



**SPECIFICATION
FOR THE
ENTERPRISE DIGITAL IF MULTI-CARRIER MODEM
(EDIM MODEM) SYSTEM**

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PM IEN
INTEGRATED ENTERPRISE NETWORK

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HISTORY OF CHANGES

[illegible]

TABLE OF CONTENTS

| | |
|---|-----|
| HISTORY OF CHANGES | i |
| TABLE OF CONTENTS | ii |
| LIST OF TABLES | xiv |
| LIST OF FIGURES | xiv |
| SPECIFICATION FOR THE EDIM MODEM SYSTEM | 1 |
| 1 SCOPE | 1 |
| 1.1 Identification | 1 |
| 1.2 General | 1 |
| 1.3 Multi-Carrier Modem Operation | 1 |
| 1.3.1 Modem Emulations | 1 |
| 1.3.2 Data Traffic Cover | 1 |
| 1.3.3 Growth in Link Rates | 2 |
| 1.4 Digital IF Migration | 2 |
| 1.5 Enterprise Applications | 2 |
| 1.6 Management and Control Flexibility | 2 |
| 1.7 Future Applications | 2 |
| 1.8 Upgradability | 2 |
| 2 APPLICABLE DOCUMENTS | 3 |
| 2.1 Government Documents | 3 |
| 2.1.1 Specifications, Standards and Handbooks | 3 |
| 2.1.2 Other Government Documents, Drawings and Publications | 4 |
| 2.2 Non-Government Documents | 5 |
| 3 REQUIREMENTS | 9 |
| 3.1 Item Definition | 9 |
| 3.1.1 External Interfaces | 11 |
| 3.1.1.1 Front Panel Interfaces | 11 |
| 3.1.1.1.1 Power Switch | 11 |
| 3.1.1.1.2 Front Panel Visual Power Indicator | 11 |
| 3.1.1.2 Rear Panel Interfaces | 11 |
| 3.1.1.2.1 Ethernet Data Traffic | 11 |
| 3.1.1.2.2 L-Band IF | 13 |
| 3.1.1.2.3 Digital IF 10GbE | 13 |
| 3.1.1.2.4 Digital IF 40/100 GbE | 13 |
| 3.1.1.2.5 Rear Panel Ethernet M&C Ports | 14 |
| 3.1.1.2.6 Time & Frequency References | 14 |
| 3.1.1.2.6.1 5/10 MHz Frequency Reference | 14 |
| 3.1.1.2.6.2 1 pps Timing Reference | 14 |

| | | |
|-------------|--|----|
| 3.1.1.2.6.3 | IRIG-B Timing Reference | 15 |
| 3.1.1.2.7 | Power | 15 |
| 3.1.1.2.8 | Ground Stud | 15 |
| 3.1.1.3 | Contractor Discretionary Interfaces | 15 |
| 3.1.2 | Signal Processing Functions | 16 |
| 3.1.2.1 | L-Band Modem (LM)..... | 16 |
| 3.1.2.2 | Digital IF Modem (DM) | 16 |
| 3.1.3 | NATO STANAG 4486 Ed4 (EBEM) Interoperability | 16 |
| 3.2 | Function and Performance..... | 19 |
| 3.2.1 | Time and Frequency Base | 19 |
| 3.2.1.1 | Date and Time Base..... | 19 |
| 3.2.1.2 | Frequency Base | 20 |
| 3.2.2 | Data Traffic Rate Estimation..... | 20 |
| 3.2.3 | L-Band IF Interface..... | 20 |
| 3.2.3.1 | L-Band IF Non-Damaging Input Power..... | 20 |
| 3.2.3.2 | L-Band IF Isolation | 20 |
| 3.2.4 | Digital IF Interface | 20 |
| 3.2.4.1 | Digital IF Capacity | 21 |
| 3.2.4.2 | IP Addressability..... | 21 |
| 3.2.4.3 | Digital IF Protocol | 21 |
| 3.2.4.4 | Digital IF Network Connectivity..... | 21 |
| 3.2.4.5 | Digital IF Networking Performance | 22 |
| 3.2.4.5.1 | Network Output Limits | 22 |
| 3.2.4.5.2 | Network Input Tolerance | 22 |
| 3.2.4.5.3 | Jumbo Frame Support..... | 22 |
| 3.2.5 | Modem Function and Performance | 22 |
| 3.2.5.1 | General..... | 22 |
| 3.2.5.1.1 | Ethernet Bridge | 22 |
| 3.2.5.1.2 | Carrier Count and Independence | 23 |
| 3.2.5.1.3 | Data Traffic Rates | 23 |
| 3.2.5.1.4 | Symbol Rates | 23 |
| 3.2.5.1.5 | FIPS Cert and General Crypto Provisions | 23 |
| 3.2.5.1.6 | Interference Mitigation | 23 |
| 3.2.5.1.6.1 | Interference Mitigation Operation..... | 24 |
| 3.2.5.1.6.2 | Interference Mitigation Performance..... | 24 |
| 3.2.5.2 | Modem Waveforms | 25 |
| 3.2.5.2.1 | NATO STANAG 4486 Ed4 (EBEM) Baseline | 25 |
| 3.2.5.2.1.1 | Payload..... | 25 |

| | | |
|---------------|---|----|
| 3.2.5.2.1.2 | Features | 25 |
| 3.2.5.2.1.3 | Bulk Encryption for Cover | 26 |
| 3.2.5.2.1.4 | Waveform | 26 |
| 3.2.5.2.2 | Support for Higher Rates | 27 |
| 3.2.5.2.2.1 | EBEM Extended Rate Operation | 27 |
| 3.2.5.2.2.2 | DVB-S2X Hub Waveform Operation | 27 |
| 3.2.5.2.2.2.1 | Waveform | 27 |
| 3.2.5.2.2.2.2 | Data Traffic Encapsulation | 28 |
| 3.2.5.2.2.2.3 | Bulk Encryption for Cover | 28 |
| 3.2.5.2.2.2.4 | DVB-S2X Feature Support | 28 |
| 3.2.5.3 | LM Operation | 29 |
| 3.2.5.3.1 | LM Transmission | 29 |
| 3.2.5.3.2 | LM Reception | 29 |
| 3.2.5.3.3 | LM Loopback Operation | 29 |
| 3.2.5.4 | LM Uplink Performance | 31 |
| 3.2.5.4.1 | LM Uplink Carrier Frequency | 31 |
| 3.2.5.4.2 | LM Uplink Frequency Stability | 31 |
| 3.2.5.4.3 | LM Uplink Frequency Accuracy | 31 |
| 3.2.5.4.4 | LM Uplink Phase Noise | 31 |
| 3.2.5.4.5 | LM Uplink Carrier Power | 33 |
| 3.2.5.4.6 | LM Uplink Power Off Performance | 33 |
| 3.2.5.4.7 | LM Uplink Spectral Confinement | 34 |
| 3.2.5.4.8 | LM Uplink Noise Floor | 36 |
| 3.2.5.4.9 | LM Uplink Spurious Emissions | 36 |
| 3.2.5.4.10 | LM Uplink Harmonics | 36 |
| 3.2.5.4.11 | LM Uplink Error Vector Magnitude (EVM) | 36 |
| 3.2.5.5 | LM Downlink Performance | 36 |
| 3.2.5.5.1 | LM Downlink Carrier Frequency | 36 |
| 3.2.5.5.2 | LM Downlink Frequency Uncertainty | 36 |
| 3.2.5.5.3 | LM Downlink Min Rx Power | 36 |
| 3.2.5.5.4 | LM Downlink Acquisition and Reacquisition | 37 |
| 3.2.5.5.5 | LM Downlink Synchronization Retention | 37 |
| 3.2.5.5.6 | LM Downlink Doppler Environment | 37 |
| 3.2.5.5.7 | LM Back-to-Back BER | 38 |
| 3.2.5.5.8 | LM Downlink Adjacent Channel Interference (ACI) | 38 |
| 3.2.5.5.9 | LM Downlink Power Disparity | 40 |
| 3.2.5.5.10 | LM Downlink Input Power Changes | 41 |
| 3.2.5.6 | DM Operation | 41 |

| | | |
|-----------|--|----|
| 3.2.5.6.1 | DM Transmission | 41 |
| 3.2.5.6.2 | DM Reception..... | 42 |
| 3.2.5.6.3 | DM Loopback Operation..... | 43 |
| 3.2.5.7 | DM Uplink Performance | 44 |
| 3.2.5.7.1 | DM Uplink Carrier Frequency | 44 |
| 3.2.5.7.2 | DM Uplink Carrier Power | 44 |
| 3.2.5.7.3 | DM Uplink Digitization Noise PSD | 44 |
| 3.2.5.7.4 | DM Uplink Spectral Confinement | 45 |
| 3.2.5.7.5 | DM Uplink EVM | 45 |
| 3.2.5.8 | DM Downlink Performance | 45 |
| 3.2.5.8.1 | DM Downlink Carrier Frequency | 45 |
| 3.2.5.8.2 | DM Downlink Frequency Uncertainty | 45 |
| 3.2.5.8.3 | DM Downlink Acquisition and Reacquisition..... | 45 |
| 3.2.5.8.4 | DM Downlink Synchronization Retention | 45 |
| 3.2.5.8.5 | DM Downlink Doppler Environment..... | 45 |
| 3.2.5.8.6 | DM Back-to-Back BER | 46 |
| 3.2.5.8.7 | DM Downlink ACI | 46 |
| 3.2.5.9 | Modem Test Features | 46 |
| 3.2.5.9.1 | Carrier Frequency Measurement..... | 46 |
| 3.2.5.9.2 | Carrier Power Measurement | 46 |
| 3.2.5.9.3 | Signal to Noise Ratio (SNR) Measurement | 46 |
| 3.2.5.9.4 | Internal Bit Error Rate Test (BERT)..... | 47 |
| 3.3 | Management and Control (M&C) | 47 |
| 3.3.1 | M&C Objectives..... | 47 |
| 3.3.2 | EDIM Modem System M&C Architecture..... | 48 |
| 3.3.2.1 | EDIM Modem Management Components | 48 |
| 3.3.2.1.1 | EDIM Modem Management System / Software (EMMS) | |
| | 48 | |
| 3.3.2.1.2 | Operator Interface (OI) | 52 |
| 3.3.2.2 | EDIM Modem | 52 |
| 3.3.3 | Site-Level Network Management System (NMS) | 53 |
| 3.3.4 | General Operation | 53 |
| 3.3.4.1 | M&C Roles | 53 |
| 3.3.4.2 | M&C Protocols | 53 |
| 3.3.4.3 | Data Traffic Integrity | 53 |
| 3.3.4.4 | Contention Resolution | 55 |
| 3.3.4.5 | Configuration Integrity | 55 |
| 3.3.4.6 | M&C Response Time | 55 |

| | | |
|---------|---|----|
| 3.3.4.7 | Factory Default State..... | 55 |
| 3.3.4.8 | Shutdown and Restart..... | 56 |
| 3.3.5 | Management Provisions..... | 56 |
| 3.3.5.1 | Power Control..... | 56 |
| 3.3.5.2 | File Transfer..... | 56 |
| 3.3.5.3 | Authentication..... | 57 |
| 3.3.5.4 | Multiple Modem Configuration Management..... | 57 |
| 3.3.5.5 | Situational Awareness..... | 58 |
| 3.3.5.6 | Modem Suite Reporting..... | 58 |
| 3.4 | Cybersecurity..... | 58 |
| 3.4.1 | System Identification Profile..... | 59 |
| 3.4.2 | Identification and Authentication..... | 59 |
| 3.4.3 | Confidentiality..... | 60 |
| 3.4.4 | Integrity..... | 60 |
| 3.4.5 | Availability..... | 61 |
| 3.4.6 | Access Control..... | 61 |
| 3.4.6.1 | Operator Roles..... | 62 |
| 3.4.6.2 | Password Policy..... | 62 |
| 3.4.7 | Network Interfaces..... | 64 |
| 3.4.8 | M&C Components and Data Storage..... | 64 |
| 3.4.9 | Auditing and Non-Repudiation..... | 64 |
| 3.4.10 | Notification..... | 66 |
| 3.5 | Built-In Test (BIT)..... | 66 |
| 3.5.1 | Hardware Fault Detection..... | 66 |
| 3.5.1.1 | Continuous Self-Test..... | 67 |
| 3.5.1.2 | Non-Disruptive Self-Test..... | 67 |
| 3.5.1.3 | Disruptive Self-Test / Power-On Self-Test (POST)..... | 67 |
| 3.5.2 | Alarms..... | 67 |
| 3.5.2.1 | Major Alarms..... | 67 |
| 3.5.2.2 | Minor Alarms..... | 68 |
| 3.5.2.3 | Alarm Logging and Access..... | 68 |
| 3.5.3 | Alarm Notifications..... | 68 |
| 3.6 | Physical Platform..... | 68 |
| 3.6.1 | Physical Platform Priorities..... | 68 |
| 3.6.2 | Life Expectancy..... | 69 |
| 3.6.3 | Transportability..... | 69 |
| 3.6.4 | 19" Rack Mountable Enclosure Packaging..... | 69 |
| 3.6.4.1 | Front Panel..... | 69 |

| | | |
|-----------|---|----|
| 3.6.4.2 | Rear Panel | 69 |
| 3.6.4.3 | Cooling | 70 |
| 3.6.4.4 | AC Power and Power Transients | 70 |
| 3.6.4.4.1 | AC Power | 70 |
| 3.6.4.4.2 | Power Transients | 70 |
| 3.6.5 | Electromagnetic Environmental Effects (E3) | 70 |
| 3.6.5.1 | Grounding, Bonding and Shielding | 70 |
| 3.6.5.2 | Electromagnetic Compatibility (EMC) | 71 |
| 3.6.5.3 | Electromagnetic Interference (EMI) | 71 |
| 3.6.5.3.1 | Conducted Emissions | 71 |
| 3.6.5.3.2 | Conducted Susceptibility | 71 |
| 3.6.5.3.3 | Radiated Emissions (2 MHz to 18 GHz) | 71 |
| 3.6.5.3.4 | Radiated Susceptibility | 71 |
| 3.6.6 | Physical Environment | 71 |
| 3.6.6.1 | Non-Operating Physical Environment | 72 |
| 3.6.6.2 | Operating Physical Environment | 72 |
| 3.6.6.3 | Seismic Conditions | 72 |
| 3.6.7 | Reliability, Maintainability and Availability | 72 |
| 3.6.7.1 | Reliability | 72 |
| 3.6.7.2 | Maintainability | 73 |
| 3.6.7.3 | Availability | 73 |
| 3.6.7.4 | FRACAS | 73 |
| 3.6.8 | Design and Construction | 73 |
| 3.6.8.1 | Manufacturing Considerations | 73 |
| 3.6.8.1.1 | Nameplates and Product Marking | 74 |
| 3.6.8.1.2 | Workmanship | 74 |
| 3.6.8.1.3 | Interchangeability | 74 |
| 3.6.8.1.4 | Finish | 74 |
| 3.6.8.1.5 | Corrosion Control | 75 |
| 3.6.8.1.6 | Prohibited Materials | 75 |
| 3.6.8.1.7 | Electrostatic Discharge (ESD) | 75 |
| 3.6.8.2 | Safety | 75 |
| 3.6.8.2.1 | Electrical Safety | 76 |
| 3.6.8.2.2 | Mechanical Safety | 76 |
| 3.6.8.2.3 | Laser Safety | 77 |
| 3.6.8.2.4 | Safety Markings and Labels | 77 |
| 3.6.8.2.5 | Environmental and Chemical Safety | 78 |
| 3.6.8.2.6 | General Safety Provisions | 78 |

| | | |
|-----------|---|----|
| 3.7 | Provisions for Upgrade | 79 |
| 3.7.1 | Upgrade Process..... | 79 |
| 3.7.2 | Future Capabilities..... | 79 |
| 3.7.2.1 | EMMS Interface to a Future Site-Level NMS..... | 79 |
| 3.7.2.2 | Spectrum Display | 80 |
| 3.7.2.3 | Dynamic Resource Allocation (DRA)..... | 80 |
| 3.7.3 | Software and Firmware Portability..... | 82 |
| 3.8 | Precedence..... | 82 |
| 4 | QUALITY ASSURANCE PROVISIONS | 83 |
| 4.1 | Quality Program..... | 83 |
| 4.1.1 | ISO 9001 | 83 |
| 4.1.2 | Responsibility | 83 |
| 4.1.3 | Quality Assurance Activities | 83 |
| 4.1.3.1 | First Article Test (FAT) | 84 |
| 4.1.3.1.1 | FAT Overview..... | 84 |
| 4.1.3.1.2 | WGS Certification Support | 84 |
| 4.1.3.1.3 | EDIM Modem Test Features | 84 |
| 4.1.3.1.4 | Automated Testing | 84 |
| 4.1.3.1.5 | Frequency and Time Integrity During FAT..... | 84 |
| 4.1.3.1.6 | EDIM Modem Control During FAT..... | 85 |
| 4.1.3.1.7 | Electromagnetic Interference to Other Systems | 85 |
| 4.1.3.1.8 | Configuration Ranges..... | 85 |
| 4.1.3.1.9 | Computational Loading | 85 |
| 4.1.3.2 | Production Qualification Test (PQT)..... | 86 |
| 4.1.3.2.1 | PQT Overview | 86 |
| 4.1.3.2.2 | Early Life Defect Prevention | 86 |
| 4.2 | Expanded Verification Cross Reference Matrix (EVC RM) | 86 |
| 4.2.1 | Inspection (I)..... | 87 |
| 4.2.2 | Analysis (A) | 87 |
| 4.2.3 | Demonstration (D) | 87 |
| 4.2.4 | Test (T)..... | 87 |
| 4.2.5 | No Requirement (N) | 87 |
| 4.3 | Requirements Verification..... | 88 |
| 4.3.1 | Item Definition | 88 |
| 4.3.1.1 | External Interfaces | 88 |
| 4.3.1.1.1 | Front Panel Interfaces | 88 |
| 4.3.1.1.2 | Rear Panel Interfaces..... | 88 |
| 4.3.1.1.3 | Contractor Discretionary Interfaces | 88 |

| | | |
|-----------------|--|----|
| 4.3.1.2 | Signal Processing Functions | 88 |
| 4.3.1.3 | NATO STANAG 4486 Ed4 (EBEM) Interoperability | 89 |
| 4.3.2 | Function and Performance | 89 |
| 4.3.2.1 | Time and Frequency Base | 89 |
| 4.3.2.2 | Data Traffic Rate Estimation..... | 89 |
| 4.3.2.3 | L-Band IF Interface..... | 89 |
| 4.3.2.3.1 | L-Band IF Non-Damaging Input Power | 90 |
| 4.3.2.3.2 | L-Band IF Isolation | 90 |
| 4.3.2.4 | Digital IF Interface | 90 |
| 4.3.2.4.1 | Digital IF Capacity | 90 |
| 4.3.2.4.2 | IP Addressability..... | 90 |
| 4.3.2.4.3 | Digital IF Protocol..... | 90 |
| 4.3.2.4.4 | Digital IF Network Connectivity..... | 90 |
| 4.3.2.4.5 | Digital IF Networking Performance..... | 91 |
| 4.3.2.5 | Modem Function and Performance | 91 |
| 4.3.2.5.1 | General..... | 91 |
| 4.3.2.5.1.1 | Ethernet Bridge..... | 91 |
| 4.3.2.5.1.2 | Carrier Count and Independence..... | 91 |
| 4.3.2.5.1.3 | Data Traffic Rates..... | 91 |
| 4.3.2.5.1.4 | Symbol Rates | 91 |
| 4.3.2.5.1.5 | FIPS Cert and General Crypto Provisions | 91 |
| 4.3.2.5.1.6 | Interference Mitigation | 91 |
| 4.3.2.5.1.6.1 | Interference Mitigation Operation..... | 91 |
| 4.3.2.5.1.6.2 | Interference Mitigation Performance | 92 |
| 4.3.2.5.2 | Modem Waveforms | 92 |
| 4.3.2.5.2.1 | NATO STANAG 4486 Ed4 (EBEM) Baseline | 93 |
| 4.3.2.5.2.1.1 | Payload..... | 93 |
| 4.3.2.5.2.1.2 | Features..... | 93 |
| 4.3.2.5.2.1.3 | Bulk Encryption for Cover | 93 |
| 4.3.2.5.2.1.4 | Waveform..... | 93 |
| 4.3.2.5.2.2 | Support for Higher Rates | 94 |
| 4.3.2.5.2.2.1 | EBEM Extended Rate Operation | 94 |
| 4.3.2.5.2.2.2 | DVB-S2X Hub Waveform Operation | 94 |
| 4.3.2.5.2.2.2.1 | Waveform..... | 94 |
| 4.3.2.5.2.2.2.2 | Data Traffic Encapsulation..... | 94 |
| 4.3.2.5.2.2.2.3 | Bulk Encryption for Cover | 94 |
| 4.3.2.5.2.2.2.4 | DVB-S2X Feature Support..... | 94 |
| 4.3.2.5.3 | LM Operation..... | 95 |

| | | |
|---------------|--|-----|
| 4.3.2.5.4 | LM Uplink Performance | 95 |
| 4.3.2.5.4.1 | LM Uplink Carrier Frequency | 95 |
| 4.3.2.5.4.2 | LM Uplink Frequency Stability | 96 |
| 4.3.2.5.4.3 | LM Uplink Frequency Accuracy | 96 |
| 4.3.2.5.4.4 | LM Uplink Phase Noise | 96 |
| 4.3.2.5.4.5 | LM Uplink Carrier Power..... | 97 |
| 4.3.2.5.4.6 | LM Uplink Power Off Performance | 98 |
| 4.3.2.5.4.7 | LM Uplink Spectral Confinement | 98 |
| 4.3.2.5.4.7.1 | Single Carrier Spectra..... | 98 |
| 4.3.2.5.4.7.2 | Multiple Carrier Spectra | 98 |
| 4.3.2.5.4.7.3 | Spectrum Data Reporting..... | 99 |
| 4.3.2.5.4.8 | LM Uplink Noise Floor | 99 |
| 4.3.2.5.4.9 | LM Uplink Spurious Emissions | 99 |
| 4.3.2.5.4.10 | LM Uplink Harmonics..... | 99 |
| 4.3.2.5.4.11 | LM Uplink Error Vector Magnitude (EVM)..... | 100 |
| 4.3.2.5.5 | LM Downlink Performance | 100 |
| 4.3.2.5.5.1 | LM Downlink Carrier Frequency | 100 |
| 4.3.2.5.5.2 | LM Downlink Frequency Uncertainty | 100 |
| 4.3.2.5.5.3 | LM Downlink Min Rx Power..... | 100 |
| 4.3.2.5.5.4 | LM Downlink Acquisition and Reacquisition | 100 |
| 4.3.2.5.5.5 | LM Downlink Synchronization Retention | 101 |
| 4.3.2.5.5.6 | LM Downlink Doppler Environment..... | 101 |
| 4.3.2.5.5.7 | LM Back-to-Back BER..... | 101 |
| 4.3.2.5.5.7.1 | Baseline BER Performance | 101 |
| 4.3.2.5.5.7.2 | BER Performance Consistency..... | 102 |
| 4.3.2.5.5.7.3 | Multiple Carrier BER Performance..... | 102 |
| 4.3.2.5.5.7.4 | Data Range and Reporting | 102 |
| 4.3.2.5.5.8 | LM Downlink Adjacent Channel Interference (ACI) 102 | |
| 4.3.2.5.5.9 | LM Downlink Power Disparity | 103 |
| 4.3.2.5.5.9.1 | Symmetrical Interference Environment .. | 103 |
| 4.3.2.5.5.9.2 | Intermod Sensitive Environment | 103 |
| 4.3.2.5.5.10 | LM Downlink Input Power Changes..... | 106 |
| 4.3.2.5.6 | DM Operation | 106 |
| 4.3.2.5.7 | DM Uplink Performance | 106 |
| 4.3.2.5.7.1 | DM Uplink Carrier Frequency | 106 |
| 4.3.2.5.7.2 | DM Uplink Carrier Power | 106 |
| 4.3.2.5.7.3 | DM Uplink Digitization Noise PSD | 106 |

| | | |
|---------------|--|-----|
| 4.3.2.5.7.4 | DM Uplink Spectral Confinement..... | 107 |
| 4.3.2.5.7.4.1 | Carrier Measurement Sets..... | 107 |
| 4.3.2.5.7.4.2 | Spectrum Data Reporting..... | 107 |
| 4.3.2.5.7.5 | DM Uplink EVM | 107 |
| 4.3.2.5.8 | DM Downlink Performance..... | 107 |
| 4.3.2.5.8.1 | DM Downlink Carrier Frequency..... | 108 |
| 4.3.2.5.8.2 | DM Downlink Frequency Uncertainty..... | 108 |
| 4.3.2.5.8.3 | DM Downlink Acquisition and Reacquisition..... | 108 |
| 4.3.2.5.8.4 | DM Downlink Synchronization Retention..... | 108 |
| 4.3.2.5.8.5 | DM Downlink Doppler Environment..... | 108 |
| 4.3.2.5.8.6 | DM Back-to-Back BER | 108 |
| 4.3.2.5.8.6.1 | Baseline BER Performance | 109 |
| 4.3.2.5.8.6.2 | BER Performance Consistency..... | 109 |
| 4.3.2.5.8.6.3 | Data Range and Reporting | 109 |
| 4.3.2.5.8.7 | DM Downlink ACI..... | 110 |
| 4.3.2.5.9 | Modem Test Features | 110 |
| 4.3.2.5.9.1 | Carrier Frequency Measurement..... | 110 |
| 4.3.2.5.9.2 | Carrier Power Measurement..... | 110 |
| 4.3.2.5.9.3 | Signal to Noise Ratio (SNR) Measurement | 110 |
| 4.3.2.5.9.4 | Internal Bit Error Rate Test (BERT) | 111 |
| 4.3.3 | Management and Control (M&C)..... | 111 |
| 4.3.3.1 | M&C Objectives..... | 111 |
| 4.3.3.2 | EDIM Modem System M&C Architecture..... | 111 |
| 4.3.3.2.1 | EDIM Modem Management Components | 111 |
| 4.3.3.2.1.1 | EDIM Modem Management System / Software (EMMS) | 111 |
| 4.3.3.2.1.2 | Operator Interface (OI) | 112 |
| 4.3.3.2.2 | EDIM Modem | 113 |
| 4.3.3.3 | Site-Level Network Management System (NMS) | 113 |
| 4.3.3.4 | General Operation..... | 113 |
| 4.3.3.4.1 | M&C Roles | 113 |
| 4.3.3.4.2 | M&C Protocols | 113 |
| 4.3.3.4.3 | Data Traffic Integrity | 114 |
| 4.3.3.4.4 | Contention Resolution | 114 |
| 4.3.3.4.5 | Configuration Integrity | 114 |
| 4.3.3.4.6 | M&C Response Time | 114 |
| 4.3.3.4.7 | Factory Default State..... | 114 |
| 4.3.3.4.8 | Shutdown and Restart..... | 115 |

| | | |
|-----------|---|-----|
| 4.3.3.5 | Management Provisions | 115 |
| 4.3.3.5.1 | Power Control..... | 115 |
| 4.3.3.5.2 | File Transfer | 116 |
| 4.3.3.5.3 | Authentication..... | 116 |
| 4.3.3.5.4 | Multiple Modem Configuration Management..... | 116 |
| 4.3.3.5.5 | Situational Awareness | 116 |
| 4.3.3.5.6 | Modem Suite Reporting..... | 117 |
| 4.3.4 | Cybersecurity | 117 |
| 4.3.4.1 | System Identification Profile | 117 |
| 4.3.4.2 | Identification and Authentication..... | 118 |
| 4.3.4.3 | Confidentiality..... | 118 |
| 4.3.4.4 | Integrity..... | 118 |
| 4.3.4.5 | Availability | 119 |
| 4.3.4.6 | Access Control | 119 |
| 4.3.4.6.1 | Operator Roles | 119 |
| 4.3.4.6.2 | Password Policy | 120 |
| 4.3.4.7 | Network Interfaces | 120 |
| 4.3.4.8 | M&C Components and Data Storage | 120 |
| 4.3.4.9 | Auditing and Non-Repudiation..... | 121 |
| 4.3.4.10 | Notification..... | 121 |
| 4.3.5 | Built-In Test (BIT) | 121 |
| 4.3.5.1 | Hardware Fault Detection..... | 121 |
| 4.3.5.1.1 | Continuous Self-Test..... | 121 |
| 4.3.5.1.2 | Non-Disruptive Self-Test | 122 |
| 4.3.5.1.3 | Disruptive Self-Test / Power-On Self-Test (POST)..... | 122 |
| 4.3.5.2 | Alarms | 122 |
| 4.3.5.2.1 | Major Alarms | 122 |
| 4.3.5.2.2 | Minor Alarms | 122 |
| 4.3.5.2.3 | Alarm Logging and Access..... | 122 |
| 4.3.5.3 | Alarm Notifications | 123 |
| 4.3.6 | Physical Platform..... | 123 |
| 4.3.6.1 | Physical Platform Priorities..... | 123 |
| 4.3.6.2 | Life Expectancy | 123 |
| 4.3.6.3 | Transportability | 123 |
| 4.3.6.4 | 19" Rack Mountable Enclosure Packaging..... | 124 |
| 4.3.6.4.1 | Front Panel..... | 124 |
| 4.3.6.4.2 | Rear Panel | 124 |
| 4.3.6.4.3 | Cooling | 124 |

| | |
|--|-----|
| 4.3.6.4.4 AC Power and Power Transients | 124 |
| 4.3.6.4.4.1 AC Power | 124 |
| 4.3.6.4.4.2 Power Transients..... | 124 |
| 4.3.6.5 Electromagnetic Environmental Effects (E3) | 124 |
| 4.3.6.5.1 Grounding, Bonding and Shielding..... | 124 |
| 4.3.6.5.2 Electromagnetic Compatibility (EMC)..... | 124 |
| 4.3.6.5.3 Electromagnetic Interference (EMI)..... | 125 |
| 4.3.6.6 Physical Environment..... | 125 |
| 4.3.6.6.1 Non-Operating Physical Environment | 125 |
| 4.3.6.6.2 Operating Physical Environment | 125 |
| 4.3.6.6.3 Seismic Conditions..... | 126 |
| 4.3.6.7 Reliability, Maintainability and Availability..... | 126 |
| 4.3.6.7.1 Reliability | 126 |
| 4.3.6.7.2 Maintainability..... | 126 |
| 4.3.6.7.3 Availability | 126 |
| 4.3.6.7.4 FRACAS..... | 126 |
| 4.3.6.8 Design and Construction | 126 |
| 4.3.6.8.1 Manufacturing Considerations..... | 126 |
| 4.3.6.8.1.1 Nameplates and Product Marking..... | 126 |
| 4.3.6.8.1.2 Workmanship..... | 126 |
| 4.3.6.8.1.3 Interchangeability..... | 127 |
| 4.3.6.8.1.4 Finish | 127 |
| 4.3.6.8.1.5 Corrosion Control..... | 127 |
| 4.3.6.8.1.6 Prohibited Materials | 127 |
| 4.3.6.8.1.7 Electrostatic Discharge (ESD) | 127 |
| 4.3.6.8.2 Safety | 127 |
| 4.3.6.8.2.1 Electrical Safety | 127 |
| 4.3.6.8.2.2 Mechanical Safety | 127 |
| 4.3.6.8.2.3 Laser Safety | 128 |
| 4.3.6.8.2.4 Safety Markings and Labels | 128 |
| 4.3.6.8.2.5 Environmental and Chemical Safety..... | 128 |
| 4.3.6.8.2.6 General Safety Provisions | 128 |
| 4.3.7 Provisions for Upgrade | 128 |
| 4.3.7.1 Upgrade Process..... | 128 |
| 4.3.7.2 Future Capabilities | 128 |
| 4.3.7.3 Software and Firmware Portability..... | 128 |
| 4.3.8 Precedence | 128 |
| APPENDIX A Acronyms and Abbreviations | A-1 |

| | | |
|------------|--|-----|
| APPENDIX B | Definitions of Terms | B-1 |
| APPENDIX C | Verification Cross Reference Matrix (VCRM) | C-1 |
| APPENDIX D | Derivation of Sampling Noise PSD | D-1 |

LIST OF TABLES

| | | |
|-----------|---|-----|
| TABLE I | Acquisition Times for Selected Symbol Rates | 37 |
| TABLE II | Doppler Parameters | 37 |
| TABLE III | BER Performance for EBEM Emulations | 39 |
| TABLE IV | Example Non-Proprietary Industry Standard Protocols | 54 |
| TABLE V | Example File Transfer Types | 57 |
| TABLE VI | Operator Role Privileges | 63 |
| TABLE VII | Verification Cross Reference Matrix (VCRM) | C-1 |

LIST OF FIGURES

| | | |
|-----------|--|-----|
| FIGURE 1 | EDIM Modem System | 10 |
| FIGURE 2 | EDIM Modem External Interface Diagram | 12 |
| FIGURE 3 | EDIM Modem Functional Use Diagram | 17 |
| FIGURE 4 | EDIM Modem Multi-Carrier LM Function | 18 |
| FIGURE 5 | EDIM Modem Multi-Carrier DM Function | 18 |
| FIGURE 6 | LM Loopbacks | 30 |
| FIGURE 7 | EDIM Modem Phase Noise PSD Limit Mask | 32 |
| FIGURE 8 | L-Band Output No-Signal Thresholds | 34 |
| FIGURE 9 | Modulator Output Carrier Spectral Density Limit Mask | 35 |
| FIGURE 10 | IF Input ACI Scenario | 40 |
| FIGURE 11 | Input Power Change Profile | 41 |
| FIGURE 12 | DM Loopbacks | 43 |
| FIGURE 13 | EDIM Modem System M&C Architecture | 49 |
| FIGURE 14 | Practical Implementation of EDIM Modem M&C | 50 |
| FIGURE 15 | Notional DRA Operation | 81 |
| FIGURE 16 | Example Symmetrical Interference Environment | 104 |
| FIGURE 17 | Example Intermod Sensitive Interference Environment | 105 |

SPECIFICATION FOR THE EDIM MODEM SYSTEM

1 SCOPE

1.1 Identification

This specification establishes the system requirements for a Frequency Division Multiple Access (FDMA) Enterprise Digital Intermediate Frequency (Digital IF) Multi-Carrier Modem (EDIM Modem) System to be used with Department of Defense (DOD) and commercial satellite systems. The EDIM Modem System includes the EDIM Modem and associated Management and Control (M&C) software components.

1.2 General

The EDIM Modem addresses L-Band port congestion at DOD SATCOM gateways by offering a multi-carrier general purpose FDMA modem capability for use in uncontested environments. The EDIM Modem is also a dual IF modem with an L-Band IF interface and a Digital IF interface. This dual IF capability enables and accelerates the migration of DOD SATCOM gateway architectures from L-Band media to Digital IF media, which further addresses L-Band port congestion and begins to address resilience.

1.3 Multi-Carrier Modem Operation

The EDIM Modem is a fully integrated multiple carrier modem addressing growing DOD Enterprise SATCOM needs for high-density, high-performance Internet Protocol (IP)-centric FDMA modem operations. The EDIM Modem supports multiple point-to-point SATCOM links by carrying Ethernet data traffic over multiple carriers employing both L-Band and Digital IF interfaces. The ability to support multiple carriers over L-Band immediately addresses L-Band switch congestion issues at Enterprise SATCOM gateways. The EDIM Modem is an operator-friendly upgradeable platform intended to introduce various new modem capabilities, both immediately and through subsequent upgrades.

1.3.1 Modem Emulations

The EDIM Modem supports an efficient subset of NATO STANAG 4486 Ed4 (Enhanced Bandwidth Efficient Modem, a.k.a. EBEM) waveforms. Provisions for ensuring high performance efficient operation include integrated interference mitigation.

1.3.2 Data Traffic Cover

The EDIM Modem is intended for operation with encrypted (i.e., black) data traffic. The EDIM Modem provides encryption for all its carriers for purposes of obscuring headers to prevent adversary data traffic analysis. Data traffic cover is in accordance with (IAW) NATO STANAG 4486 Ed4 for interoperability with EBEM. The EDIM Modem is to be certified at Security Level 2 IAW Federal Information Processing Standards (FIPS) Publication (PUB) 140-3.

1.3.3 Growth in Link Rates

EDIM Modem provides for growth in link rates available to users, including higher maximum data traffic rates and symbol rates. Provisions for raising link rates include offering the Digital Video Broadcasting Second Generation Extensions (DVB-S2X) waveform, IAW ETSI EN 302 307-2, at the discretion of the Contractor.

1.4 Digital IF Migration

Digital IF Enterprise terminal infrastructure is key to supporting DOD SATCOM growth and resilience. The EDIM Modem supports the transition from L-Band to Digital IF infrastructures by offering dual IF interface sets. Operation over the L-Band IF is compliant with MIL-STD-188-165B. The Digital IF interface is IEEE-ISTO 4900-2021 Digital IF Interoperability Standard (DIFI Standard) compliant to ensure interoperability with an existing base of commercial equipment and with subsequent emerging SATCOM Digital IF infrastructure equipment. Digital IF performance supports end-to-end performance of Digital IF signal chains equivalent to or exceeding the performance required of corresponding L-Band signal chains.

1.5 Enterprise Applications

The initial application of the EDIM Modem is for Enterprise Earth terminal deployment.

The Government plans to install the EDIM Modem in DOD Joint SATCOM Gateways that access Wideband Global SATCOM (WGS) and commercial satellites. The EDIM Modem operates with earth terminals in the SHF (C, X, Ku and Ka) band as a replacement for the EBEM, which is reaching its end of life. The EDIM Modem is packaged in a 1RU chassis for efficient modular deployment, maximizing capability provided relative to rack space occupied. The EDIM Modem is mounted in EIA/ECA-310-E compliant racks.

1.6 Management and Control Flexibility

The EDIM Modem supports remote management and control, future centralized power management, and lights out operation.

1.7 Future Applications

The Government may consider revised or upgraded versions of the EDIM Modem in the future for application in shipboard, land mobile, airborne SATCOM, special missions, and virtualization. Such revisions may include upgraded capabilities and/or new size, weight and power (SWaP) requirements.

1.8 Upgradability

The EDIM Modem is software (SW) / firmware (FW) upgradable and open to additional capabilities. The SW/FW upgrade process will be simple, local and remote capable, and over-the-air capable.

2 APPLICABLE DOCUMENTS

The latest version of the following documents form a part of this specification to the extent specified herein. In the event of conflict between this specification and the documents referenced below, the precedence shall be as stated in Section 3.8. Nothing in this document, however, supersedes applicable laws and regulations, unless a specific exemption has been obtained.

2.1 Government Documents

Copies of specifications, standards and other publications required by suppliers in connection with specific procurement functions should be obtained from the contracting agency, or as directed by the Contracting Officer (KO).

2.1.1 Specifications, Standards and Handbooks

Handbooks

MIL-HDBK-310 – Global Climatic Data for Developing Military Products, 23 June 1997

MIL-HDBK-419A – Grounding, Bonding, and Shielding for Electronic Equipments and Facilities, 29 December 1987

MIL-HDBK-1857 – Grounding, Bonding, and Shielding Design Practices, 27 March 1998

MIL-HDBK-2155, Military Handbook: Failure Reporting, Analysis and Corrective Action Taken, 11 Dec 1995

Federal Standards

AMS-STD-595A – Colors Used in Government Procurement, 10 February 2017

Military Standards

MIL-STD-188-124B – Grounding, Bonding, and Shielding for Common Long Haul/Tactical Communication Systems Including Ground Based Communications-Electronics Facilities and Equipments, 1 February 1992

MIL-STD-130N w/ CHANGE 1 – Identification Marking of US Military Property, 16 November 2012

MIL-STD-188-164C – Interoperability of Superhigh Frequency (SHF) Satellite Communications Terminals, 16 November 2018

MIL-STD-188-165B – Interoperability of SHF Satellite Communications PSK Modems, 26 March 2018

MIL-STD-461G – Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment, 11 December 2015

MIL-STD-464C – Electromagnetic Environmental Effects Requirements for Systems, 1 December 2010

MIL-STD-810H – Environmental Engineering Considerations and Laboratory Tests, 31 January 2019

MIL-STD-1472G – Department of Defense Design Criteria Standard, Human Engineering, 11 January 2012

2.1.2 Other Government Documents, Drawings and Publications

Code of Federal Regulations (CFR)

29 CFR § 1910.1000 - Air Contaminants

47 CFR Part 15 –Radio Frequency Devices

DOD Instructions

Department of Defense Instruction (DODI) 5000.02 w/Change 1 –Operation of the Adaptive Acquisition Framework, 8 June 2022

DODI 8500.01 w/ Change 1 –Cybersecurity, 7 October 2019

DODI 8510.01 –Risk Management Framework for DOD Systems, 19 July 2022

DODI 8520.02 –Public Key Infrastructure (PKI) and Public Key (PK) Enabling, 24 May 2011

DODI 8520.03 w/Change 1 –Identity Authentication for Information Systems, 27 July 2017

DSD Memos

Deputy Secretary of Defense Memorandum, Implementation of Microsoft Windows 10 Secure Host Baseline, 26 February 2016

International Standardization Agreements

NATO STANAG 4486 Edition 4 – Super High Frequency (SHF) Military Satellite Communications (MILSATCOM) Frequency Division Multiple Access (FDMA) Non-EPM Modem for Services conforming to Class-B of STANAG 4484, 4 November 2016

National Institute of Standards and Technology (NIST)

FIPS PUB 140-3 – Security Requirements for Cryptographic Modules, 1 May 2019

NIST Special Publication 800-53 (Rev. 4) - Security and Privacy Controls for Federal Information Systems and Organizations, April 2013

Range Commanders Council (RCC)

IRIG Standard 200-16 – IRIG Serial Time Code Formats, August 2016

United States Army

Army Regulation (AR) 25-2 – Army Cybersecurity, 4 April 2019

Department of the Army Pamphlet (DA PAM) 385-16 – System Safety Management Guide, 13 August 2013

Technical Bulletin (TB) 43-0134 - Battery Disposition and Disposal, Department of the Army, 30 May 2018.

United States Army Space and Missile Defense Command

Wideband Consolidated Satellite Communications (SATCOM) System Expert (WB C-SSE) Terminal Performance Certification Test Procedures v3.00. U.S. Army Space and Missile Defense Command / Satellite Operations Brigade Wideband (USASMDC/SATOPS BDE WB), formerly Army Forces Strategic Command (USASMDC/ARSTRAT), 17 June 2019.

Wideband FDMA Modem Performance Certification: Frequency Division Multiple Access (FDMA) Modem Performance Requirements v1.2. U.S. Army Space and Missile Defense Command / Satellite Operations Brigade Wideband (USASMDC/SATOPS BDE WB), formerly Army Forces Strategic Command (USASMDC/ARSTRAT), 17 April 2015.

2.2 Non-Government Documents

American National Standards Institute (ANSI)

ANSI Z136.1– American National Standard for Safe Use of Lasers, 10 December 2013

ANSI Z136.2 – American National Standard for Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources, 19 December 2012

ANSI Z535.4-2011 – American National Standard for Product Safety Signs and Labels, 6 December 2017

ANSI/VITA 49.2-2017 - VITA Radio Transport (VRT) Electromagnetic Spectrum: Signals and Applications, 2017

ANSI/VITA 49a-2015 - Spectrum Survey Interoperability, 2015

Electronic Components Industry Association (ECIA)

ECIA EIA/ECA-310-E - Cabinets, Racks, Panels, and Associated Equipment, December 2005

European Telecommunications Standards Institute (ETSI)

ETSI EN 302 307-1 v1.4.1 (2014-11) - Digital Video Broadcasting (DVB); Second Generation Framing Structure, Channel Coding and Modulation Systems for Broadcasting, Interactive Services, News Gathering and Other Broadband Satellite Applications; Part 1” DVB-S2

ETSI EN 302 307-2 v1.1.1 (2014-10) - Digital Video Broadcasting (DVB); Second Generation Framing Structure, Channel Coding and Modulation

Systems for Broadcasting, Interactive Services, News Gathering and Other Broadband Satellite Applications; Part 2: DVB-S2 Extensions (DVB-S2X)

Institute of Electrical and Electronic Engineers (IEEE)

IEEE 1100-2005 - IEEE Recommended Practice for Powering and Grounding Electronic Equipment, 24 May 2006

IEEE 1588-2019 - IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems, 16 June 2020

IEEE 802.1AB - IEEE Standard for Local and metropolitan area networks - Station and Media Access Control Connectivity Discovery, 11 March 2016

IEEE 802.1Q-2018 - IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks, 06 July 2018

IEEE 802.3 – IEEE Standard for Ethernet, 31 August 2018

IEEE C63.16-2016 – American National Standard Guide for Electrostatic Discharge Test Methodologies and Acceptance Criteria for Electronic Equipment, 06 May 2016

IEEE Industry Standards and Technology Organization (IEEE-ISTO)

IEEE-ISTO Std 4900-2021: Digital IF Interoperability Standard v1.1. Digital IF Interoperability Consortium, August 09, 2022.

International Electrotechnical Commission (IEC)

IEC 60950-1 Edition 2.2 – Information Technology Equipment – Safety – Part 1: General Requirements, May 2013

International Standardization Organization (ISO)

ISO 9001:2015 – Quality Management Systems – Requirements, Edition E, 05 September 2015

Internet Engineering Taskforce (IETF)

D. Carrel and Lol Grant, The TACACS+ Protocol, Version 1.78, IETF Draft, January 1997

IETF RFC 791 – Internet Protocol, DARPA Internet Program Protocol Specification, September 1981

IETF RFC 1035 – Domain Names – Implementation and Specification, November 1987

IETF RFC 1492 - An Access Control Protocol, Sometimes Called TACACS, July 1993

IETF RFC 2131 – Dynamic Host Configuration Protocol, March 1997

IETF RFC 2660 – The Secure HyperText Transfer Protocol, August 1999

IETF RFC 2818 – HTTP Over TLS, May 2000

IETF RFC 2865 - Remote Authentication Dial In User Service (RADIUS), June 2000

IETF RFC 3411 – An Architecture for Describing Simple Network Management Protocol (SNMP) Management Frameworks, December 2002

IETF RFC 4251 - The Secure Shell (SSH) Protocol Architecture, January 2006

IETF RFC 4253 – The Secure Shell (SSH) Transport Layer Protocol, January 2006

IETF RFC 4511 – Lightweight Directory Access Protocol (LDAP), June 2006

IETF RFC 5424 - The Syslog Protocol, March 2009

IETF RFC 5578 – PPP over Ethernet (PPPoE) Extensions for Credit Flow and Link Metrics, February 2010

IETF RFC 5905 – Network Time Protocol Version 4: Protocol and Algorithms Specification, June 2010

IETF RFC 5906 – Network Time Protocol Version 4: Autokey Specification, June 2010
IETF RFC 8200 – Internet Protocol, Version 6 (IPv6) Specification, July 2017

IETF RFC 6241 - Network Configuration Protocol (NETCONF), June 2011

IETF RFC 7950 - The YANG 1.1 Data Modeling Language, August 2016

IETF RFC 7992 - HTML Format for RFCs, December 2016

IETF RFC 8175 - Dynamic Link Exchange Protocol (DLEP), June 2017

IETF RFC 8446 – Transport Layer Security (TLS), August 2018

IETF RFC 8651 - Dynamic Link Exchange Protocol (DLEP) Control-Plane-Based Pause Extension, October 2019

JEDEC Solid State Technology Association (JEDEC)

JESD 471 (formerly EIA-471) – Symbol and Label for Electrostatic Discharge Sensitive Devices, May 2018

Microsoft MSDN Library

MS-ADTS: Active Directory Technical Specification, v54.0, June 25, 2021

National Fire Protection Association

NFPA 70 – National Electric Code - 2020, 6 September 2019

Telcordia

GR-63-CORE – NEBS™ Requirements: Physical Protection, Issue 5,
December 2017

SR-332 – Reliability Prediction Procedure for Electronic Equipment, Issue 4,
March 2016

Underwriters Laboratories (UL)

UL 969 – Standard for Marking and Labeling Systems, 30 March 2018

World Wide Web Consortium (W3C)

W3C CSS – CSS Basic User Interface Module Level 3 (CSS3 UI), 21 June
2018

3 REQUIREMENTS

The following subsections employ deliberate language as follows.

- “shall” indicates a binding requirement that is to be met or implemented and will be verified
- “will” is used to indicate an intent (usually a Government intent) or a statement of fact. “Will” statements are not necessarily binding or verified.
- “may” usually indicates an optional action or capability
- “up to” indicates a threshold where function or performance is required of the range within the indicated limit
- “at least,” “no less than” and “no higher than” indicate thresholds at which there may added value in exceeding the threshold
- “up to at least” indicates
 - an expected operating range (“up to”) threshold
 - where there may be added value in exceeding the threshold (“at least”)

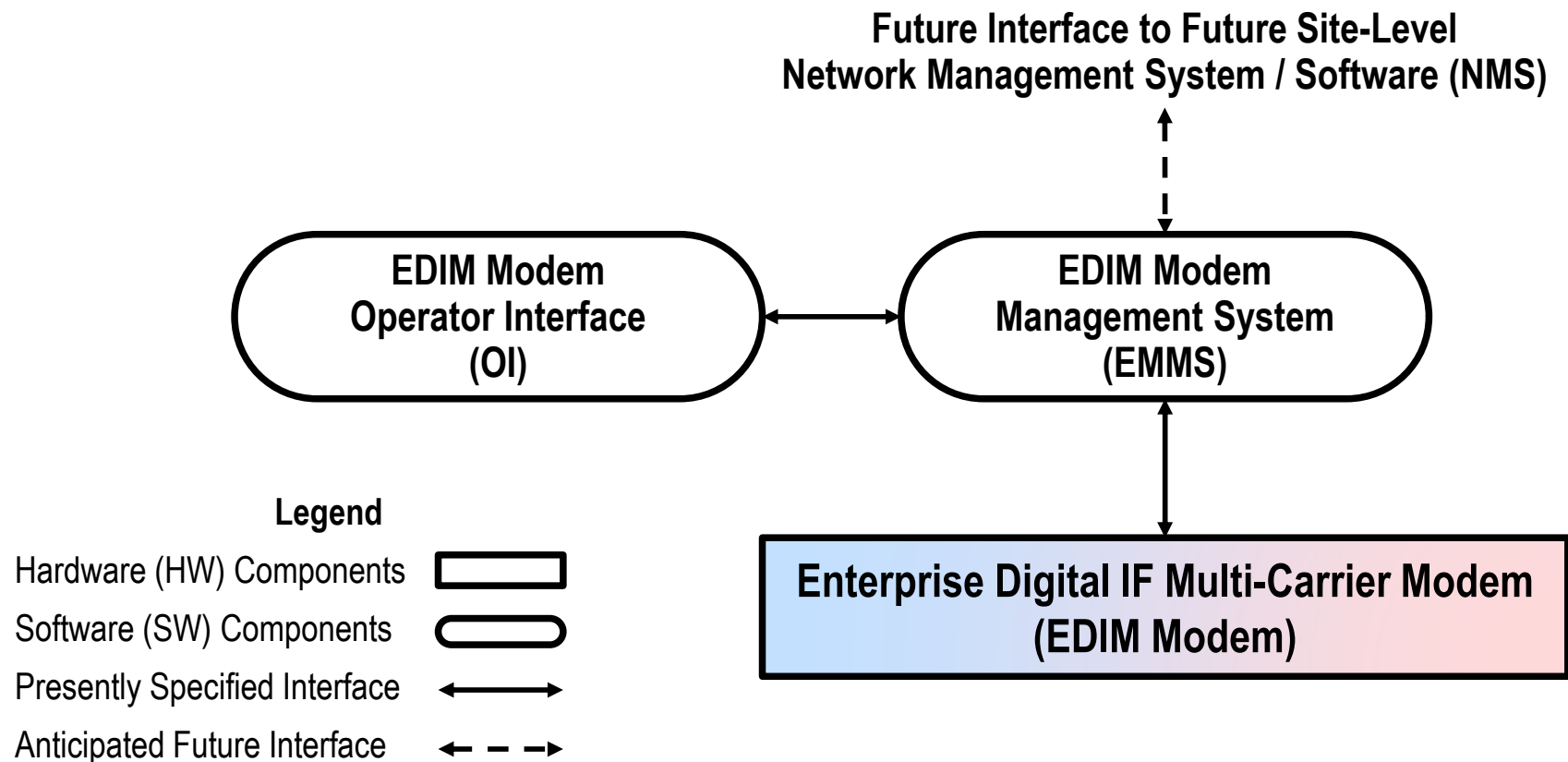
3.1 Item Definition

The EDIM Modem System consists of the following three components:

- The EDIM Modem, a hardware component, described below
- The EDIM Modem Management System / EDIM Modem Management Software (EMMS), a software component, described in Section 3.3 as the central point of control for all EDIM Modems
- The EDIM Modem Operator Interface (OI), a second software component, also described in Section 3.3, as the human interface to the EMMS for direct comprehensive management of all EDIM Modems by operators

The EDIM Modem System is illustrated in FIGURE 1. This illustration includes an interface contemplated for a future site-level Network Management System (NMS). This future site-level NMS interface is described as a future capability in Section 3.7.2.1.

The EDIM Modem shall be a single fully integrated hardware appliance. The EDIM Modem presents interfaces for timing and frequency reference, power, IP data traffic, L-Band IF, Digital IF, and management and control (M&C). The EDIM Modem delivers multi-carrier capabilities, including L-Band modem and Digital IF modem, while being backwards compatible with legacy modems and interfaces.

**FIGURE 1 EDIM Modem System**

3.1.1 External Interfaces

The following sections describe external interfaces on the EDIM Modem front and rear panel, as illustrated in FIGURE 2.

3.1.1.1 Front Panel Interfaces

The following subsections describe external interfaces on the EDIM Modem front panel.

3.1.1.1.1 Power Switch

A circuit breaker/on-off power switch, compliant with the electrical safety provisions of Section 3.6.8.2.1, shall be provided on the EDIM Modem front panel for purposes of EDIM Modem activation and deactivation. The EDIM Modem power switch shall be protected to prevent accidental actuation and deactivation. The EDIM Modem power-up cycle, from switch actuation to operational readiness, shall not exceed five (5) minutes.

3.1.1.1.2 Front Panel Visual Power Indicator

The EDIM Modem Front Panel shall present visual power indication.

3.1.1.2 Rear Panel Interfaces

The following subsections describe external interfaces on the EDIM Modem rear panel.

3.1.1.2.1 Ethernet Data Traffic

The EDIM Modem rear panel shall present two 10/100/1000BaseT Ethernet data traffic RJ-45 interfaces implemented IAW IEEE 802.3i (10Base-T), IEEE 802.3u (100Base-T) and IEEE 802.3ab (1000Base-T).

The purpose of two data traffic ports is the to provide flexibility to support:

- spine-leaf network architecture
- make-before-break network cut-over
- dual networks
- redundancy
- independent data traffic sources
- general flexibility

The EDIM Modem shall be capable of configurable prioritization of traffic from one port over the other.

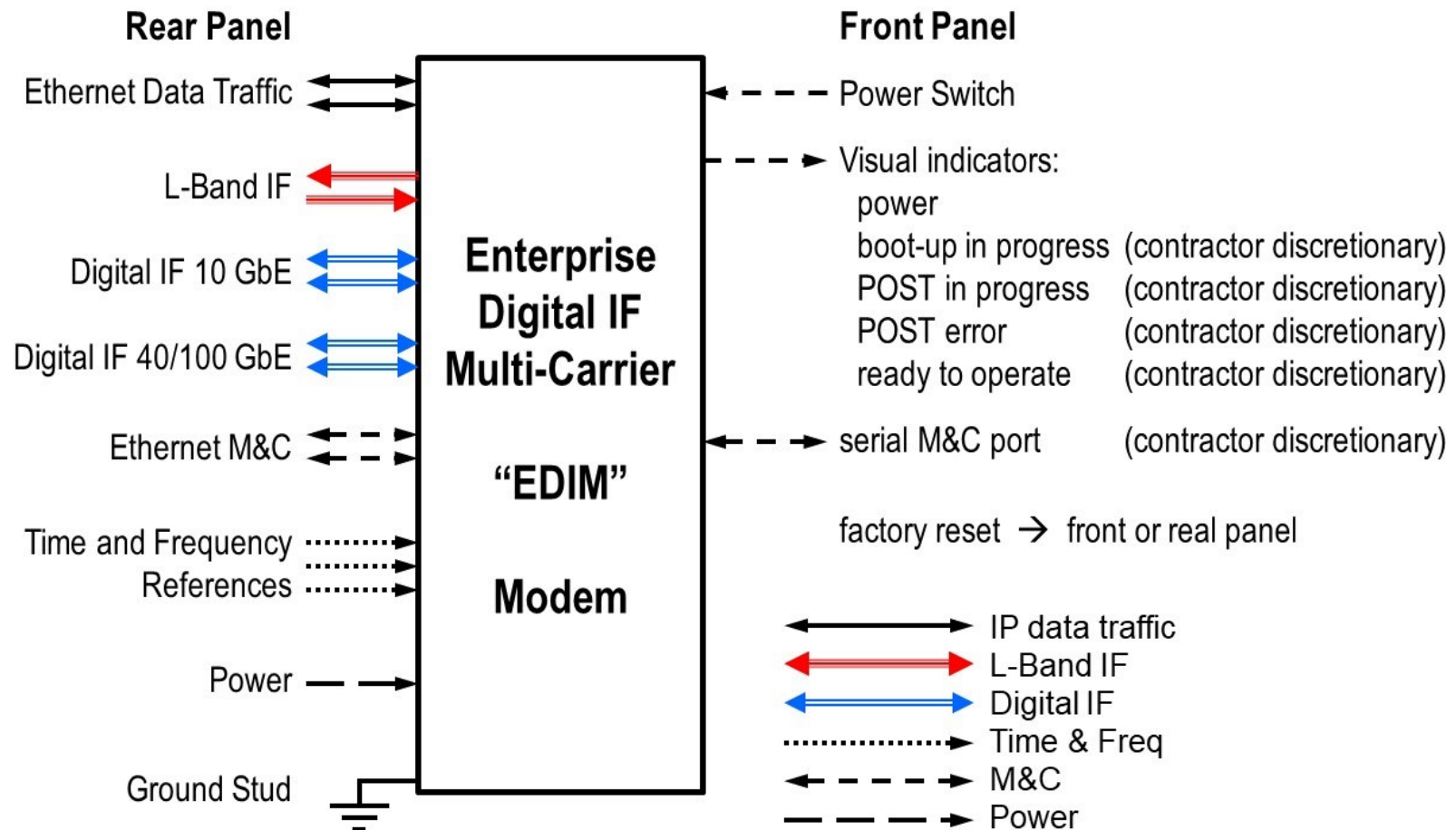


FIGURE 2 EDIM Modem External Interface Diagram

3.1.1.2.2 L-Band IF

The EDIM Modem rear panel shall present separate L-Band IF Transmit and Receive interfaces as follows:

- a. Connector: chosen by the Contractor from industry-standard non-proprietary choices (e.g. Type N, SMA, TNC, etc.), and subject to Government approval. (Note: SMB and BNC are not durable enough and will not be approved).
- b. Input impedance: 50 ohms
- c. VSWR not to exceed (NTE) 2.0:1 over the L-Band operating bandwidth (BW), as specified in Section 3.2.3
- d. Any analog IF capability at frequencies below the specified L-Band operating BW shall exhibit VSWR NTE 1.5:1. For example, if unspecified 70 or 700 MHz capabilities were to be included, the 1.5:1 VSWR threshold would apply over those bands.
- e. Connector Spacing: clearance space (closest edge to closest edge) between each connector and any other obstruction shall be at least 25 millimeters (1 inch) for accessibility with bare fingers.

3.1.1.2.3 Digital IF 10GbE

The EDIM Modem rear panel shall present two Digital IF ports that each support 10 Gbps Ethernet rates. These ports shall be physically reconfigurable to support:

- RJ-45 twisted pair (default configuration) IAW IEEE 802.3an
- twinaxial copper IAW IEEE 802.3ak
- multi-mode fiber (MMF) and single-mode fiber (SMF) IAW IEEE 802.3ae

The purpose of physically reconfigurable Ethernet interfaces for Digital IF is to provide the flexibility to support multiple Digital IF network configurations. The purpose of two 10GbE ports is to provide the flexibility to support:

- spine-leaf network architecture
- make-before-break network cut-over
- dual networks
- redundancy
- 20 Gbps of Digital IF stream traffic over 10 GbE interfaces
- general flexibility

3.1.1.2.4 Digital IF 40/100 GbE

The EDIM Modem rear panel shall present two Digital IF ports that each support 40 and 100 Gbps Ethernet rates. These ports shall be physically reconfigurable to support:

- 40 GbE MMF and SMF IAW IEEE 802.3ba
- 100 GbE MMF and SMF (default configuration) IAW IEEE 802.3cd

The purpose of physically reconfigurable Ethernet interfaces for Digital IF is to provide the flexibility to support multiple Digital IF network configurations. The purpose of two 40GbE/100GbE ports is to provide the flexibility to support:

- spine-leaf network architecture
- make-before-break network cut-over
- redundancy
- high Digital IF stream traffic capacity
- general flexibility

3.1.1.2.5 Rear Panel Ethernet M&C Ports

The EDIM Modem rear panel shall present two 10/100/1000BaseT Ethernet M&C RJ-45 interfaces implemented IAW IEEE 802.3i (10Base-T), IEEE 802.3u (100Base-T) and IEEE 802.3ab (1000Base-T). The purpose of two rear panel M&C ports is to provide the flexibility to support:

- spine-leaf network architecture
- make-before-break network cut-over for continuity of M&C operation
- redundancy
- general flexibility

3.1.1.2.6 Time & Frequency References

The following subsections specify rear panel time and frequency reference inputs.

3.1.1.2.6.1 5/10 MHz Frequency Reference

The EDIM Modem rear panel shall present a 5/10 MHz frequency reference input, compatible with input signals as follows.

- a. Connector: chosen by the Contractor from industry-standard non-proprietary choices (e.g. Type N, SMA, TNC, etc.), and subject to Government approval. (Note: SMB and BNC are not durable enough and will not be approved).
- b. Frequency: 5 or 10 MHz sinusoidal
- c. Frequency selection: automatically detected
- d. Input signal level: 0 to 13 dBm into 50 ohms
- e. Input impedance: 50 ohms (nominal)
- f. VSWR: 1.4:1 maximum

3.1.1.2.6.2 1 pps Timing Reference

The EDIM Modem rear panel shall present a 1 pps timing reference input, compatible with input signals as follows:

- a. Connector: chosen by the Contractor from industry-standard non-proprietary choices (e.g. Type N, SMA, TNC, etc.), and subject to Government approval. (Note: SMB and BNC are not durable enough and will not be approved).
- b. Input impedance: 50 ohms \pm 25%

- c. Level: +2.4 to +5.0 V when true, 0.0 to +0.4 V when false, into 50 ohms
- d. Frequency: 1 pps
- e. Accuracy: ± 1 μ sec relative to coordinated universal time (UTC) when referenced to the rising edge of the pulse
- f. Width: 20 μ s \pm 1 μ s
- g. Rise time: \leq 50 nanoseconds (ns), 10% to 90%
- h. Fall time: \leq 2 μ s, 90% to 10%
- i. Jitter, pulse-to-pulse: \leq 5 ns RMS

3.1.1.2.6.3 IRIG-B Timing Reference

The EDIM Modem rear panel shall present an IRIG-B timing reference input, compatible with input signals as follows:

- a. Connector: chosen by the Contractor from industry-standard non-proprietary choices (e.g. Type N, SMA, TNC, etc.), and subject to Government approval. (Note: SMB and BNC are not durable enough and will not be approved).
- b. Input impedance: 50 ohms \pm 25%
- c. Formats: IRIG-B000 and IRIG-B127 IAW IRIG Standard 200-16
- d. Level: +2.4 to +5.0 V when true, 0.0 to +0.4 V when false, into 50 ohms
- e. Rise time: \leq 1 μ s, 10% to 90%
- f. Fall time: \leq 1 μ s, 90% to 10%
- g. Jitter, pulse to pulse: \leq 200 ns max

3.1.1.2.7 Power

The EDIM Modem rear panel shall be equipped with a standard IEC 60320 style AC power connector compliant with the electrical safety provisions of Section 3.6.8.2.1.

3.1.1.2.8 Ground Stud

The EDIM Modem unit shall be equipped with a rear-panel grounding stud.

3.1.1.3 Contractor Discretionary Interfaces

to the Contractor may supplement EDIM Modem management through a serial port interface (optional serial M&C port).

The EDIM Modem shall provide the means for the operator to initiate a factory reset IAW Section 3.3.4.7. Its placement (i.e., front panel or rear panel) is at the discretion of the Contractor. The Contractor may provide the means of initiating a factory reset through the optional serial M&C port.

The EDIM Modem system shall present visual indication of the following conditions for each EDIM Modem:

- boot-up in progress
- POST (disruptive self-test) in progress IAW Section 3.5.1.3
- POST error IAW Section 3.5.1.3

- factory reset initiated IAW Section 3.3.4.7

These indications may be presented on the OI, through the optional serial M&C port, or directly on the EDIM Modem front panel. Should these indications be presented directly on the EDIM Modem front panel, then the term “visual indication” may be applied in the most general sense. Such acceptable front panel “visual indication” methods include separate lights, different colors, different blinking patterns, or any combination of these. Front panel visual indication methods may be duplicated when the underlying context is sufficient to differentiate between the conditions indicated. For example, “boot-up in progress” could be the same indication as “factory reset initiated” because the EDIM Modem has just been powered on in the first case, and a factory reset has just been initiated in the second case.

3.1.2 Signal Processing Functions

FIGURE 3 illustrates the use of the EDIM Modem as a multi-carrier L-Band modem (LM, once), and as Digital IF modem (DM) banks (4 places). Either function, LM or DM, shall be available to any of EDIM Modem’s duplex carriers.

3.1.2.1 L-Band Modem (LM)

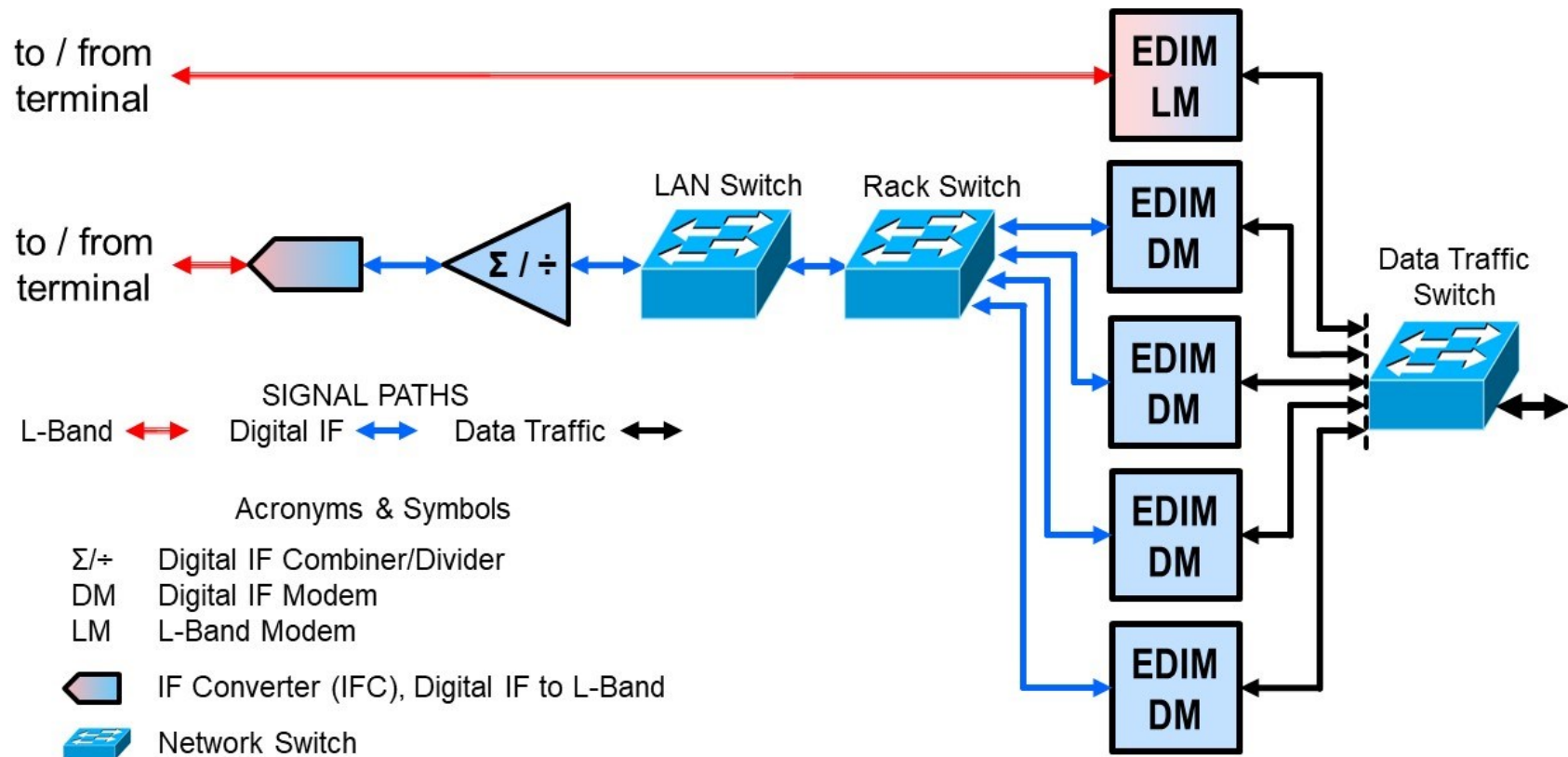
The EDIM Modem shall selectively provide a multi-carrier LM function between the Ethernet data traffic port and the L-Band IF interface IAW Section 3.2.5. The EDIM Modem multi-carrier LM function is illustrated in FIGURE 4.

3.1.2.2 Digital IF Modem (DM)

The EDIM Modem shall selectively provide a multi-carrier DM function between the Ethernet data traffic port and the Digital IF interface IAW Section 3.2.5. The EDIM Modem multi-carrier DM function is illustrated in FIGURE 5.

3.1.3 NATO STANAG 4486 Ed4 (EBEM) Interoperability

The EDIM Modem shall be fully compatible and interoperable, with respect to (WRT) waveforms and features specified in Section 3.2.5.2 and its subsections, with the ViaSat MD-1366.



Shown: Any EDIM Modem unit may function as either an LM or a DM.
 Not shown: Any EDIM Modem unit may function simultaneously as an LM and as a DM
 subject to a limit of up to at least 8 duplex carriers total.
 Not shown: Additional routers in hierarchical Digital IF network paths
 to and from both Digital IF combiner/divider and IFC

FIGURE 3 EDIM Modem Functional Use Diagram

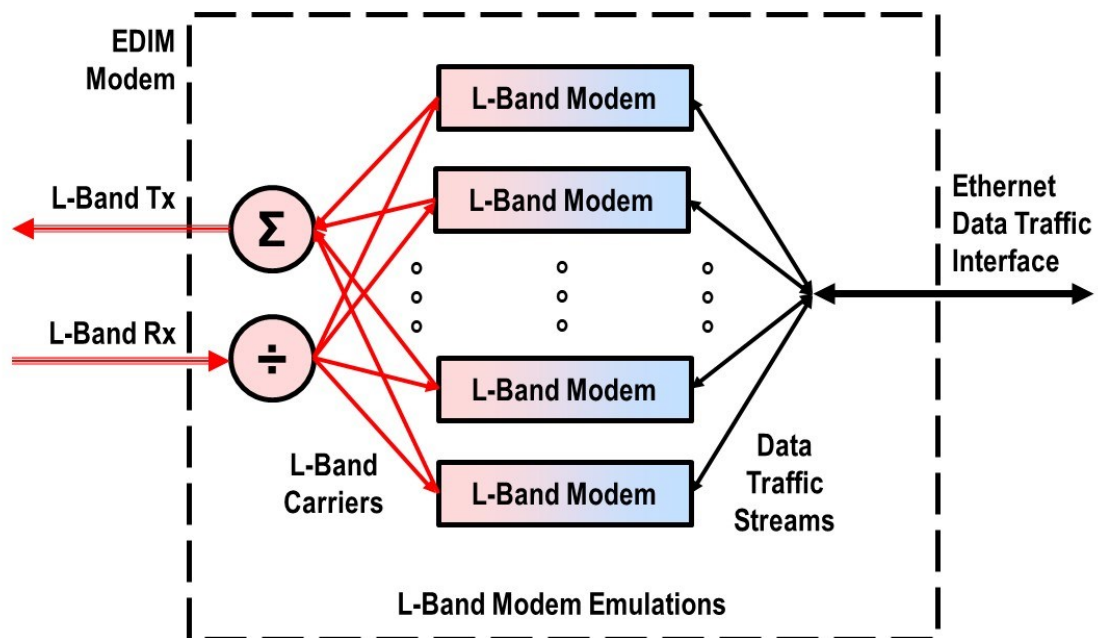


FIGURE 4 EDIM Modem Multi-Carrier LM Function

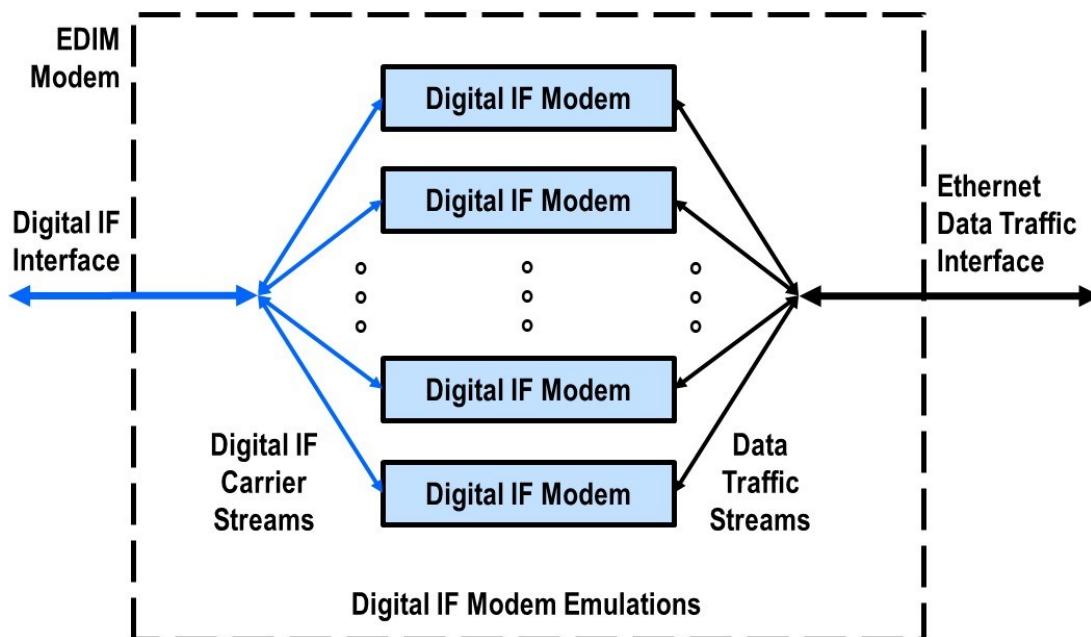


FIGURE 5 EDIM Modem Multi-Carrier DM Function

3.2 Function and Performance

The EDIM Modem shall be a multi-carrier modem capable of supporting prescribed signal processing on up to a total of at least 8 duplex carriers simultaneously. Modem functions shall be selectable for use, as illustrated in FIGURE 3. Each carrier shall be independently configurable. There shall be no restrictions as to symmetry; for example, symmetry of link (i.e., simplex vs duplex), symmetry of rate (Tx vs Rx data traffic and/or symbol rate) or symmetry of waveform (i.e., CW vs EBEM).

Both IPv4 and IPv6 addressing shall be supported on all Ethernet interfaces.

Third party licensing WRT the EDIM Modem or any supporting applications, tools, software or components shall be transparent to the operator and to the procuring authority.

The following subsections specify the functional and performance characteristics of the EDIM Modem as a component of a military SATCOM system.

3.2.1 Time and Frequency Base

The following subsections specify internal time and frequency reference function and performance.

3.2.1.1 Date and Time Base

The EDIM Modem shall maintain a system time base adequate to support all EDIM Modem functions including:

- Digital IF timestamping
- M&C timestamping
- EDIM Modem function, as appropriate, including encryption and logging

This system time base shall be synchronized to UTC (“Zulu time”) through the following external sources:

- The IRIG-B timing reference through the IRIG-B timing port indicated in Section 3.1.1.2.6.3. Formats supported shall include:
 - IRIG-B000 IAW IRIG Standard 200-16
 - IRIG-B127 IAW IRIG Standard 200-16
 - Auto-sensing and interchangeability without operator configuration or intervention
- NTP and/or PTP timing references available through Ethernet interfaces indicated in Section 3.1.1.2.5. Formats supported shall include:
 - NTP IAW RFC 5905
 - Authenticated NTP IAW IETF RFC 5906
 - PTP IAW IEEE 1588-2019
 - Auto-sensing and interchangeability without operator configuration or intervention
- The 1 pps timing reference through the 1 pps timing port indicated in Section 3.1.1.2.6.2 may be used for stabilization of other sources

In the absence of external time sources, it shall be possible for the operator to configure EDIM Modem system time of modems individually, and to configure modem suites under centralized management. Upon loss of external time sources, system time shall be maintained to a degree adequate to support all EDIM Modem functions.

3.2.1.2 Frequency Base

The EDIM Modem shall monitor, accept and reconcile frequency reference information from the 5/10 MHz timing reference through the 5/10 MHz timing port indicated in Section 3.1.1.2.6.1.

The EDIM Modem shall maintain internal frequency reference adequate to support:

- all management and control interface functions and performance
- all Ethernet data traffic interface functions and performance
- all IF interface functions and performance

3.2.2 Data Traffic Rate Estimation

The EDIM Modem shall estimate (average and report) the rate of actual data traffic (i.e., the incident on the data traffic ports indicated in Section 3.1.1.2.1), as intended for each uplink carrier. Data traffic rate estimation will be used to:

- assess link utilization
- eventually support Dynamic Resource Allocation (DRA) of satellite power WRT data traffic demand and link conditions IAW Section 3.7.2.3. (Note: Dynamics of data traffic rate estimation shall be tailored to this purpose.)

3.2.3 L-Band IF Interface

The EDIM Modem shall support all specified L-Band modem function, at least within any single tunable 600 MHz interval, from at least 950 to 2000 MHz over the L-Band IF interface set indicated in Section 3.1.1.2.2. L-band performance specified in this document shall be met for all waveforms whose -25 dBc BWs are contained, at least within any single tunable 600 MHz interval, between 950 and at least 2000 MHz.

3.2.3.1 L-Band IF Non-Damaging Input Power

The EDIM Modem shall not be damaged by a continuous input of up to +25 dBm on the L-Band IF Receive interface indicated in Section 3.1.1.2.2.

3.2.3.2 L-Band IF Isolation

Isolation between L-Band ports shall exceed 74 dB.

3.2.4 Digital IF Interface

The EDIM Modem shall support all modem functions over the Digital IF interface indicated in Section 3.1.1.2.3. Digital IF performance specified in this document shall be met for all waveforms whose -25 dBc BWs are contained within

$$f_{C| \text{Samp}} \pm \frac{1}{2} 0.8 R_{\text{Samp}}$$

where

$f_{C| \text{Samp}}$ is the relevant sampling center frequency

R_{Samp} is the relevant complex sample rate, a.k.a. the sampling BW

The following subsections specify Digital IF interface function and protocols.

3.2.4.1 Digital IF Capacity

The Digital IF interface, at a minimum, shall simultaneously support up to:

- At least 8 carriers or channels total on each uplink and downlink
- At least 16 bit sample depths

3.2.4.2 IP Addressability

The source and sink of each Digital IF carrier shall be associated with a configurable socket (i.e., IP address and port number pair).

3.2.4.3 Digital IF Protocol

The Digital IF interface shall support Digital IF streaming compliant with the IEEE-ISTO 4900-2021 DIFI Standard. This standard consists largely of extensions to the ANSI/VITA-49.2 standard framework.

3.2.4.4 Digital IF Network Connectivity

The EDIM Modem shall support Digital IF stream establishment and operation using protocols determined IAW Section 3.2.4.3. This includes:

- a. Auto-discovery to enable auto-population of configuration screens with Digital IF components available on the Digital IF network
- b. Cooperative source-sink establishment of Digital IF streams where:
 - i. establishment will be initiated at either the source or the sink
 - ii. streaming is predicated on operator consent at both ends
 - iii. Digital IF stream establishment includes:
 1. source socket
 2. sink socket
 3. sampling center frequency resolution to the third significant figure of complex sample rate
 4. complex sample rate resolution to the third significant figure (e.g. 99.8 MSamp/s, 99.9 MSamp/s, 10.0 MSamp/s, 10.1 MSamp/s, but not 99.85 or 10.05 MSamp/s)
 5. sample depth from 4 bits to at least 16 bits
- c. Relevant configuration exception signaling and operator warnings; for example, parameters out of range (e.g. an EDIM Modem capable of 950 to 2000 MHz requested to operate from 600 to 800 MHz)
- d. Multicast streaming (i.e., any stream to one or multiple destinations)

- e. Soft termination of Digital IF streams (i.e. both ends expect it and do not alarm)
- f. Provisions for unexpected loss of stream

Provisions for supporting and facilitating Digital IF network connectivity shall support and be cooperative with provisions for general Management and Control (M&C) identified in Section 3.3, and with the provisions for a built-in test (BIT) identified in Section 3.5.

3.2.4.5 Digital IF Networking Performance

The following networking performance requirements apply to the Digital IF Ethernet ports specified in Sections 3.1.1.2.3 and 3.1.1.2.4.

3.2.4.5.1 Network Output Limits

EDIM Modem output jitter shall not exceed:

- 10 us over 10 GbE Digital IF interfaces
- 1 us over 100 GbE Digital IF interfaces

3.2.4.5.2 Network Input Tolerance

The EDIM Modem shall meet all performance requirements when network input conforms to the following tolerances:

- Input jitter NTE 8 ms
- Total network delay NTE 1s, including satellite delay

EDIM Modem carriers operating at their Quasi-Error Free (QEF) E_{Sym}/N_0 shall not lose sync when subject to packet loss rates of up to 10^{-4} .

3.2.4.5.3 Jumbo Frame Support

EDIM Modem Digital IF interfaces shall support jumbo frames.

3.2.5 Modem Function and Performance

This section specifies EDIM Modem requirements relevant to modem signal processing functions using the Ethernet data traffic interface specified in Section 3.1.1.2.1.

3.2.5.1 General

The following subsections specify EDIM Modem requirements general to all modem emulations supported, and to operation over both IF interfaces.

3.2.5.1.1 Ethernet Bridge

Interoperating modems shall function as an Ethernet bridge supplying Data Link Layer connectivity between their respective Ethernet traffic ports. The EDIM Modem shall provide adequate routing support to ensure that data traffic is routed appropriately between the various data traffic interfaces and the various carriers. If VLAN tagging is employed, then:

- VLAN tagging shall conform to IEEE 802.1Q-2018, and
- VLAN ID ranges shall be configurable by the operator.

The EDIM Modem shall support jumbo frames on its data traffic interfaces.

3.2.5.1.2 Carrier Count and Independence

The EDIM Modem shall support up to at least 8 simultaneous duplex modem links. Each carrier, and each carrier's Tx and Rx, shall be independently configurable in all aspects, including data traffic rate, waveform, configuration, employment of test features, symmetry of operation (Tx, Rx or full duplex) and symmetry of configuration (i.e., waveform, rates, features).

3.2.5.1.3 Data Traffic Rates

EDIM Modem carriers shall support data traffic rates from 512 kbps to at least 600 Mbps. EDIM Modem traffic rates shall be configurable in 1 bps increments, subject to waveform restrictions. It will be permissible for:

- the sum of Tx data traffic rates over all carriers to be capped at a threshold of at least 800 Mbps
- the sum of Rx data traffic rates over all carriers to be capped at a threshold of at least 800 Mbps

3.2.5.1.4 Symbol Rates

EDIM Modem carriers shall support symbol rates from 512 ksym/s to at least 200 Msym/s. EDIM Modem symbol rates shall be configurable in 1 sym/s increments, subject to waveform restrictions. It will be permissible for:

- the sum of Tx symbol rates over all carriers to be capped at a threshold of at least 400 Msym/s
- the sum of Rx symbol rates over all carriers to be capped at a threshold of at least 400 Msym/s

3.2.5.1.5 FIPS Cert and General Crypto Provisions

The EDIM Modem shall be certified by NIST at Security Level 2, as described in FIPS PUB 140-3. EDIM Modem management provisions identified in Section 3.3.2.1.2 (Operator Interface (OI)) and Section 3.3.5.4 (Multiple Modem Configuration Management) shall support:

- loading of EBEM SMATs IAW Section 3.2.5.2.1.3
- "zeroize" function to permanently delete all cryptographic key material, including SMATs, IAW Section 3.2.5.2.1.3; all keys, tokens, checksums and encryption components derived from it or otherwise; and all stored configurations.

3.2.5.1.6 Interference Mitigation

The EDIM Modem shall implement Interference Mitigation to address blue on blue and gray on blue interference as follows:

- on NATO STANAG 4486 (EBEM) waveforms
- on DVB-S2X waveforms to the extent that they are implemented IAW Section 3.2.5.2.2.2
- on at least one downlink carrier at a time
- at carrier of interest (COI) symbol rates up to at least 6 Msym/s
- at COI modulation formats up to at least the first 7 mod-cods identified in TABLE III

3.2.5.1.6.1 Interference Mitigation Operation

The EDIM Modem shall:

- a. Monitor all carriers for potential interference and alert the operator accordingly. This will support:
 - i. operator selection of carrier eligibility for interference mitigation
 - ii. operator selection of carrier engagement of interference mitigation
 - iii. EDIM Modem interference mitigation auto-engage and auto-disengage
- b. Allow the operator to choose which carriers are eligible for interference mitigation
- c. Accommodate seamless operation (i.e., no loss of data traffic) while interference mitigation is engaged and disengaged
- d. Allow the operator to engage and disengage interference mitigation on any eligible carrier
- e. Support interference mitigation auto-engage and disengage as follows:
 - i. monitor individual carrier performance and determine if there are performance issues, determine if those performance issues are due to carrier fading or interference, and apply interference mitigation appropriately on any carrier, as necessary
 - ii. with interference mitigation engaged, EDIM Modem shall continue to monitor carrier performance, and shall disengage interference mitigation when no longer needed and/or engage interference mitigation on a different carrier
 - iii. provide the operator the ability to override interference mitigation auto-engage and auto-disengage decisions

3.2.5.1.6.2 Interference Mitigation Performance

Consider the carriers identified in Section 3.2.5.1.6

- operating at C/N 6 dB over the QEF E_{Sym}/N_0 value
- this QEF E_{Sym}/N_0 value being defined as 0.1 dB over the E_{Sym}/N_0 threshold indicated in TABLE III for BER performance of 10^{-8}

Interference Mitigation, when engaged, shall enable QEF operation of these links in the presence of an interfering phase modulated carrier in at least 60% of the conditions defined by equally weighted joint uncorrelated uniform distributions across the following ranges:

- a. interferer modulation formats at least BPSK, QPSK and 8-PSK

- b. I/S from at least -10 to +13 dB, where I/S is the ratio of interfering carrier power to the signal power of the COI
- c. Spectral overlap from 0 to 100%

3.2.5.2 Modem Waveforms

3.2.5.2.1 NATO STANAG 4486 Ed4 (EBEM) Baseline

The following subsections detail EDIM Modem support of baseline NATO STANAG 4486 (EBEM) modem emulations ("EBEM emulations") in support of the following rates:

- data traffic rates from 512 kbps to 155.52 Mbps
- symbol rates from 512 ksym/s to 60 Msym/s

3.2.5.2.1.1 Payload

The EBEM emulation shall support the EBEM waveform, as found in NATO STANAG 4486 Ed4 ANNEX F, specifically:

- An "Embedded Channel" IAW Section 3.1.2, "Embedded Channel," on pages F-6 through F-7, to support the features indicated in Section 3.2.5.2.1.2
- A "User Data 1 Channel" IAW Section 3.1.3, "User Data 1 Channel," on page F-7, to support internal Bit Error Rate Test (BERT) operation interoperability with legacy EBEM
- A "User Data 2 Channel" IAW Section 3.1.4, "User Data 2 Channel," on pages F-7 through F-8, to support Ethernet data traffic

3.2.5.2.1.2 Features

The EBEM emulation shall support the following features:

- Selectable data traffic rate IAW NATO STANAG 4486 Ed4, ANNEX F, Section 3.3.4.1.2.1, "Mode #1," on pages F-13 and F-14
- Selectable symbol rate IAW NATO STANAG 4486 Ed4, ANNEX F, Section 3.3.4.1.2.2, "Mode #2," on pages F-14 and F-15
- Selectable scrambling IAW NATO STANAG 4486 Ed4, ANNEX F, Section 3.3.4.2, "Scrambler," on pages F-15 through F-16, "enabled" by default
- Selectable Adaptive Coding and Modulation (ACM) IAW NATO STANAG 4486 Ed4, ANNEX G, Section 5.1, "ITA" (Information Throughput Adaptation), on pages G-53 through G-59, "disabled" by default
- Selectable Distant End Monitoring (DEM) IAW NATO STANAG 4486 Ed4, ANNEX G, Section 5.3 "DEM" on pages G-60 through G-81, "enabled" by default
- Selectable BERT patterns IAW NATO STANAG 4486 Ed4, ANNEX G, Appendix 2, Sections 8.8.1, "Bit Error Rate Test (BERT) Transmit Pattern," and 8.8.2, "Bit Error Rate Test (BERT) Receive Pattern," on pages G-2-47 through G-2-49

3.2.5.2.1.3 Bulk Encryption for Cover

The EBEM emulation shall support selectable “encryption,” “enabled” by default, IAW:

- NATO STANAG 4486 Ed4, ANNEX F, Section 3.5, “Encryption,” on pages F-61 through F-67, as applicable to “SMAT-authenticated circuits” to the exclusion of “PKI-authenticated (simplex capable) circuits”
- NATO STANAG 4486 Ed4, ANNEX G, Section 5.4, “Encryption,” on pages G-81 through G-107, as applicable to “SMAT-authenticated circuits” to the exclusion of “PKI-authenticated (simplex capable) circuits”

SMAT loading and management, as well as activation or deactivation of cryptography on any carrier, shall not require EDIM Modem reboot or interrupt the operation of other carriers.

3.2.5.2.1.4 Waveform

The EBEM emulation shall support:

- Frame Format #1 (ITA) IAW NATO STANAG 4486 Ed4, ANNEX F, Sections 3.3, “Frame Format #1 (ITA),” through 3.3.4.2, “Scrambler,” on pages F-8 through F-16
- “Turbo Code” FEC and symbol mapping IAW NATO STANAG 4486 Ed4, ANNEX F, Sections 3.3.4.3.1, “Turbo Code,” through 3.3.4.3.1.7, “Symbol Mapping,” on pages F-16 through F-34

The EBEM emulation shall support the following EBEM Turbo mod-cods to the exclusion of all others:

- BPSK 1/2
- QPSK 1/2
- QPSK 2/3
- QPSK 3/4
- QPSK 7/8
- 16-APSK 1/2
- 8-PSK 3/4
- 16-APSK 2/3
- 16-APSK 3/4
- 16-APSK 7/8
- 16-APSK 19/20

These mod-cods shall be presented to the operator as follows:

- In order of spectral efficiency
- With an indication of spectral efficiency (bps/Hz, same as bits/symbol)
- With an indication of QEF E_b/N_0 performance (bit power efficiency)
- With an indication of QEF C/N performance (C/N demand)
- Accurate to the relevant Turbo block size, subject to data or symbol rate

The EDIM Modem shall be capable of EBEM waveform “uncoded” operation IAW NATO STANAG 4486 Ed4, ANNEX F, Section 3.3.4.3.1.6.5, “Symbol Generation for Uncoded Modes,” on page F-33, for test and diagnostic purposes. Configuration for uncoded EBEM emulation shall be separate from the typical mod-cods presented to the operator, as indicated above.

3.2.5.2.2 Support for Higher Rates

The EDIM Modem shall support operation up to the following rates:

- data traffic rates up to 600 Mbps
- symbol rates up to 200 Msym/s

by employing at least one of the following methods:

- extending EBEM waveform support to higher rates IAW Section 3.2.5.2.2.1, below;
- introducing DVB-S2X Hub Waveform operation IAW Section 3.2.5.2.2.2, below.

3.2.5.2.2.1 EBEM Extended Rate Operation

This section is relevant to the first of two choices for extending EDIM Modem rates beyond baseline EBEM rate limits indicated in Section 3.2.5.2.1. Pursuant to this choice, the EDIM Modem shall support the requirements of Section 3.2.5.2.1 and its subsections while:

- extending allowable data traffic rates up to at least 600 Mbps
- extending allowable symbol rates up to at least 200 Msym/s
- making no other waveform changes

3.2.5.2.2.2 DVB-S2X Hub Waveform Operation

This section, and its subsections, are relevant to the second of two choices for extending EDIM Modem rates beyond baseline EBEM rate limits indicated in Section 3.2.5.2.1. Pursuant to this choice, the EDIM Modem shall support communications between two modems, with each link using the forward path (Hub Waveform) specified for DVB-S2X IAW ETSI EN 302 307-2 as qualified in the following subsections.

3.2.5.2.2.2.1 Waveform

The DVB-S2X emulation shall support the DVB-S2X mod-cods indicated in ETSI EN 302 307-2, specifically Table 20a, at least to the extent necessary to support data traffic rates up to 600 Mbps at symbol rates up to 200 Msym/s. These mod-cods shall be employed to the exclusion of all other mod-cods, and shall be presented to the operator:

- in order of spectral efficiency
- with an indication of spectral efficiency (bits/symbol or bps/Hz)
- with an indication of QEF E_b/N_0 performance (bit power efficiency)
- with an indication of C/N demand (QEF E_{Sym}/N_0)

Normal FECFRAMES shall be supported. Short and medium FECFRAMES may be offered for optional DVB-S2(X) interoperability at lower rates.

It shall be possible to operate the DVB-S2X waveform “uncoded” IAW ETSI EN 302 307-2 for test and diagnostic purposes. Configuration for uncoded DVB-S2X emulation shall be separate from the typical mod-cods presented to the operator above. The means shall be provided to support BERT.

3.2.5.2.2.2.2 Data Traffic Encapsulation

DVB-S2X carrier encapsulation shall be selectable by the operator, on a per-carrier basis, to employ one of the following methods:

- Generic Stream Encapsulation (GSE) IAW ETSI EN 302 307-2, Section 5.1.8.3
- Multi-protocol Encapsulation (MPE) IAW ETSI EN 302 307-1, Section 4.1

Waveform constructs necessary to establish full interoperability with each data traffic encapsulation method offered, in excess of those already indicated in ETSI EN 302 307-1 and -2, shall be fully documented and disclosed, then subject to Government review, peer review, Government approval, and publication. An example of such a construct might be some GSE traffic encapsulation detail that remains, in ETSI EN 302 307-2, ambiguous or otherwise subject to interpretation.

3.2.5.2.2.2.3 Bulk Encryption for Cover

The DVB-S2X emulation shall support selectable “encryption,” “enabled” by default, IAW fully documented and disclosed methods subject to Government review, peer review, Government approval, and publication. An example of the level of appropriate documentation and disclosure can be found in the NATO STANAG 4486 Ed4 sections identified in Section 3.2.5.2.1.3.

3.2.5.2.2.2.4 DVB-S2X Feature Support

The EDIM Modem shall support ETSI EN 302 307-2, Section D.5, “Signalling of reception quality via return channel (Normative for ACM),” for the sake of implementing selectable:

- ACM
- DRA

Waveform constructs necessary to meet these capabilities, in excess of those already indicated in ETSI EN 302 307-2, shall be fully documented and disclosed, then subject to Government review, peer review, Government approval, and publication. An example of such a construct might be the means of signaling demodulator reception quality to the corresponding distant end modulator.

3.2.5.3 LM Operation

This section specifies EDIM Modem requirements relevant to the L-Band Modem function, illustrated in FIGURE 4, operating over the L-Band interface specified in Sections 3.1.1.2.2 and 3.2.3.

3.2.5.3.1 LM Transmission

WRT Tx carriers on the L-Band interface, the EDIM Modem shall enable operators, on a per-carrier basis, to:

- configure:
 - modulation: CW or EBEM IAW Section 3.2.5.2
 - carrier frequency f_c IAW Section 3.2.5.4.1
 - carrier power P_c IAW Section 3.2.5.4.5
- activate and deactivate carrier
- raise and lower power in increments of 0.1 and 1 dB
- to the extent they are supported, access capabilities detailed in:
 - Section 3.7.2.2, Spectrum Display
 - Section 3.7.2.3, Dynamic Resource Allocation (DRA)

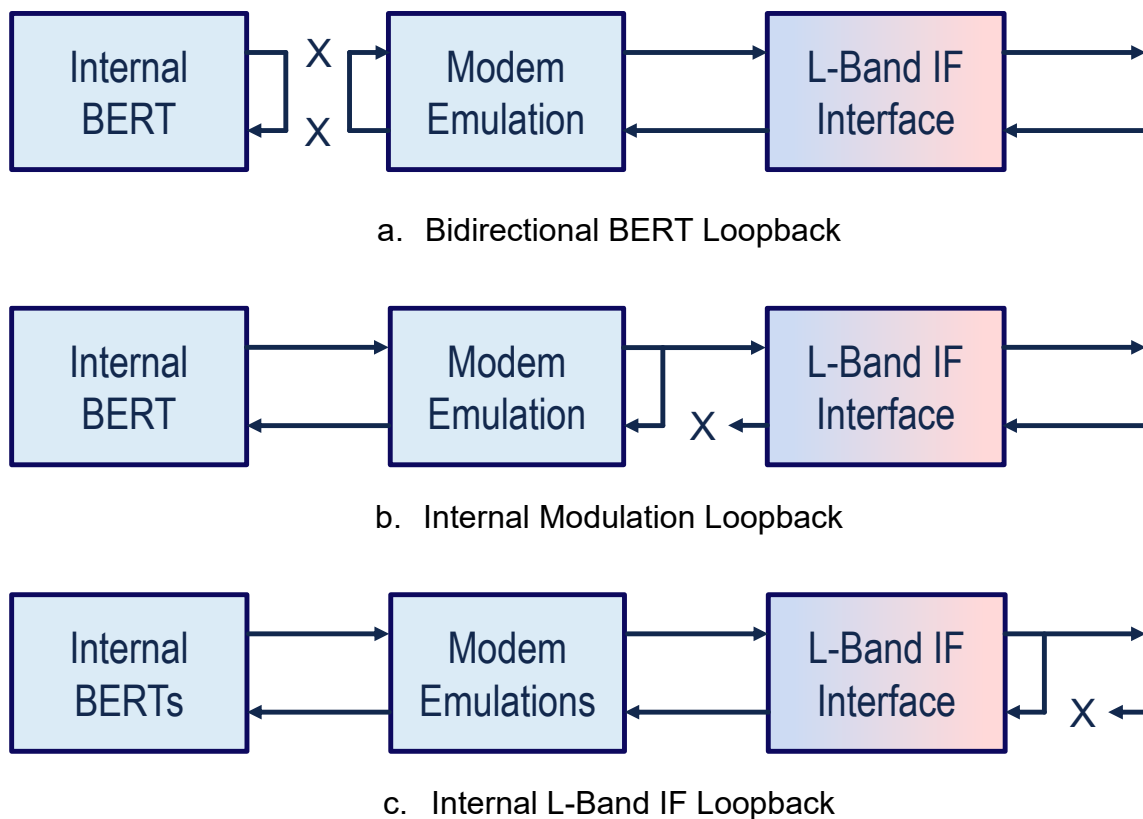
3.2.5.3.2 LM Reception

WRT Rx carriers on the L-Band interface, the EDIM Modem shall enable operators, on a per-carrier basis, to:

- configure:
 - modulation waveform: EBEM IAW Section 3.2.5.2
 - carrier frequency f_c IAW Section 3.2.5.5.1
- monitor, whether CW or modulated, Rx:
 - actual carrier center frequency f_c IAW Section 3.2.5.9.1
 - carrier center frequency offset Δf_c accordingly
 - carrier power P_c IAW Section 3.2.5.9.2
 - whether modulation is on or off
- monitor, with modulation present:
 - E_b/N_0 IAW Section 3.2.5.9.3
 - C/N IAW Section 3.2.5.9.3
 - carrier lock
 - data lock
 - encryption lock
- access Interference Mitigation capabilities detailed in Section 3.2.5.1.6 and its subsections
- to the extent they are supported, access capabilities detailed in:
 - Section 3.7.2.2, Spectrum Display
 - Section 3.7.2.3, Dynamic Resource Allocation (DRA)

3.2.5.3.3 LM Loopback Operation

For test, diagnostic and troubleshooting purposes WRT LM function, the EDIM Modem shall offer loopback operation, as illustrated in FIGURE 6:

**FIGURE 6 LM Loopbacks**

- a. Bidirectional BERT Loopback:
 - i. Applicable to individual carriers
 - ii. BERT output traffic looped back to BERT input
 - iii. Demodulated traffic stream looped back to modulator input without processing
 - iv. Intended for testing, diagnostics and troubleshooting with serial BERT traffic enabled in both directions
- b. Internal Modulation Loopback:
 - i. Applicable to individual carriers
 - ii. Modulated carrier looped back to demodulator input while continuing through the L-Band IF interface
 - iii. Demodulator input from L-Band IF interface interrupted
- c. Internal L-Band IF Loopback:
 - i. Applicable to all carriers at once over the entire L-Band IF interface
 - ii. L-Band IF output looped back to L-Band IF input while continuing to output through the L-Band IF interface:
 - iii. L-Band IF input interrupted
 - iv. Providing assistance to the operator in reassigning carrier configurations for the duration of the loopback

Individual carrier loopbacks shall not cause interruption or degradation to any other individual carrier or channel. Individual loopbacks shall not cause interruption or degradation to carriers on paths described as unaffected. For example, the performance of a carrier undergoing LM Internal Modulation Loopback shall be unaffected at the distant end modem.

3.2.5.4 LM Uplink Performance

Performance indicated in the following subsections applies to L-Band Modulation.

3.2.5.4.1 LM Uplink Carrier Frequency

LM output carrier frequencies shall be configurable in 1-kHz steps over a range of at least 950 MHz to 2000 MHz.

3.2.5.4.2 LM Uplink Frequency Stability

IF output carrier frequencies shall be stable to within 10^{-8} per day without frequency source adjustments.

3.2.5.4.3 LM Uplink Frequency Accuracy

The IF output carrier frequency, WRT the configured value, shall be:

- within 10^{-7} after a 1-hour warm-up period when an external frequency reference is not present
- within 10^{-7} without a warm-up period when an external frequency reference is present

3.2.5.4.4 LM Uplink Phase Noise

Single-sided phase noise power spectral density (PSD) $S_{\phi}(f)$ of each L-Band output carrier shall not exceed the PSD thresholds indicated in FIGURE 7. This phase noise mask is based on:

- minimum modem symbol rate of 512 ksym/s; a reduction of the minimum modem symbol rate shall necessitate extension of the $1/f$ region lower
- maximum EDIM Modem symbol rate of 200 Msym/s; any proposed increase in the maximum modem symbol rate beyond 200 Msym/s shall necessitate extension of the $1/f$ region higher
- modem support of a maximum QEF E_{Sym}/N_0 of 24.2 dB; an increase in the maximum QEF E_{Sym}/N_0 supported by the modem, beyond 24.2 dB, shall necessitate proportional lowering of the $1/f$ region

EDIM Modem Phase Noise PSD Limit Mask

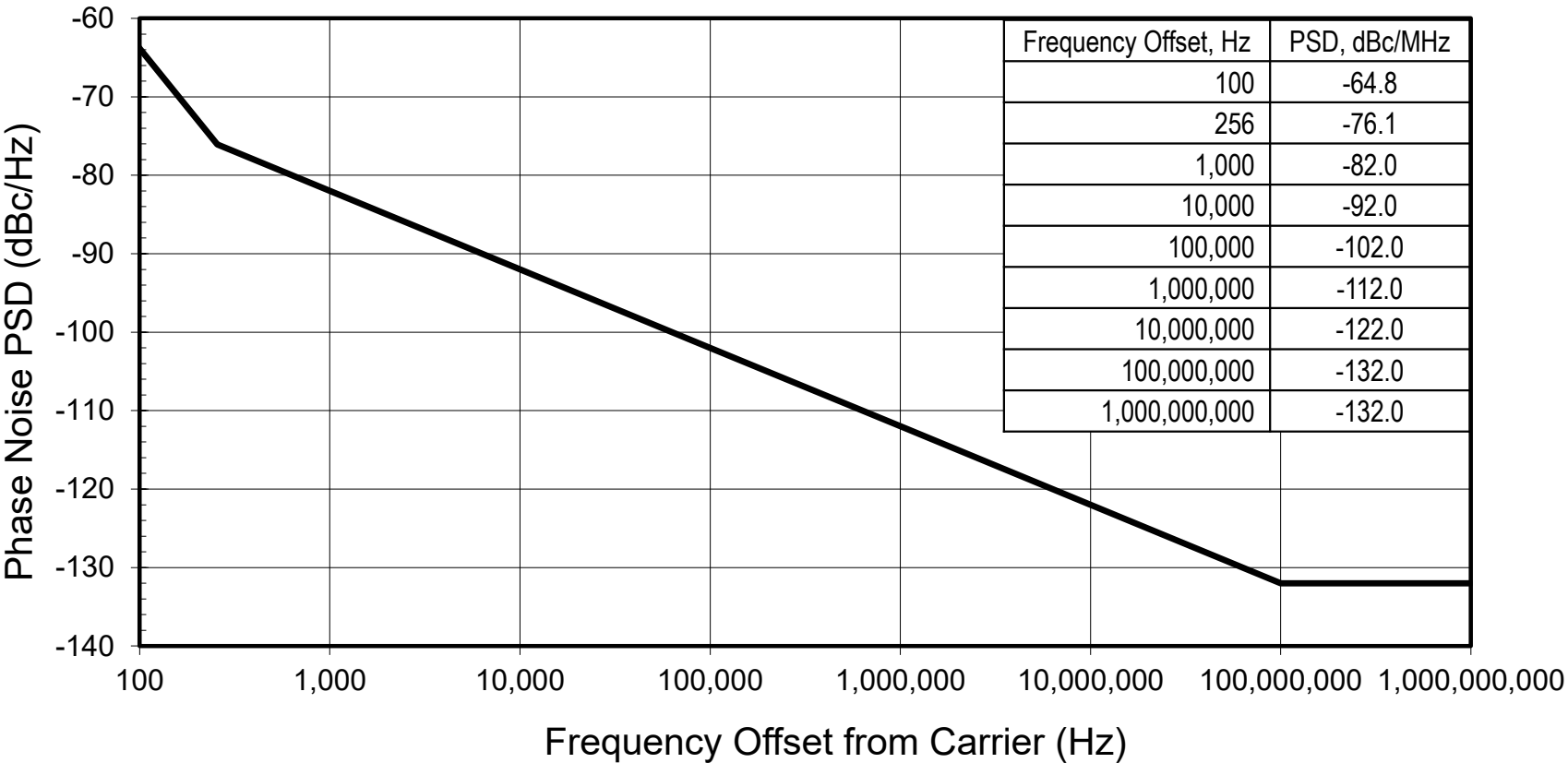


FIGURE 7 EDIM Modem Phase Noise PSD Limit Mask

If single-sided phase noise PSD $S_{\phi}(f)$ exceeds $S_{\phi\max}(f)$ indicated in FIGURE 7 for any frequency offset f from the carrier, it shall then be required that integrated phase noise N_{ϕ} , defined using

$$N_{\phi} = 2 \int_{0.0005 R_{\text{Sym}}}^{0.5 R_{\text{Sym}}} S_{\phi}(f) df$$

not exceed -40.6 dBc (0.535 degrees RMS) for symbol rates R_{Sym} from 512 ksym/s to 200 Msym/s. The -40.6 dBc threshold is based on modem support of:

- max QEF E_{Sym}/N_0 of 21.2 dB degrading by ≤ 0.05 dB due to phase noise
- max QEF E_{Sym}/N_0 of 24.2 dB degrading by ≤ 0.1 dB due to phase noise
- maximum 1/f limit proposed for Draft MIL-STD-188-164C-C1 section 4.2.11 “Phase noise”

3.2.5.4.5 LM Uplink Carrier Power

LM output carrier power shall be subject to configuration and accuracy as follows:

- Power Control Range: Carrier output power shall be adjustable over the range of 0 to -40 dBm
- Power Control Step size: The minimum step size shall not exceed 0.1 dB
- Absolute Accuracy: The power of each L-Band carrier shall be within ± 1.0 dB of its configured value
- Same-Carrier Relative Accuracy: The relative carrier accuracy associated with the smallest step increment of a given carrier shall be ± 0.1 dB
- Other-Carrier Relative Accuracy: The relative carrier accuracy associated with the smallest step increment of a different carrier shall be ± 0.1 dB
- Max Total Power: Total power (i.e., sum of all carriers) shall be capped at 0 dBm
- Same-Carrier Integrity: When a power change is initiated, carrier output power shall transition monotonically, and shall not induce errors into the carrier’s bit stream WRT subsequent processing and demodulation
- Other-Carrier Integrity: A power change on one carrier shall not induce errors in another carrier:
 - operating at its QEF E_{Sym}/N_0
 - spaced such that -25 dBc carrier BWs do not overlap
 - WRT subsequent processing and demodulation

3.2.5.4.6 LM Uplink Power Off Performance

When all carriers are disabled, signals present at the output, from 0 to 4,000 MHz, and beyond $2 R_{\text{Sym}}$ (twice the symbol rate) the center of any active carrier, shall not exceed:

- -70 dBm across any 3 MHz BW
- -80 dBm across any 30 kHz BW
- Subject to exceptions for noise floors or digitization noise, as appropriate

These transmission carrier no-signal thresholds are illustrated in FIGURE 8.

3.2.5.4.7 LM Uplink Spectral Confinement

Each LM output carrier shall meet the modulator output carrier spectral density limit mask shown in FIGURE 9, subject to LM uplink thermal noise specified in Section 3.2.5.4.8 (i.e. meet the mask or the Tx noise floor, whichever is greater). The L-Band outer mask is based on a sampled symbol shape model where:

- RRC SSF = 0.21
- Symbol duration of 14 symbol intervals
- 8 samples per symbol
- 12.5 bits per sample

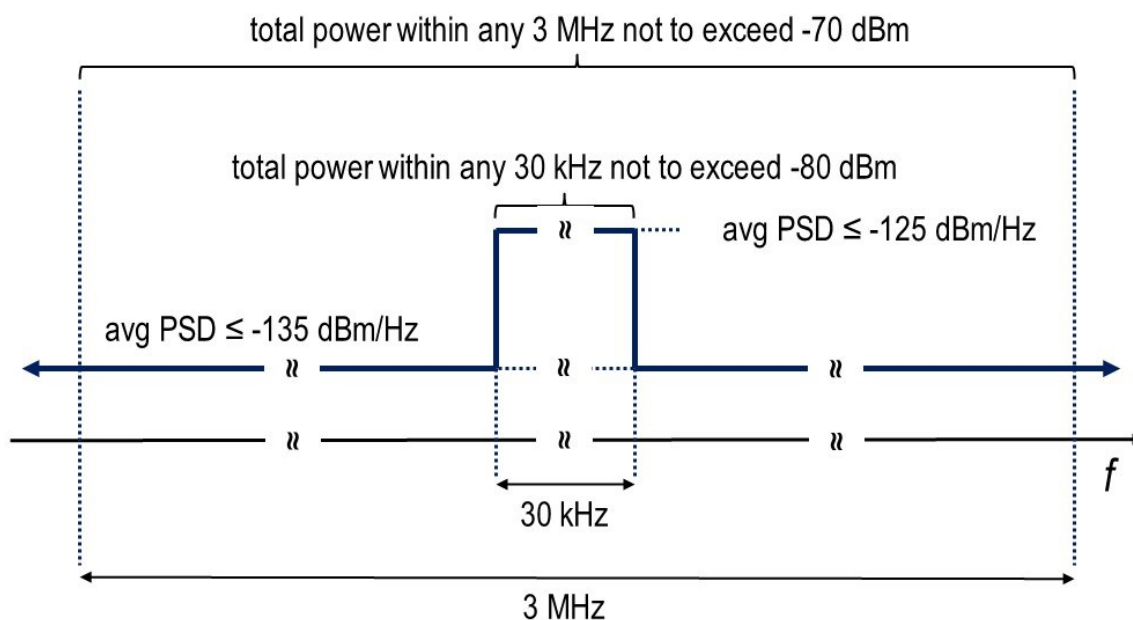


FIGURE 8 L-Band Output No-Signal Thresholds

It will be permissible for transmission spectra to exhibit the following:

- Carrier nulls at the carrier for BPSK modulation only
- Clock nulls, offset by half the symbol rate from the carrier, for BPSK modulation only
- PSD NTE the Tx thermal noise floor threshold specified in Section 3.2.5.4.8 when this threshold exceeds the PSD outer mask limit for L-Band carriers shown in FIGURE 9
- Output spurious and harmonic emissions compliant with Section 3.2.5.4.9

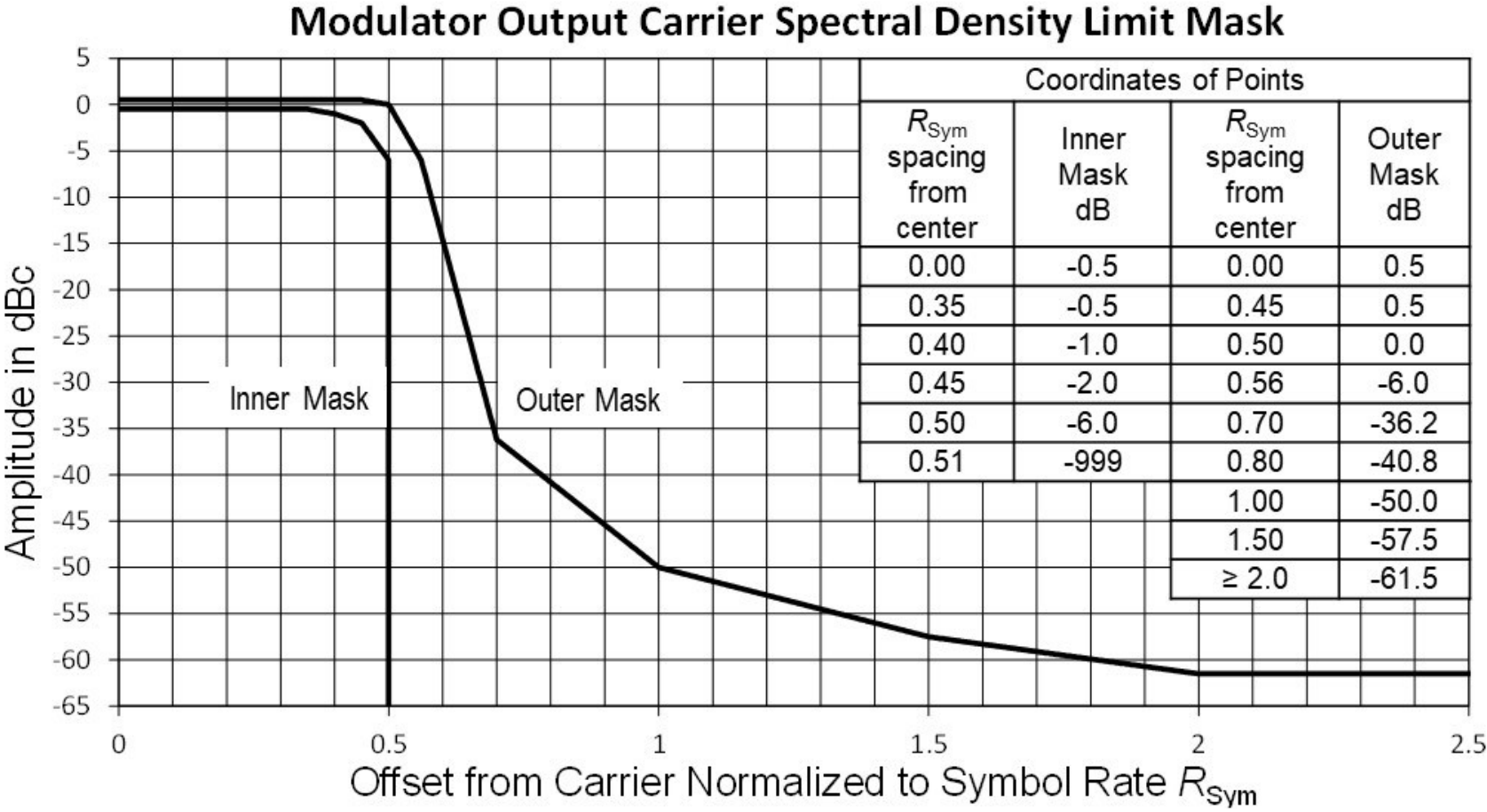


FIGURE 9 Modulator Output Carrier Spectral Density Limit Mask

3.2.5.4.8 LM Uplink Noise Floor

The L-Band IF output thermal noise density, over the full IF band, shall not exceed -147 dBm/Hz.

3.2.5.4.9 LM Uplink Spurious Emissions

L-Band output power in any 10 kHz BW across the full IF band due to spurious emissions shall not exceed -70 dBm. (Note: This requirement applies to multi-carrier operation). Relevant scenarios include:

- No carriers for baseline spurious performance
- One carrier at 0 dBm
- Two carriers at -3 dBm each
- Five carriers at -7 dBm each

3.2.5.4.10 LM Uplink Harmonics

L-Band output power in any 10 kHz BW across the full IF band due to harmonic emissions shall not exceed -70 dBm.

3.2.5.4.11 LM Uplink Error Vector Magnitude (EVM)

LM carrier EVM shall not exceed 3%.

3.2.5.5 LM Downlink Performance

Performance indicated in the following subsections shall apply to L-Band demodulation when, at a minimum:

- L-Band IF input carrier PSD does not exceed -83 dBm/Hz (-23 dBm/MHz)
- Individual L-Band IF input carrier power does not exceed -7 dBm
- Total L-Band IF input power does not exceed 0 dBm

3.2.5.5.1 LM Downlink Carrier Frequency

LM input carrier frequencies shall be configurable in 1-kHz steps over a range of at least 950 MHz to 2000 MHz.

3.2.5.5.2 LM Downlink Frequency Uncertainty

The LM Downlink function shall acquire and demodulate carriers that are within 30 kHz of the nominal expected frequency (Section 3.2.5.5.1). This includes the maximum offset due to Doppler shift (Section 3.2.5.5.6).

3.2.5.5.3 LM Downlink Min Rx Power

The LM demodulator shall operate to a minimum carrier level P_{\min} , such that

$$P_{\min} = -130 \text{ dBm/Hz} + E_{\text{Sym}}/N_0 + 10 \log R_{\text{Sym}} \text{ [dBm]}$$

where:

E_{Sym}/N_0 [dB] is the specified threshold performance value for a BER of 10^{-8}

R_{Sym} is the symbol rate in symbols per second

3.2.5.5.4 LM Downlink Acquisition and Reacquisition

The acquisition & synchronization reference E_{Sym}/N_0 is defined as the threshold E_{Sym}/N_0 , specified for back-to-back BER performance, that corresponds to a BER of 10^{-4} . If a threshold E_{Sym}/N_0 is not specified for back-to-back error performance of BER = 10^{-4} , then the acquisition & synchronization reference E_{Sym}/N_0 is extrapolated from the threshold E_{Sym}/N_0 of the highest specified BER point at a rate of 0.05 dB of E_{Sym}/N_0 per BER factor of 10.

The LM demodulation function shall achieve initial acquisition within the times shown in TABLE I, with a confidence level of 95 percent over a frequency uncertainty of ± 30 kHz at the reference E_{Sym}/N_0 .

Reacquisition shall be similarly achieved IAW TABLE I using the same confidence level upon carrier return, at the acquisition & synchronization reference E_{Sym}/N_0 , to within 500 Hz of the carrier frequency at the time of loss.

TABLE I Acquisition Times for Selected Symbol Rates

| Symbol Rate Range [ksym / s] | Maximum Initial Acquisition Time [s] | Maximum Reacquisition Time [s] |
|----------------------------------|---|-----------------------------------|
| $512 \leq R_{\text{Sym}} < 1544$ | 10 | 5 |
| $1544 \leq R_{\text{Sym}}$ | 1 | 1 |

3.2.5.5.5 LM Downlink Synchronization Retention

LM demodulator carrier synchronization shall be maintained at the acquisition & synchronization reference E_{Sym}/N_0 defined in Section 3.2.5.5.4, for a signal loss of up to 200 modulation symbol periods with a probability of at least 90%.

3.2.5.5.6 LM Downlink Doppler Environment

The LM demodulator shall meet all specified requirements when subject to Doppler shift, rate of change and acceleration as presented in TABLE II at the same acquisition & synchronization reference E_{Sym}/N_0 defined in Section 3.2.5.5.4.

TABLE II Doppler Parameters

| Parameter | X-Band | Military Ka-Band |
|--|-------------|------------------|
| Doppler shift ¹ [Hz] | $\pm 3,535$ | $\pm 11,810$ |
| Doppler rate of change ² [Hz/s] | ± 270 | $\pm 1,046$ |
| Doppler acceleration ² [Hz/s ²] | ± 290 | $\pm 1,124$ |

¹ Doppler shift corresponds to geostationary satellite inclinations up to 7°

² Doppler rate of change and acceleration correspond to Navy requirements based on shipboard motion

3.2.5.5.7 LM Back-to-Back BER

EDIM Modems functioning as LMs employing EBEM emulations shall support BER performance in back-to-back configurations, as indicated in TABLE III, where Turbo Block Size is selected IAW NATO STANAG 4486 Ed4, ANNEX F, Section 3.3.4.3.1.1, “Turbo Block Sizes and Frame Sizes.”

If the DVB-S2X hub waveform is chosen IAW Section 3.2.5.2.2.2 to implement higher rates IAW Section 3.2.5.2.2, then EDIM Modems functioning as LMs employing such emulations shall support QEF operation ($\text{BER} < 10^{-8}$) to E_s/N_0 thresholds, determined by adding 0.8 dB plus 0.05 dB times the modulation order, to the “Ideal E_s/N_0 [dB] for (AWGN Linear Channel)” indicated in ETSI EN 302 307-2, Table 20a.

3.2.5.5.8 LM Downlink Adjacent Channel Interference (ACI)

LM Back-to-Back BER requirements, as indicated in Section 3.2.5.5.7, shall be met in the presence of ACI, consisting of interfering carriers:

- whose 25 dB BWs ($\sim 1.21 R_{\text{Sym}}$) are separated from that of the COI by 200 kHz, and
- whose PSDs exceed that of the COI by 13 dB

This ACI scenario is illustrated in FIGURE 10.

TABLE III BER Performance for EBEM Emulations

| EBEM Mod-Cods, Spectral Efficiency and BER Performance Thresholds vs Turbo Code Block Size | | | | | | | | | | | | | |
|--|--|---------------------|------------------|-------------------------|------------------|---------------------|------------------|-------------------------|------------------|---|---|-------------------------------|----------------|
| Turbo Block Size | 16,384 bits (sum of data traffic rates ≥4096 kbps) | | | | | | | | | 4096 bits (4096 kbps > sum of data traffic rates ≥ 1024 kbps) | 1024 bits (sum of data traffic rates < 1024 kbps) | | |
| mod-cod | spectral efficiency in bps/Hz | L-Band | | | | Digital IF | | | | spectral efficiency in bps/Hz | BER thresholds | spectral efficiency in bps/Hz | BER thresholds |
| | | E_b/N_0 vs BER of | | E_{Sym}/N_0 vs BER of | | E_b/N_0 vs BER of | | E_{Sym}/N_0 vs BER of | | | | | |
| | | 10 ⁻⁶ | 10 ⁻⁸ | 10 ⁻⁶ | 10 ⁻⁸ | 10 ⁻⁶ | 10 ⁻⁸ | 10 ⁻⁶ | 10 ⁻⁸ | | | | |
| BPSK 1/2 | 0.497 | 2.45 | 2.50 | -0.49 | -0.44 | 2.10 | 2.15 | -0.84 | -0.79 | 0.493 | add 0.8 dB | 0.475 | add 1.6 dB |
| QPSK 1/2 | 0.991 | 2.55 | 2.60 | 2.51 | 2.56 | 2.15 | 2.20 | 2.11 | 2.16 | 0.982 | | 0.947 | |
| QPSK 2/3 | 1.319 | 3.40 | 3.45 | 4.60 | 4.65 | 3.00 | 3.05 | 4.20 | 4.25 | 1.307 | | 1.261 | |
| QPSK 3/4 | 1.482 | 3.90 | 4.00 | 5.61 | 5.71 | 3.50 | 3.60 | 5.21 | 5.31 | 1.468 | | 1.414 | |
| QPSK 7/8 | 1.726 | 4.60 | 4.70 | 6.97 | 7.07 | 4.20 | 4.30 | 6.57 | 6.67 | 1.710 | | 1.648 | |
| 16-APSK 1/2 | 1.970 | 4.90 | 5.00 | 7.84 | 7.94 | 4.40 | 4.50 | 7.34 | 7.44 | 1.953 | | 1.883 | |
| 8-PSK 3/4 | 2.213 | 6.50 | 6.55 | 9.95 | 10.00 | 6.05 | 6.10 | 9.50 | 9.55 | 2.192 | | 2.111 | |
| 16-APSK 2/3 | 2.616 | 6.65 | 6.75 | 10.83 | 10.93 | 6.15 | 6.25 | 10.33 | 10.43 | 2.593 | | 2.501 | |
| 16-APSK 3/4 | 2.937 | 7.60 | 7.95 | 12.28 | 12.63 | 7.10 | 7.45 | 11.78 | 12.13 | 2.910 | | 2.803 | |
| 16-APSK 7/8 | 3.416 | 9.05 | 9.15 | 14.39 | 14.49 | 8.55 | 8.65 | 13.89 | 13.99 | 3.382 | | 3.251 | |
| 16-APSK 19/20 | 3.703 | 11.70 | 11.80 | 17.39 | 17.49 | 11.20 | 11.30 | 16.89 | 16.99 | 3.670 | 3.533 | | |

3.2.5.5.9 LM Downlink Power Disparity

LM Back-to-Back BER requirements, as indicated in Section 3.2.5.5.7, shall be met in the presence of high levels of in-band interference, such that:

- COI PSD $\geq -111 \text{ dBPTOT/Hz} + E_{\text{Sym}}/N_0$
 - where E_{Sym}/N_0 [dB] is the specified threshold performance value for a BER of 10^{-8}
- ACI thresholds indicated in Section 3.2.5.5.8 are not exceeded

The rationale for $-111 \text{ dBPTOT/Hz} + \text{QEF } E_{\text{Sym}}/N_0$ is as follows:

- protect the performance of a 1 MHz BW carrier in the presence of +40 dBc total power at mod-cods through 8-PSK rate 3/4 waveform
- COI PSD = $-40 \text{ dBPTOT} - 10 \log_{10}(1 \times 10^6 \text{ Hz}) = -100 \text{ dBPTOT/Hz}$
- 8-PSK 3/4 threshold E_{Sym}/N_0 , at $R_{\text{Sym}} = 1 \text{ MHz}$ (or $R_D \sim 2.192 \text{ Mbps}$) is $10.8 \text{ dB} = 11 \text{ dB}$ with 0.2 dB of margin
- max noise floor N_0 is then $-100 \text{ dBPTOT/Hz} - 11 \text{ dB} = -111 \text{ dBPTOT/Hz}$

Realizability is considered as follows:

- a sampling noise floor $\sim 13 \text{ dB}$ below input noise N_0 raises N_0 by the allowed 0.2 dB of margin
- corresponding target quantization noise PSD $N_Q = -111 \text{ dBPTOT/Hz} - 13 \text{ dB} = -124 \text{ dBPTOT/Hz}$
- $N_Q = -124 \text{ dBPTOT/Hz}$ may be realized with 9 effective number of bits (EnoB) per sample at a sample rate of 625 Msamp/s

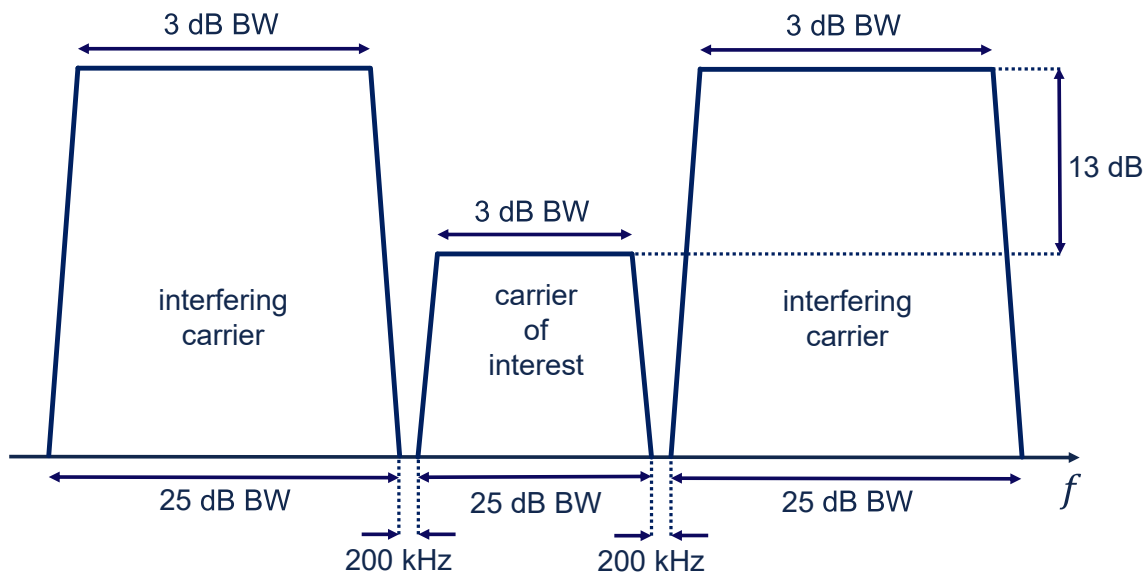
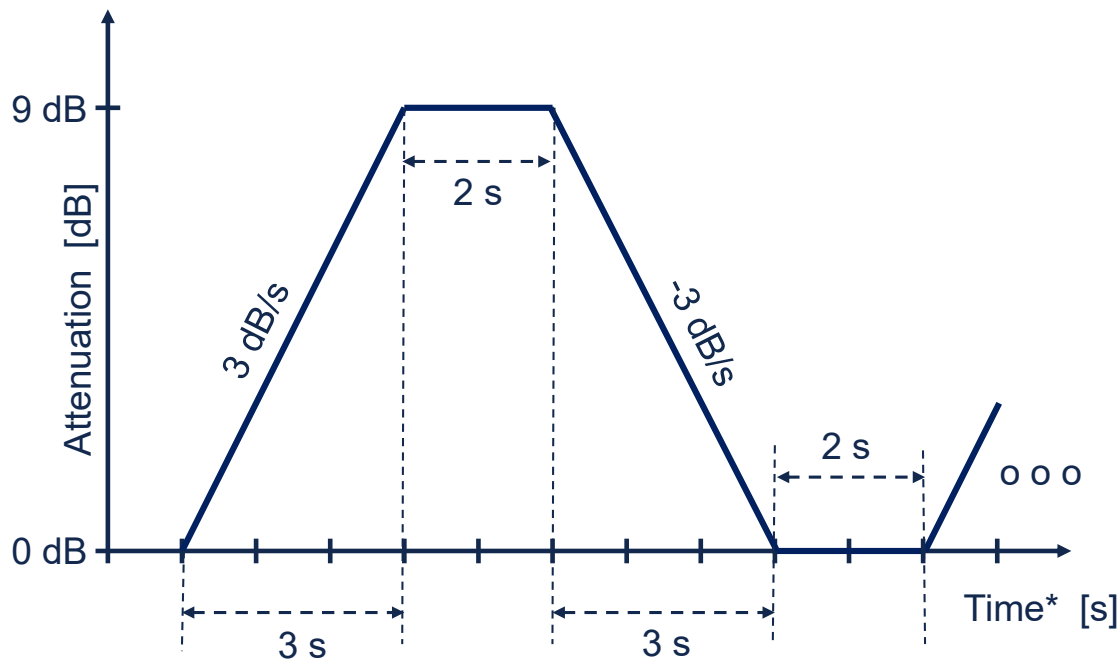


FIGURE 10 IF Input ACI Scenario

3.2.5.5.10 LM Downlink Input Power Changes

LM Back-to-Back BER requirements, as indicated in Section 3.2.5.5.7, shall be met, with no loss of synchronization, at a constant E_{Sym}/N_0 in the presence of power change as a function of time, as shown in FIGURE 11.



*Repeats every 10 seconds

FIGURE 11 Input Power Change Profile

3.2.5.6 DM Operation

This section specifies EDIM Modem requirements relevant to the Digital IF Modem function, illustrated in FIGURE 5, operating over the Digital IF interface specified in Sections 3.1.1.2.3, 3.1.1.2.4, and 3.2.4.

3.2.5.6.1 DM Transmission

WRT Tx carriers on the Digital IF interface, the EDIM Modem shall enable operators, on a per-carrier basis, to:

- configure:
 - modulation: CW or EBEM IAW Section 3.2.5.2
 - carrier frequency f_c IAW Section 3.2.5.7.1
 - carrier power P_c IAW Section 3.2.5.7.2
- Enable Digital IF output connectivity IAW Section 3.2.4.4, including configuration of:

- Digital IF sampling center frequency, in 1 kHz steps, over the range supported by the Digital IF protocol IAW Section 3.2.4.3
- Digital IF sample rate, in 1 kHz steps, over a range adequate to support EDIM Modem symbol rates of 128 ksym/s to 200 Msym/s
- Digital IF sample depth over the range supported by the Digital IF protocol IAW Section 3.2.4.3
- activate and deactivate carrier
- raise and lower power in increments of 0.1 and 1 dB
- to the extent they are supported, access capabilities detailed in:
 - Section 3.7.2.2, Spectrum Display
 - Section 3.7.2.3, Dynamic Resource Allocation (DRA)

3.2.5.6.2 DM Reception

WRT Rx carriers on the Digital IF interface, the EDIM Modem shall enable operators, on a per-carrier basis, to:

- configure:
 - modulation: EBEM IAW Section 3.2.5.2
 - carrier frequency f_c IAW Section 3.2.5.8.1
- Enable Digital IF input connectivity IAW Section 3.2.4.4, including configuration of"
 - Digital IF sampling center frequency, in 1 kHz steps, over the range supported by the Digital IF protocol IAW Section 3.2.4.3
 - Digital IF sample rate, in 1 kHz steps, over a range adequate to support EDIM Modem symbol rates of 128 ksym/s to 200 Msym/s
 - Digital IF sample depth over the range supported by the Digital IF protocol IAW Section 3.2.4.3
- monitor, whether CW or modulated, Rx:
 - actual carrier center frequency f_c IAW Section 3.2.5.9.1
 - carrier center frequency offset Δf_c accordingly
 - carrier power P_c IAW Section 3.2.5.9.2
 - whether modulation is on or off
- monitor, with modulation present:
 - E_b/N_0 IAW Section 3.2.5.9.3
 - C/N IAW Section 3.2.5.9.3
 - carrier lock
 - data lock
 - encryption lock
- access Interference Mitigation capabilities detailed in Section 3.2.5.1.6 and its subsections
- to the extent they are supported, access capabilities detailed in
 - Section 3.7.2.2, Spectrum Display
 - Section 3.7.2.3, Dynamic Resource Allocation (DRA)

3.2.5.6.3 DM Loopback Operation

For test, diagnostic and troubleshooting purposes WRT DM function, the EDIM Modem shall offer loopback operation, as illustrated in FIGURE 12:

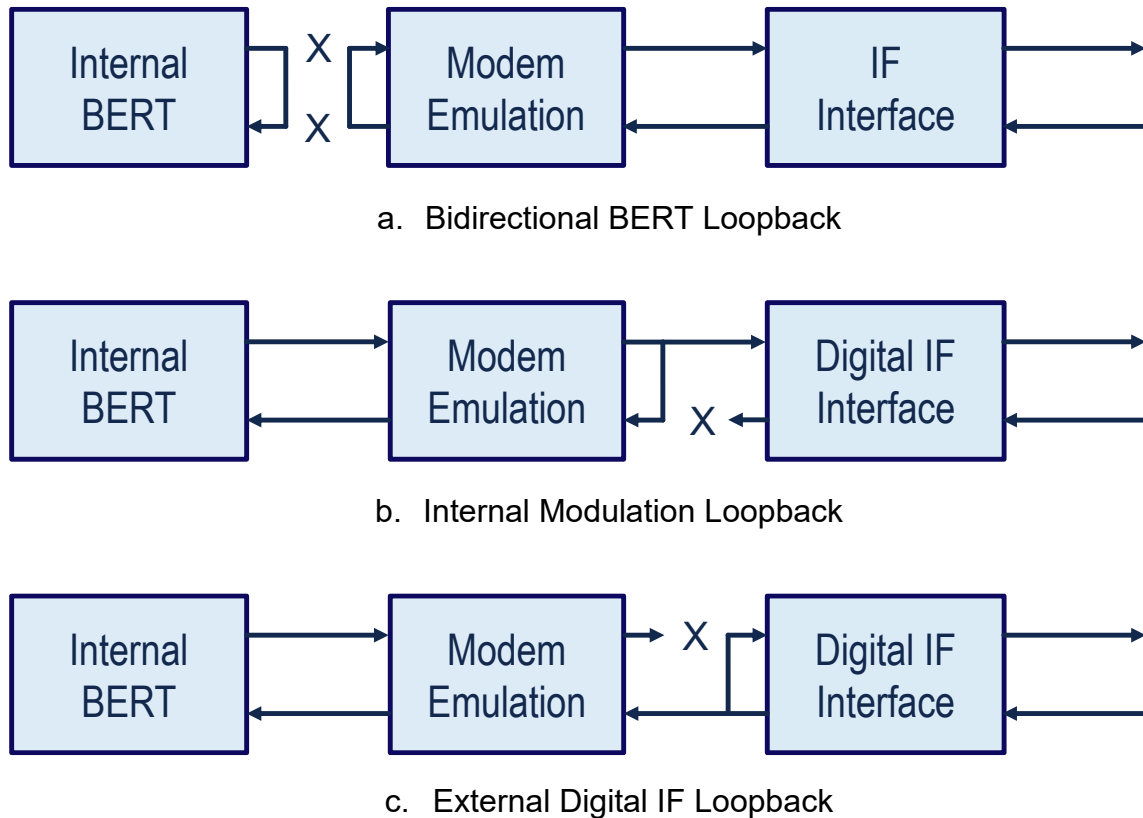


FIGURE 12 DM Loopbacks

- a. Bidirectional BERT Loopback:
 - i. Applicable to individual carriers
 - ii. BERT output traffic looped back to BERT input
 - iii. Demodulator output traffic stream looped back to modulator input
 - iv. Intended for testing with serial BERT traffic enabled in both directions
- b. Internal Modulation Loopback:
 - i. Applicable to individual carriers
 - ii. Modulator output carrier looped back to demodulator input while continuing to pass through to Digital IF interface
 - iii. Demodulator input from Digital IF interface interrupted
- c. External Digital IF Loopback:
 - i. Applicable to individual carriers
 - ii. Demodulator input from Digital IF interface looped back out to Digital IF interface while continuing to pass to demodulator input
 - iii. Modulator output to Digital IF interface interrupted
 - iv. Digital IF sample streams are looped back

Individual carrier loopbacks shall not cause interruption or degradation to any other individual carrier or channel. Individual loopbacks shall not cause interruption or degradation to carriers on paths described as unaffected. For example, the performance of a carrier undergoing DM Internal Modulation Loopback shall be unaffected at the distant end modem.

3.2.5.7 DM Uplink Performance

Performance indicated in the following subsections applies to Digital IF modulation.

3.2.5.7.1 DM Uplink Carrier Frequency

DM output carrier frequencies shall be configurable in 1-kHz steps over the range supported by the Digital IF protocol IAW Section 3.2.4.3.

3.2.5.7.2 DM Uplink Carrier Power

Carrier power shall be subject to configuration and accuracy as follows:

- Power Control Range: Carrier output power shall be adjustable over the range of 0 to –40 dBm
- Power Control Step Size: The minimum step size shall not exceed 0.1 dB
- Accuracy: The carrier power represented in the Digital IF waveform shall be within 0.1 dB of the selected value
- Same-Carrier Integrity: When a power change is initiated, carrier power represented in the Digital IF waveform shall transition monotonically, and shall not induce errors into the carrier's bit stream WRT subsequent processing and demodulation

3.2.5.7.3 DM Uplink Digitization Noise PSD

Digital IF sampling noise PSD $N_{\text{Samp}}|_{P_{\text{TOT}}}$ shall be controlled, at a minimum, to

$$N_{\text{Samp}}|_{P_{\text{TOT}}} \leq 18 - 6.02 N_{\text{bits}} - 10 \log_{10}(R_{\text{Samp}}) \text{ [dB}P_{\text{TOT}}/\text{Hz]}$$

where

P_{TOT} is the total output carrier power as represented in the output Digital IF stream

$N_{\text{Samp}}|_{P_{\text{TOT}}}$ is Digital IF sampling noise PSD normalized to total digitized signal power

N_{bits} is the Digital IF output stream sample depth

R_{Samp} is the Digital IF output stream sample rate

dB P_{TOT} /Hz represents PSD units of dB WRT total waveform power per Hz

The derivation of this sampling noise PSD threshold is provided in APPENDIX D.

3.2.5.7.4 DM Uplink Spectral Confinement

Each DM output carrier shall meet the modulator output carrier spectral density limit mask shown in FIGURE 9, subject to DM uplink digitization noise specified in Section 3.2.5.7.3 (i.e., greater of mask threshold or digitization noise floor threshold).

3.2.5.7.5 DM Uplink EVM

DM uplink EVM shall not exceed 1% to the extent that sample depth supports this threshold. The expectation is that of all-digital modulation accuracy to the limits of quantization error.

3.2.5.8 DM Downlink Performance

Performance indicated in the following subsections applies to Digital IF demodulation.

3.2.5.8.1 DM Downlink Carrier Frequency

DM input carrier frequencies shall be configurable in 1-kHz steps over the range supported by the Digital IF protocol IAW Section 3.2.4.3.

3.2.5.8.2 DM Downlink Frequency Uncertainty

The DM Downlink function shall acquire and demodulate carriers that are within 30 kHz of the nominal expected frequency (Section 3.2.5.8.1). This includes the maximum offset due to Doppler shift (Section 3.2.5.8.5).

3.2.5.8.3 DM Downlink Acquisition and Reacquisition

The DM demodulation function shall achieve initial acquisition within the times shown in TABLE I, with a confidence level of 95 percent over a frequency uncertainty of ± 30 kHz at the acquisition & synchronization reference E_{Sym}/N_0 defined in Section 3.2.5.5.4.

Reacquisition shall be similarly achieved IAW TABLE I using the same confidence level upon carrier return, at the acquisition & synchronization reference E_{Sym}/N_0 defined in Section 3.2.5.5.4, to within 500 Hz of the carrier frequency at the time of loss.

3.2.5.8.4 DM Downlink Synchronization Retention

DM demodulator waveform synchronization shall be maintained, at the acquisition & synchronization reference E_{Sym}/N_0 defined in Section 3.2.5.5.4, when subject to the loss of two consecutive Digital IF stream packets occurring up to once every 5 seconds.

3.2.5.8.5 DM Downlink Doppler Environment

The DM demodulator shall meet all specified requirements when subject to Doppler shift, rate of change and acceleration, as presented in TABLE II, at the same acquisition & synchronization reference E_{Sym}/N_0 defined in Section 3.2.5.5.4.

3.2.5.8.6 DM Back-to-Back BER

EDIM Modems functioning as DMs employing EBEM emulations shall support BER performance in back-to-back configurations, as indicated in TABLE III, where Turbo Block Size is selected IAW NATO STANAG 4486 Ed4, ANNEX F, Section 3.3.4.3.1.1, “Turbo Block Sizes and Frame Sizes.”

If the DVB-S2X hub waveform is chosen IAW Section 3.2.5.2.2.2 to implement higher rates IAW Section 3.2.5.2.2, then EDIM Modems functioning as LMs employing such emulations shall support QEF operation ($BER < 10^{-8}$) to E_s/N_0 thresholds determined by adding 0.5 dB to the “Ideal E_s/N_0 [dB] for (AWGN Linear Channel)” indicated in ETSI EN 302 307-2, Table 20a.

3.2.5.8.7 DM Downlink ACI

DM Back-to-Back BER requirements, as indicated in Section 3.2.5.8.6, shall be met in the presence of ACI consisting of interfering carriers:

- whose 25 dB BWs ($\sim 1.21 R_{\text{Sym}}$) are separated from that of the COI by 200 kHz, and
- whose PSDs exceed that of the COI by 13 dB

This ACI scenario is illustrated in FIGURE 10.

3.2.5.9 Modem Test Features

This subsection specifies test features common to all EBEM emulations supported by the EDIM Modem.

3.2.5.9.1 Carrier Frequency Measurement

The EDIM Modem shall measure and report the frequency of each incident carrier to at least 100 Hz accuracy.

3.2.5.9.2 Carrier Power Measurement

The EDIM Modem shall measure and report the power of each incident carrier, in dBm, monotonically with respect to actual carrier power, and to an accuracy of at least:

- ± 1 dB WRT carriers on the L-Band IF interface IAW Sections 3.1.1.2.2 and 3.2.3
- ± 0.5 dB WRT carriers on the Digital IF interface IAW Sections 3.1.1.2.3, 3.1.1.2.4, and 3.2.4

3.2.5.9.3 Signal to Noise Ratio (SNR) Measurement

The EDIM Modem shall measure and report:

- the ratio of energy per bit to noise power spectral density (E_b/N_0) of each carrier, monotonically with respect to actual carrier E_b/N_0 , over a range of 0 dB to +20 dB,

- the carrier to noise ratio (C/N , identical to E_{Sym}/N_0) of each carrier, monotonically with respect to actual carrier C/N , over a range of -3 dB to +20 dB,

each to the following accuracies:

- ± 0.75 dB for $-3 \text{ dB} < C/N \leq 5 \text{ dB}$
- ± 1.0 dB for $5 \text{ dB} < C/N \leq 10 \text{ dB}$
- ± 1.5 dB for $10 \text{ dB} < C/N \leq 15 \text{ dB}$
- ± 2.0 dB for $15 \text{ dB} < C/N \leq 20 \text{ dB}$

The EDIM Modem System, when configured to do so, shall report (e.g. update EMMS and OI WRT) E_b/N_0 and C/N at intervals from 0.25 s to at least 60 s, as configured by the operator. The E_b/N_0 and C/N measurement windows shall in no case exceed the reporting interval.

3.2.5.9.4 Internal Bit Error Rate Test (BERT)

The EDIM Modem shall implement an internal BERT capability on each carrier IAW NATO STANAG 4486 Ed4, Annex G, Appendix 2, Sections 8.8.1 through 8.8.4. (Note: In this reference, the BERT patterns and measurement dynamics are relevant, not necessarily the M&C messaging). The EDIM Modem internal BERT capability shall be interoperable with that of the MD-1366 configured for BERT traffic on its serial channel.

If the higher rates specified in Section 3.2.5.2.2 are supported by DVB-S2X hub waveforms IAW Section 3.2.5.2.2.2, then this DVB-S2X emulation shall be capable of an equivalent BERT capability.

3.3 Management and Control (M&C)

The means shall be provided to manage and control all functions of multiple networked EDIM Modems IAW the M&C objectives, architecture, function, and performance indicated in this section and its subsections.

3.3.1 M&C Objectives

The EDIM Modem System is intended to meet the following M&C objectives, in order of precedence:

- a. Operator Friendly – ease of use
- b. Reliable – mature WRT development, available WRT link execution
- c. Secure – computer and network protection
- d. Maintainable – life cycle sustainment
- e. Scalable – scales from 1 to N modems and/or control software instances
 - i. Simple Single Modem Management – facilitates operation at a single-modem sites
 - ii. Straightforward Multi-Modem Management – facilitates operation in a multi-operator / multi-modem environment
- f. Adaptable – supports the addition of new functions and capabilities
- g. Update Friendly – easy to update cybersecurity, software, and firmware

- h. Machine-Machine Capable – straightforward inter-machine interfaces
- i. Third-Party Integration Flexibility – well-defined access for Government or third party add-ons

3.3.2 EDIM Modem System M&C Architecture

The EDIM Modem M&C architecture is illustrated in FIGURE 13 and consists of the components described in the following subsections.

3.3.2.1 EDIM Modem Management Components

FIGURE 14 illustrates EDIM Modem M&C systems, reflecting variety in network connectivity and host platforms for M&C software. FIGURE 14-a illustrates EDIM Modem EMMS instances hosted on secure host baseline (SHB) servers, as contemplated for larger sites. FIGURE 14-b illustrates EMMS instances hosted directly on SHB workstations, as contemplated for smaller sites. FIGURE 14-a and FIGURE 14-b together reflect general EMMS flexibility WRT host platforms.

The integrity and self-consistency of shared resources, such as databases, shall be maintained across all users and actions, including EMMS failover and restoral operations.

In the following sections, the term “connection” refers to connectivity between neighboring components, as between the OI and EMMS, and the term “session” refers to end-to-end communication, as between the OI and EDIM Modem.

3.3.2.1.1 EDIM Modem Management System / Software (EMMS)

The EMMS shall be the central point of secure machine control for up to 256 locally networked EDIM Modems. The EMMS shall consist of software operable on both SHB platforms IAW Section 3.4.8 and virtual machines. The EDIM Modem System shall support 1 to 4 EMMS instances. The EMMS shall support minimal operation that consists of a single EMMS and a single OI collocated on the same hardware platform. EMMS instances shall securely support at least 16 concurrent OI connections and 256 concurrent EDIM Modem connections. EMMS instances shall concurrently support at least 16 active secure sessions between OIs and EDIM Modems.

EMMS instances shall be simultaneously operable on separate hardware platforms for the sake of redundancy and availability. It will be acceptable to employ load-sharing across multiple EMMS instances. Failure of any EMMS instance shall be automatically detected, upon which surviving EMMS instances shall continue supporting EDIM Modem System functions with minimal, if any, interruption.

Each EMMS instance shall automatically detect the presence of each new EDIM Modem on the M&C network and enable subsequent operation. Each EMMS instance shall detect the presence of each new EMMS instance on the M&C network and allow the operator to enable subsequent operation. Each EMMS instance shall detect the presence of each new OI on the M&C network and enable their subsequent operation.

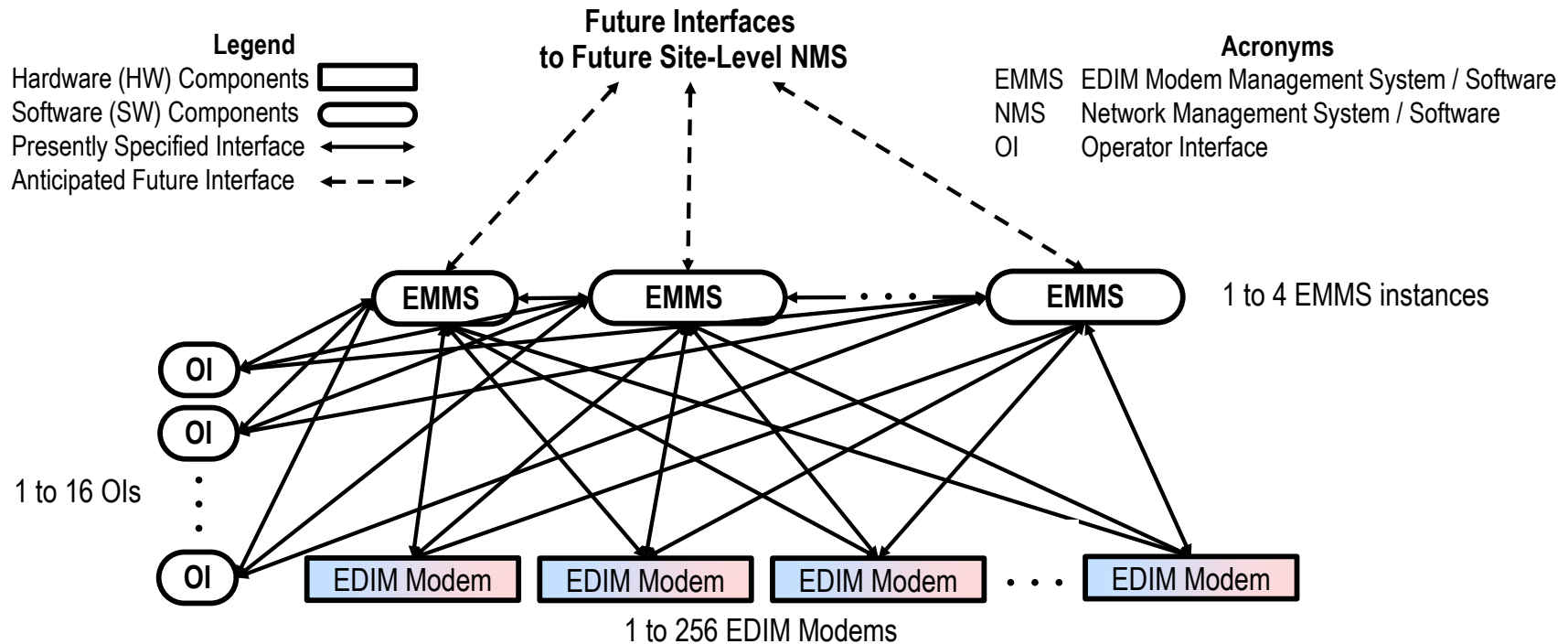
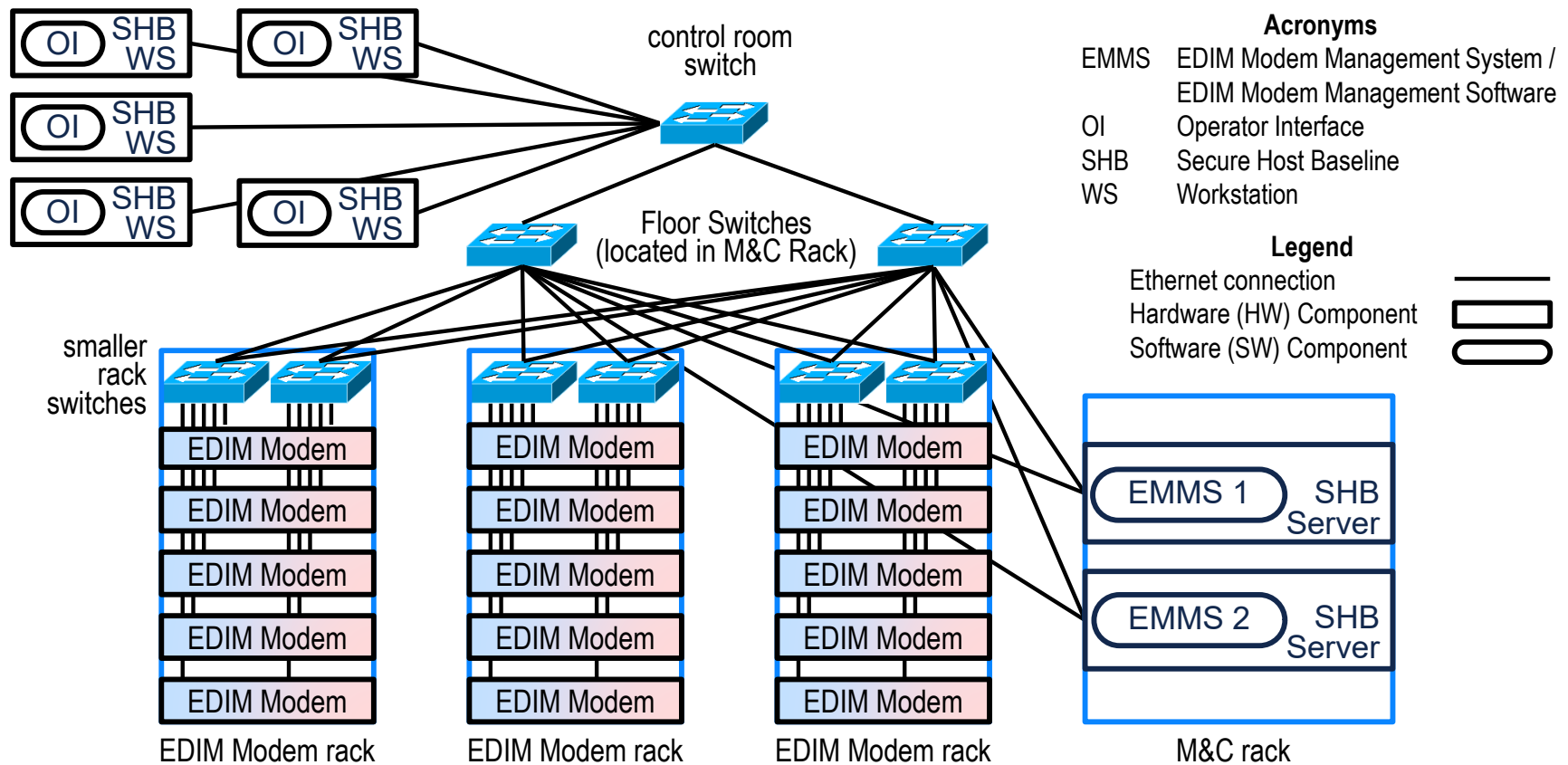
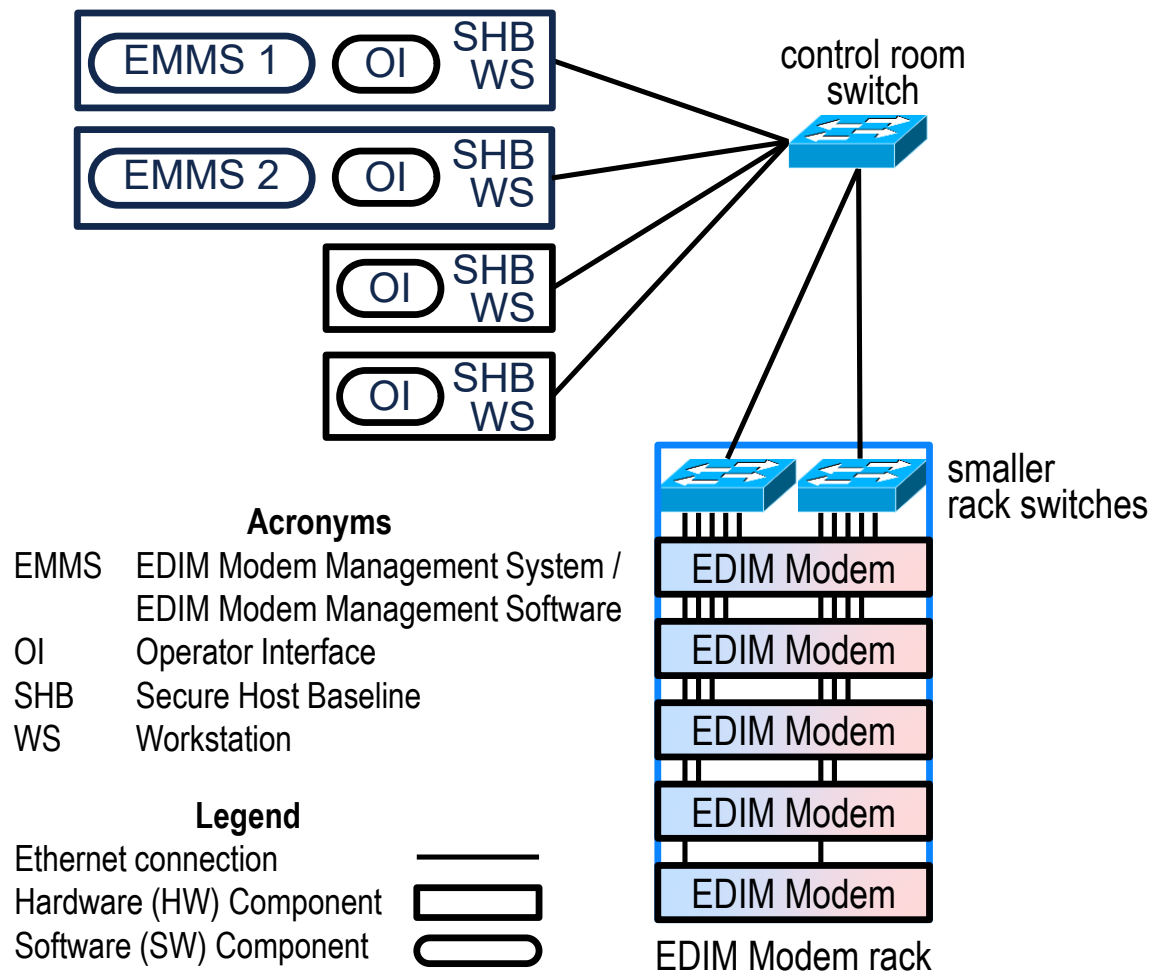


FIGURE 13 EDIM Modem System M&C Architecture



a. Larger Site Example (EMMS instances running on SHB servers)

FIGURE 14 Practical Implementation of EDIM Modem M&C



b. Smaller Site Example (EMMS instances running on SHB workstations)

FIGURE 14 Practical Implementation of EDIM Modem M&C (continued)

Any software installation required to implement the EMMS shall be readily completed by a 25S Military Occupational Specialty (MOS) level technician in less than 60 minutes.

3.3.2.1.2 Operator Interface (OI)

The OI shall serve as the human interface, providing the operator with efficient and effective access to all M&C functions IAW all M&C and Cybersecurity requirements specified in this document. The OI shall consist of software operable on both SHB platforms IAW Section 3.4.8 and virtual machines. Each OI shall be able to securely access up to at least 256 EDIM Modems via the various EMMS instances to perform all M&C functions. The OI shall be capable of displaying on high-definition display(s) with a resolution of 1920x1080 or higher.

OI functions shall include configuration, SMAT maintenance, software and firmware updates, security, audit, alarm log collection and dissemination, and data file transfer. The active configuration of each EDIM Modem, and at least 100 additional backup configurations stored on EMMS instances, shall be accessible and editable through the OI. The OI shall signal the presence of alarms on any EDIM Modem with clear visual warnings, identifying the source, and with clear audible warnings.

OI sessions shall time out after an inactivity interval configurable by an Administrator, after which the operator must log in again to resume EDIM Modem System management. Semi-autonomous functions, such as Multiple Modem Configuration Management IAW Section 3.3.5.4, or Situational Awareness IAW Section 3.3.5.5, shall timeout due to operator inactivity, but shall continue performing their task. For example,

- In the case of Multiple Modem Configuration Management IAW Section 3.3.5.4, CM processes initiated before time out, but not yet completed upon time out, shall complete after time out
- In the case of Situational Awareness IAW Section 3.3.5.5, situational awareness monitoring initiated before time out shall continue after time out
- In the case of Modem Suite Reporting IAW Section 3.3.5.6, reports initiated before time out, but not yet completed upon time out, shall complete after time out

After such a timeout, an Operator shall be able to login again in order to regain management over the function. Any software installation required to implement the OI shall be readily completed by a 25S MOS level technician in less than 10 minutes.

3.3.2.2 EDIM Modem

Networked EDIM Modem M&C shall be accessed through the Rear Panel Ethernet M&C Ports indicated in Section 3.1.1.2.5. The EDIM Modem shall enable concurrent configuration of different links on common EDIM Modems by different OI sessions.

3.3.3 Site-Level Network Management System (NMS)

A site-level NMS is contemplated for future development. The management workflows between this future site-level NMS and the EDIM Modem EMMS are currently under development. Requirements for a Northbound EMMS interface to this future site-level NMS are addressed in Section 3.7.2.1.

3.3.4 General Operation

The following subsections indicate general EDIM Modem M&C requirements.

3.3.4.1 M&C Roles

EDIM Modem System operator accounts shall each be associated with one role, assignable by any Administrator from the following list in the following order of precedence:

1. Administrator
2. Power Control
3. Standard Operator
4. Monitor-Only

This listed order of role precedence is relevant to resolution of operator contention IAW Section 3.3.4.4. EDIM Modem System role-based access privileges are identified in TABLE VI.

3.3.4.2 M&C Protocols

M&C protocols utilized to implement required functions shall be chosen from non-proprietary industry standards to the greatest practical extent possible. TABLE IV lists example non-proprietary industry standard protocols. Where no suitable non-proprietary alternative is available, a proprietary protocol may be used with Government approval. All protocols utilized shall at least be the latest issue at the time of contract award.

3.3.4.3 Data Traffic Integrity

The attachment and removal of cables to and from any M&C interface shall not interrupt modem traffic. The loss, resumption, or replacement of control links or M&C components shall not disrupt modem traffic. No M&C function shall disrupt traffic (e.g., File Transfer IAW Section 3.3.5.2, Authentication IAW Section 3.3.5.3, Situational Awareness IAW Section 3.3.5.5, Modem Suite Reporting IAW Section 3.3.5.6, configuration of other links, etc.).

TABLE IV Example Non-Proprietary Industry Standard Protocols

| Protocol | Standard | Function | Section References |
|---|--|--|------------------------------------|
| Remote Access Dial-in User Service (RADIUS) | RFC 2865 | Authentication, authorization, and accounting | 3.3.5.3 |
| System Logging Protocol (SYSLOG) | RFC 5424 | Logging | 3.3.5.6 |
| Dynamic Host Configuration Protocol (DHCP) | RFC 2131 | Networking | 3.1.1.2.5 3.3.2.1.1 |
| Network and Precision Time Protocol (NTP/PTP) | RFC 5905 (NTPv4) RFC 5906 (NTP Autokey) IEEE 1588-2019 (PTP) | Networking | 3.2.1.1 3.4.5 |
| HyperText Transfer Protocol Secure (HTTPS) | RFC 2660 | Browser-based configuration / operator interface | 3.3.5.2 |
| Network Configuration (NETCONF) | RFC 6241 | Configuration | 3.7.2.1 |
| Yet Another Next Generation [data modeling language] (YANG) | RFC 7950 | Configuration | 3.7.2.1 |
| Secure Shell Host (SSH) | RFC 4253 | Configuration | 3.3.5.2 |
| Cascading Style Sheets Level 3 (CSS3 UI) | W3C CSS | Configuration | 3.3.2.1.1, 3.3.2.1.2 3.3.5.6 |
| HyperText Markup Language 5 (HTML5) | RFC 7992 | Configuration | 3.3.2.1.1, 3.3.2.1.2 3.3.5.6 |
| Simple Network Protocol Version 3 (SNMPv3) | RFC 3411 | Configuration | 3.3.2.1.1 |
| SSH File Transfer Protocol (SFTP) | RFC 4251 RFC 4253 | Data transfer | 3.3.5.2 |
| Lightweight Directory Access Protocol (LDAP) | RFC 4511 | Authentication, Authorization | 3.3.5.3 |
| Active Directory | MS-ADTS | Authentication, Authorization | 3.3.5.3 |
| Transport Layer Security (TLS) 1.3 | RFC 8446 | Transport | 3.4.3 |

3.3.4.4 Contention Resolution

Any authorized operator shall be able to request configuration control authority from the operator that currently holds control authority over any given configuration dataset (e.g., EDIM Modem link configuration). The operator with current control authority shall then be able to choose whether or not to relinquish control to the other operator. A higher privileged operator shall be able to seize control authority from an operator with current control authority who fails to relinquish control, in which case the operator losing control shall be notified.

In the case of Power Control IAW Section 3.3.5.1, if another operator holds configuration control authority at the time of Power Control operator action (e.g., carrier activation, deactivation, or power change), then:

- the Power Control operator is not required to request configuration control authority to take Power Control operator action
- the operator with configuration control authority is notified
- when the Power Control operator action is completed, control is immediately returned to the operator with configuration control authority

3.3.4.5 Configuration Integrity

Before committing a configuration change, EDIM Modem System shall automatically:

- a. detect issues within the EDIM Modem System that will result from impending changes and affect other configuration datasets,
- b. alert the controlling operator of the issues, and
- c. enable the controlling operator to reconcile any issues before committing to the configuration change.

3.3.4.6 M&C Response Time

For all M&C interfaces, the response time from invocation of an M&C command to command execution, shall not exceed 0.25 seconds. Parameters shall be refreshed periodically for all OIs to maintain consistency with the current operation of each EDIM Modem.

3.3.4.7 Factory Default State

The EDIM Modem shall be delivered in the factory default state. The factory default state is the EDIM Modem state under the following conditions.

- a. factory default account credentials
- b. data traffic and all links disabled
- c. zeroized cryptographic state
- d. absence of any stored configurations
- e. no potentially sensitive files that are unnecessary for operation
- f. all other settings to their intended factory default state

The EDIM Modem shall offer a factory reset capability to restore it to its factory default state. The EDIM Modem System shall likewise offer a factory reset capability to restore any EDIM Modem to its factory default state.

In its factory default state, the EDIM Modem shall offer the means to change the M&C interface IP settings so that it can initiate communicate with an EMMS.

3.3.4.8 Shutdown and Restart

An operator-initiated shutdown of any component of the EDIM Modem System shall be accomplished in an orderly manner after the active state is saved and any configurations currently being edited are saved. Should any component of the EDIM Modem System, or its host hardware, encounter an unexpected shutdown, as would occur during a power failure, EDIM Modem System configuration shall be preserved. Upon return to normal operating conditions (e.g., restoration of power), each affected EDIM Modem System component shall return to its last active configuration. In the case of the EDIM Modem, uplink carriers shall not be activated, but downlink signals shall be re-acquired.

3.3.5 Management Provisions

Required EDIM Modem System functions are indicated in the following subsections.

3.3.5.1 Power Control

The Power Control role is identified in Sections 3.3.4.1 and 3.4.6.1. Power Control operator access shall be limited to only one Power Control operator login per configuration dataset (i.e., per modem link) at any given time. The Power Control operator shall be permitted to activate and deactivate carriers and adjust carrier power levels regardless of general configuration and control authority. Power Control operators shall time out after inactivity intervals configurable by any Administrator.

3.3.5.2 File Transfer

The OI shall provide the means to manage file transfers necessary in support of all EDIM Modem System functions. Files required in support of EDIM Modem System functions may include, but are not necessarily limited to, those indicated in TABLE V.

TABLE V Example File Transfer Types

| File Type | File Format | Export from Modem | Import to Modem | Internal Modem Storage Capacity | Section References |
|--|--------------------|--------------------------|------------------------|--|---------------------------|
| Software and Firmware, Patch Installation, and Upgrade Files | TBD | | X | primary, alternate and backup | 3.7 |
| Log Files | TBD | X | | 14 days | 3.4.9 |
| Alarm Log Files | TBD | X | | up to at least 100 records | 3.5.2.3 |
| Configuration Datasets | TBD | X | X | 25 | 3.4.8 |

3.3.5.3 Authentication

The means shall be provided for the EDIM Modem System to interface with one or more external authentication servers that provide centralized management for authentication, authorization, and accounting (AAA) services. The EDIM Modem System shall support the following external authentication server functions:

- Remote Authentication Dial-In User Service (RADIUS) IAW IETF RFC 2865
- Terminal Access Controller Access-Control System Plus (TACACS+) IAW "The TACACS+ Protocol" (IETF Draft)
- Lightweight Directory Access Protocol (LDAP) IAW IETF RFC 4511
- Active Directory IAW MS-ADTS

Operator authentication shall take place at the OI. In the case that an authentication server is not present or is unavailable, the EDIM Modem System shall reliably maintain a local operator authentication database. Local login services shall be provided by the EDIM Modem System for up to at least 256 operators.

3.3.5.4 Multiple Modem Configuration Management

The OI shall provide the means to select single modems, groups of modems, or all modems, up to at least 256, and to jointly manage such modem sets WRT:

- a. Software, firmware and cybersecurity updates
- b. Cryptographic "zeroize" functions IAW Section 3.2.5.1.5
- c. Factory reset functions IAW Section 3.3.4.7
- d. Other management functions

3.3.5.5 Situational Awareness

The OI shall provide the means to support the monitoring of up to at least 256 EDIM Modems, and to provide continuous situational awareness status, to include:

- a. a single screen summary status for all modems
- b. comprehensive status pages for each modem

The situational awareness function shall signal the presence of alarms on all EDIM Modems with clear visual warnings, identifying the source, and with clear audible warnings. The means shall be provided to select modems and parameters for monitoring in this context.

3.3.5.6 Modem Suite Reporting

The OI shall provide the means to generate various reports, over multiple selectable modems, up to at least 256, with selectable reporting fields, including, but not limited to:

- a. security, audit and alarm log collection comparable to that of SYSLOG
- b. parameters and metrics selectable by the operator, including link name, metric type, modem name, IP address, IP port, and carrier information (e.g., E_b/N_0 , C/N, transmit power, receive power, data rate, mod-cod, symbol rate, etc.)
- c. versioning reports that identify the modem hardware and software versions
- d. network reports that identify all network information related to a given modem
- e. alarm and fault reports, including active and historical alarms and faults
- f. cryptographic reports of expiring key material

It shall be possible to generate or export all reports to common file formats, such as CSV, TXT, HTML, PDF, XML, JSON, etc., chosen based on industry best practices.

3.4 Cybersecurity

All Information Technology (IT) products, whose function is covered by an established DOD Unified Capabilities (UC) product category, shall be selected from the current UC approved products list (APL) or those products currently under UC validation, to the maximum extent possible. The Contractor shall provide justification for using UC products not on the UC APL. All IT products that perform any type of data encryption shall be certified by NIST at Security Level 2, as described in FIPS PUB 140-3, and employ FIPS approved cryptography. All IT products shall be hardened and maintained IAW applicable Defense Information System Agency (DISA) Security Technical Information Guides (STIGs), Security Requirements Guides (SRGs), Best Business Practices (BBPs), and security patches, where applicable. The EDIM Modem System will generate and process controlled unclassified information (CUI) data.

The following subsections specify cybersecurity requirements for the EDIM Modem System, including EDIM Modem, EMMS, OI, and any additional supporting software or applications.

3.4.1 System Identification Profile

The EDIM Modem System shall be implemented, certified, accredited, operated, and maintained IAW the DOD RMF process. Security controls applicable to the EDIM Modem System shall be IAW the following:

- a. Confidentiality, Integrity, and Availability (CIA), as defined by DODI 8500.01, Cybersecurity
- b. Categorized CIA impact level is expected to be C=MODERATE, I=MODERATE, A=MODERATE, as defined by Committee on National Security Systems Instruction (CNSSI) 1253
- c. Criticality level determined as Mission Essential
- d. Security Control definition, as defined by NIST Special Publication 800-53
- e. Security Control management, as defined by DODI 8510.01, Risk Management Framework for DOD Systems
- f. Cybersecurity in the Defense Acquisition System IAW DODI 5000.02, Operation of the Adaptive Acquisition Framework

3.4.2 Identification and Authentication

The EDIM Modem System shall provide a verification service which allows only authorized operators to gain access to the system or internal components. This service shall include the following provisions:

- a. The EDIM Modem System shall provide a comprehensive account management process that ensures only authorized operators can gain logical access to the information consistent with the defined operator's role.
- b. The EDIM Modem System shall be capable of requiring operators (e.g., human, machine, process) to successfully authenticate themselves before allowing any other actions on behalf of the operator.
- c. The EDIM Modem System shall require two-factor authentication of all operators, with the Administrator role having the ability to enable or disable this restriction.
- d. The EDIM Modem System shall require a password authentication scheme, at a minimum, to grant access.
- e. The EDIM Modem System shall be capable of expiring and replacing passwords and other authentication mechanisms.
- f. The EDIM Modem System shall disable or lock operator accounts after inactivity over a time interval configurable by the Administrator, with default of 35 days.
- g. The EDIM Modem System shall provide a timeout function when no keyboard/mouse activity is entered within a configurable time period. During timeout, the system shall take on the Monitor-only role until a login function is entered to reestablish all original role permissions.

3.4.3 Confidentiality

The EDIM Modem System shall prevent sensitive information that is traversed or stored within the system from being disclosed to unauthorized persons, processes, or devices. The potential impact definitions for the confidentiality security objective are identified as follows:

- LOW – The unauthorized disclosure of information could be expected to have a limited adverse effect on organizational operations, organizational assets, or individuals
- MODERATE - The unauthorized disclosure of information could be expected to have a serious adverse effect on organizational operations, organizational assets, or individuals
- HIGH - The unauthorized disclosure of information could be expected to have a severe or catastrophic adverse effect on organizational operations, organizational assets, or individuals

The EDIM Modem System shall protect all network information, including associated security attributes, exchanged with external information management systems via the Ethernet interfaces using secure industry standard protocols, such as those suggested in TABLE IV. Unsecure protocols, such as FTP or TELNET, shall not be implemented within the EDIM Modem System.

3.4.4 Integrity

The EDIM Modem System shall provide assurance that information is protected from unauthorized modification or destruction. The potential impact definitions for the integrity security objective are identified as, follows:

- LOW – The unauthorized modification or destruction of information could be expected to have a limited adverse effect on organizational operations, organizational assets, or individuals
- MODERATE - The unauthorized modification or destruction of information could be expected to have a serious adverse effect on organizational operations, organizational assets, or individuals
- HIGH - The unauthorized modification or destruction of information could be expected to have a severe or catastrophic adverse effect on organizational operations, organizational assets, or individuals

The following requirements further support system integrity:

- a. The EDIM Modem System shall ensure that system initialization, shutdown, and abort actions do not compromise the secure state of either the respective component in particular, or the EDIM Modem System in general.
- b. The EDIM Modem System shall automatically monitor components and applications, and shall detect when unauthorized changes are attempted.
- c. The EDIM Modem System and its components shall transmit and receive control or management information in a manner protected from modification, deletion, insertion, and replay errors. The EDIM Modem

System shall provide replay protection for, and preserve the integrity of, management and control plane information.

- d. The EDIM Modem System shall provide the ability to successfully recover all security functions after a hostile attempt against the security of the system, and shall ensure recovery to a secure state without compromise.
- e. The EDIM Modem System shall enforce digitally signed software/firmware during upgrades to ensure its integrity and authenticity.

3.4.5 Availability

The EDIM Modem System shall ensure that resources, services, and other data are available in a timely manner to authorized entities. The potential impact definitions for the availability security objective are identified as follows:

- LOW – The disruption of access to or use of information or an information system could be expected to have a limited adverse effect on organizational operations, organizational assets, or individuals
- MODERATE – The disruption of access to or use of information or an information system could be expected to have a serious adverse effect on organizational operations, organizational assets, or individuals
- HIGH – The disruption of access to or use of information or an information system could be expected to have a severe or catastrophic adverse effect on organizational operations, organizational assets, or individuals

The following requirements are intended to further support availability:

- a. All security functions shall complete successfully when uninterrupted or recover to a secure state, without operator intervention, when interrupted.
- b. All failure scenarios shall result in prompt recovery to a secure state without operator intervention
- c. The EDIM Modem System shall minimize degradation of operator services and/or network management operations due to a surge in security or non-security related management/control messages.
- d. The EDIM Modem System shall support replication of all components and network files, including configuration parameters that ensure a quick recovery in event of a hostile attempt or a failure in operations with the component or the primary management system.
- e. The EDIM Modem System and its components shall support synchronization of internal clocks to multiple NTP/PTP servers and, where appropriate and when available, to IRIG source time for redundancy purposes.

3.4.6 Access Control

The EDIM Modem System shall ensure that M&C resources are available only to authorized operators and services. Access control shall include the following provisions:

- a. Discretionary/role-based access control to ensure that M&C data is accessed and changed only by authorized personnel
- b. Capability to establish and administer all privileged operator accounts IAW the role-based access scheme defined in Section 3.3.4.1
- c. Access procedures enforcing the principles of separation of duties and least privilege based on approved role
- d. Presentation of the DOD Login Banner, as defined in AR 25-2, that the operator must acknowledge
- e. Presentation of an “Operator Name” and “Password” prompt, or DoD ID Certificate and PIN number prompt, after the DOD Login Banner is acknowledged

3.4.6.1 Operator Roles

Access to the EDIM Modem System and account security features shall be determined by operator roles and corresponding privileges. The operator roles, as identified in Section 3.3.4.1, shall be assigned privileges IAW TABLE VI. Necessary privileges not identified in TABLE VI shall be assigned by the Contractor, subject to Government approval.

3.4.6.2 Password Policy

The EDIM Modem System shall support password characteristics, as defined in DOD password standards and IAW applicable STIGs in place at the time of contract award. Mechanisms shall be in place to ensure the password policy is enforced. Because password policies may vary based on changes in policy, regulations and STIG requirements, the EDIM Modem System password policies shall be configurable. The following are examples of present password requirements:

- a. Complex passwords require a minimum of one uppercase letter, one lowercase letter, one number, and one special character and a minimum of 15 characters in length
- b. Maximum password lifetime restriction is set to 60 days
- c. Password history set to a minimum of 5 previous passwords before reuse
- d. Minimum change of 50% of the minimum password length when changing a password
- e. Minimum password lifetime restriction configurable by the Administrator with the default set to 24 hours
- f. Operator account password change required upon first login, and after password change by the Administrator
- g. Password disabled: (1) after 3 consecutive unsuccessful login attempts, requiring the Administrator to unlock; or (2) based on an established timeout period, depending on the configuration, with the length of time being configurable by an Administrator as either indefinitely or a set value. (Note: Administrator accounts are never locked out indefinitely).
- h. Passwords that are stored or in transmission to be cryptographically protected
- i. Operators can change their own account passwords

TABLE VI Operator Role Privileges

| Functions | Administrator | | Standard Operator | | Monitor Only | Power Control | |
|---|---------------|---------|-------------------|---------|--------------|---------------|---------|
| | Monitor | Control | Monitor | Control | Monitor | Monitor | Control |
| Create/Modify/Delete Operator Accounts | X | X | X | | X | | |
| Lock & unlock accounts | X | X | X | | X | | |
| Configure Password Policy | X | X | X | | X | | |
| Enable/Disable Unsecure Protocols (default = Disable) | X | X | X | | X | | |
| Configure Security Features | X | X | X | | X | | |
| Initiate Factory Reset | X | X | X | | X | | |
| Initiate Cryptographic Zeroize | X | X | X | | X | | |
| Configure operator inactivity interval | X | X | X | | X | | |
| Configure operator session timeout value (default = 10 min) | X | X | X | | X | | |
| Configure concurrent operator sessions (default = 50 sessions) | X | X | X | | X | | |
| Manage Encryption Features (certificate upload; monitor status only) | X | X | X | | X | | |
| View/Clear/export Audit Log | X | X | X | | X | | |
| Download/Install Software/Firmware | X | X | X | | X | | |
| Configure M&C Components (EMMS, Configuration Management, Situational Awareness, Suite Reporting; EDIM Modem units to address and relevant authentication server) | X | X | X | | X | | |
| Configure Network Interfaces | X | X | X | | X | | |
| | | | | | | | |
| Transfer/Backup Files | X | X | X | X | X | | |
| Initiate Shutdown & Restart | X | X | X | X | X | | |
| Configure Modem Encryption (SMAT entry, bulk encryption config) | X | X | X | X | X | | |
| Access M&C Components (EMMS, Configuration Management, Situational Awareness, Suite Reporting; M&C configuration parameter sets, status items and audit data including export and transfer) | X | X | X | X | X | | |
| | | | | | | | |
| Equipment Status, Link Status | X | X | X | X | X | X | |
| Link Configuration | X | X | X | X | X | X | X |
| Enable/Disable Modem Tx | X | X | X | X | X | X | X |
| Configure Modem Tx Power | X | X | X | X | X | X | X |

3.4.7 Network Interfaces

The three sets of EDIM Modem Ethernet interfaces, identified in Sections 3.1.1.2.1 (Data Traffic), 3.1.1.2.3 (Digital IF), 3.1.1.2.4 (also Digital IF), and 3.1.1.2.5 (M&C), shall be network isolated. EDIM Modem resources dedicated to these separate processes shall also be likewise isolated.

3.4.8 M&C Components and Data Storage

The following requirements apply to all EDIM Modem System components, and to corresponding information storage.

- a. The EMMS shall be capable of being executed on, or otherwise accessed in its entirety, from an SHB Microsoft Windows-based server or computer. The OI shall be capable of being executed on, or otherwise accessed in its entirety, from an SHB Microsoft Windows-based computer. For guidance on the implementation of Microsoft Windows SHB, please refer to DSD Memorandum, dated Feb 26, 2016, and entitled "Implementation of Microsoft Windows 10 Secure Host Baseline." Supporting software and storage necessary for each component shall be capable of residing on the same component's hardened platform.
- b. The EMMS, OI, and any other relevant EDIM Modem System component shall be PKI enabled IAW DODI 8520.02 and DODI 8520.03.
- c. The EMMS, OI, EDIM Modem, and any other relevant EDIM Modem System component shall include provisions to store operator names, hashed passwords, and role assignments, as necessary and appropriate to their function;
- d. The EMMS, OI, EDIM Modem, and any other relevant EDIM Modem System component shall include provisions, as appropriate to the EDIM Modem System implementation, to store the names and IP addresses, for tracking purposes, of all modems controlled, monitored or otherwise managed;
- e. The EDIM Modem System shall support simultaneous access, by all relevant EDIM Modem System components, to all M&C parameters;
- f. The EDIM Modem System shall provide the means to export EDIM Modem System configuration sets for storage, for backup, and for use on relevant EDIM Modem System components, such as other OIs;
- g. The EDIM Modem System shall provide the means to push stored EDIM Modem configuration sets to EDIM Modems, both immediately and as scheduled.

3.4.9 Auditing and Non-Repudiation

The EDIM Modem System shall provide a monitoring capability and relevant information in log files about security-related events, as well as non-disputable evidence of what has transpired between operators and system resources. This capability includes the following features:

- a. The EDIM Modem System shall be capable of uniquely identifying each operator (operator, processes, and remote systems) and associating the identity with all auditable actions taken by that operator.
- b. The EDIM Modem System shall provide an automated, continuous on-line monitoring audit trail creation function, with the ability to immediately alert identified personnel of security and non-security events.
- c. The EDIM Modem System shall generate human readable audit records, as necessary, including, but not limited to, security events such as:
 - i. Start-up and shutdown of the audit function
 - ii. Distribution or revocation of access rights and functions
 - iii. Changes of access rights associated with resources (i.e., privileges required of an operator and a channel/port to access a resource)
 - iv. Successful and unsuccessful logins, including number of subsequent unsuccessful login attempts up to the next successful login
 - v. Denial of access resulting from excessive number of login attempts
 - vi. Privileged activities and other system level access
 - vii. Changes made in an operator's security profiles and attributes associated with a channel/port
 - viii. Creation and modification of component resources performed via standard operations and maintenance procedures
 - ix. Changes made in the security configuration of the system or component
 - x. Successful and unsuccessful attempts to access security files (i.e. any file storing secure or otherwise sensitive information, such as system configuration files, crypto keys, password files, etc.)
 - xi. Activities that might modify, bypass, or negate safeguards controlled by the system
 - xii. Blocking or blacklisting of operator account, terminal or access port and the reason for the action
 - xiii. Changes made regarding network management and/or configuration
 - xiv. Any attempts by operators to execute a command they do not have permission to use
 - xv. Updates to accounts, including creation, modification, enabling, removing, disabling, locking, and unlocking
- d. EDIM Modem System audit records shall include:
 - i. Operator account identification and authentication method
 - ii. Date and time of event
 - iii. Type of event
 - iv. Success or failure of event
- e. The EDIM Modem System shall ensure that all access and changes to data are stored in logs. Notification of the time and date of the last change in data content will be included.
- f. The EDIM Modem System shall provide the ability to export audit records.
- g. The EDIM Modem System shall provide mechanisms to protect against unauthorized access, modification, or deletion of audit trails.
- h. The EDIM Modem System shall provide alert mechanisms(s) for operator or remote system notification of security-related events, failures, and errors.

- i. The EDIM Modem System shall provide a means to review and generate reports from audit records.
- j. The EDIM Modem System shall provide the capability to display in human readable format:
 - i. All Audit records
 - ii. Subsets of audit records filtered on object identity, operator identity, subject identity, specific EDIM Modems accessed, and event type
- k. The EDIM Modem System shall allocate memory, dedicated to audit log storage, as follows:
 - i. At least eight files worth of memory for audit logging
 - ii. Each file to shall allow for 1 Megabyte per EDIM Modem, or for one day of audit logging, whichever comes first
 - iii. When the last allocated file is completed due to the time or size limit, the oldest file will be deleted to free up space for the next file
 - iv. The EDIM Modem System shall generate an alarm when the next to last allocated audit log file is completed due to the time or size limit, thus giving the operator a warning to back up the audit log before the next file rollover

3.4.10 Notification

Each EDIM Modem System component, as appropriate, shall ensure the following notifications are provided:

- a. Generate a log entry and event notification when an account is created, enabled, modified, disabled, removed, locked, or unlocked
- b. Generate logout confirmation after each operator session ends
- c. Upon each operator login event, generate a log entry of the date, time, and location, as well as an event notification to the Administrator

3.5 Built-In Test (BIT)

Built-In Test (BIT), consisting of hardware fault detection, alarms and alarm notifications, are described in the following subsections.

3.5.1 Hardware Fault Detection

Fault detection and diagnostic functions shall not require the use of any equipment external to the EDIM Modem. The ability of the EDIM Modem to perform its intended function shall not be impaired by a malfunction of its fault detection and diagnostics function.

Diagnostic functions shall identify all EDIM Modem failures and malfunctions to the following levels:

- a. Component level, where possible, as in the case of fans and power supplies
- b. Mezzanine card level, where appropriate
- c. Circuit card assembly (CCA) or assemblies, at a minimum

Diagnostic functions shall identify what failed, the conditions for the failure, the date and time of the failure, and the diagnostic test that identified the failure.

3.5.1.1 Continuous Self-Test

The EDIM Modem shall be equipped with continuously operating BIT functionality to detect hardware malfunctions, to alert the operator accordingly, and to aid diagnostic and maintenance processes. During normal operation, the self-testing shall periodically execute a series of benign (not to interfere with normal operation) tests designed to detect failures in the EDIM Modem.

3.5.1.2 Non-Disruptive Self-Test

The EDIM Modem shall enable the operator to initiate a comprehensive non-disruptive (i.e., does not interrupt data traffic, cause data traffic to otherwise be interrupted, or overwrite critical data items) self-test during normal modem operation. Comprehensive non-disruptive self-test time shall not exceed two (2) minutes.

3.5.1.3 Disruptive Self-Test / Power-On Self-Test (POST)

During startup, the EDIM Modem shall automatically perform POST diagnostics. POST shall include the memory and processor tests that are part of the boot process. The POST shall test basic processor functionality and verify the proper operation of all volatile and non-volatile memory. The POST shall also check the basic functionality of L-Band IF circuitry.

The EDIM Modem System shall enable the operator to initiate POST, during normal modem operation, from the OI. Operator-initiated POST shall be disruptive (i.e., may disrupt normal operation of the modem or any of its functions), but shall provide the ability to repeatedly test select portions of the modem without a power cycle or reboot. POST results shall be delivered through the initiating OI and detail the specific reasons for any failures. POST duration shall not exceed four (4) minutes.

3.5.2 Alarms

EDIM Modem alarms shall be generated under the following conditions:

- a. Upon hardware fault detection
- b. When parameters exceed their constraint values or normal tolerances during normal modem operation
- c. On all conditions that interrupt data traffic flow anywhere in the signal chain
- d. On all conditions that threaten reliable continuing operation
- e. As otherwise deemed appropriate by the Contractor

3.5.2.1 Major Alarms

Alarms shall be classified as “major” if the alarm condition interrupts data traffic or will otherwise directly cause data traffic to be interrupted.

3.5.2.2 Minor Alarms

Alarms shall be classified as “minor” if the alarm conditions do not interrupt data traffic or will not otherwise directly cause data traffic to be interrupted.

3.5.2.3 Alarm Logging and Access

The EDIM Modem System shall maintain, in non-volatile storage, a record of each EDIM Modem’s most recent 100 alarm events in order of occurrence. This record, which shall be accessible from any control interface, shall identify:

- a. Nature of the alarm event
- b. Date and time initiated
- c. Acknowledgement status

The EDIM Modem System shall enable export of these alarm logs in CSV file format.

3.5.3 Alarm Notifications

Alarms shall be indicated by way of the following:

- a. Alarm record, as indicated in Section 3.5.2.3
- b. OI pop-up windows
- c. OI audible indicators

The OI shall enable the operator to receive and acknowledge:

- alarms individually
- all alarms for a given carrier
- all alarms for a given EDIM Modem
- all alarms for a given EDIM Modem operator’s data set (i.e., individual links chosen by and/or assigned to that operator)
- all alarms for the entire modem suite

If an alarm condition stops and returns, the alarm shall only regenerate if the first alarm was acknowledged.

3.6 Physical Platform

The physical platform requirements specified in the following subsections reflect the intent to deploy the EDIM Modem in Enterprise SATCOM Gateway sites.

3.6.1 Physical Platform Priorities

The allocation of operational and maintenance functions to personnel and equipment shall be consistent with the required safety, reliability, personnel skill levels, functional precision, and time constraints necessary for mission-effective EDIM Modem performance. The following priorities shall be applied to the design of the EDIM Modem physical platform.

- a. Safety, reliability and performance
- b. Ease of operation, maintenance and supply supportability

- c. Use of “off-the-shelf” proven components and/or assemblies
- d. Adaptability to new deployment environments
- e. Minimum power consumption

3.6.2 Life Expectancy

The electrical and mechanical design of the EDIM Modem shall support an expected useful life of 15 years under continuous operation. All EDIM Modem units delivered over the course of the program shall be backward compatible with all previously delivered EDIM Modem units.

3.6.3 Transportability

The EDIM Modem, when packaged for shipment, shall be transportable within the Continental United States (CONUS) or overseas, by means of land, sea, or air transportation.

3.6.4 19” Rack Mountable Enclosure Packaging

The EDIM Modem enclosure shall be designed for installation in an EIA/ECA-310-E compliant rack using standard drawer slides. EDIM Modem height shall not exceed one (1) rack unit (RU) (i.e., 1.75 inches) with the following rationale:

- Maintain 1 RU footprint of present modems
- Accomplish physical integration (i.e., carriers per RU) within a smaller footprint (i.e., 1RU vs 2RU or greater)
- Achieve higher carrier-level availability (i.e., a single enclosure-level failure causes fewer carriers to fail per 1RU enclosure than the presumably higher carrier capacity of a 2U enclosure).

The EDIM Modem shall not project greater than 40 millimeters from the face of the panel (not including operating handles), and shall not exceed 29 inches in depth behind the mounting panel. The Contractor may include provisions for rear or side physical support to mitigate torque on the modem front panel. EDIM Modem packaging shall enable the performance of all modem maintenance activities from the front of the rack in which it is installed.

3.6.4.1 Front Panel

Design and layout shall be optimized for operator accessibility and ease of use. MIL-STD-1472G may be used for guidance for safety, acoustic noise, design of controls and indicators, and their arrangement on operator panels.

3.6.4.2 Rear Panel

The rear panel shall allow for horizontal and vertical routing of cables as follows:

- Supporting all rear panel interfaces cited in Section 3.1.1.2 and its subsections
- Not to exceed a minimum cable bend radius of 1.50 inches
- When mounted in an EIA/ECA-310-E compliant rack of 30 inches depth
- Along with 24 modems installed in the same rack

3.6.4.3 Cooling

The EDIM Modem enclosure shall be equipped with cooling features drawing air from the rack in which it is installed. Forced cooling air at a minimum flow rate of 400 cubic feet per minute (CFM) at a maximum temperature of 17°C will be provided through the rack floor plenum. For up to 24 EDIM Modems, or their thermal equivalents, installed in the rack, the total rack temperature rise (i.e., rack floor plenum input temperature minus rack top exhaust temperature) shall not exceed 23°C. This shall apply to an EIA/ECA-310-E compliant rack with minimum dimensions of 45 RU height, 19" width and 36" depth, and with solid sides, vented top and bottom, and solid or louvered doors.

3.6.4.4 AC Power and Power Transients

The following subsections detail EDIM Modem requirements WRT AC power, supplied through the rear panel power interface, as indicated in Section 3.1.1.2.7, and corresponding power transients.

3.6.4.4.1 AC Power

The EDIM Modem shall operate, without degradation, from an AC prime power source with the following characteristics:

- a. Voltage: 108 to 126 or 200 to 240 Volts Alternating Current (VAC) without the need for deliberate voltage selection
- b. Frequency: 47 to 63 Hz
- c. Phase: 1 phase, 3 wire
- d. Power: no higher than 500 Watts

3.6.4.4.2 Power Transients

The EDIM Modem shall withstand any transient (i.e., less than one minute) in input power, to the extent described below, without damage or alteration of electrical characteristics:

- a. Voltage: 120/240 VAC $\pm 20\%$
- b. Frequency: 50/60 Hz $\pm 10\%$

3.6.5 Electromagnetic Environmental Effects (E3)

The following subsections detail EDIM Modem E3 requirements.

3.6.5.1 Grounding, Bonding and Shielding

The EDIM Modem shall comply with the applicable grounding and bonding requirements of MIL-STD-188-124, Sections 5.1 and 5.2, and applicable provisions of NFPA 70, Articles 250, 645 and 800. The EDIM Modem shall comply with the applicable shielding requirements of MIL-STD-188-124, Section 5.3. MIL-HDBK-419, MIL-HDBK-1857 and IEEE Std 1100 may be used for additional guidance. The grounding, bonding and shielding scheme of the EDIM Modem shall be designed to provide effective shielding and minimize ground loops and common current returns for signal and power circuits. Each modem chassis shall be

independently grounded to the rear panel ground stud specified in Section 3.1.1.2.8. Electrical supply grounds shall not be grounded to the racks, but shall be connected back to the common ground of the supply.

3.6.5.2 Electromagnetic Compatibility (EMC)

The EDIM Modem shall operate, as specified and without adverse effects, in a worldwide electromagnetic environment encompassing both intra-system and inter-system electromagnetic compatibility. The EDIM Modem shall not cause interference to other co-located systems.

3.6.5.3 Electromagnetic Interference (EMI)

The following subsections detail EDIM Modem requirements WRT conducted emissions, conducted susceptibility, radiated emissions and radiated susceptibility.

3.6.5.3.1 Conducted Emissions

The EDIM Modem shall meet the following conducted emissions requirements, as defined in MIL-STD-461G, specifically:

- CE102
- CE106

3.6.5.3.2 Conducted Susceptibility

The EDIM Modem shall meet the following conducted susceptibility requirements, as defined in MIL-STD-461G, specifically:

- CS101
- CS114 (Bulk cable injection susceptibility signals of Figure CS114-1; Curve #3 (10 kHz to 2 MHz) and Curve #4 (2 MHz to 200 MHz) apply)
- CS115
- CS116

3.6.5.3.3 Radiated Emissions (2 MHz to 18 GHz)

The EDIM Modem shall meet the radiated emissions requirements, as defined in RE102 of MIL-STD-461G using the "Navy Fixed and Air Force limits (Figure RE102-4). Radiated emissions limits shall be measured using the BW and dwell times specified in MIL-STD-461G.

3.6.5.3.4 Radiated Susceptibility

The EDIM Modem shall meet the radiated susceptibility requirements, as defined in RS103, Table VII, of MIL-STD-461G, for ARMY.

3.6.6 Physical Environment

The following subsections detail EDIM Modem physical environmental requirements. MIL-HDBK-310 may be used for additional guidance on environmental conditions.

3.6.6.1 Non-Operating Physical Environment

The EDIM Modem shall suffer no degradation in specified performance after exposure to any combination of the following conditions during non-use, bench handling, storage, or transit:

- a. Temperature: Continuous exposure to air temperatures from -40°C to +65°C, without solar radiation, and with negligible air movement
- b. Relative Humidity: Relative humidity (RH) as low as 10% and as high as 90%, at an air temperature of 40°C, without condensation
- c. Altitude: Up to 15,000 ft. above sea level
- d. Vibration: The EDIM Modem shall withstand the vibration encountered during ground, sea and air transport
- e. Fungus: Prolonged periods of exposure to a fungus growth environment, as encountered in tropical areas (including fungus-laden air), shall not result in evidence of fungus growth on any component or equipment surface
- f. Transport Shock: The EDIM Modem shall withstand shocks from transportation environments that create a repetitive shock load
- g. Bench Handling Shock: The individual electronic equipment shall withstand shocks associated with a bench handling environment

3.6.6.2 Operating Physical Environment

The EDIM Modem shall suffer no degradation in specified performance during or after exposure to any combination of the following conditions while operating:

- a. Ambient Temperature: 5°C to +40°C
- b. Relative Humidity: Maximum 70%, non-condensing
- c. Altitude: Up to 10,000 feet above sea level
- d. Functional Shock: The EDIM Modem shall withstand a functional shock environment, as defined in MIL-STD-810H, Method 516.8

3.6.6.3 Seismic Conditions

The EDIM Modem, installed in an EIA/ECA-310-E compliant, GR-63-CORE Zone 4 certified rack, shall survive Zone 4 seismic events, as defined in Telcordia GR-63-CORE, without damage or interruption of service. Operation during a seismic event is not required; however, the Modem shall automatically return to normal operation after the event. The Modem shall not pose a safety hazard during or after the seismic event.

3.6.7 Reliability, Maintainability and Availability

EDIM Modem reliability, maintainability and availability requirements are identified in the following subsections.

3.6.7.1 Reliability

The EDIM Modem operating in a ground fixed environment shall have a Mean Time Between Failure (MTBF) of no less than 30,000 hours, as determined using the Bellcore Reliability Prediction Procedure SR-332 using the environment

classification “Ground Fixed Uncontrolled.” A failure shall be defined as any malfunction that causes user traffic to be disrupted or degraded below specified performance parameters.

There shall be no need for recurring maintenance requiring the EDIM Modem to be taken out of service. Any necessary recurring maintenance event that requires the EDIM Modem to be taken out of service shall be treated as a failure WRT reliability, maintainability and availability.

3.6.7.2 Maintainability

The EDIM Modem shall be continuously operable. The Mean-Time-to-Repair (MTTR) shall be 15 minutes or less at the organizational level of maintenance. The maximum time to repair for corrective maintenance at the organizational level, 95th percentile of the repair time distribution (Mmax), shall not exceed one (1) hour. Repair time shall be defined as the total of the times required for fault location, fault isolation, equipment disassembly, component interchange, equipment reassembly, alignment, and check out. Repair time shall not include administrative time, logistic time, time required to transit between equipment locations, or preventative maintenance time expended while the mission critical equipment is in operation.

3.6.7.3 Availability

The inherent availability for EDIM Modem shall be at least 0.9999.

3.6.7.4 FRACAS

A Failure Reporting, Analysis, and Corrective Action System (FRACAS) shall be implemented by the Contractor and any of their subcontractors. The system shall be maintained for reporting, analysis, and correction of hardware failures and software errors that occur in contractually specified levels of assembly during in-plant tests, and that occur at installation or remote test sites. Failures occurring in specified levels of assemblies in tests at subcontractors’ facilities shall be integrated into the Contractor’s data collection system for tracking and incorporation in the failure summary and status reports. The Contractor’s existing data collection, analysis, and corrective action system shall be used, with modification only as necessary to meet EDIM Modem requirements. MIL HDBK 2155 may be used as guidance.

3.6.8 Design and Construction

The following subsections address various aspects of EDIM Modem design and construction, specifically manufacturing considerations and safety.

3.6.8.1 Manufacturing Considerations

The following subsections address various manufacturing considerations, including:

- Nameplates and Product Marking
- Workmanship

- Interchangeability
- Finish
- Corrosion Control
- Prohibited Materials
- Electrostatic Discharge (ESD)

3.6.8.1.1 Nameplates and Product Marking

All EDIM Modem enclosures and Line Replaceable Units (LRUs) shall have permanent and permanently attached Unique Item Identifiers (UIIs) and/or bar codes IAW MIL-STD-130. UIIs, nameplates, safety markings and warnings, cable labeling and other markings shall be accomplished in such a way as to ensure that they remain securely attached and legible when the equipment is subjected to the environmental conditions specified herein, and to the effects of wear and tear due to transportation, installation, operation, and maintenance. All UIIs and bar codes shall be located such that they can be viewed and scanned when the item is in the installed position.

3.6.8.1.2 Workmanship

EDIM Modem workmanship standards shall be IAW best commercial practices, as well as the following:

- a. Cabling and connectors shall be arranged to satisfy material bend radius limits, and to eliminate damage, breaks, safety hazards, and unserviceability under all conditions
- b. Parts and assembled equipment shall be free of loose or spattered solder, loose weld metal, metal chips, mold release agents, and other foreign materials
- c. Riveted and machine screw assemblies, welding, brazing, soldering, plating, and painting shall be free from burrs, sharp edges, and fraying
- d. Finishes shall be applied to surfaces to form an even, adherent, protective film. Finished surfaces shall be smooth and free from foreign debris.

3.6.8.1.3 Interchangeability

All EDIM Modem equipment assemblies and subassemblies shall be interchangeable IAW the following:

- a. like assemblies and replaceable parts shall be physically and functionally interchangeable, without modification or modification to other equipment
- b. individual parts shall not be handpicked for fit or performance
- c. reliance shall not be placed on any unspecified dimension, rating, characteristic, etc.

3.6.8.1.4 Finish

Unless otherwise specified by the Government, the EDIM Modem enclosure front panel shall be finished in Color 26622 (light gray) per AMS-STD-595A.

3.6.8.1.5 Corrosion Control

EDIM Modem mechanical components shall have protective coatings to protect against corrosion, or to enhance the corrosion resistance of base materials. Incompatible metals shall not be placed in direct contact, and materials that may emit products that are corrosive to adjacent materials shall not be used. If liquids or chemical solvents are used in the construction of EDIM Modem equipment to clean or otherwise condition parts or surfaces, such liquids shall be completely neutralized and removed, and the parts shall be clean and dry before application of finish or completion of assembly.

3.6.8.1.6 Prohibited Materials

The following materials shall not be used in the construction, operation, or maintenance of the EDIM Modem, unless explicitly approved by the Government:

- a. Asbestos: asbestos compounds and asbestos filled compounds
- b. Cadmium
- c. Carcinogens
- d. Chlorofluorocarbons (CFCs)
- e. Lithium and lithium compounds (except for COTS batteries)
- f. Magnesium and magnesium alloys
- g. Mercury and its compounds and amalgams
- h. Polychlorinated Biphenyls (PCBs)
- i. Polyvinyl Chloride (PVC)
- j. Zinc and zinc alloys, unless otherwise specified
- k. Beryllium Oxide
- l. Radioactive materials

3.6.8.1.7 Electrostatic Discharge (ESD)

The EDIM Modem shall not be damaged, and shall continue to operate without interruption of communications traffic or loss of any management function, when any item subject to human contact during normal operation and maintenance is subjected to an electrostatic discharge.

Parts, assemblies, and components sensitive to ESD shall be designed, packaged, installed, and processed to prevent inadvertent ESD damage during storage, assembly, test, maintenance, and handling. ESD sensitive parts, assemblies and equipment shall be marked IAW MIL-STD-130 section 5.9.

3.6.8.2 Safety

The EDIM Modem shall be designed so that it protects against the risk of electric shock and other hazards at all times (e.g., installation, deinstallation, transportation, operation, maintenance, and disposal), under all system functions described in Section 3.1.2, and under all likely fault conditions, including human error). All hazards shall be eliminated or reduced to the lowest risk level practicable using methods in the following order of precedence:

1. design

2. incorporation of safety devices
3. incorporation of warning devices
4. procedures
5. training

Catastrophic and critical hazards, as defined in DA PAM 385-16, shall not rely solely on warnings, cautions, procedures, or training for control of risk.

3.6.8.2.1 Electrical Safety

EDIM Modem electrical safety requirements include the following:

- a. Operators shall not be exposed to components with voltages exceeding 30 volts direct current (VDC) or 30 VAC root-mean-square (RMS). Operators shall not be exposed to stored energy shock at the disconnecting means IAW IEC 60950-1, Section 2.1.1.7.
- b. Protection shall be provided to personnel during maintenance and repair to prevent unintentional contact with voltages exceeding 30 VDC or 30 VAC RMS
- c. Capacitors shall be discharged to less than 30 VDC and 20 Joules of energy prior to maintainer access
- d. Voltage measurements required by maintainers shall not exceed 300 VDC or 300 VAC RMS
- e. Circuits and components exceeding 500 VDC or 500 VAC RMS shall be completely enclosed and interlocked. It shall not be possible to bypass interlocks for circuits exceeding 500 VDC or 500 VAC RMS. Interlocks shall comply with IEC 60950-1, Section 2.8
- f. Interface with power sources and disconnecting means shall be IAW NFPA 70 and IEC 60950-1, Section 3.4
- g. Equipment leakage current to ground shall not exceed 3.5 milliamperes (mA) when tested IAW IEC 60950-1, Sections 5.1.2 through 5.1.7. Redundant equipment grounding conductors shall be required where currents exceed 3.5 mA and shall require Government approval.
- h. Connector selection and design shall comply with or exceed the requirements of IEC 60950-1, Sections 3.2.1 and 4.3.5. Connectors shall include provisions for strain relief.

3.6.8.2.2 Mechanical Safety

EDIM Modem mechanical safety requirements include the following:

- a. The equipment shall provide maximum access and safety to personnel during installation, deinstallation, operation, and maintenance.
- b. The equipment shall comply with the applicable mechanical stability and mechanical hazard requirements of IEC 60950-1, Sections 4.1 through 4.2.11. Under the conditions of normal use and maintenance, the equipment shall not become physically unstable to the degree that it could become a hazard to operators or maintainers.

- c. Provisions shall be made to prevent accidental pulling out of modem drawers. Latches used to secure doors, drawers, or other items in an open or closed position shall be accessible without the need to remove obstacles, such as cabinet side panels.
- d. Operator accessible parts shall comply with the temperature limits shown in IEC 60950-1, Section 4.5.4, given an ambient room air operating temperature of 25°C (77°F).
- e. The equipment shall be able to be removed, handled, and lifted safely. Equipment lift limits, handles and labeling shall comply with MIL-STD-1472G, Sections 5.8.6.3.1 and 5.8.6.3.12.
- f. Equipment power switches and circuit breakers shall incorporate guards or similar means to prevent accidental actuation if such an actuation could pose a hazard to operators or maintainers or interrupt critical operations.
- g. The equipment shall be flush-mounted or recessed with no chassis or cabling protrusions that could be damaged or disrupted by movement of personnel within the facility, or that could pose a physical hazard to personnel.
- h. All hardware that is removable in the course of site installation and maintenance, excluding modem front panel rack mounting screws, shall be secured with captive-type fasteners

3.6.8.2.3 Laser Safety

Fiber Optic Interfaces utilizing lasers shall not exceed Class 1 or Class 1M laser Accessible Emission Limits, as defined in ANSI Z136.1, during the installation, use and maintenance of components. Proper warning labels shall be affixed to the equipment near the beam exit ports for all lasers exceeding Class 1 requirements, as per ANSI Z136.1.

All Optical Fiber Communications Systems shall comply with the appropriate safety and labeling requirements, as defined in ANSI Z136.2. Where power levels must exceed Class 1 levels during normal operation with all fiber optic cables connected, control measures, such as Automatic Power Reduction (APR), shall be used to reduce laser radiation levels to Class 1 limits during maintenance, when connectors are removed, during optically-aided viewing, or in the event of a fiber break. Control measure shall be reliable and fail safe.

3.6.8.2.4 Safety Markings and Labels

EDIM Modem safety markings and label requirements include the following:

- a. Safety markings and labels shall be provided to identify any potential hazards to personnel. Safety markings and labels shall comply with the requirements of ANSI Z535.4 and IEC 60950-1, Sections 1.7 through 1.7.14, including the subclauses listed in IEC 60950-1, Section 1.7, as applicable. All labels shall comply with the durability requirements of IEC 60950-1, Section 1.7.13, or UL 969.

- b. Safety markings and labels for voltages in excess of 30 volts (V) shall use the signal word "WARNING." Safety markings and labels for voltages in excess of 500 V shall use the signal word "DANGER."
- c. Markings shall be visible from operator and maintainer work locations. Markings shall not be removed when a barrier or access door is opened or removed.

3.6.8.2.5 Environmental and Chemical Safety

EDIM Modem environmental and safety requirements include the following:

- a. To the extent practicable, nonflammable material shall be used in the construction of the EDIM Modem.
- b. Hazardous materials that can be exposed to personnel or released into the environment during any operational procedure (to include fabrication, transportation, and setup/teardown), maintenance procedure, or damage to the equipment, or that require special disposal procedures, shall be kept to a minimum. Non-toxic and environmentally acceptable substitutes shall be used whenever practicable.
- c. Materials capable of producing dangerous toxic effects or causing an explosion shall not be used.
- d. Class I and Class II Ozone Depleting Substances (ODSs) shall not be used.
- e. Use of hazardous materials and disposal of hazardous waste shall be IAW current applicable Federal, State and local laws, regulations, standards and requirements.
- f. Hazardous material exposure to personnel shall be controlled to levels below the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs), as defined in 29CFR1910.1000, and the ACGIH® TLVs® and BEIs®.
- g. Modem internal wiring shall employ Low Smoke Zero Halogen (LSZH) insulation.
- h. Use of radioactive material shall be kept to an absolute minimum. Non-radioactive substitutes shall be used whenever possible. Where substitution is not possible, the least hazardous type and form of radioisotope shall be chosen.

3.6.8.2.6 General Safety Provisions

EDIM Modem general safety requirements include the following:

- a. All Modem software shall be designed to minimize the risk associated with any safety-critical functions.
- b. Colors of safety critical controls and indicators shall be yellow for caution and red for danger. Any color is permitted for functional controls or indicators, provided it is clear that safety is not involved.
- c. Audible/visual warning devices shall be provided to indicate any malfunctions that could cause severe injury or equipment damage. Audible warning signals shall be distinguishable from other sounds under normal

operating conditions. Visual warning signals shall be visible and recognizable from operator and maintainer work locations.

3.7 Provisions for Upgrade

Provisions for upgrade, described in the following subsections, include:

- Operator-friendly upgrade process
- Spare processing capacity
- Portability of software and firmware

3.7.1 Upgrade Process

The EDIM Modem shall support an upgrade process, not requiring hardware revision, which is

- a. Consolidated to launch the upgrade of the software, firmware, and operating system bundled, as necessary, into a single operation
- b. Integrated such that no intermediate versions or updates need to be installed as prerequisites
- c. Backward compatible with predecessor versions to allow interoperation
- d. Performed using upgrade files that are digitally signed to ensure their authenticity and integrity
- e. Capable of recovering from a failed upgrade and restoring the previous operational state
- f. Accomplished through local/remote M&C networks, with secure in-band upgrade file download available through the LM and DM interfaces referenced in Sections 3.1.1.2.2, 3.1.1.2.3, and 3.1.1.2.4
- g. Readily completed by a 25S MOS level technician in 30 minutes or less, not including file transfer

3.7.2 Future Capabilities

The capabilities described in the following subsections are envisioned for future EDIM Modem upgrades in order of importance. To that end,

- The EDIM Modem platform shall include spare operating capacity and resources sufficient to reasonably implement these features.
- The EDIM Modem System shall support corresponding capability upgrades.

3.7.2.1 EMMS Interface to a Future Site-Level NMS

As indicated in Section 3.3.3 and illustrated in FIGURE 13, a future site-level NMS is contemplated for automation-assisted management of equipment strings. EDIM Modem management through such a site level NMS will be realized through Northbound EMMS interfaces.

Management through such a Northbound EMMS interface will be accomplished through one or more of the following methods:

- one or more Application Programming Interfaces (APIs), accompanied by appropriate documentation
- industry-standard toolsets, such as NETCONF and YANG

Explicit management workflows between this future site-level NMS and EDIM Modem EMMS instances are currently under development. It is expected, however, that the site-level NMS will impose the following new computational burdens on the EDIM Modem EMMS:

- Northbound link status reporting
- Northbound reporting of resource availability
- support for automated signal chain orchestration (i.e., EMMS selection of available EDIM Modem resources to assign to new site-level NMS signal chain requirements)
- automated configuration (i.e., detailed EDIM Modem link configuration based on general signal chain configuration requirements received from the site-level NMS)

3.7.2.2 Spectrum Display

Upon operator request, the EDIM Modem M&C function may:

- display the aggregate L-Band Tx or Rx spectrum
- display the L-Band Tx or Rx spectrum associated with any given carrier
- display the Digital IF spectrum associated with any Digital IF stream on the Digital IF interface
- make all such spectra available for download, through the Graphic User Interface (GUI), in CSV file format

Spectrum resolution may meet or exceed the lesser of 100 Hz or 4000 points across the BW of interest.

3.7.2.3 Dynamic Resource Allocation (DRA)

The EDIM Modem may support DRA of satellite power, subject to data traffic demand and link conditions, selectable WRT each carrier. DRA provisions for each carrier may include the following components:

- a. The EDIM Modem may estimate Tx data traffic demand by analyzing relevant TCP and UDP traffic
- b. DRA may work cooperatively with the Power Control operator, IAW Section 3.3.5.1, as a proxy for satellite network control (e.g. PCMS), as follows:
 - i. When Tx data traffic demand begins to approach or exceed Tx channel capacity, the EDIM Modem may request, of the Power Control operator identified in Sections 3.3.4.1 and 3.4.6.1, a power increase for that carrier

- ii. When Tx data traffic demand begins to fall appreciably below capacity, Tx carrier power may be reduced accordingly, and the Power Control operator notified of the reduction
- c. ACM may be used to maintain links through dynamic power changes (DRA) and channel conditions (weather)
- d. DRA dynamics and thresholds may be optimized with respect to carrier efficiency necessary to support data traffic demand without loss of link

Notional DRA operation is illustrated in FIGURE 15.

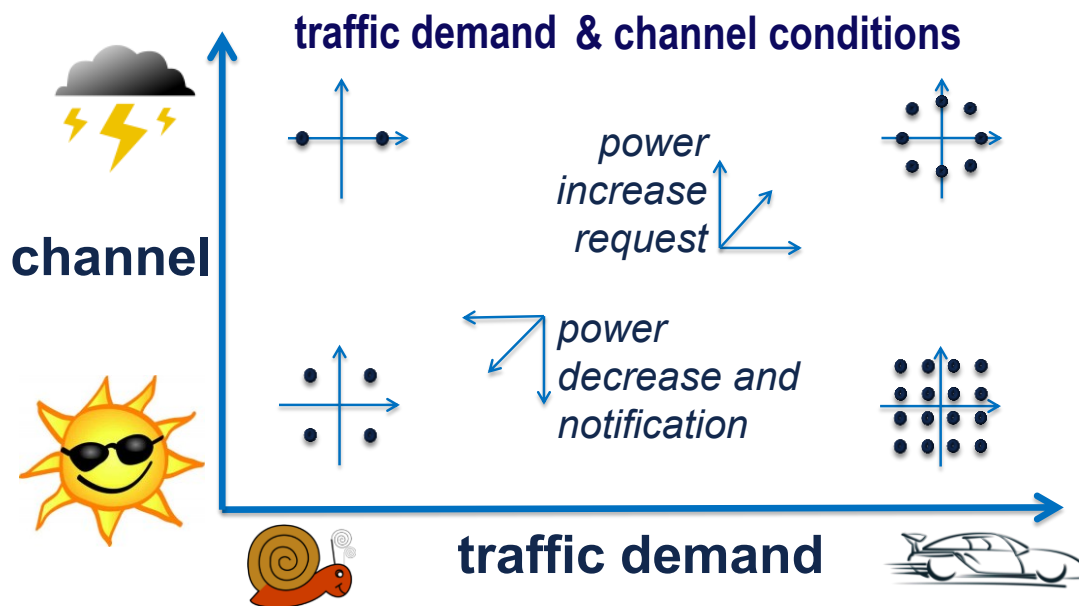


FIGURE 15 Notional DRA Operation

3.7.3 Software and Firmware Portability

The EDIM Modem shall be designed to support portability of software and firmware to future platform variants for deployment beyond Enterprise Gateway sites. Target architectures for software and firmware portability include tactical platforms and virtualization.

3.8 Precedence

In the event of a conflict between this specification and another contractual document, the following order of precedence shall apply:

1. Contract
2. Performance Work Statement (PWS)
3. Contract Data Requirements List (CDRL)
4. This document
5. Referenced documents
6. Second tier documents, with the revision corresponding to the issue in effect on the date of issuance of the higher tier document

The Contractor shall notify the Government of each instance of conflicting requirements.

4 QUALITY ASSURANCE PROVISIONS

The following sections describe quality assurance provisions.

4.1 Quality Program

The following sections describe mandatory aspects of the EDIM Modem quality program.

4.1.1 ISO 9001

The Contractor shall fabricate, inspect, and test EDIM Modem equipment IAW ISO 9001:2015 and the terms of the contract.

4.1.2 Responsibility

The Contractor is responsible for EDIM Modem equipment construction and performance in compliance with the requirements of this specification and the contract. This section shall be used to verify that the requirements meet the need and intent of the PWS. Contractor verification requirements include the following:

- a. The Contractor shall be responsible for developing detailed test plans and procedures, and for the performance of all inspections, analysis, tests, and demonstrations, as specified herein, for all FAT and PQT activities. Instrumentation, equipment, and facilities required for these activities shall also be the Contractor's responsibility.
- b. The Contractor shall obtain written approval from the Contracting Officer's Representative (COR) for testing facility utilization prior to the commencement of any tests at the system level.
- c. The Contractor shall notify the COR at least 30 days in advance to allow Government representatives to witness and verify applicable inspections and/or tests.
- d. The Government reserves the right to perform additional inspections, tests, and demonstrations beyond those contained in approved test procedures that are deemed necessary to assure that supplies and services conform to prescribed requirements.
- e. The Contractor shall provide the necessary test equipment and test stations for such Government inspections, tests, and demonstrations.
- f. Performance and environment measurements shall be made with calibrated instruments. Calibration requirements shall be consistent with approved test procedures. The Contractor shall ensure that all test equipment that can be calibrated, including Government Furnished Equipment (GFE) items, are duly calibrated before being used for formal EDIM Modem testing.
- g. The Contractor shall supply all additional hardware, cables, and bulk material necessary for in-plant testing of the EDIM Modem

4.1.3 Quality Assurance Activities

The EDIM Modem System shall be subjected to the following quality assurance activities.

4.1.3.1 First Article Test (FAT)

FAT consists of the examinations and tests that encompass functional, interface, interoperability, and performance tests throughout the entire range of operation. These tests will also prove-out the Contractor's production processes and facilities and serve to assure that corrective actions indicated by previous tests are adequate and timely.

4.1.3.1.1 FAT Overview

The Contractor shall plan and conduct a comprehensive FAT program that thoroughly evaluates all EDIM Modem requirements specified in Section 3, as outlined in the Verification Cross Reference Matrix (VCRM) in APPENDIX C. These evaluation activities shall be conducted at the Contractor's in-plant facilities and/or other Government-approved facilities. The Contractor shall devise evaluation regimes for all requirements, using the VCRM for guidance, including those for which specific direction is not identified herein. FAT shall not proceed until the Contractor-developed FAT Plan and comprehensive FAT Procedures have been approved by the Government. Any production begun before approval of the FAT Report shall be at the Contractor's risk, unless otherwise specifically authorized in the contract.

4.1.3.1.2 WGS Certification Support

Because WGS Certification is a program requirement, it is expected that some FAT testing and results will be applied to support Phase 1 WGS Modem Certification.

4.1.3.1.3 EDIM Modem Test Features

to the Contractor may employ EDIM Modem test features, provided they are first validated by Government-witnessed verification testing and analysis and subsequently approved by the Government for use in FAT. The validation of EDIM Modem Test Features shall include the comparison of measurements by the EDIM Modem and by external TMDE to demonstrate that the outcomes are equivalent.

4.1.3.1.4 Automated Testing

The Contractor may use automatic testing techniques, provided they are first validated by Government-witnessed verification testing and analysis and subsequently approved by the Government. The validation process shall include the performance of equivalent manual and automated tests to demonstrate that the outcomes are identical or equivalent, as appropriate.

4.1.3.1.5 Frequency and Time Integrity During FAT

Attention shall be paid to frequency and time integrity during FAT. This includes timestamp accuracy, M&C and otherwise, Digital IF timestamping considerations and carrier frequency accuracies. Any time or frequency error, omission, unintentional artifact, anomaly, or glitch shall be reported, and shall constitute, and be addressed as, a FAT failure subject to analysis and appropriate correction.

4.1.3.1.6 EDIM Modem Control During FAT

Unless otherwise specified for individual tests or necessitated by automation, M&C provisions specified in Section 3.3 and its subsections shall be used throughout the FAT process. Attention shall be paid to Section 3.3 (M&C function), Section 3.4 (Cybersecurity) and Section 3.5 (BIT) throughout all tests. Any M&C, Cybersecurity or BIT error, omission, unintentional artifact, anomaly, or glitch shall be reported, and shall constitute, and be addressed as, a FAT failure subject to analysis and appropriate correction.

4.1.3.1.7 Electromagnetic Interference to Other Systems

The EDIM Modem shall be monitored throughout FAT for potential electromagnetic interference with other systems in violation 3.6.5.2 (EMC). Suspicion of interference with other systems shall be reported, and shall constitute, and be addressed as, a FAT failure subject to analysis and appropriate correction.

4.1.3.1.8 Configuration Ranges

Tests shall be planned with Test Cases to exercise the EDIM Modem across wide cross-sections of all applicable configuration values. For example, L-Band test scenarios shall include test cases that exercise the EDIM Modem over adequately representative ranges of IF frequency and power level. Modem performance testing in general shall comprehensively exercise:

- adequately comprehensive ranges of low, medium, and high data and symbol rates
- all applicable mod-cods, each employing all relevant Turbo block sizes IAW TABLE III

Test scenarios shall include Test Cases whose configurations will be selected by the Government at the time of the test, without prior knowledge of the Contractor.

4.1.3.1.9 Computational Loading

In every practical condition, testing shall be performed while the EDIM Modem is loaded near capacity to its maximum computational load. This shall include:

- multiple carriers being modulated and demodulated simultaneously, at or near the carrier count indicated in Section 3.2.5.1.2, whose total data traffic rates and symbol rates are near the EDIM Modem thresholds indicated in Sections 3.2.5.1.3 and 3.2.5.1.4
- multiple operators accessing EDIM Modem M&C, beginning with multiple automated Monitor-Only role queries

Bit errors, loss of carrier synchronization and M&C anomalies or interruptions WRT carriers or M&C traffic introduced for computational loading purposes shall constitute, and be addressed as, FAT failures subject to analysis and appropriate correction.

4.1.3.2 Production Qualification Test (PQT)

After acceptance of the FAT Report, the Contractor shall conduct PQT on the items produced for delivery to validate the quality of each item, and to validate its conformance to the fabrication, integration, and functional operation requirements of this specification.

4.1.3.2.1 PQT Overview

The Contractor shall plan and conduct a comprehensive PQT program that thoroughly evaluates hardware/firmware/software functionality to verify adequate manufacturing of each production unit. Each delivered unit shall be accompanied by a complete copy of its respective PQT report. Electronic copies shall be made available to the Government upon request.

PQT shall include those verification activities indicated in APPENDIX C. PQT shall not proceed until the Contractor-developed PQT Plan and PQT Procedures have been approved by the Government. PQT shall not be deemed accepted until all test cases are successfully completed by the Contractor.

4.1.3.2.2 Early Life Defect Prevention

PQT shall include provisions to prevent, or otherwise minimize, early life defects. The effectiveness of these provisions shall be continuously monitored by the Contractor WRT the number of defects found during the first six months of item use (i.e., early life). Based on the results of early life defect monitoring, provisions to detect and prevent early life defects may be altered, subject to Government approval. Early life failures shall require that provisions to prevent early life defects be strengthened.

4.2 Expanded Verification Cross Reference Matrix (EVC RM)

EDIM Modem requirements specified in Section 3 shall be verified IAW the VCRM in APPENDIX C (TABLE VII), which identifies FAT and PQT requirements for inspection, analysis, demonstration, or testing corresponding to EDIM Modem requirements. The Contractor shall further prepare an EVC RM, as part of the FAT Plan, based on the APPENDIX C VCRM. The EVC RM shall ensure complete FAT and PQT verification of the following:

- All EDIM Modem requirements specified in Section 3
- All EDIM Modem requirements which flow down from Section 3 requirements through external references
- All EDIM Modem requirements which flow down from documents referenced at all levels from other referenced documents
- All additional features and capabilities introduced by the Contractor

The EVC RM shall be subject to Government review and approval. The body of the specification takes precedence in the event of a conflict with the VCRM.

Verification methods identified in the VCRM, and to be used in the EVC RM, are defined in the following subsections.

4.2.1 Inspection (I)

Inspection is a method of verification of the physical characteristics by examination of the equipment and associated documentation. Inspections are conducted with the use of inspection tools, measurement devices, visual means, and comparison. Most inspections apply to verification of requirements associated with physical characteristics, such as size, weight, and appearance; adherence to specified standards and engineering practices; and construction supported with quality documentation.

4.2.2 Analysis (A)

Analysis is a method of verification through technical evaluation of calculations, computations, models, and analytical solutions; use of studies; reduced data; and/or representative data to determine that the item conforms to the specified requirements of Section 3.

4.2.3 Demonstration (D)

Demonstration is a method of verification whereby the properties, characteristics, and parameters of the item are determined by observation alone, and without the use of instrumentation for quantitative measurements. This is used when a Section 3 requirement does not contain a specific numerical parameter that must be measured. Pass/fail criteria are simple accept/reject indications of functional performance since no quantitative values are specified.

4.2.4 Test (T)

Test is a method to verify that a specified requirement is met by thorough exercising the applicable item under specified conditions and using appropriate instrumentation IAW test procedures. This method is used when it is possible to make direct or indirect measurement of a specific numerical parameter to verify compliance with a Section 3 requirement. Actual measured values are recorded, and pass/fail is determined by comparing the measured value with the specified value.

4.2.5 No Requirement (N)

This method indicates that verification is not required because of one of the following reasons:

- the section is not applicable to this specification
- the section is a title, heading, or general introduction that has specific requirements specified in subsections
- the section contains no requirements
- the requirement is associated with GFE, and the requirement is verified by Government conducted tests on the equipment

4.3 Requirements Verification

The following requirements verification subsections (4.3.X.Y.Z) describe verification required against corresponding function and performance requirements subsections (3.X.Y.Z).

4.3.1 Item Definition

The EDIM Modem shall be inspected to verify that it consists of a single integrated platform, as specified in Section 3.1.

4.3.1.1 External Interfaces

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4.3.1.1.1 Front Panel Interfaces

The presence of the power switch specified in Section 3.1.1.1.1, and the visual power indicator specified in Section 3.1.1.1.2, shall be verified by inspection. The function of these interfaces shall be verified by demonstration. Section 3.1.1.1.1 power-up time shall be verified by test (i.e., timed).

4.3.1.1.2 Rear Panel Interfaces

The presence of all interfaces specified in Sections 3.1.1.2.1 through 3.1.1.2.8 shall be verified by inspection. The function of all interfaces specified in Sections 3.1.1.2.1 through 3.1.1.2.7 shall be verified by demonstration. Connector spacing, as described in Section 3.1.1.2.2.e, shall be verified by measurement.

In the case of Sections 3.1.1.2.3 and 3.1.1.2.4, Ethernet physical media reconfigurability shall be verified by demonstrating Ethernet port reconfiguration, as well as specification compliant operation before and after each Ethernet port reconfiguration.

In the case of Section 3.1.1.2.2, L-Band IF VSWR, Tx and Rx shall be determined by measuring the reflection coefficient “S11” WRT 50 ohms on each L-Band port, with the EDIM Modem active, using a vector network analyzer (VNA) equipped with an S-Parameter Test Set. Measurements shall be taken with the EDIM Modem operating as an LM IAW Section 3.1.2.1. All measurements shall be across the entire functional band, even if the functional band exceeds the minimum BW indicated in Section 3.2.3. The Contractor shall deliver both Smith charts and VSWR plots.

4.3.1.1.3 Contractor Discretionary Interfaces

The requirements of Section 3.1.1.3 shall be verified by inspection and demonstration.

4.3.1.2 Signal Processing Functions

The requirements of Sections 3.1.2, 3.1.2.1 and 3.1.2.2 shall be verified by demonstration in the course of verifying the various subsections of Section 3.2.5.

4.3.1.3 NATO STANAG 4486 Ed4 (EBEM) Interoperability

The requirements of Section 3.1.3 shall be verified by test, as follows:

- measure BER vs E_{Sym}/N_0 on back-to-back EBEMs for baseline results
- measure BER vs E_{Sym}/N_0 on EDIM Modem Tx to EBEM Rx to verify EDIM Modem modulator interoperability through non-degradation
- measure BER vs E_{Sym}/N_0 on EBEM Tx to EDIM Modem Rx to verify EDIM Modem demodulator interoperability through non-degradation

This set of tests and comparisons shall be repeated over a minimum of 150 modem configurations that include:

- the lowest and highest data traffic rate supported by each Turbo block size for each of the 11 mod-cods indicated in Section 3.2.5.2.1.4
- the lowest and highest data traffic rate supported by each Turbo block size for uncoded operation at each modulation format as indicated in Section 3.2.5.2.1.4
- high, medium and low carrier frequencies
- high, medium and low data traffic and symbol rates
- high, medium and low power levels
- a minimum of 60 additional configurations to be selected by formal Government witnesses at the time of the test

This sequence of tests shall be conducted for both

- direct EBEM interoperation through the EDIM Modem L-Band interface
- indirect EBEM interoperation through a suitable edge device in series with the EDIM Modem Digital IF interface

4.3.2 Function and Performance

The requirements of Section 3.2 shall be verified by demonstration. The third-party licensing requirement shall be verified by analysis.

4.3.2.1 Time and Frequency Base

The requirements of Sections 3.2.1.1 and 3.2.1.2 shall be verified directly by demonstration, as well as indirectly by analysis of the results of Section 4.1.3.1.5.

4.3.2.2 Data Traffic Rate Estimation

The requirements of Section 3.2.2 shall be verified by measuring deterministic rates of traffic generated using an IP traffic emulator or a packet error rate test set (PERTS). Testing will be conducted over a wide range of conditions, as generally indicated in Section 4.1.3.1.8.

4.3.2.3 L-Band IF Interface

The requirements of Section 3.2.3 shall serve to guide test conditions used to verify the requirements of Sections 3.2.5.3 through 3.2.5.5 and their subsections. The requirements of Section 3.2.3 shall then be verified by analysis of the EDIM

Modem design and the results of testing against the requirements of Sections 3.2.5.3 through 3.2.5.5 and their subsections.

4.3.2.3.1 L-Band IF Non-Damaging Input Power

The requirements of Section 3.2.3.1 shall be verified by test. The EDIM Modem shall sustain +25 dBm of input power on its L-Band Rx port for at least 60 minutes each at the low, medium, and high portions of the L-Band port BW.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Section 5.22]

4.3.2.3.2 L-Band IF Isolation

The requirements of Section 3.2.3.2 shall be verified by test. L-Band Tx to Rx cross-talk levels may be inferred from measured demodulator performance impact.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Section 5.16]

4.3.2.4 Digital IF Interface

The requirements of Section 3.2.4 shall serve to guide test conditions used to test the requirements of Sections 3.2.5.6 through 3.2.5.8 and their subsections. The requirements of Section 3.2.4 shall then be verified by analysis of the EDIM Modem design and the results of testing against the requirements of Sections 3.2.5.6 through 3.2.5.8 and their subsections.

4.3.2.4.1 Digital IF Capacity

Digital IF performance testing against the requirements of Sections 3.2.5.6 through 3.2.5.8 and their subsections shall be performed, to the maximum extent practical, while EDIM Modem emulates modems and supports links to the maximum EDIM Modem carrier capacity IAW Section 3.2.4.1 and otherwise. For the duration of FAT, any error, unintended function, artifact, anomaly, or glitch WRT any such background operation shall be reported, and shall constitute, and be addressed as, a FAT failure subject to analysis and appropriate correction.

4.3.2.4.2 IP Addressability

The requirements of Section 3.2.4.2 shall be verified by test.

4.3.2.4.3 Digital IF Protocol

Compliance with required protocols shall be verified by third party certification. To the extent that third party certification is not available, compliance with required protocols shall be verified by test.

4.3.2.4.4 Digital IF Network Connectivity

The requirements of Section 3.2.4.4 shall be verified by demonstration and utilized throughout the verification of Sections 3.2.5.6 through 3.2.5.8 and their subsections. For the duration of FAT, any failure or anomaly WRT the operations specified in Section 3.2.4.4 shall be reported, and shall constitute, and be addressed as, a FAT failure subject to analysis and appropriate correction.

4.3.2.4.5 Digital IF Networking Performance

The Digital IF networking requirements of Sections 3.2.4.5.1 through 3.2.4.5.3 shall be verified by test using IP network emulators and analyzers.

4.3.2.5 Modem Function and Performance

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4.3.2.5.1 General

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4.3.2.5.1.1 Ethernet Bridge

The requirements of Section 3.2.5.1.1 shall be verified by test. Compliance with these requirements shall be verified throughout the FAT program.

4.3.2.5.1.2 Carrier Count and Independence

The requirements of Section 3.2.5.1.2 shall be verified by demonstration. Testing against all subsections of Section 3.2.5 shall be performed, to the maximum extent practical, while EDIM Modems emulations support links to the maximum EDIM Modem carrier capacity IAW Section 3.2.5.1.2 and otherwise. For the duration of FAT, any error, unintended function, artifact, anomaly, or glitch WRT any such background operation shall be reported, and shall constitute, and be addressed as, a FAT failure subject to analysis and appropriate correction.

4.3.2.5.1.3 Data Traffic Rates

The requirements of Section 3.2.5.1.3 shall be verified by test.

4.3.2.5.1.4 Symbol Rates

The requirements of Section 3.2.5.1.4 shall be verified by test.

4.3.2.5.1.5 FIPS Cert and General Crypto Provisions

The requirements of Section 3.2.5.1.5 shall be verified by documentation of relevant certification (analysis), by demonstration of SMAT loading, and by subsequent demonstration of modem operation under cryptographic cover (i.e., data traffic header obfuscation).

4.3.2.5.1.6 Interference Mitigation

The requirements of Section 3.2.5.1.6 shall be verified by analysis of the results of the following subsections.

4.3.2.5.1.6.1 Interference Mitigation Operation

The requirements of Section 3.2.5.1.6.1 shall be verified by demonstration. Tests may be required to verify seamless engagement and disengagement of Interference Mitigation WRT associated signal processing delay.

4.3.2.5.1.6.2 Interference Mitigation Performance

The requirements of Section 3.2.5.1.6.2 shall be verified by test. The large multidimensional set of specified operating conditions constitute an enormous set of potential test conditions. As such, the following measures may be employed to manage required test volume:

- coarse sampling of specified operating ranges; for example,
 - I/S from -10 to +13 dB could be sampled
 - in 5 places as -7.6, -3.1, 1.5, 6.1 and 10.7 dB
 - or in 4 places as -7.125, -1.375, 4.375 and 10.125 dB
 - spectral overlap from 0% to 100% could be sampled
 - in 5 places as 10%, 30%, 50%, 70% and 90%
 - or in 4 places as 12.5%, 37.5%, 62.5% and 87.5%
- invocation of “worst case” conditions, provided they are spot-tested; for example,
 - if it can be shown that Interference Mitigation is more difficult at higher COI rates than at lower COI rates, then
 - spot-test multiple COI rates to confirm the premise to the Government test team
 - test at all high rates, taking credit for performance at lower rates without actually testing them
 - if it can be shown that Interference Mitigation is more difficult at higher COI mod-cods, then
 - spot-test at various mod-cods to prove the premise to the Government test team
 - test at the more difficult mod-cod that passes, taking credit for lower mod-cods without having to actually test them
- “giving up” upon failure
 - if the Contractor reaches a threshold where the rest of the test conditions will fail, then the rest of the test conditions can be failed by forfeit, saving test time
- other such strategies may be employed, subject to review and approval of the Government test team

Strategic employment of these measures suggests that substantial comprehensive verification of Section 3.2.5.1.6.2 may be accomplished within fewer than 100 test conditions.

To the extent that individual test condition results may constitute sensitive information WRT potential interference threats, it may be necessary to:

- run individual test conditions in a classified environment
- classify the results of individual test condition

4.3.2.5.2 Modem Waveforms

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4.3.2.5.2.1 NATO STANAG 4486 Ed4 (EBEM) Baseline

Interoperability across the full range of EDIM Modem data and symbol rates shall be verified by analyzing the configuration and results of verification relevant to the following subsections.

4.3.2.5.2.1.1 Payload

The requirements of Section 3.2.5.2.1.1 shall be verified by demonstration.

4.3.2.5.2.1.2 Features

The requirements of Section 3.2.5.2.1.2 shall be verified by demonstrating interoperation of the EDIM Modem with the MD-1366 in terms of the following:

- selectable data traffic rate
- selectable symbol rate
- selectable scrambling
- ACM IAW EBEM ITA
- DEM in both directions
- all BERT patterns

Relevant interoperation of the EDIM Modem with the MD-1366 shall include:

- direct EBEM interoperation through the EDIM Modem L-Band interface
- indirect EBEM interoperation through a suitable edge device in series with the EDIM Modem Digital IF interface

4.3.2.5.2.1.3 Bulk Encryption for Cover

The requirements of Section 3.2.5.2.1.3 shall be verified by demonstrating interoperation of the EDIM Modem with the MD-1366 in terms of bulk encryption and associated SMAT keying.

4.3.2.5.2.1.4 Waveform

The requirements of Section 3.2.5.2.1.4 shall be verified by demonstrating the following:

- operator control schemes for the mod-cods indicated
- operator accessibility of uncoded mod-cods for test purposes
- interoperation with MD-1366 WRT
 - indicated operational mod-cods
 - uncoded operation for test purposes

Relevant interoperation of the EDIM Modem with the MD-1366 shall include:

- direct EBEM interoperation through the EDIM Modem L-Band interface
- indirect EBEM interoperation through a suitable edge device in series with the EDIM Modem Digital IF interface

4.3.2.5.2.2 Support for Higher Rates

The requirements of Section 3.2.5.2.2 shall be verified through the verification of at least one of its subsections.

4.3.2.5.2.2.1 EBEM Extended Rate Operation

The requirements of section 3.2.5.2.2.1 shall be verified by:

- testing the EDIM Modem in a back-to-back configuration at the higher specified rates
- verifying conformance with NATO STANAG 4486 through analysis

4.3.2.5.2.2.2 DVB-S2X Hub Waveform Operation

The requirements of Section 3.2.5.2.2.2 and its subsections shall be verified, to the maximum extent possible, through interoperability with legacy DVB-S2X modems presently in DOD SATCOM service. Section 4.3.1.3 shall be used as a guideline to ensure adequate verification scope. Additional verification considerations are indicated in the following subsections. Any peer review employed (e.g., third party verification) shall be subject to advance Government approval.

4.3.2.5.2.2.2.1 Waveform

The mod-cod support and operator control detail indicated in Section 3.2.5.2.2.2.1 shall be verified by demonstration.

4.3.2.5.2.2.2.2 Data Traffic Encapsulation

The data traffic encapsulation methods indicated in Section 3.2.5.2.2.2.2, shall be verified, as follows:

- wherever possible, by demonstrating interoperability with relevant legacy DVB-S2X modems in DOD SATCOM service
- in all cases, by using analysis and tests to verify the implementation against documented data traffic encapsulation methods

4.3.2.5.2.2.2.3 Bulk Encryption for Cover

The bulk data traffic encryption requirements of Section 3.2.5.2.2.2.3 shall be verified by:

- analyzing bulk data traffic encryption methods for adequacy
- verifying the implementation against documented encryption methods

4.3.2.5.2.2.2.4 DVB-S2X Feature Support

The DVB-S2X feature support requirements in Section 3.2.5.2.2.2.4, shall be verified, as follows:

- wherever possible, by demonstrating interoperability with relevant legacy DVB-S2X modems in DOD SATCOM service

- in all cases, by using analysis and test to verify the implementation against documented messaging protocols

4.3.2.5.3 LM Operation

The requirements of Sections 3.2.5.3.1 through 3.2.5.3.3 shall be verified by demonstration. Each loopback specified in Section 3.2.5.3.3 shall be verified in multiple EDIM Modem configurations. Non-degradation relevant to loopback operation, as specified in Section 3.2.5.3.3, shall be verified by BER measurement, subject to calibrated AWGN insertion.

- a. Bidirectional BERT Loopback:
 - i. Applicable to individual carriers
 - ii. BERT output traffic looped back to BERT input
 - iii. Demodulated traffic stream looped back to modulator input without processing
 - iv. Intended for testing, diagnostics and troubleshooting with serial BERT traffic enabled in both directions
- b. Internal Modulation Loopback:
 - i. Applicable to individual carriers
 - ii. Modulated carrier looped back to demodulator input while continuing through the L-Band IF interface
 - iii. Demodulator input from L-Band IF interface interrupted
- c. Internal L-Band IF Loopback:
 - i. Applicable to all carriers at once over the entire L-Band IF interface
 - ii. L-Band IF output looped back to L-Band IF input while continuing to output through the L-Band IF interface:
 - iii. L-Band IF input interrupted
 - iv. Providing assistance to the operator in reassigning carrier configurations for the duration of the loopback

Individual carrier loopbacks shall not cause interruption or degradation to any other individual carrier or channel. Individual loopbacks shall not cause interruption or degradation to carriers on paths described as unaffected. For example, the performance of a carrier undergoing LM Internal Modulation Loopback shall be unaffected at the distant end modem.

4.3.2.5.4 LM Uplink Performance

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4.3.2.5.4.1 LM Uplink Carrier Frequency

The LM uplink carrier frequency setability requirement of Section 3.2.5.4.1 shall be verified by demonstration.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Section 5.27]

4.3.2.5.4.2 LM Uplink Frequency Stability

The LM uplink carrier frequency stability requirement of Section 3.2.5.4.2 shall be verified over 10-day test intervals using unmodulated carriers and frequent precision frequency measurement.

This verification process shall be repeated at each of 3 carrier frequencies chosen at the time of this test during FAT by the assigned Government test witness. These 3 carrier frequencies will be representative of the low, middle, and high regions of the L-Band range as implemented.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Section 5.26]

4.3.2.5.4.3 LM Uplink Frequency Accuracy

The LM uplink carrier frequency accuracy requirement of Section 3.2.5.4.3 shall be verified over 10-day test intervals using unmodulated carriers and frequent precision frequency measurement.

This verification process shall be repeated at each of 3 carrier frequencies chosen at the time of this test during FAT by the assigned Government test witness. These 3 carrier frequencies will be representative of the low, middle, and high regions of the L-Band range as implemented.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Section 5.27]

4.3.2.5.4.4 LM Uplink Phase Noise

The requirements of Section 3.2.5.4.4 shall be verified, as follows.

- The EDIM Modem shall be configured to transmit a CW signal at 0 dBm
- Phase noise PSD shall be measured over the range of 10 Hz to 1 GHz
- Measured phase noise PSD shall be plotted against the phase noise PSD threshold indicated in FIGURE 7
- These phase noise PSD measurements and the integrated phase noise N_{Φ} integral indicated in Section 3.2.5.4.4

$$N_{\Phi} = 2 \int_{0.0005 R_S}^{0.5 R_S} S_{\phi}(f) df$$

shall be used to estimate $N_{\Phi \max}$, the maximum integrated phase noise WRT all symbol rates R_{Sym} from 512 ksym/s to 200 Msym/s

- It shall be verified that this $N_{\Phi \max}$ estimate does not exceed -40.6 dBc (0.535 degrees RMS)

This verification process shall be repeated at each of 3 carrier frequencies chosen at the time of this test during FAT by the assigned Government test witness. These 3 carrier frequencies will be representative of the low, middle, and high regions of the L-Band range as implemented.

Inconsistencies between phase noise profiles at tested frequencies shall necessitate phase noise testing at additional frequencies at the discretion of the assigned Government test witness.

$N_{\Phi \max}$ estimates shall be tabulated for all carrier frequencies at which phase noise is measured.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Section 5.10]

If single-sided phase noise PSD $S_{\phi}(f)$ exceeds $S_{\phi \max}(f)$ indicated in FIGURE 7 for any frequency offset f from the carrier, it shall then be required that integrated phase noise N_{Φ} , defined using

$$N_{\Phi} = 2 \int_{0.0005 R_{\text{Sym}}}^{0.5 R_{\text{Sym}}} S_{\phi}(f) df$$

not exceed -40.6 dBc (0.535 degrees RMS) for symbol rates R_{Sym} from 128 ksym/s to 200 Msym/s. The -40.6 dBc threshold is based on modem support of:

- max QEF E_{Sym}/N_0 of 21.2 dB degrading by ≤ 0.05 dB due to phase noise
- max QEF E_{Sym}/N_0 of 24.2 dB degrading by ≤ 0.1 dB due to phase noise
- maximum 1/f limit proposed for Draft MIL-STD-188-164C-C1 section 4.2.11 “Phase noise”

4.3.2.5.4.5 LM Uplink Carrier Power

The LM uplink carrier power accuracy and stability requirements of Section 3.2.5.4.5 shall be tested as follows:

- Verifying power control in cases of both single-carrier and multiple-carrier operation
 - using a precision power meter to measure carrier power in single-carrier operation
 - using a spectrum analyzer to measure carrier power in multiple-carrier operation
 - verifying “other-carrier integrity” in the multiple-carrier case, where adjacent channels are restricted in power and frequency separation IAW Section 3.2.5.5.8 and FIGURE 10
- Testing power control range
 - over a variety of EBEM waveforms and rates
 - over the entire power control range in each case
 - verifying power control range, step size, absolute accuracy, relative accuracy, and same-carrier integrity
- Testing LM uplink carrier stability (long-term accuracy of ± 1.0 dB)
 - for one EBEM waveform and rate (per carrier frequency below) selected at the time of FAT by the assigned Government test witness
 - over a 10-day interval

These verification processes shall be repeated at each of 3 carrier frequencies chosen at the time of this test during FAT by the assigned Government test witness. These 3 carrier frequencies will be representative of the low, middle, and high regions of the L-Band range as implemented.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Section 5.25, items a.-d., and Section 5.25]

4.3.2.5.4.6 LM Uplink Power Off Performance

The LM uplink “power off” requirements of Section 3.2.5.4.6 shall be verified using a spectrum analyzer and over a frequency range of DC to 4 GHz.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, section 5.24 item e.]

4.3.2.5.4.7 LM Uplink Spectral Confinement

This section addresses verification and data reporting WRT the LM uplink spectral confinement requirements indicated in Section 3.2.5.4.7.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Sections 5.11 through 5.13]

4.3.2.5.4.7.1 Single Carrier Spectra

EDIM Modem output spectra shall be measured over the following waveforms:

- At the minimum and maximum data traffic rate for each Turbo block size relevant to each modulation format indicated in Section 3.2.5.2.1.4
- At data traffic rate intervals NTE 50 Mbps
- Over $\pm 3 R_{\text{Sym}}$, unless otherwise prevented by L-Band IF range
- At maximum carrier power

This verification sequence shall be repeated at each of 4 carrier frequencies chosen at the time of this test during FAT by the assigned Government test witness. These 4 carrier frequencies will include representation of the low, middle, and high regions of the L-Band range as implemented. EBEM waveform “encryption” and “scrambling” shall be operated as follows:

- both enabled for one center selected center frequency
- encryption enabled and scrambling disabled for a second center frequency
- encryption disabled and scrambling enabled for a third center frequency
- both disabled for a fourth center frequency

4.3.2.5.4.7.2 Multiple Carrier Spectra

The single carrier measurements shall be supplemented with ample measurements in the multiple carrier case to ensure spectral confinement compliance and consistency.

4.3.2.5.4.7.3 Spectrum Data Reporting

All measured spectra will be plotted with the inner and outer spectrum masks indicated in FIGURE 8 overlaid. If spectral mask compliance is not clear, then spectra will be re-plotted with appropriate resolution to clarify.

For each combination of mod-cod and Turbo block size, relevant spectrum measurements shall be normalized WRT symbol rate, plotted together and averaged. The Contractor shall produce an interpolated “50 point spectrum occupancy” table from each average, consisting of normalized carrier frequency offsets from 0 to $2000/49^2$ (0 to $\sim 0.8330 R_{\text{Sym}}$) in steps of $40/49^2$ ($\sim 0.0167 R_{\text{Sym}}$) and their corresponding relative PSD (51 points per set). This data shall be used in each case to determine the normalized 25 dB BW ($\sim 1.2 R_{\text{Sym}}$) and the nominal spectrum variability.

4.3.2.5.4.8 LM Uplink Noise Floor

The LM uplink noise floor requirement of Section 3.2.5.4.8 shall be verified by test. Results of Section 4.3.2.5.4.7 and its subsections will be allowed if they can be used to verify the LM uplink noise floor.

4.3.2.5.4.9 LM Uplink Spurious Emissions

The spurious emissions requirements of Section 3.2.5.4.9 shall be verified by measuring spurious emissions on a spectrum analyzer under the following conditions.

- no carriers
- one carrier at 0 dBm
- two carriers at -3 dBm each (total power 0 dBm)
- five carriers at -7 dBm each (total power 0 dBm)

Carriers shall all be modulated at the lowest configurable symbol rate. Spurious emissions shall be measured from band-edge to band-edge, omitting verification within $\pm 1 R_{\text{Sym}}$ of each carrier center frequency.

This test shall be repeated for all modulation formats, BPSK through 16-APSK, and again with stated carriers in the low, middle, and high portions of the IF range.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Section 5.18]

4.3.2.5.4.10 LM Uplink Harmonics

The harmonic emissions requirement of Section 3.2.5.4.8 shall be verified by spectrum analyzer measurements while transmitting an unmodulated carrier. Spectrum measurements shall be taken over at least 1 MHz ranges centered around each integer multiple of the unmodulated carrier up to 4 GHz.

This verification sequence shall be repeated at each of 3 carrier frequencies chosen at the time of this test during FAT by the assigned Government test witness. These 3 carrier frequencies will be representative of the low, middle, and high regions of the L-Band range as implemented.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Section 5.19]

4.3.2.5.4.11 LM Uplink Error Vector Magnitude (EVM)

The EVM requirements of Section 3.2.5.4.11 shall be verified by VNA measurement over a range of power levels (e.g., every 10 dB) at each Turbo block size for each mod-cod. EVM shall be measured under single carrier conditions, as well as under multiple carrier conditions.

This verification sequence shall be repeated at each of 3 carrier frequencies chosen at the time of this test during FAT by the assigned Government test witness. These 3 carrier frequencies will be representative of the low, middle, and high regions of the L-Band range as implemented.

4.3.2.5.5 LM Downlink Performance

The downlink performance requirements of Section 3.2.5.5 shall be verified by strategic selection of test conditions within the following subsections, and by analysis of the subsequent results.

4.3.2.5.5.1 LM Downlink Carrier Frequency

The LM input carrier frequency control requirement specified in Section 3.2.5.5.1 shall be verified by demonstration.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Section 5.28]

4.3.2.5.5.2 LM Downlink Frequency Uncertainty

The LM receive carrier frequency uncertainty requirement of Section 3.2.5.5.2 shall be verified, for each Turbo block size of every mod-cod indicated in TABLE III, by analysis of the results of Section 4.3.2.5.5.4 testing.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Section 5.29]

4.3.2.5.5.3 LM Downlink Min Rx Power

The BER performance specified in Section 3.2.5.5.7 shall be verified at the minimum power levels specified in Section 3.2.5.5.3

- for each Turbo block size of each mod-cod indicated in Section 3.2.5.2.1.4
- at the highest and lowest data traffic rates of each mod-cod indicated in Section 3.2.5.2.1.4

4.3.2.5.5.4 LM Downlink Acquisition and Reacquisition

The requirements of Section 3.2.5.5.4 shall be verified by testing required acquisition and reacquisition performance of every mod-cod indicated in Section 3.2.5.2.1.4 at each Turbo block size. Verification over all mod-cods and Turbo block sizes will be conducted at specific data traffic rates, power levels and center frequencies chosen by the assigned Government test witness at the time of the test.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Section 5.20, items a. and b.]

4.3.2.5.5.5 LM Downlink Synchronization Retention

The requirements of Section 3.2.5.5.5 shall be verified by testing required synchronization retention performance of every mod-cod indicated in Section 3.2.5.2.1.4 at each Turbo block size. Verification over all mod-cods and Turbo block sizes will be conducted at specific data traffic rates, power levels and center frequencies chosen by the assigned Government test witness at the time of the test.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Section 5.20, item c.]

4.3.2.5.5.6 LM Downlink Doppler Environment

The requirements of Section 3.2.5.5.6 shall be verified by conducting a statistically representative portion of the following tests under specified Doppler impairment:

- LM Downlink Acquisition and Reacquisition IAW Section 4.3.2.5.5.4
- LM Downlink Synchronization Retention IAW Section 4.3.2.5.5.5
- LM Back-to-Back BER IAW Section 4.3.2.5.5.7

4.3.2.5.5.7 LM Back-to-Back BER

This section addresses verification and data reporting WRT the LM BER performance requirements indicated in Section 3.2.5.5.7.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Sections 5.5 and 5.6]

4.3.2.5.5.7.1 Baseline BER Performance

EDIM Modem BER Performance shall be measured over the following waveforms:

- At the minimum and maximum data traffic rate for each Turbo block size relevant to each modulation format indicated in Section 3.2.5.2.1.4
- At data traffic rate intervals NTE 50 Mbps

This verification sequence shall be repeated for each mod-cod at each of 4 carrier frequencies chosen at the time of this test during FAT by the assigned Government test witness. These 4 carrier frequencies per mod-cod will be representative of the low, middle, and high regions of the L-Band range as implemented. EBEM waveform “encryption” and “scrambling” shall be operated as follows:

- both enabled for one center selected center frequency
- encryption enabled and scrambling disabled for a second center frequency
- encryption disabled and scrambling enabled for a third center frequency
- both disabled for the fourth center frequency

Power levels for BER testing shall be chosen at the time of the test by the assigned Government test witness.

4.3.2.5.5.7.2 BER Performance Consistency

A minimum of 60 configurations, selected at the time of this test during FAT by the assigned Government test witness, shall be tested to ensure consistency of BER performance over all configurations.

4.3.2.5.5.7.3 Multiple Carrier BER Performance

The majority of BER performance testing shall be conducted under multiple carrier operating conditions to ensure BER performance under multiple carrier operation. Automated test provisions should ensure that adjacent channel separation is maintained to a minimum IAW Section 3.2.5.5.8 and FIGURE 10.

4.3.2.5.5.7.4 Data Range and Reporting

Each BER performance test range shall:

- begin at acquisition
- continue to $\text{BER} \geq 10^{-7}$ for data traffic rates < 10 Mbps
- continue to $\text{BER} \geq 10^{-9}$ for data traffic rates ≥ 10 Mbps
- each BER performance data point shall accumulate at least
 - 300 errors for data traffic rates < 10 Mbps
 - 1000 errors for data traffic rates ≥ 10 Mbps

All measured BER performance data shall be tabulated and the E_{Sym}/N_0 required to achieve $\text{BER}=10^{-6}$ shall be interpolated.

All measured BER performance curves shall be plotted with threshold performance and theoretical performance limits overlaid. It will be acceptable, for this purpose, to use the Shannon-Hartley theorem to infer each theoretical performance limit curve as

$$\text{BER}_{\min} = \frac{1}{2} \left(1 - \frac{\log_2 \left(1 + \frac{E_{\text{Sym}}}{N_0} \right)}{\frac{R_D}{R_{\text{Sym}}}} \right)$$

For each combination of mod-cod and Turbo block size, relevant BER performance shall be overlaid and plotted with performance threshold and theoretical performance limit also overlaid.

4.3.2.5.5.8 LM Downlink Adjacent Channel Interference (ACI)

The requirements of Section 3.2.5.5.8 shall be verified by testing BER performance on the COI in the interfering environment, as illustrated in FIGURE 10, as follows:

- each interfering carrier symbol rate = twice the COI symbol rate
- at four mod-cods, one modulation format each, chosen at the time of this test during FAT by the assigned Government test witness

- each at data traffic rates and center frequencies chosen at the time of this test during FAT by the assigned Government test witness
- each at power levels from minimum COI power to maximum total power at increments NTE 5 dB
- each with EDIM Modem processing multiple carriers

[FDMA Modem Performance Requirements v1.2, 17 April 2015, section 5.30]

4.3.2.5.5.9 LM Downlink Power Disparity

The requirements of Section 3.2.5.5.9 shall be verified by testing BER performance on the COI in the presence of high levels of in-band interferences as follows:

- at four mod-cods, one modulation format each, chosen at the time of this test during FAT by the assigned Government test witness
- each at data traffic rates and center frequencies chosen at the time of this test during FAT by the assigned Government test witness
- at least six interfering carriers shall be introduced, both higher and lower in frequency, such that COI carrier PSD = $-100 \text{ dB}_{\text{P}_{\text{TOT}}/\text{Hz}}$ where “ P_{TOT} ” refers to total power, carrier plus interferer
- this test shall be repeated at power levels from minimum COI power to maximum total power at increments NTE 5 dB
- with EDIM Modem processing multiple carriers during this test

Each power disparity test shall be repeated under two sets of interfering conditions, a symmetrical interference environment and an intermodulation sensitive interference environment. These are each described in the following subsections.

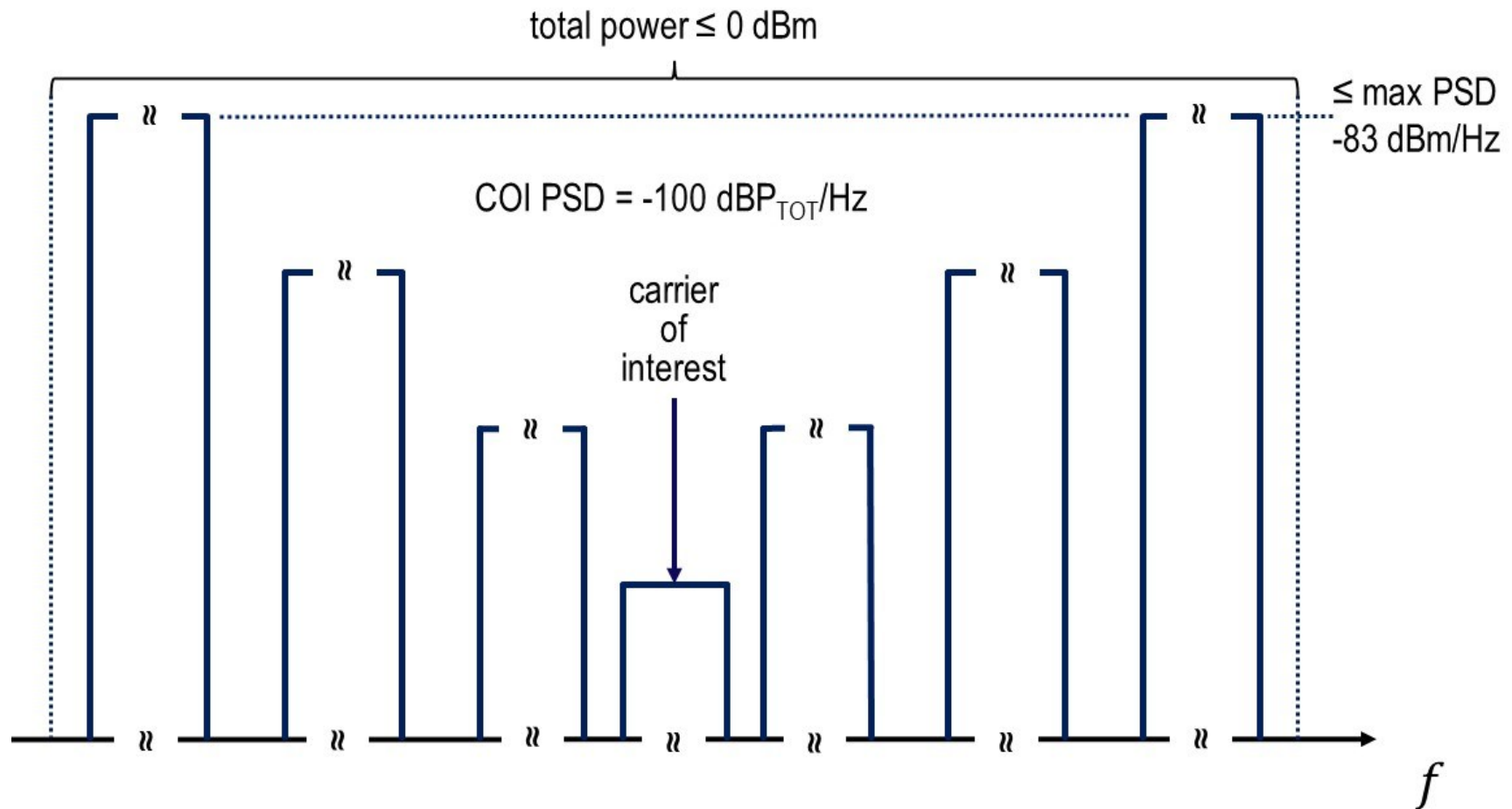
[FDMA Modem Performance Requirements v1.2, 17 April 2015, section 5.21]

4.3.2.5.5.9.1 Symmetrical Interference Environment

The first set of interfering conditions, the symmetrical interference environment, consists of symmetrically placed interferers whose spacing is generally compliant with the ACI limits indicated in Section 3.2.5.5.9 and FIGURE 10. The purpose of this configuration is to generally test demodulation performance of low-level carriers in the presence of higher-level carriers. An example of symmetrical interference environment is illustrated in FIGURE 16.

4.3.2.5.5.9.2 Intermod Sensitive Environment

The second set of interfering conditions, the intermodulation sensitive interference environment, consists of interferers spaced such that their intermods fall on the COI. Relative carrier spacing is still generally compliant with the ACI limits indicated in Section 3.2.5.5.9 and FIGURE 10. The purpose of this configuration is to generally test demodulation performance of low-level carriers in the presence of potential downlink intermodulation components. An example of intermodulation sensitive interference environment is illustrated in FIGURE 17.

**FIGURE 16 Example Symmetrical Interference Environment**

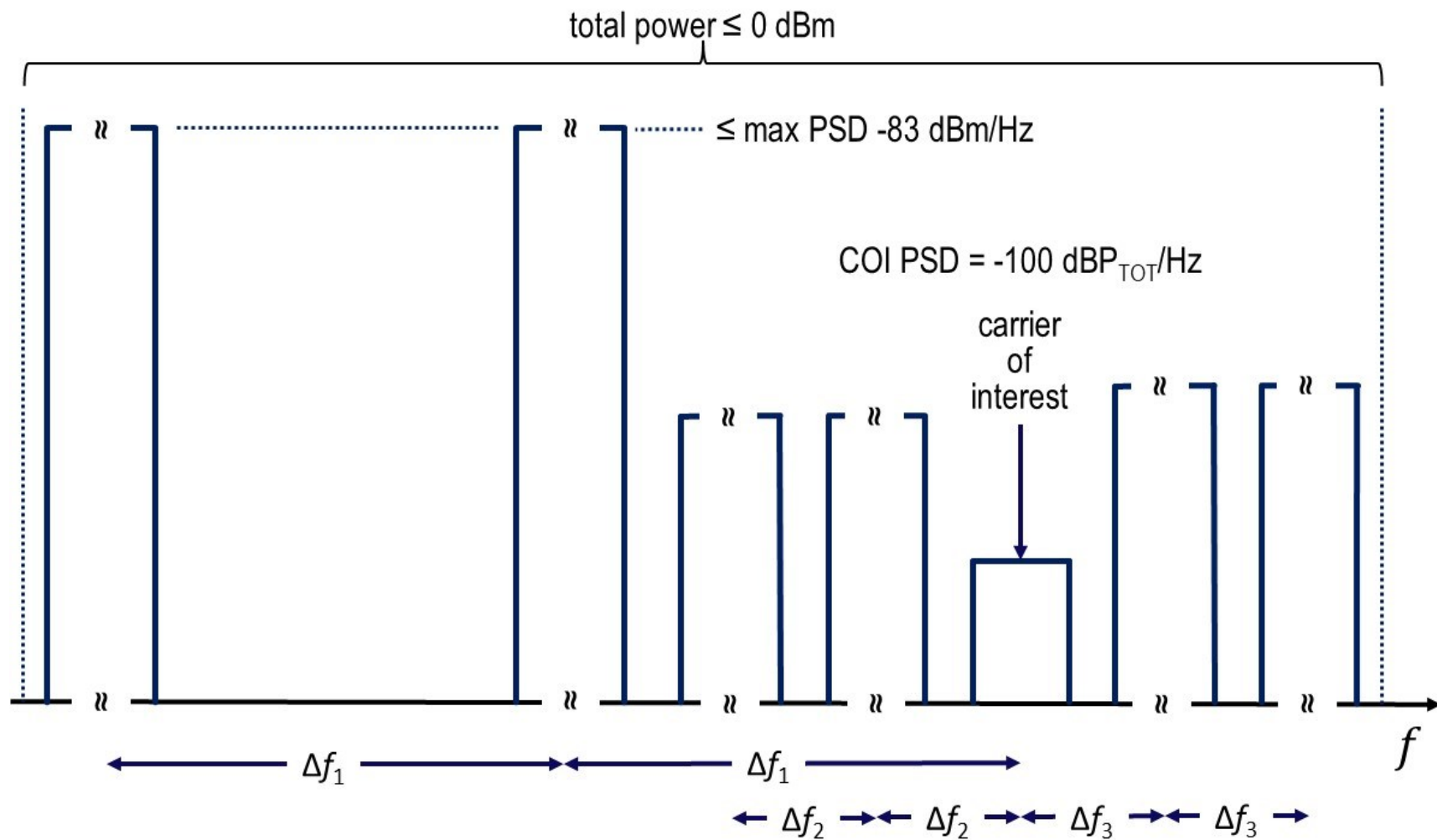


FIGURE 17 Example Intermod Sensitive Interference Environment

4.3.2.5.5.10 LM Downlink Input Power Changes

The requirements of Section 3.2.5.5.10 shall be verified by conducting a statistically representative portion of LM Back-to-Back BER testing IAW Section 4.3.2.5.5.7, subject to the input power change impairment indicated in FIGURE 11.

4.3.2.5.6 DM Operation

The requirements of Sections 3.2.5.6.1 through 3.2.5.6.3 shall be verified by demonstration. Each loopback specified in Section 3.2.5.6.3 shall be verified in multiple EDIM Modem configurations. Non-degradation relevant to loopback operation, as specified in Section 3.2.5.6.3, shall be verified by BER measurement, subject to calibrated AWGN insertion.

4.3.2.5.7 DM Uplink Performance

NR

4.3.2.5.7.1 DM Uplink Carrier Frequency

The DM uplink carrier frequency setability requirement of Section 3.2.5.7.1 shall be verified by demonstration.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, section 5.27]

4.3.2.5.7.2 DM Uplink Carrier Power

The DM uplink carrier power configuration and accuracy requirements of Section 3.2.5.7.2 shall be tested as follows:

- Verifying power control WRT power level as represented in the Digital IF signal stream
- Testing power control range
 - over a variety of EBEM waveforms and rates
 - over the entire power control range in each case
 - verifying power control range, step size, accuracy and same-carrier integrity

Same-carrier integrity testing shall include demodulation by:

- EDIM Modem through its L-Band Rx port
- suitable edge device followed by EDIM Modem through its Digital IF port
- MD-1366 EBEM

[FDMA Modem Performance Requirements v1.2, 17 April 2015, section 5.25 items a.-d. and 5.25]

4.3.2.5.7.3 DM Uplink Digitization Noise PSD

The DM uplink noise floor requirement of Section 3.2.5.7.3 shall be verified by test. Results of Section 3.2.5.7.4 will be allowed if they can be used to verify the DM uplink noise floor. Digitization noise PSD shall be verified at all allowable sample depths, and at sample rates that significantly exceed carrier BW ($\geq 6 R_{\text{Sym}}$).

4.3.2.5.7.4 DM Uplink Spectral Confinement

This section addresses verification and data reporting WRT the DM uplink spectral confinement requirements indicated in Section 3.2.5.4.7.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, sections 5.11 through 5.13]

4.3.2.5.7.4.1 Carrier Measurement Sets

EDIM Modem output spectra shall be measured over the following waveforms:

- At the minimum and maximum data traffic rate for each Turbo block size relevant to each modulation format indicated in Section 3.2.5.2.1.4
- At data traffic rate intervals NTE 50 Mbps
- Over $\pm 3 R_{\text{Sym}}$, unless otherwise prevented by L-Band IF range

This verification sequence shall be repeated with EBEM waveform “encryption” and “scrambling” operated as follows:

- both enabled
- encryption enabled and scrambling disabled
- encryption disabled and scrambling enabled
- both disabled

4.3.2.5.7.4.2 Spectrum Data Reporting

All measured spectra will be plotted with the inner and outer spectrum masks indicated in FIGURE 8 overlaid. If spectral mask compliance is not clear, then spectra will be re-plotted with appropriate resolution to clarify.

For each combination of mod-cod and Turbo block size, relevant spectrum measurements shall be normalized WRT symbol rate, plotted together and averaged. The Contractor shall produce an interpolated “50 point spectrum occupancy” table from each average, consisting of normalized carrier frequency offsets from 0 to $2000/49^2$ (0 to $\sim 0.8330 R_{\text{Sym}}$) in steps of $40/49^2$ ($\sim 0.0167 R_{\text{Sym}}$) and their corresponding relative PSD (51 points per set). This data shall be used in each case to determine the normalized 25 dB BW ($\sim 1.2 R_{\text{Sym}}$) and the nominal spectrum variability.

4.3.2.5.7.5 DM Uplink EVM

The EVM requirement of Section 3.2.5.7.5 shall be verified by capture and off-line analysis of the output Digital IF stream. Verification shall include each Turbo block size for each mod-cod.

4.3.2.5.8 DM Downlink Performance

NR

4.3.2.5.8.1 DM Downlink Carrier Frequency

The DM input carrier frequency control requirement specified in Section 3.2.5.8.1 shall be verified by demonstration.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, section 5.28]

4.3.2.5.8.2 DM Downlink Frequency Uncertainty

The DM receive carrier frequency uncertainty requirement of Section 3.2.5.8.2 shall be verified, for each Turbo block size of every mod-cod indicated in TABLE III, by analysis of the results of Section 4.3.2.5.8.3 testing.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, section 5.29]

4.3.2.5.8.3 DM Downlink Acquisition and Reacquisition

The requirements of Section 3.2.5.8.3 shall be verified by testing required acquisition and reacquisition performance of every mod-cod indicated in Section 3.2.5.2.1.4 at each Turbo block size. Verification over all mod-cods and Turbo block sizes will be conducted at specific data traffic rates, power levels and center frequencies chosen by the assigned Government test witness at the time of the test.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, section 5.20 items a. and b.]

4.3.2.5.8.4 DM Downlink Synchronization Retention

The requirements of Section 3.2.5.8.4 shall be verified by testing required synchronization retention performance of every mod-cod indicated in Section 3.2.5.2.1.4 at each Turbo block size. Verification over all mod-cods and Turbo block sizes will be conducted at specific data traffic rates, power levels and center frequencies chosen by the assigned Government test witness at the time of the test.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, section 5.20 item c.]

4.3.2.5.8.5 DM Downlink Doppler Environment

The requirements of Section 3.2.5.8.5 shall be verified by conducting a statistically representative portion of the following tests under specified Doppler impairment.

- DM Downlink Acquisition and Reacquisition IAW Section 4.3.2.5.5.4
- DM Downlink Synchronization Retention IAW Section 4.3.2.5.8.4
- DM Back-to-Back BER IAW Section 4.3.2.5.8.6

4.3.2.5.8.6 DM Back-to-Back BER

This section addresses verification and data reporting WRT the LM BER performance requirements indicated in Section 3.2.5.8.6.

[FDMA Modem Performance Requirements v1.2, 17 April 2015, sections 5.5 & 5.6]

4.3.2.5.8.6.1 Baseline BER Performance

EDIM Modem BER Performance shall be measured over the following waveforms:

- At the minimum and maximum data traffic rate for each Turbo block size relevant to each modulation format indicated in Section 3.2.5.2.1.4
- At data traffic rate intervals NTE 50 Mbps

This verification sequence shall be repeated for each mod-cod at each of 4 carrier frequencies chosen at the time of this test during FAT by the assigned Government test witness. These 4 carrier frequencies per mod-cod will be representative of the low, middle, and high regions of the L-Band range as implemented. EBEM waveform “encryption” and “scrambling” shall be operated as follows:

- both enabled for one center selected center frequency
- encryption enabled and scrambling disabled for a second center frequency
- encryption disabled and scrambling enabled for a third center frequency
- both disabled

Power levels for BER testing shall be chosen at the time of the test by the assigned Government test witness.

4.3.2.5.8.6.2 BER Performance Consistency

A minimum of 60 configurations, selected at the time of this test during FAT by the assigned Government test witness, shall be tested to ensure consistency of BER performance over all configurations.

4.3.2.5.8.6.3 Data Range and Reporting

Each BER performance test ranges shall:

- begin at acquisition
- continue to $\text{BER} \geq 10^{-7}$ for data traffic rates < 10 Mbps
- continue to $\text{BER} \geq 10^{-9}$ for data traffic rates ≥ 10 Mbps
- each BER performance data point shall accumulate at least
 - 300 errors for data traffic rates < 10 Mbps
 - 1000 errors for data traffic rates ≥ 10 Mbps

All measured BER performance data shall be tabulated and the E_{Sym}/N_0 required to achieve $\text{BER}=10^{-6}$ shall be interpolated.

All measured BER performance curves shall be plotted with threshold performance and theoretical performance limits overlaid. It will be acceptable, for this purpose, to use the Shannon-Hartley theorem to infer each theoretical performance limit curve as

$$\text{BER}_{\min} = \frac{1}{2} \left(1 - \frac{\log_2 \left(1 + \frac{E_{\text{Sym}}}{N_0} \right)}{\frac{R_D}{R_{\text{Sym}}}} \right)$$

For each combination of mod-cod and Turbo block size, relevant BER performance shall be overlaid and plotted with performance threshold and theoretical performance limit also overlaid.

4.3.2.5.8.7 DM Downlink ACI

The requirements of Section 3.2.5.8.7 shall be verified by testing BER performance on the COI in the interfering environment, as illustrated in FIGURE 10, as follows:

- each interfering carrier symbol rate = twice the COI symbol rate
- at four mod-cods, one modulation format each, chosen at the time of this test during FAT by the assigned Government test witness
- each at data traffic rates and center frequencies chosen at the time of this test during FAT by the assigned Government test witness
- each with EDIM Modem processing multiple carriers

[FDMA Modem Performance Requirements v1.2, 17 April 2015, Section 5.30]

4.3.2.5.9 Modem Test Features

NR

4.3.2.5.9.1 Carrier Frequency Measurement

The requirements of Section 3.2.5.9.1 shall be verified by test, as follows:

- through both IF interfaces, L-Band and Digital IF
- at all modulation formats
- over a wide range of data rates, power levels and carrier frequencies

4.3.2.5.9.2 Carrier Power Measurement

The requirements of Section 3.2.5.9.2 shall be verified, by test, as follows:

- through both IF interfaces, L-Band and Digital IF
- at all modulation formats
- over a wide range of data rates, power levels and carrier frequencies
- by comparing EDIM Modem power measurement to:
 - actual incident power at L-Band
 - incident power, at Digital IF, as represented by relevant DIFI Stream components
- with verification at Digital IF limited to cases where the bit depth supports the required measurement accuracy

4.3.2.5.9.3 Signal to Noise Ratio (SNR) Measurement

The requirements of Section 3.2.5.9.3 shall be verified by test, as follows:

- through both IF interfaces, L-Band and Digital IF
- at all modulation formats
- over a wide range of data rates, power levels and carrier frequencies
- by comparing measured C/N and E_b/N_0 to known incident C/N and E_b/N_0

4.3.2.5.9.4 Internal Bit Error Rate Test (BERT)

The requirements of Section 3.2.5.9.4 shall be verified by test, as follows:

- WRT each BERT pattern
- WRT all measurement features
- through EBEM interoperation
- over all EBEM mod-cods and Turbo block sizes indicated in TABLE III

4.3.3 Management and Control (M&C)

The requirements of Section 3.3 shall be verified by analysis and demonstration, both explicitly and as a component of FAT.

4.3.3.1 M&C Objectives

NR

4.3.3.2 EDIM Modem System M&C Architecture

NR

4.3.3.2.1 EDIM Modem Management Components

The requirements of Section 3.3.2.1 shall be verified, by test, WRT the integrity and self-consistency of shared resources, such as databases, being maintained across all users and actions, including EMMS failover and restoral operations.

4.3.3.2.1.1 EDIM Modem Management System / Software (EMMS)

The requirements of Section 3.3.2.1.1 shall be verified by analysis, demonstration, and test, as follows:

- a. Use an appropriate combination of test, demonstration, and analysis to verify that the EMMS can be configured as the central point of secure machine control for up to 256 locally networked EDIM Modems
- b. Test that the EMMS is software operable on both SHB platforms and virtual machines
- c. Demonstrate that the EDIM Modem system can support 1 to 4 EMMS instances
- d. Demonstrate the EDIM Modem M&C can support minimal operation that consists of a single EMMS instance and a single OI collocated on the same hardware platform
- e. Demonstrate and test that the EMMS can support at least 16 concurrent OI connections and 256 concurrent EDIM Modem connections
- f. Demonstrate and test that EMMS can concurrently support at least 16 active secure sessions between OIs and EDIM Modems

- g. Test that EMMS instances are simultaneously operable on separate hardware platforms
- h. Demonstrate that, upon failure of any EMMS instance, the surviving EMMS instance(s) will continue supporting M&C with minimal interruption
- i. Demonstrate that new EMMS instances, operating on new host platforms, can be introduced into a given site's existing EDIM Modem system
- j. Demonstrate that the EMMS can automatically detect the presence of a new EDIM Modem on the M&C network and enable subsequent operations with this new EDIM Modem
- k. Demonstrate that the EMMS can automatically detect the presence of a new EMMS instance on the M&C network and enable subsequent operations with the new EMMS instance
- l. Demonstrate that the EMMS can automatically detect the presence of a new OI on the M&C network and enable subsequent OI operations
- m. Test that EMMS software installation can be completed in less than 60 minutes.

4.3.3.2.1.2 Operator Interface (OI)

The requirements of Section 3.3.2.1.2 shall be verified by analysis, demonstration, and test, as follows:

- a. Test and demonstrate that the OI provides efficient and effective access to all M&C functions IAW all M&C and Cybersecurity requirement specified in this document
- b. Test that the OI is software operable on both SHB platforms and virtual machines
- c. Test, demonstrate and analyze that the OI is able to securely access up to at least 256 modems through the EMMS instance(s) on the local network to perform M&C functions
- d. Test that the OI is capable of displaying on a high-definition display(s) with a resolution of 1920x1080 or higher
- e. Test that the OI is capable of providing configuration, SMAT maintenance, software and firmware updates, security, audit, alarm log collection and dissemination, and data file transfer
- f. Test that the EMMS can store all active EDIM Modem configurations and at least 100 additional backup configurations for each EDIM Modem, and that the OI can access and edit each EDIM Modem configuration stored on the EMMS
- g. Demonstrate the OI can signal the presence of alarms on any EDIM Modem, and that the signal has a clear visual warning, a clear audible warning and identifies the source of the alarm
- h. Test that an OI session will time out after an inactivity interval and will require an operator to log in to resume EDIM Modem System Management
- i. Demonstrate that the inactivity interval is configurable by an Administrator
- j. Demonstrate that semi-autonomous functions can timeout due to operator inactivity

- k. Demonstrate that semi-autonomous functions will continue performing their task after a timeout occurs
- l. Demonstrate that, upon a timeout for a semi-autonomous function, an Operator is able to login again to regain management over the function
- m. Test that the OI software installation can be completed in less than 10 minutes

4.3.3.2.2 EDIM Modem

The requirements of Section 3.3.2.2 shall be verified by demonstration, as follows:

- a. Demonstrate that the EDIM Modem M&C can be accessed through the Rear Panel Ethernet M&C Ports
- b. Demonstrate that the EDIM Modem System will allow concurrent configuration of different links on common EDIM Modems by different OI sessions

4.3.3.3 Site-Level Network Management System (NMS)

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4.3.3.4 General Operation

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4.3.3.4.1 M&C Roles

The requirements of Section 3.3.4.1 shall be verified by demonstration, as follows:

- a. Demonstrate that each operator account can only be associated with one of the roles listed in Section 3.3.4.1
- b. Demonstrate that the precedence of each role is set in the order listed in Section 3.3.4.1
- c. Demonstrate role assignment by the Administrator role
- d. Demonstrate that each role can manage and control only the role privileges allowed IAW TABLE VI

4.3.3.4.2 M&C Protocols

The requirements of Section 3.3.4.2 shall be verified by analysis and inspection, as follows:

- a. Verify, by analysis, the use of non-proprietary industry standard protocols for all M&C interfaces, such as those listed in TABLE IV
- b. Verify, by analysis, that any additional protocols used, but not listed in TABLE IV, are non-proprietary and industry standard
- c. Verify, by inspection, that any proprietary protocols have been approved by the Government
- d. Verify, by inspection, that all M&C protocols implement the latest issue as of the time of contract award

4.3.3.4.3 Data Traffic Integrity

Data traffic integrity (non-interruption of traffic) shall be verified, by demonstration, under all actions and conditions identified in Section 3.3.4.3.

4.3.3.4.4 Contention Resolution

The contention resolution requirements of Section 3.3.4.4 shall be verified by demonstration, to include the following:

- a. Configuration control authority request
- b. Configuration control authority request acceptance
- c. Configuration control authority request denial
- d. Inability to override configuration control authority request denial by a lower privileged operator
- e. Configuration control authority request denial override by a higher privileged operator
- f. Notification of original control authority operator upon override, by a higher privileged operator, of a configuration control authority request denial
- g. Power Control operator exemption from such requests
- h. Notification of the configuration control authority operator of applicable Power Control operator configuration action
- i. Immediate return of configuration control authority to the operator interrupted by the Power Control operator

4.3.3.4.5 Configuration Integrity

Demonstrate that before committing a configuration change on a dataset, the EDIM Modem System

- a. detects issues within the EDIM Modem System that will result from impending changes and affect other configuration datasets,
- b. alerts the controlling operator of the issues, and
- c. enables the controlling operator to reconcile any issues before committing to the configuration change.

4.3.3.4.6 M&C Response Time

The requirements of Section 3.3.4.6 shall be verified by demonstration and test, as follows:

- a. Test that the response time from the invocation of every M&C command to command execution does not exceed 0.25 seconds
- b. Demonstrate that parameters are refreshed periodically.

4.3.3.4.7 Factory Default State

The requirements of Section 3.3.4.7 shall be verified by demonstration and test, as follows:

- a. Demonstrate and test that the EDIM Modem factory default state is in the following conditions:
 - i. factory default account credentials
 - ii. data traffic and all links disabled
 - iii. zeroized cryptographic state
 - iv. absence of any stored configurations
 - v. no potentially sensitive files that are unnecessary for operation
 - vi. all other settings to their intended factory default state
- b. Demonstrate that the EDIM Modem is delivered in a factory default state
- c. Demonstrate that the EDIM Modem has a factory reset capability to restore itself to a factory default state
- d. Demonstrate that the EDIM Modem System has a factory reset capability that can restore any EDIM Modem to its factory default state
- e. Demonstrate that the EDIM Modem, while in its factory default state, can have its rear panel M&C interface IP settings configured so that it can communicate with the EMMS

4.3.3.4.8 Shutdown and Restart

The requirements of Section 3.3.4.8 shall be verified by demonstration, as follows:

- a. Demonstrate that each EDIM Modem System component will shut down in an orderly manner and will save the active state during an operator-initiated shutdown
- b. Demonstrate that each EDIM Modem System component will preserve its modem configuration after an unscheduled shutdown
- c. Demonstrate that, upon return to normal operating conditions after an unscheduled shutdown, each EDIM Modem System component will return to its last active configuration, with the exception of the EDIM Modem deactivating all uplink carriers

4.3.3.5 Management Provisions

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4.3.3.5.1 Power Control

The requirements of Section 3.3.5.1 shall be verified by demonstration and test, as follows:

- a. Demonstrate operation and control for Power Control operators and the restriction of only one Power Control operator login per configuration dataset (i.e., per modem link) at any given time
- b. Test that Power Control operators can activate and deactivate carriers and adjust carrier power levels regardless of general configuration and control authority
- c. Test that Power Control operators will time out after an inactivity interval

4.3.3.5.2 File Transfer

The requirements of Section 3.3.5.2 shall be verified by demonstration, as follows:

- a. Demonstrate that the OI provides a file transfer capability in support of all relevant EDIM Modem System functions
- b. Demonstrate that all EDIM Modem System file transfers are accomplished using secure and non-proprietary industry-standard protocols
- c. Demonstrate that the EDIM Modem is configured with sufficient file storage capacity, as indicated in TABLE V

4.3.3.5.3 Authentication

The requirements of Section 3.3.5.3 shall be verified by demonstration, as follows:

- a. Demonstrate the EDIM Modem System capability to interface with multiple external authentication servers for centralized management and AAA services
- b. Demonstrate that the EDIM Modem System can support communication with authentication servers that use the following AAA protocols:
 - i. RADIUS IAW IETF RFC 2865
 - ii. TACACS+ IAW "The TACACS+ Protocol"
 - iii. LDAP IAW RFC IETF 4511
 - iv. Active Directory IAW MS-ADTS
- c. Demonstrate that operator authentication takes place at the OI
- d. Demonstrate that the EDIM Modem local operator authentication database can support a minimum of 256 operators

4.3.3.5.4 Multiple Modem Configuration Management

The requirements of Section 3.3.5.4 shall be verified by demonstration, as follows:

- a. Demonstrate that the OI enables selection of a single modem, a group of modems, or all modems, up to at least 256, for configuration management purposes, as indicated in Section 3.3.5.4.
- b. Demonstrate that selected modems can be jointly managed WRT
 - i. Software, firmware, and cybersecurity updates
 - ii. Cryptographic "zeroize" function IAW Section 3.2.5.1.5
 - iii. Factory reset functions IAW Section 3.3.4.7
 - iv. Other management functions

4.3.3.5.5 Situational Awareness

The requirements of Section 3.3.5.5 shall be verified by demonstration and analysis, as follows:

- a. Demonstrate that the OI provides continuous situational awareness status of modems, to include
 - i. a single screen summary status for all modems
 - ii. comprehensive status pages for each modem

- b. Verify, by demonstration and/or analysis, that a minimum of 256 modems can be jointly monitored
- c. Demonstrate that the situational awareness function can signal the presence of alarms on any EDIM Modem, and that the signal has a clear visual warning, a clear audible warning and identifies the source of the alarm
- d. Demonstrate that select modems and parameters can be continuously monitored

4.3.3.5.6 Modem Suite Reporting

The requirements of Section 3.3.5.6 shall be verified by demonstration, as follows:

- a. Demonstrate that the EDIM Modem provides security, audit, and alarm log reports comparable to SYSLOG
- b. Demonstrate that the EDIM Modem reports include parameters and metrics selectable by the operator, as defined in Section 3.3.5.6
- c. Demonstrate that the EDIM Modem versioning report identifies the hardware and software information, including version numbers
- d. Demonstrate that the EDIM Modem network report identifies all network information relating to a given modem
- e. Demonstrate that the EDIM Modem reports includes all active and historical alarms and faults
- f. Demonstrate that the EDIM Modem Cryptographic report identifies expiring keying material
- g. Demonstrate that the EDIM Modem can export generated reports and logs to a common file format, as defined in Section 3.3.5.6

4.3.4 Cybersecurity

The requirements of Section 3.4 shall be verified by analysis, testing and demonstration, as follows:

- a. Verify through analysis that applicable EDIM Modem System components are on the UC APL or appropriately justified if not on the UC APL
- b. Verify that the EDIM Modem, and all relevant EDIM Modem System components, have been certified by NIST at Security Level 2, as described in FIPS PUB 140-3, and employ FIPS approved cryptography
- c. Verify through analysis, testing, and demonstration that all EDIM Modem System software and applications have been hardened IAW appropriate STIGs, SRGs, BBPs, and patches.

4.3.4.1 System Identification Profile

The requirements of Section 3.4.1 shall be verified by evaluating Security Controls, as determined and implemented for the EDIM Modem System IAW the RMF process, for categorized CIA Impact levels of C=MODERATE, I=MODERATE, and A=MODERATE, or as approved for the Mission Essential System IAW Section 3.4.1 a-f.

4.3.4.2 Identification and Authentication

The requirements of Section 3.4.2 shall be verified by demonstration and test, as follows:

- a. Demonstrate operator account and password authentication and subsequent role-based access control for all roles
- b. Demonstrate operator and machine authentication and role-based access control before allowing operator actions
- c. Demonstrate the ability of Administrator to enable/disable two-factor authentication, and the execution of two-factor authentication and subsequent role-based access control for operators, including each role
- d. Demonstrate the granting of operator access to EDIM Modem system through password authentication
- e. Demonstrate and test the expiring and replacing of passwords and other supported authentication mechanisms, as appropriate
- f. Demonstrate and test the disabling or locking of accounts after inactivity for a default of 35 days, or as configured by Administrator
- g. Demonstrate and test
 - i. operator timeout, after a configurable time period, for no keyboard or mouse activity
 - ii. Monitor-only role function during this timeout condition
 - iii. the requirement to login to reestablish all original role permissions

4.3.4.3 Confidentiality

The requirements of Section 3.4.3 shall be verified by demonstration, as follows:

- a. Demonstrate the access protections and usage of secure protocols for data exchange
- b. Demonstrate how all protocols used for management are secure
- c. Demonstrate how the EDIM Modem System prevents sensitive data from unauthorized disclosure during transmission or while stored

4.3.4.4 Integrity

The requirements of Section 3.4.4 shall be verified by demonstration, as follows:

- a. Demonstrate how the EDIM Modem System provides assurance that information is protected from unauthorized modification or destruction.
- b. Demonstrate how the EDIM Modem System ensures that system initialization, shutdown, and abort actions do not compromise the secure state of either the respective component in particular, or the EDIM Modem System in general.
- c. Demonstrate how the EDIM Modem System automatically monitors components and applications and detects when unauthorized changes are attempted.
- d. Demonstrate how the EDIM Modem System and its components transmit and receive control and management information in a manner protected from modification, deletion, insertion, and replay errors, and how the EDIM

Modem System provides replay protection for, and preserves the integrity of, management and control plane information.

- e. Demonstrate how the EDIM Modem System provides the ability to successfully recover all security functions after hostile attempts against the security of the system and ensures recovery to a secure state without compromise.
- f. Demonstrate how the EDIM Modem System enforces digitally signed software/firmware during upgrades to ensure its integrity and authenticity.

4.3.4.5 Availability

The requirements of Section 3.4.5 shall be verified by demonstration, as follows:

- a. Demonstrate the ability to successfully complete security function activities, such as account management and audit functions, when the system is interrupted, or to automatically recover to a secure state once interrupted
- b. Demonstrate the ability to promptly recovery from any failure scenarios to a secure state without operator intervention
- c. Demonstrate the ability to minimize the degradation of operator services and/or network management services due to a surge in security or non-security activities and notifications
- d. Demonstrate the ability to quickly recover network files and configurations after a hostile attempt or operational failure
- e. Demonstrate the ability of the to synchronize internal clocks to multiple NTP/PTP servers for redundancy purposes, as well as to an IRIG source time

4.3.4.6 Access Control

The requirements of Section 3.4.6 shall be verified by demonstration, as follows:

- a. Demonstrate EDIM Modem support for role-based access control and change by authorized role-based operators
- b. Demonstrate EDIM Modem support for a role-based access scheme and privileges
- c. Demonstrate how the access control scheme supports separation of duties and least privilege based on approved roles
- d. Demonstrate the operator login functions, including banners and acknowledgements
- e. Demonstrate presentation of an “Operator Name” and “Password” prompt, or DoD ID Certificate and PIN number prompt, after the DOD Login Banner is acknowledged.

4.3.4.6.1 Operator Roles

The requirements of Section 3.4.6.1 shall be verified by demonstration, as follows:

- a. That access to the EDIM Modem System and account security features are determined by operator roles and corresponding privileges.

- b. That operator roles, as identified in Section 3.3.4.1, are assigned privileges IAW TABLE VI. For all privileges,
 - i. Privilege assignment shall be verified by demonstrating access;
 - ii. Privilege non-assignment shall be verified by demonstrating denial of access.

Verification shall include all necessary privileges not identified in TABLE VI, but assigned by the Contractor with requisite Government approval.

4.3.4.6.2 Password Policy

The requirements of Section 3.4.6.2 shall be verified by demonstration and test, to include the following:

- a. Demonstrate and test that the password policy characteristics for ensuring password complexity with the proper restrictions and protections meet the requirements identified in Section 3.4.6.2, items a-g
- b. Demonstrate and test that password cryptographic protection during storage and transmission meets the requirements identified in Section 3.4.6.2, item h
- c. Demonstrate that operators can manage their own password, as required in Section 3.4.6.2, item i
- j.

4.3.4.7 Network Interfaces

EDIM Modem network interface isolation shall be verified by demonstration. Corresponding internal resource isolation shall be verified by analysis of the EDIM Modem design.

4.3.4.8 M&C Components and Data Storage

The requirements of Section 3.4.8 shall be verified by demonstration, to include the following:

- a. Demonstrate that the EMMS can be executed on, or otherwise accessed, from
 - i. a SHB Microsoft Windows based server or computer.
 - ii. a SHB Microsoft Windows based computer.
- b. Demonstrate that relevant EDIM Modem System components support DoD-approved PKI encryption
- c. Demonstrate that relevant EDIM Modem System components provide the capability to store operator names, hashed passwords, and role assignment information, as necessary and appropriate to their function
- d. Demonstrate that each relevant EDIM Modem System component includes provisions, appropriate to the implementation, to store the names and IP addresses, for tracking purposes, of all modems controlled, monitored or otherwise managed;
- e. Demonstrate that the EDIM Modem System provides simultaneous access, by all relevant EDIM Modem System components, to all M&C parameters

- f. Demonstrate that the EDIM Modem System provides the means to export EDIM Modem System configuration sets for storage, for backup, and for use on relevant EDIM Modem System components, such as other OIs
- g. Demonstrate that the EDIM Modem System provides the means to push stored EDIM Modem configuration sets to EDIM Modems, both immediately and as scheduled

4.3.4.9 Auditing and Non-Repudiation

The requirements of Section 3.4.9 shall be verified by demonstration, to include each hierarchically numbered feature indicated in Section 3.4.9.

4.3.4.10 Notification

The requirements of Section 3.4.10 shall be verified by demonstration, as follows:

- a. Demonstrate that the EDIM Modem System generates a log entry and event notification during account management activities (i.e., creation, enabling, modification, disabling, removing, locking, or unlocking)
- b. Demonstrate that the EDIM Modem System generates a logout confirmation after each operator session ends
- c. Demonstrate that each operator login event generates a log entry of the date, time, and location, as well as an event notification to the Administrator

4.3.5 Built-In Test (BIT)

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4.3.5.1 Hardware Fault Detection

The requirements of Section 3.5.1 shall be verified by demonstration and analysis, as follows:

- a. Verify, by analysis, that EDIM Modem BIT requires no external equipment
- b. Demonstrate that the EDIM Modem BIT functionality is not impaired by a malfunction of the fault detection and diagnostic function
- c. Demonstrate that the diagnostic functions identify all EDIM Modem failures and malfunctions to the level identified in Section 3.5.1
- d. Demonstrate that the diagnostic functions identify what failed, the conditions for the failure, date and time of the failure, and the diagnostic test that identified the failure

4.3.5.1.1 Continuous Self-Test

The requirements of Section 3.5.1.1 shall be verified by demonstration, as follows:

- a. Demonstrate that the EDIM Modem continuously operates BIT functionality to detect hardware malfunctions, to notify the operator accordingly, and to aid diagnostic and maintenance processes

- b. Demonstrate that the EDIM Modem self-test periodically executes a series of non-disruptive tests designed to detect modem failure and does not interfere with normal operation

4.3.5.1.2 Non-Disruptive Self-Test

Demonstration and test shall be used to verify the requirements specified in Section 3.5.1.2 (i.e., that the EDIM Modem enables the operator to initiate comprehensive non-disruptive self-test during normal modem operation, and that non-disruptive self-test does not exceed two (2) minutes).

4.3.5.1.3 Disruptive Self-Test / Power-On Self-Test (POST)

The requirements of Section 3.5.1.3 shall be verified by demonstration and test, as follows:

- a. Test and demonstrate that the EDIM Modem automatically performs POST during startup, and that it does not exceed four (4) minutes
- b. Test and demonstrate that the POST diagnostic includes testing basic processor functionality, verifying the proper operation of all volatile and non-volatile memory, and checking the basic functionality of L Band and IF circuitry
- c. Test and demonstrate that the operator can initiate POST during normal modem operation, from the OI, and that these self-tests, although disruptive, provide the ability to repeatedly test selected portions of the modem without a power cycle or reboot
- d. Demonstrate that all POST results, to include detailed specifics on any failures, are delivered through the initiating OI
- e. Demonstrate that Disruptive Self-Test / POST can be initiated from each OI

4.3.5.2 Alarms

Demonstration and analysis shall be used to verify that the EDIM Modem generates alarms on all conditions listed in Section 3.5.2, items a. through e.

4.3.5.2.1 Major Alarms

Demonstration shall be used to verify that those alarms reflecting conditions which interrupt traffic, or otherwise directly cause traffic to be interrupted, are classified as “major” alarms IAW Section 3.5.2.1.

4.3.5.2.2 Minor Alarms

Demonstration shall be used to verify that those alarms reflecting conditions which do not interrupt traffic, and which do not otherwise directly cause traffic to be interrupted, are classified as “minor” alarms IAW Section 3.5.2.2.

4.3.5.2.3 Alarm Logging and Access

The requirements of Section 3.5.2.3 shall be verified by demonstration and inspection, as follows:

- a. Demonstrate that records of each EDIM Modem's most recent 100 alarms, in order of occurrence, are maintained in non-volatile storage by inspecting the content of the records
- b. Demonstrate that the EDIM Modem alarm events are accessible from all control interfaces
- c. Demonstrate that the records of EDIM Modem alarm events contain the information specified in Section 3.5.2.3 by inspecting the content of the records
- d. Demonstrate that EDIM Modem alarm logs are exportable in CSV format

4.3.5.3 Alarm Notifications

The requirements of Section 3.5.3 shall be verified by demonstration, as follows:

- a. Demonstrate that the EDIM Modem generates alarms based on the indicators identified in Section 3.5.3
- b. Demonstrate that the OI allows the operator to receive and acknowledge alarms by the options identified in Section 3.5.3
- c. Demonstrate that the EDIM Modem only regenerates alarms on recurring conditions when the first alarm was acknowledged

4.3.6 Physical Platform

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4.3.6.1 Physical Platform Priorities

The requirements of Section 3.6.1 shall be verified, as follows:

- a. "Safety, reliability and performance" by analysis
- b. "Ease of operation, maintenance and supply supportability" by analysis and demonstration
- c. "Use of "off-the-shelf" proven components and/or assemblies" by inspection and analysis
- d. "Adaptability to new deployment environments" by analysis and demonstration
- e. "Minimum power consumption" by analysis and test

4.3.6.2 Life Expectancy

The EDIM Modem's expected useful life of 15 years under continuous operation IAW Section 3.6.2 shall be verified by analysis. Provisions for ensuring compatibility of each modem produced with each previously produced modem IAW Section 3.6.2 shall be verified by analysis.

4.3.6.3 Transportability

EDIM Modem transportability requirements shall be verified by demonstrating that the standard EDIM Modem packaging is suitable for shipment IAW Section 3.6.3.

4.3.6.4 19" Rack Mountable Enclosure Packaging

The requirements of Section 3.6.4 shall be verified by inspection, analysis, and demonstration.

4.3.6.4.1 Front Panel

The requirements of Section 3.6.4.1 shall be verified by analysis, demonstration, inspection, and test.

4.3.6.4.2 Rear Panel

The requirements of Section 3.6.4.2 shall be verified by inspection and analysis.

4.3.6.4.3 Cooling

The design requirements of Section 3.6.4.3 shall be verified by analysis, and the performance requirements of Section 3.6.4.3 shall be verified by test.

4.3.6.4.4 AC Power and Power Transients

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4.3.6.4.4.1 AC Power

The design requirements of Section 3.6.4.4.1 shall be verified by analysis, and the performance requirements of Section 3.6.4.4.1 shall be verified by test.

4.3.6.4.4.2 Power Transients

The requirements of Section 3.6.4.4.2 shall be verified by test.

4.3.6.5 Electromagnetic Environmental Effects (E3)

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4.3.6.5.1 Grounding, Bonding and Shielding

The bonding resistance of all power, control, signal, and ground conductors, and the bonding resistance across all seams and joints required to provide electromagnetic shielding, shall be individually measured to verify compliance with Section 3.6.5.1. The design requirements of Section 3.6.5.1 shall be verified by analysis.

4.3.6.5.2 Electromagnetic Compatibility (EMC)

The requirements of Section 3.6.5.2 shall be considered verified upon successful verification of the EMI requirements of Section 3.6.5.3 and its subsections, along with the successful verification of all Section 3.2 Function and Performance requirements subject to Section 4.1.3.1.7. EMC compliance shall be verified by analysis of

- the results of EMI testing performed IAW Section 4.3.6.5.3
- the results of Function and Performance requirements verification IAW Section 4.3.2 and its subsections

- any EMI reported IAW Section 4.1.3.1.7

4.3.6.5.3 Electromagnetic Interference (EMI)

WRT all functions specified in Sections 3.2 through 3.2.5.9.4, the requirements of Sections 3.6.5.3.1 through 3.6.5.3.4 shall be verified, as defined in their cited sections of MIL STD 461G.

4.3.6.6 Physical Environment

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4.3.6.6.1 Non-Operating Physical Environment

The requirements of Section 3.6.6.1 shall be verified, as follows:

- a. Temperature: IAW MIL-STD-810H:
 - i. Method 501.7, Procedure I, to verify the high temperature threshold;
 - ii. Method 502.7, Procedure I, to verify the low temperature threshold.
- b. Relative Humidity: IAW MIL-STD-810H, Method 507.6, Procedure I, to verify the high relative humidity storage requirement. Modification of temperature and humidity profiles IAW Section 3.6.6.1 thresholds will be subject to Government approval.
- c. Altitude: IAW MIL-STD-810H, Method 500.6, Procedure I, to verify its ability to withstand storage and transport in low pressure conditions
- d. Vibration: IAW MIL STD 810H, Method 514.8, Procedure I, with the EDIM Modem packed for shipment
- e. Fungus: By analysis and/or test, as follows:
 - i. Vendor certifications of potentially fungus nutrient materials used in the fabrication of EDIM Modem hardware and descriptions of manufacturing processes and cleaning procedures
 - ii. If vendor certifications are unavailable or considered unacceptable, representative samples of exposed coatings, cables, gaskets, and other potentially fungus nutrient materials shall be subjected to the testing of MIL-STD-810H, Method 508.8
- f. Transportation Shock: IAW MIL STD 810H, Method 516.8, Procedure II, with the EDIM Modem packed for shipment
- g. Bench Handling Shock: IAW MIL-STD-810H, Method 516.8, Procedure VI

4.3.6.6.2 Operating Physical Environment

The requirements of Section 3.6.6.2 shall be verified, as follows:

- a. Ambient Temperature: IAW MIL-STD-810H:
 - i. Method 501.7, Procedure II to verify high temperature operation
 - ii. Method 502.7, Procedure II to verify low temperature operation
- b. Relative Humidity: Environmental conditions (temperature and relative humidity) at the FAT facility shall be measured and recorded at the start and end of each day of testing. Compliance with the operating relative humidity requirement shall be verified by analysis of daily relative humidity

- measurements against satisfactory EDIM Modem performance, as recorded throughout FAT.
- c. Altitude: IAW MIL-STD-810H, Method 500.6, Procedure II, to verify operation during specified high altitude conditions
 - d. Functional Shock: IAW MIL-STD-810H, Method 516.8, Procedure I

4.3.6.6.3 Seismic Conditions

The requirements of Section 3.6.6.3 shall be verified at the module and rack levels by test IAW GR-63-CORE.

4.3.6.7 Reliability, Maintainability and Availability

NR

4.3.6.7.1 Reliability

The requirements of Section 3.6.7.1, beginning with MTBF > 30,000 hours, shall be verified by analysis. The requirement of Section 3.6.7.1, for MTBF of no less than 30,000 hours, shall be verified by analysis using the mathematical reliability model defined in Bellcore SR-332 for a ground fixed environment. This model and corresponding failure rate and MTBF predictions shall be applied to the overall EDIM Modem as purposed for each System Function identified in Section 3.1.2 and operated at maximum capacity. The analysis shall also verify that the EDIM Modem design has no need for recurring maintenance requiring it to be taken out of service.

4.3.6.7.2 Maintainability

The requirements of Section 3.6.7.2 shall be verified by analysis and demonstration.

4.3.6.7.3 Availability

Availability > 0.99999, as required in Section 3.6.7.3, shall be verified by analysis.

4.3.6.7.4 FRACAS

The proposed FRACAS solution, as required in Section 3.6.7.4, shall be verified by analysis.

4.3.6.8 Design and Construction

NR

4.3.6.8.1 Manufacturing Considerations

NR

4.3.6.8.1.1 Nameplates and Product Marking

The requirements of Section 3.6.8.1.1 shall be verified by inspection.

4.3.6.8.1.2 Workmanship

The requirements of Section 3.6.8.1.2 shall be verified by inspection.

4.3.6.8.1.3 Interchangeability

The requirements of Section 3.6.8.1.3 shall be verified by inspection and demonstration.

4.3.6.8.1.4 Finish

The requirements of Section 3.6.8.1.4 shall be verified by inspection.

4.3.6.8.1.5 Corrosion Control

The requirements of Section 3.6.8.1.5 shall be verified by analysis.

4.3.6.8.1.6 Prohibited Materials

The requirements of Section 3.6.8.1.6 shall be verified by analysis and the submission of a certificate of compliance (CoC).

4.3.6.8.1.7 Electrostatic Discharge (ESD)

The requirements of Section 3.6.8.1.7, paragraph 1, shall be verified IAW IEEE C63.16-2016. The requirements of Section 3.6.8.1.7, paragraph 2, shall be verified by inspection, analysis and the submission of a CoC.

4.3.6.8.2 Safety

The requirements of Section 3.6.8.2 shall be verified by analysis of all likely fault conditions, at all times, and the methods used to eliminate or reduce them.

4.3.6.8.2.1 Electrical Safety

The lettered requirements of Section 3.6.8.2.1 shall be verified, as specified in the VCRM, for each EDIM Modem signal processing function specified in Section 3.1.2. Verification of electrical safety shall include, but not be limited to, the following tests:

- item c: retained charge test for all components with internal voltages exceeding 30 volts that contain components capable of charge storage (e.g., capacitors)
- item g: leakage current test on all AC powered components utilizing the method specified in UL60950-1, Sections 5.1.2 through 5.1.7

4.3.6.8.2.2 Mechanical Safety

The lettered requirements of Section 3.6.8.2.2 shall be verified, as specified in the VCRM, for each EDIM Modem signal processing function specified in Section 3.1.2. Verification of mechanical safety shall include, but not be limited to, the following tests:

- item b: applicable mechanical stability and mechanical hazard requirements IAW IEC 60950-1, Sections 4.1 through 4.2.11
- item d: temperature of operator accessible parts IAW IEC 60950-1, Section 4.5.2

4.3.6.8.2.3 Laser Safety

The requirements of Section 3.6.8.2.3 shall be verified, as follows.

- Fiber Optic interfaces by test
- Control measures by test
- Safety and labeling by analysis and inspection

4.3.6.8.2.4 Safety Markings and Labels

The lettered requirements of Section 3.6.8.2.4 shall each be verified by inspection.

4.3.6.8.2.5 Environmental and Chemical Safety

The lettered requirements of Section 3.6.8.2.5 shall each be verified by analysis.

4.3.6.8.2.6 General Safety Provisions

The lettered requirements of Section 3.6.8.2.6 shall be verified, as specified in the VCRM.

4.3.7 Provisions for Upgrade

NR

4.3.7.1 Upgrade Process

The requirements of Section 3.7.1 shall be verified by demonstrating the specified upgrade activities under specified conditions.

4.3.7.2 Future Capabilities

It shall be verified, by analysis, that spare EDIM Modem platform capacity, and the ability to upgrade EDIM Modem System software, both on and off of the EDIM Modem Platform, are all reasonably sufficient to implement the future capabilities indicated in Subsections 3.7.2.1 through 3.7.2.3.

4.3.7.3 Software and Firmware Portability

The software and firmware portability requirements of Section 3.7.3 shall be verified by analysis.

4.3.8 Precedence

The order of precedence indicated in Section 3.8 shall be referenced as guidance.

APPENDIX A Acronyms and Abbreviations

| | |
|---------|--|
| μs | microsecond(s) |
| 8-PSK | 8-ary Phase Shift Keying |
| 16-APSK | 16-ary Amplitude Phase Shift Keying |
| 25S | Satellite Communication Systems Operator-Maintainer (enlisted) |
| °C | degrees Celsius |
| A/D | Analog to Digital |
| AAA | Authentication, Authorization and Accounting |
| AC | Alternating Current |
| ACGIH® | American Conference of Governmental Industrial Hygienists |
| ACI | Adjacent Channel Interference |
| ACM | Adaptive Coding and Modulation |
| AGC | Automatic Gain Control |
| AH | Antenna Handover |
| ANSI | American National Standards Institute |
| API | Application Programming Interface |
| APL | Approved Product List |
| APR | Automatic Power Reduction |
| APSK | Amplitude and Phase-Shift Keying |
| AR | Army Regulation |
| ASCII | American Standard Code for Information Interchange |
| AUPC | Automatic Uplink Power Control |
| AWGN | Additive White Gaussian Noise |
| BBPs | Best Business Practices |
| BEIs® | Biological Exposure Indices |
| BER | Bit Error Rate |
| BERT | Bit Error Rate Test |
| BIT | Built-in Test |
| BNC | Bayonet Neill-Concelman (type of connector) |
| BPS | Bits Per Second |
| BPSK | Binary Phase Shift Keying |
| BW | Bandwidth |
| C | carrier power |
| CCA | Circuit Card Assembly |
| CDRL | Contract Data Requirements List |
| CE | Constellation Error |

| | |
|--------|--|
| CEVD | Convolutional Encoding and Viterbi Decoding |
| CFCs | Chlorofluorocarbons |
| CFM | Cubic Feet per Minute |
| CFR | Code of Federal Regulations |
| CIA | Confidentiality, Integrity, and Availability |
| CJCSI | Chairman of the Joint Chiefs of Staff Instruction |
| CLB | Configurable Logic Block |
| C/N | Carrier to Noise Ratio |
| CoC | Certificate of Compliance |
| COI | Carrier of Interest |
| CONUS | Continental United States |
| COR | Contract Officer's Representative |
| COTS | Commercial off-the-Shelf |
| CNSSI | Committee on National Security Systems Instruction |
| CRL | Certificate Revocation List |
| CSS | Cascading Style Sheets |
| CSV | Comma Separated Values |
| CUI | Controlled Unclassified Information |
| CW | Continuous Wave (unmodulated carrier) |
| | |
| D/A | Digital to Analog |
| DA PAM | Department of the Army Pamphlet |
| DAD | Digital IF Aggregation and De-Aggregation |
| dB | Decibel |
| dBA | A-weighted Decibels |
| dBc | Decibel referenced to the carrier |
| dBFS | Decibels with respect to full scale amplitude or power |
| dBm | Decibel relative to 1 milliwatt |
| dBW | Decibel relative to 1 Watt |
| DC | Direct Current |
| DCT | DCS Connectivity Test |
| DEM | Distant-End Monitoring |
| DHCP | Dynamic Host Configuration Protocol |
| DISA | Defense Information Systems Agency |
| DLEP | Dynamic Link Exchange Protocol |
| DM | Digital IF Modem |
| DOD | Department of Defense |
| DODI | Department of Defense Instruction |
| DRA | Dynamic Resource Allocation |
| DRBG | Deterministic Random Bit Generator |

| | |
|----------------------|---|
| DSP | Digital Signal Processing |
| E3 | Electromagnetic Environmental Effects |
| E_b/N_0 | Energy per Bit to Noise Ratio |
| EBEM | Enhanced Bandwidth Efficient Modem |
| ECC CDH | Elliptic Curve Cryptography Cofactor Diffie-Hellman |
| ECIA | Electronic Components Industry Association |
| EDIM Modem | Enterprise Digital Intermediate Frequency Multi-Carrier Modem |
| EIA | Electronic Industries Association |
| EMC | Electromagnetic Compatibility |
| EMI | Electromagnetic Interference |
| ENoB | Effective Number of Bits |
| ESD | Electrostatic Discharge |
| ESEM | Ethernet Service Expansion Module |
| E_{Sym}/N_0 | Ratio of Energy per Symbol to Noise PSD |
| E_{Sym} | Energy Per Symbol |
| ET | Earth Terminal |
| ETSI | European Telecommunications Standards Institute |
| EVC RM | Expanded Verification Cross Reference Matrix |
| EVM | Error Vector Magnitude |
| | |
| FAT | First Article Test |
| FCC | Federal Communications Commission |
| FDMA | Frequency Division Multiple Access |
| FEC | Forward Error Correction |
| FER | Frame Error Rate |
| FIPS | Federal Information Processing Standard |
| FM | Frequency Modulation |
| FRACAS | Failure Reporting, Analysis and Corrective Action System |
| FPGA | Field-Programmable Gate Array |
| FS | Full Scale |
| FTP | File Transfer Protocol |
| FW | Firmware |
| | |
| GbE | Gigabit Ethernet |
| GFE | Government Furnished Equipment |
| GHz | Gigahertz |
| GSE | Generic Stream Encapsulation |
| GUI | Graphic User Interface |

| | |
|-----------------|---|
| HPA | High Power Amplifier |
| HTML | Hypertext Markup Language |
| HTTPS | Hypertext Transfer Protocol Secure |
| HV | High Voltage |
| Hz | Hertz |
| I/S | ratio of interfering carrier power to COI signal power |
| IAW | In Accordance With |
| ICD | Interface Control Document |
| IEC | International Electrotechnical Commission |
| IEEE | Institute of Electrical and Electronic Engineers |
| IESS | INTELSAT Earth Station Standards |
| IETF | Internet Engineering Taskforce |
| IF | Intermediate Frequency |
| IFC | IF Converter (Digital IF to L-Band, L-Band to Digital IF) |
| ILT | Integrated Loopback Test |
| IP | Internet Protocol |
| IP ₃ | Third-order intercept point |
| IRIG | Inter-Range Instrumentation Group |
| ISO | International Standards Organization |
| IT | Information Technology |
| ITA | Information Throughput Adaptation |
| JSON | JavaScript Object Notation |
| Kblock | Kilo-block |
| Kbps | Kilobits Per Second |
| kHz | Kilohertz |
| ksym/ | kilo-symbols per second |
| LAN | Local Area Network |
| LED | Light Emitting Diode (optical fiber Ethernet context) |
| LM | L-Band Modem |
| LMA | L-Band Modem Adapter |
| LNA | Low Noise Amplifier |
| LRI | Line Replaceable Item |
| LRU | Line Replaceable Unit |
| LSS | [MET] L-Band Switching Subsystem |
| LSZH | Low Smoke Zero Halogen |

| | |
|------------------|---|
| LUT | Lookup Table |
| M&C | Management and Control |
| mA | Milliamperes |
| MAC | Media Access Control |
| Mbps | Megabits Per Second |
| MET | Modernization of Earth Terminals |
| MHz | Megahertz |
| MIB | Management Information Base |
| MIL-STD | Military Standard |
| M _{max} | 95 th percentile of the repair time distribution |
| MMF | Multi-Mode Fiber |
| Mod-cod | Modulation and code rate combination |
| MOS | Military Occupational Specialty |
| MPE | Multi-protocol Encapsulation |
| ms | Milliseconds |
| Msym/s | Mega-symbols per second |
| MTBF | Mean Time Between Failures |
| MTTR | Mean Time to Repair |
| mW | Milliwatt |
| N | noise power |
| N/A | Not Applicable |
| NATO | North Atlantic Treaty Organization |
| NDI | Non-Developmental Item |
| NET | New Equipment Training |
| NETCONF | Network Configuration Protocol |
| NFPA | National Fire Protection Association |
| NIST | National Institute of Standards and Technology |
| NMS | Network Management System / Network Management Software |
| NR | No Requirement |
| ns | Nanosecond(s) |
| NSA | National Security Agency |
| NTE | Not to Exceed |
| NTP | Network Time Protocol |
| ODSs | Ozone Depleting Substances |
| OID | Object Identifier |
| OOLK | Out of Lock Condition |
| OQPSK | Offset Quadrature Phase Shift Keying |

| | |
|--------------|---|
| OSHA | Occupational Safety and Health Administration |
| OS | Operating System |
| OSI | Open Systems Interconnection |
| PAR | Phase Ambiguity Resolution |
| PC | Personal Computer |
| PCBs | Polychlorinated Biphenyls |
| PCMS | Power Control and Management Subsystem |
| PdM WESS | Product Manager Wideband Enterprise Satellite Systems |
| PELs | Permissible Exposure Limits |
| PER | Packet Error Rate |
| PK | Public Key |
| PKI | Public Key Infrastructure |
| PM | Phase Modulation |
| PM IEN | Program Manager Integrated Enterprise Network |
| POST | Power-On Self-Test |
| PPPoE | Point-to-Point Protocol over Ethernet |
| pps | pulse per second |
| PQT | Production Qualification Test |
| ps | Picosecond |
| P_{Σ} | Total digitally sampled power |
| PTP | Precision Time Protocol |
| PSD | Power Spectral Density |
| PVC | Polyvinyl Chloride |
| PWS | Performance Work Statement |
| QEF | Quasi Error Free |
| QPSK | Quadrature Phase Shift Keying |
| R2RI | Radio-to-Router Interface |
| RADIUS | Remote Authentication Dial-In User Service |
| RAM | Random Access Memory |
| RCC | Range Commanders Council |
| REST | Representational State Transfer |
| RF | Radio Frequency |
| RFP | Request for Proposal |
| RH | Relative Humidity |
| RMF | Risk Management Framework |
| RMS | Root Mean Square |
| RRC | Root Raised Cosine |

| | |
|-------------------|---|
| R_{Samp} | sample rate |
| RSS | Root Sum Square |
| R_{Sym} | Symbol Rate |
| RTL | Register Transfer Level |
| RU | Rack Unit |
| Rx | Reception |
| samp | sample |
| SATCOM | Satellite Communications |
| SCPC | Single Channel Per Carrier |
| SFP | Small Form-factor Pluggable |
| SFTP | Secure File Transfer Protocol |
| SHB | Secure Host Baseline |
| SHF | Super High Frequency |
| SMAT | Shared Message Authentication Token |
| SMB | Subminiature Version B |
| SMF | Single Mode Fiber |
| SNMP | Simple Network Management Protocol |
| SNR | Signal to Noise Ratio |
| SP | Special Publication |
| SRGs | Security Requirements Guides |
| SSF | Spectral Shape Factor |
| SSH | Secure Shell |
| STANAG | [NATO] Standardisation Agreement |
| STIG | Security Technical Implementation Guide |
| SW | Software |
| SwaP | Size, Weight, and Power |
| sym | symbol |
| sym/s | symbol per second |
| SYSLOG | System Logging Protocol |
| T&M | Test and Measurement |
| TCM | Trellis Code Modulation |
| TELNET | Terminal Network |
| TerrXpt | Terrestrial Transport |
| THz | Terahertz |
| TLVs® | Threshold Limit Values |
| TMDE | Test Measurement and Diagnostic Equipment |
| Tx | Transmission |
| TxPI | Transmit Power Inhibit |

| | |
|-------|--|
| TXT | Text-Formatted Data |
| UC | Unified Capabilities |
| UDP | User Datagram Protocol |
| UIIs | Unique Item Identifiers |
| UL | Underwriters Laboratories |
| UTC | Coordinated Universal Time |
| V | Volts |
| VAC | Volts Alternating Current |
| VCRM | Verification Cross Reference Matrix |
| VDC | Volts Direct Current |
| VLAN | Virtual Local Area Network |
| VNA | Vector Network Analyzer |
| VSWR | Voltage Standing Wave Ratio |
| WAN | Wide Area Network |
| WESS | Wideband Enterprise Satellite System |
| WGS | Wideband Global SATCOM |
| WNBCT | WSP Narrowband Connectivity Test |
| WRT | With Respect To |
| XML | Extensible Markup Language |
| YANG | Yet Another Next Generation [data modeling language] |

APPENDIX B Definitions of Terms

Accuracy: The degree of conformity of a measured or calculated value to its definition, related to the offset from an ideal value.

Acq or Acquisition: The point at which performance evaluation test equipment achieves synchronization with a signal from a communications satellite

Acquisition & Synchronization Reference E_{Sym}/N_0 : The threshold E_{Sym}/N_0 , as specified for back-to-back BER performance, that corresponds to a BER of 10^{-4} . If a threshold E_{Sym}/N_0 is not specified for back-to-back error performance of BER = 10^{-4} , then the reference E_{Sym}/N_0 is extrapolated from the threshold E_{Sym}/N_0 of the highest specified BER point at a rate of -0.05 dB of E_{Sym}/N_0 per BER factor of 10.

Agent [SNMPv3]: Device subject to control. The EDIM Modem is the SNMPv3 agent.

Aggregate: An IF waveform comprised of component channels. Aggregates include DCS waveforms as well as combined WSP waveforms.

Atomic transaction: An indivisible and irreducible series of database operations such that either all occur, or nothing occurs. (i.e., other operators are locked out while one operator reads and writes a group of interrelated parameters). This way parameters in that group do not change in the middle of a read. A guarantee of atomicity prevents updates to the database occurring only partially, which can cause greater problems than rejecting the whole series outright.

Back to back: Refers to Intermediate Frequency (IF) testing of modems in which two identical modems are used with adequate physical separation to prevent any interaction beyond IF connectivity.

Bit Error Ratio (BER): The number of bit errors divided by the total number of transferred bits during a specified time interval.

Central Limit Theorem: Establishes that, in many situations, when independent random variables are added, their properly normalized sum tends toward a normal distribution (informally a bell curve), even if the original variables themselves are not normally distributed. The theorem is a key concept in probability theory because it implies that probabilistic and statistical methods that work for normal distributions can be applicable to many problems involving other types of distributions.

Certification: The acknowledgment that a validation has been completed and the criteria established by the certifying organization for issuing a certificate has been met.

Channel: An IF waveform subject to combination or resulting from division. Channels include LMA waveforms, as well as divided WSP waveforms.

COMSEC (Communications Security): Encryption used to protect IP payload messages. The EDIM Modem is intended to transport COMSEC encrypted data traffic.

Configure: To set up for operation in a particular way, with a view to a specific application, usage or mission.

Cover [Encryption]: Encryption used to protect IP headers to prevent exploitation of traffic patterns. The EDIM Modem can be configured to provide cover through its modem emulations. The default configuration is for cover to be enabled.

Data Link Layer: Layer 2 in the Open Systems Interconnection (OSI) Model. The data link layer provides node-to-node data transfer (i.e., a link between two directly connected nodes). It detects and possibly corrects errors that may occur in the physical layer. It defines the protocol to establish and terminate a connection between two physically connected devices. It also defines the protocol for flow control between them.

Data rate (R_D): The rate at which data traffic, incident upon one or more data interfaces, is transferred across a satellite channel, measured in bits per second (bits/s).

dB_C: Ratio of a non-carrier power component to the total power in a carrier, expressed in decibels.

Digital IF: A digital waveform medium, where waveforms are digitally sampled and presented in a predetermined format.

E_b/N_0 The ratio of energy per bit to noise Power Spectral Density (PSD) . Converts from E_{Sym}/N_0 using

$$\frac{E_b}{N_0} = \frac{R_{Sym}}{R_D} \times \frac{E_{Sym}}{N_0}$$

EDIM Modem Management System (EMMS): Application for managing EDIM Modems as M&C network nodes.

EDIM Modem System: The EDIM Modem, associated GUI, and all supporting software and platforms.

Error Vector Magnitude (EVM): Sometimes referred to as “constellation error” (CE), EVM is a measurement used to quantify the performance of a digital radio transmitter. EVM is expressed in percent Root Mean Square (RMS), and is computed as follows:

$$EVM = \frac{\sqrt{\frac{1}{N_S} \sum_{k_S=0}^{N_S-1} EVM^2(k_S)}}{\sqrt{\frac{1}{N_C} \sum_{k_C=0}^{N_C-1} I_{ref}^2(k_C) + Q_{ref}^2(k_C)}}$$

where

N_S = the number of symbols over which the EVM measurement is taken;
 k_S = the symbol index;
 N_C = the number of constellation points in the modulation waveform = $2^{\text{mod index}}$;
 k_C = the constellation point index;
 $I_{\text{ref}}(k_C)$ = in-phase coordinate of k_C indexed ideal constellation point;
 $Q_{\text{ref}}(k_C)$ = quadrature-phase coordinate of k_C indexed ideal constellation point.

and

$$EVM(k_S) = \sqrt{I_{\text{err}}^2(k_S) + Q_{\text{err}}^2(k_S)}$$

where

$I_{\text{err}}(k_S) = I_{\text{actual}}(k_S) - I_{\text{ref}}(k_S)$;
 $I_{\text{actual}}(k_S)$ = in-phase coordinate of k_S indexed actual constellation point;
 $Q_{\text{err}}(k_S) = Q_{\text{actual}}(k_S) - Q_{\text{ref}}(k_S)$;
 $Q_{\text{actual}}(k_S)$ = quadrature coordinate of k_S indexed actual constellation point.

E_{Sym}/N_0 : The ratio of energy per symbol to noise PSD. Converts from E_b/N_0 using

$$\frac{E_{\text{Sym}}}{N_0} = \frac{R_D}{R_{\text{Sym}}} \times \frac{E_b}{N_0}$$

Flow: A unidirectional stream of packets from a specific source to a specific destination.

Frequency uncertainty: The difference between a received signal's expected frequency and its actual frequency. Frequency uncertainty results when (1) a difference in frequency between reference oscillators exists, (2) Doppler effects cause frequency shifts, or (3) frequency setting inaccuracies exist.

Gaussian: Normal distribution is a type of continuous probability distribution for a real-valued random variable.

Infant mortality: Early life failure. Failure of equipment within the first six months of deployment.

Jumbo frames: Ethernet frames with more than 1500 bytes of payload, the limit set by the IEEE 802.3 standard.

MAC address: Short for "Media Access Control" address – a hardware address that uniquely identifies each node of a network.

Manager [SNMPv3]: Device controlling the agent. Any M&C device imposing control over the EDIM Modem is its SNMPv3 manager.

Mod-cod: Specific combination of modulation format (mod) and code rate (cod).

Modem emulation: A standardized or otherwise prescribed set of rules governing the signal processing and waveform construction required to produce a conforming modulation waveform. Conformance to specified modem emulations is the basis for waveform-level interoperability between modems.

Operator: A person or entity that employs the EDIM Modem System to exercise M&C over EDIM Modems.

Packet Channel: A bidirectional traffic channel provided for transport of encapsulated Ethernet Frames.

Precedence: Role-based operator order of attention, as indicated in Section 3.3.4.1.

Priority: Data traffic order of importance assigned by Chairman of the Joint Chiefs of Staff Instruction (CJCSI) designator.

QEF E_{Sym}/N_0 : The threshold E_{Sym}/N_0 , as specified for back-to-back BER performance, that corresponds to a BER of 10^{-10} . If a threshold E_{Sym}/N_0 is not specified for back-to-back error performance of $\text{BER} = 10^{-10}$, then the reference E_{Sym}/N_0 is extrapolated from the threshold E_{Sym}/N_0 for the lowest specified BER point at a rate of +0.05 dB of E_{Sym}/N_0 per BER factor of 10^{-1} .

SATCOM Gateway: Strategic entry point for terrestrial data traffic into SATCOM communications link, and for SATCOM data traffic into terrestrial distribution.

Secure Host Baseline: A pre-configured and security hardened machine-ready image that contains a common Operating Systems (OS) and mandatory application software with initial STIGs, patches, and security policy configuration settings applied.

Signal Chain Alignment: At L-Band, “signal chain alignment” refers to the one-to-one correspondence between power and frequency at IF WRT RF. IF frequency and power maps directly into corresponding RF frequency and power, and vice-versa. At Digital IF, “signal chain alignment” refers to the use of Digital IF protocol constructs to track amplitude and frequency WRT equivalent analog amplitude and frequency at the edge device. Digital IF waveforms, from edge device output and downstream, should all reflect analog frequency and power at the edge device input. Likewise analog edge device output should be true to frequency and power, as characterized in the Digital IF input.

[Digital IF] Sink: A Digital IF stream destination point identified by a network IP socket.

[IP] Socket: IP address and port number pair.

[Digital IF] Source: A Digital IF stream origination point identified by a network IP socket.

Stability: The degree of conformity of a measured or calculated value to its original value at the beginning of some prescribed time interval, related to the offset from a prior state.

Strategic SATCOM Enterprise: Aggregated SATCOM resources for widespread DOD use.

Symbol rate (R_{Sym}): The rate at which symbols are transferred across a satellite channel, measured in symbols per second (sym/s).

Throughput: The number of bits, frames or packets per second passing through an interface or device. The ITA throughput rate changes in response to changing link conditions. This, in turn, changes the Packet Channel rate in scenarios employing the Packet Channel.

Threshold E_b/N_0 : The E_b/N_0 at which the measured BER must not exceed the specified BER. Threshold $E_b/N_0 = \text{threshold } E_{\text{Sym}}/N_0 \times R_{\text{Sym}}/R_D$.

User: Person or entity using a SATCOM link for transport of data traffic. SATCOM users are prioritized by CJCSI designation.

Utilization: The percent of a resource that is in use. Packet Channel utilization refers to the percent of the Packet Channel rate that is carrying traffic plus overhead.

Validation: the process of testing implementations for conformance. The validation process consists of the steps necessary to perform the conformance testing by using an official test suite in a prescribed manner. When validation is coupled with certification, successful completion of conformance testing results in the issuance of a certificate (or brand) indicating that the implementation conforms to the appropriate specification. It is important to note that certification cannot exist without validation, but validation can exist without certification. Similarly, validation cannot exist without conformance testing (i.e., a test suite), but conformance testing can be performed without validation.

Windows User: Any Windows SHB user, including EDIM Modem M&C operators. Windows Users have their own Microsoft Windows OS specific roles, such as “[Windows OS] User” and “Windows Administrator.” Windows Users are not to be confused with EDIM Modem users (data traffic customers) or EDIM Modem operators (control via EDIM Modem System M&C).

Zeroize: To permanently delete of all cryptographic key material, including SMATs IAW Section 3.2.5.2.3 and all keys, tokens, checksums, and encryption components derived from them or otherwise. “Zeroize” also permanently deletes all stored configurations.

APPENDIX C Verification Cross Reference Matrix (VCRM)

TABLE VII Verification Cross Reference Matrix (VCRM)

| Verification Cross Reference Matrix | | | | | | | | | | | | |
|-------------------------------------|--|----------------------|-----|---|---|---|---|-----|---|---|---|---|
| Reqt Section | Title | Verification Section | FAT | | | | | PQT | | | | |
| | | | I | A | D | T | N | I | A | D | T | N |
| 3.1 | Item Definition | 4.3.1 | I | | | | | | | | | N |
| 3.1.1 | External Interfaces | 4.3.1.1 | | | | | N | | | | | N |
| 3.1.1.1 | Front Panel Interfaces | 4.3.1.1.1 | | | | | N | | | | | N |
| 3.1.1.1.1 | Power Switch | 4.3.1.1.1 | I | | D | T | | I | | D | | |
| 3.1.1.1.2 | Front Panel Visual Power Indicator | 4.3.1.1.1 | I | | D | | | I | | D | | |
| 3.1.1.2 | Rear Panel Interfaces | 4.3.1.1.2 | | | | | N | | | | | N |
| 3.1.1.2.1 | Ethernet Data Traffic | 4.3.1.1.2 | I | | D | | | | | D | | |
| 3.1.1.2.2 | L-Band IF | 4.3.1.1.2 | I | | D | T | | | | D | T | |
| 3.1.1.2.3 | Digital IF 10GbE | 4.3.1.1.2 | I | | D | | | | | D | | |
| 3.1.1.2.4 | Digital IF 40/100 GbE | 4.3.1.1.2 | I | | D | | | | | D | | |
| 3.1.1.2.5 | Rear Panel Ethernet M&C Ports | 4.3.1.1.2 | I | | D | | | | | D | | |
| 3.1.1.2.6 | Time & Frequency References | 4.3.1.1.2 | I | | D | | | | | D | | |
| 3.1.1.2.6.1 | 5/10 MHz Frequency Reference | 4.3.1.1.2 | I | | D | | | | | D | | |
| 3.1.1.2.6.2 | 1 pps Timing Reference | 4.3.1.1.2 | I | | D | | | | | D | | |
| 3.1.1.2.6.3 | IRIG-B Timing Reference | 4.3.1.1.2 | I | | D | | | | | D | | |
| 3.1.1.2.7 | Power | 4.3.1.1.2 | I | | D | | | | | D | | |
| 3.1.1.2.8 | Ground Stud | 4.3.1.1.2 | I | | | | | I | | | | |
| 3.1.1.3 | Contractor Discretionary Interfaces | 4.3.1.1.3 | | | D | | | | | D | | |
| 3.1.2 | Signal Processing Functions | 4.3.1.2 | | | D | | | | | D | | |
| 3.1.2.1 | L-Band Modem (LM) | 4.3.1.2 | | | D | | | | | D | | |
| 3.1.2.2 | Digital IF Modem (DM) | 4.3.1.2 | | | D | | | | | D | | |
| 3.1.3 | NATO STANAG 4486 Ed4 (EBEM) Interoperability | 4.3.1.3 | | | | T | | | | | | N |
| 3.2 | Function and Performance | 4.3.2 | | | D | | | | | D | | |
| 3.2.1 | Time and Frequency Base | 4.3.2.1 | | | | | N | | | | | N |
| 3.2.1.1 | Date and Time Base | 4.3.2.1 | | A | D | | | | | | | N |
| 3.2.1.2 | Frequency Base | 4.3.2.1 | | A | D | | | | | | | N |
| 3.2.2 | Data Traffic Rate Estimation | 4.3.2.2 | | | | T | | | | | | N |
| 3.2.3 | L-Band IF Interface | 4.3.2.3 | | A | | | | | | | | N |
| 3.2.3.1 | L-Band IF Non-Damaging Input Power | 4.3.2.3.1 | | | | T | | | | | | N |
| 3.2.3.2 | L-Band IF Isolation | 4.3.2.3.2 | | | | T | | | | | T | |
| 3.2.4 | Digital IF Interface | 4.3.2.4 | | A | | | | | | | | N |
| 3.2.4.1 | Digital IF Capacity | 4.3.2.4.1 | | | D | T | | | | D | | |
| 3.2.4.2 | IP Addressability | 4.3.2.4.2 | | | | T | | | | | T | |
| 3.2.4.3 | Digital IF Protocol | 4.3.2.4.3 | | A | | T | | | | | T | |

| Verification Cross Reference Matrix | | | | | | | | | | | | |
|-------------------------------------|---|-------------------------|-----|---|---|---|---|-----|---|---|---|---|
| Req't Section | Title | Verification Section | FAT | | | | | PQT | | | | |
| | | | I | A | D | T | N | I | A | D | T | N |
| 3.2.4.4 | Digital IF Network Connectivity | 4.3.2.4.4 | | | D | | | | | D | | |
| 3.2.4.5 | Digital IF Networking Performance | 4.3.2.4.5 | | | | | N | | | | | N |
| 3.2.4.5.1 | Network Output Limits | 4.3.2.4.5 | | | | T | | | | | T | |
| 3.2.4.5.2 | Network Input Tolerance | 4.3.2.4.5 | | | | T | | | | | T | |
| 3.2.4.5.3 | Jumbo Frame Support | 4.3.2.4.5 | | | | T | | | | | T | |
| 3.2.5 | Modem Function and Performance | 4.3.2.5 | | | | | N | | | | | N |
| 3.2.5.1 | General | 4.3.2.5.1 | | | | | N | | | | | N |
| 3.2.5.1.1 | Ethernet Bridge | 4.3.2.5.1.1 | | | | T | | | | | | N |
| 3.2.5.1.2 | Carrier Count and Independence | 4.3.2.5.1.2 | | | D | | | | | D | | |
| 3.2.5.1.3 | Data Traffic Rates | 4.3.2.5.1.3 | | | | T | | | | | T | |
| 3.2.5.1.4 | Symbol Rates | 4.3.2.5.1.4 | | | | T | | | | | T | |
| 3.2.5.1.5 | FIPS Cert and General Crypto Provisions | 4.3.2.5.1.5 | | A | D | | | | | D | | |
| 3.2.5.1.6 | Interference Mitigation | 4.3.2.5.1.6 | | A | | | | | | | | N |
| 3.2.5.1.6.1 | Interference Mitigation Operation | 4.3.2.5.1.6.1 | | | D | T | | | | D | | |
| 3.2.5.1.6.2 | Interference Mitigation Performance | 4.3.2.5.1.6.2 | | | | T | | | | | T | |
| 3.2.5.2 | Modem Waveforms | 4.3.2.5.2 | | | | | N | | | | | N |
| 3.2.5.2.1 | NATO STANAG 4486 Ed4 (EBEM) Baseline | 4.3.2.5.2.1 | | | | | N | | | | | N |
| 3.2.5.2.1.1 | Payload | 4.3.2.5.2.1.1 | | | D | | | | | | | N |
| 3.2.5.2.1.2 | Features | 4.3.2.5.2.1.2 | | | D | | | | | | | N |
| 3.2.5.2.1.3 | Bulk Encryption for Cover | 4.3.2.5.2.1.3 | | | D | | | | | | | N |
| 3.2.5.2.1.4 | Waveform | 4.3.2.5.2.1.4 | | | D | | | | | | | N |
| 3.2.5.2.2 | Support for Higher Rates | 4.3.2.5.2.2 | | | | | N | | | | | N |
| 3.2.5.2.2.1 | EBEM Extended Rate Operation | 4.3.2.5.2.2.1 | | A | | T | | | | | | N |
| 3.2.5.2.2.2 | DVB-S2X Hub Waveform Operation | 4.3.2.5.2.2.2 | | | D | T | | | | | | N |
| 3.2.5.2.2.2.1 | Waveform | 4.3.2.5.2.2.2.1 | | | D | | | | | | | N |
| 3.2.5.2.2.2.2 | Data Traffic Encapsulation | 4.3.2.5.2.2.2.2 | | A | D | T | | | | | | N |
| 3.2.5.2.2.2.3 | Bulk Encryption for Cover | 4.3.2.5.2.2.2.3 | | A | | T | | | | | | N |
| 3.2.5.2.2.2.4 | DVB-S2X Feature Support | 4.3.2.5.2.2.2.4 | | A | D | T | | | | | | N |
| 3.2.5.3 | LM Operation | 4.3.2.5.3 | | | | | N | | | | | N |
| 3.2.5.3.1 | LM Transmission | 4.3.2.5.3 | | | D | | | | | | | N |
| 3.2.5.3.2 | LM Reception | 4.3.2.5.3 | | | D | | | | | | | N |
| 3.2.5.3.3 | LM Loopback Operation | 4.3.2.5.3 | | | D | | | | | | | N |
| 3.2.5.4 | LM Uplink Performance | 4.3.2.5.4 | | | | | N | | | | | N |

| Verification Cross Reference Matrix | | | | | | | | | | | | |
|-------------------------------------|--|-------------------------|-----|---|---|---|---|-----|---|---|---|---|
| Req't Section | Title | Verification Section | FAT | | | | | PQT | | | | |
| | | | I | A | D | T | N | I | A | D | T | N |
| 3.2.5.4.1 | LM Uplink Carrier Frequency | 4.3.2.5.4.1 | | | D | | | | | D | | |
| 3.2.5.4.2 | LM Uplink Frequency Stability | 4.3.2.5.4.2 | | | | T | | | | | T | |
| 3.2.5.4.3 | LM Uplink Frequency Accuracy | 4.3.2.5.4.3 | | | | T | | | | | T | |
| 3.2.5.4.4 | LM Uplink Phase Noise | 4.3.2.5.4.4 | | A | | T | | | | | T | |
| 3.2.5.4.5 | LM Uplink Carrier Power | 4.3.2.5.4.5 | | | | T | | | | | T | |
| 3.2.5.4.6 | LM Uplink Power Off Performance | 4.3.2.5.4.6 | | | | T | | | | | T | |
| 3.2.5.4.7 | LM Uplink Spectral Confinement | 4.3.2.5.4.7 | | | | | N | | | | | N |
| 3.2.5.4.7 | LM Uplink Spectral Confinement: Single Carrier Spectra | 4.3.2.5.4.7.1 | | | | T | | | | | T | |
| 3.2.5.4.7 | LM Uplink Spectral Confinement: Multiple Carrier Spectra | 4.3.2.5.4.7.2 | | | | T | | | | | T | |
| 3.2.5.4.7 | LM Uplink Spectral Confinement: Spectrum Data Reporting | 4.3.2.5.4.7.3 | | A | | | | | | | | N |
| 3.2.5.4.8 | LM Uplink Noise Floor | 4.3.2.5.4.8 | | | | T | | | | | T | |
| 3.2.5.4.9 | LM Uplink Spurious Emissions | 4.3.2.5.4.9 | | | | T | | | | | T | |
| 3.2.5.4.10 | LM Uplink Harmonics | 4.3.2.5.4.10 | | | | T | | | | | T | |
| 3.2.5.4.11 | LM Uplink Error Vector Magnitude (EVM) | 4.3.2.5.4.11 | | | | T | | | | | T | |
| 3.2.5.5 | LM Downlink Performance | 4.3.2.5.5 | | | | | N | | | | | N |
| 3.2.5.5.1 | LM Downlink Carrier Frequency | 4.3.2.5.5.1 | | | D | | | | | D | | |
| 3.2.5.5.2 | LM Downlink Frequency Uncertainty | 4.3.2.5.5.2 | | A | | | | | | | | N |
| 3.2.5.5.3 | LM Downlink Min Rx Power | 4.3.2.5.5.3 | | | | T | | | | | T | |
| 3.2.5.5.4 | LM Downlink Acquisition and Reacquisition | 4.3.2.5.5.4 | | | | T | | | | | T | |
| 3.2.5.5.5 | LM Downlink Synchronization Retention | 4.3.2.5.5.5 | | | | T | | | | | T | |
| 3.2.5.5.6 | LM Downlink Doppler Environment | 4.3.2.5.5.6 | | | | T | | | | | | N |
| 3.2.5.5.7 | LM Back-to-Back BER | 4.3.2.5.5.7 | | | | | N | | | | | N |
| 3.2.5.5.7 | LM Back-to-Back BER: Baseline BER Performance | 4.3.2.5.5.7.1 | | | | T | | | | | T | |
| 3.2.5.5.7 | LM Back-to-Back BER: BER Performance Consistency | 4.3.2.5.5.7.2 | | | | T | | | | | | N |
| 3.2.5.5.7 | LM Back-to-Back BER: Multiple Carrier BER Performance | 4.3.2.5.5.7.3 | | | | T | | | | | T | |

| Verification Cross Reference Matrix | | | | | | | | | | | | |
|-------------------------------------|---|-------------------------|-----|---|---|---|---|-----|---|---|---|---|
| Req Section | Title | Verification Section | FAT | | | | | PQT | | | | |
| | | | I | A | D | T | N | I | A | D | T | N |
| 3.2.5.5.7 | LM Back-to-Back BER: Data Range and Reporting | 4.3.2.5.5.7.4 | | A | | | | | | | | N |
| 3.2.5.5.8 | LM Downlink Adjacent Channel Interference (ACI) | 4.3.2.5.5.8 | | | | T | | | | | | N |
| 3.2.5.5.9 | LM Downlink Power Disparity | 4.3.2.5.5.9 | | | | T | | | | | | N |
| 3.2.5.5.9 | LM Downlink Power Disparity: Symmetrical Interference Environment | 4.3.2.5.5.9.1 | | | | T | | | | | | N |
| 3.2.5.5.9 | LM Downlink Power Disparity: Intermod Sensitive Environment | 4.3.2.5.5.9.2 | | | | T | | | | | | N |
| 3.2.5.5.10 | LM Downlink Input Power Changes | 4.3.2.5.5.10 | | | | T | | | | | | N |
| 3.2.5.6 | DM Operation | 4.3.2.5.6 | | | D | | | | | D | | |
| 3.2.5.6.1 | DM Transmission | 4.3.2.5.6 | | | D | | | | | D | | |
| 3.2.5.6.2 | DM Reception | 4.3.2.5.6 | | | D | | | | | D | | |
| 3.2.5.6.3 | DM Loopback Operation | 4.3.2.5.6 | | | D | | | | | D | | |
| 3.2.5.7 | DM Uplink Performance | 4.3.2.5.7 | | | | | N | | | | | N |
| 3.2.5.7.1 | DM Uplink Carrier Frequency | 4.3.2.5.7.1 | | | D | | | | | | T | |
| 3.2.5.7.2 | DM Uplink Carrier Power | 4.3.2.5.7.2 | | | | T | | | | | T | |
| 3.2.5.7.3 | DM Uplink Digitization Noise PSD | 4.3.2.5.7.3 | | | | T | | | | | T | |
| 3.2.5.7.4 | DM Uplink Spectral Confinement | 4.3.2.5.7.4 | | | | | N | | | | | N |
| 3.2.5.7.4 | DM Uplink Spectral Confinement: Carrier Measurement Sets | 4.3.2.5.7.4.1 | | | | T | | | | | T | |
| 3.2.5.7.4 | DM Uplink Spectral Confinement: Spectrum Data Reporting | 4.3.2.5.7.4.2 | | A | | | | | | | | N |
| 3.2.5.7.5 | DM Uplink EVM | 4.3.2.5.7.5 | | A | | T | | | | | | N |
| 3.2.5.8 | DM Downlink Performance | 4.3.2.5.8 | | | | | N | | | | | N |
| 3.2.5.8.1 | DM Downlink Carrier Frequency | 4.3.2.5.8.1 | | | D | | | | | D | | |
| 3.2.5.8.2 | DM Downlink Frequency Uncertainty | 4.3.2.5.8.2 | | A | | | | | | | | N |
| 3.2.5.8.3 | DM Downlink Acquisition and Reacquisition | 4.3.2.5.8.3 | | | | T | | | | | T | |
| 3.2.5.8.4 | DM Downlink Synchronization Retention | 4.3.2.5.8.4 | | | | T | | | | | T | |
| 3.2.5.8.5 | DM Downlink Doppler Environment | 4.3.2.5.8.5 | | | | T | | | | | T | |
| 3.2.5.8.6 | DM Back-to-Back BER | 4.3.2.5.8.6 | | | | | N | | | | | N |

| Verification Cross Reference Matrix | | | | | | | | | | | | |
|-------------------------------------|--|-------------------------|-----|---|---|---|---|-----|---|---|---|---|
| Req't Section | Title | Verification Section | FAT | | | | | PQT | | | | |
| | | | I | A | D | T | N | I | A | D | T | N |
| 3.2.5.8.6 | DM Back-to-Back BER: Baseline BER Performance | 4.3.2.5.8.6.1 | | | | T | | | | | T | |
| 3.2.5.8.6 | DM Back-to-Back BER: BER Performance Consistency | 4.3.2.5.8.6.2 | | | | T | | | | | | N |
| 3.2.5.8.6 | DM Back-to-Back BER: Data Range and Reporting | 4.3.2.5.8.6.3 | | A | | | | | | | | N |
| 3.2.5.8.7 | DM Downlink ACI | 4.3.2.5.8.7 | | | | T | | | | | | N |
| 3.2.5.9 | Modem Test Features | 4.3.2.5.9 | | | | | N | | | | | N |
| 3.2.5.9.1 | Carrier Frequency Measurement | 4.3.2.5.9.1 | | | | T | | | | | T | |
| 3.2.5.9.2 | Carrier Power Measurement | 4.3.2.5.9.2 | | | | T | | | | | T | |
| 3.2.5.9.3 | Signal to Noise Ratio (SNR) Measurement | 4.3.2.5.9.3 | | | | T | | | | | T | |
| 3.2.5.9.4 | Internal Bit Error Rate Test (BERT) | 4.3.2.5.9.4 | | | | T | | | | D | | |
| 3.3 | Management and Control (M&C) | 4.3.3 | | | D | | | | | | | N |
| 3.3.1 | M&C Objectives | 4.3.3.1 | | A | D | | | | | | | N |
| 3.3.2 | EDIM Modem System M&C Architecture | 4.3.3.2 | | | | | N | | | | | N |
| 3.3.2.1 | EDIM Modem Management Components | 4.3.3.2.1 | | | | T | | | | | | N |
| 3.3.2.1.1 | EDIM Modem Management System / Software (EMMS) | 4.3.3.2.1.1 | | A | D | T | | | | D | | |
| 3.3.2.1.2 | Operator Interface (OI) | 4.3.3.2.1.2 | I | A | D | T | | | | D | | |
| 3.3.2.2 | EDIM Modem | 4.3.3.2.2 | | | D | | | | | D | | |
| 3.3.3 | Site-Level Network Management System (NMS) | 4.3.3.3 | | | | | N | | | | | N |
| 3.3.4 | General Operation | 4.3.3.4 | | | | | N | | | | | N |
| 3.3.4.1 | M&C Roles | 4.3.3.4.1 | | | D | | | | | D | | |
| 3.3.4.2 | M&C Protocols | 4.3.3.4.2 | I | A | | | | | | | | N |
| 3.3.4.3 | Data Traffic Integrity | 4.3.3.4.3 | | | D | | | | | D | | |
| 3.3.4.4 | Contention Resolution | 4.3.3.4.4 | | | D | | | | | | | N |
| 3.3.4.5 | Configuration Integrity | 4.3.3.4.5 | | | D | T | | | | | | N |
| 3.3.4.6 | M&C Response Time | 4.3.3.4.6 | | | D | T | | | | | | N |
| 3.3.4.7 | Factory Default State | 4.3.3.4.7 | | | D | T | | | | | | N |
| 3.3.4.8 | Shutdown and Restart | 4.3.3.4.8 | | | D | | | | | | | N |
| 3.3.5 | Management Provisions | 4.3.3.5 | | | | | N | | | | | N |
| 3.3.5.1 | Power Control | 4.3.3.5.1 | | | D | T | | | | D | | |
| 3.3.5.2 | File Transfer | 4.3.3.5.2 | | | D | | | | | D | | |
| 3.3.5.3 | Authentication | 4.3.3.5.3 | | | D | | | | | | | N |

| Verification Cross Reference Matrix | | | | | | | | | | | | |
|-------------------------------------|--|-------------------------|-----|---|---|---|---|-----|---|---|---|---|
| Req Section | Title | Verification Section | FAT | | | | | PQT | | | | |
| | | | I | A | D | T | N | I | A | D | T | N |
| 3.3.5.4 | Multiple Modem Configuration Management | 4.3.3.5.4 | | | D | | | | | | | N |
| 3.3.5.5 | Situational Awareness | 4.3.3.5.5 | | A | D | | | | | | | N |
| 3.3.5.6 | Modem Suite Reporting | 4.3.3.5.6 | | | D | | | | | | | N |
| 3.4 | Cybersecurity | 4.3.4 | | A | D | T | | | | | | N |
| 3.4.1 | System Identification Profile | 4.3.4.1 | | A | | | | | | | | N |
| 3.4.2 | Identification and Authentication | 4.3.4.2 | | | D | T | | | | | | N |
| 3.4.3 | Confidentiality | 4.3.4.3 | | | D | | | | | | | N |
| 3.4.4 | Integrity | 4.3.4.4 | | | D | | | | | | | N |
| 3.4.5 | Availability | 4.3.4.5 | | | D | | | | | | | N |
| 3.4.6 | Access Control | 4.3.4.6 | | | D | | | | | | | N |
| 3.4.6.1 | Operator Roles | 4.3.4.6.1 | | | D | | | | | | | N |
| 3.4.6.2 | Password Policy | 4.3.4.6.2 | | | D | T | | | | | | N |
| 3.4.7 | Network Interfaces | 4.3.4.7 | | | D | | | | | | | N |
| 3.4.8 | M&C Components and Data Storage | 4.3.4.8 | | | D | | | | | | | N |
| 3.4.9 | Auditing and Non-Repudiation | 4.3.4.9 | | | D | | | | | | | N |
| 3.4.10 | Notification | 4.3.4.10 | | | D | | | | | | | N |
| 3.5 | Built-In Test (BIT) | 4.3.5 | | | | | N | | | | | N |
| 3.5.1 | Hardware Fault Detection | 4.3.5.1 | | A | D | | | | | D | | |
| 3.5.1.1 | Continuous Self-Test | 4.3.5.1.1 | | | D | | | | | D | | |
| 3.5.1.2 | Non-Disruptive Self-Test | 4.3.5.1.2 | | | D | T | | | | D | | |
| 3.5.1.3 | Disruptive Self-Test / Power-On Self-Test (POST) | 4.3.5.1.3 | | | D | T | | | | D | | |
| 3.5.2 | Alarms | 4.3.5.2 | | A | D | | | | | D | | |
| 3.5.2.1 | Major Alarms | 4.3.5.2.1 | | | D | | | | | D | | |
| 3.5.2.2 | Minor Alarms | 4.3.5.2.2 | | | D | | | | | D | | |
| 3.5.2.3 | Alarm Logging and Access | 4.3.5.2.3 | I | | D | | | | | D | | |
| 3.5.3 | Alarm Notifications | 4.3.5.3 | | | D | | | | | D | | |
| 3.6 | Physical Platform | 4.3.6 | | | | | N | | | | | N |
| 3.6.1 | Physical Platform Priorities | 4.3.6.1 | I | A | D | T | | | | | | N |
| 3.6.2 | Life Expectancy | 4.3.6.2 | | A | | | | | | | | N |
| 3.6.3 | Transportability | 4.3.6.3 | | | D | | | | | | | N |
| 3.6.4 | 19" Rack Mountable Enclosure Packaging | 4.3.6.4 | I | A | D | | | | | | | N |
| 3.6.4.1 | Front Panel | 4.3.6.4.1 | I | A | D | T | | | | | | N |
| 3.6.4.2 | Rear Panel | 4.3.6.4.2 | I | A | | | | | | | | N |
| 3.6.4.3 | Cooling | 4.3.6.4.3 | | A | | T | | | | | | N |
| 3.6.4.4 | AC Power and Power Transients | 4.3.6.4.4 | | | | | N | | | | | N |
| 3.6.4.4.1 | AC Power | 4.3.6.4.4.1 | | A | | T | | | | | | N |
| 3.6.4.4.2 | Power Transients | 4.3.6.4.4.2 | | | | T | | | | | | N |

| Verification Cross Reference Matrix | | | | | | | | | | | | |
|-------------------------------------|---|-------------------------|-----|---|---|---|---|-----|---|---|---|---|
| Req't Section | Title | Verification Section | FAT | | | | | PQT | | | | |
| | | | I | A | D | T | N | I | A | D | T | N |
| 3.6.5 | Electromagnetic Environmental Effects (E3) | 4.3.6.5 | | | | | N | | | | | N |
| 3.6.5.1 | Grounding, Bonding and Shielding | 4.3.6.5.1 | | A | | T | | | | | | N |
| 3.6.5.2 | Electromagnetic Compatibility (EMC) | 4.3.6.5.2 | | A | | | | | | | | N |
| 3.6.5.3 | Electromagnetic Interference (EMI) | 4.3.6.5.3 | | | | | N | | | | | N |
| 3.6.5.3.1 | Conducted Emissions | 4.3.6.5.3 | | A | | T | | | | | | N |
| 3.6.5.3.2 | Conducted Susceptibility | 4.3.6.5.3 | | A | | T | | | | | | N |
| 3.6.5.3.3 | Radiated Emissions (2 MHz to 18 GHz) | 4.3.6.5.3 | | A | | T | | | | | | N |
| 3.6.5.3.4 | Radiated Susceptibility | 4.3.6.5.3 | | A | | T | | | | | | N |
| 3.6.6 | Physical Environment | 4.3.6.6 | | | | | N | | | | | N |
| 3.6.6.1 | Non-Operating Physical Environment | 4.3.6.6.1 | | A | | T | | | | | | N |
| 3.6.6.2 | Operating Physical Environment | 4.3.6.6.2 | | A | | T | | | | | | N |
| 3.6.6.3 | Seismic Conditions | 4.3.6.6.3 | | | | T | | | | | | N |
| 3.6.7 | Reliability, Maintainability and Availability | 4.3.6.7 | | | | | N | | | | | N |
| 3.6.7.1 | Reliability | 4.3.6.7.1 | | A | | | | | | | | N |
| 3.6.7.2 | Maintainability | 4.3.6.7.2 | | A | D | | | | | | | N |
| 3.6.7.3 | Availability | 4.3.6.7.3 | | A | | | | | | | | N |
| 3.6.7.4 | FRACAS | 4.3.6.7.4 | | A | | | | | | | | N |
| 3.6.8 | Design and Construction | 4.3.6.8 | | | | | N | | | | | N |
| 3.6.8.1 | Manufacturing Considerations | 4.3.6.8.1 | | | | | N | | | | | N |
| 3.6.8.1.1 | Nameplates and Product Marking | 4.3.6.8.1.1 | I | | | | | I | | | | |
| 3.6.8.1.2 | Workmanship | 4.3.6.8.1.2 | I | | | | | I | | | | |
| 3.6.8.1.3 | Interchangeability | 4.3.6.8.1.3 | I | | D | | | I | | | | |
| 3.6.8.1.4 | Finish | 4.3.6.8.1.4 | I | | | | | I | | | | |
| 3.6.8.1.5 | Corrosion Control | 4.3.6.8.1.5 | | A | | | | | | | | N |
| 3.6.8.1.6 | Prohibited Materials | 4.3.6.8.1.6 | | A | | | | I | | | | |
| 3.6.8.1.7 | Electrostatic Discharge (ESD) | 4.3.6.8.1.7 | I | A | | T | | | | | | N |
| 3.6.8.2 | Safety | 4.3.6.8.2 | | A | | | | | | | | N |
| 3.6.8.2.1 | Electrical Safety | 4.3.6.8.2.1 | | | | | N | | | | | N |
| 3.6.8.2.1 a. | Exposure to voltages | 4.3.6.8.2.1 | | | | T | | | | | | N |
| 3.6.8.2.1 b. | Protection during maintenance | 4.3.6.8.2.1 | | | | T | | | | | | N |
| 3.6.8.2.1 c. | Capacitor discharge | 4.3.6.8.2.1 | | | | T | | | | | | N |
| 3.6.8.2.1 d. | Required voltages to measure | 4.3.6.8.2.1 | | A | | | | | | | | N |
| 3.6.8.2.1 e. | HV enclosure & interlock | 4.3.6.8.2.1 | | A | D | | | | | | | N |

| Verification Cross Reference Matrix | | | | | | | | | | | | |
|-------------------------------------|-------------------------------------|-------------------------|-----|---|---|---|---|-----|---|---|---|---|
| Req't Section | Title | Verification Section | FAT | | | | | PQT | | | | |
| | | | I | A | D | T | N | I | A | D | T | N |
| 3.6.8.2.1 f. | Power source interface & disconnect | 4.3.6.8.2.1 | I | | | | | | | | | N |
| 3.6.8.2.1 g. | Leakage currents | 4.3.6.8.2.1 | | | | T | | | | | | N |
| 3.6.8.2.1 h. | Connector selection & design | 4.3.6.8.2.1 | I | | | | | | | | | N |
| 3.6.8.2.2 | Mechanical Safety | 4.3.6.8.2.2 | | | | | N | | | | | N |
| 3.6.8.2.2 a | Maximum access and safety | 4.3.6.8.2.2 | | A | | | | | | | | N |
| 3.6.8.2.2 b | Mechanical stability | 4.3.6.8.2.2 | | | | T | | | | | | N |
| 3.6.8.2.2 c | Secure drawers and latching | 4.3.6.8.2.2 | I | | | | | | | | | N |
| 3.6.8.2.2 d | Safe temperatures | 4.3.6.8.2.2 | | | | T | | | | | | N |
| 3.6.8.2.2 e | Safe lifting | 4.3.6.8.2.2 | | A | D | | | | | | | N |
| 3.6.8.2.2 f | Power switch actuation guards | 4.3.6.8.2.2 | I | | | | | | | | | N |
| 3.6.8.2.2 g | Flush-mounted or recessed | 4.3.6.8.2.2 | I | | | | | | | | | N |
| 3.6.8.2.2 h | Captive-type fasteners | 4.3.6.8.2.2 | I | | | | | | | | | N |
| 3.6.8.2.3 | Laser Safety | 4.3.6.8.2.3 | I | A | | T | | | | | | N |
| 3.6.8.2.4 | Safety Markings and Labels | 4.3.6.8.2.4 | I | | | | | I | | | | |
| 3.6.8.2.5 | Environmental and Chemical Safety | 4.3.6.8.2.5 | | A | | | | | | | | N |
| 3.6.8.2.6 | General Safety Provisions | 4.3.6.8.2.6 | | | | | N | | | | | N |
| 3.6.8.2.6 a. | SW | 4.3.6.8.2.6 | | A | | | | | | | | N |
| 3.6.8.2.6 b. | Colors | 4.3.6.8.2.6 | I | | | | | | | | | N |
| 3.6.8.2.6 c. | Audible / visible warning | 4.3.6.8.2.6 | | | D | | | | | | | N |
| 3.7 | Provisions for Upgrade | 4.3.7 | | | | | N | | | | | N |
| 3.7.1 | Upgrade Process | 4.3.7.1 | | | D | | | | | | | N |
| 3.7.2 | Future Capabilities | 4.3.7.2 | | A | | | | | | | | N |
| 3.7.3 | Software and Firmware Portability | 4.3.7.3 | | A | | | | | | | | N |
| 3.8 | Precedence | 4.3.8 | | | | | N | | | | | N |

APPENDIX D Derivation of Sampling Noise PSD

This appendix derives the expression for DM Uplink Digitization Noise PSD, $N_{\text{Samp}}|_{\text{PTOT}}$, found in Section 3.2.5.7.3, and for sampling noise in general.

First consider average total signal power WRT full scale digitization amplitude:

$$P_{\text{TOT}}|_{\text{FS}} = -3.01 - 14.00 - 2.75 \text{ [dBFS]} = -19.76 \text{ dBFS}$$

where

- 3.01 dB = ratio of constant sinusoidal RMS power to peak amplitude
- 14.00 dB = generous peak/avg ratio assuming Gaussian amplitude distros
- 2.75 dB = practical implementation margin (arbitrary but generous)
- “FS” = full scale quantizer (D/A or A/D) amplitude

Also consider quantization noise PSD on the digitization scale:

$$N_{\text{Samp}}|_{\text{FS}} = -1.76 - 6.02 \text{ ENoB} - 10 \log_{10} R_{\text{Samp}} \text{ [dBFS/Hz]}$$

where

- 1.76 = average power of uniformly distributed quantization error
- 6.02 ENoB = dynamic range WRT effective bit count (6.02 dB per bit)
- ENoB = effective number of bits of sample depth
- R_{Samp} = sampling rate in samples per second (samp/s)
- dBFS/Hz = power spectral density (PSD) WRT FS quantization amplitude

Now divide the latter by the former:

$$\begin{aligned} N_{\text{Samp}}|_{\text{PTOT}} &= N_{\text{Samp}}|_{\text{FS}} - P_{\text{TOT}}|_{\text{FS}} \\ &= (-1.76 - 6.02 \text{ ENoB} - 10 \log_{10} R_{\text{Samp}}) \text{ dBFS/Hz} - (-19.76 \text{ dBFS}) \\ &= 18 - 6.02 \text{ ENoB} - 10 \log_{10} R_{\text{Samp}} \text{ [dBPTOT/Hz]} \end{aligned}$$

where

18 scales quantization amplitude WRT total power subject to Gaussian amplitude distribution of carrier envelope plus margin

ENoB = effective number of bits of sample depth

R_{Samp} = sampling rate in samp/s

$\text{dBP}_{\text{TOT}}/\text{Hz}$ = PSD WRT total digitized power over a Hz frequency scale

Hence sampling noise N_{Samp} , reasonably upper-bounded WRT total power P_{TOT} , as a function of effective sample depth ENoB in bits per sample at a sample rate of R_{Samp} in samples per second.

$$N_{\text{Samp}}|_{P_{\text{TOT}}} = 18 - 6.02 \text{ ENoB} - 10 \log_{10} R_{\text{Samp}} \text{ [dBP}_{\text{TOT}}/\text{Hz}]$$