at a high elevation point in the MLA near Mount Lasso would be interconnected and distribute the required voice, video, and data communications to the base camp and individual ranges.

The military requires reliable and redundant telecommunications infrastructure for the ranges and ADN video, voice, and data communications connectivity. In addition to the outside plant infrastructure, radio and microwave communications could be employed to support the requirement for redundancy. Additionally, communications from Tinian would be required to have connections to a Range Control Facility on Guam to manage training on Tinian in the event of a communications failure at the Tinian Range Control Facility. The TRCRD identifies a leased circuit, point-to-point microwave, or satellite communication as possible methods for redundant connections to Guam. A circuit would likely be leased by the Defense Information Systems Agency, and the circuit could be provided through the IT&E CLF in San Jose, Tinian. This circuit would connect from the CLF to the base camp through hardwired cabling infrastructure. Communications, including Enterprise Land Mobile Radio capabilities, could be provided through a microwave connection between Mount Lasso on Tinian and Mount Tapochau on Saipan.

For Pagan, required U.S. military IT/COMM infrastructure would be provided temporarily by the training units via organic tactical assets or Training and Education Command-provided assets such as netted Iridium hand-held devices, including those for the Digital Tactical Communication System. No permanent U.S. military IT/COMM infrastructure would be constructed on Pagan.

3.2 COMMERCIAL IT/COMM TECHNICAL REQUIREMENTS

If required, commercial IT/COMM services including plain old telephone service (POTS) systems, TV, and internet would be delivered to each facility via separate infrastructure to a dedicated IT/COMM closet for commercial (non-government) equipment. All necessary equipment and cabling for commercial telephone, TV, and internet service would be provided by the commercial service providers.

No commercial IT/COMM would be required for Pagan.

3.2.1 Plain Old Telephone Service System

POTS circuits are available from IT&E on Tinian. The commercial telephone system would provide POTS circuits to serve the commercial telephone requirements.

3.2.2 Cable Television

Cable TV is available from Marianas Cable Vision Broadband on Tinian.

3.2.3 Internet

Commercial internet service is available from IT&E on Tinian through digital subscriber line technology.

CHAPTER 4.
RECOMMENDED IT/COMM INFRASTRUCTURE

4.1 CONNECTIVITY AND CONCEPTUAL ROUTINGS

The proposed telecommunications system for each alternative would consist of a combination of overhead pole-mounted cabling and underground conduits, manholes/handholes, and pull-boxes that would provide the site infrastructure to support government communications systems (e.g., government telephone, government data, security, and closed circuit TV), as well as commercial utility services, including commercial telephone, internet, and cable TV. These proposed solutions would include new core backbone fiber and copper connections between the ADNs at the base camp and an ADN near Mount Lasso. New distribution infrastructure originating at the two ADNs would distribute telecommunications services to end-user buildings and facilities in the base camp, ranges, and other facilities. Pedestals would be provided for termination of the cabling at the range entrances to facilitate installation and testing of the connections to the ranges. Proposed core IT/COMM hardwired cable connections through overhead pole-supported cabling and underground concrete-encased duct banks and cabling would connect the ADN at the base camp to the ADN near Mount Lasso and to range entrances. Distribution from the ADN near Mount Lasso would be provided through underground concrete-encased duct banks and cabling for connections to the range entrances. Easements and rights-of-way would be required for above- and underground IT/COMM routes outside the MLA. Commercial telephone, internet, and cable TV services would be provided to the base camp through infrastructure provided by the commercial utility providers. The cables are anticipated to be installed mostly overhead except for routing that crosses the runway clear zone, which would be installed underground if required. Inside the base camp, the cables for commercial telephone, internet, and cable TV service would be distributed around the base camp through overhead pole-supported cabling.

The recommended conceptual IT/COMM distribution plans are shown in Appendix A and include the base camp and the island-wide IT/COMM connection layouts. The plan for the base camp is the same for all three proposed alternatives. Appendix B shows a general overview of the IT/COMM distribution and connectivity between the ADN facilities, the ranges, and the observation points.

For Pagan, temporary bivouac-style U.S. military IT/COMM infrastructure would be provided by the training units.

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CHAPTER 5. POTENTIAL IMPACTS AND ISSUES

5.1 POTENTIAL IMPACTS AND ISSUES

New IT/COMM connectivity and distribution for each area would involve similar work. This work would include vegetation clearance, excavation and trenching for underground conduits and cables, manholes, hand-holes, and pedestals for telecommunications equipment, as well as installation of utility poles. Commercial telephone, TV, and internet services may also include service pedestals or equipment cabinets for commercial telephone and TV service in barracks and tent areas.

New underground duct banks and overhead distribution poles would be installed for each proposed alternative. The conceptual development plans shown in Appendix A for the IT/COMM systems provide notional outside plant cable routing plans and would have the following potential impacts associated with construction and operation of these improvements:

- Below-grade impacts from trenching for the construction of the proposed new IT/COMM concrete-encased conduit.
- Impacts associated with construction activities that consist primarily of vegetation clearance for utility pole and overhead line installations, and trenching for underground duct banks. These impacts would include lane closures and traffic delays as a result of construction along the roadways.
- Impacts on existing commercial telephone, TV, and internet services during construction would be limited to potential short outages that would be necessary to facilitate new connections to the existing systems. The effect of any potential outages would be minimized through planning and coordination with the utility provider during the design and construction stages. There would be one or two outages that would last approximately 2 hours or less each.

Below-grade impacts are quantified by estimating the volume of soil disturbed for the trenching of the proposed IT/COMM duct banks. Estimates of the soil volume disturbed for installation of the IT/COMM duct banks for the alternatives are shown in Table 5.1-1.

Table 5.1-1. Estimated Volume of Soil Disturbed during IT/COMM Trenching

Alternative	*Site Location*	*Volume of Disturbance (cubic yards [cubic meters])*
All Alternatives	MSA	0 [0]
All Alternatives	Base Camp	10005 [7649]
All Alternatives	(final build-out)	0 [0]
Alternative No. 1	Ranges and Range Facilities	15735 [12030]
Alternative No. 2	Ranges and Range Facilities	15735 [12030]
Alternative No. 3	Ranges and Range Facilities	15735 [12030]

Legend: MSA = Munitions Storage Area; No. = number.
Source: DoN 2014.

The potential for electromagnetic interference exists. According to the TRCRD (DoN 2013):

> Potential radio frequency interference/electromagnetic interference (RFI/EMI) during the installation process is expected to be minimal and may be generated by: handheld radios used to communicate during construction, power generators, tools, and heavy machinery required to complete the install. Testing of radio communications during the installation process also may produce RFI/EMI from the antennas under test. The frequencies being used include the ISM band for radios and the VHF/UHF/L-band/Ku band frequencies that the training equipment will operate.

Additionally, in response to the Marine Corps' request to conduct an EMI analysis, the Joint Spectrum Center produced the *Electromagnetic Interference Analysis* report included as Appendix C. The EMI analysis report analyzes the potential for EMI between existing and planned communications-electronics systems on Tinian and Pagan. The analysis indicates that there is the potential for EMI between the proposed Marine Corps facilities and other military, non-military, and civil wireless frequency assignments on Tinian and Pagan from the frequency resource record system. The report provides data including frequency-distance plots to be used by the Marine Corps as a guideline in performing the actions recommended in the EMI analysis report to minimize EMI in the final training and range design. The recommended actions include avoiding the use of frequencies on the affected systems that are close to the assigned frequencies of other systems in the electromagnetic environment, and maintaining minimum separation distances from the other systems that comply with the frequency-distance plots. A recommendation is also made for the Marine Corps frequency manager to contact local frequency managers for frequency coordination. Coordination of operating frequencies and operating schedules between the Marine Corps and other system operators in the electromagnetic environment on Tinian and Pagan may reduce the potential for EMI.

CHAPTER 6. REFERENCES

Defense Information Systems Agency. 2014. *Electromagnetic Interference Analysis.* Consulting Report – Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement. DSO-CR-12-011. Joint Spectrum Center, Annapolis, MD. April 11, 2014.

DoN. 2013. *Commonwealth of the Northern Mariana Islands Training Range Communication Requirements Document* (TRCRD). Naval Facilities Engineering Command (NAVFAC), NSWC-CORDIV-RS10-TR-20120607-001. June.

DoN. 2014. *Draft V1, Commonwealth of the Northern Mariana Islands Joint Military Training, Unconstrained Training Concept for Tinian and Pagan.* April.

IT&E. n.d. “About IT&E.” *IT&E*. Available at http://www.ite.net/about_us.cfm. Accessed January 29, 2014.

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Appendix A
IT/COMM Conceptual Development Plans

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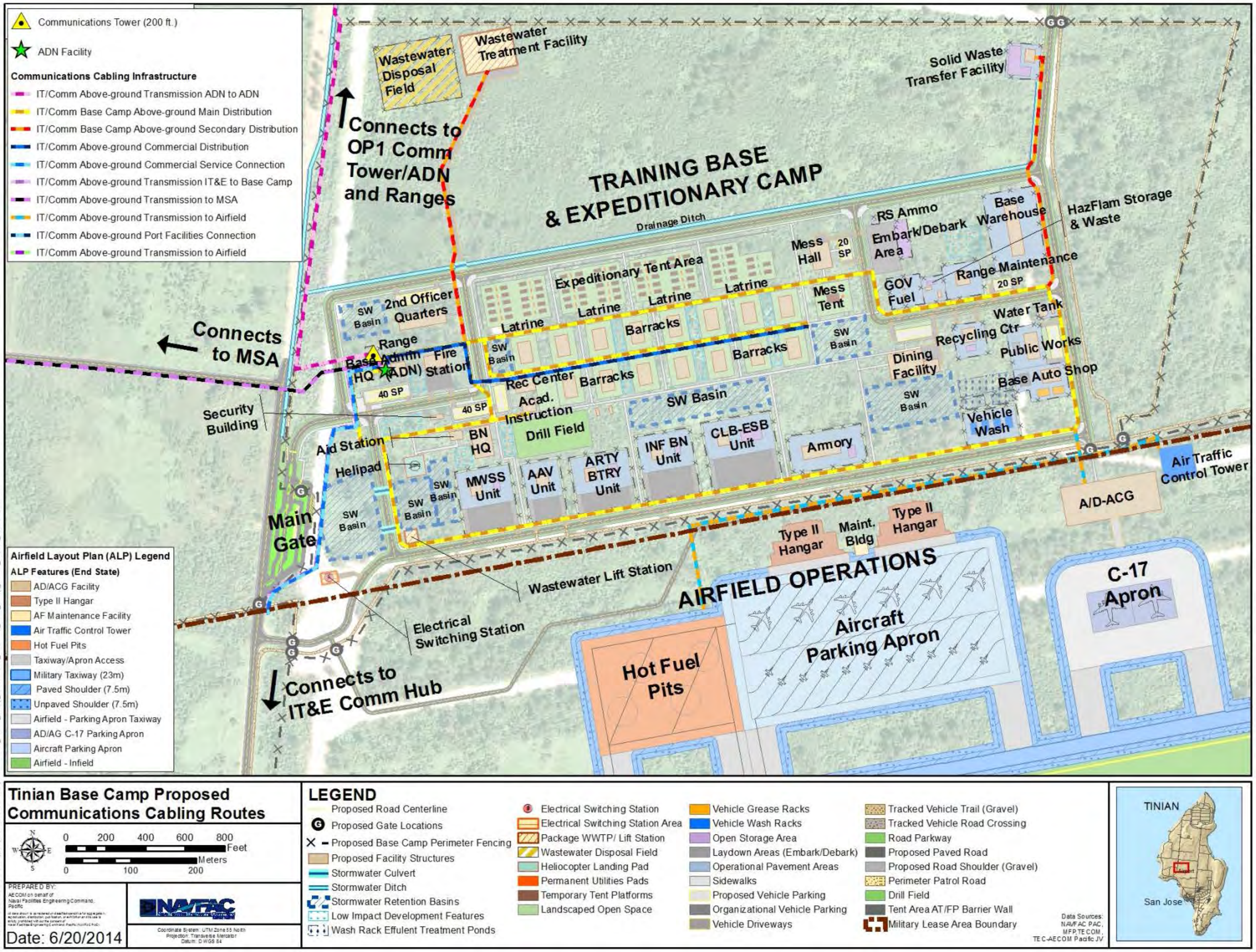
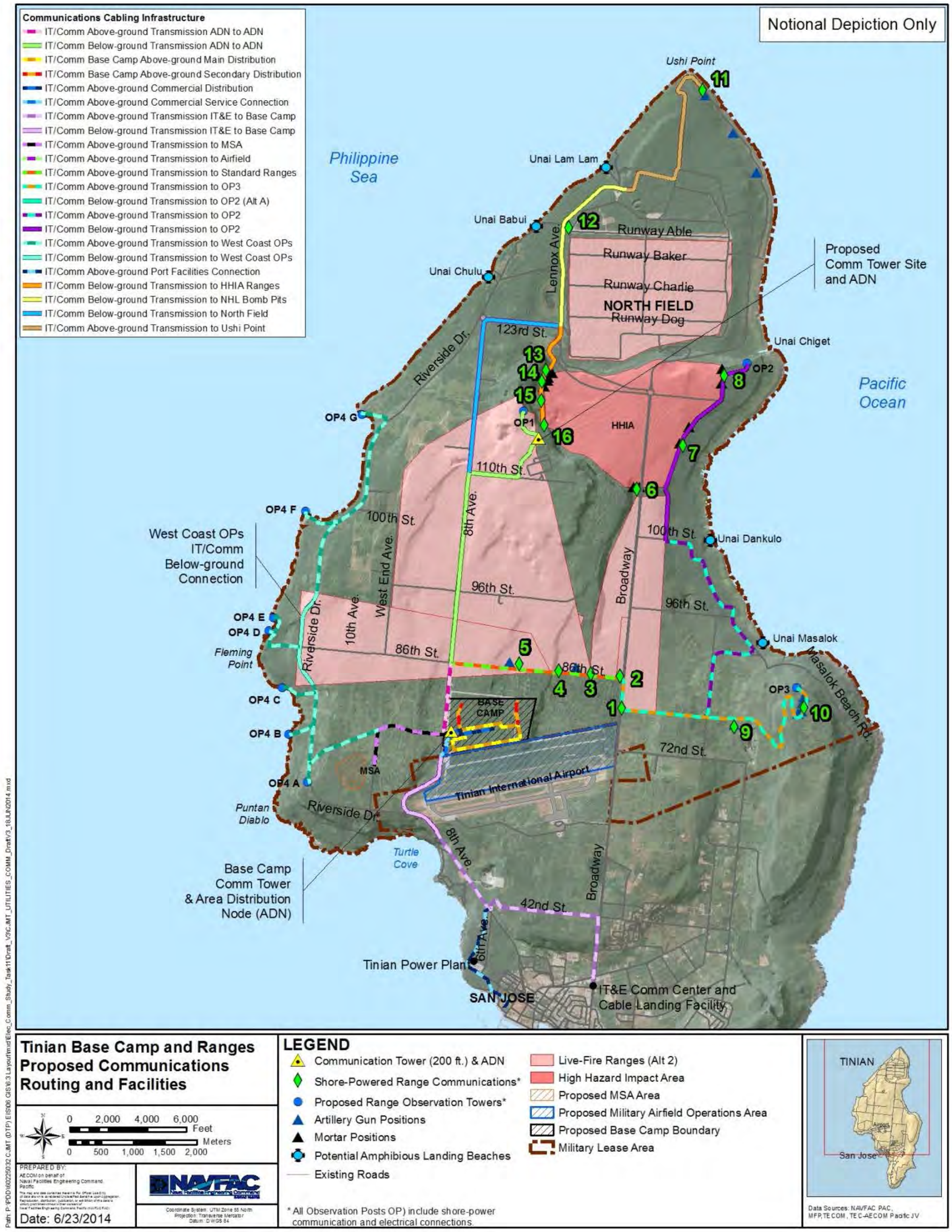

Tinian Base Camp Proposed Communications Cabling Routes
Date: 6/20/2014
Communications Tower (200 ft.)
ADN Facility
Communications Cabling Infrastructure
IT/Comm Above-ground Transmission ADN to ADN
IT/Comm Base Camp Above-ground Main Distribution
IT/Comm Base Camp Above-ground Secondary Distribution
IT/Comm Above-ground Commercial Distribution
IT/Comm Above-ground Commercial Service Connection
IT/Comm Above-ground Transmission IT&E to Base Camp
IT/Comm Above-ground Transmission to MSA
IT/Comm Above-ground Transmission to Airfield
IT/Comm Above-ground Port Facilities Connection
IT/Comm Above-ground Transmission to Airfield
Connects to OP1 Comm Tower/ADN and Ranges
Connects to MSA
Connects to IT&E Comm Hub
TRAINING BASE & EXPEDITIONARY CAMP
AIRFIELD OPERATIONS
Wastewater Disposal Field
Wastewater Treatment Facility
Solid Waste Transfer Facility
Drainage Ditch
Expeditionary Tent Area
Mess Hall
20 SP
RS Ammo
Embark/Debark Area
Base Warehouse
HazFlam Storage & Waste
GOV Fuel
Range Maintenance
Mess Tent
Water Tank
Recycling Ctr
Public Works
Dining Facility
Base Auto Shop
Vehicle Wash
2nd Officer Quarters
Range Base Admin HQ
(ADN)
Fire Station
40 SP
Latrine
Barracks
Rec Center
Acad. Instruction
SW Basin
Security Building
Aid Station
BN HQ
Drill Field
Helipad
MWSS Unit
AAV Unit
ARTY BTRY Unit
INF BN Unit
CLB-ESB Unit
Armory
Air Traffic Control Tower
A/D-ACG
Main Gate
Wastewater Lift Station
Electrical Switching Station
Type II Hangar
Maint. Bldg
C-17 Apron
Aircraft Parking Apron
Hot Fuel Pits
Airfield Layout Plan (ALP) Legend
ALP Features (End State)
AD/ACG Facility
Type II Hangar
AF Maintenance Facility
Air Traffic Control Tower
Hot Fuel Pits
Taxiway/Apron Access
Military Taxiway (23m)
Paved Shoulder (7.5m)
Unpaved Shoulder (7.5m)
Airfield - Parking Apron Taxiway
AD/AG C-17 Parking Apron
Aircraft Parking Apron
Airfield - Infield
LEGEND
Proposed Road Centerline
Proposed Gate Locations
Proposed Base Camp Perimeter Fencing
Proposed Facility Structures
Stormwater Culvert
Stormwater Ditch
Stormwater Retention Basins
Low Impact Development Features
Wash Rack Effluent Treatment Ponds
Electrical Switching Station
Electrical Switching Station Area
Package WWTP/ Lift Station
Wastewater Disposal Field
Heliocopter Landing Pad
Permanent Utilities Pads
Temporary Tent Platforms
Landscaped Open Space
Vehicle Grease Racks
Vehicle Wash Racks
Open Storage Area
Laydown Areas (Embark/Debark)
Operational Pavement Areas
Sidewalks
Proposed Vehicle Parking
Organizational Vehicle Parking
Vehicle Driveways
Tracked Vehicle Trail (Gravel)
Tracked Vehicle Road Crossing
Road Parkway
Proposed Paved Road
Proposed Road Shoulder (Gravel)
Perimeter Patrol Road
Drill Field
Tent Area AT/FP Barrier Wall
Military Lease Area Boundary
0 200 400 600 800 Feet
0 100 200 Meters
TINIAN
San Jose
Data Sources: NAVFAC PAC, MFP TECOM, TEC-AECOM Pacific JV
NAVFAC


Communications Cabling Infrastructure
IT/Comm Above-ground Transmission ADN to ADN
IT/Comm Below-ground Transmission ADN to ADN
IT/Comm Base Camp Above-ground Main Distribution
IT/Comm Base Camp Above-ground Secondary Distribution
IT/Comm Above-ground Commercial Distribution
IT/Comm Above-ground Commercial Service Connection
IT/Comm Above-ground Transmission IT&E to Base Camp
IT/Comm Below-ground Transmission IT&E to Base Camp
IT/Comm Above-ground Transmission to MSA
IT/Comm Above-ground Transmission to Airfield
IT/Comm Above-ground Transmission to Standard Ranges
IT/Comm Above-ground Transmission to OP3
IT/Comm Below-ground Transmission to OP2 (Alt A)
IT/Comm Above-ground Transmission to OP2
IT/Comm Below-ground Transmission to OP2
IT/Comm Above-ground Transmission to West Coast OPs
IT/Comm Below-ground Transmission to West Coast OPs
IT/Comm Above-ground Port Facilities Connection
IT/Comm Below-ground Transmission to HHIA Ranges
IT/Comm Below-ground Transmission to NHL Bomb Pits
IT/Comm Below-ground Transmission to North Field
IT/Comm Above-ground Transmission to Ushi Point
Notional Depiction Only
Ushi Point
Philippine Sea
Unai Lam Lam
Unai Babui
Unai Chulu
Lennox Ave.
Runway Able
Runway Baker
Runway Charlie
NORTH FIELD
Runway Dog
Proposed Comm Tower Site and ADN
Unai Chiget
OP2
Pacific Ocean
123rd St.
Riverside Dr.
OP4 G
OP1
HHIA
110th St.
OP4 F
100th St.
8th Ave.
West End Ave.
Unai Dankulo
West Coast OPs IT/Comm Below-ground Connection
96th St.
Broadway
OP4 E
OP4 D
10th Ave.
Fleming Point
86th St.
Unai Masalok
Masalok Beach Rd.
OP4 C
BASE CAMP
OP3
OP4 B
72nd St.
MSA
OP4 A
Tinian International Airport
Puntan Diablo
Riverside Dr.
Turtle Cove
Base Camp Comm Tower & Area Distribution Node (ADN)
42nd St.
Tinian Power Plant
8th Ave.
SAN JOSE
IT&E Comm Center and Cable Landing Facility
Tinian Base Camp and Ranges Proposed Communications Routing and Facilities
0 2,000 4,000 6,000 Feet
0 500 1,000 1,500 2,000 Meters
PREPARED BY:
Date: 6/23/2014
NAVFAC
LEGEND
Communication Tower (200 ft.) & ADN
Shore-Powered Range Communications*
Proposed Range Observation Towers*
Artillery Gun Positions
Mortar Positions
Potential Amphibious Landing Beaches
Existing Roads
Live-Fire Ranges (Alt 2)
High Hazard Impact Area
Proposed MSA Area
Proposed Military Airfield Operations Area
Proposed Base Camp Boundary
Military Lease Area
* All Observation Posts OP) include shore-power communication and electrical connections.
TINIAN
San Jose
Data Sources: NAVFAC PAC, MFP, TEC OM, TEC-AECOM Pacific JV

Appendix B
IT/COMM Connection Diagrams

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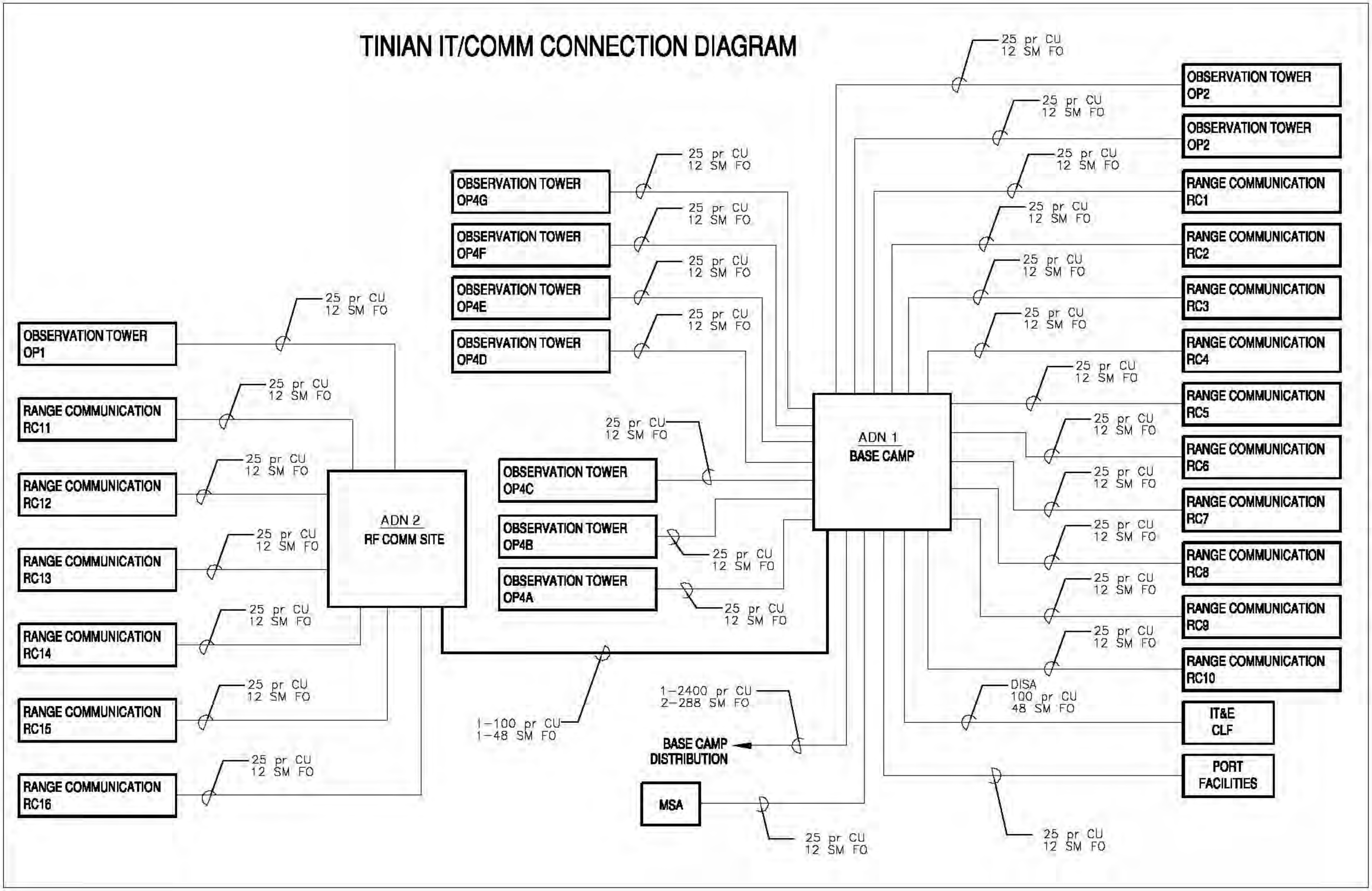
TINIAN IT/COMM CONNECTION DIAGRAM
OBSERVATION TOWER OP1
RANGE COMMUNICATION RC11
RANGE COMMUNICATION RC12
RANGE COMMUNICATION RC13
RANGE COMMUNICATION RC14
RANGE COMMUNICATION RC15
RANGE COMMUNICATION RC16
ADN 2 RF COMM SITE
OBSERVATION TOWER OP4G
OBSERVATION TOWER OP4F
OBSERVATION TOWER OP4E
OBSERVATION TOWER OP4D
OBSERVATION TOWER OP4C
OBSERVATION TOWER OP4B
OBSERVATION TOWER OP4A
ADN 1 BASE CAMP
OBSERVATION TOWER OP2
OBSERVATION TOWER OP2
RANGE COMMUNICATION RC1
RANGE COMMUNICATION RC2
RANGE COMMUNICATION RC3
RANGE COMMUNICATION RC4
RANGE COMMUNICATION RC5
RANGE COMMUNICATION RC6
RANGE COMMUNICATION RC7
RANGE COMMUNICATION RC8
RANGE COMMUNICATION RC9
RANGE COMMUNICATION RC10
IT&E CLF
PORT FACILITIES
MSA
BASE CAMP DISTRIBUTION
25 pr CU 12 SM FO
1–100 pr CU 1–48 SM FO
1–2400 pr CU 2–288 SM FO
DISA 100 pr CU 48 SM FO

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Appendix C
Defense Information Systems Agency Consulting Report – Electromagnetic Interference Analysis

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Defense Information Systems Agency

Defense Spectrum Organization

Joint Spectrum Center

Annapolis, Maryland 21402

Consulting Report

Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement Electromagnetic Interference Analysis

DSO-CR-14-011

11 April 2014

Prepared for:

Marine Corps Forces, Pacific
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APR 17 2014

IN REPLY REFER TO: Joint Spectrum Center (J8)

JSC/OS48-14/067

MEMORANDUM FOR DISTRIBUTION

SUBJECT: Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement Electromagnetic Interference Analysis (DSO-CR-14-011)

Reference: Task Order TO-0787 (T3614)

1. Enclosed, in accordance with Reference (a), is the Consulting Report (DSO-CR-14-011) Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement Electromagnetic Interference Analysis. The CR details the electromagnetic interference analysis and frequency-distance curves generated to assist the Marine Corps in the planning of the training range on the islands of Tinian and Pagan. This study was conducted by the Joint Spectrum Center in support of the Marine Corps Forces, Pacific.

2. The JSC point of contact is Mr. Robert Channas at (410) 293-2516 or DSN 281-2516.

Dennis R. Love
Acting Chief, Applied Engineering Branch
Joint Spectrum Center

1 Enclosure:
DSO-CR-14-011

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This report is approved for publication.

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14. ABSTRACT

The United States Marine Corps (USMC) is planning to develop a training area and range in the Commonwealth of the Northern Mariana Islands (CNMI) on either Tinian or Pagan. Equipment layouts have been developed for five possible locations (three for Tinian and two for Pagan). As part of this development, the USMC is preparing the CNMI Joint Military Training (CJMT) Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS). In support of the CJMT EIS/OEIS, the USMC has requested that the Joint Spectrum Center conduct an electromagnetic interference analysis and generate frequency-distance plots for range and training areas on Tinian and Pagan.

15. SUBJECT TERMS

Commonwealth of the Northern Mariana Islands, CNMI, CNMI Joint Military Training, CJMT, Electromagnetic Interference, EMI, Environmental Impact Statement, EIS, Frequency-Distance, F-D, Overseas Environmental Impact Statement, OEIS, United States Marine Corps, USMC

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EXECUTIVE SUMMARY

The United States Marine Corps (USMC) is planning to develop a training area and range in the Commonwealth of the Northern Mariana Islands (CNMI) on either Tinian or Pagan. Equipment layouts have been developed for five possible locations (three for Tinian and two for Pagan). As part of this development, the USMC is preparing the CNMI Joint Military Training (CJMT) Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS). In support of the CJMT EIS/OEIS, the USMC requested that the Joint Spectrum Center (JSC) conduct an Electromagnetic Interference (EMI) analysis and generate Frequency-Distance (F-D) plots for range and training areas on Tinian and Pagan to minimize the potential impact from EMI.

Systems in the Electromagnetic Environment (EME) were identified by retrieving all of the federal military, federal nonmilitary, and civil frequency assignments on Tinian and Pagan from the Frequency Resource Record System, the Government Master File, the Federal Communications Commission, and the International Telecommunication Union databases available at the JSC. Interactions between USMC and EME communications-electronics systems were then analyzed.

Systems in the EME were analyzed by calculating the Required Frequency Separation (RFS) at 1 km between each USMC and EME system to achieve an interference-to-noise ratio of -6 dB or less. A distance of 1 km was assumed to be the closest approach between a USMC and EME system. A conservative guardband of 50 MHz was added to each calculated result. System interactions with RFSs, including the guardband, that were less than the frequency band separation between USMC and EME systems were considered not to have the potential for EMI and were culled. System interactions with RFSs, including the guardband, that were greater than the frequency band separation were identified as having the potential for EMI. System interactions that have no frequency band separation, i.e., frequencies overlap, were considered to have the potential for EMI.

USMC/EME system pairs that were not culled were tabulated and F-D plots were generated to assist in the mitigation of EMI.

The results indicate that there are USMC/EME system pairs that have the potential for EMI. It is recommended that the F-D plots contained herein be used to establish frequency/distance separations to reduce the potential for EMI. It is also recommended that the USMC frequency manager contact local frequency managers for frequency coordination.

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1. INTRODUCTION

1.1 BACKGROUND

The United States Marine Corps (USMC) is planning to develop a training area and range in the Commonwealth of the Northern Mariana Islands (CNMI) on either Tinian or Pagan. Equipment layouts have been developed for five possible locations (three for Tinian and two for Pagan). As part of this development, the USMC is preparing the CNMI Joint Military Training (CJMT) Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS). In support of the CJMT EIS/OEIS, the USMC requested that the Joint Spectrum Center (JSC) conduct an Electromagnetic Interference (EMI) analysis and generate Frequency-Distance (F-D) plots for range and training areas on Tinian and Pagan to minimize the potential impact from EMI.

1.2 OBJECTIVE

The objective of this task was to analyze the potential for EMI between existing and planned communications-electronics systems on Tinian and Pagan, and for cases where EMI is predicted, generate F-D plots that will aid the USMC in the final training and range design to minimize the potential impact from EMI.

1.3 APPROACH

The technical parameters of the USMC systems were extracted from the latest available J/F 12 Application for Equipment Frequency Allocation, Defense Department (DD) Form 1494s. If a DD Form 1494 was not available, data was extracted from the JSC Joint Equipment, Tactical, and Space (JETS) database or was provided by the USMC.

Systems in the Electromagnetic Environment (EME) were identified by retrieving all of the federal military, federal nonmilitary, and civil frequency assignments on Tinian and Pagan from the Frequency Resource Record System (FRRS), the Government Master File (GMF), the Federal Communications Commission (FCC), and the International Telecommunication Union (ITU) databases available at the JSC.

Systems in the EME were analyzed by calculating the Required Frequency Separation (RFS) at 1 km between each USMC and EME system to achieve an Interference-to-Noise ratio (I/N) of -6 dB or less. An I/N of -6 dB corresponds to a 1 dB increase in the receiver noise level, which is the degradation limit for Department of Defense radio receiver equipment per the *Communications Receiver Performance Degradation Handbook* [1]. A distance of 1 km was assumed to be the closest approach between a USMC and EME system. A conservative guardband of 50 MHz was added to each calculated result. System interactions with RFSs, including the guardband, that were less than the frequency band separation between USMC and EME systems were considered not to have the potential for EMI and were culled. System interactions with RFSs, including the guardband, that were greater than the frequency band separation were identified as having the potential for EMI. System interactions that have no frequency band separation, i.e., frequencies overlap, were considered to have the potential for EMI.

USMC/EME system pairs that were not culled were tabulated and F-D plots were generated to assist in the mitigation of EMI.

2. TECHNICAL SYSTEM DESCRIPTIONS

This section contains the technical parameters of the USMC and EME systems. The technical parameters of the USMC systems are summarized in Section 2.1. The technical parameters of the EME systems are summarized in Section 2.2.

2.1 USMC SYSTEMS TECHNICAL PARAMETERS

Basic technical parameters of the USMC systems are listed in Table 2-1.

Table 2-1. Basic Technical Parameters of USMC Systems

Nomenclature	J/F 12 Number	Frequency (MHz)	Transmitter Power (dBm)	Antenna Gain (dBi)
AN/MRC-145A[a]	4967	30 – 87.975	46.99	1.05
AN/MRC-145B[a]	4967	30 – 87.975	46.99	1.05
AN/MRC-148	7985	1.6 – 60	51.76	6.00
AN/PRC-117F	7852	30 – 512	43.01	2.15
AN/PRC-117G	9512	30 – 2000	46.99	3.00
AN/PRC-119F	4967	30 – 87.975	36.99	1.05
AN/PRC-150	7985	1.6 – 60	43.01	6.00
AN/PRC-152	6013	30 – 512	36.99	1.00
AN/PRC-153	[b]	380 – 470	36.99	2.50
AN/VRC-92D	[b]	30 – 87.975	46.99	-1.10
AN/VRC-103	8188	30 – 512	46.99	2.50
AN/VRC-104	[b]	1.6 – 60	51.76	2.10
AN/VRC-110	9317	30 – 512	46.99	-1.10
AN/VRC-112	[b]	30 – 512	46.99	-1.10
BFT	[b]	1610 – 1660 1525 – 1559	38.45	1.00[c]
BFT Base Station	[b]	1610 – 1660 1525 – 1559	38.45	1.00[c]
Raven RQ-11B DDL	9670	1350, 1800	36.02	2.00
SWAN	[b]	14,000 – 14,500	10.00	43.20

[a] The AN/MRC-145A and AN/MRC-145B use identical system components and will subsequently be referred to as AN/MRC-145.
[b] Technical parameters were obtained from the JETS database or provided by the USMC. A J/F 12 number was not given.
[c] No antenna data was given. 1.00 dBi was assumed as the nominal gain of an omnidirectional antenna.
BFT – Blue Force Tracking
DDL – Digital Data Link
SWAN – Support Wide Area Network

The detailed and calculated technical parameters of the USMC systems used in the analysis are listed in Table 2-2. Composite selectivity curves were calculated using the Radio Frequency (RF) selectivity data available in the DD Form 1494s. If no RF selectivity data was available, the -20 dB emission bandwidth was used. All other system parameters were extracted from respective system DD Form 1494s.

Table 2-2. Detailed Technical Parameters of USMC Systems

Nomenclature	Emission Bandwidth (kHz)			Composite Selectivity (kHz)			Noise Figure (dB)	Antenna Beamwidth (deg)
	-3 dB	-20 dB	-60 dB	-3 dB	-20 dB	-60 dB		
AN/MRC-145	16	20	70	15	26	38	N/A	360°H/60°V
AN/MRC-148	17.5	21.3	66.3	17	21	28	15.00	360°H/75°V
AN/PRC-117F	17.4	22	114	40	70	145	4.00	360°H/80°V
AN/PRC-117G	4000	5400	45,000	7200	19,170	28,000	8.50	360°H/80°V
AN/PRC-119F	16	20	70	15	26	38	N/A	360°H/60°V
AN/PRC-150	17.5	21.3	66.3	17	21	28	15.00	360°H/75°V
AN/PRC-152	20	48	160	15	51	105	9.5	360°H/75°V
AN/PRC-153	N/A	20	N/A	N/A	20	N/A	N/A	N/A
AN/VRC-92D	16	20	70	15	26	38	N/A	360°H/60°V
AN/VRC-103	18.6	25	125	30	65	130	5.00	360°H/75°V
AN/VRC-104	17.5	21.3	66.3	17	21	28	15.00	360°H/75°V
AN/VRC-110	20	48	160	15	51	105	9.5	360°H/75°V
AN/VRC-112	20	48	160	15	51	105	9.5	360°H/75°V
BFT	N/A							
BFT Base Station	N/A							
Raven RQ-11B DDL	800	2100	4500	4800	6800	7800	4.5	360°H/78°V
SWAN	N/A							1.15°*

* -3 dB beamwidth
N/A – Not Available
H – Horizontal
V – Vertical

2.2 EME SYSTEMS TECHNICAL PARAMETERS

This section lists the technical parameters for the EME systems on Tinian and Pagan. Technical parameters for the EME systems were extracted from the FRRS, GMF, FCC, and ITU databases at the JSC. The technical parameters of the EME systems located on Tinian are listed in Table 2-3. The technical parameters of the EME systems located on Pagan are listed in Table 2-4.

Table 2-3. Tinian EME Systems Technical Parameters

Agency Serial Number	Frequency (MHz)	Station Class	Transmitter Power (dBm)	Transmitter Bandwidth (kHz)	Receiver Bandwidth (kHz)	Antenna Gain (dBi)
DHS 096606	164.44 – 172.7625	Mobile	40.42	11	11	3.00
FAA 061031	118.4	Aeronautical	46.99	6	20	0.00
FAA 061032	290.5	Aeronautical	46.99	6	20	0.00
FCC 3FBBFE	154.04 – 155.75	Mobile	45.44	20	20	1.05
FCC 18C26D	158.14 – 159.91	Mobile	45.44	20	20	1.05
FCC 42A238	461.25 – 467.52	Mobile	46.98	20	20	6.40
FCC 185AA3	150.84 – 152.90	Mobile	48.75	20	20	4.25
FCC 18340D	857.43 – 861.936	Mobile	41.76	20	20	2.40
NG 943370	3.99 – 13.81	Aeronautical	51.76	2.8	2.8	0.00
DHS – Department of Homeland Security FAA – Federal Aviation Administration NG – Non-Government						

Table 2-4. Pagan EME Systems Technical Parameters

Agency Serial Number	Frequency (MHz)	Station Class	Transmitter Power (dBm)	Transmitter Bandwidth (kHz)	Receiver Bandwidth (kHz)	Antenna Gain (dBi)
I 104160	3.18 – 25.11	Mobile	60.00	2.8	2.8	12.00
I 104161	3.18 – 25.11	Mobile	51.76	2.8	2.8	12.00
I – Department of the Interior						

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3. ANALYSIS METHODOLOGY

This section describes the procedures, calculations, and equations pertaining to the analysis.

The EMEs on Tinian and Pagan were defined by identifying all known terrestrial frequency assignments in the 1 MHz – 100 GHz frequency band. There were no classified frequency assignments in the EMEs. The numbers of RF systems and frequency assignments in the EMEs are listed in Table 3-1.

Table 3-1. Numbers of RF Systems and Frequency Assignments in the EMEs

Location	Number of RF Systems	Number of Frequency Assignments
Tinian	9	149
Pagan	2	29

An RF system may have multiple frequency assignments; hence, the number of frequency assignments in the EMEs can be greater than the number of RF systems.

Systems in the EMEs were analyzed by calculating the RFS at 1 km between each USMC and EME system to achieve an I/N of -6 dB or less. The RFSs were calculated using the Frequency Dependent Rejection Calculation engineering tool as described in the *FDR User's Manual* [2]. A distance of 1 km was assumed to be the closest approach between a USMC and EME system. A conservative guardband of 50 MHz was added to each calculated result. USMC/EME system pairs that satisfy Equation 3-1 were considered not to have the potential for EMI.

$$RFS + 50 < f_s \qquad (3\text{-}1)$$

where

RFS = Required Frequency Separation between a USMC/EME system pair, in MHz

f_s = frequency band separation between a USMC/EME system pair, in MHz

The frequency band separation between a USMC and EME system can be determined by Equation 3-2.

$$f_s = B_{min} - A_{max} \qquad (3\text{-}2)$$

where

B_{min} = minimum frequency of the higher frequency band, in MHz

A_{max} = maximum frequency of the lower frequency band, in MHz

and other terms as previously defined.

System interactions with RFSs, including the guardband, that were less than the frequency band separation were considered not to have the potential for EMI and were culled.

System interactions with RFSs, including the guardband, that were greater than the frequency band separation were identified as having the potential for EMI. USMC/EME system pairs with a $f_s \leq 0$ were assumed to have overlapping frequency bands and thus have the potential for EMI.

3.1 FREQUENCY-DISTANCE PLOTS

F-D plots were generated for USMC/EME system pairs that were not culled. The F-D plots were generated to determine a range of frequencies and distances that achieve an I/N of -6 dB between USMC/EME system pairs using the JSC Spherical Earth Model as described in the *TIREM/SEM Handbook* [3].

An additional parameter, antenna height, was factored into generating the F-D plots, and the estimated height values are listed in Table 3-2. When applicable, different antenna heights were assumed for EME systems according to their station class.

Table 3-2. Estimated Transmitter and Receiver Antenna Heights

System	Estimated Antenna Height (m)
USMC	10
EME Aeronautical	100
EME Mobile	3

4. RESULTS

This section summarizes the EMI analysis results of the interactions between the USMC and EME systems. The analysis results are given in Sections 4.1 through 4.17. The RFSs at 1 km listed for each system interaction, if applicable, do not include the 50 MHz guardband. The F-D plots for these interactions are included in Appendix A for EME systems on Tinian and in Appendix B for EME systems on Pagan.

4.1 AN/MRC-145

The calculated minimum RFSs at 1 km for the AN/MRC-145 are listed in Table 4-1.

Table 4-1. Minimum RFSs for the AN/MRC-145

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	DHS 096606	No EMI Predicted	No EMI Predicted
	FAA 061031	No EMI Predicted	No EMI Predicted
	FAA 061032	No EMI Predicted	No EMI Predicted
	FCC 3FBBFE	No EMI Predicted	No EMI Predicted
	FCC 18C26D	No EMI Predicted	No EMI Predicted
	FCC 42A238	No EMI Predicted	No EMI Predicted
	FCC 185AA3	No EMI Predicted	No EMI Predicted
	FCC 18340D	No EMI Predicted	No EMI Predicted
	NG 943370	No EMI Predicted	No EMI Predicted
Pagan	I 104160	0.60	4.58
	I 104161	0.31	4.20

4.2 AN/MRC-148

The calculated minimum RFSs at 1 km for the AN/MRC-148 are listed in Table 4-2.

Table 4-2. Minimum RFSs for the AN/MRC-148

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	DHS 096606	No EMI Predicted	No EMI Predicted
	FAA 061031	No EMI Predicted	No EMI Predicted
	FAA 061032	No EMI Predicted	No EMI Predicted
	FCC 3FBBFE	No EMI Predicted	No EMI Predicted
	FCC 18C26D	No EMI Predicted	No EMI Predicted
	FCC 42A238	No EMI Predicted	No EMI Predicted
	FCC 185AA3	No EMI Predicted	No EMI Predicted
	FCC 18340D	No EMI Predicted	No EMI Predicted
	NG 943370	0.96	2.87
Pagan	I 104160	1.73	5.39
	I 104161	0.79	4.30

4.3 AN/PRC-117F

The calculated minimum RFSs at 1 km for the AN/PRC-117F are listed in Table 4-3.

Table 4-3. Minimum RFSs for the AN/PRC-117F

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	DHS 096606	0.81	2.98
	FAA 061031	4.26	2.15
	FAA 061032	3.57	2.12
	FCC 3FBBFE	3.88	1.71
	FCC 18C26D	1.76	2.35
	FCC 42A238	1.01	0.98
	FCC 185AA3	2.27	1.74

Table 4-3. Minimum RFSs for the AN/PRC-117F (Continued)

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	FCC 18340D	No EMI Predicted	No EMI Predicted
	NG 943370	No EMI Predicted	No EMI Predicted
Pagan	I 104160	2.72	7.86
	I 104161	2.46	6.70

4.4 AN/PRC-117G

The calculated minimum RFSs at 1 km for the AN/PRC-117G are listed in Table 4-4.

Table 4-4. Minimum RFSs for the AN/PRC-117G

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	DHS 096606	45.23	37.55
	FAA 061031	41.69	38.07
	FAA 061032	39.46	36.33
	FCC 3FBBFE	43.51	48.86
	FCC 18C26D	44.23	39.13
	FCC 42A238	40.44	25.64
	FCC 185AA3	42.57	35.38
	FCC 18340D	36.19	24.06
	NG 943370	55.42	32.78
Pagan	I 104160	29.50	109.68
	I 104161	27.77	76.62

4.5 AN/PRC-119F

The calculated minimum RFSs at 1 km for the AN/PRC-119F are listed in Table 4-5.

Table 4-5. Minimum RFSs for the AN/PRC-119F

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	DHS 096606	No EMI Predicted	No EMI Predicted
	FAA 061031	No EMI Predicted	No EMI Predicted
	FAA 061032	No EMI Predicted	No EMI Predicted
	FCC 3FBBFE	No EMI Predicted	No EMI Predicted
	FCC 18C26D	No EMI Predicted	No EMI Predicted
	FCC 42A238	No EMI Predicted	No EMI Predicted
	FCC 185AA3	No EMI Predicted	No EMI Predicted
	FCC 18340D	No EMI Predicted	No EMI Predicted
	NG 943370	No EMI Predicted	No EMI Predicted
Pegan	I 104160	1.74	6.65
	I 104161	1.46	3.50

4.6 AN/PRC-150

The calculated minimum RFSs at 1 km for the AN/PRC-150 are listed in Table 4-6.

Table 4-6. Minimum RFSs for the AN/PRC-150

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	DHS 096606	No EMI Predicted	No EMI Predicted
	FAA 061031	No EMI Predicted	No EMI Predicted
	FAA 061032	No EMI Predicted	No EMI Predicted
	FCC 3FBBFE	No EMI Predicted	No EMI Predicted
	FCC 18C26D	No EMI Predicted	No EMI Predicted
	FCC 42A238	No EMI Predicted	No EMI Predicted
	FCC 185AA3	No EMI Predicted	No EMI Predicted
	FCC 18340D	No EMI Predicted	No EMI Predicted

Table 4-6. Minimum RFSs for the AN/PRC-150 (Continued)

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	NG 943370	0.62	2.74
Pagan	I 104160	1.47	8.00
	I 104161	1.02	4.99

4.7 AN/PRC-152

The calculated minimum RFSs at 1 km for the AN/PRC-152 are listed in Table 4-7.

Table 4-7. Minimum RFSs for the AN/PRC-152

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	DHS 096606	0.76	1.31
	FAA 061031	1.52	1.76
	FAA 061032	0.67	2.51
	FCC 3FBBFE	1.82	2.42
	FCC 18C26D	1.22	2.39
	FCC 42A238	1.03	1.82
	FCC 185AA3	2.64	2.21
	FCC 18340D	No EMI Predicted	No EMI Predicted
	NG 943370	No EMI Predicted	No EMI Predicted
Pagan	I 104160	1.40	6.07
	I 104161	0.92	5.18

4.8 AN/PRC-153

The calculated minimum RFSs at 1 km for the AN/PRC-153 are listed in Table 4-8.

Table 4-8. Minimum RFSs for the AN/PRC-153

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	DHS 096606	No EMI Predicted	No EMI Predicted
	FAA 061031	No EMI Predicted	No EMI Predicted
	FAA 061032	No EMI Predicted	No EMI Predicted
	FCC 3FBBFE	No EMI Predicted	No EMI Predicted
	FCC 18C26D	No EMI Predicted	No EMI Predicted
	FCC 42A238	0.74	0.62
	FCC 185AA3	No EMI Predicted	No EMI Predicted
	FCC 18340D	No EMI Predicted	No EMI Predicted
	NG 943370	No EMI Predicted	No EMI Predicted
Pagan	I 104160	No EMI Predicted	No EMI Predicted
	I 104161	No EMI Predicted	No EMI Predicted

4.9 AN/VRC-92D

The calculated minimum RFSs at 1 km for the AN/VRC-92D are listed in Table 4-9.

Table 4-9. Minimum RFSs for the AN/VRC-92D

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	DHS 096606	No EMI Predicted	No EMI Predicted
	FAA 061031	No EMI Predicted	No EMI Predicted
	FAA 061032	No EMI Predicted	No EMI Predicted
	FCC 3FBBFE	No EMI Predicted	No EMI Predicted
	FCC 18C26D	No EMI Predicted	No EMI Predicted
	FCC 42A238	No EMI Predicted	No EMI Predicted
	FCC 185AA3	No EMI Predicted	No EMI Predicted

Table 4-9. Minimum RFSs for the AN/VRC-92D (Continued)

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	FCC 18340D	No EMI Predicted	No EMI Predicted
	NG 943370	No EMI Predicted	No EMI Predicted
Pagan	I 104160	1.78	8.48
	I 104161	1.30	6.11

4.10 AN/VRC-103

The calculated minimum RFSs at 1 km for the AN/VRC-103 are listed in Table 4-10.

Table 4-10. Minimum RFSs for the AN/VRC-103

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	DHS 096606	1.53	1.44
	FAA 061031	1.74	1.38
	FAA 061032	1.93	1.78
	FCC 3FBBFE	1.48	1.85
	FCC 18C26D	2.04	1.69
	FCC 42A238	1.54	1.46
	FCC 185AA3	2.14	1.55
	FCC 18340D	No EMI Predicted	No EMI Predicted
Pagan	I 104160	2.49	11.00
	I 104161	1.72	6.33

4.11 AN/VRC-104

The calculated minimum RFSs at 1 km for the AN/VRC-104 are listed in Table 4-11.

Table 4-11. Minimum RFSs for the AN/VRC-104

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	DHS 096606	No EMI Predicted	No EMI Predicted
	FAA 061031	No EMI Predicted	No EMI Predicted

Table 4-11. Minimum RFSs for the AN/VRC-104 (Continued)

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	FAA 061032	No EMI Predicted	No EMI Predicted
	FCC 3FBBFE	No EMI Predicted	No EMI Predicted
	FCC 18C26D	No EMI Predicted	No EMI Predicted
	FCC 42A238	No EMI Predicted	No EMI Predicted
	FCC 185AA3	No EMI Predicted	No EMI Predicted
	FCC 18340D	No EMI Predicted	No EMI Predicted
	NG 943370	1.26	3.58
Pagan	I 104160	2.60	16.39
	I 104161	1.76	8.85

4.12 AN/VRC-110

The calculated minimum RFSs at 1 km for the AN/VRC-110 are listed in Table 4-12.

Table 4-12. Minimum RFSs for the AN/VRC-110

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	DHS 096606	1.23	1.67
	FAA 061031	1.16	2.43
	FAA 061032	1.32	1.91
	FCC 3FBBFE	2.42	2.33
	FCC 18C26D	2.51	2.18
	FCC 42A238	1.37	1.73
	FCC 185AA3	2.65	2.00
	FCC 18340D	No EMI Predicted	No EMI Predicted
	NG 943370	No EMI Predicted	No EMI Predicted
Pagan	I 104160	2.78	14.20
	I 104161	1.75	4.50

4.13 AN/VRC-112

The calculated minimum RFSs at 1 km for the AN/VRC-112 are listed in Table 4-13.

Table 4-13. Minimum RFSs for the AN/VRC-112

Location	EME System Agency Serial Number	RFS at 1 km (MHz)	
		From EME	To EME
Tinian	DHS 096606	1.49	1.69
	FAA 061031	1.08	1.44
	FAA 061032	0.88	1.64
	FCC 3FBBFE	1.63	2.10
	FCC 18C26D	1.71	1.92
	FCC 42A238	1.85	1.87
	FCC 185AA3	2.14	2.33
	FCC 18340D	No EMI Predicted	No EMI Predicted
	NG 943370	No EMI Predicted	No EMI Predicted
Pagan	I 104160	3.56	10.92
	I 104161	2.65	7.13

4.14 BFT

The calculated RFSs plus the guardbands between the BFT and EME systems were within the frequency separation limits; therefore, no EMI issues were predicted for this system.

4.15 BFT BASE STATION

The calculated RFSs plus the guardbands between the BFT Base Station and EME were within the frequency separation limits; therefore, no EMI issues were predicted for this system.

4.16 RAVEN RQ-11B DDL

The calculated RFSs plus the guardbands between the Raven RQ-11B DDL and EME systems were within the frequency separation limits; therefore, no EMI issues were predicted for this system.

4.17 SWAN

The calculated RFSs plus the guardbands between the SWAN and EME systems were within the frequency separation limits; therefore, no EMI issues were predicted for this system.

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5. RECOMMENDATIONS

The analysis results indicate that there are USMC/EME system pairs that have the potential for EMI. Based on the technical parameters, the USMC systems have an adequate tuning range to tune away from the assigned frequencies of the EME systems. Using the data provided in the F-D plots as a guideline, it is recommended that the USMC perform either (or both) of the following actions:

- Avoid using frequencies on the affected systems that are close to the assigned frequencies of the EME systems.
- Maintain minimum separation distances from the EME systems that comply with the F-D plots.

Using a combination of the above recommendations may further reduce the potential for EMI.

It is also recommended that the USMC frequency manager contact local frequency managers for frequency coordination. Frequency coordination may reduce the potential for EMI by assigning the USMC and EME systems different operating frequencies or scheduling system operations during different time periods.

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6. REFERENCES

1. John Wesdock, et al. *Communications Receiver Performance Degradation Handbook.* JSC-CR-10-004. JSC. Annapolis, MD: 11 August 2010.
2. P. Cragg. *FDR User's Manual.* ECAC-UM-87-012. Electromagnetic Compatibility Analysis Center. Annapolis, MD: April 1988.
3. David Eppink and Wolf Kuebler. *TIREM/SEM Handbook.* ECAC-HDBK-93-076. Electromagnetic Compatibility Analysis Center. Annapolis, MD: March 1994.

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APPENDIX A. F-D PLOTS FOR USMC AND EME SYSTEMS ON TINIAN

This section contains the F-D plots for the USMC and EME systems on Tinian Island. The RFS data points in the F-D plots do not include the 50 MHz guardband.

A.1 AN/MRC-145

The calculated RFSs plus the guardbands between the AN/MRC-145 and EME systems on Tinian were within the frequency separation limits; therefore, no EMI issues were predicted for this system.

A.2 AN/MRC-148

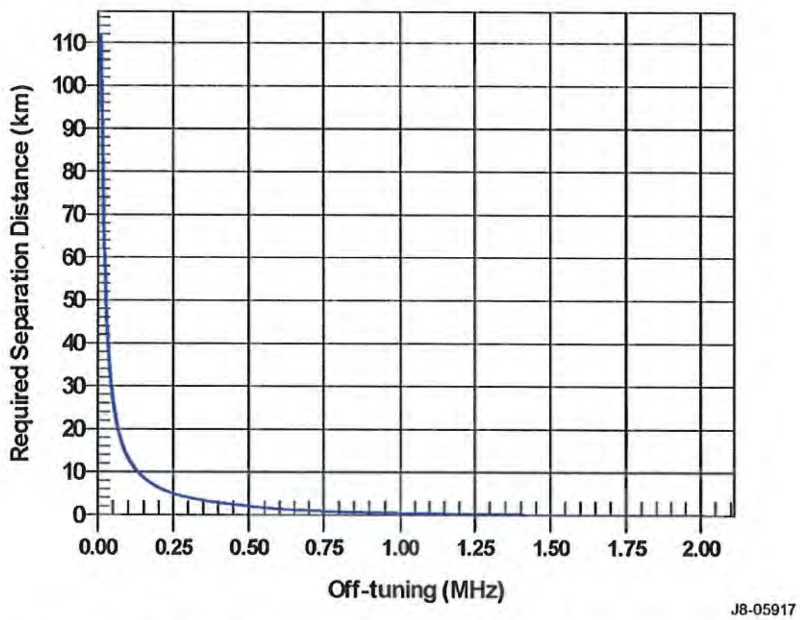

Figure A-1. NG 943370 Transmitter versus AN/MRC-148 Receiver F-D Plot

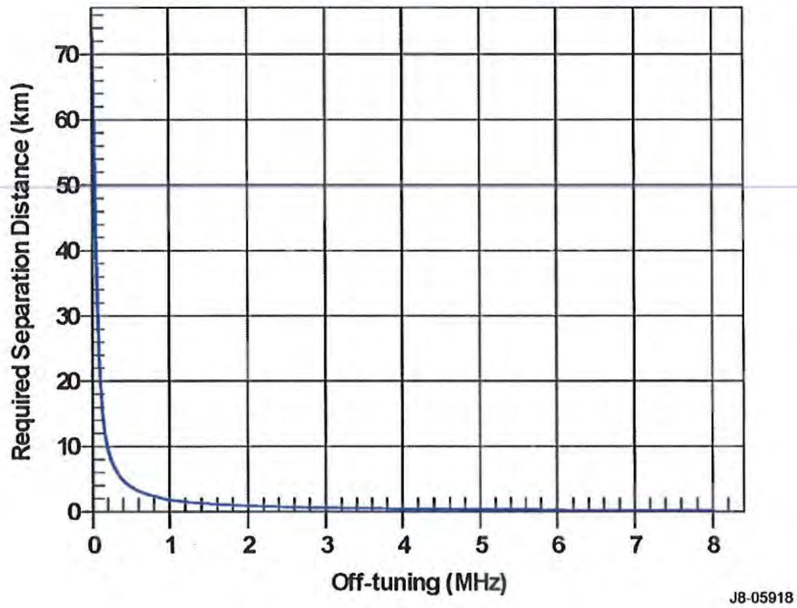

Figure A-2. AN/MRC-148 Transmitter versus NG 943370 Receiver F-D Plot

A.3 AN/PRC-117F

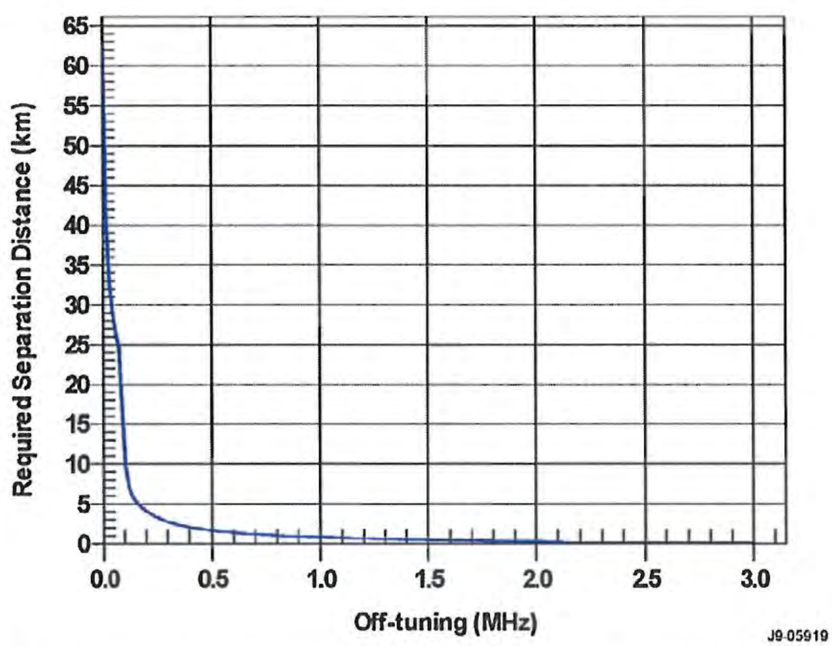

Figure A-3. DHS 096606 Transmitter versus AN/PRC-117F Receiver F-D Plot

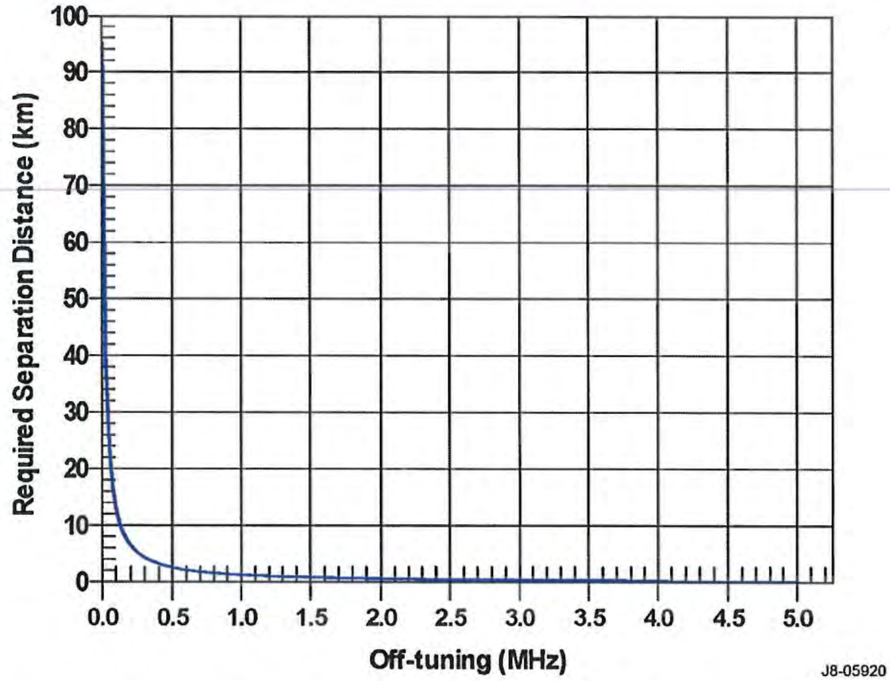

Figure A-4. AN/PRC-117F Transmitter versus DHS 096606 Receiver F-D Plot

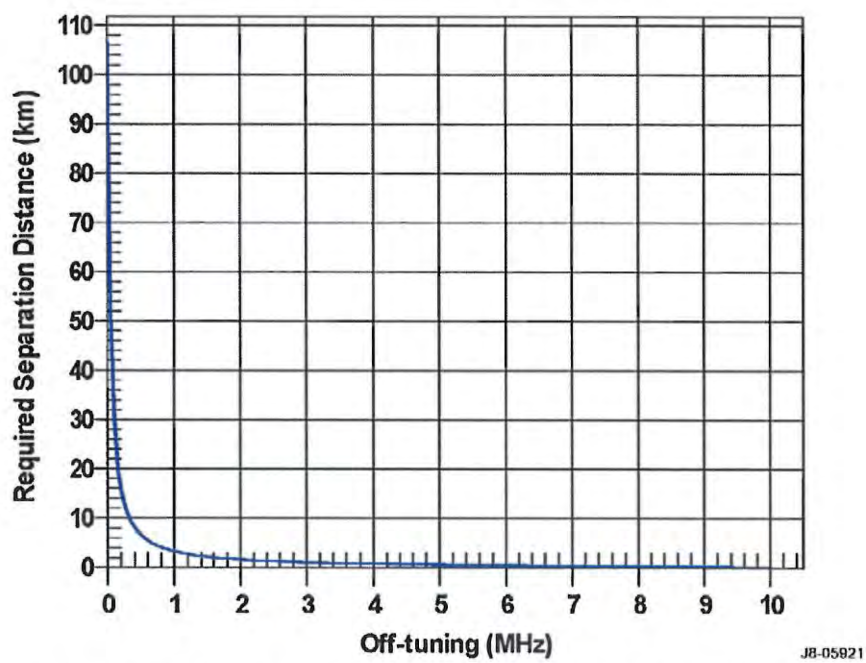

Figure A-5. FAA 061031 Transmitter versus AN/PRC-117F Receiver F-D Plot

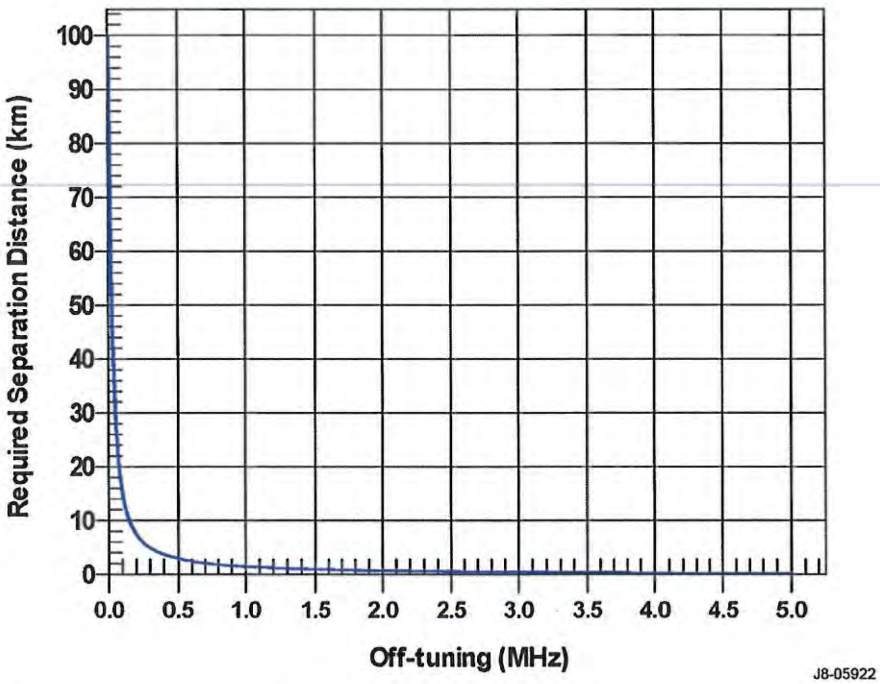

Figure A-6. AN/PRC-117F Transmitter versus FAA 061031 Receiver F-D Plot

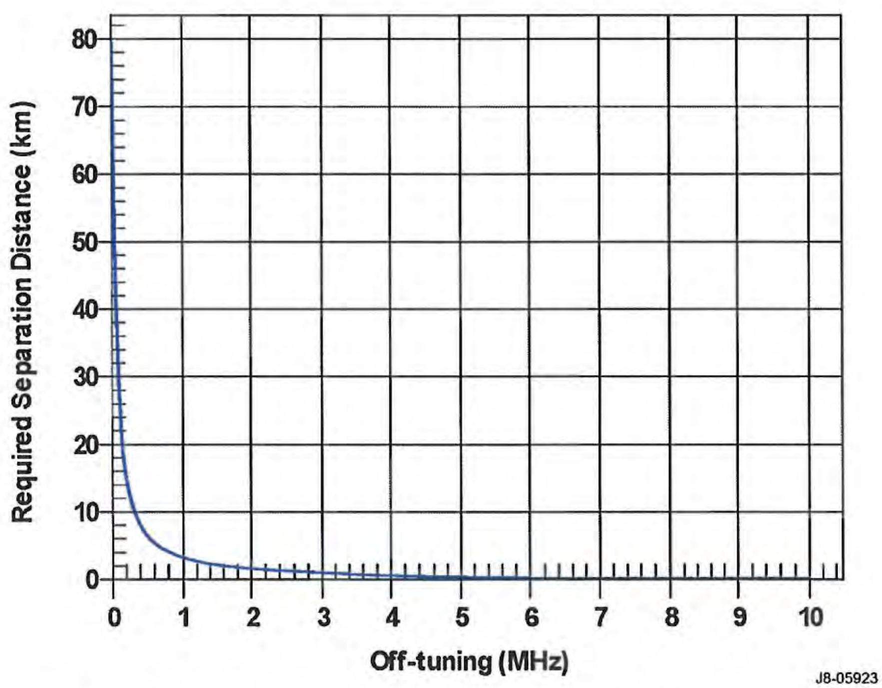

Figure A-7. FAA 061032 Transmitter versus AN/PRC-117F Receiver F-D Plot

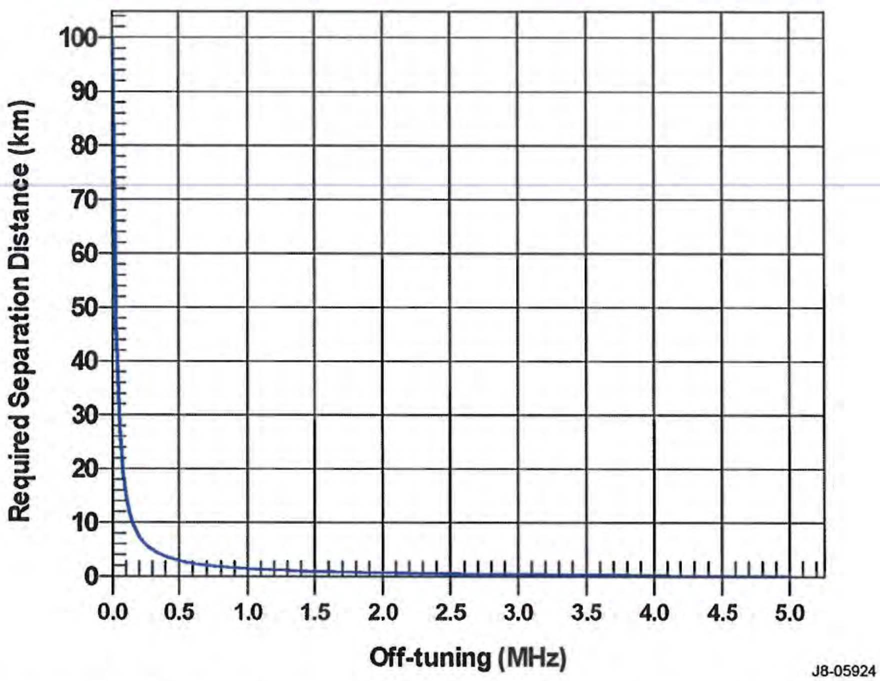

Figure A-8. AN/PRC-117F Transmitter versus FAA 061032 Receiver F-D Plot

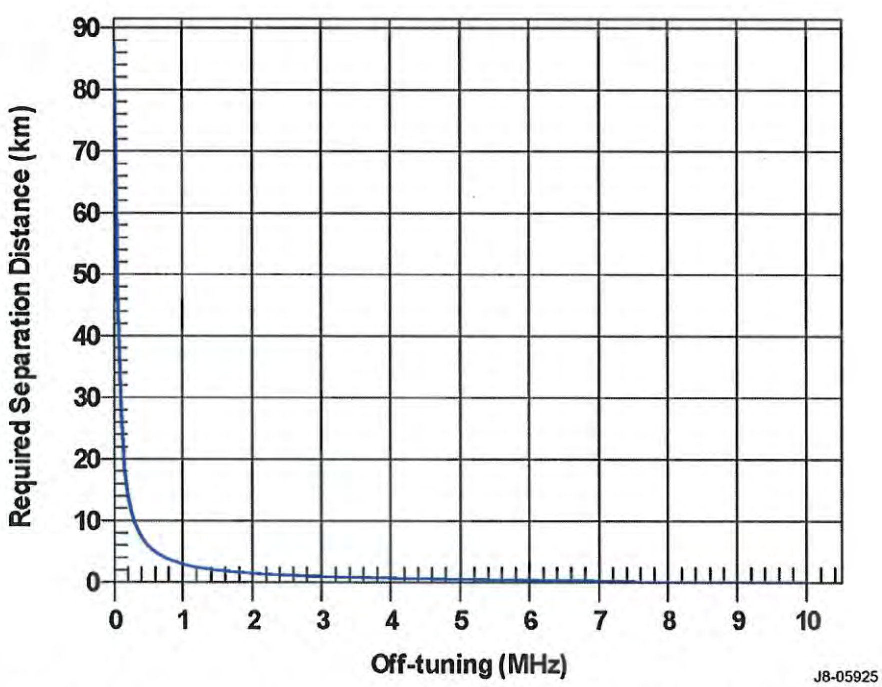

Figure A-9. FCC 3FBBFE Transmitter versus AN/PRC-117F Receiver F-D Plot

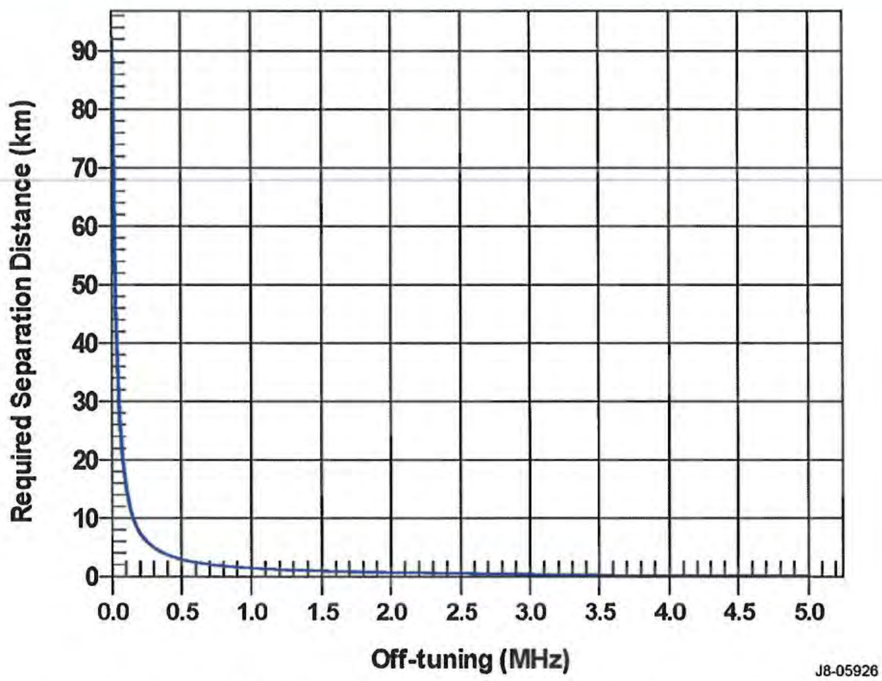

Figure A-10. AN/PRC-117F Transmitter versus FCC 3FBBFE Receiver F-D Plot

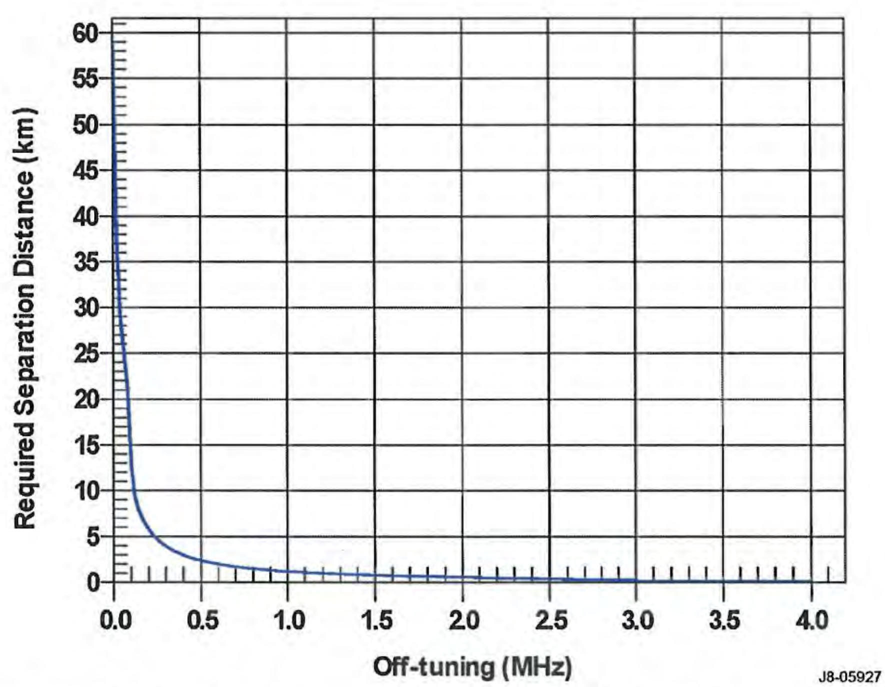

Figure A-11. FCC 18C26D Transmitter versus AN/PRC-117F Receiver F-D Plot

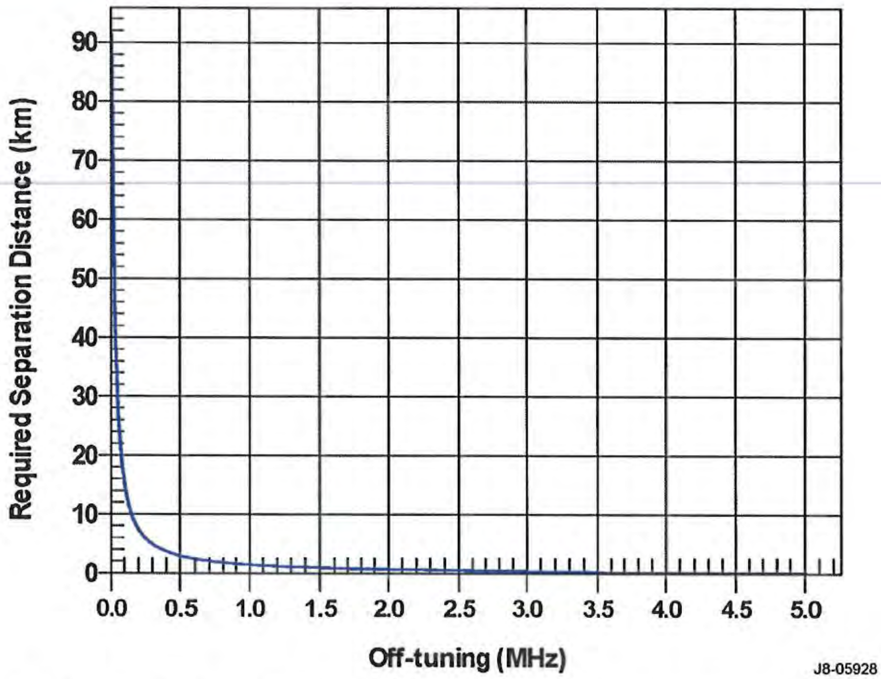

Figure A-12. AN/PRC-117F Transmitter versus FCC 18C26D Receiver F-D Plot

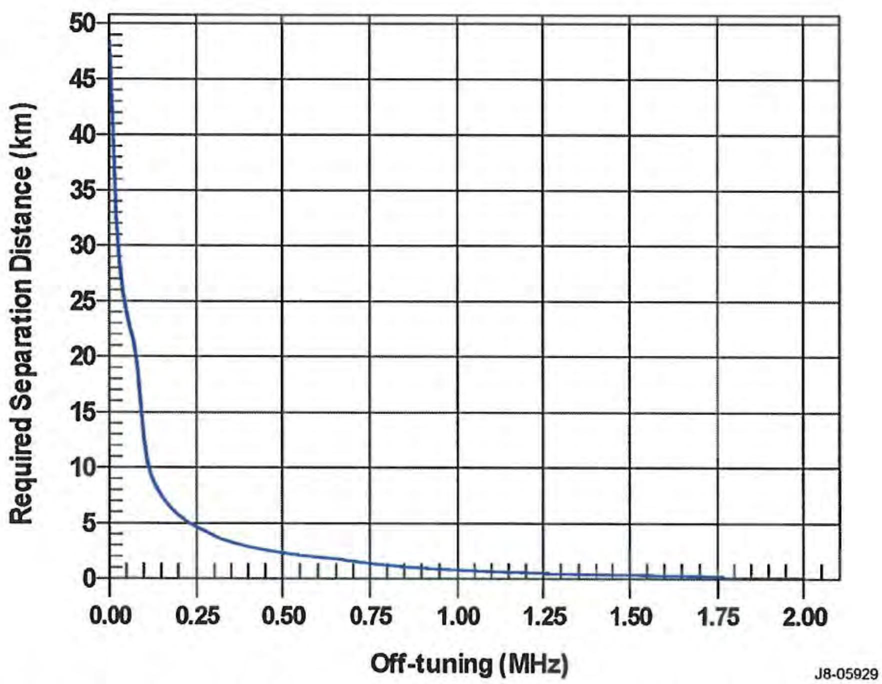

Figure A-13. FCC 42A238 Transmitter versus AN/PRC-117F Receiver F-D Plot

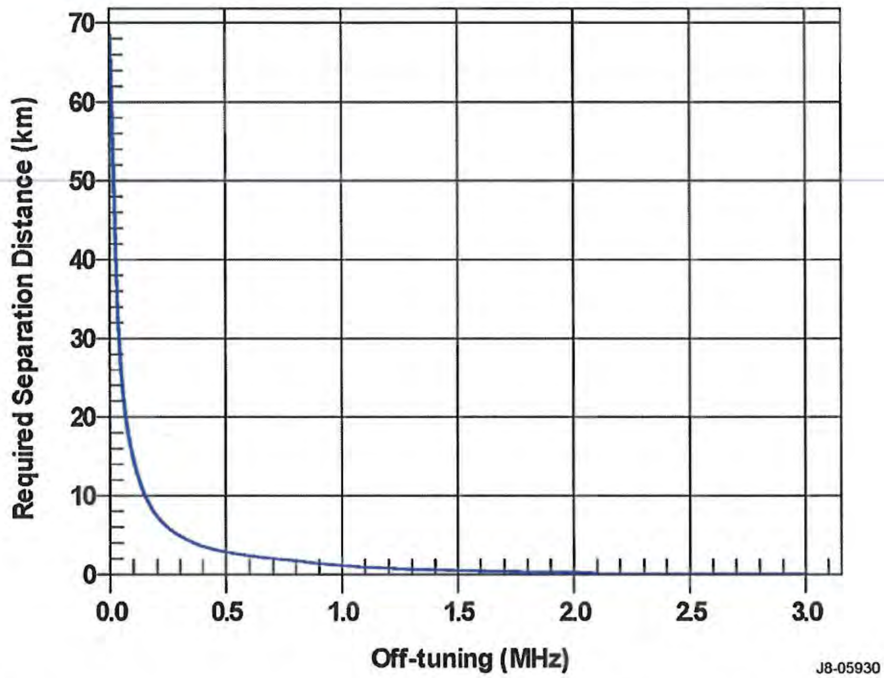

Figure A-14. AN/PRC-117F Transmitter versus FCC 42A238 Receiver F-D Plot

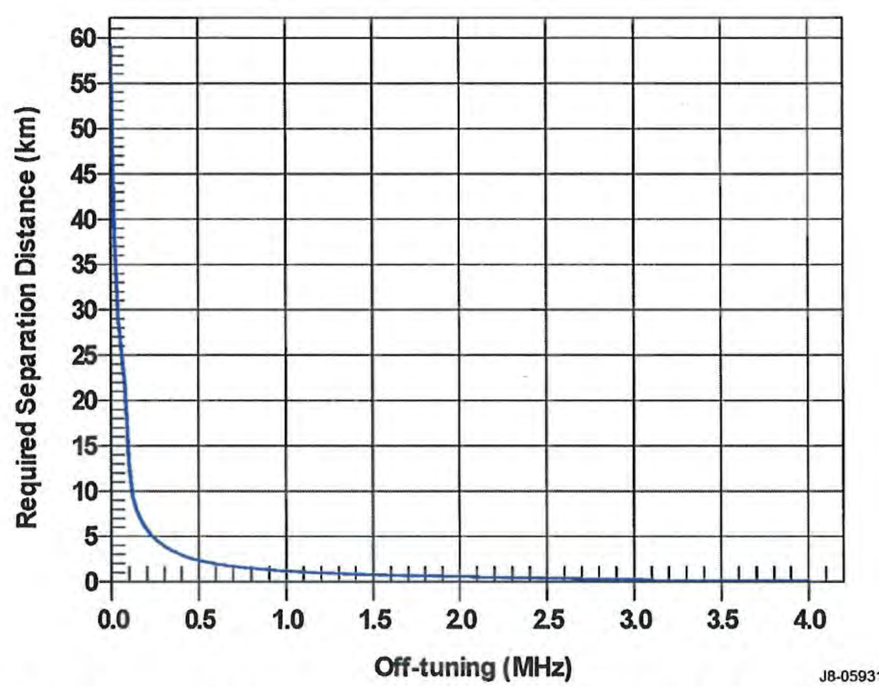

Figure A-15. FCC 185AA3 Transmitter versus AN/PRC-117F Receiver F-D Plot

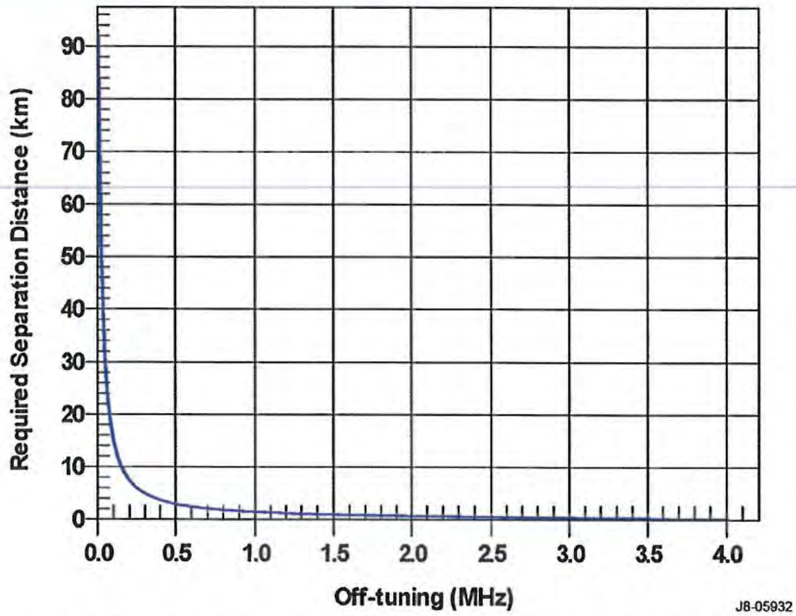

Figure A-16. AN/PRC-117F Transmitter versus FCC 185AA3 Receiver F-D Plot

A.4 AN/PRC-117G

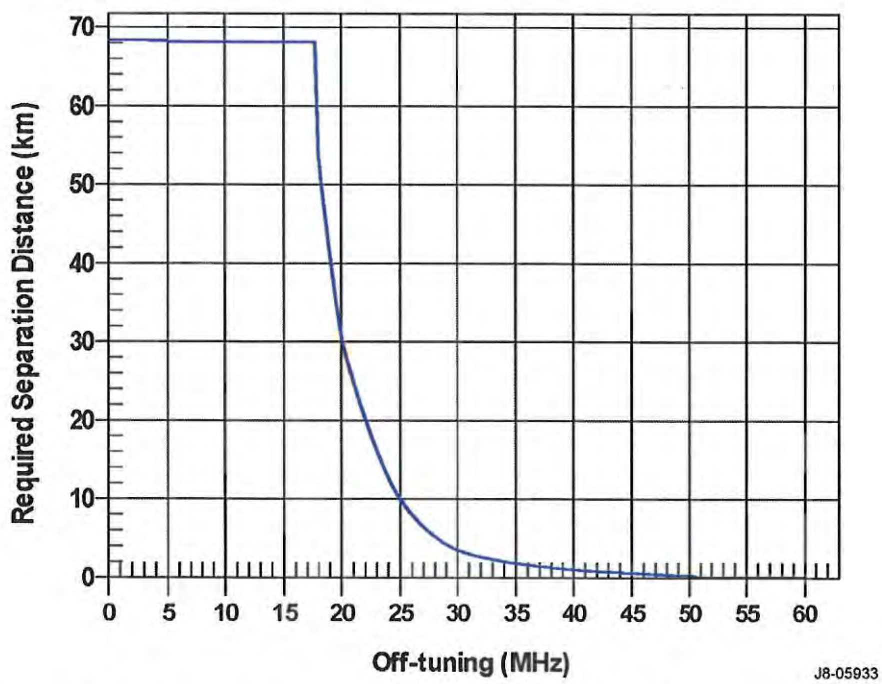

Figure A-17. DHS 096606 Transmitter versus AN/PRC-117G Receiver F-D Plot

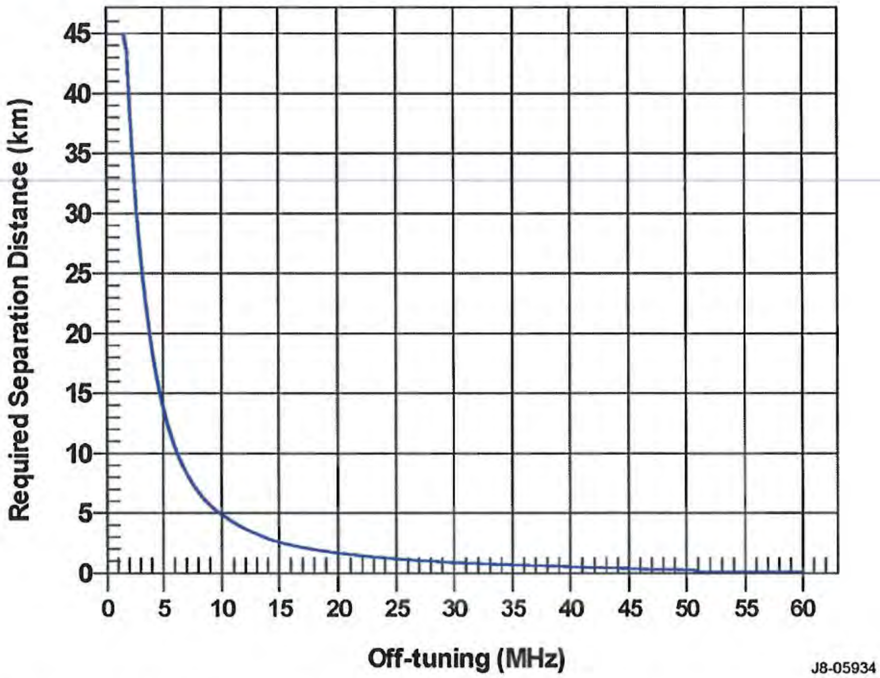

Figure A-18. AN/PRC-117G Transmitter versus DHS 096606 Receiver F-D Plot

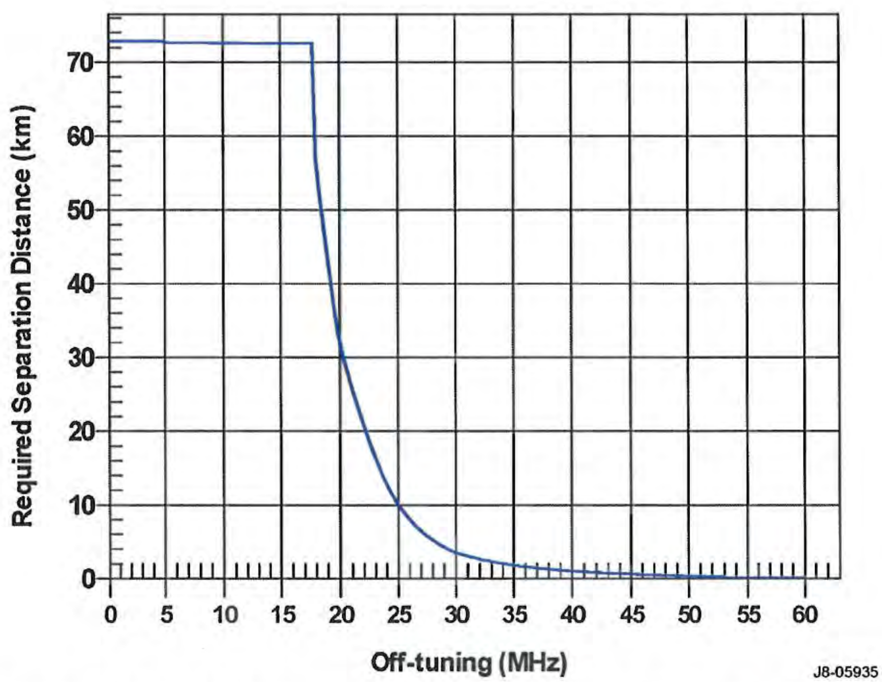

Figure A-19. FAA 061031 Transmitter versus AN/PRC-117G Receiver F-D Plot

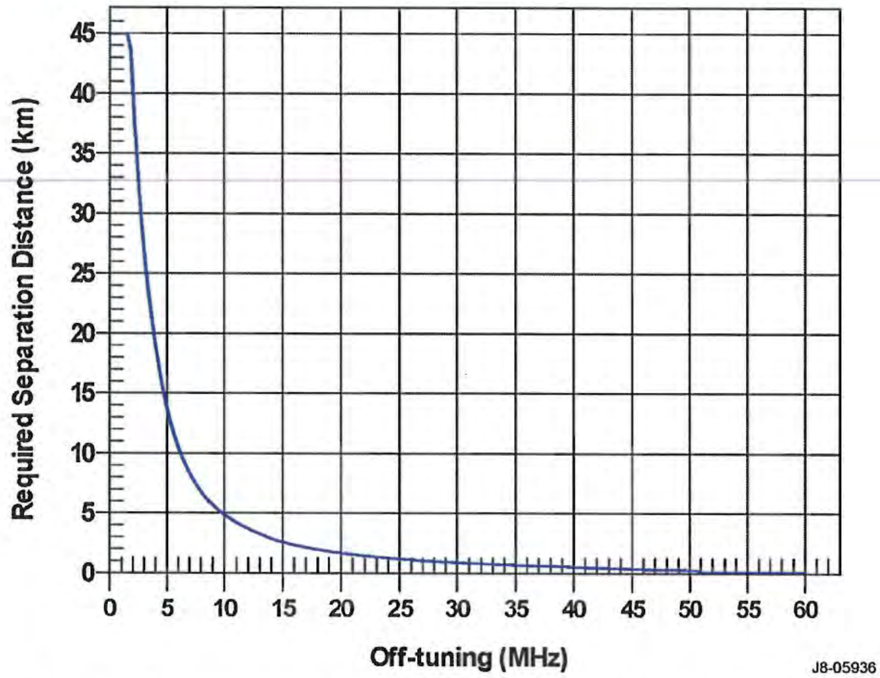

Figure A-20. AN/PRC-117G Transmitter versus FAA 061031 Receiver F-D Plot

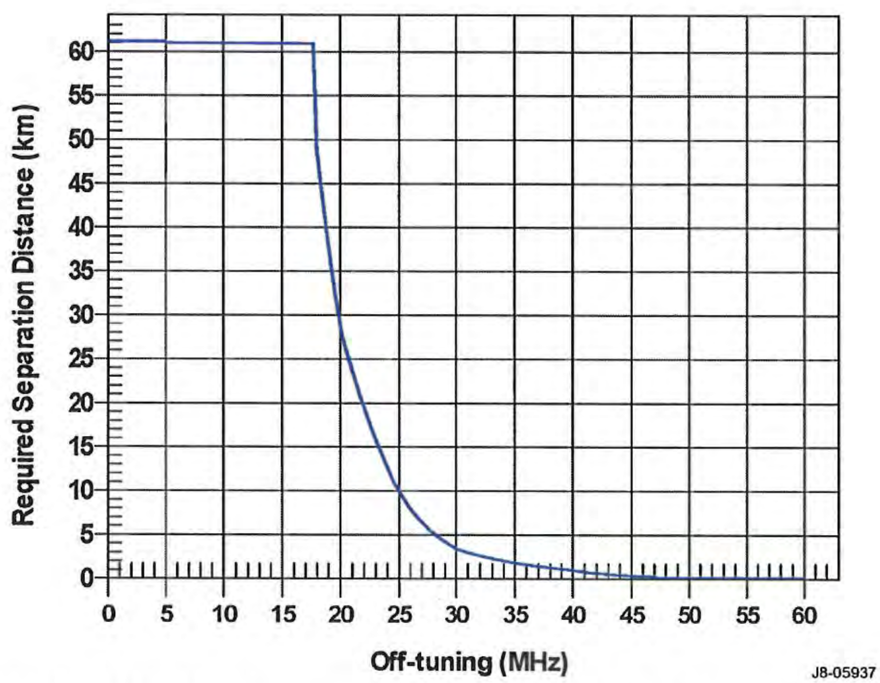

Figure A-21. FAA 061032 Transmitter versus AN/PRC-117G Receiver F-D Plot

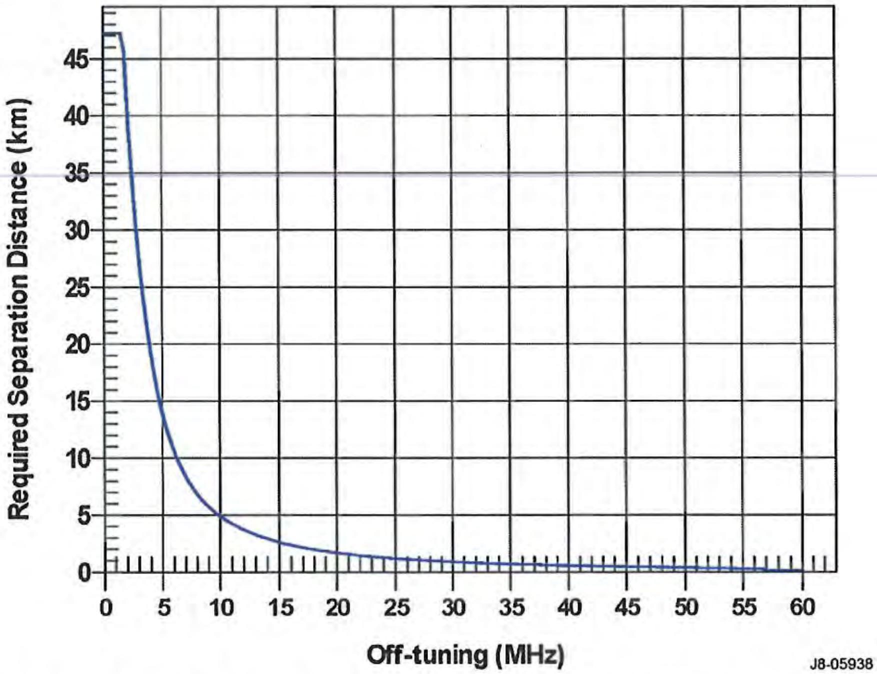

Figure A-22. AN/PRC-117G Transmitter versus FAA 061032 Receiver F-D Plot

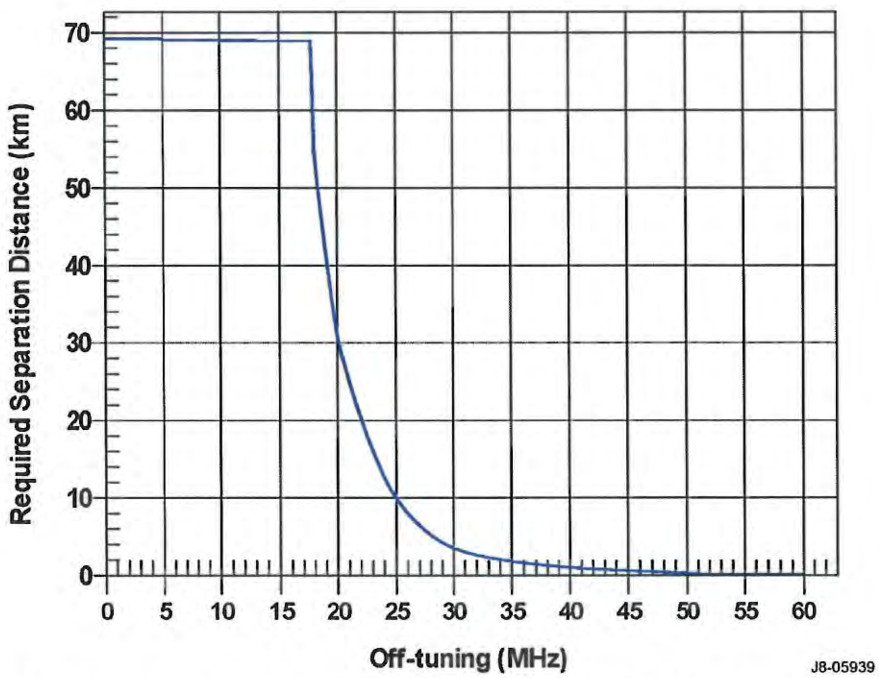

Figure A-23. FCC 3FBBFE Transmitter versus AN/PRC-117G Receiver F-D Plot

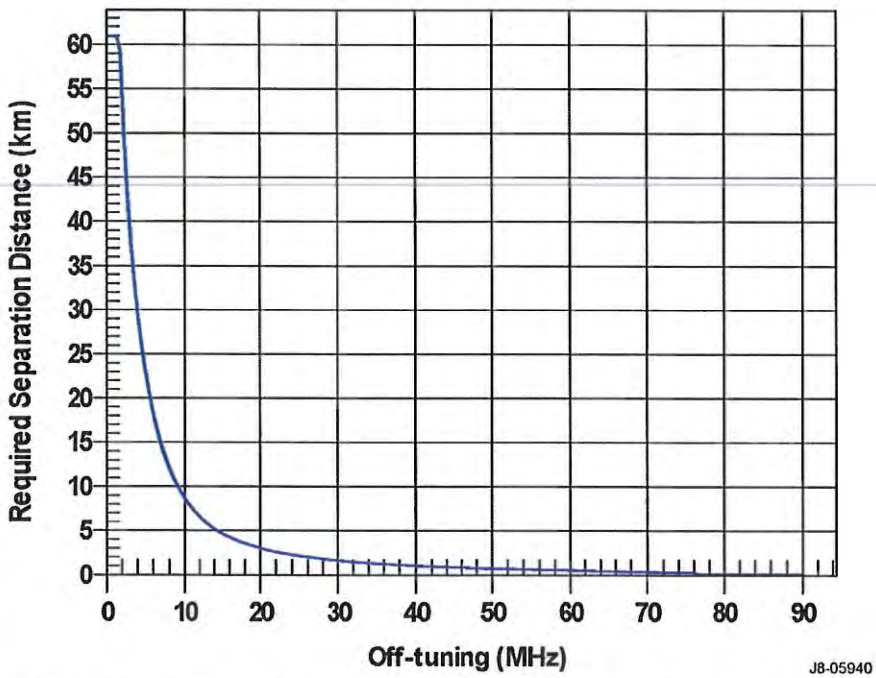

Figure A-24. AN/PRC-117G Transmitter versus FCC 3FBBFE Receiver F-D Plot

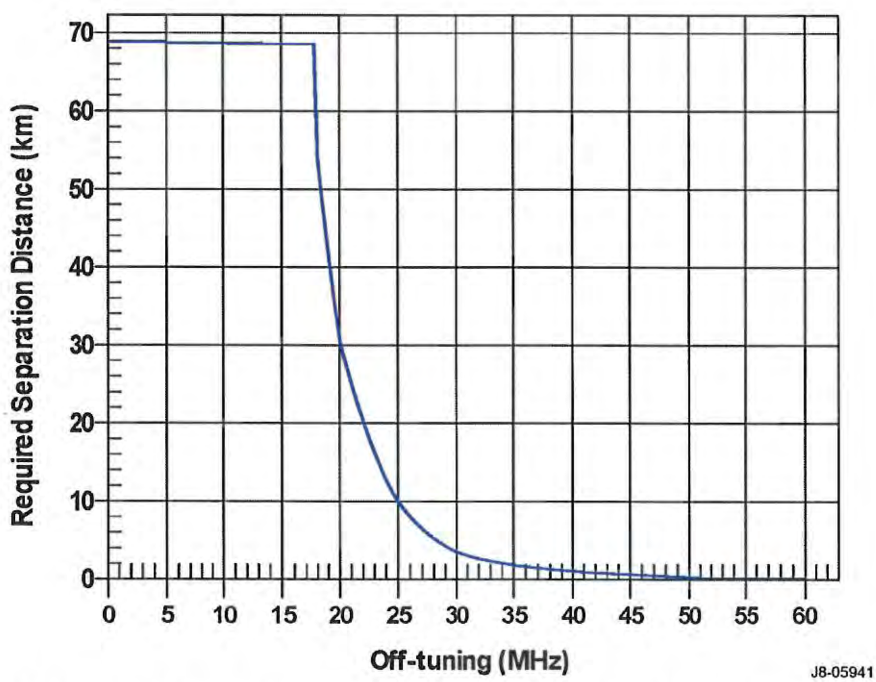

Figure A-25. FCC 18C26D Transmitter versus AN/PRC-117G Receiver F-D Plot

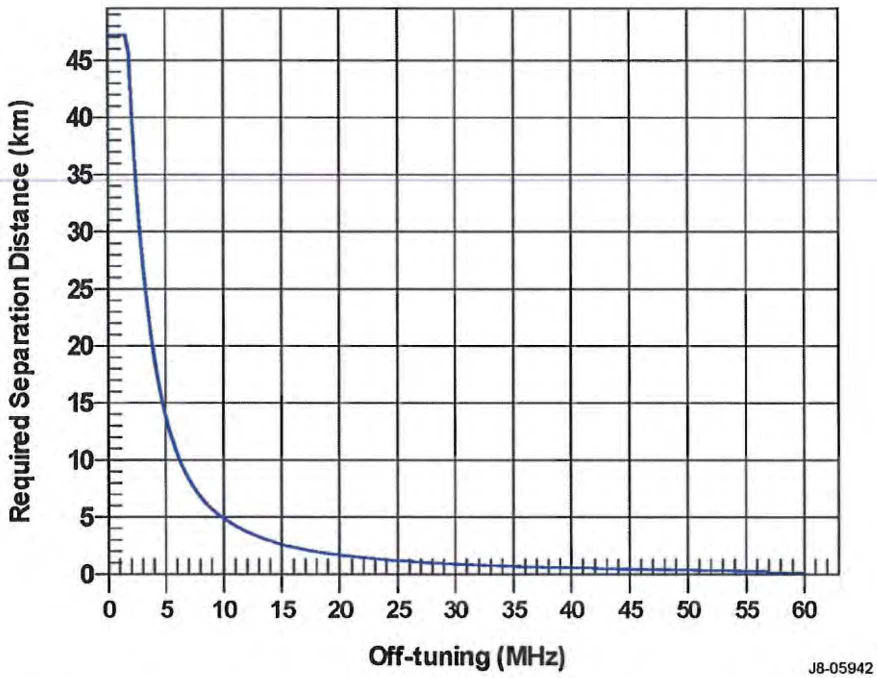

Figure A-26. AN/PRC-117G Transmitter versus FCC 18C26D Receiver F-D Plot

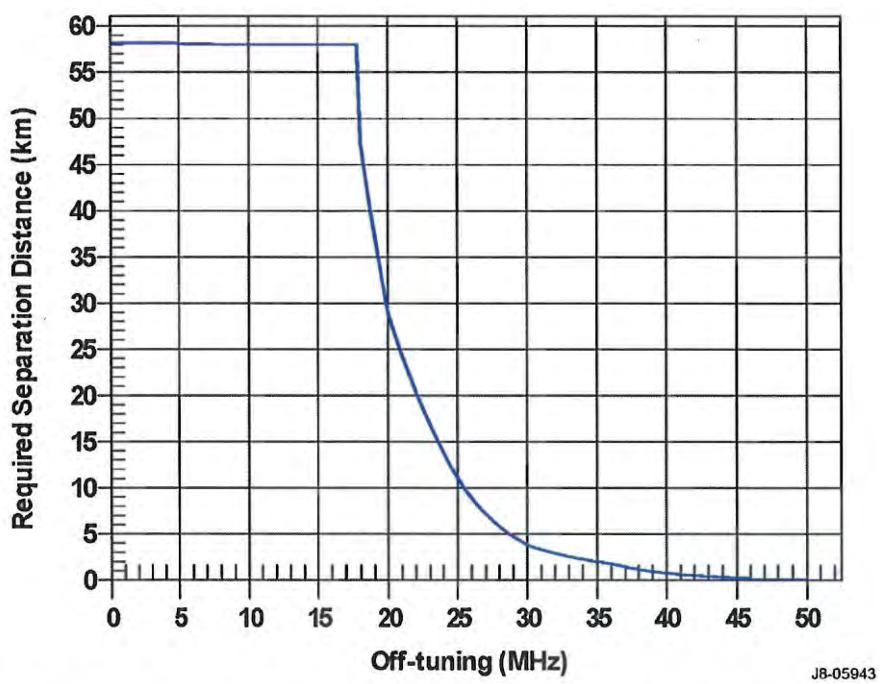

Figure A-27. FCC 42A238 Transmitter versus AN/PRC-117G Receiver F-D Plot

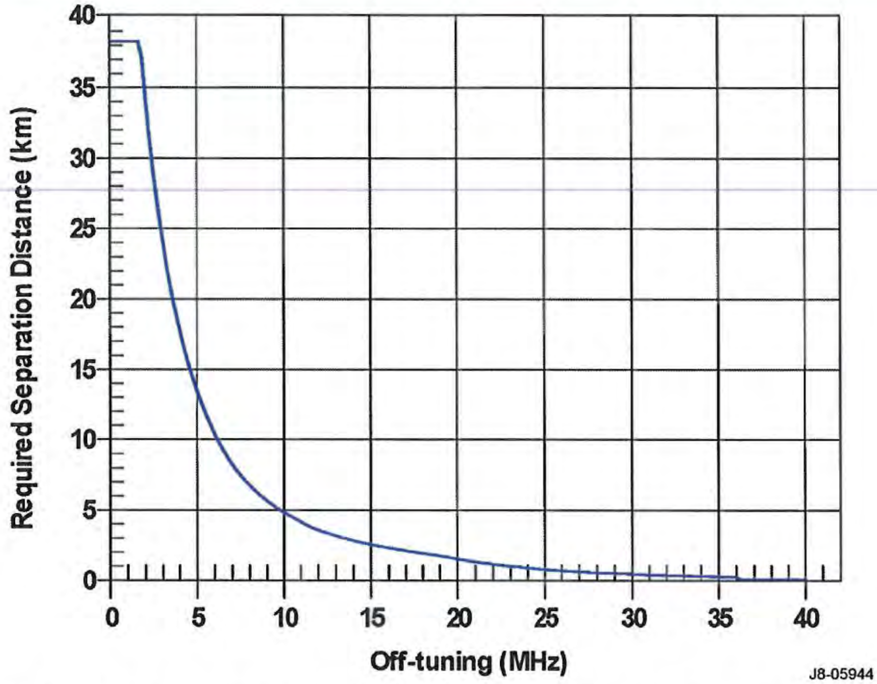

Figure A-28. AN/PRC-117G Transmitter versus FCC 42A238 Receiver F-D Plot

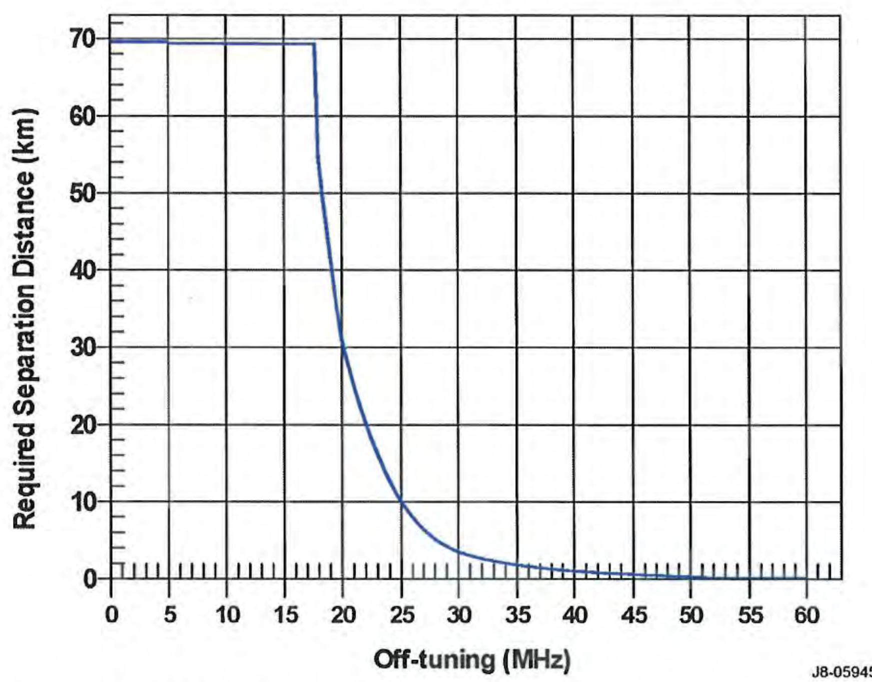

Figure A-29. FCC 185AA3 Transmitter versus AN/PRC-117G Receiver F-D Plot

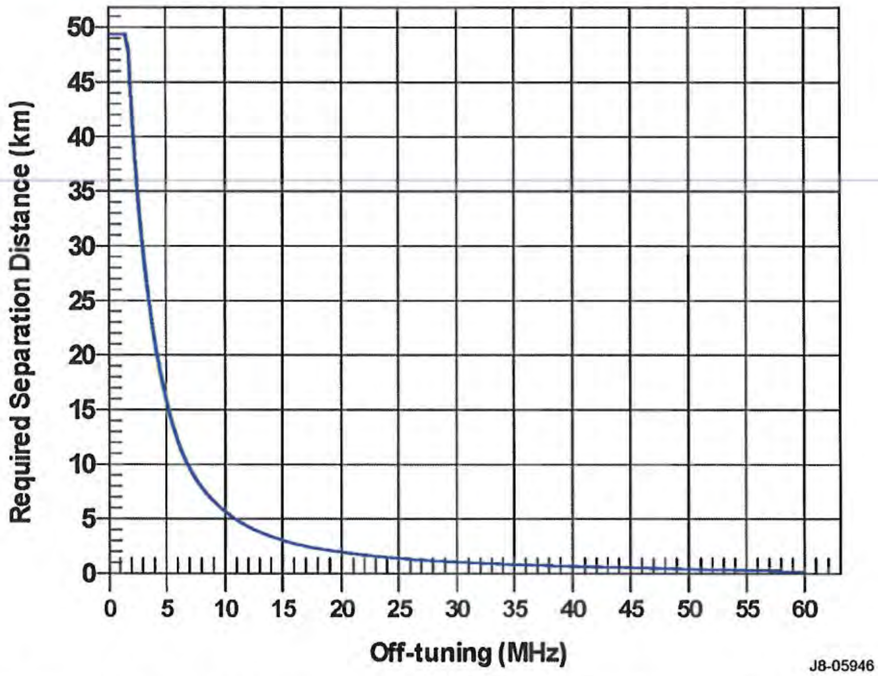

Figure A-30. AN/PRC-117G Transmitter versus FCC 185AA3 Receiver F-D Plot

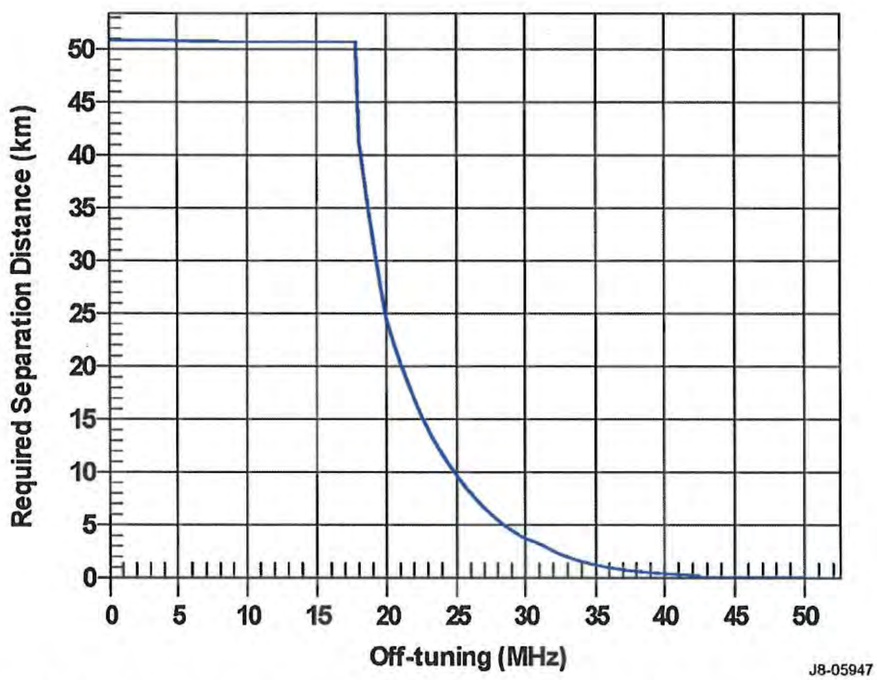

Figure A-31. FCC 18340D Transmitter versus AN/PRC-117G Receiver F-D Plot

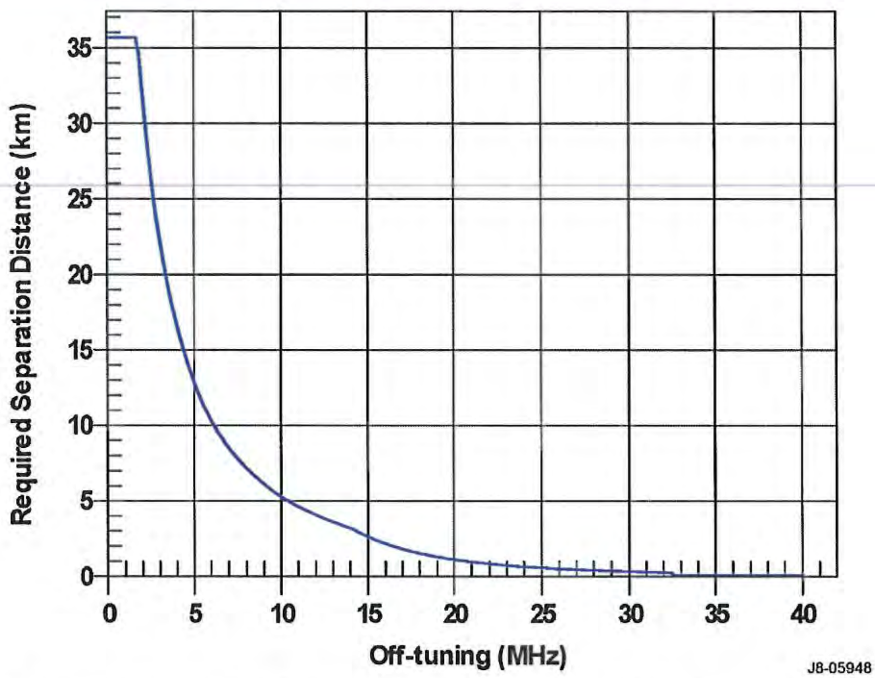

Figure A-32. AN/PRC-117G Transmitter versus FCC 18340D Receiver F-D Plot

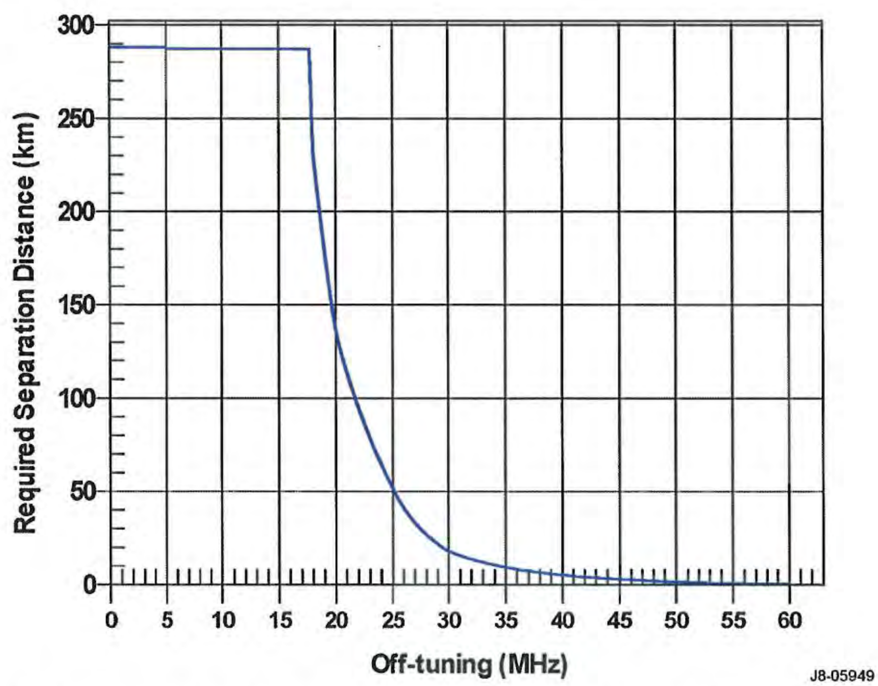

Figure A-33. NG 943370 Transmitter versus AN/PRC-117G Receiver F-D Plot

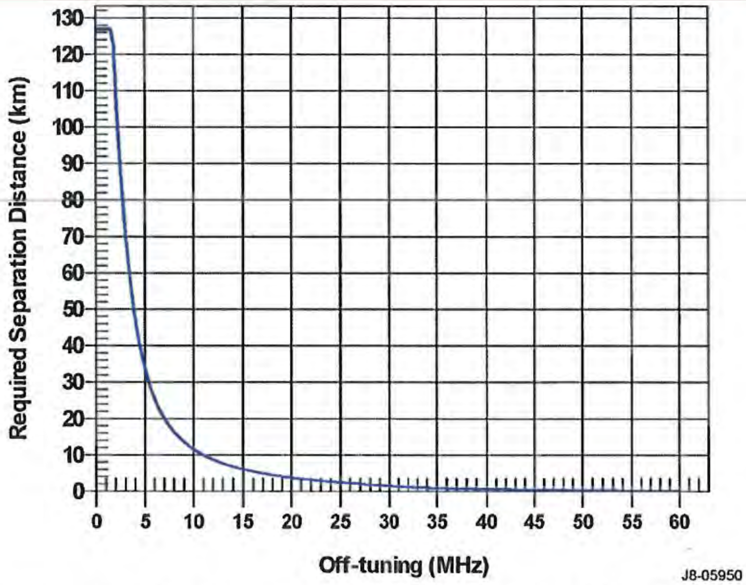

Figure A-34. AN/PRC-117G Transmitter versus NG 943370 Receiver F-D Plot

A.5 AN/PRC-119F

The calculated RFSs plus the guardbands between the AN/PRC-119F and EME systems on Tinian were within the frequency separation limits; therefore, no EMI issues were predicted for this system.

A.6 AN/PRC-150

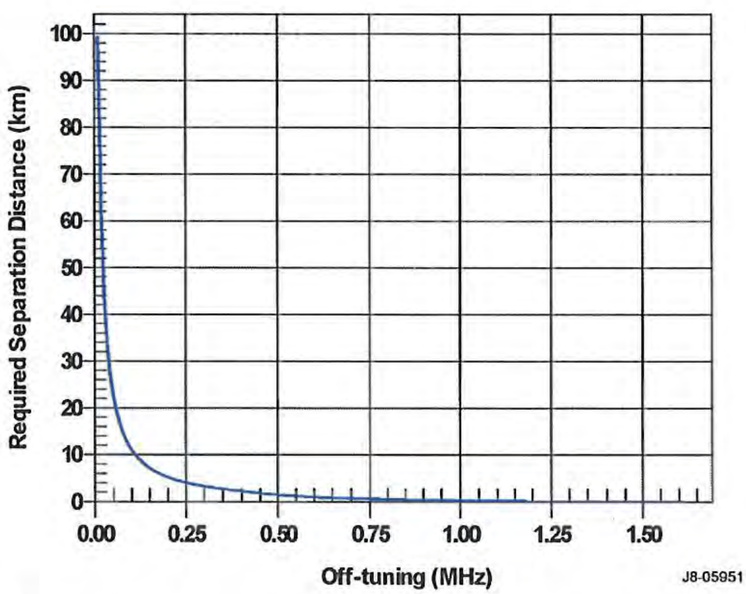

Figure A-35. NG 943370 Transmitter versus AN/PRC-150 Receiver F-D Plot

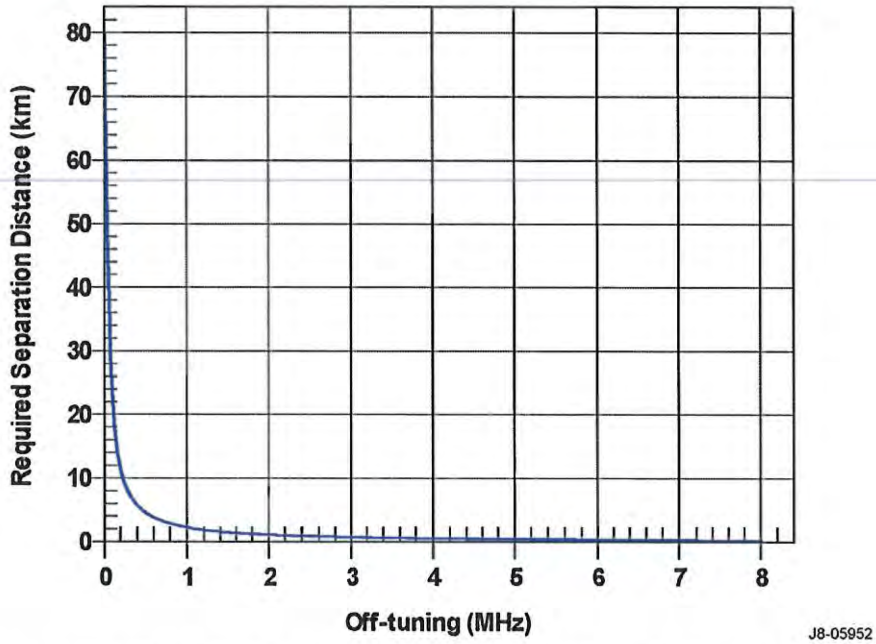

Figure A-36. AN/PRC-150 Transmitter versus NG 943370 Receiver F-D Plot

A.7 AN/PRC-152

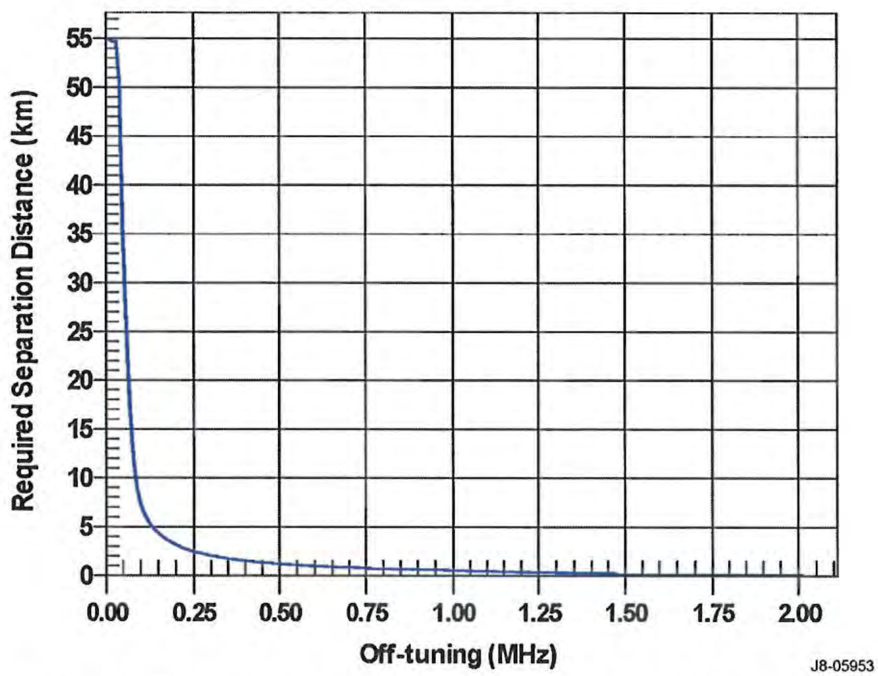

Figure A-37. DHS 096606 Transmitter versus AN/PRC-152 Receiver F-D Plot

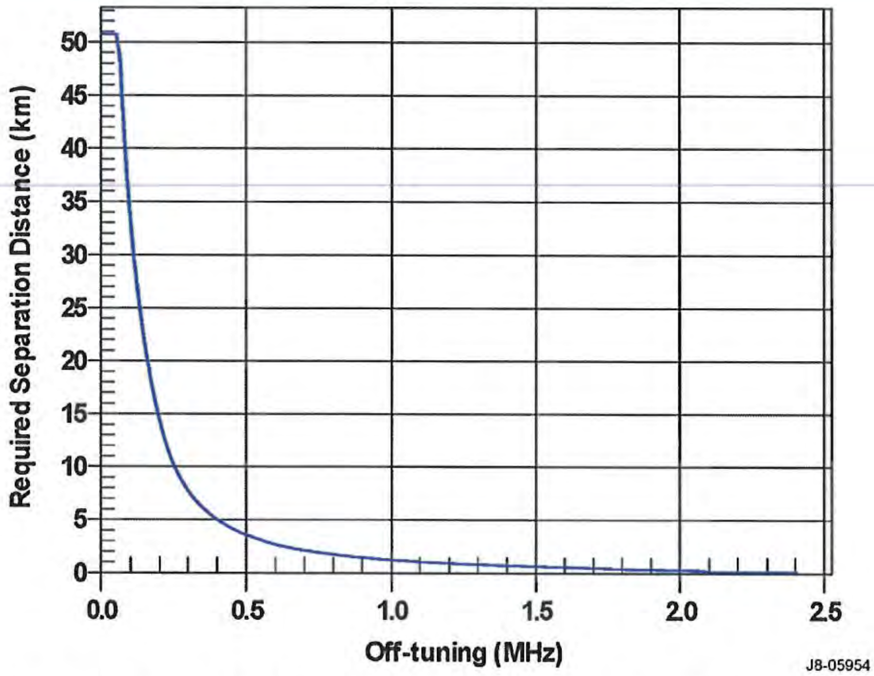

Figure A-38. AN/PRC-152 Transmitter versus DHS 096606 Receiver F-D Plot

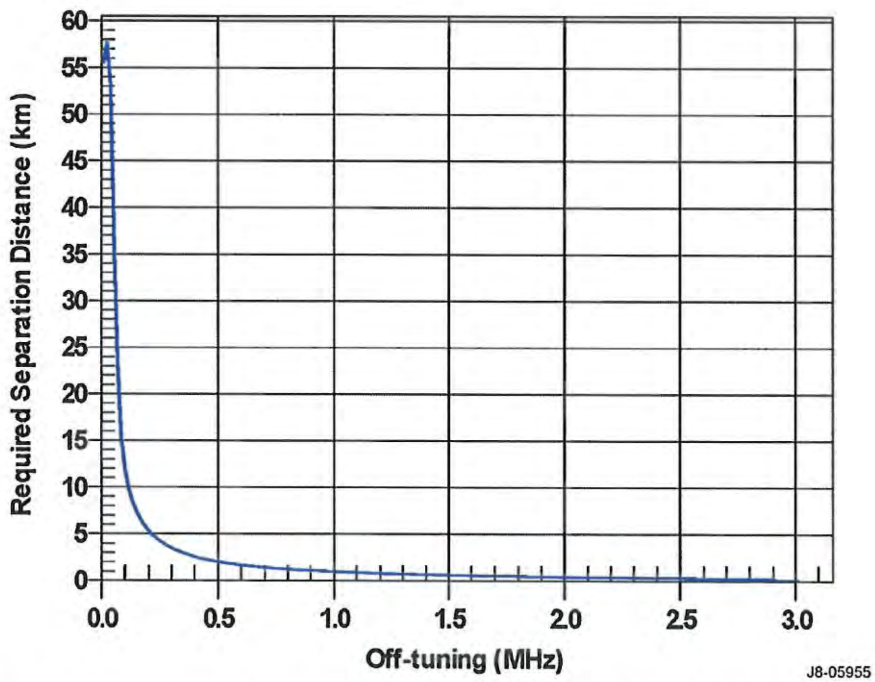

Figure A-39. FAA 061031 Transmitter versus AN/PRC-152 Receiver F-D Plot

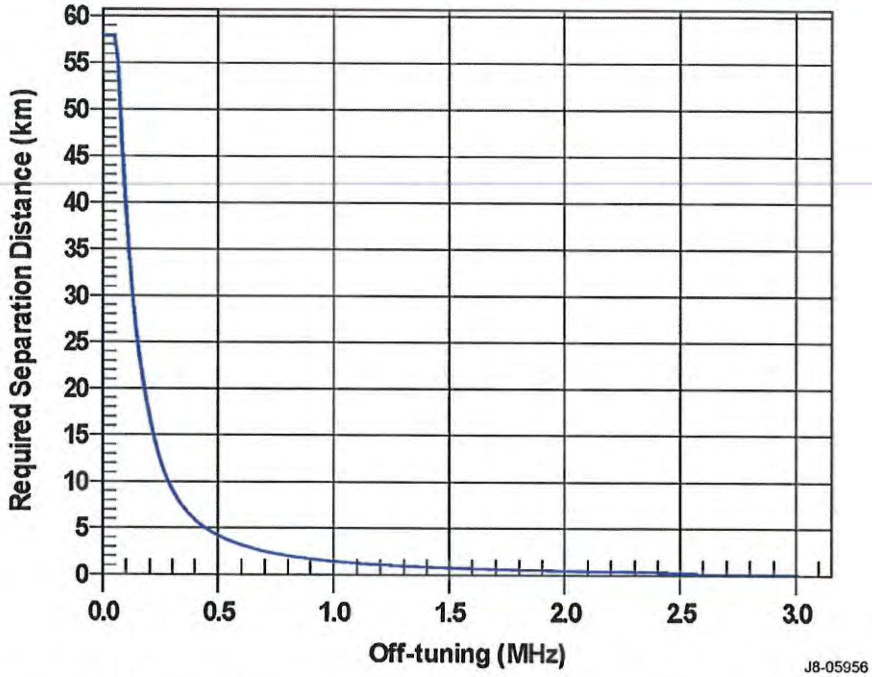

Figure A-40. AN/PRC-152 Transmitter versus FAA 061031 Receiver F-D Plot

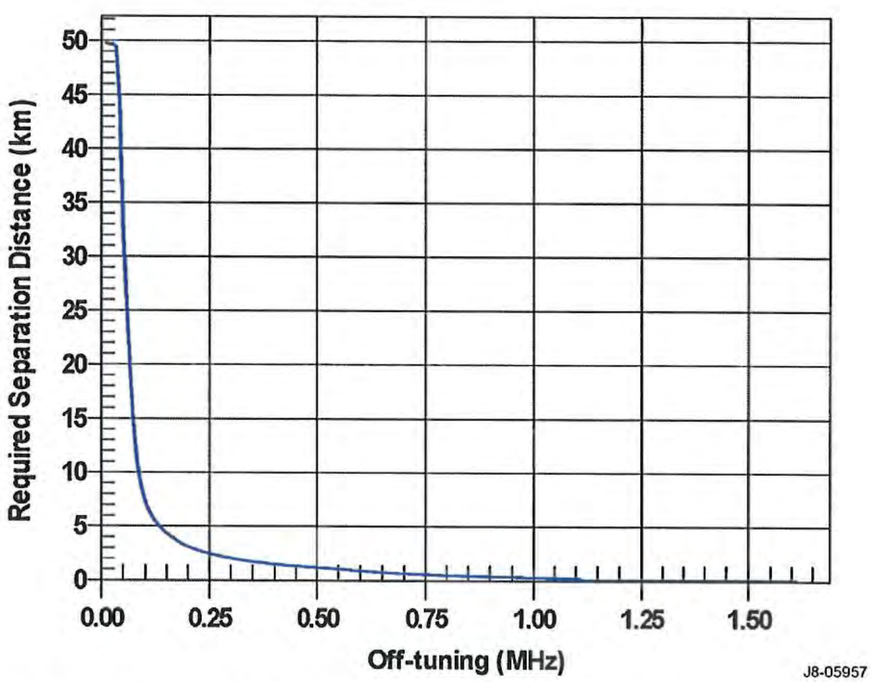

Figure A-41. FAA 061032 Transmitter versus AN/PRC-152 Receiver F-D Plot

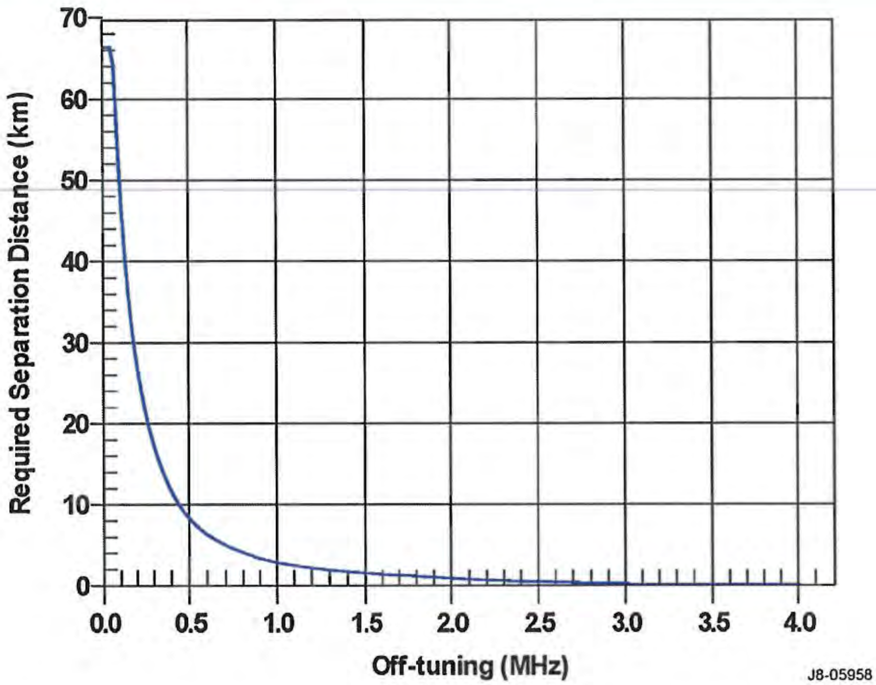

Figure A-42. AN/PRC-152 Transmitter versus FAA 061032 Receiver F-D Plot

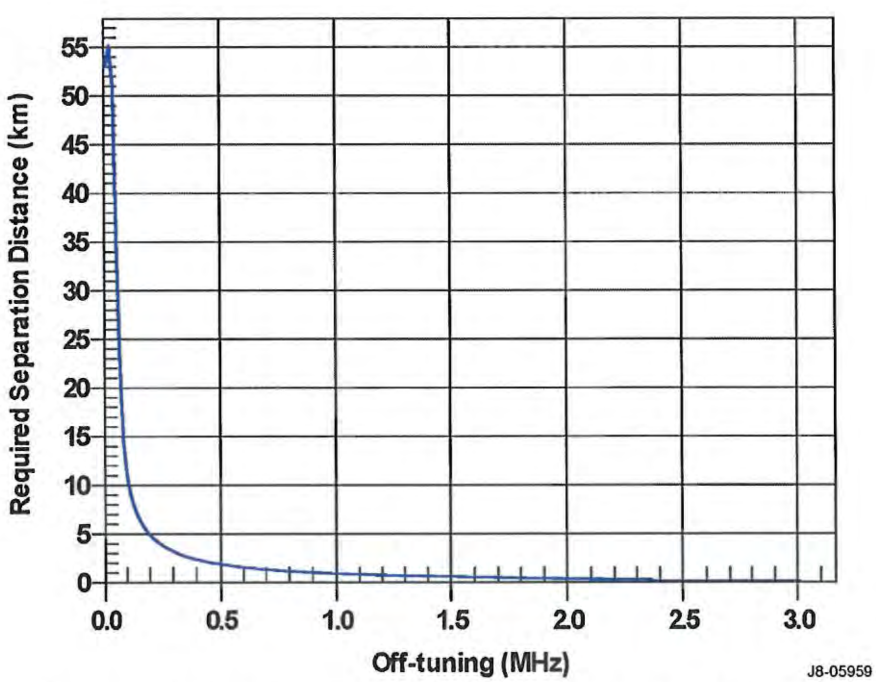

Figure A-43. FCC 3FBBFE Transmitter versus AN/PRC-152 Receiver F-D Plot

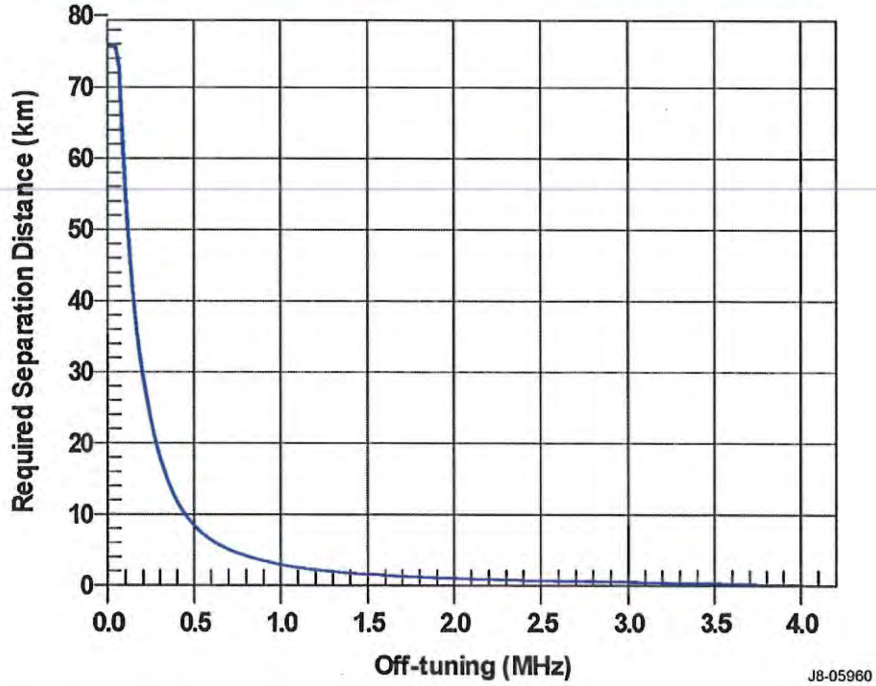

Figure A-44. AN/PRC-152 Transmitter versus FCC 3FBBFE Receiver F-D Plot

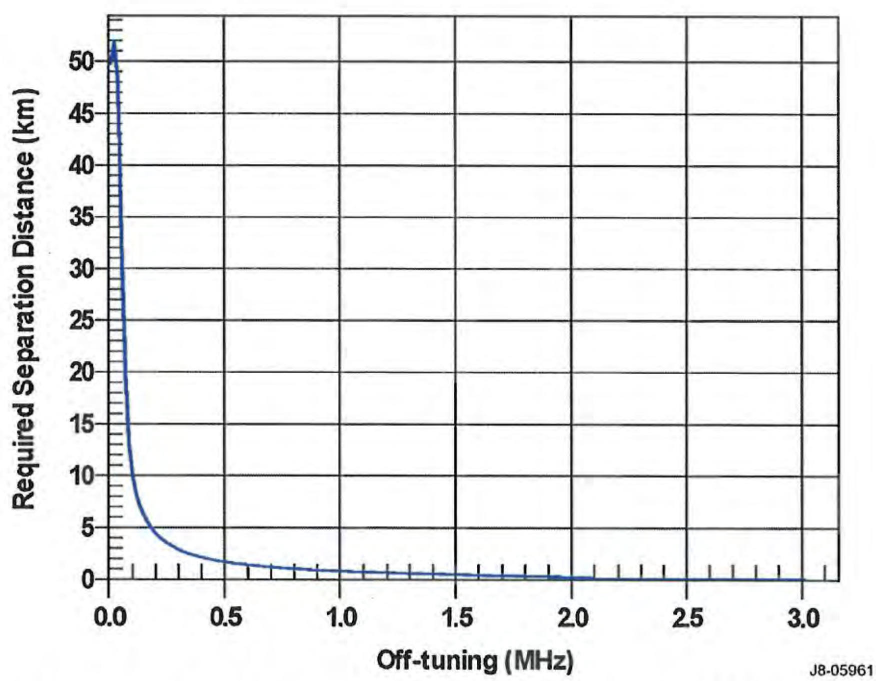

Figure A-45. FCC 18C26D Transmitter versus AN/PRC-152 Receiver F-D Plot

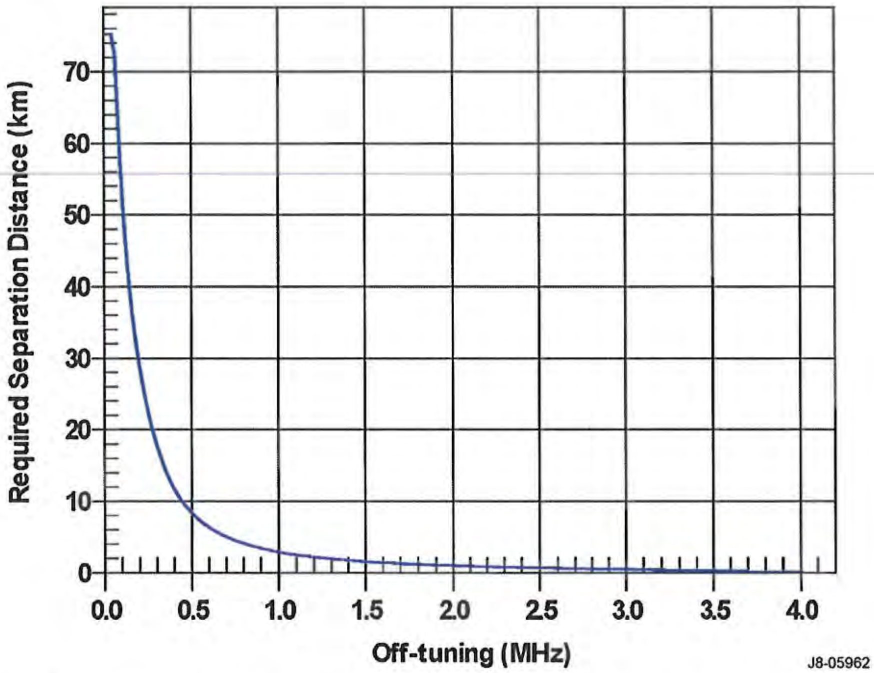

Figure A-46. AN/PRC-152 Transmitter versus FCC 18C26D Receiver F-D Plot

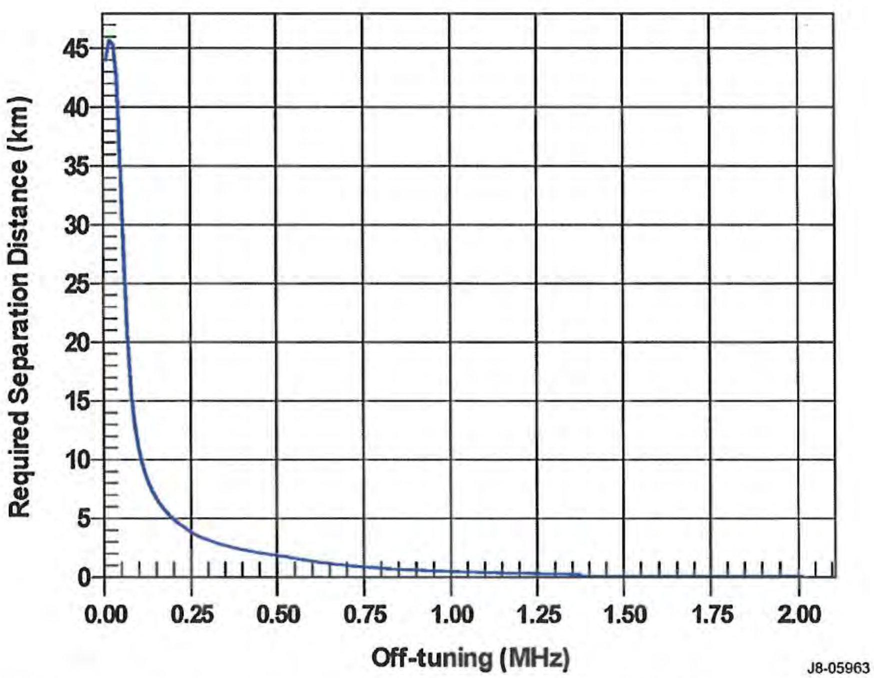

Figure A-47. FCC 42A238 Transmitter versus AN/PRC-152 Receiver F-D Plot

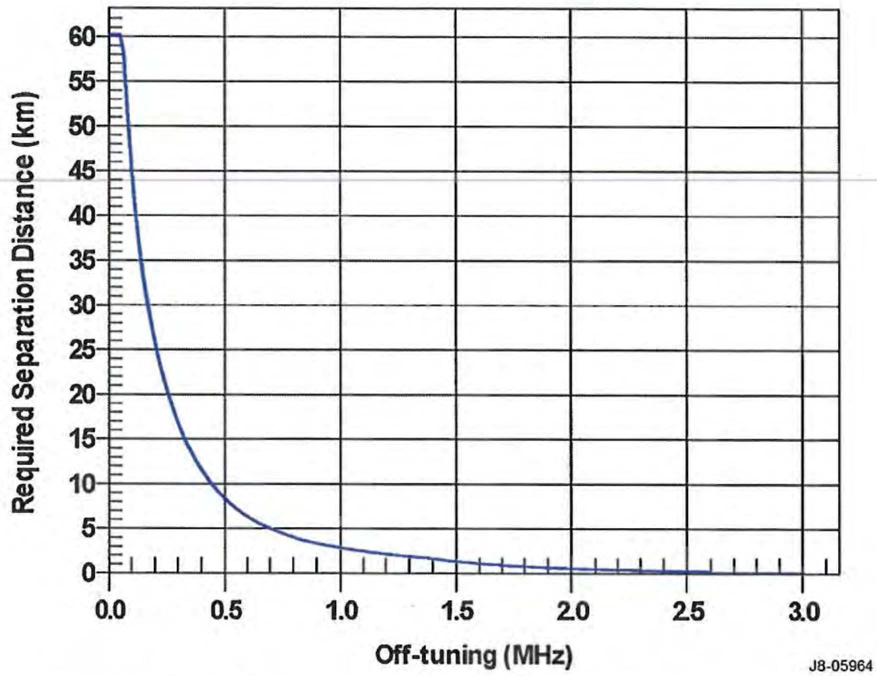

Figure A-48. AN/PRC-152 Transmitter versus FCC 42A238 Receiver F-D Plot

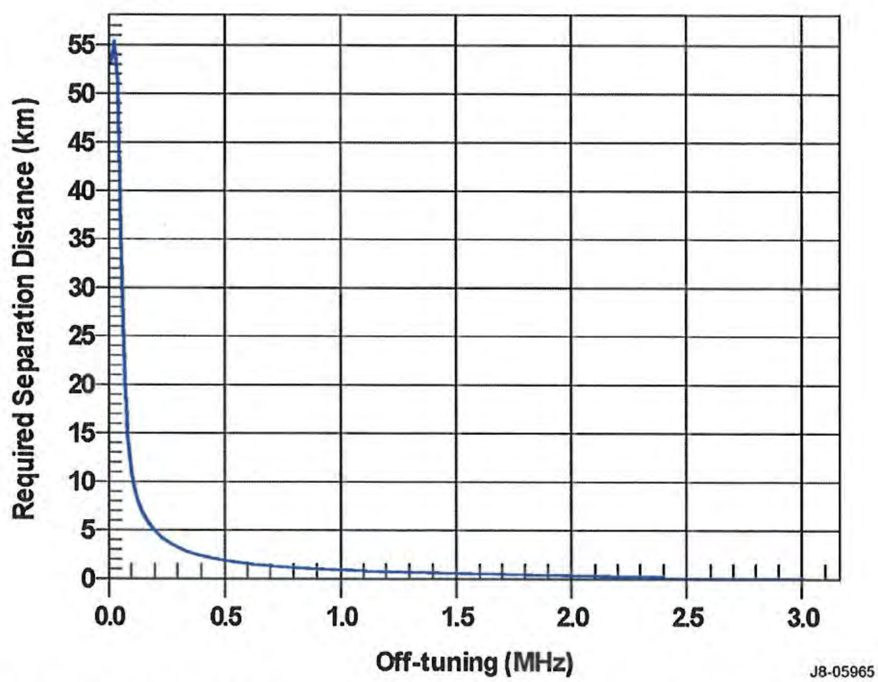

Figure A-49. FCC 185AA3 Transmitter versus AN/PRC-152 Receiver F-D Plot

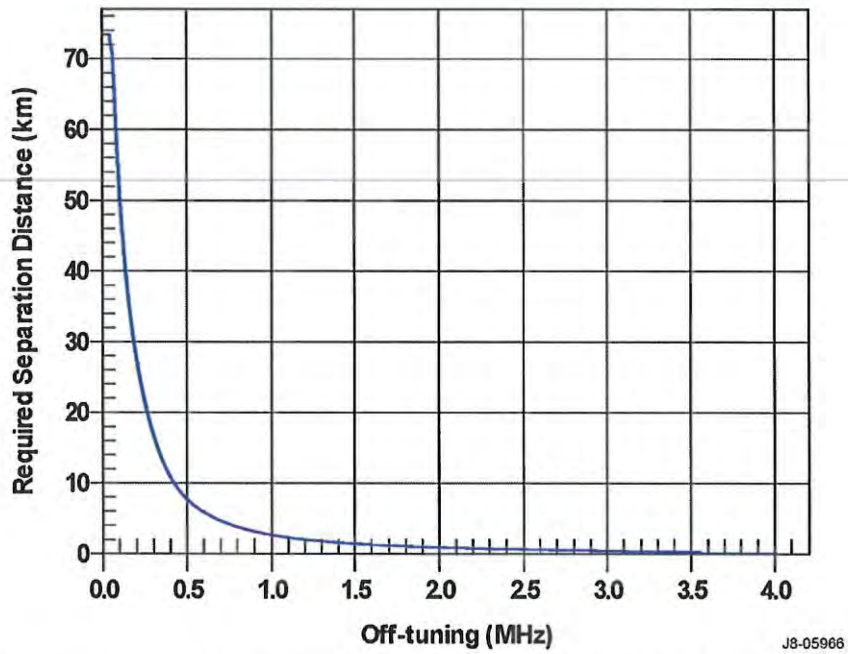

Figure A-50. AN/PRC-152 Transmitter versus FCC 185AA3 Receiver F-D Plot

A.8 AN/PRC-153

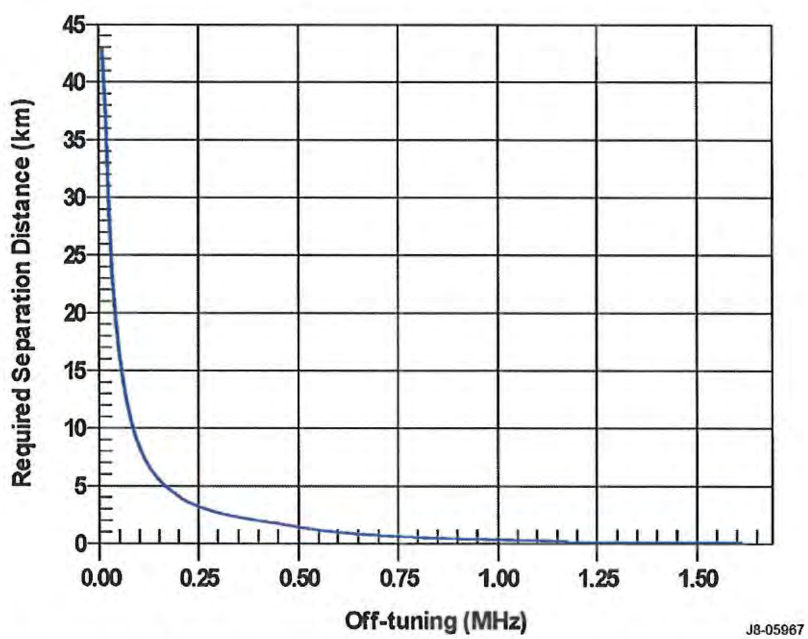

Figure A-51. FCC 42A238 Transmitter versus AN/PRC-153 Receiver F-D Plot

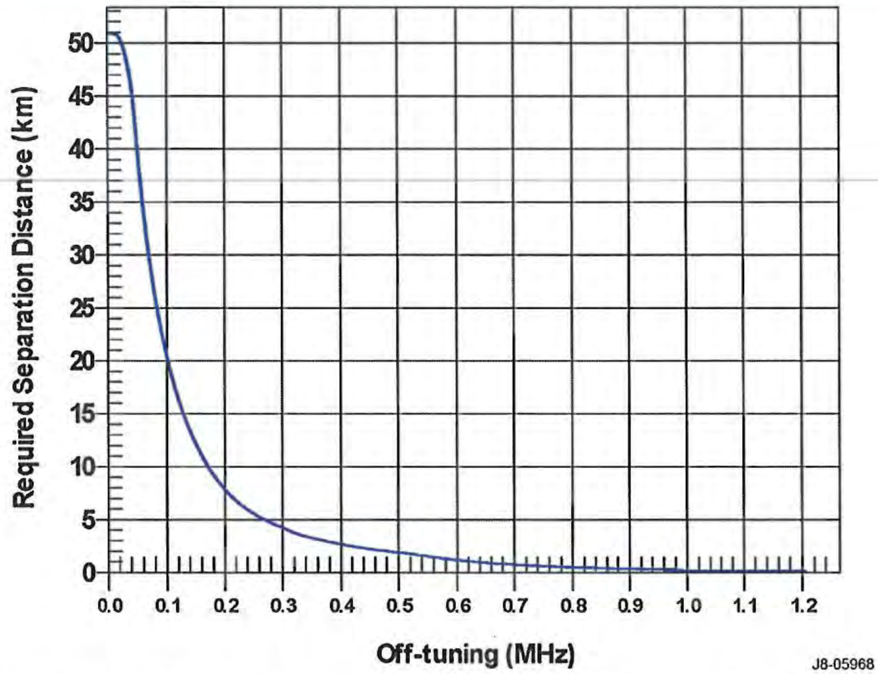

Figure A-52. AN/PRC-153 Transmitter versus FCC 42A238 Receiver F-D Plot

A.9 AN/VRC-92D

The calculated RFSs plus the guardbands between the AN/VRC-92D and EME systems on Tinian were within the frequency separation limits; therefore, no EMI issues were predicted for this system.

A.10 AN/VRC-103

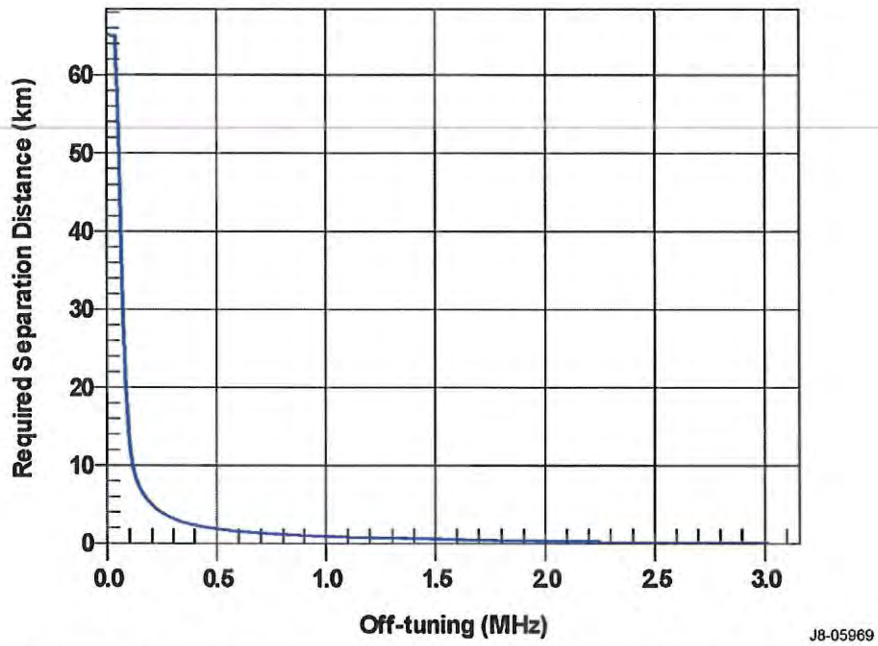

Figure A-53. DHS 096606 Transmitter versus AN/VRC-103 Receiver F-D Plot

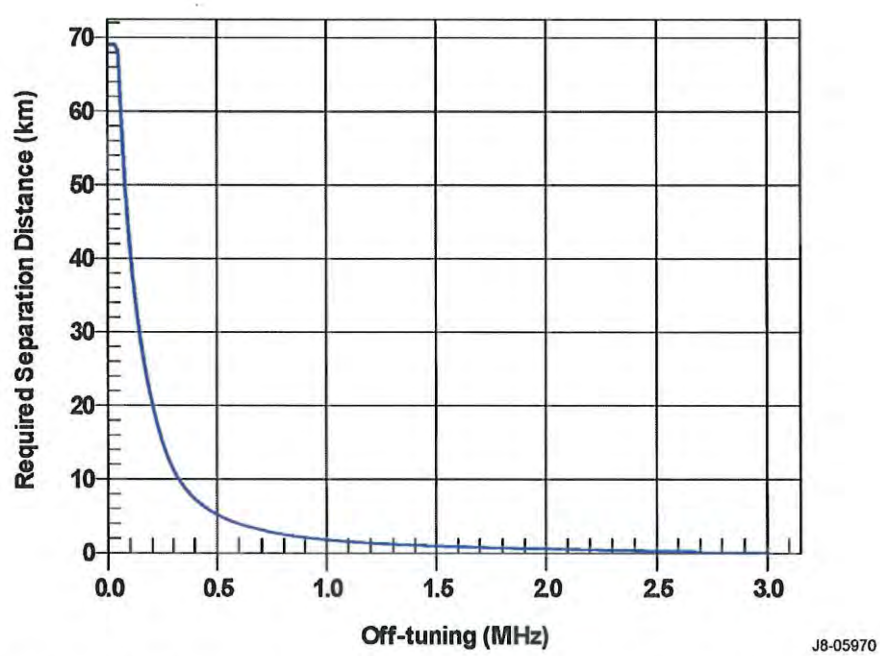

Figure A-54. AN/VRC-103 Transmitter versus DHS 096606 Receiver F-D Plot

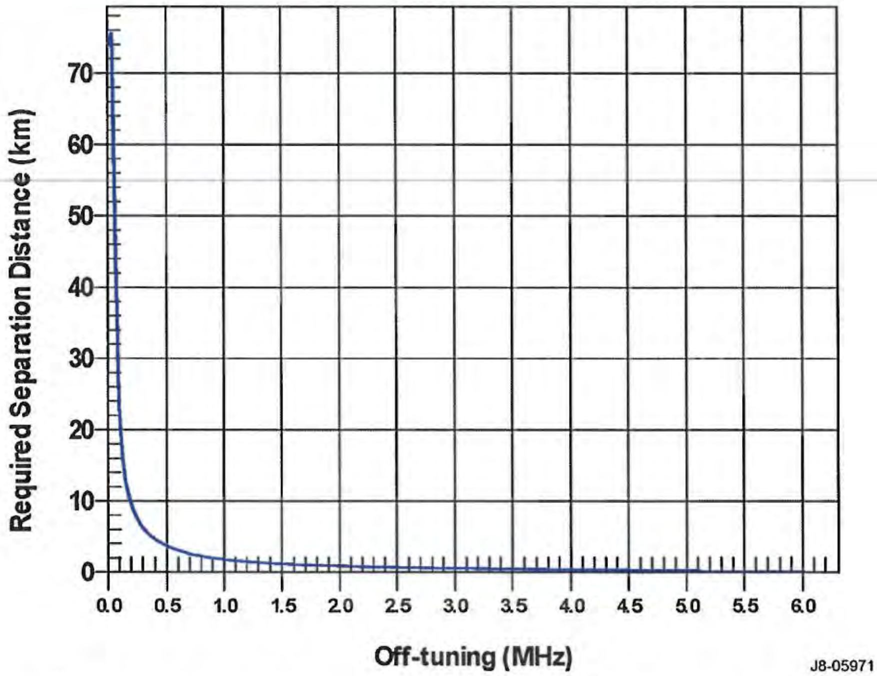

Figure A-55. FAA 061031 Transmitter versus AN/VRC-103 Receiver F-D Plot

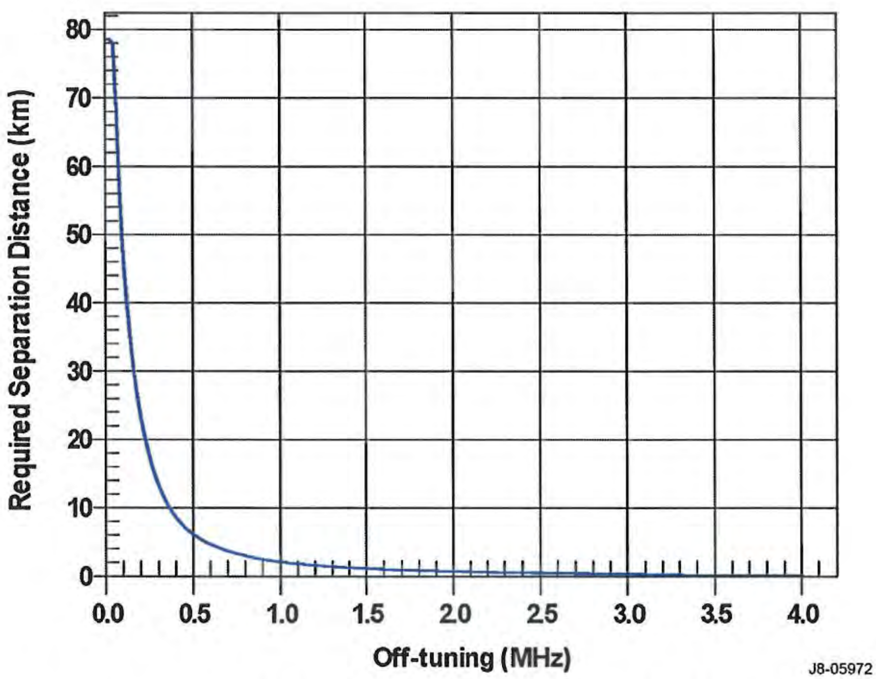

Figure A-56. AN/VRC-103 Transmitter versus FAA 061031 Receiver F-D Plot

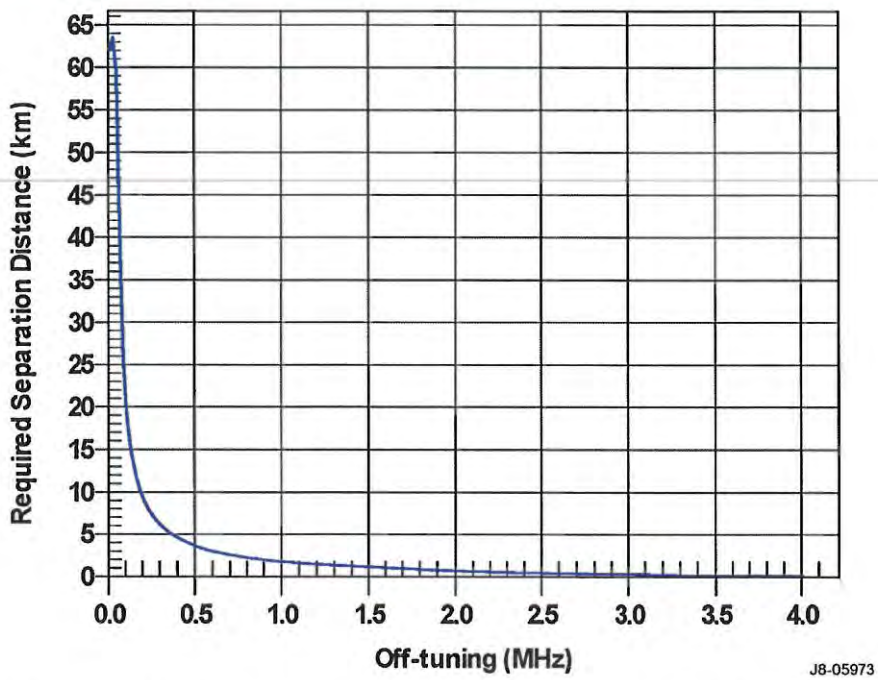

Figure A-57. FAA 061032 Transmitter versus AN/VRC-103 Receiver F-D Plot

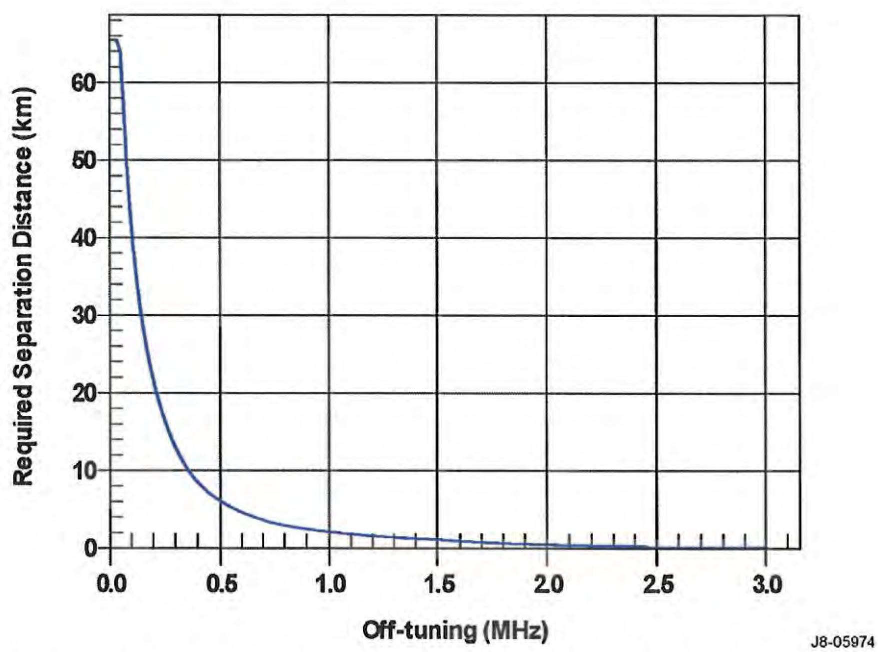

Figure A-58. AN/VRC-103 Transmitter versus FAA 061032 Receiver F-D Plot

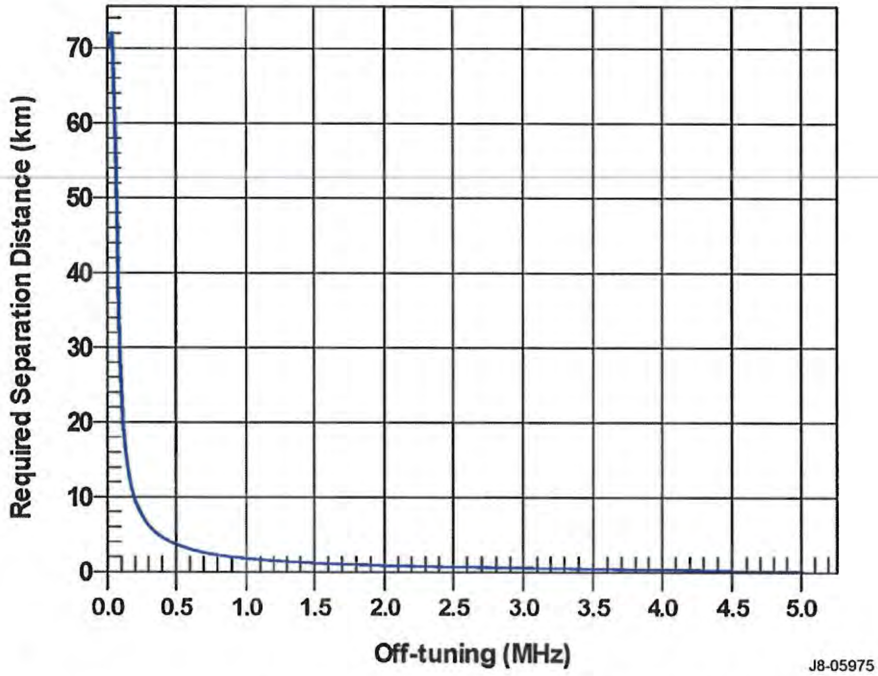

Figure A-59. FCC 3FBBFE Transmitter versus AN/VRC-103 Receiver F-D Plot

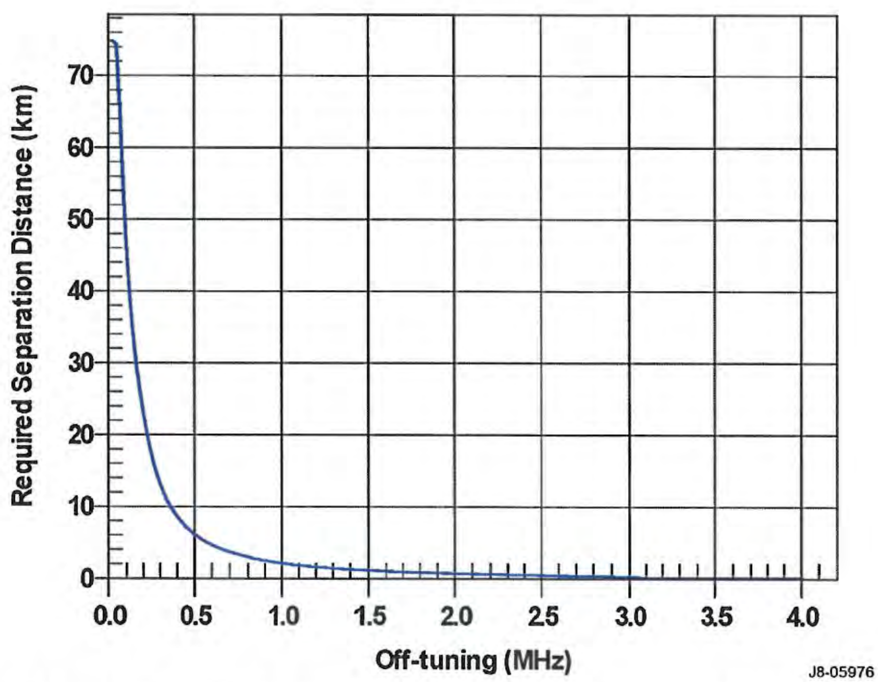

Figure A-60. AN/VRC-103 Transmitter versus FCC 3FBBFE Receiver F-D Plot

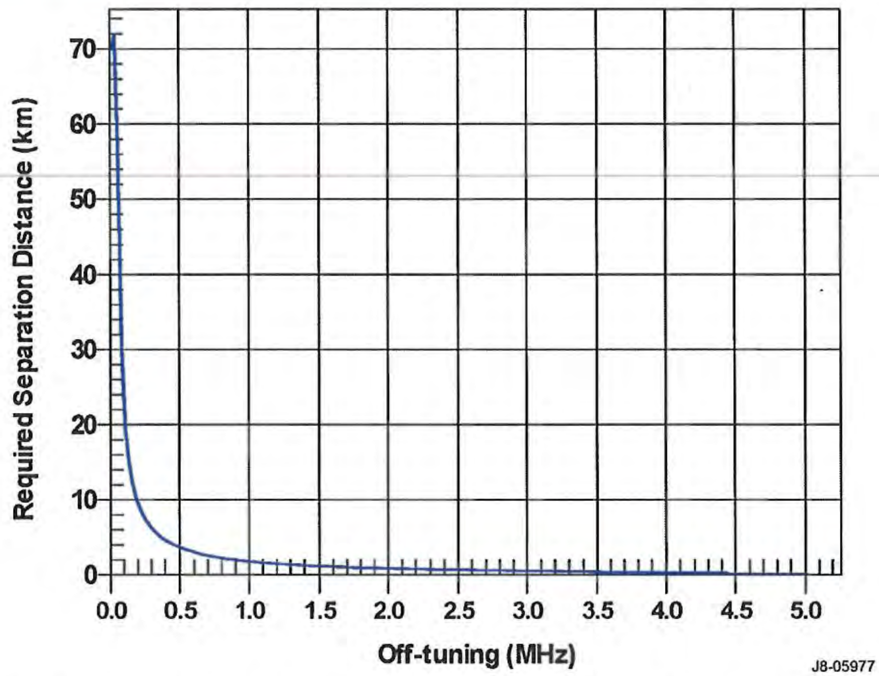

Figure A-61. FCC 18C26D Transmitter versus AN/VRC-103 Receiver F-D Plot

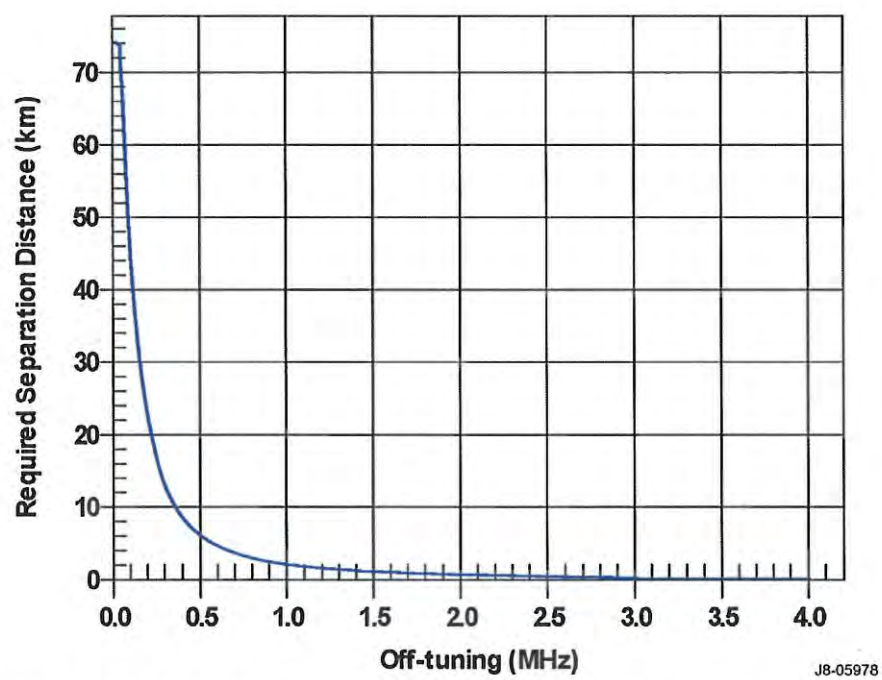

Figure A-62. AN/VRC-103 Transmitter versus FCC 18C26D Receiver F-D Plot

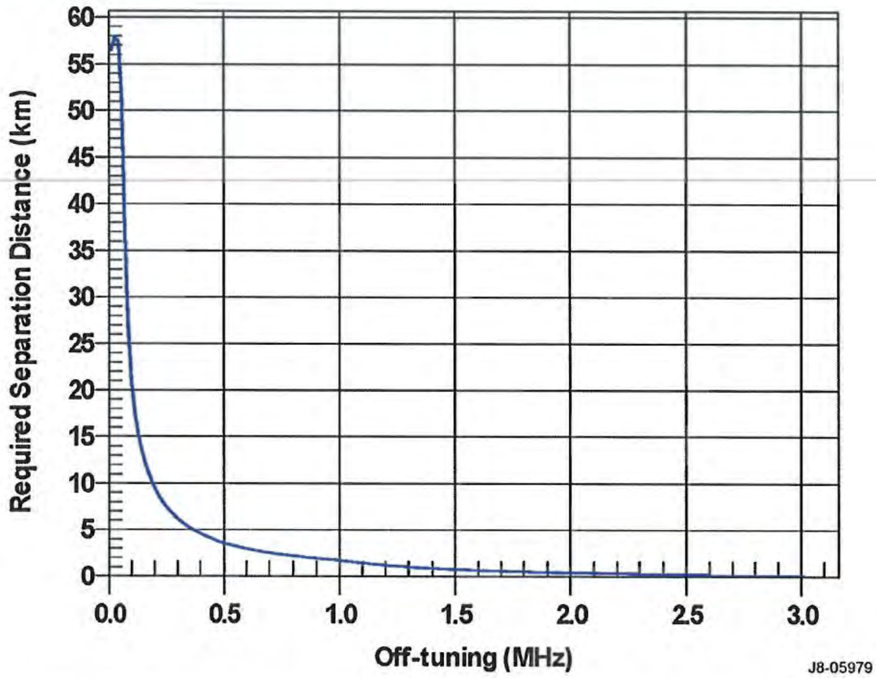

Figure A-63. FCC 42A238 Transmitter versus AN/VRC-103 Receiver F-D Plot

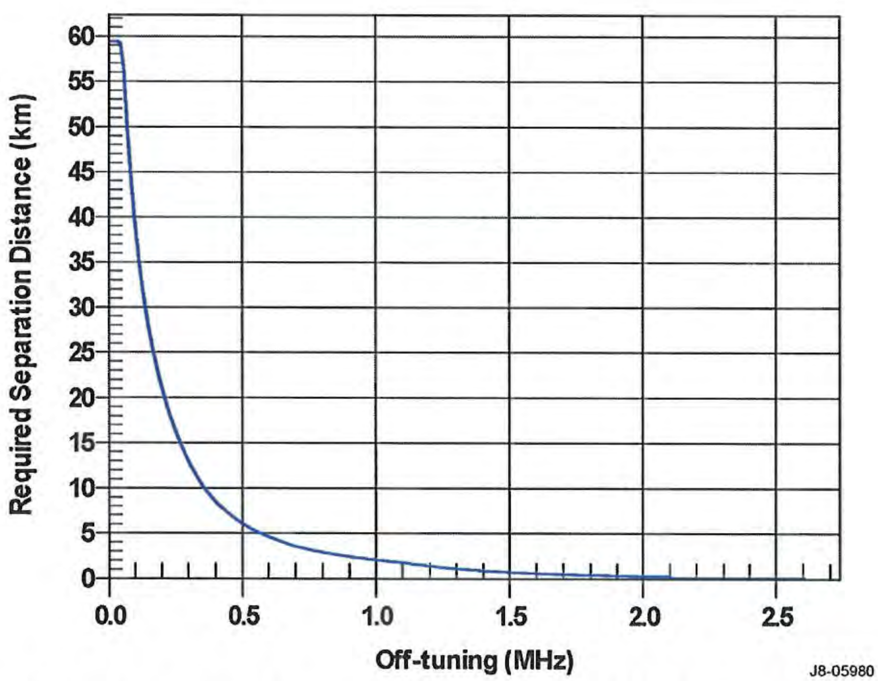

Figure A-64. AN/VRC-103 Transmitter versus FCC 42A238 Receiver F-D Plot

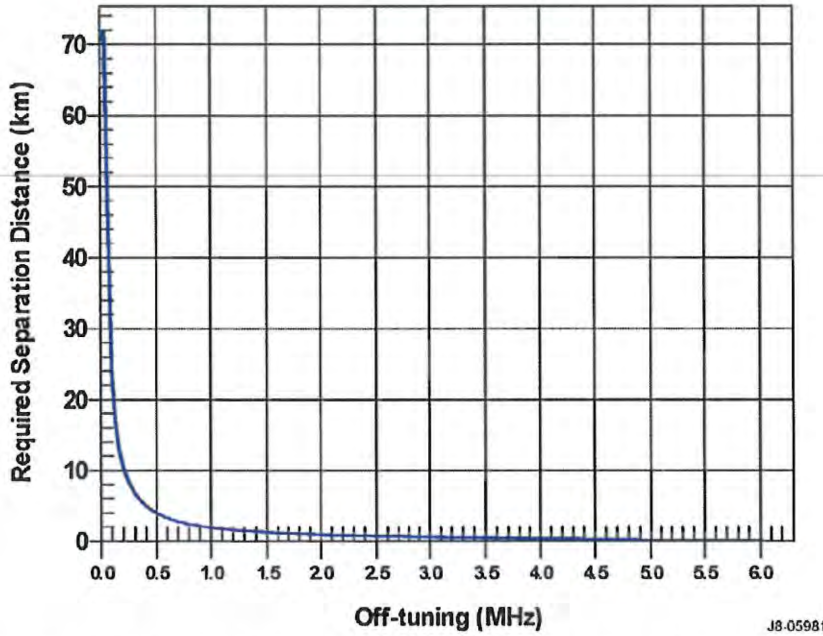

Figure A-65. FCC 185AA3 Transmitter versus AN/VRC-103 Receiver F-D Plot

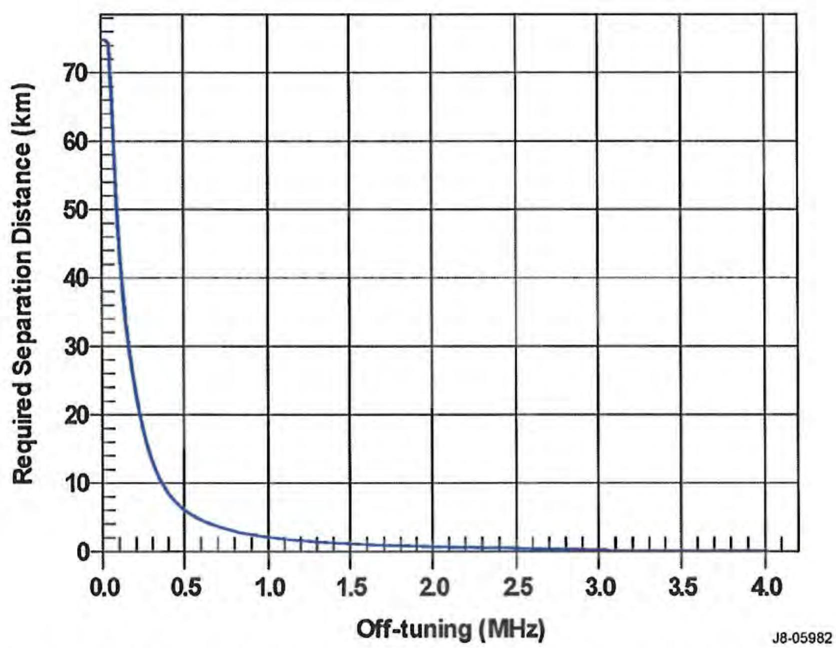

Figure A-66. AN/VRC-103 Transmitter versus FCC 185AA3 Receiver F-D Plot

A.11 AN/VRC-104

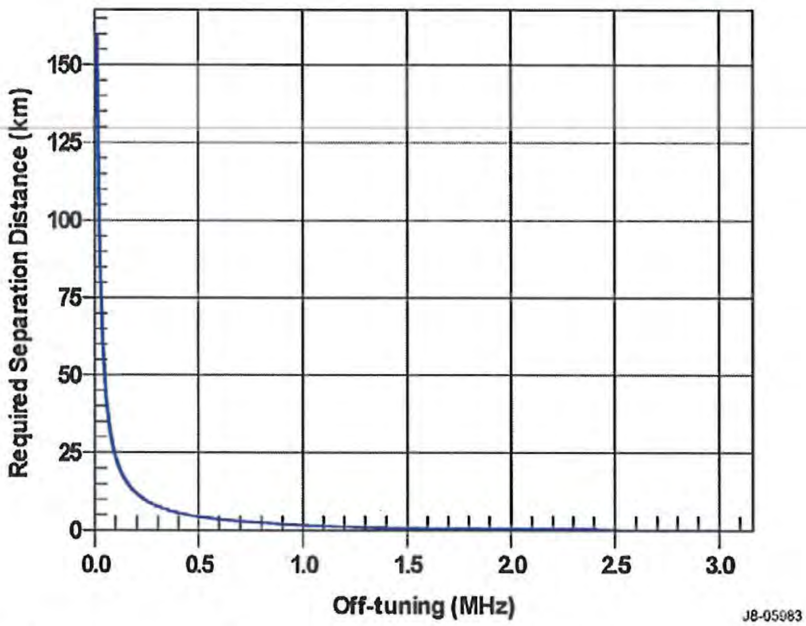

Figure A-67. NG 943370 Transmitter versus AN/VRC-104 Receiver F-D Plot

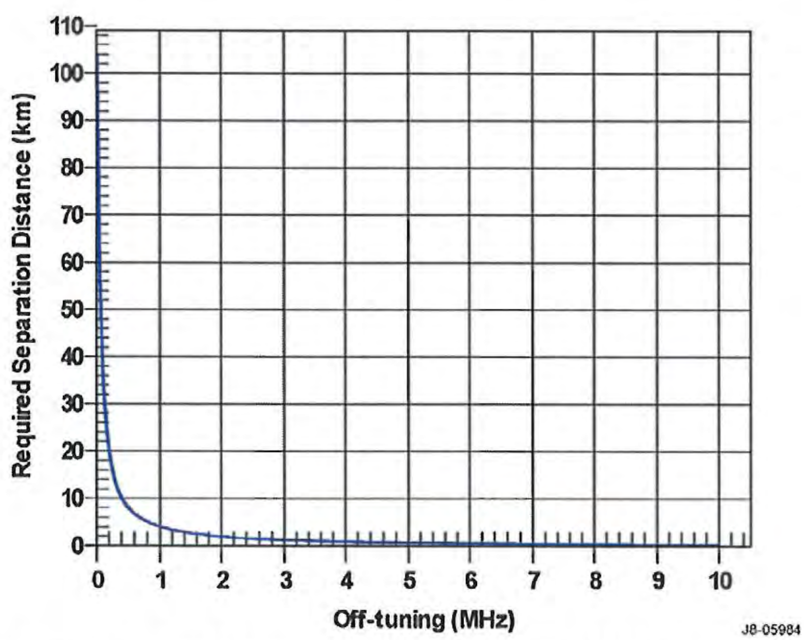

Figure A-68. AN/VRC-104 Transmitter versus NG 943370 Receiver F-D Plot

A.12 AN/VRC-110

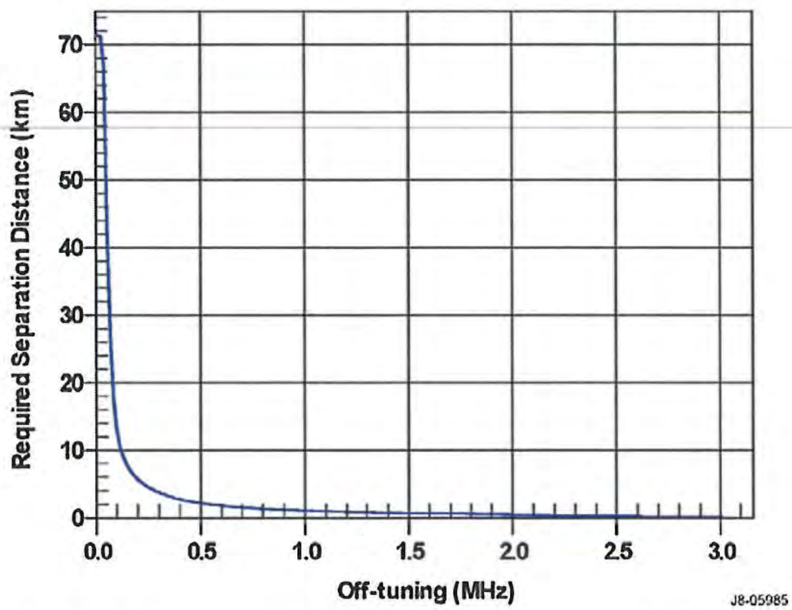

Figure A-69. DHS 096606 Transmitter versus AN/VRC-110 Receiver F-D Plot

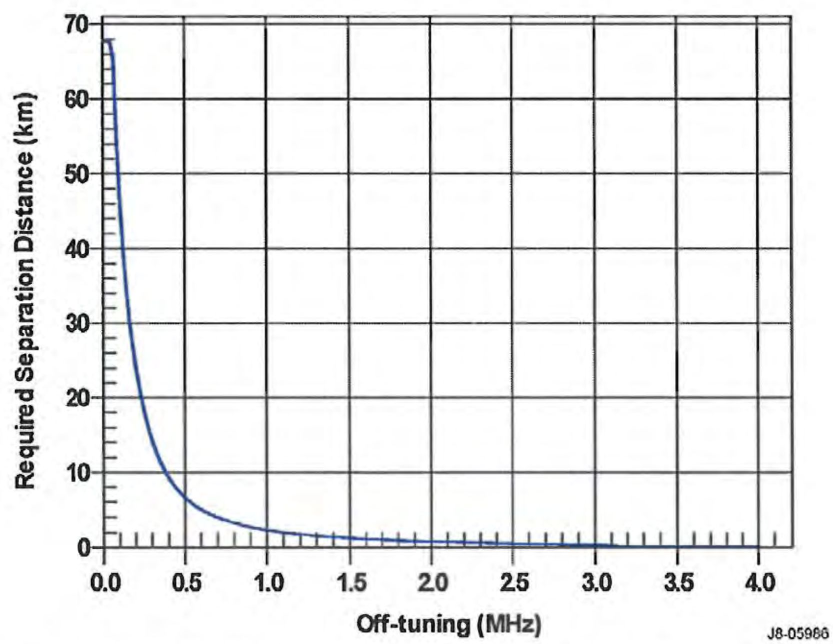

Figure A-70. AN/VRC-110 Transmitter versus DHS 096606 Receiver F-D Plot

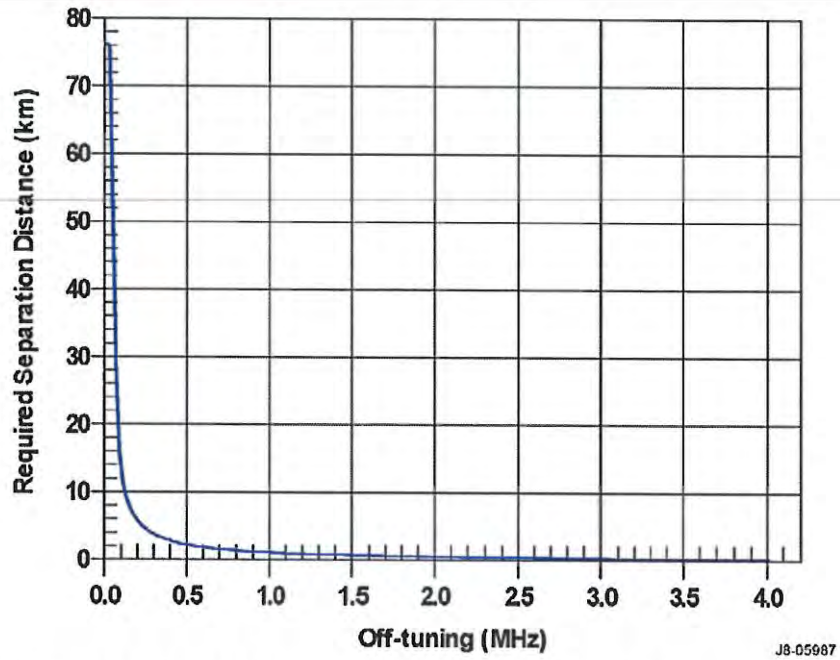

Figure A-71. FAA 061031 Transmitter versus AN/VRC-110 Receiver F-D Plot

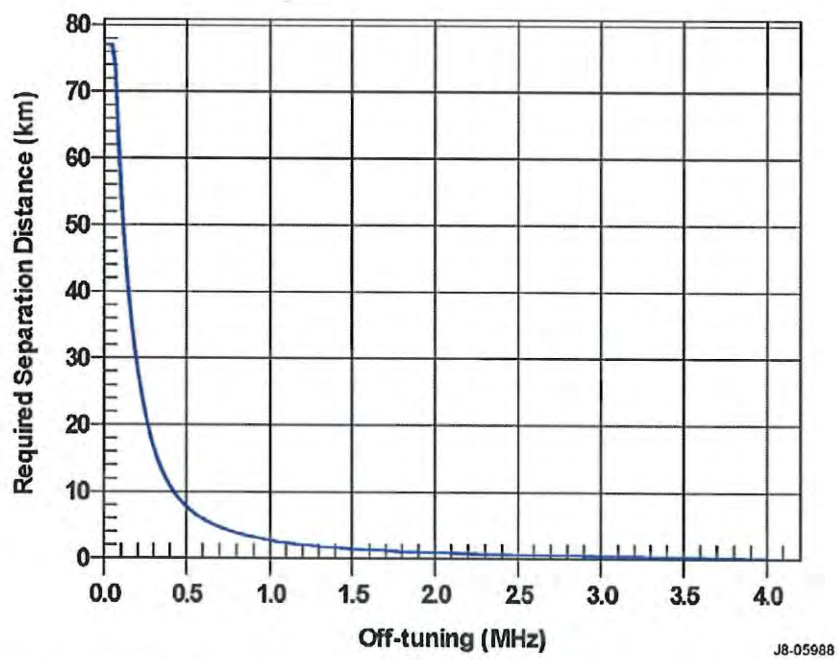

Figure A-72. AN/VRC-110 Transmitter versus FAA 061031 Receiver F-D Plot

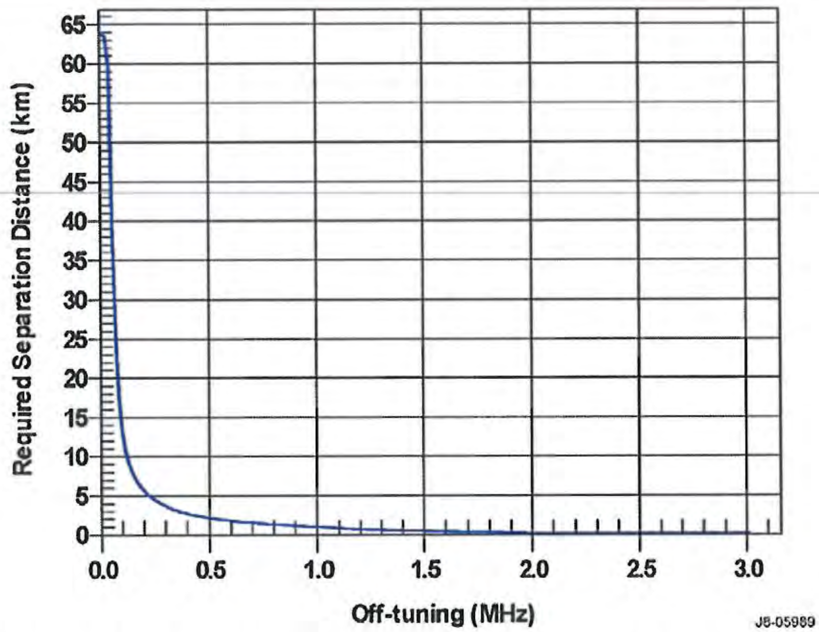

Figure A-73. FAA 061032 Transmitter versus AN/VRC-110 Receiver F-D Plot

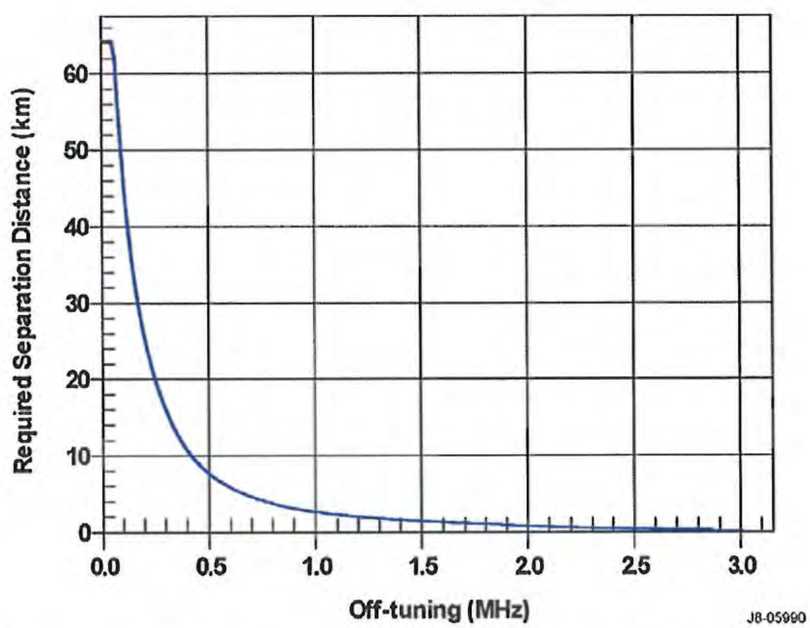

Figure A-74. AN/VRC-110 Transmitter versus FAA 061032 Receiver F-D Plot

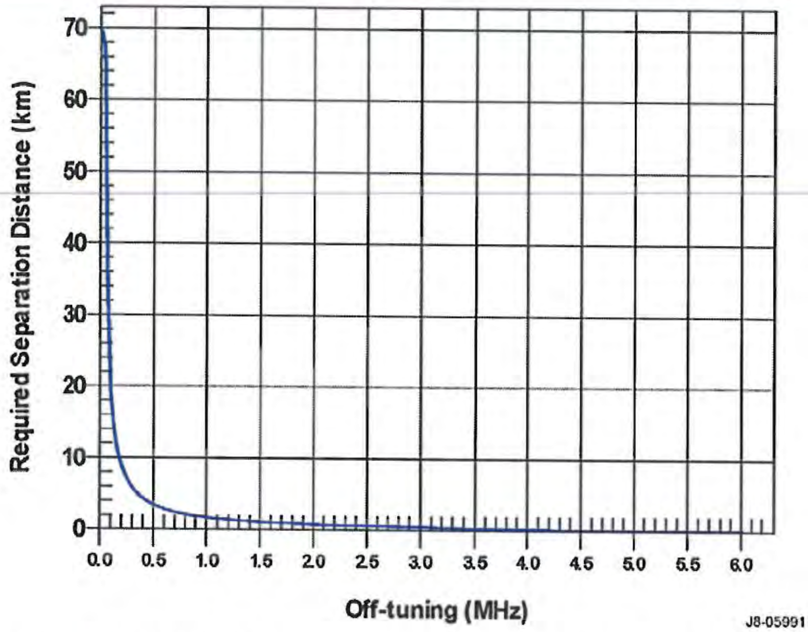

Figure A-75. FCC 3FBBFE Transmitter versus AN/VRC-110 Receiver F-D Plot

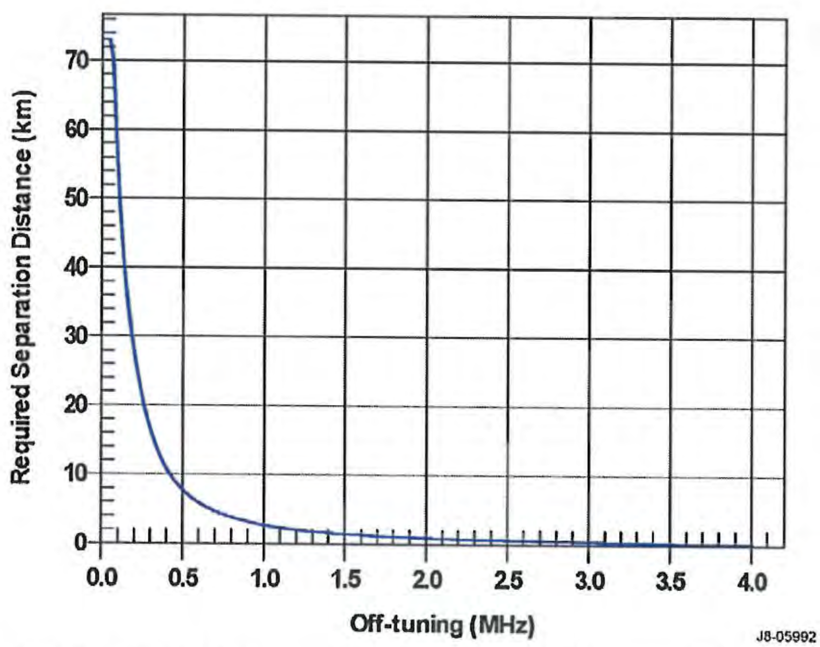

Figure A-76. AN/VRC-110 Transmitter versus FCC 3FBBFE Receiver F-D Plot

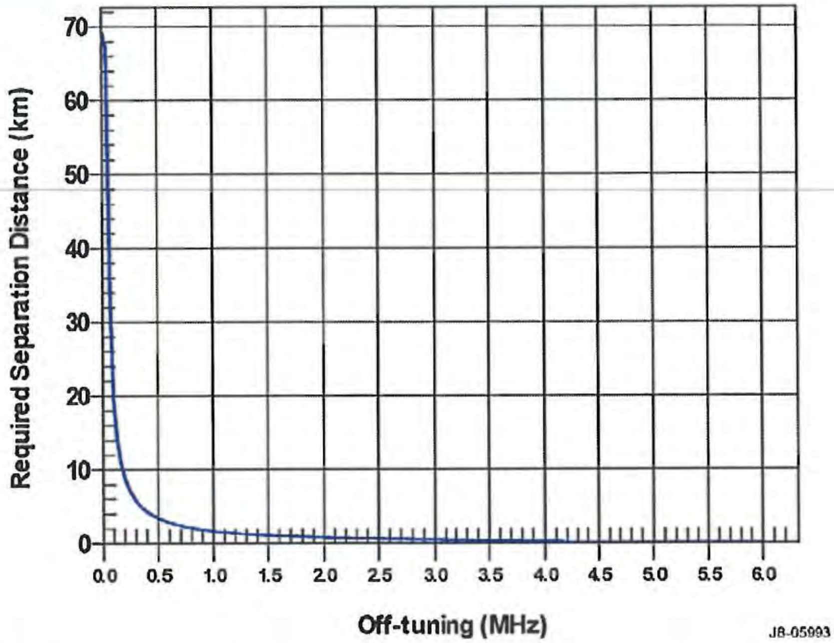

Figure A-77. FCC 18C26D Transmitter versus AN/VRC-110 Receiver F-D Plot

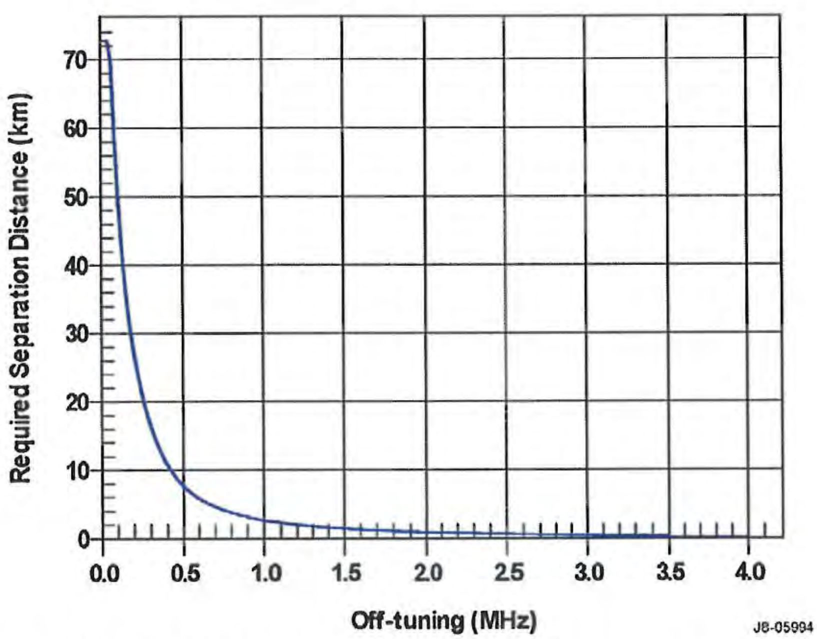

Figure A-78. AN/VRC-110 Transmitter versus FCC 18C26D Receiver F-D Plot

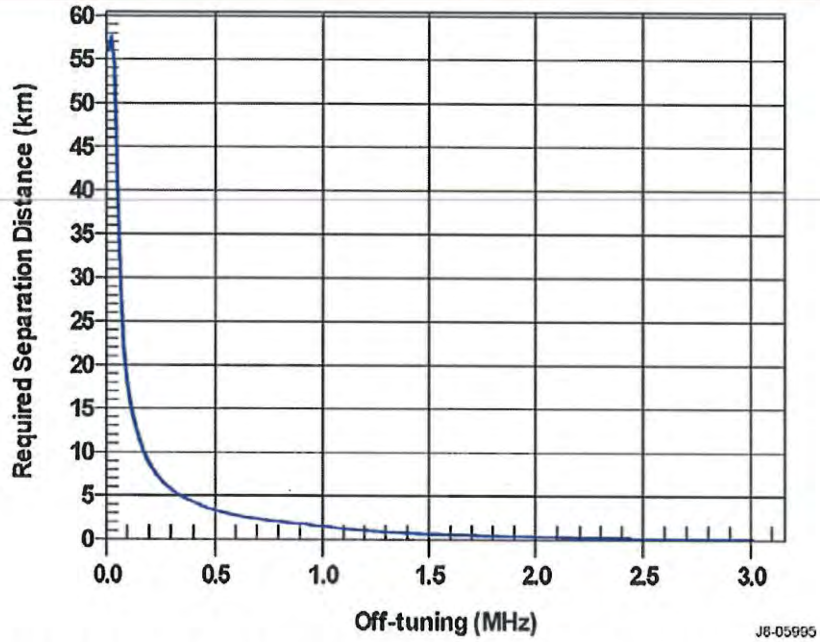

Figure A-79. FCC 42A238 Transmitter versus AN/VRC-110 Receiver F-D Plot

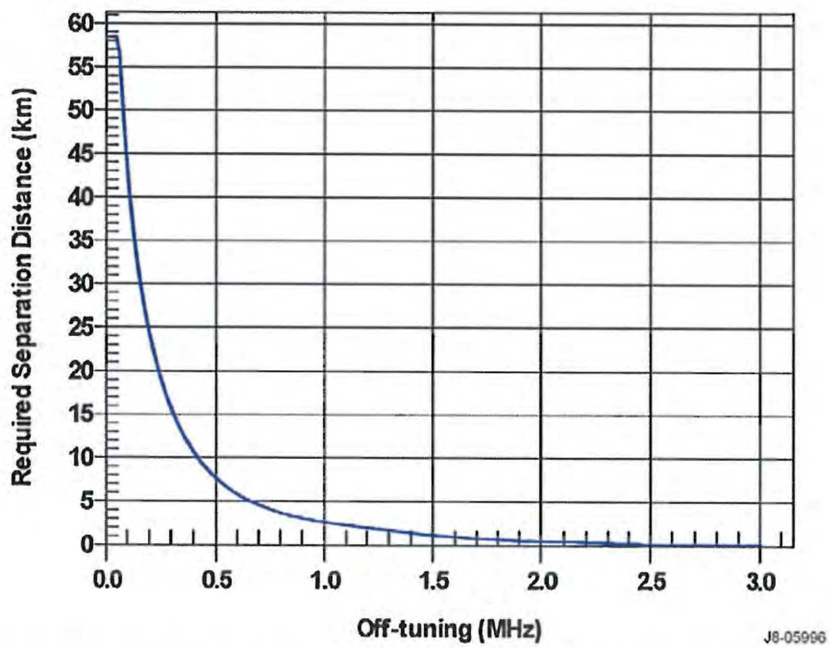

Figure A-80. AN/VRC-110 Transmitter versus FCC 42A238 Receiver F-D Plot

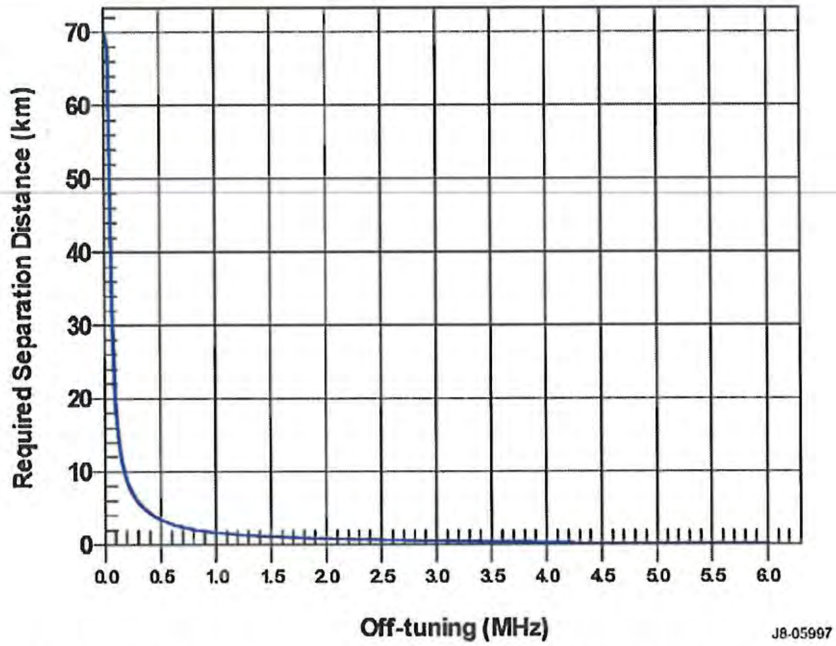

Figure A-81. FCC 185AA3 Transmitter versus AN/VRC-110 Receiver F-D Plot

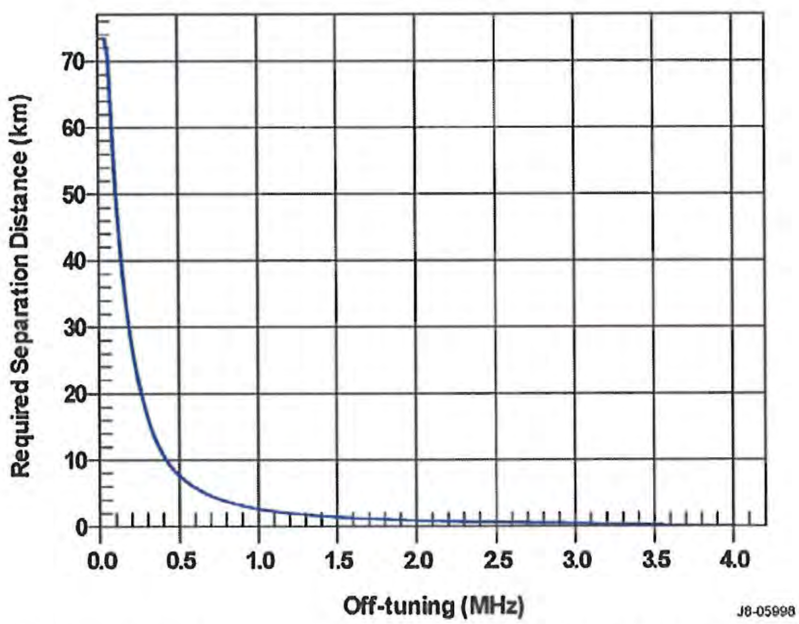

Figure A-82. AN/VRC-110 Transmitter versus FCC 185AA3 Receiver F-D Plot

A.13 AN/VRC-112

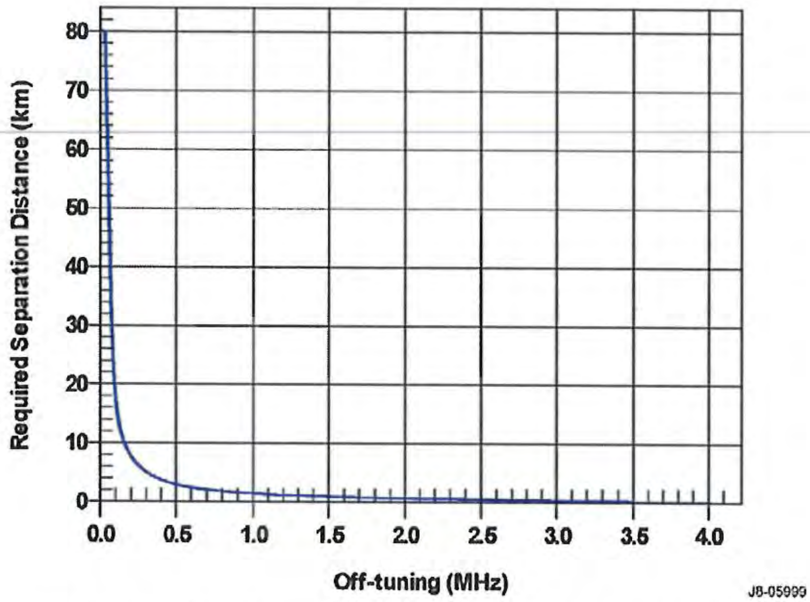

Figure A-83. DHS 096606 Transmitter versus AN/VRC-112 Receiver F-D Plot

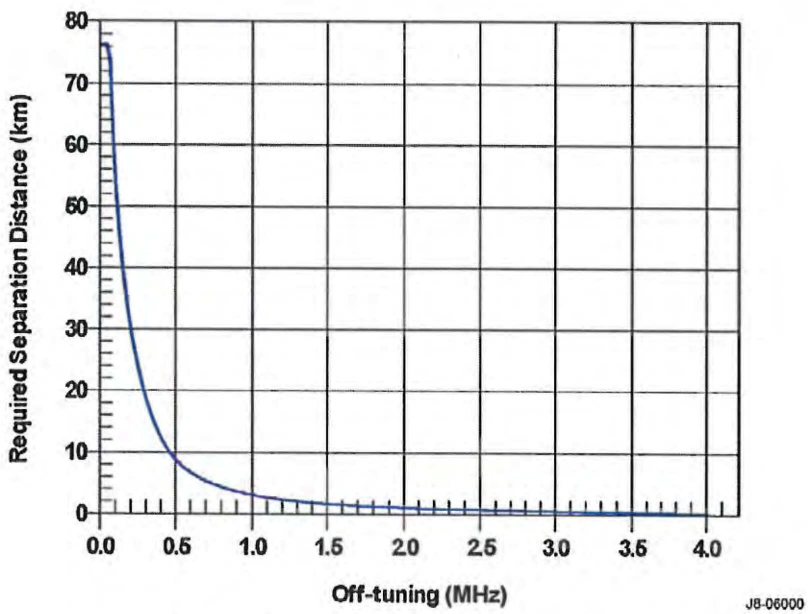

Figure A-84. AN/VRC-112 Transmitter versus DHS 096606 Receiver F-D Plot

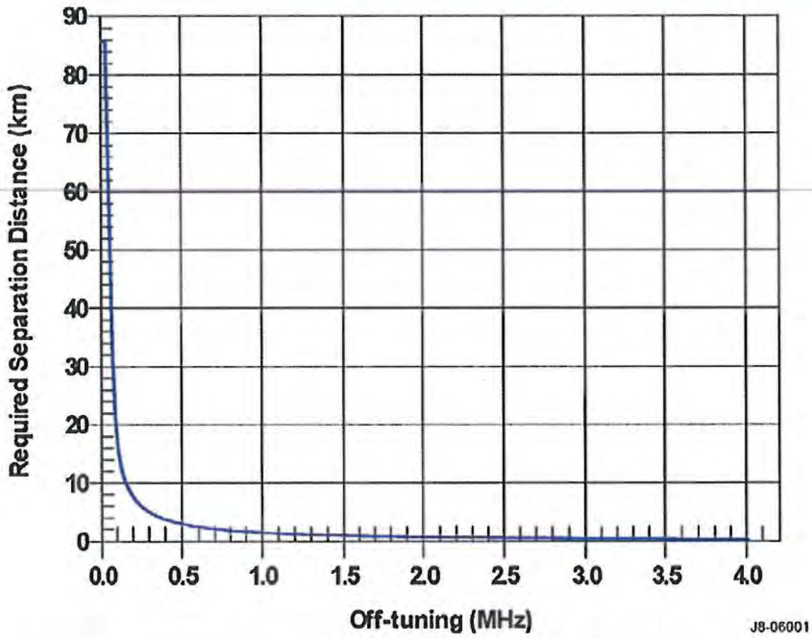

Figure A-85. FAA 061031 Transmitter versus AN/VRC-112 Receiver F-D Plot

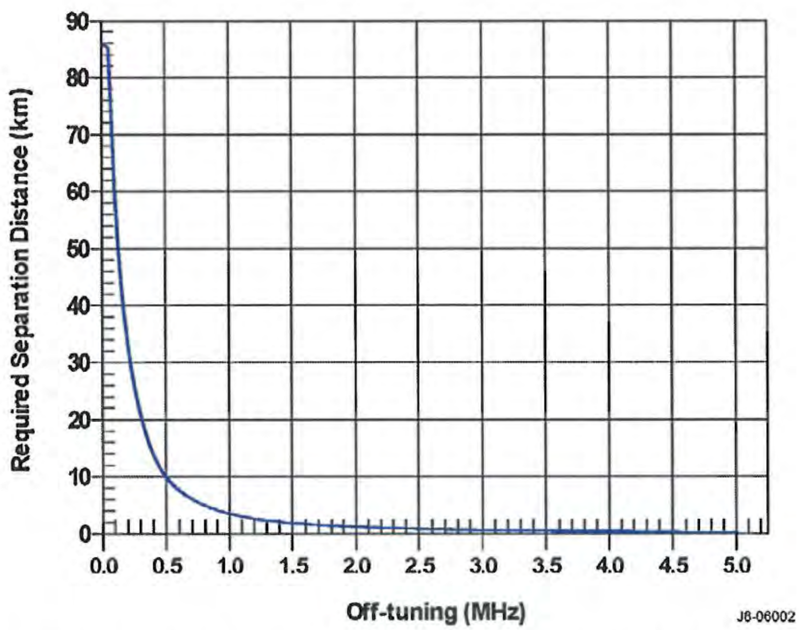

Figure A-86. AN/VRC-112 Transmitter versus FAA 061031 Receiver F-D Plot

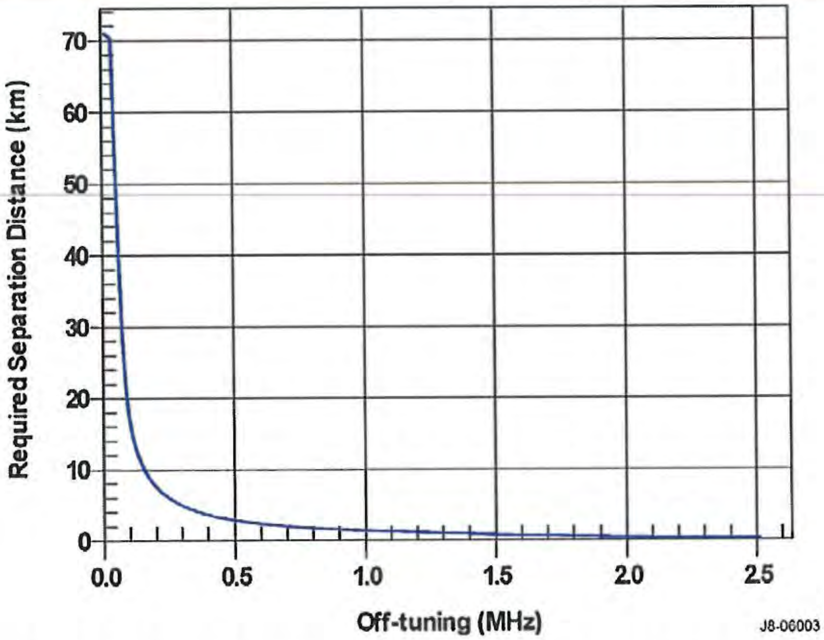

Figure A-87. FAA 061032 Transmitter versus AN/VRC-112 Receiver F-D Plot

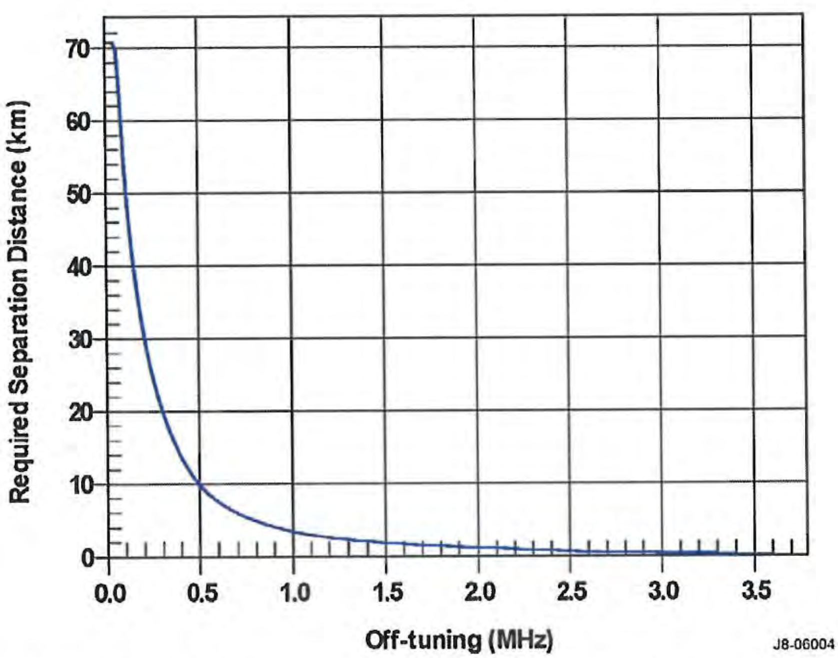

Figure A-88. AN/VRC-112 Transmitter versus FAA 061032 Receiver F-D Plot

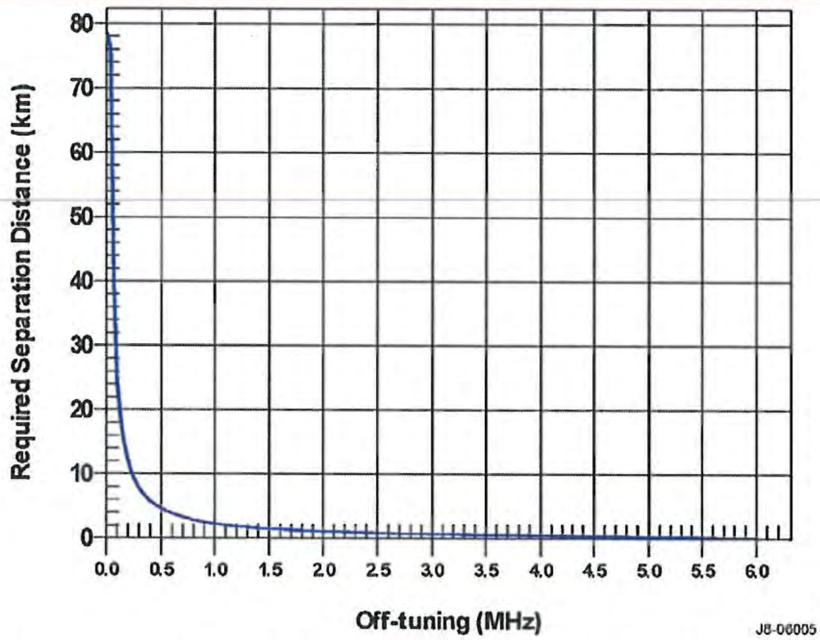

Figure A-89. FCC 3FBBFE Transmitter versus AN/VRC-112 Receiver F-D Plot

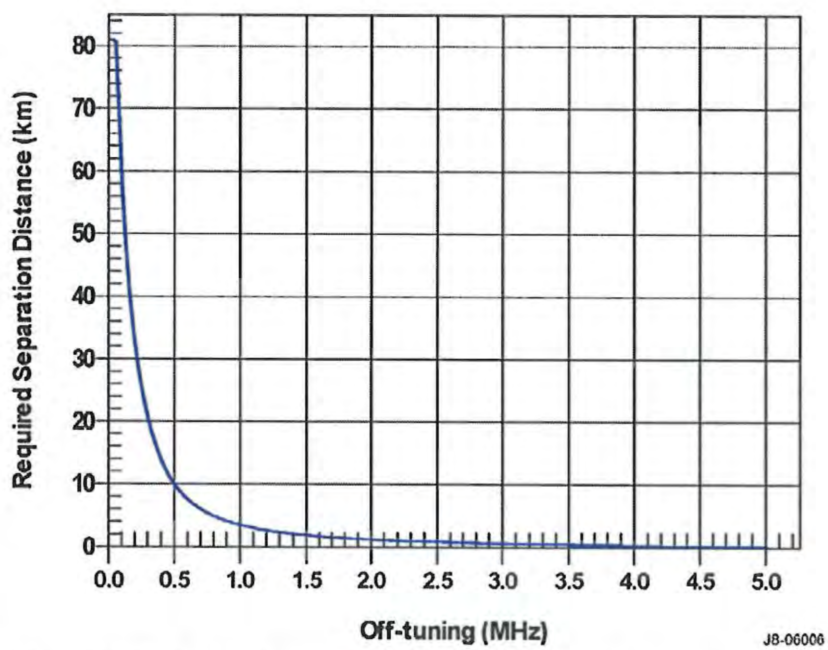

Figure A-90. AN/VRC-112 Transmitter versus FCC 3FBBFE Receiver F-D Plot

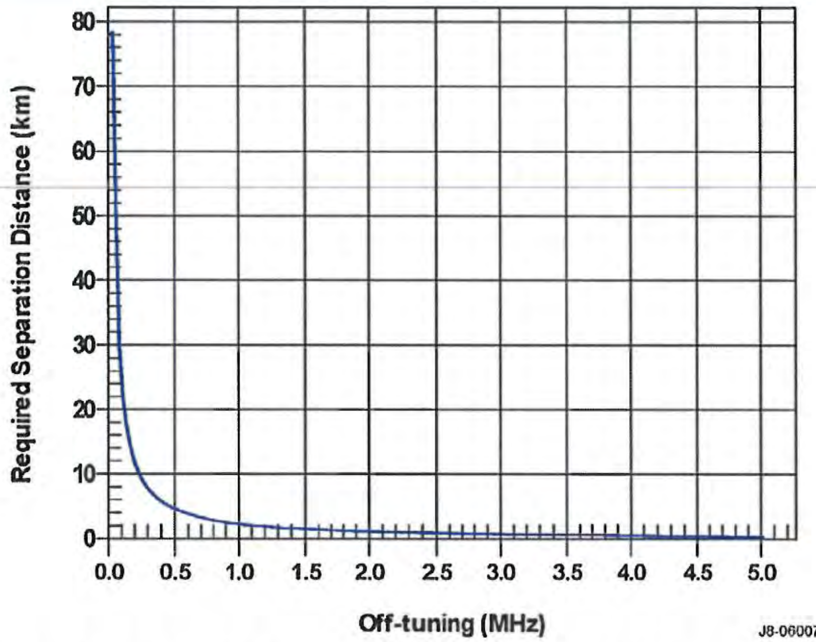

Figure A-91. FCC 18C26D Transmitter versus AN/VRC-112 Receiver F-D Plot

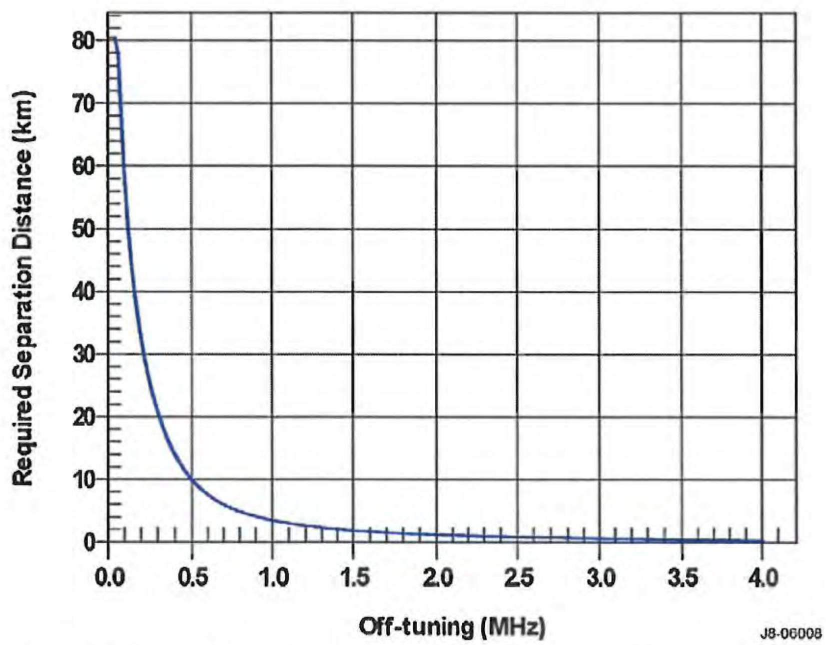

Figure A-92. AN/VRC-112 Transmitter versus FCC 18C26D Receiver F-D Plot

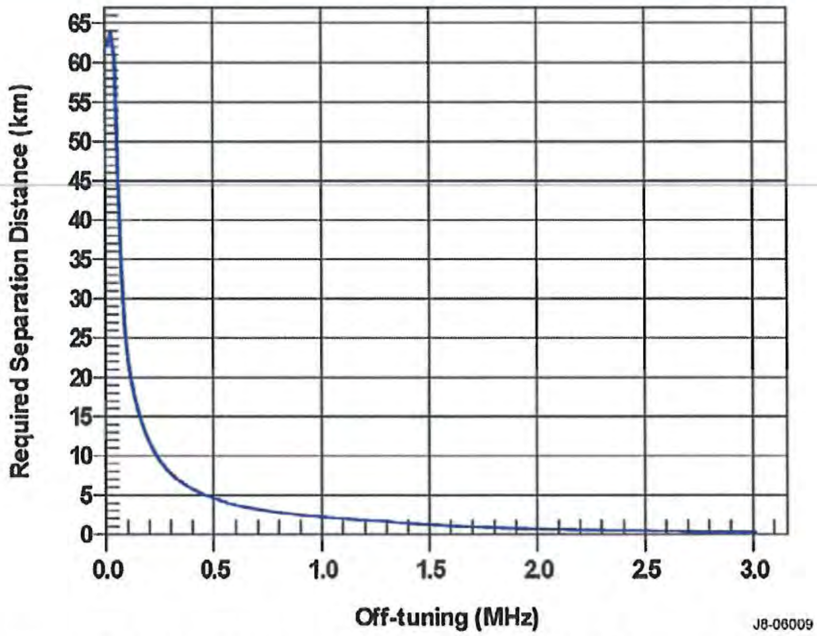

Figure A-93. FCC 42A238 Transmitter versus AN/VRC-112 Receiver F-D Plot

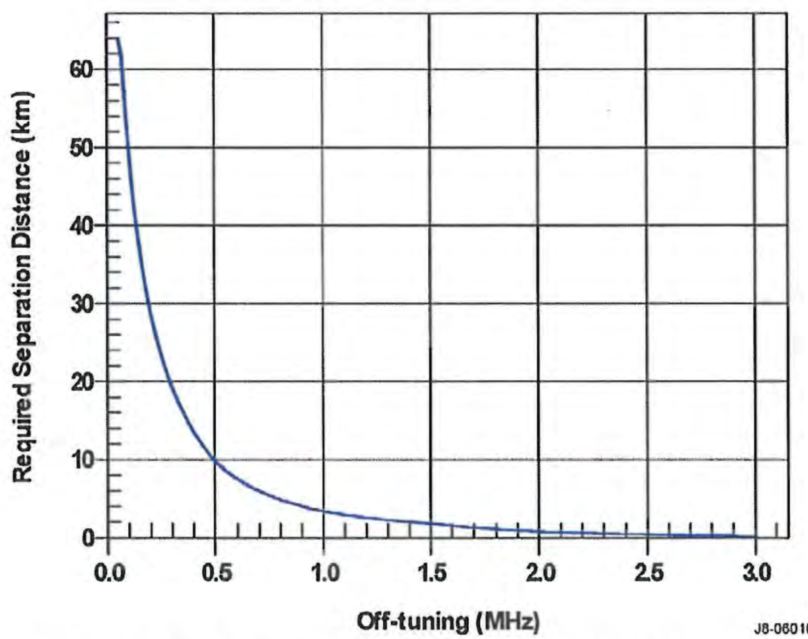

Figure A-94. AN/VRC-112 Transmitter versus FCC 42A238 Receiver F-D Plot

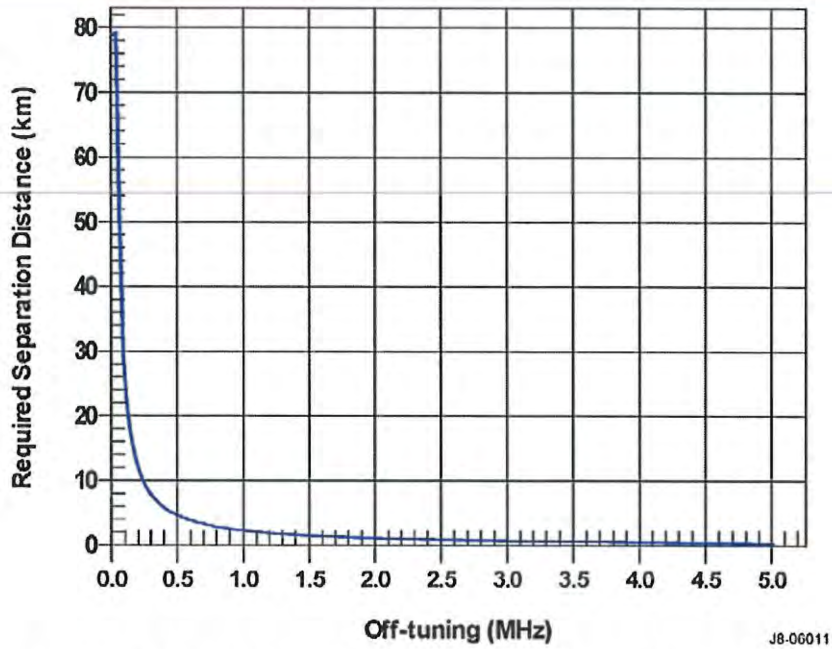

Figure A-95. FCC 185AA3 Transmitter versus AN/VRC-112 Receiver F-D Plot

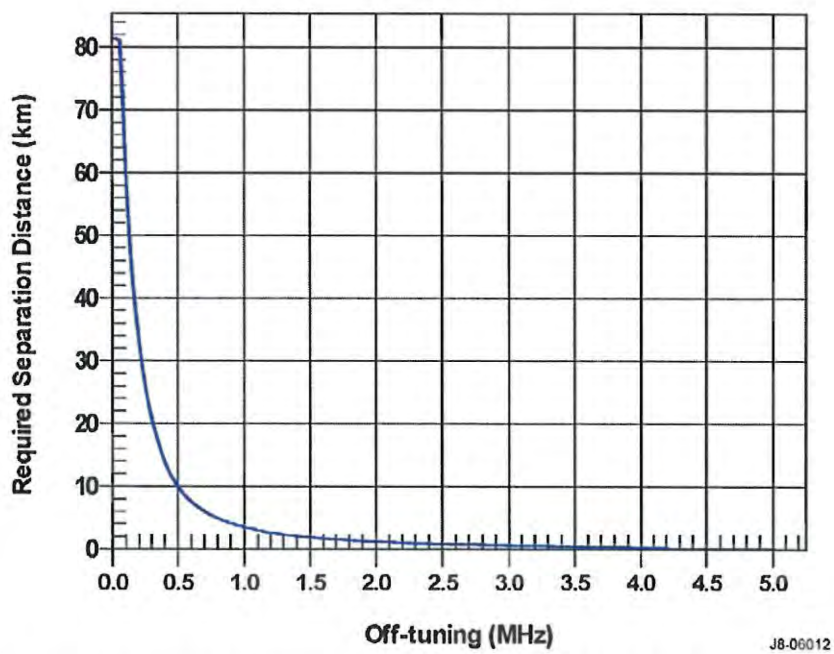

Figure A-96. AN/VRC-112 Transmitter versus FCC 185AA3 Receiver F-D Plot

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APPENDIX B. F-D PLOTS FOR USMC AND EME SYSTEMS ON PAGAN

This section contains the F-D plots for the USMC and EME systems on Pagan Island. The RFS data points in the F-D plots do not include the 50 MHz guardband.

B.1 AN/MRC-145

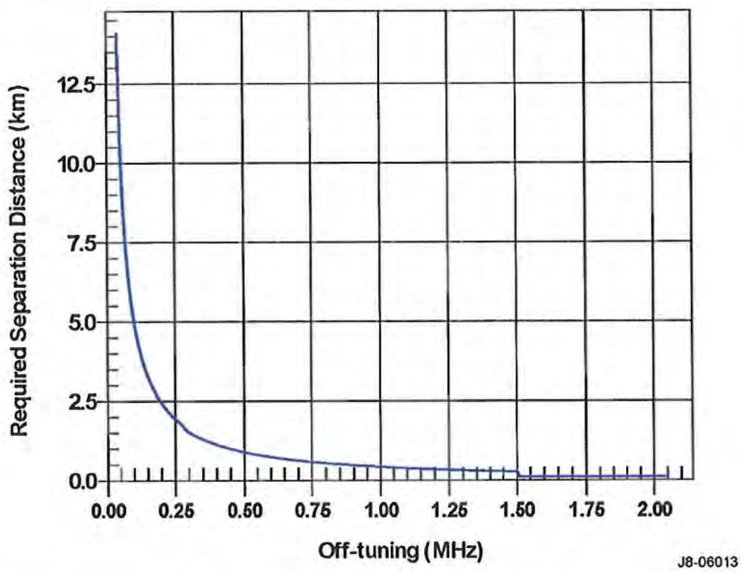

Figure B-1. I 104160 Transmitter versus AN/MRC-145 Receiver F-D Plot

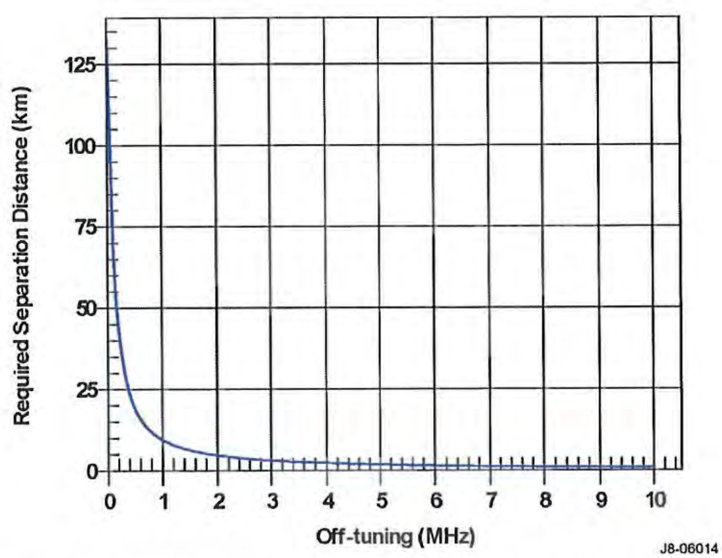

Figure B-2. AN/MRC-145 Transmitter versus I 104160 Receiver F-D Plot

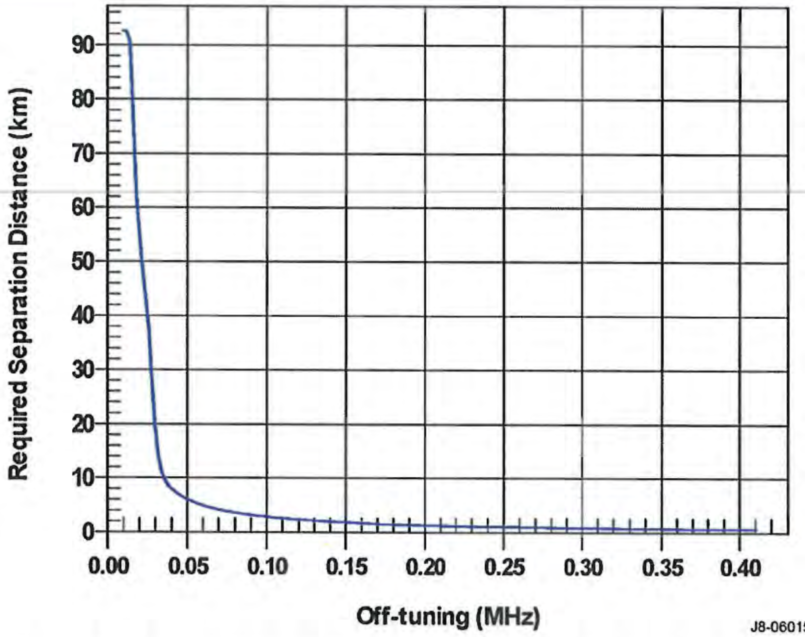

Figure B-3. I 104161 Transmitter versus AN/MRC-145 Receiver F-D Plot

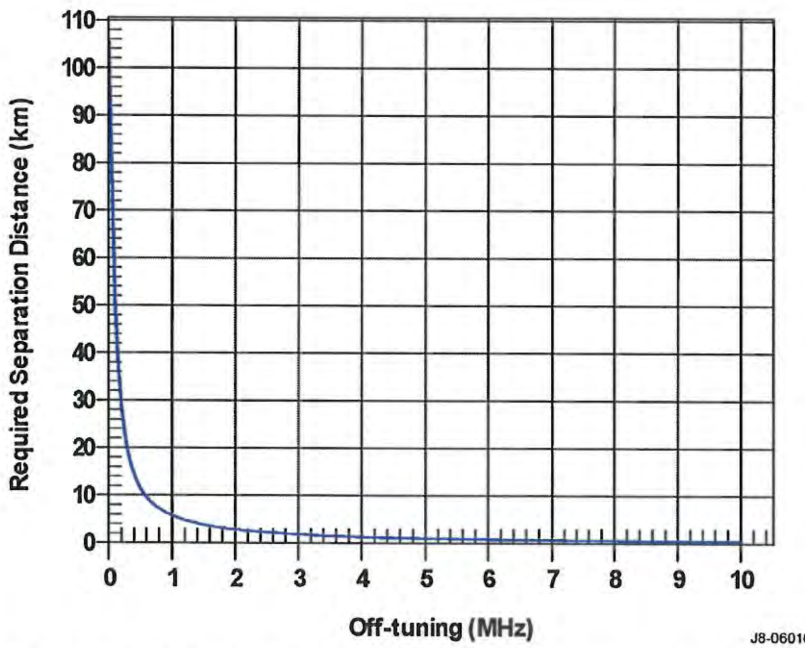

Figure B-4. AN/MRC-145 Transmitter versus I 104161 Receiver F-D Plot

B.2 AN/MRC-148

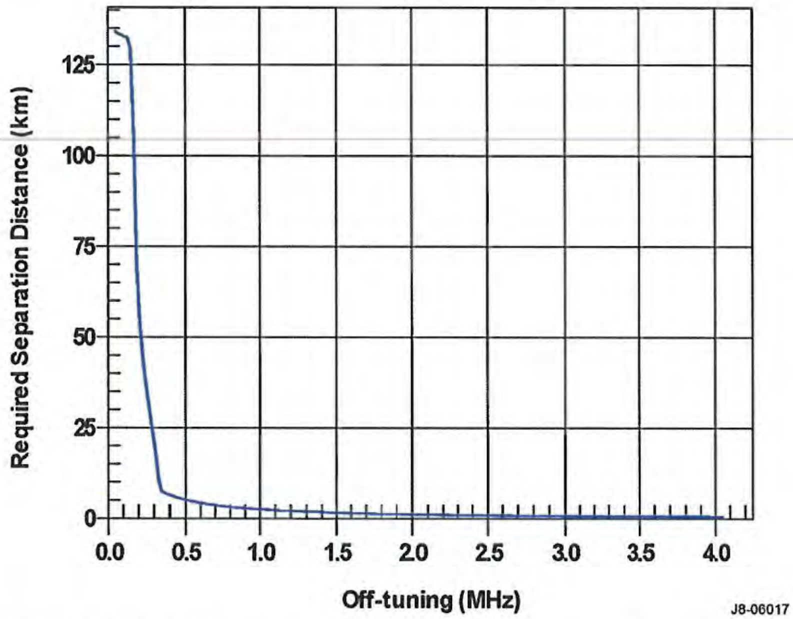

Figure B-5. I 104160 Transmitter versus AN/MRC-148 Receiver F-D Plot

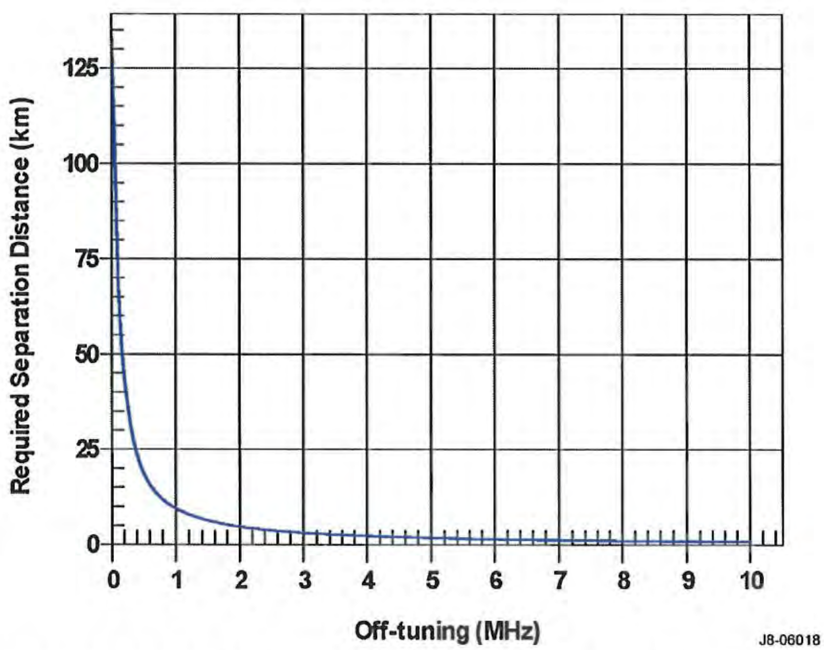

Figure B-6. AN/MRC-148 Transmitter versus I 104160 Receiver F-D Plot

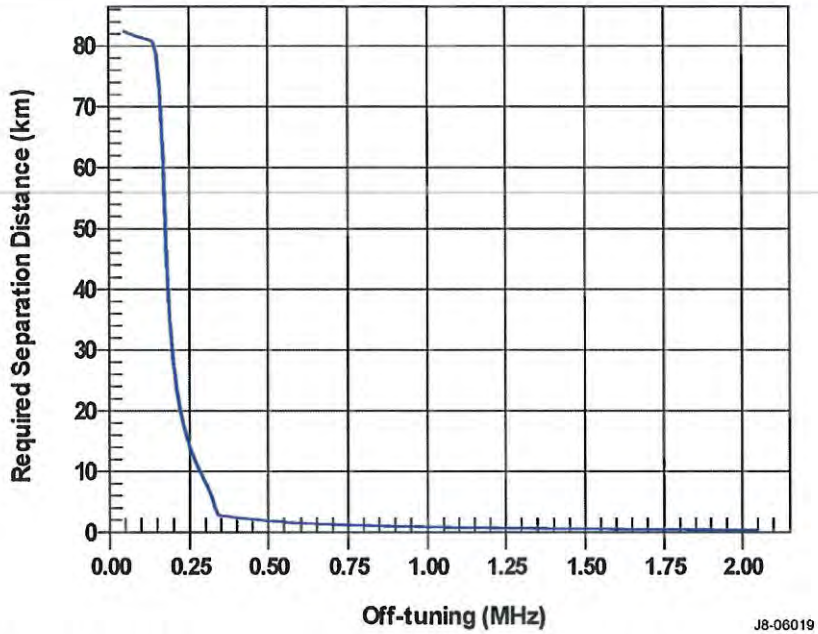

Figure B-7. I 104161 Transmitter versus AN/MRC-148 Receiver F-D Plot

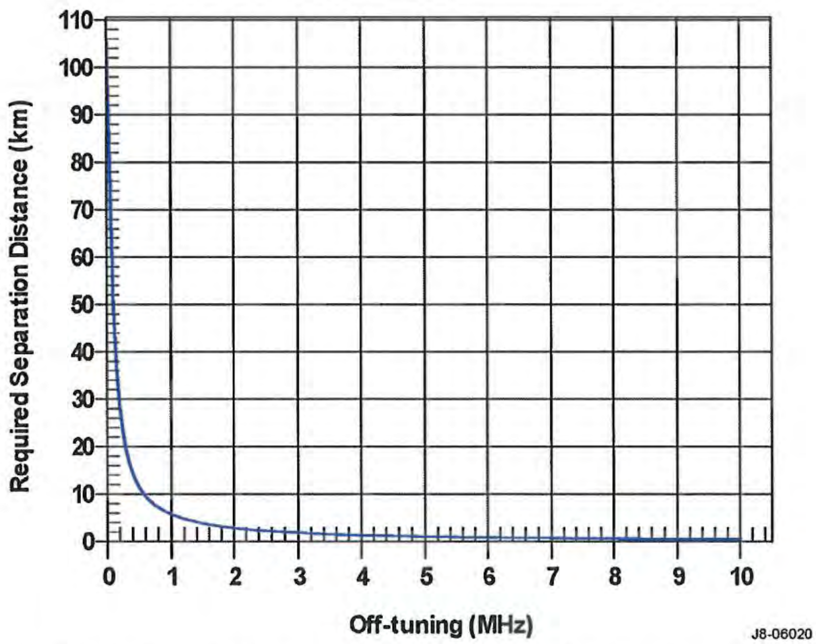

Figure B-8. AN/MRC-148 Transmitter versus I 104161 Receiver F-D Plot

B.3 AN/PRC-117F

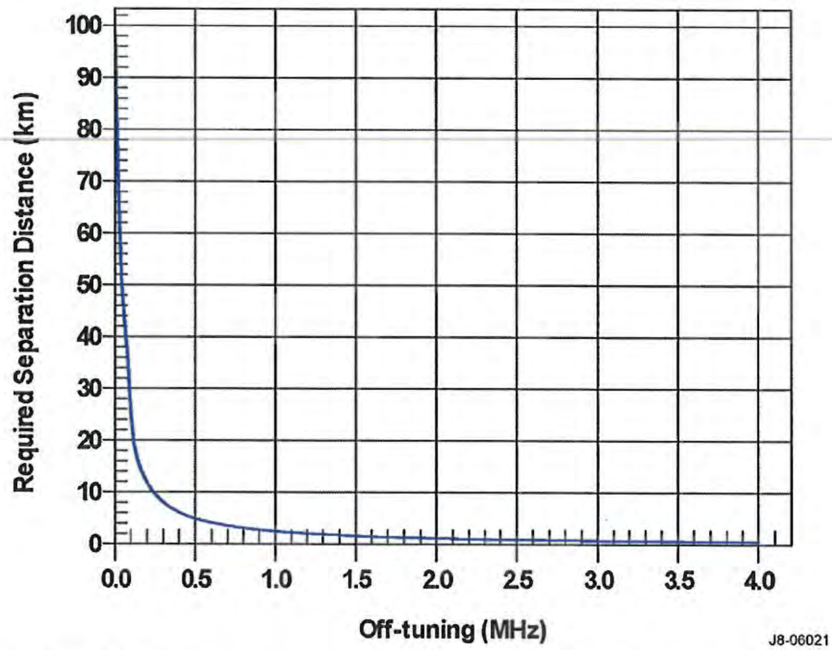

Figure B-9. I 104160 Transmitter versus AN/PRC-117F Receiver F-D Plot

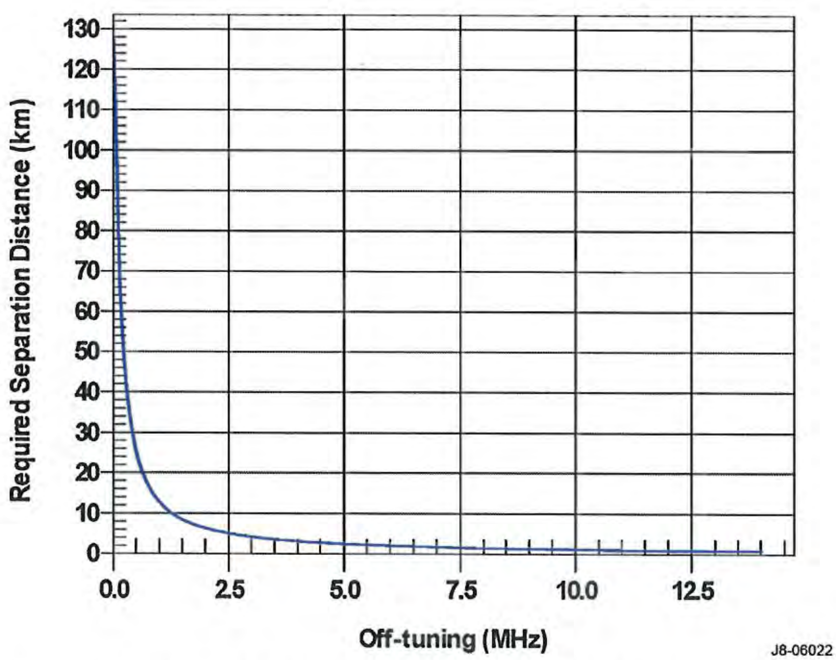

Figure B-10. AN/PRC-117F Transmitter versus I 104160 Receiver F-D Plot

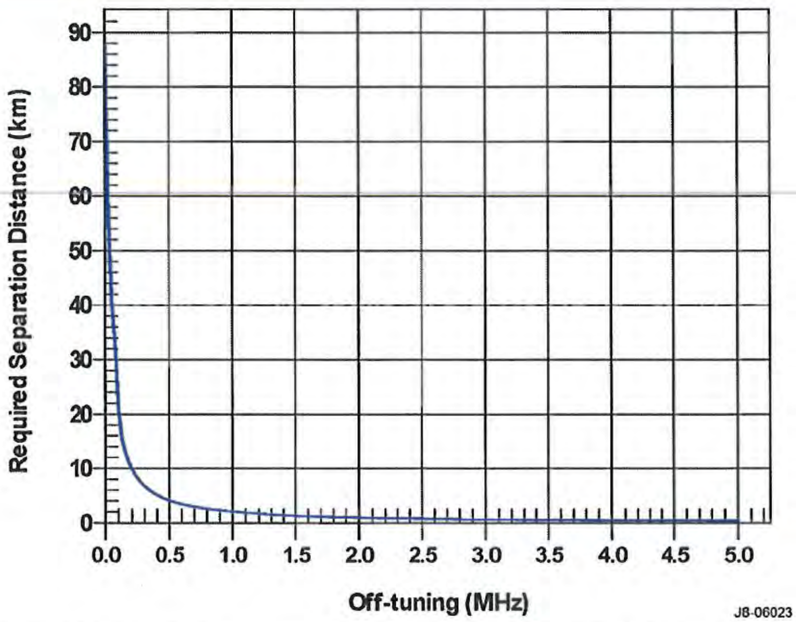

Figure B-11. I 104161 Transmitter versus AN/PRC-117F Receiver F-D Plot

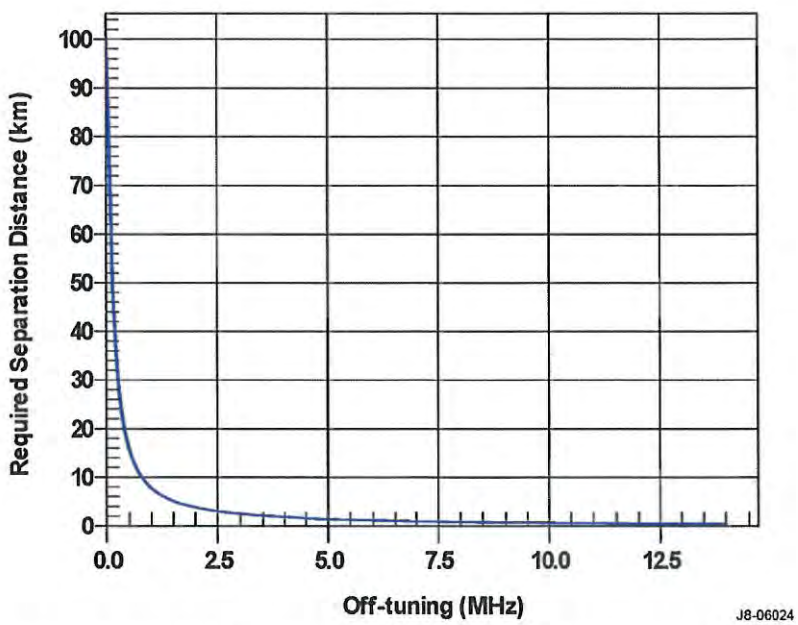

Figure B-12. AN/PRC-117F Transmitter versus I 104161 Receiver F-D Plot

B.4 AN/PRC-117G

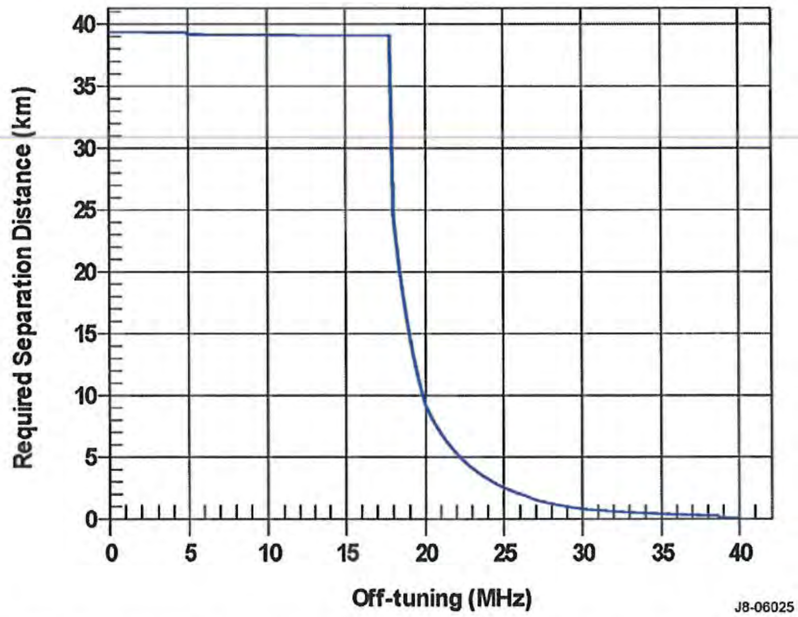

Figure B-13. I 104160 Transmitter versus AN/PRC-117G Receiver F-D Plot

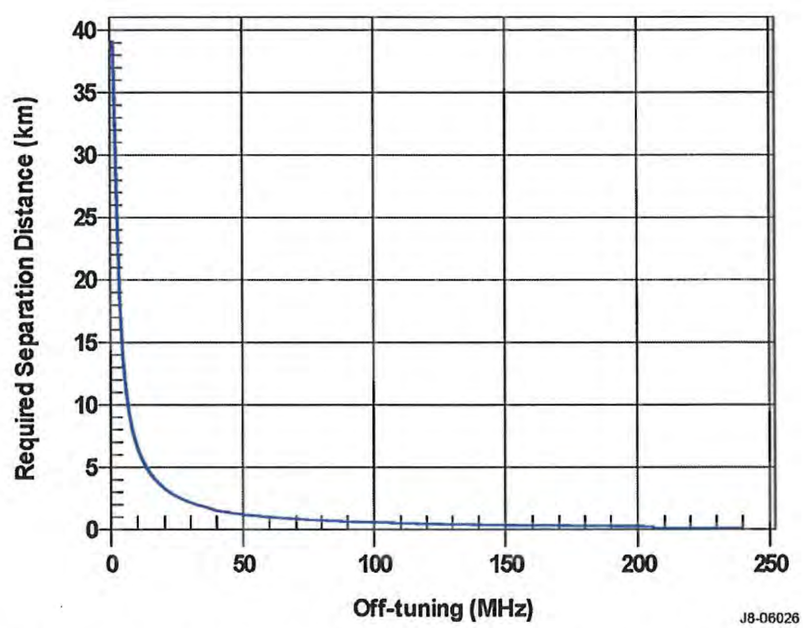

Figure B-14. AN/PRC-117G Transmitter versus I 104160 Receiver F-D Plot

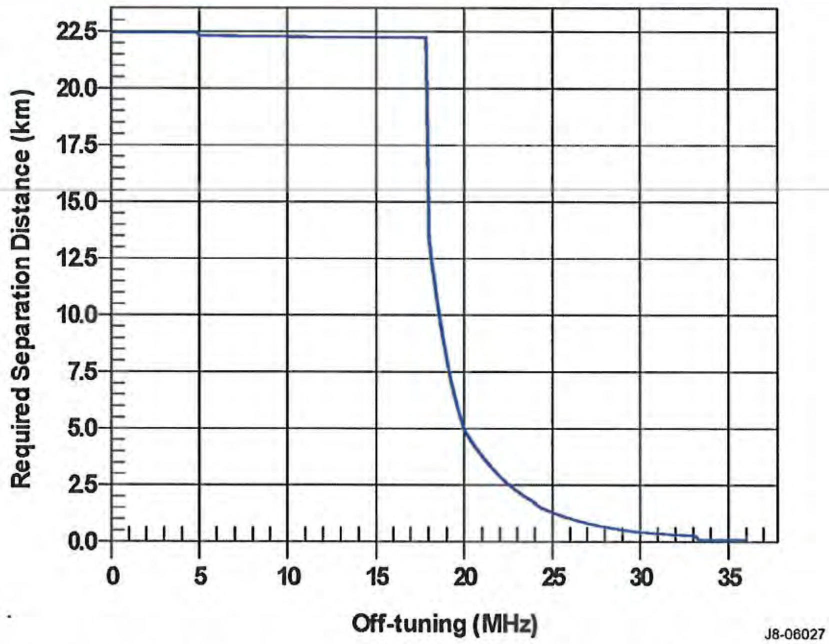

Figure B-15. I 104161 Transmitter versus AN/PRC-117G Receiver F-D Plot

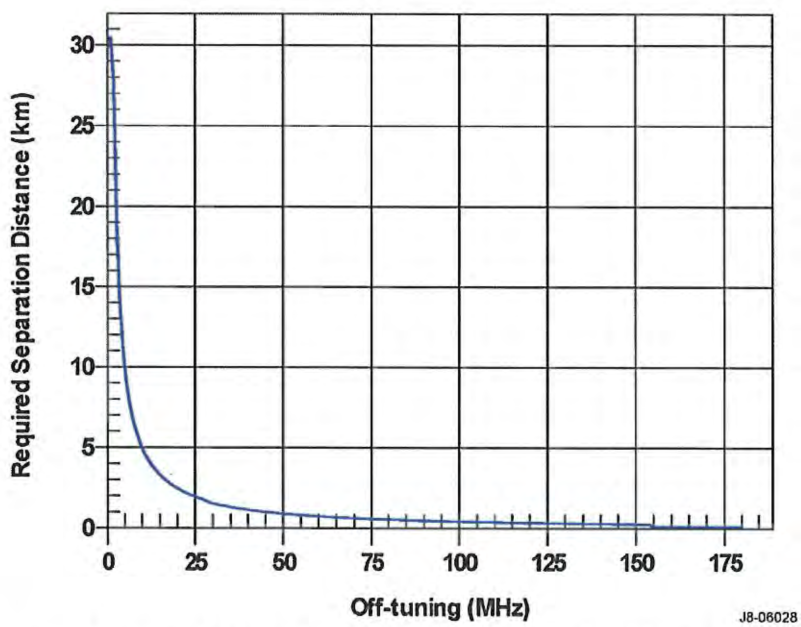

Figure B-16. AN/PRC-117G Transmitter versus I 104161 Receiver F-D Plot

B.5 AN/PRC-119F

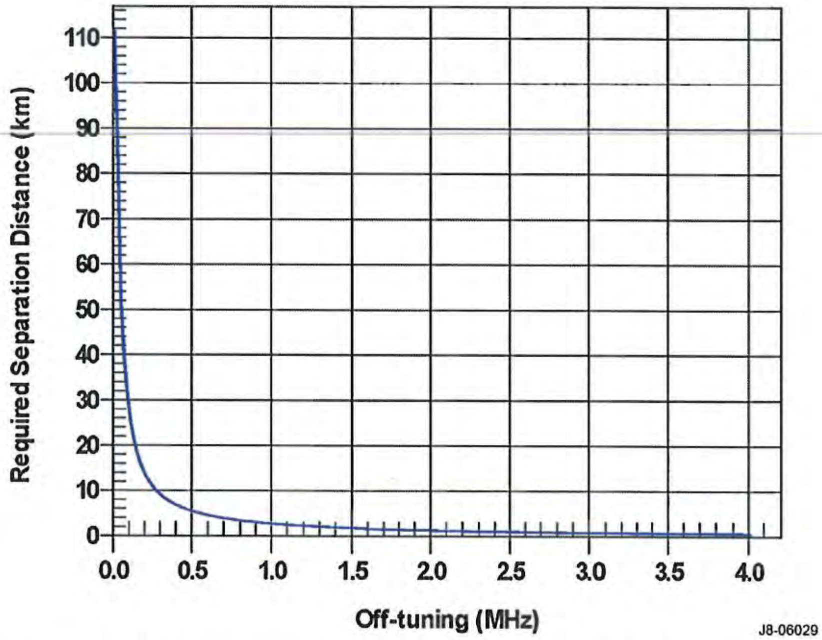

Figure B-17. I 104160 Transmitter versus AN/PRC-119F Receiver F-D Plot

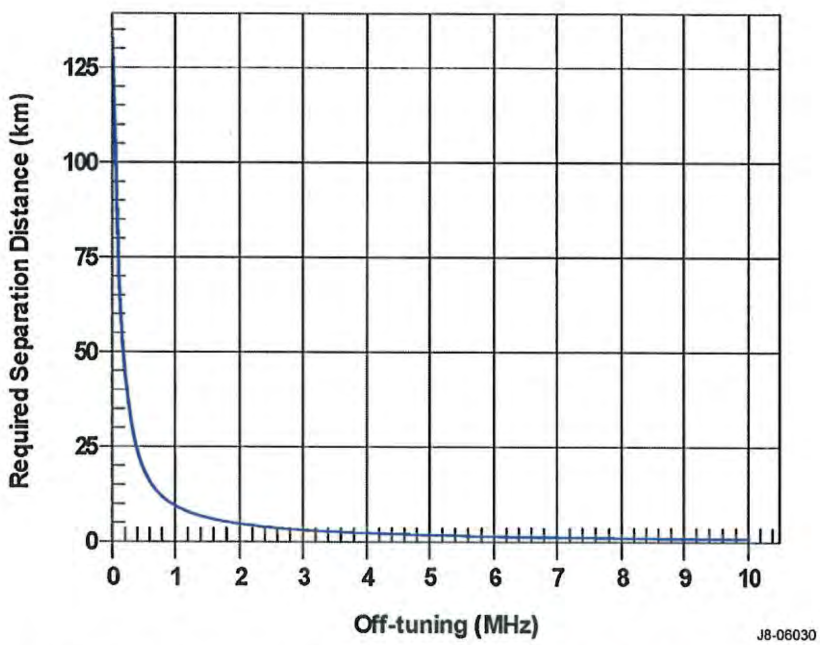

Figure B-18. AN/PRC-119F Transmitter versus I 104160 Receiver F-D Plot

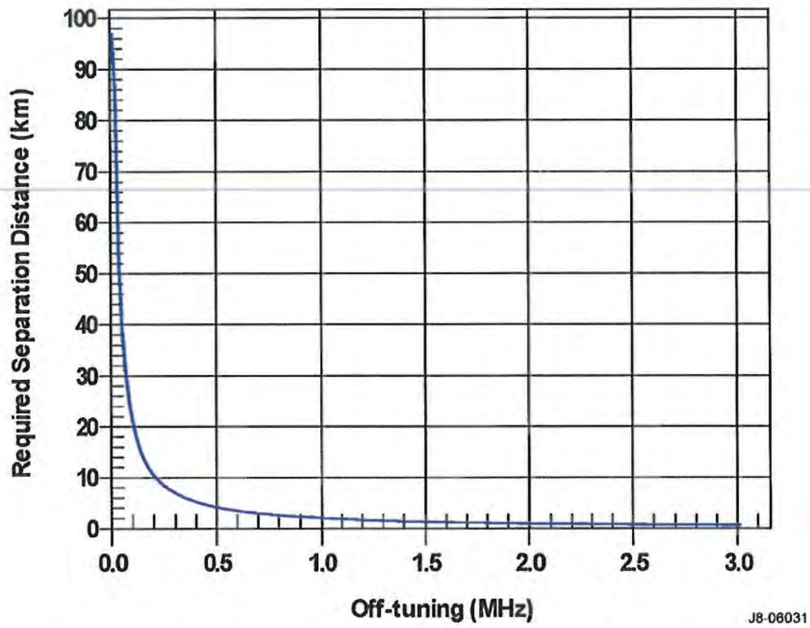

Figure B-19. I 104161 Transmitter versus AN/PRC-119F Receiver F-D Plot

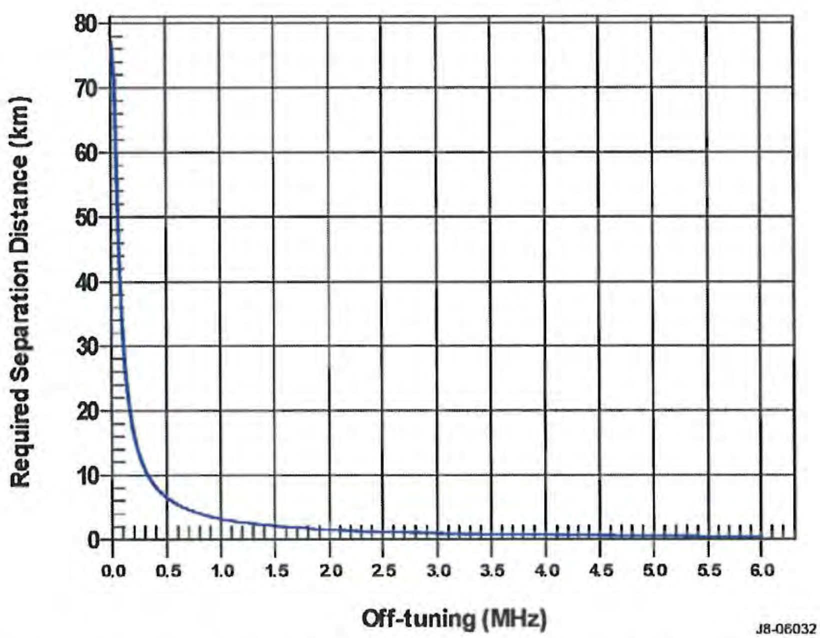

Figure B-20. AN/PRC-119F Transmitter versus I 104161 Receiver F-D Plot

B.6 AN/PRC-150

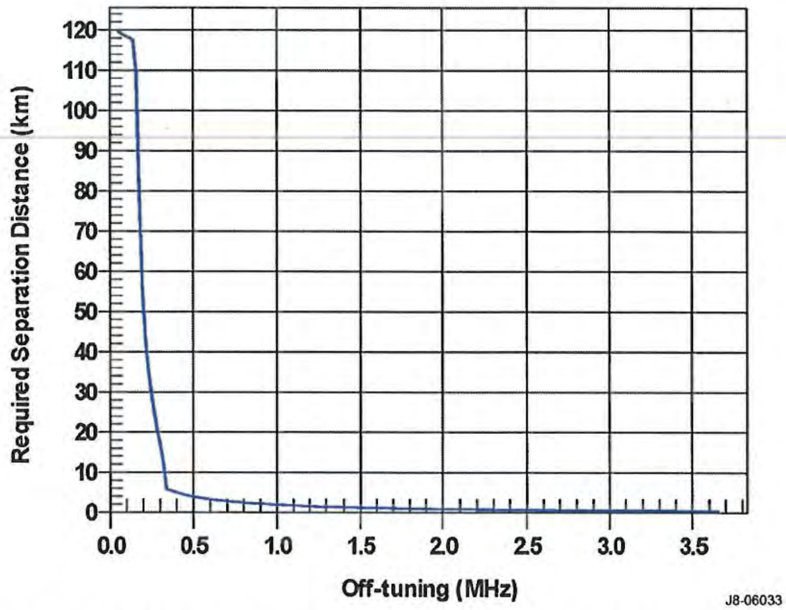

Figure B-21. I 104160 Transmitter versus AN/PRC-150 Receiver F-D Plot

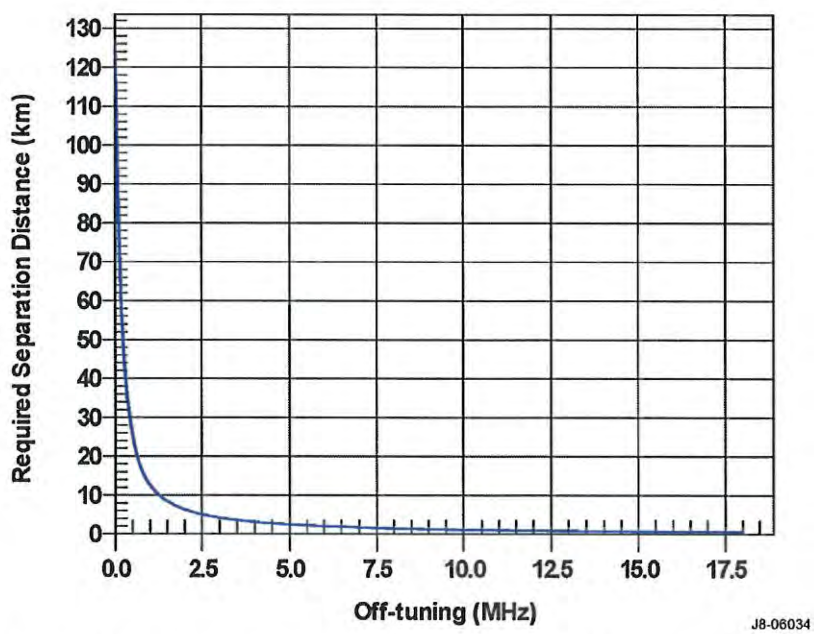

Figure B-22. AN/PRC-150 Transmitter versus I 104160 Receiver F-D Plot

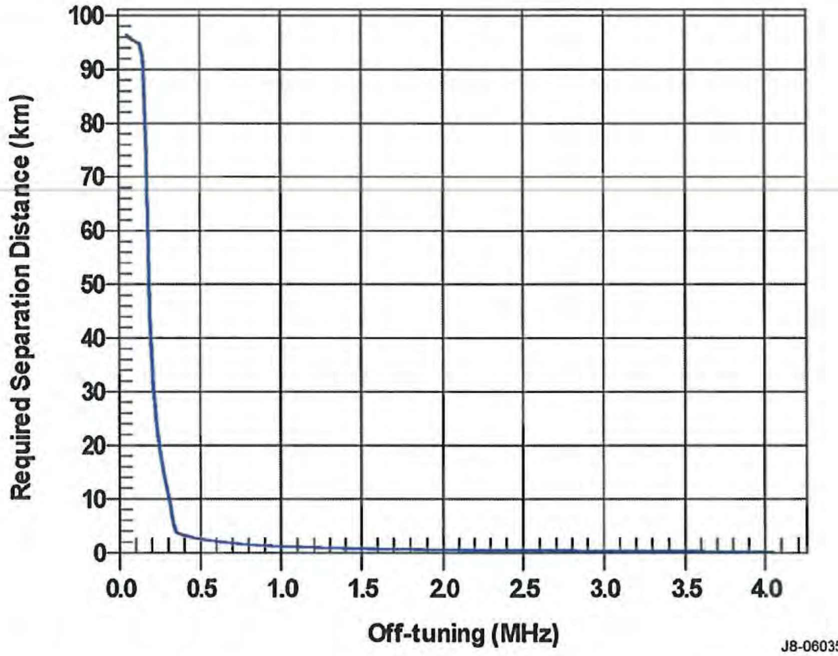

Figure B-23. I 104161 Transmitter versus AN/PRC-150 Receiver F-D Plot

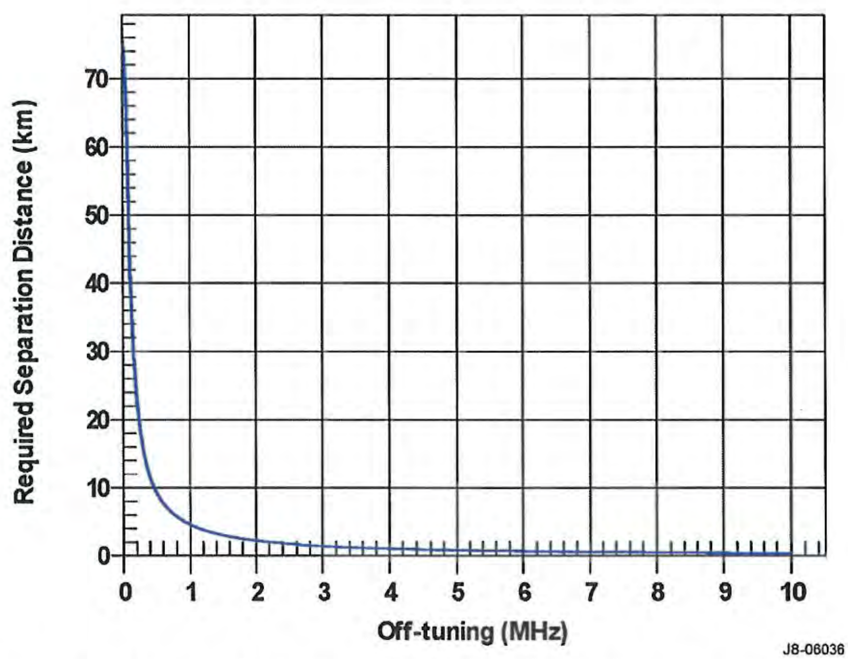

Figure B-24. AN/PRC-150 Transmitter versus I 104161 Receiver F-D Plot

B.7 AN/PRC-152

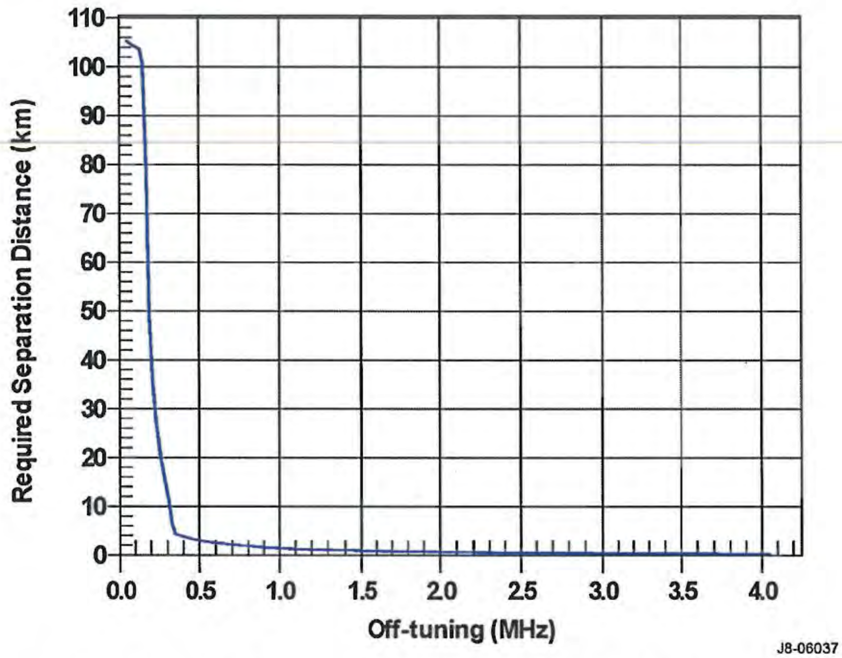

Figure B-25. I 104160 Transmitter versus AN/PRC-152 Receiver F-D Plot

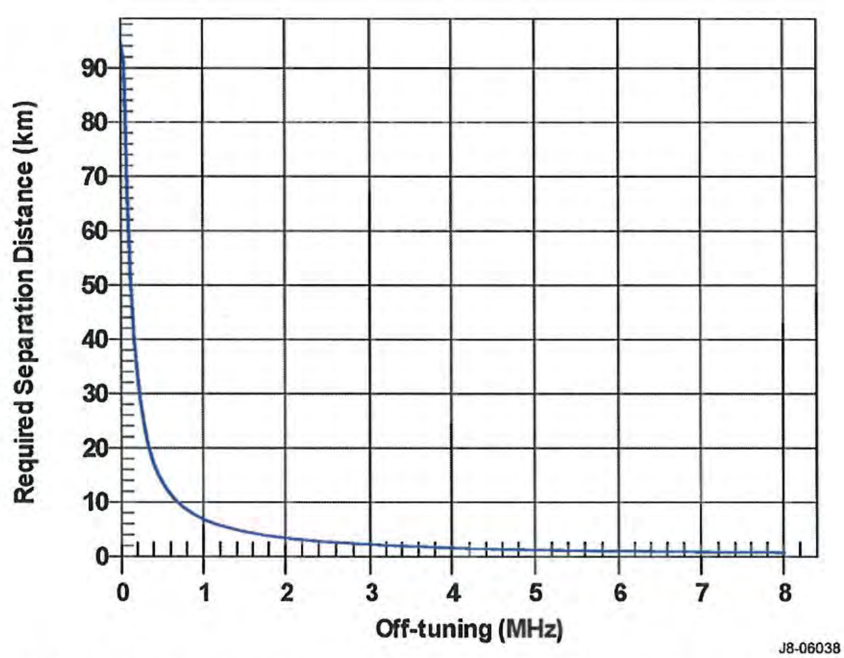

Figure B-26. AN/PRC-152 Transmitter versus I 104160 Receiver F-D Plot

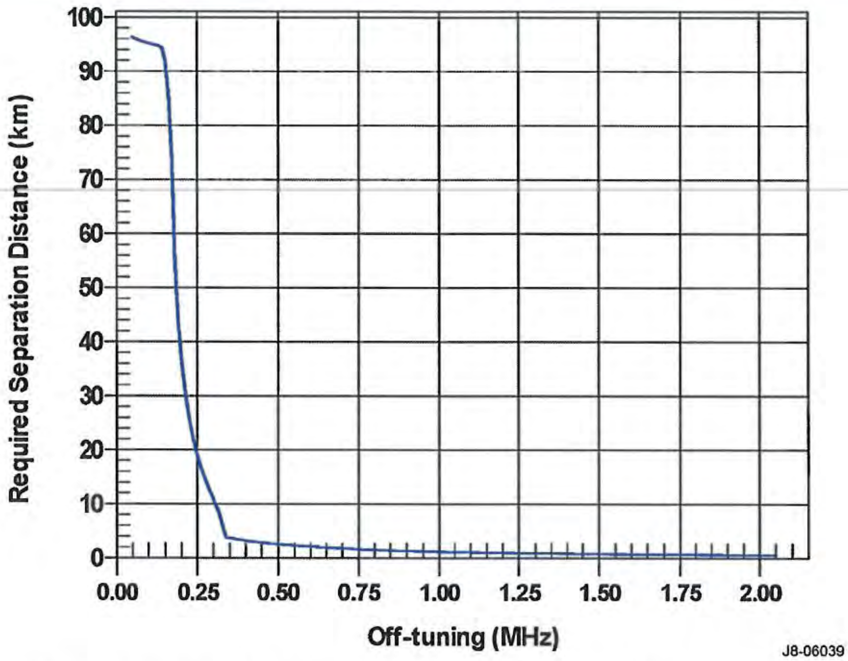

Figure B-27. I 104161 Transmitter versus AN/PRC-152 Receiver F-D Plot

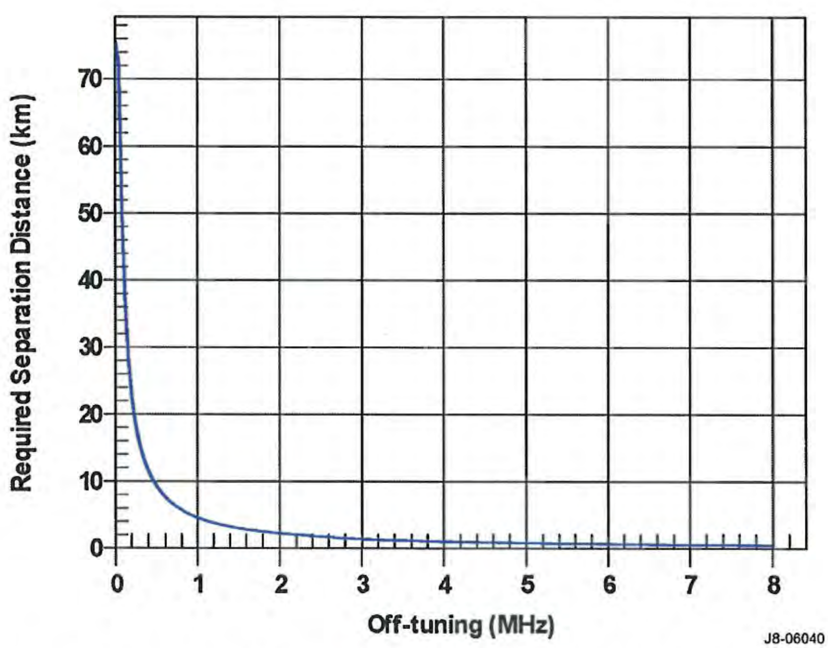

Figure B-28. AN/PRC-152 Transmitter versus I 104161 Receiver F-D Plot

B.8 AN/PRC-153

The calculated RFSs plus the guardbands between the AN/PRC-153 and EME systems on Pagan were within the frequency separation limits; therefore, no EMI issues were predicted for this system.

B.9 AN/VRC-92D

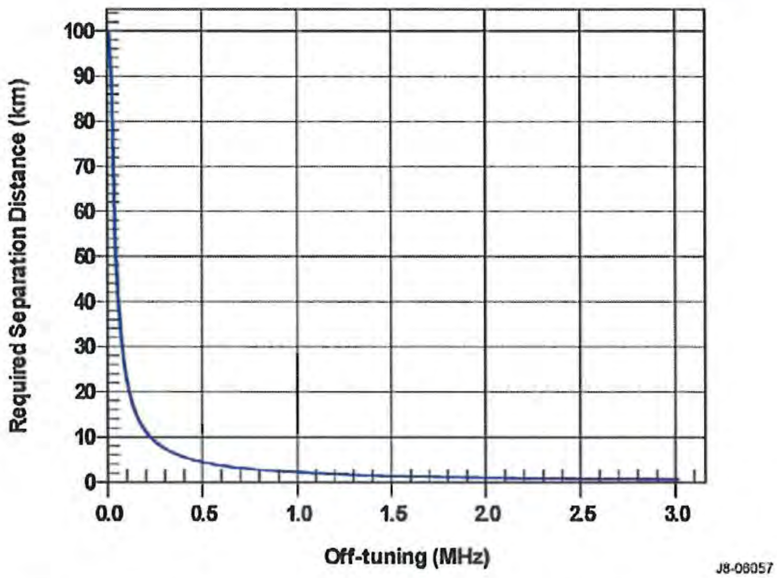

Figure B-29. I 104160 Transmitter versus AN/VRC-92D Receiver F-D Plot

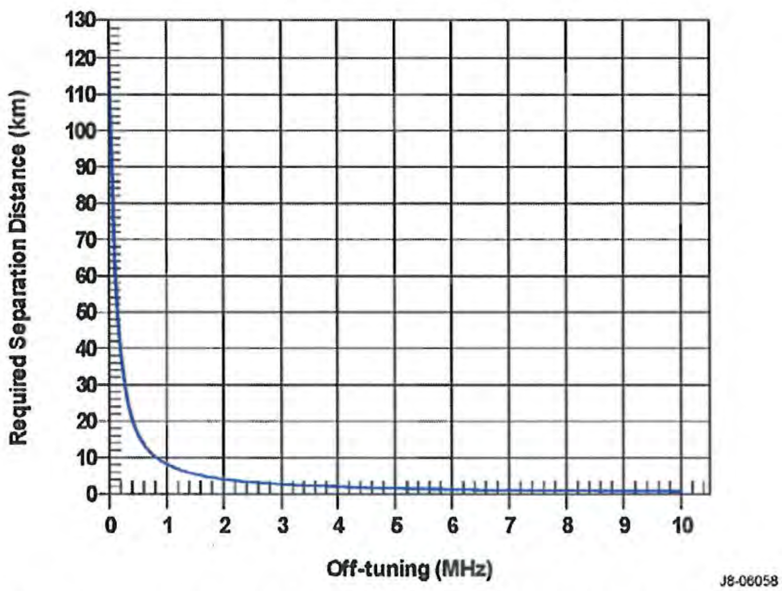

Figure B-30. AN/VRC-92D Transmitter versus I 104160 Receiver F-D Plot

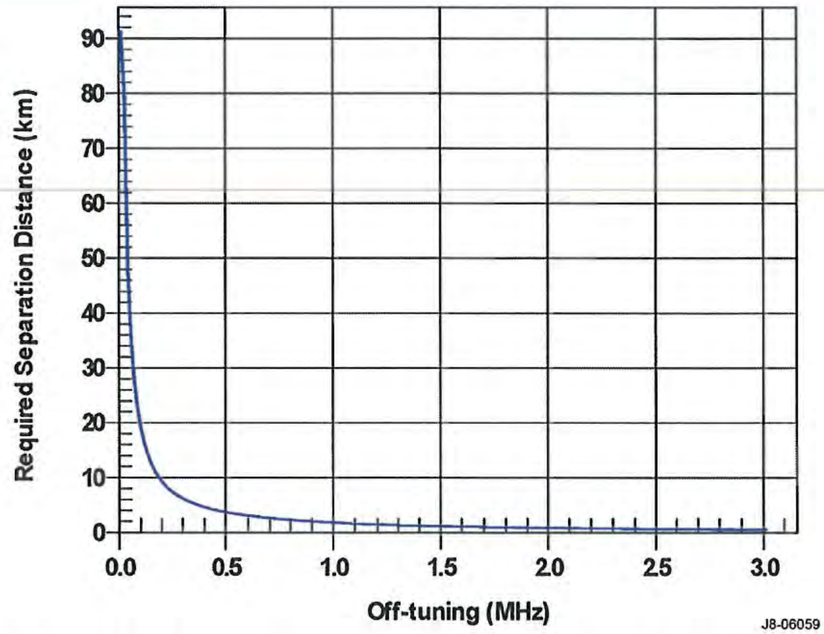

Figure B-31. I 104161 Transmitter versus AN/VRC-92D Receiver F-D Plot

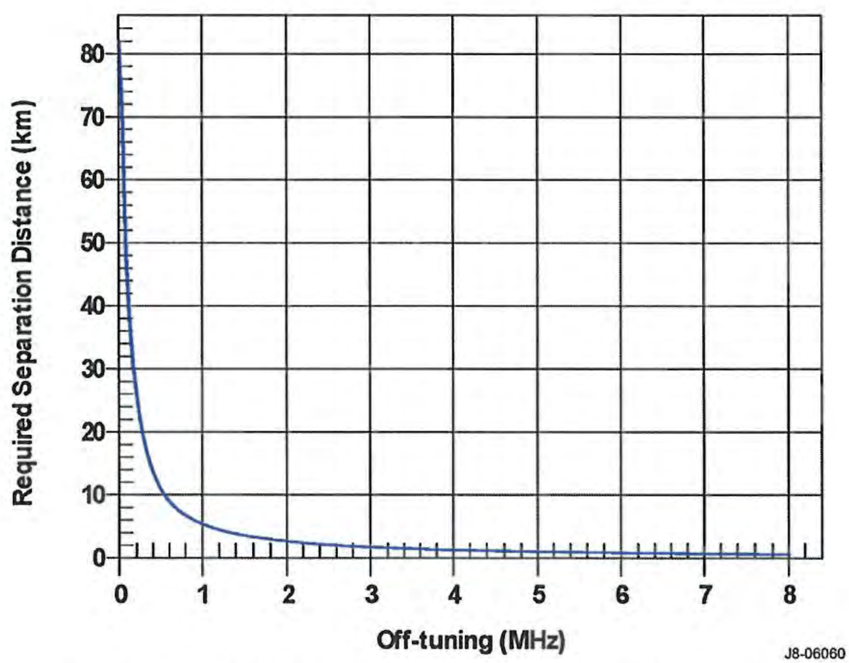

Figure B-32. AN/VRC-92D Transmitter versus I 104161 Receiver F-D Plot

B.10 AN/VRC-103

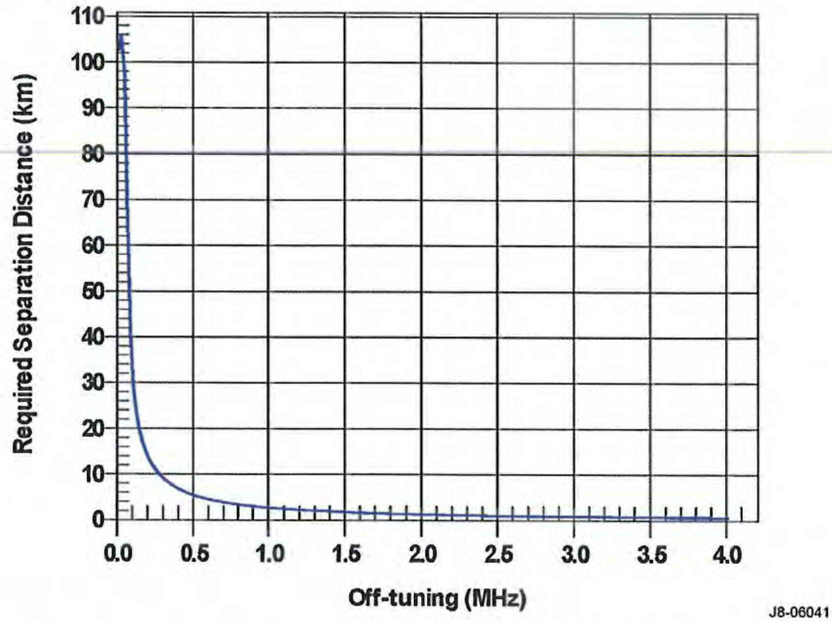

Figure B-33. I 104160 Transmitter versus AN/VRC-103 Receiver F-D Plot

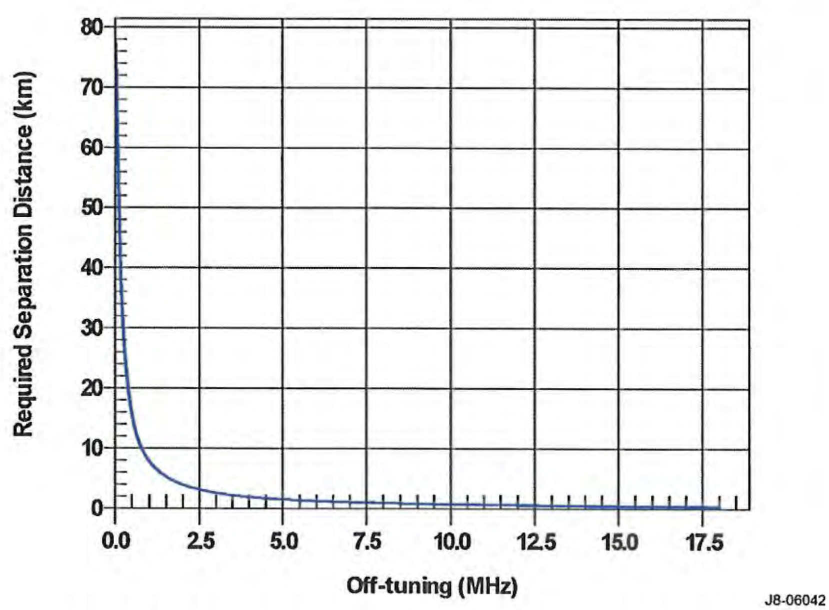

Figure B-34. AN/VRC-103 Transmitter versus I 104160 Receiver F-D Plot

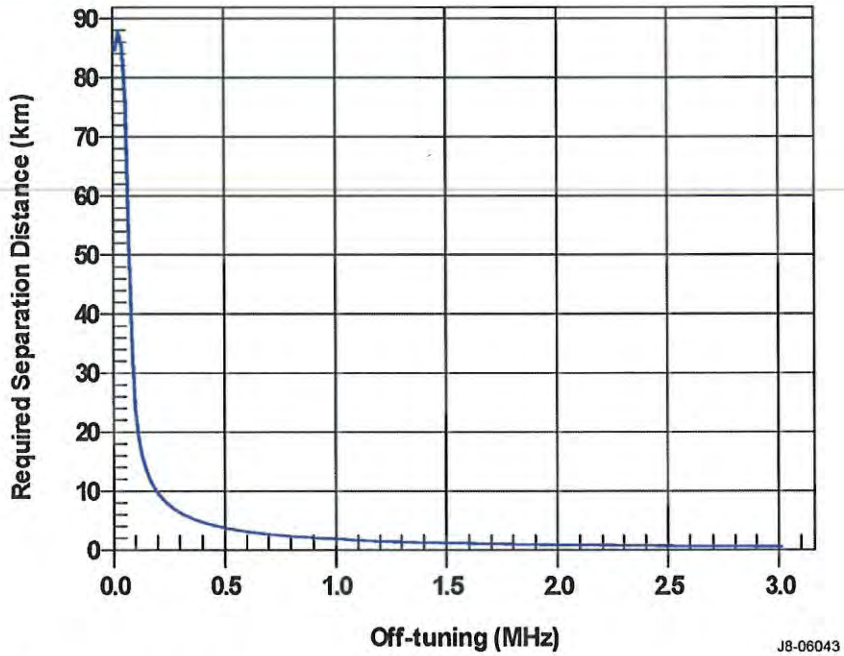

Figure B-35. I 104161 Transmitter versus AN/VRC-103 Receiver F-D Plot

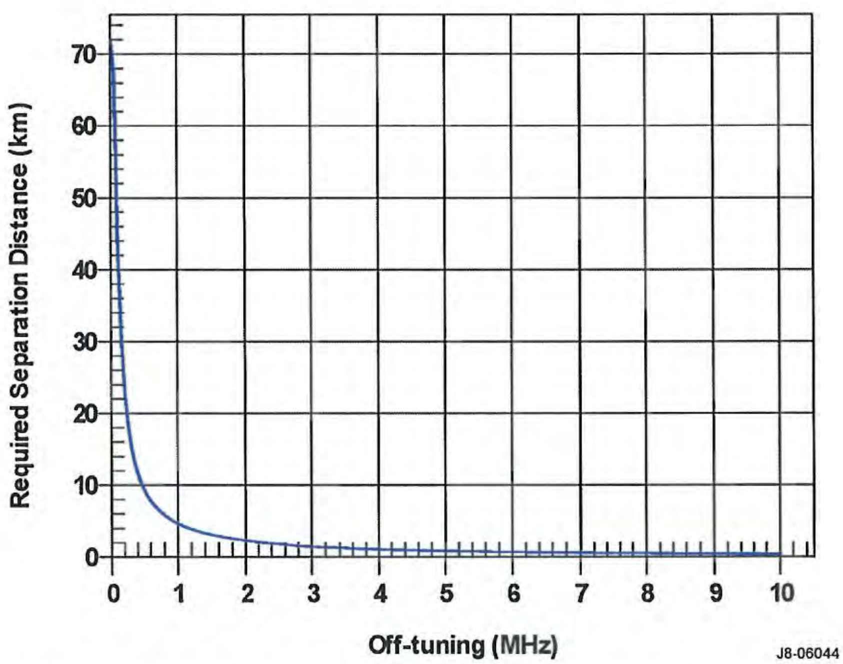

Figure B-36. AN/VRC-103 Transmitter versus I 104161 Receiver F-D Plot

B.11 AN/VRC-104

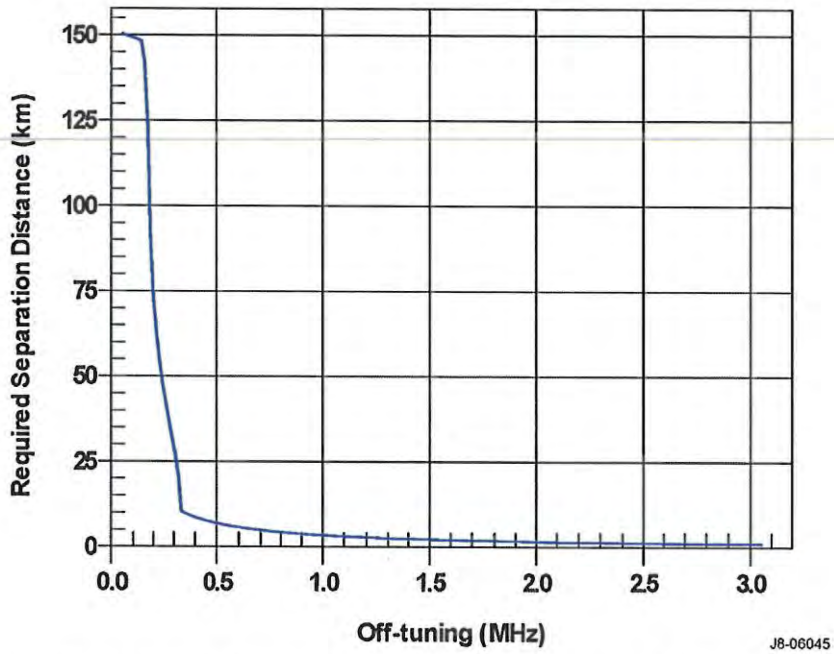

Figure B-37. I 104160 Transmitter versus AN/VRC-104 Receiver F-D Plot

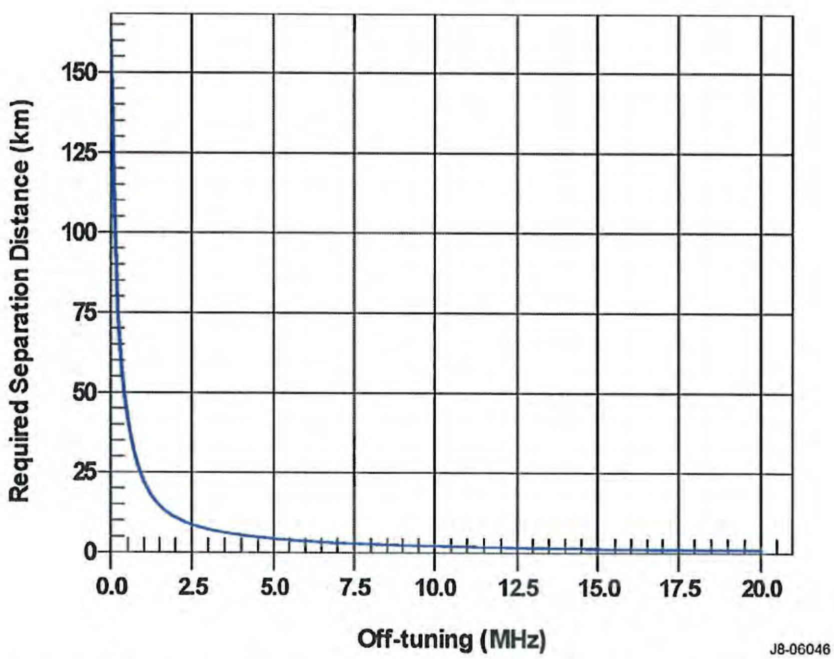

Figure B-38. AN/VRC-104 Transmitter versus I 104160 Receiver F-D Plot

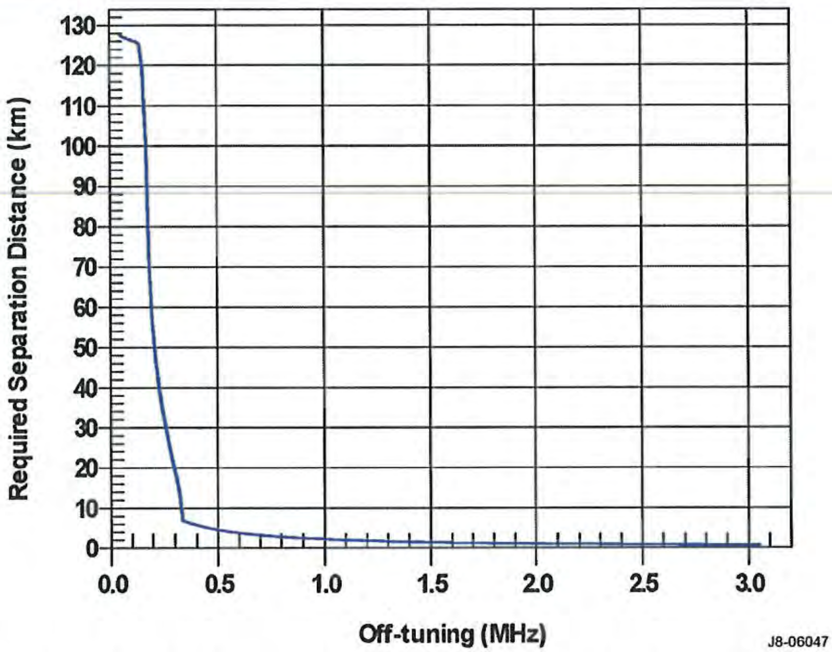

Figure B-39. I 104161 Transmitter versus AN/VRC-104 Receiver F-D Plot

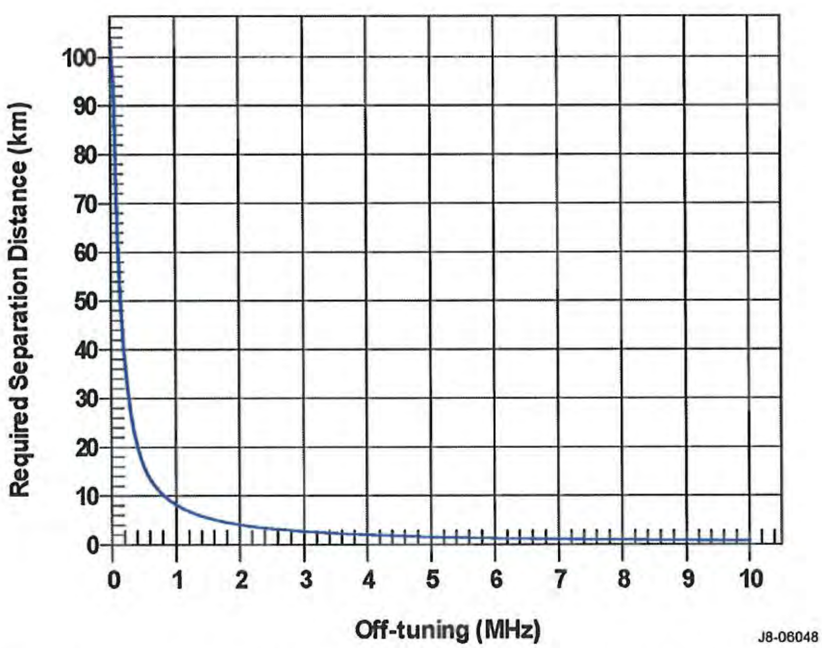

Figure B-40. AN/VRC-104 Transmitter versus I 104161 Receiver F-D Plot

B.12 AN/VRC-110

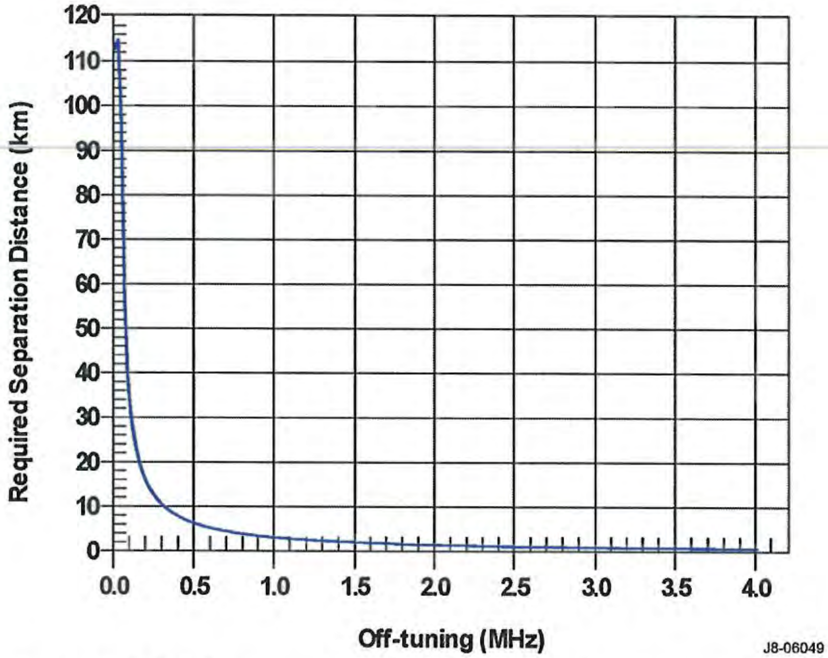

Figure B-41 I 104160 Transmitter versus AN/VRC-110 Receiver F-D Plot

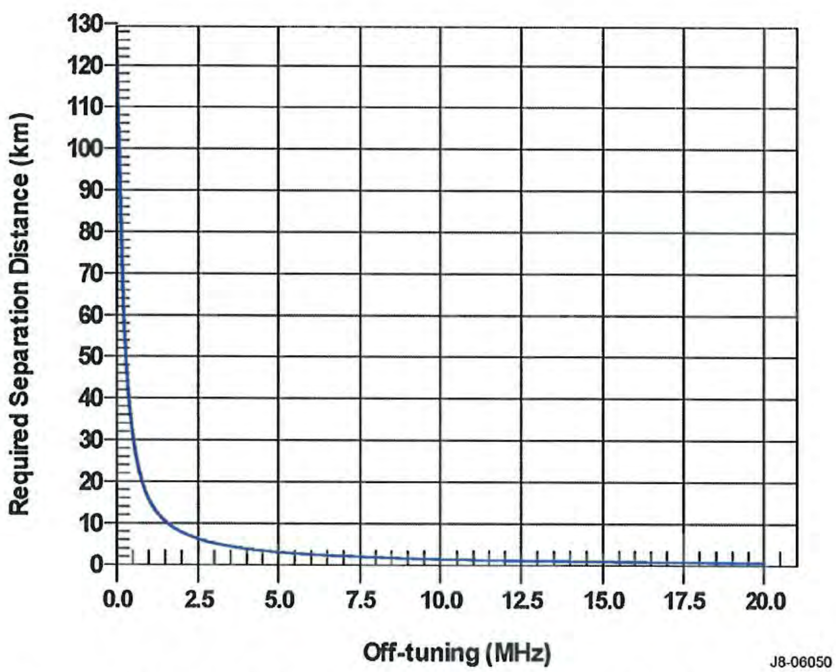

Figure B-42. AN/VRC-110 Transmitter versus I 104160 Receiver F-D Plot

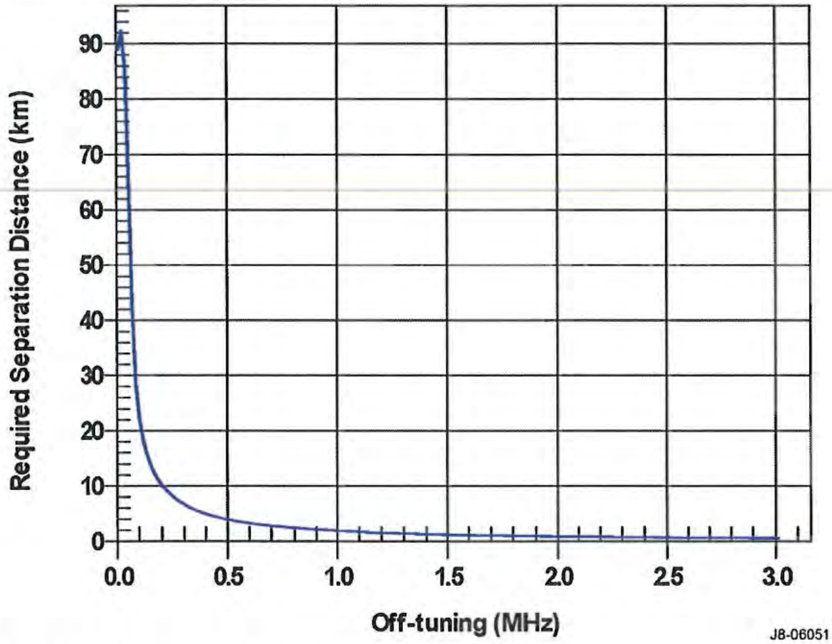

Figure B-43. I 104161 Transmitter versus AN/VRC-110 Receiver F-D Plot

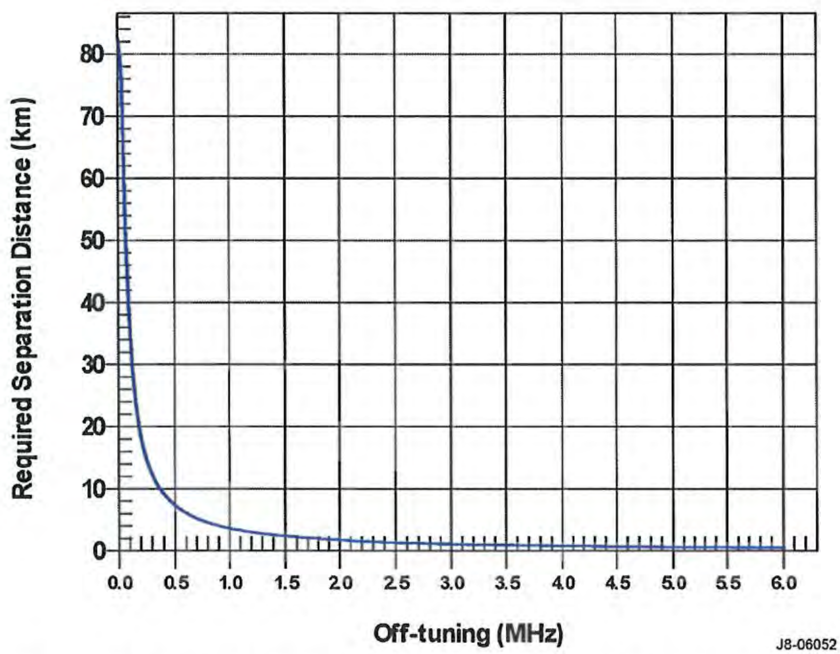

Figure B-44. AN/VRC-110 Transmitter versus I 104161 Receiver F-D Plot

B.13 AN/VRC-112

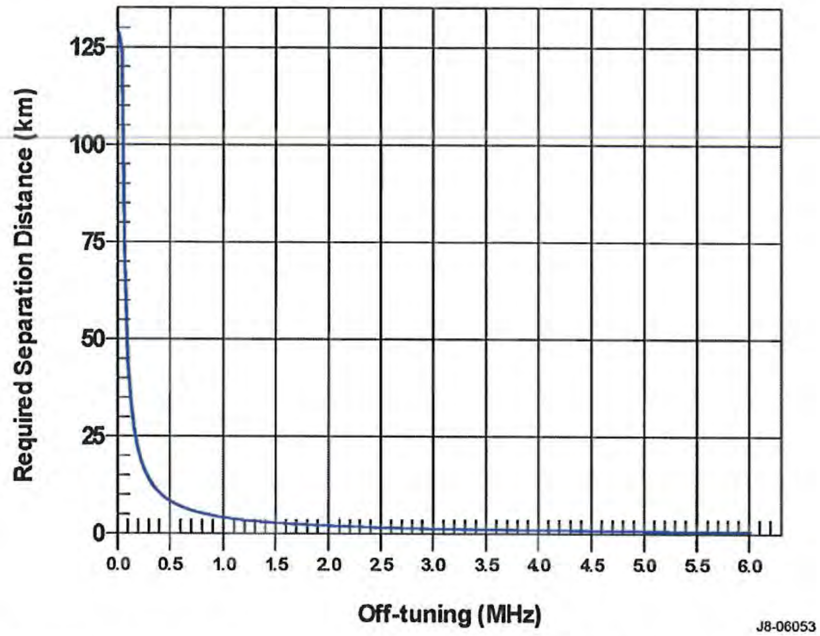

Figure B-45. I 104160 Transmitter versus AN/VRC-112 Receiver F-D Plot

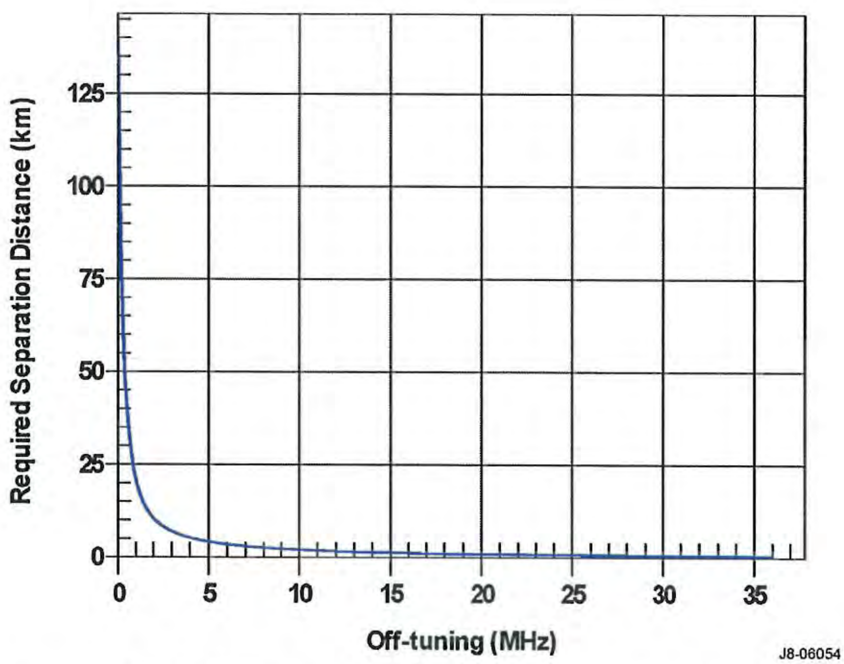

Figure B-46. AN/VRC-112 Transmitter versus I 104160 Receiver F-D Plot

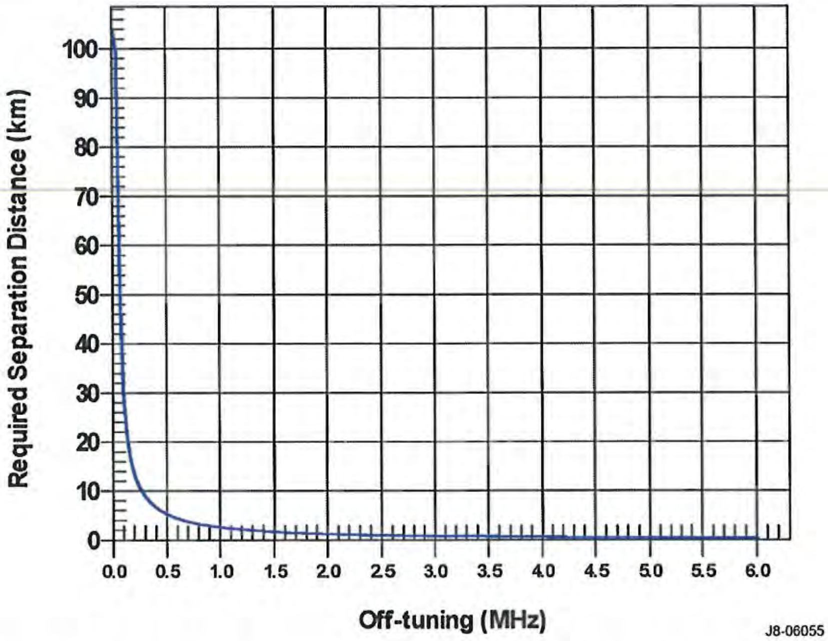

Figure B-47. I 104161 Transmitter versus AN/VRC-112 Receiver F-D Plot

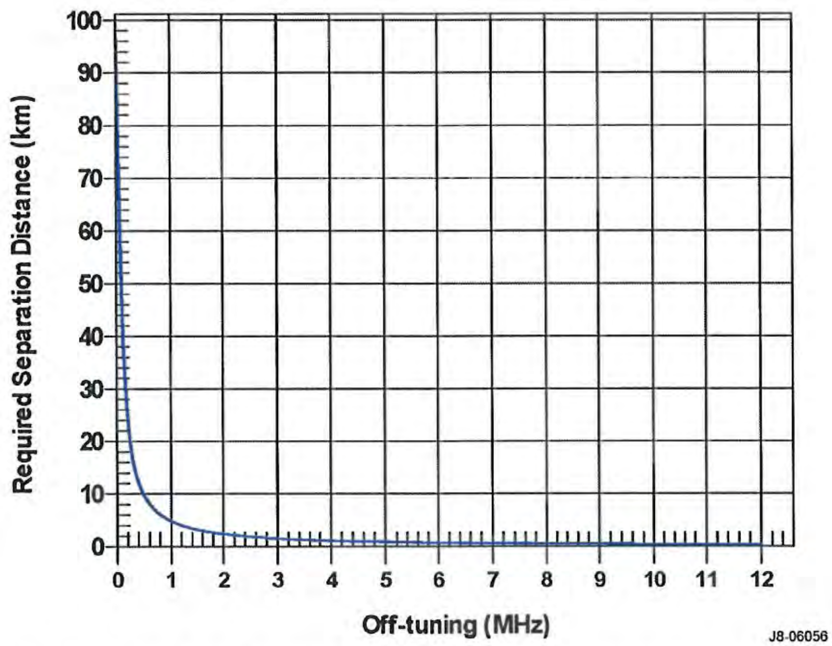

Figure B-48. AN/VRC-112 Transmitter versus I 104161 Receiver F-D Plot

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