G-6 Directorate
Communications and Information Systems

Marine Air Ground Task Force Training Command, Marine Corps Air Ground Combat Center

Telecommunications Design Standards

United States Marine Corps Base
Twentynine Palms, CA 92278

EXECUTIVE SUMMARY

This document establishes the telecommunications design standards to be used as the baseline requirements for all equipment and components installed and integrated into the telecommunications infrastructure as directed by the G-6 Directorate, Communications and Information Systems, at the Marine Air Ground Task Force Training Command, Marine Corps Air Ground Combat Center. This document also addresses waiver requests and identifies the authorities commissioned to grant such exemptions. This document however does not provide procedural guidance, nor does it provide health, safety, and environmental guidelines.

NOTE: All deviations from the standards defined in this document shall be submitted to the G-6 for its written approval.

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REFERENCES

This document cannot attempt to replace the publications that have been produced to support the design of Department of Defense (DoD) telecommunications systems for military construction. All codes, standards, and specifications stated herein shall be considered the minimum requirements and implemented in order to provide a seamless integration of new equipment and components into the telecommunications infrastructure aboard at the Marine Air Ground Task Force Training Command (MAGTFTC), Marine Corps Air Ground Combat Center (MCAGCC); hereinafter referred to as the *Combat Center*. The references listed—while not necessarily all of the documents for the required standards—provide additional guidance. Where requirements conflict, the most stringent shall govern. If the standard sought does not appear in these requirements, contact the G-6's Operations Division for guidance.

The publications listed herein form a part of this document to the extent referenced and are referred to in the text by the basic designation only.

A registered communications distribution designer (RCDD), a DoD requirement, must have the ability to design, integrate, and implement information and communications technology and related infrastructure components across multiple disciplines and applications; therefore, they must have the requisite knowledge, skills, and abilities when working with DoD standards.

NOTE: References listed herein may have been superseded or deemed obsolete by their respective issuing authorities since the release of this publication; however, the publication may still apply to the most recent version of a code, standard, specification, or regulation listed in this document, and may therefore remain hereinafter.

Document No.	Document Title	Revision/Date
7 CFR 1755.200	RUS Standard for Splicing Copper and Fiber Optic Cables	e-CFR data is current as of 9 Oct 2015.
7 CFR 1755.390	RUS Specification for Filled Telephone Cables	e-CFR data is current as of 9 Oct 2015.
7 CFR 1755.910	RUS Specification for Outside Plant Housing and Serving Area Interface Systems	e-CFR data is current as of 9 Oct 2015.
ASTM B1	Standard Specification for Hard-Drawn Copper Wire	2013 Ed., Oct 2013
ASTM B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft	2011 Ed., Apr 2011
ASTM D709	Laminated Thermosetting Materials	2013 Ed., Nov 2013
ASTM E814	Standard Test Method for Fire Tests of Penetration Firestop Systems	Rev 2013A, Dec 2013
ASTM D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 [2,700 kN-m/ m^3])	12th Ed., May 2012
ECIA EIA/ECA 310-E	Cabinets, Racks, Panels, and Associated Equipment	2005

Document No.	Document Title	Revision/Date
ICEA S-80-576	Standard for Category 1 & 2 Individually Unshielded Twisted Pair Indoor Cables (With or Without an Overall Shield) for Use in Communications Wiring Systems Technical Requirements	Jan 2012
ICEA S-87-640	Fiber Optic Outside Plant Communications Cable	Jan 2011; 5th Ed.
ICEA S-98-688	Broadband Twisted Pair, Telecommunications Cable, Aircore, Polyolefin Insulated, Copper Conductors Technical Requirements	Jan 2012
ICEA S-99-689	Broadband Twisted Pair Telecommunications Cable Filled, Polyolefin Insulated, Copper Conductors Technical Requirements	Jan 2012
IEEE C2	National Electrical Safety Code	2012; Errata 2012; INT 1-4 2012; INT 5-7; INT 8-10 2014; INT 11 2015
IEEE Stds Dictionary	IEEE Standards Dictionary: Glossary of Terms & Definitions	2009
NEMA ANSI C62.61	American National Standard for Gas Tube Surge Arresters on Wire Line Telephone Circuits	Jan 1993
NEMA Standards Publication WC 63.1-2005	Performance Standard for Twisted Pair Premise Voice and Data Communications Cables	2005
NFPA 70	National Electrical Code	2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014
RUS Bull 345-50	Trunk Carrier Systems (PE-60)	Sept 1979
RUS Bull 345-65	Shield Bonding Connectors (PE-65)	Mar 1985
RUS Bull 345-72	Filled Splice Closures (PE-74)	Oct 1985
RUS Bull 345-83	Gas Tube Surge Arrestors (PE-80)	1979; Rev Oct 1982
RUS Bull 1751F-630	Design of Aerial Plant	Jan 1996
RUS Bull 1751F-640	Design of Buried Plant, Physical Considerations	Mar 1995
RUS Bull 1751F-643	Underground Plant Design	Aug 2002
RUS Bull 1751F-815	Electrical Protection of Outside Plant	May 1995
RUS Bull 1753F-201	Acceptance Tests of Telecommunications Plant (PC-4)	Aug 1997
RUS Bull 1753F-401	Splicing Copper and Fiber Optic Cables (PC-2)	Mar 1995
RUS 1755	Telecommunications Standards and Specifications for Materials, Equipment and Construction	1 Jan 1999
SSPC SP 6/NACE No. 3	Commercial Blast Cleaning	2007

Document No.	Document Title	Revision/Date
TIA-222	Structural Standards for Antenna Structures and Antennas	Rev G, Dec 2012; Add 4, Dec 2014
TIA-455	General Requirements for Standard Test Procedures for Optical Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components	Rev C, Aug 2014
TIA-455-21	FOTP-21 Mating Durability of Fiber Optic Interconnecting Devices	Rev A, Nov 1988; R Jan 2012
TIA-455-78	FOTP-78 Optical Fibers – Part 1-40: Measurement Methods and Test Procedures – Attenuation	Rev B, Nov 2002
TIA-455-107	FOTP-107 Determinations of Component Reflectance or Link/System Return Loss Using a Loss Test Set	Rev A, Mar 1999
TIA-455-204	FOTP-204 Measurement of Bandwidth on Multimode Fiber	Rev A, Dec 2000
TIA-472D000	Sectional Specification (Adopted ANSI/ICEA S-87-640-2006) Standard for Optical Fiber Outside Plant Communications Cable	Rev B, July 2007
TIA-492AAAA	Detail Specification for 62.5-µm Core Diameter/125-µm Cladding Diameter Class 1a Graded-Index Multimode Optical Fibers	Rev B, Nov 2009
TIA-492AAAB	Detail Specification for 50-µm Core Diameter/125-µm Cladding Diameter Class IA Graded-Index Multimode Optical Fibers	Rev A, Nov 2009
TIA-492CAAA	Detailed Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers	May 1998; R Sept 2002
TIA-492E000	Sectional Specification for Class IVd Nonzero-Dispersion Single-Mode Optical Fibers for the 1550 nm Window	Nov 1996; R Sept 2002
TIA-526-7	Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant, Adoption of IEC 61280-4-2 edition 2: Fibre-Optic Communications Subsystem Test Procedures – Part 4-2: Installed Cable Plant – Single-Mode Attenuation and Optical Return Loss Measurement	Rev A, July 2015
TIA-526-14	Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant; Modification of IEC 61280-4-1 edition 2, Fiber-Optic Communications Subsystem Test Procedures- Part 4-1: Installed Cable Plant-Multimode Attenuation Measurement	Rev C, Apr 2015
TIA-568.0-D	Generic Telecommunications Cabling for Customer Premises	Sept 2015
TIA-568.1-D	Commercial Building Telecommunications Infrastructure Standard	Sept 2015
TIA-568-C.2	Balanced Twisted-Pair Telecommunications Cabling and Component Standards	Aug 2009; Errata 2010; Add 2 2014

Document No.	Document Title	Revision/Date
TIA-568-C.3	Optical Fiber Cabling Components Standard	June 2008; Add 1 2011
TIA-569	Telecommunications Pathways and Spaces	Rev D, Apr 2015
TIA-590	Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant – ANSI APPROVAL WITHDRAWN JUNE 2003	Rev A, Jan 1997
TIA-598	Optical Fiber Cable Color Coding	Rev D, July 2014
TIA-606	Administration Standard for the Telecommunications Infrastructure	Rev B, June 2012
TIA-607	Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises	Rev B, Aug 2011
TIA-758	Customer-Owned Outside Plant Telecommunications Infrastructure Standard	Rev B, Mar 2012
TIA-942	Telecommunications Infrastructure Standard for Data Centers	Rev A, Mar 2014
UFC-4-133-01N	Navy Air Traffic Control Facilities with Changes 4-5	July 2007
UFGS Section 01 78 23	Operation and Maintenance Data	July 2006
UFGS Section 26 00 00.00 20	Basic Electrical Materials and Methods	July 2006
UFGS Section 27 10 00	Building Telecommunications Cabling System	Aug 2011
UFGS Section 33 71 02	Underground Transmission and Distribution	Feb 2015
UL 83	Thermoplastic-Insulated Wires and Cables	Mar 2014
UL 444	Communications Cables	2008; Reprint Apr 2015
UL 467	Grounding and Bonding Equipment	2007
UL 497	Standard for Protectors for Paired Conductor Communication Circuits	2001; Reprint July 2013
UL 510	Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape	2005; Reprint July 2013
UL 514C	Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers	2014, Reprint Dec 2014
UL 969	Standard for Marking and Labeling Systems	1995; Reprint Sept 2014
UL 1286	Office Furnishings	2008; Reprint Feb 2015
UL 1666	Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts	2007; Reprint June 2012
UL 1863	Communication Circuit Accessories	2004; Reprint Nov 2012

CHAPTER 1. INTRODUCTION

1.1 Purpose

This document, published as an enclosure to Combat Center Order (CCO) 2010.1A, *Telecommunications Design Standards*, establishes the baseline requirements for all equipment and components to be installed and integrated into the telecommunications infrastructure as required by the G-6 Directorate, Communications and Information Systems, at the Combat Center. While most standards were created using Unified Facilities Guide Specifications (UFGSs), others are unique or tailored UFGSs to mitigate the risks associated with the extreme topographical and climatological conditions experienced at the Combat Center. This document also addresses waiver requests and identifies the authorities commissioned to grant such exemptions. This document however does not provide guidance on:

- standard operating procedures;
- Federal, State, and local health, safety, and environmental laws and regulations; and
- protective distribution systems that safeguard Secret Internet Protocol Router Network communications systems.

For clarification of the standards described throughout this document, contact the G-6's Operations Division. **NOTE**: All deviations from this document shall be submitted to the G-6 for its written approval.

1.2 Scope

This document applies to all persons in the provision of telecommunications products and services as directed by the G-6. In addition, all telecommunications work performed aboard the Combat Center shall be in compliance with:

- DoD, United States (U.S.) Navy (USN), and U.S. Marine Corps (USMC) Information Assurance (IA)/Cybersecurity directives and orders;
- Federal, State, and local health, safety, and environmental laws, regulations, and guidelines; and
- DoD, USN, and USMC operational security policies and procedures.

Prior to the commencement of telecommunications work, all designs and submittals shall be approved by a Building Industry Consulting Service International (BICSI) RCDD for all projects.

CHAPTER 2. ADMINISTRATIVE REQUIREMENTS

2.1 Contractor or Vendor Support

Telecommunications infrastructure and information system services and products provided by telecommunications contractors, hereinafter referred to as the *Contractor*, and commercial vendors shall comply with all requirements and references listed herein, including CCO 5239.2B; *Marine Air Ground Task Force Training Command (MAGTFTC), Marine Corps Air Ground Combat Center (MCAGCC) Cybersecurity.*

2.2 Contractor Damage

In every event of Contractor-inflicted damage, the Contractor shall immediately notify the Contracting Officer and the G-6 of the damage. Repairs shall be done posthaste, before work continues. Promptly repair indicated utility lines or systems that are damaged throughout the course of work being performed. Damage to lines or systems not indicated, which are caused by Contractor operations, shall be treated as *changes* under the terms of the contract clauses. When the Contractor is advised in writing of the location of a non-indicated line or system, such notice shall provide that portion of the line or system with *indicated* status in determining the liability for damages.

2.3 Telecommunications Qualifications

The approved Contractor shall provide qualified personnel to perform work under this section and provide the equipment used. Qualifications of work shall be provided for the telecommunications system contractor, the telecommunications system installer, the supervisor (if different from the installer), and the cable splicing and terminating personnel. At a minimum of 30 days prior to installation, the Contractor shall submit documentation to the Contracting Officer listing their experience as well as that of the key personnel.

Qualified personnel are defined as those with the knowledge, skills, and abilities that have been certified in the field of telecommunications. Various entities provide certification, including the Telecommunications Industry Association (TIA), BICSI, the Fiber Optic Association (FOA), the Centre National d'Études des Télécommunications (CNET), and the Electronics Technicians Association (ETA) International.

Examples of certifications are as follows:

- Certified Fiber Optic Technician (CFOT). The FOA certification for general fiber optics applications. CFOTs have appropriate knowledge, skills, and abilities in fiber optics that can be applied to almost any job (e.g., design, installation, operation), for almost any application (e.g., outside plant [OSP], premises, manufacturing).
- Certified Premises Cabling Technician. The FOA certification for designers, installers, and operators of premises cabling networks. Certification includes all types of infrastructure for premises cabling and communications (e.g., copper and fiber cabling, wireless systems).

- Certified Network Cable Installer (CNCI). The CNET program and certification that shows an individual has the knowledge and skills to confidently install, test, and certify a complete copper and fiber cable installation.
- Certified Draka UC Connect-Approved Installer. A trained individual who has successfully completed the program covering copper and fiber optic installation practices as prescribed by Draka.
- BICSI Information Technology (IT) Systems (ITS) Installers and Technicians. Installers and technicians proficient in the ITS industry standards and code requirements, and in various topics that include the pulling, terminating, testing, and troubleshooting of copper and optical fiber using BICSI global best practices.

ETA International represents a wide variety of professionals from many industries, including data cabling, fiber optics, and wireless communications. ETA's certification program criteria and testing benchmarks conform to the highest international electronics standards.

2.3.1 Contractor

The Contractor shall:

- be a firm that is regularly and professionally engaged in the business of the application, installation, and testing of specified telecommunications systems and equipment;
- demonstrate experience in providing successful telecommunications systems that include OSP and broadband cabling within the past three years; and
- submit documentation for a minimum of three and a maximum of five successful telecommunications system installations to the Contracting Officer. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past three years in accordance with (IAW) TIA-758.

NOTE: All contractors must comply with current IA/Cybersecurity, Federal Information Systems Management Act (FISMA), and Combat Center policies.

2.3.2 Key Personnel

Provide key personnel who are regularly and professionally engaged in the application, installation, and testing of the specified telecommunications systems and equipment required by the design. Key personnel are defined the same as qualified personnel listed in paragraph 2.3. There may be one or more key persons proposed for this solicitation depending on the key roles each has successfully provided. Each key person shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Cable splicing and terminating personnel assigned to the installation of this system or any of its components shall have training in the proper techniques required for the work and have a minimum 3 years of experience in splicing and terminating the specified cables. Modular splices

shall be performed by factory-certified personnel or under the direct supervision of factory-trained personnel for the products used.

Supervisors and installers assigned to the installation of this system or any of its components shall have factory or factory-approved certification from each equipment manufacturer indicating that they are qualified to install and test the products provided.

The Contractor shall submit documentation to the Contracting Officer for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include:

- at least two successful system installations provided that are equivalent in system size and construction complexity to the telecommunications system proposed for the solicitation;
- specific experience in the installation and testing of telecommunication OSPs, including broadband cabling; and
- the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling systems.

All telecommunications system installations offered by key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for the solicitation. Provide:

- the name and role of the key person;
- the title, location, and completed installation date of the referenced project;
- the referenced project owner point of contact information (i.e., name, organization, title, telephone number); and
- a general description of the referenced project that identifies the system's size and the complexity of construction, if applicable.

Indicate that all key persons are currently employed by the Contractor or have a commitment to the Contractor to work on the project. All key persons shall be employed by the Contractor at the date of issuance of the solicitation or, if not, have a commitment to the Contractor to work on the project by the date that the bid was due to the Contracting Officer.

NOTE: Only key personnel approved by the Contracting Officer in the successful proposal shall perform the work on the solicitation's telecommunications system. Key personnel shall function in the same roles in the contract as they functioned in the successful experience offered. Substitutions for key personnel require Contracting Officer approval before substitutions can be made.

2.4 Standard Products

Provide materials and equipment that are standard products of manufacturers that are regularly engaged in the production of such products. Products—which are of equal material, design, and workmanship—shall be manufacturers' latest standard designs that have been in satisfactory commercial or industrial use for a minimum of 2 years prior to bid opening. The 2-year period shall include the applications of equipment and materials under similar circumstances and be of similar size, while the products shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures.

Products supplied shall be specifically designed and manufactured for use with telecommunications systems. Where two or more items of the same class of equipment are required, these items shall be the products of a single manufacturer. All products installed shall be approved by the G-6.

2.5 Alternative Qualifications

Products having a field service record of less than 2 years will be acceptable if a certified record of satisfactory field operation is provided for a minimum of 6,000 hours—exclusive of the manufacturer's factory or laboratory tests. All products installed shall be approved by the G-6.

2.6 Material and Equipment Manufacturing Date

Products manufactured 3 years or later prior to the date of the products being delivered to the site shall not be used unless approved by the G-6.

2.7 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word *shall* has been substituted for *should* wherever it appears. Interpret references in these publications to the *authority having jurisdiction*, or words of similar meaning, to mean the *Contracting Officer*. Equipment, materials, installation, and workmanship shall be IAW the mandatory and advisory provisions of National Fire Protection Association (NFPA) 70 unless more stringent requirements are specified by the G-6.

2.8 Delivery, Storage, and Handling

For all real estate assigned either for storage or operations aboard the Combat Center, Public Works Division (PWD) approval shall be obtained. In addition, the following requirements apply:

- Cables shall be delivered in standard reel lengths IAW the manufacturer's pair count for copper cable and the strand count for fiber optic cable.
- Both cable ends shall be accessible for testing.

- A permanent, water-resistant label shall be attached to each reel indicating—in indelible writing—length, the cable identification number, cable size and type, and the date of manufacture.
- Cables shall be factory-sealed to prevent moisture from entering the cable.
- Reels with cable shall be suitable for outside storage conditions when temperatures range from minus 40 degrees Fahrenheit (°F) to plus 149 °F (metric: minus 40 degrees Celsius [°C] to plus 65 °C), with relative humidity from 0 to 100 percent.
- Equipment other than cable that is delivered and placed in storage shall be stored in such a manner to protect it from weather, humidity, and temperature variations as well as dirt, dust, other contaminants, rodents, and other animals IAW manufacturers' requirements.

2.9 Record Documentation

Provide record documentation as specified in UFGS Section 27 10 00 or as required by the G-6. Final reports and other text documents shall be provided in Microsoft® Word 2010 format and Adobe® Portable Document Format (PDF). Spreadsheet files shall be provided in Microsoft® Excel® 2010 format. All text and spreadsheet files shall be delivered on a compact disc read-only memory (ROM), digital versatile disc ROM, or portable external hard drive—all of which would require scanning by Cybersecurity for viruses and malware.

2.9.1 Telecommunications Drawings

Provide RCDD-approved drawings to the G-6 in electronic (i.e., AutoCAD and Adobe® PDF) and hard copy formats and IAW TIA-606. The identifier for each termination and cable shall appear on the drawings. Drawings shall depict final telecommunications-installed wiring system infrastructure. The drawings should provide details required to prove that the distribution system shall properly support connectivity from the entrance facility (EF) telecommunications and entrance room (ER) telecommunications to the telecommunications work area outlets. Depict the EF and layout of cabling and pathway runs, the distribution frame, cross-connect points, the single-point ground system, and terminating block arrangements.

Drawings shall depict the final telecommunications cabling configuration, including the location of the terminating blocks layout at cross-connect points and patch panels after telecommunications cable installation. Drawings will include cable types and termination hardware. The final package shall be a single complete and accurate set of record documentation for the entire telecommunications system with respect to each specific project. Telecommunications drawings consist of the following types as well as a Telecommunications Change Sheet:

- T0. Campus or site plan (i.e., exterior pathways and inter-building backbone cable and pathways).
- T1. Layout of a complete building per floor - building area/serving zone boundaries, backbone systems, structural cabling system and horizontal pathways. These drawings depict the location of building areas, serving zones, vertical backbone diagrams,

telecommunications rooms (TRs), access points, pathways, the grounding system, and other systems that need to be viewed from the complete building perspective.

- T2. Serving zones/building area drawings – drop locations and cable identifications. These drawings depict the building area and the serving zone within the building as well as depict drop locations, TRs, access points, and detail call-outs for common equipment rooms and other congested areas.
- T3. Telecommunications equipment rooms (i.e., plan views of telecommunications racks, walls, equipment and power, plumbing elevations ([racks and walls]). The drawings shall be provided for an EF's telecommunications IAW TIA-606. Drawings shall include pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, cabinets, racks, backboards, and wall elevations. Drawings shall show layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks, patch panels, equipment spaces, and cabinet/racks. Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings.
- T4. Typical Detail Drawings - Faceplate Labeling, Firestopping, Americans with Disabilities Act, Safety, and the Department of Transportation. These drawings depict detailed drawings of symbols and typicals such as faceplate labeling, faceplate types, faceplate population installation procedures, detail racking, and raceways.
- T5. These drawings depict schedule information for cutover and cable plant management, maintenance hole, and conduit pathways (to include Geographic Information Systems coordinates), patch panel layouts and cover plate assignments, cross-connect information, and connecting terminal layout as a minimum. Provide T5 drawing documentation listed in paragraphs 2.9.2.1 and 2.9.2.2.

2.9.2 Cables

A record of installed cable shall be provided IAW TIA-606. The cable records shall include the required data fields for each cable and a complete end-to-end circuit report for each complete circuit from the assigned outlet to the EF IAW TIA-606. Include the manufacture date of cable with the submittal.

2.9.2.1 Copper

Records for copper cable shall include cable specification sheets from the manufacturer, cable routing and locations, all splice-point locations, patch panel and jack locations, cable lengths, cable reel numbers and installation locations, and test results in both hard and soft copy.

2.9.2.2 Fiber Optic

Records for fiber shall be consistent with the requirements listed for copper in paragraph 2.9.2.1.

2.9.3 Termination Hardware

A record of installed patch panels, cross-connect points, distribution frames, terminating block arrangements and type(s), and outlets shall be provided IAW TIA-606.

2.9.4 Spare Parts

In addition to the requirements of UFGS Section 01 78 23, provide a complete list of parts and supplies that includes current unit prices and sources of supply as well as a list of spare parts recommended for stocking.

2.10 Warranties

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

2.11 Submittals

The submittals listed in Table 2-1 shall be provided IAW UFGS Section 01 33 00 and IAW Combat Center geospatial information and services standards. All electronic submissions shall be formatted and configured in such a way as to allow direct import to the G-6 Master File. Additional submittal requirements of material, equipment, and design must be approved by the Assistant Chief of Staff (AC/S) G-6.

Table 2-1. List of Submittals

Category	Artifacts
SD-02 Shop Drawings	• Telecommunications drawings • Grounding and bonding drawings • Cable tray drawings • ISP distribution • OSP distribution • Seismic drawings • Distribution frames • Rack elevations • Telecommunications OSP • Telecommunications cabling and pathway drawings • EF drawings (includes ac or dc connects) • TR/Comm room drawings (includes ac or dc connects)

Category	Artifacts
SD-03 Product Data	• Telecommunications cabling (backbone and horizontal) • Patch panels (fiber optic and copper) • All types of wire and cable • Cable splices and connectors • Splice closures • Cross-connect terminal cabinets (fiber optic and copper) • All infrastructures (e.g., conduits, maintenance holes, hand holes, poles, towers, support cables, mounting brackets) • Seismic parts and system applications • Spare parts • Telecommunications outlet/connector assemblies • Equipment support frame • Building protector assemblies • Connector blocks • Protector modules • Grounding and bonding (cabling and connector assemblies) • All components that comprise of a telecommunications system
SD-06 Test Reports	• Telecommunications cabling testing • Grounding tests • System performance tests • Factory reel tests • Load test for infrastructure • Load tests and burn-in results for systems
SD-07 Certificates	• Contractor qualifications • IA compliancy • FISMA compliancy • Manufacturer qualifications • Radio Frequency Spectrum compliance certifications • Test plan(s)
SD-08 Manufacturer's Instructions	• Building protector assembly installation • Cable tensions • Seismic applications • Grounding and/or bonding systems • Fiber optic splices • Submit instructions prior to installation.
SD-10 O&M Data	• Telecommunications cabling and pathway system • System O&M procedures • Submit O&M data IAW UFGS Section 01 78 23 as specified herein and/or as designated by the AC/S G-6.
SD-11 Closeout Submittals	Record documentation

2.12 Labeling

All equipment and components shall be labeled as described in paragraphs 2.12.1–2.12.8. Visibility, durability, size, color, and contrast of all labeling products should be selected to ensure that the identifiers are easily readable and produced using the thermal ink transfer process or a laser printer.

Labels should be:

- visible during installation and normal maintenance of the infrastructure,
- resistant to the environmental conditions (e.g., moisture, heat, ultraviolet light) at the point of installation, and
- of a design life equal to or greater than that of the labeled component.

All conduits—whether empty or used—shall be clearly and permanently marked at both ends to indicate destination. Markings must be clearly visible after construction ends. **NOTE:** All labels shall be generated by a mechanical device.

2.12.1 Building Entrance Terminals

Label each BET by cable name (e.g., ACO 50) and pair count range (e.g., 1701–1750). Use black-on-yellow reflective letters and numbers with a 1-inch letter height. For an example, see Figure 2-1.

Figure 2-1. BET Labels – Example

2.12.2 Racks

Label each rack (e.g., Rack 2) on the uppermost crossbeam of the frame in front of the rack, in sequential order starting from the first rack on the left in an arrangement of two or more racks. For an example, see Figure 2-2.

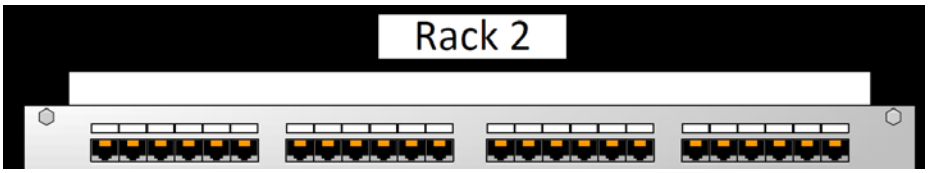

Figure 2-2. Rack Label – Example

2.12.3 Patch Panels

2.12.3.1 Copper

Label each panel sequentially (e.g., PP1, PP2, PP3) to the left of the ports. Label each port with the room number and the voice or data jack number (e.g., 205-D1 for the first data port in the example in Figure 2-3), with identifiers separated by a hyphen.

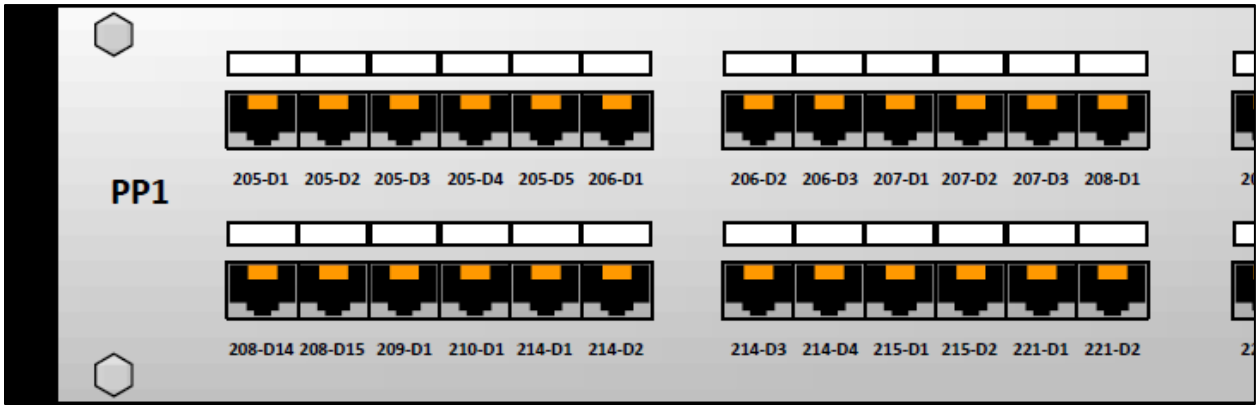

Figure 2-3. Copper Patch Panel Label – Example

2.12.3.2 Fiber Optic

For cabling terminated on a fiber optic patch panel (i.e., light interface unit [LIU]), label each patch panel with the building number, cable name, and number of strands terminated (e.g., Building [Bldg.] 1981, FOC-1981-C, 1-72). For cabling run out, create a label with the strand count, followed by the building to which the cables are being run (e.g., 37-48 to Bldg. 1825). For an example, see Figure 2-4.

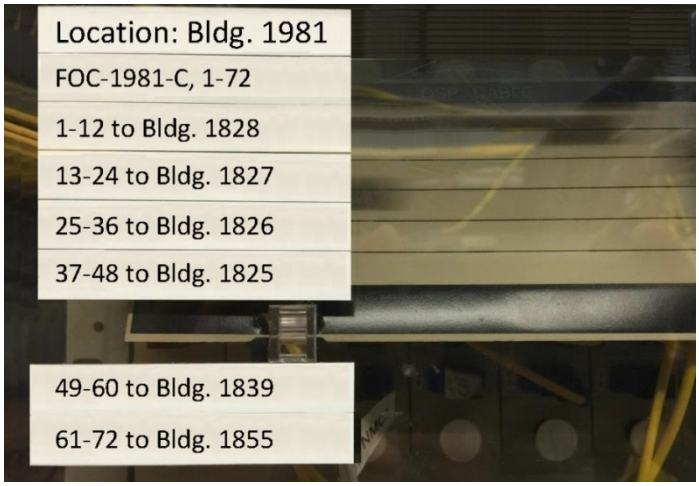

Figure 2-4. Fiber Optical Patch Panel – Example

2.12.4 Adapter Modules

Label each adapter module by configuration type as depicted in Figure 2-5.

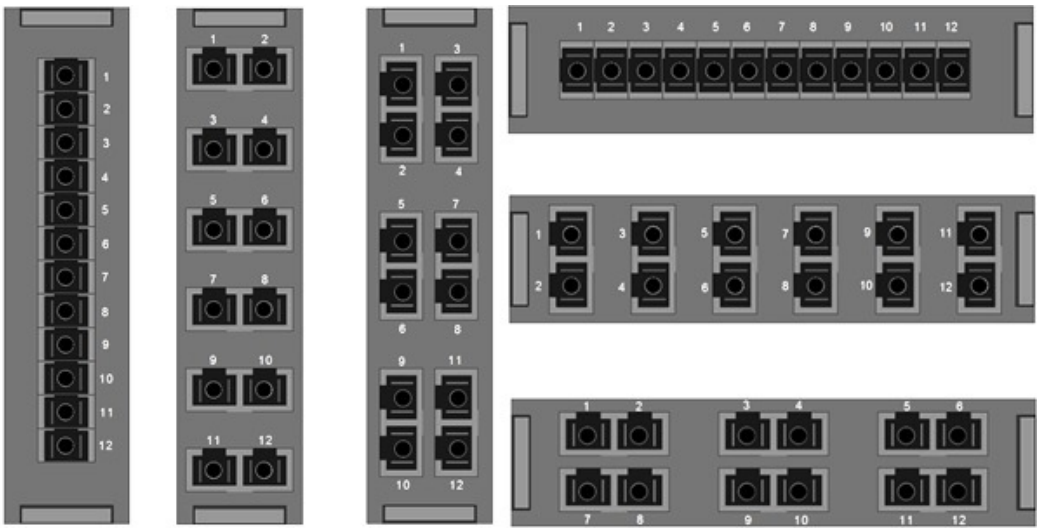

Figure 2-5. Adapter Modules – Examples

2.12.5 Faceplates

Label each faceplate as follows:

- Top label: Label with the building number, room number, and corresponding voice/data port number, with identifiers separated by a hyphen. **NOTE:** Voice jacks are white and data jacks are red.
- Bottom label: Label with the telecommunications/Communications (Comm) room number, rack number, and patch panel number, with identifiers separated by a hyphen. For an example, see Figure 2-6.

Figure 2-6. Faceplate – Example

Figure 2-7 depicts the correlation of the labeling conventions applied to Figure 2-6.

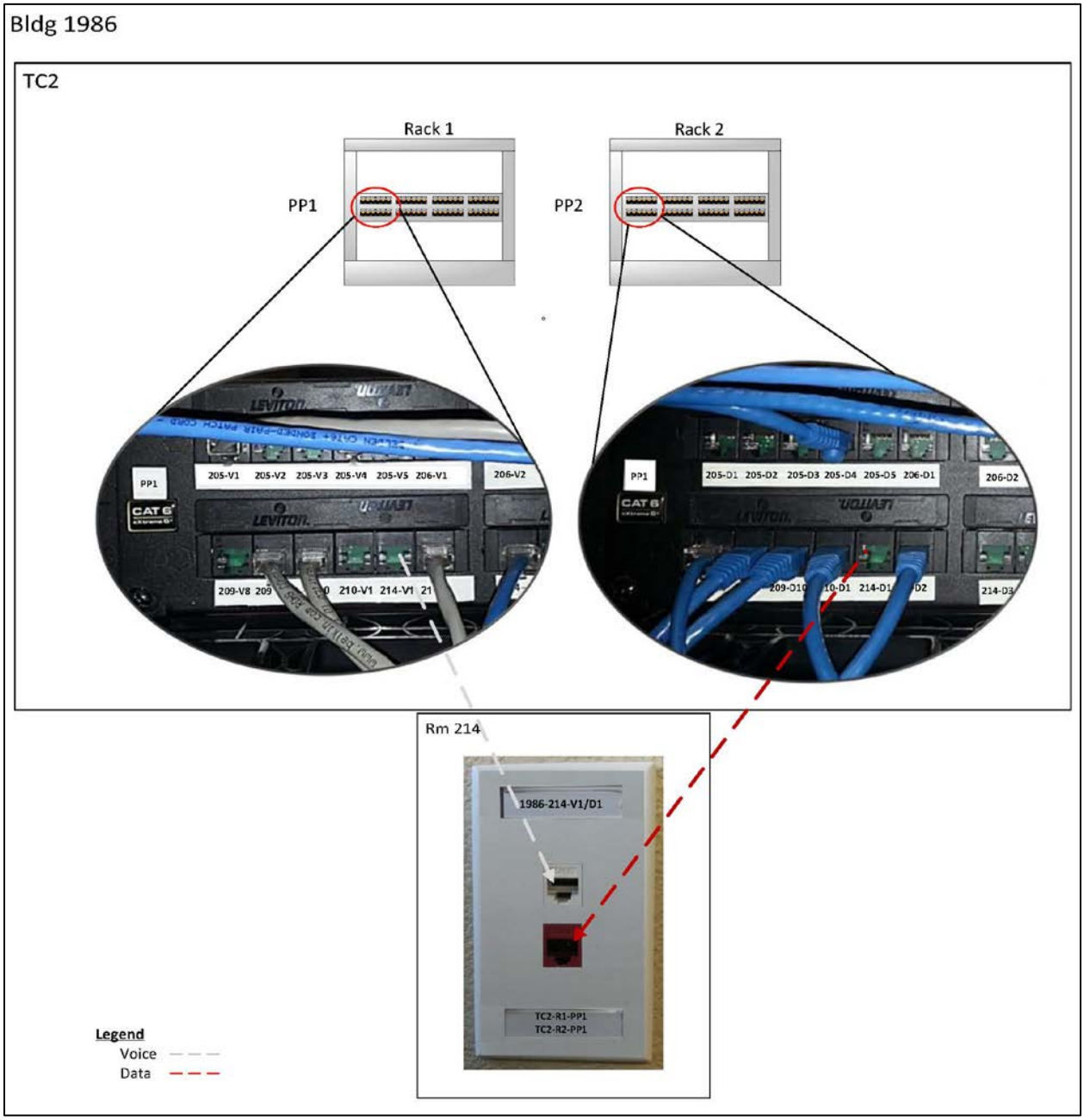

Figure 2-7. Correlation between Labels – Example

2.12.6 Cables - Fiber Optic and Copper OSP Telephone

Label each telephone cable by cable name, pair/strand count, and cut dead (XD). For an example, see Figure 2-8.

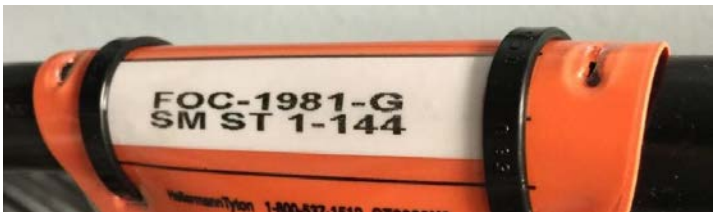

Figure 2-8. Fiber Optic OSP Telephone Cable Label – Example

NOTE: This labeling convention is applicable to both copper and fiber optic cabling.

2.12.7 Firestopping

Label all firestopping with *Installed by* or *Re-entered by* information, at a minimum. For labeling conventions, see Table 2-2.

Table 2-2. Firestopping Label Information

Installed by (enter company name)	Re-entered by (enter company name)
Date (mm/dd/yy)	Date (mm/dd/yy)
Technician (first and last name)	Technician (first and last name)
UL System No.	State License No.
Cables installed (type and number)	Cables installed (type and number)

For an example of the labeling convention applied, see Figure 2-9.

Figure 2-9. Firestopping Label – Example

2.12.8 Electrical Outlets

Label electric outlets with the type of circuit the outlet supports, the amperage, the panel designation, and the breaker number.

For an example of a three-wire, 20 ampere (A), dedicated data circuit (DDC), 120 Vac (non-switchable), quadraplex electrical outlet that is connected to the 21st breaker in Panel L1DA, see Figure 2-10.

Figure 2-10. Dedicated Outlet Labels – Example

CHAPTER 3. GROUNDING AND BONDING

3.1 General

Grounding and bonding shall comply with the current Underwriter Laboratories (UL) 467, TIA-607, and NFPA 70. Components shall be identified as required by TIA-606 and TIA-607. The designer should verify the existence of grounding facilities. It is essential that all grounding facilities—new and existing—conform to the standards. TIA-607 provides telecommunications grounding practices and acceptable electrical characteristics. **NOTE:** Ground rods shall not be used in buildings that support telecommunications.

Provide grounding and bonding conductors IAW 7 Code of Federal Regulations (CFR) 1755.200, American Society for Testing and Materials (ASTM) B1, Institute of Electrical and Electronics Engineers (IEEE) C2, and NFPA 70. For grounding and bonding conductors within EFs and/or TRs, they shall be green, sheathed copper conductors—either stranded or solid—and labeled as suitable for use as such and tagged “DO NOT REMOVE”. Insulated conductors shall have 600 volt (V), Type TW insulation that meet the requirements of UL 83.

Ground wire shall be no smaller than No. 6 American Wire Gauge (AWG) (0.16 inch or 4.1 millimeter [mm]). Direct attachment shall be to the closest point in the building’s electrical service grounding electrode system.

EFs and/or TRs will be equipped with a copper grounding busbar (GBB) that is 4 long by 10 wide inches by a quarter inch thick and permanently bonded to the electric service entrance panel IAW current National Electrical Code (NEC) standards. **NOTE:** Prior to installation, PWD shall approve all ground systems/configurations.

3.2 Grounding Busbar

GBBs shall be drilled with parallel holes to accommodate two-hole lugs. All GBBs will be located as to not interfere with telecommunications cabling or technician workspace. All connectors used for grounding and bonding within TRs shall be two-hole lugs that are double-crimped (compression) or welded (exothermic) to the conductor. For examples, see Figure 3-1.

Figure 3-1. GBB and Two-Hole Lugs – Examples

3.3 Telecommunications Main Grounding Bar

The telecommunications main grounding busbar (TMGB) is the hub of the basic telecommunications grounding system, providing a common point of connection for grounding from the outside cable, campus distributor (CD), and equipment. Establish a TMGB as a connection point for cable stub shields to CD protector assemblies as specified by the design. The TMGB will be a minimum 4 by 10 inches by a quarter inch. **NOTE:** The required ground for the TMGB will be to the main electrical distribution panel (EDP).

3.4 Incoming Cable Shields

Shields shall not be bonded across the splice to the cable stubs. In the EF, ground the shields of incoming cables to the TMGB.

3.5 Telecommunications Bonding Backbone

A telecommunications bonding backbone TBB shall be established to connect the TMGB to the telecommunications grounding busbar (TGB) located in the TRs. On every floor, a separate connection will be provided, connecting one TGB to another. All metallic conduit used will be bonded to the ground wire at the entry and exit points of the conduit. The TMGB serves as the dedicated extension of the building grounding electrode system for the telecommunications infrastructure and shall be placed in the EF. The TMGB shall be bonded to the power bonding and grounding system (serving that room) to ensure the two systems maintain minimal potential difference. The TGB is the grounding connection point for telecommunications systems and equipment in the areas served by a TR. For TBB conductor size-versus-length standards IAW TIA-607, see Table 3-1.

Table 3-1. TBB Conductor Size versus Length

TBB Linear Length Feet (Meters)	TBB Size (AWG)
Less than 13 (4)	6
14–20 (4–6)	4
21–26 (6–8)	3
27–33 (8–10)	2
34–41 (10–13)	1
42–52 (13–16)	1/0
53–66 (16–20)	2/0
67–84 (20–26)	3/0
85–105 (26–32)	4/0
106–125 (32–38)	250 kcmil
126–150 (38–46)	300 kcmil
151–175 (46–53)	350 kcmil

TBB Linear Length Feet (Meters)	TBB Size (AWG)
176–250 (53–76)	500 kcmil
251–300 (76–91)	600 kcmil
Greater than 301 (91)	750 kcmil

3.6 Communication Racks

All switches and patch panels will be bonded to the racks using an outward-turned star washer touching bare metal or bonded to the rack with an individual 6 AWG green wire. All ladder racking and communications racks will be permanently bonded to the copper GBB. All grounding cables will be installed with minimal bends.

3.7 Electrical Distribution Panel

The TMGB shall be connected to the main EDP. **NOTE:** An EDP shall not be located in a communications space.

3.8 Bonding Connections

Bonding connections will be compression or exothermic. Mechanical connections can be used when connecting a conductor to equipment, raceways or cable trays. To bond racks to ground, use the following methods:

- Install a horizontal rack GBB located at the top or bottom of the rack. Each piece of equipment in the rack/cabinet is bonded directly to the horizontal rack GBB via a unit bonding conductor. The horizontal rack GBB is then bonded to the telecommunications equipment bonding conductor (TEBC) via a rack bonding conductor using an irreversible two-hole compression connector sized to match conductor gauges.
- Install a vertical rack GBB that runs almost the entire length of the rack/cabinet. The equipment is then bonded to the vertical rack GBB via a short unit bonding conductor. The vertical rack GBB is then bonded to the TEBC via a rack bonding conductor using an irreversible two-hole compression connector sized to match the conductor gauges.
- Attach the equipment to a rack bonding conductor that extends from the equipment rack/cabinet to the TEBC using an irreversible two-hole compression connector sized to match conductor gauges or a nationally recognized testing laboratory-listed grounding block. The TEBC is then bonded directly to the TMGB/TGB.

3.9 Maintenance Holes and Hand Holes

All maintenance holes and hand holes shall have a ground rod installed. Provide a grounding braid that provides low electrical impedance connections for dependable shield bonding IAW 7 CFR 1755.200. The braid shall be made from flat tin-plated copper.

3.10 Codes and Standards

Because of the numerous systems supported at the Combat Center, all grounding and bonding systems must be applicable to the support requirements and its environment. The standards are NFPA 70, UL 467, and TIA-607, and include the following:

- MIL-STD-188-124B; *Notice 4, Grounding, Bonding and Shielding for Common Long Haul/Tactical Communication Systems Including Ground Based Communications Electronics Facilities and Equipments*
- UFC-4-133-01N, *Navy Air Traffic Control Facilities with Changes 4-5*, which lists two Federal Aviation Administration (FAA) requirements for USN air traffic control facilities:
  - FAA-STD-019E; *Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment*
  - FAA-STD-020B; *Transient Protection, Grounding, Bonding and Shielding Requirements for Electronic Equipment*
- The Motorola R56 standard

CHAPTER 4. TESTING

4.1 General

Perform telecommunications cabling inspection, verification, and performance tests IAW TIA-568.1-D, TIA-568-C.2, and TIA-568-C.3. Test equipment shall conform to TIA-1152.

4.2 Testing

4.2.1 Pre-Installation

Perform optical fiber field inspection tests via attenuation measurements on factory reels. Measurements shall be tabulated on a pair-by-pair or strand-by-strand basis.

4.2.1.1 Cable Capacitance

Perform capacitance tests on all pairs within a cable to determine whether cable capacitance is within the limits specified.

4.2.1.2 Loop Resistance

Perform direct current (dc) loop resistance on all of the pairs within a cable to determine whether dc loop resistance is within the manufacturer's specifications.

4.2.2 Inspections

Visually inspect:

- unshielded twisted pair (UTP) and optical fiber jacket materials for UL or third-party certification markings;
- cabling terminations in TRs and at workstations to confirm color coding for T568A or T568B pin assignments;
- cabling connections to confirm compliance with TIA-568.1-D, TIA-568-C.2, and TIA-568-C.3;
- Category (Cat) 6 markings of outlets, jacks, and patch panels; and
- cable reels for cuts, nicks or other damage. Damaged cable shall be replaced or repaired to the satisfaction of the Contracting Officer. Reel wraps shall remain intact on the reel until the cable is ready for placement.

4.2.3 Acceptance

Perform acceptance testing IAW Rural Utility Services (RUS) Bulletin (Bull) 1753F-201 and as specified in this section where applicable. Provide personnel, equipment, instrumentation, and supplies necessary to perform required testing. Notification of any planned testing shall be given to the Contracting Officer at least 15 to 30 days prior to any test unless specified otherwise. **NOTE:** Testing shall not proceed until the Contractor has received the Contracting Officer's written approval of the test plans as specified.

4.2.3.1 Verification

UTP backbone copper cabling shall be tested for dc loop resistance, shorts, opens, intermittent faults, and polarity between conductors as well as between conductors and shield (if cable has overall shield). Test the operation of shorting bars in connection blocks. Test cables after termination but prior to being cross-connected.

4.2.3.2 Performance

Perform Cat 6 link tests IAW TIA-568.1-D and TIA-568-C.2. Tests shall include the following:

- Wire map, length, insertion loss
- Near-end crosstalk (NEXT)
- Power-sum NEXT (PSNEXT)
- Attenuation-to-crosstalk ratio, far-end (ACRF) (formerly known as equal-level far-end crosstalk [ELFEXT])
- Power-sum attenuation-to-crosstalk ratio, far-end (PSACRF) (formerly known as power-sum equal-level far-end crosstalk [PSELFEXT])
- Return loss
- Propagation delay
- Delay skew

4.2.3.3 End-to-End

One hundred percent end-to-end testing of all cable installations shall be performed.

4.2.3.4 OSP Copper Cable

For OSP copper cable, perform the following tests IAW TIA-758:

- Continuity-to-remote end
- Crossed pairs/reversed pairs/split pairs
- Shorts between two or more conductors

4.2.3.5 Optical Fiber

For optical fiber, which applies to inside plant (ISP) and OSP, perform bidirectional end-to-end attenuation tests at 1,310 nanometers (nm) and 1,550 nm IAW TIA-568-C.3; TIA-526-7 using Method A, Optical Power Meter and Light Source; and TIA-526-14 using Method B, Optical Time Domain Reflectometer (OTDR).

For optical fiber links where only one end is terminated, perform OTDR tests only IAW TIA-568-C.3. For optical fiber attenuation (link loss) budgets, see Table 4-1.

Table 4-1. Optical Fiber Attenuation (Link Loss) Budgets

Optical Fiber Type or Connection Type	Allowable Loss per Kilometer at Wavelength
Single-mode ISP/OSP	• 1.0 dB @ 1,310 nm / (0.5 dB @ 1,310 nm) • 1.0 dB @ 1,550 nm / (0.5 dB @ 1,550 nm)
Multimode ISP and OSP	3.5 dB @ 850 nm; 1.5 dB @ 1,300 nm
Connector loss (mated pair)	0.75 dB
Splice (per each)	0.3 dB **NOTE:** Optical fiber splices shall be measured IAW TIA-455-78 for field testing.

4.2.3.6 OSP Duct System

Test all duct systems using mandrels proportionately sized to the ducts being tested.

4.2.4 Final Verification

Perform final verification testing as directed by the G-6, which are as follows:

- Voice Tests. These tests, which assume that dial tone service has been installed, are performed as follows:
  a Connect to the network interface device at the demarcation point.
  b Go off-hook, listen, and receive a dial tone. If a test number is available, make and receive a local, long distance, and Defense Switched Network telephone call.
- Data Tests. These tests, which assume the IT staff has a network installed and are available to assist with testing, are performed as follows:
  a Connect to the network interface device at the demarcation point.
  b Log onto the network to ensure proper connection to the network.

4.2.5 Grounding Systems

Test grounding systems and provide test results IAW paragraph 4.4.2.3.

4.3 Field Quality Control

Provide at least 10 working days of notice to the Contracting Officer and the G-6 prior to each test. Provide labor, equipment, and incidentals required for testing. Submit a signed copy of the test results to the Contracting Officer within 3 working days after tests for each segment of construction completed. **NOTE:** Do not wait until all construction is complete to commence field tests; perform testing as construction progresses.

4.4 Test Documentation

4.4.1 Test Plans

Prepare and provide a complete and detailed test plan for field tests of the OSP—including a complete list of test equipment for copper conductor and fiber optic cables, components, and accessories—for Contracting Officer approval. Include a cutover plan with procedures and schedules for the relocation of facility station numbers without interrupting service to any active location. At least 30 days prior to tests, submit the plan for Contracting Officer approval. Provide testing and performance measurement criteria IAW TIA-568.1-D and 7 CFR 1755.200. Include procedures for certification, validation, and testing that includes fiber optic link performance criteria.

Test plans shall:

- define the tests required to ensure that the system meets technical, operational, and performance specifications;
- define milestones for the tests, equipment, personnel, facilities, and supplies required; and
- identify the capabilities and functions to be tested.

4.4.2 Test Reports

Once testing of the installed system has been completed, provide test reports—in booklet form—showing all field tests performed. Submit all test reports to the Contracting Office and the G-6 as specified by the contract.

4.4.2.1 Factory Reel Tests

Provide test results along with manufacturer certification(s).

4.4.2.2 Pre-Installation Tests

At least 10 working days before the start of installation, provide test results to the Contracting Officer and the G-6. Results shall indicate the reel number of the cable, manufacturer, cable size(s), pairs tested, and readings recorded. **NOTE:** When pre-installation tests indicate that cable does not meet specifications, remove the cable from the job site.

4.4.2.3 Grounding System Tests

Provide test results and include a certified record of the ground-resistance tests on each driven ground rod, ground rod assembly, or other grounding electrodes; the number of rods driven and their depth at each location to meet the required resistance-to-ground measurements specified; and a statement describing the condition of the soil at the time of measurement.

CHAPTER 5. INSIDE PLANT

5.1 Pathways (Backbone and Horizontal)

5.1.1 General

Pathway shall be conduit, cable tray, under floor duct, and access floor, and shall be installed IAW TIA-568.1-D and TIA-569 as applicable. The following standards apply:

- Pathways shall be installed IAW the following minimum clearance distances:
  - Four feet (1.2 meters) from motors, generators, frequency converters, transformers, x–ray equipment or uninterruptible power systems.
  - Twelve inches (300 mm) from power conduits and cable systems.
  - Five inches (125 mm) from fluorescent or high-frequency lighting system fixtures.
- All conduits entering the TR will be home run conduits and shall extend up from the floor 3 to 4 inches or down from the ceiling 3 to 4 inches. All metal conduits will be bonded to the TMGB or TGB.
- All penetrations will be sealed and sleeved IAW design specifications.
- A minimum of two 4-inch conduits will be installed between the main TR and any secondary TRs.
- All empty conduits shall be clearly and permanently marked at both ends to indicate destination. **NOTE:** Marking must be clearly visible after construction is completed.
- A pull string shall be installed in all conduit serving telecommunications outlets that do not initially have cable installed in them.
- A pull string shall be left in all conduits after cable installations as well as in all empty conduits.
- All conduit pathways shall have a pull box placed every 100 feet at a minimum.
- The bend radii for conduit are as follows:
  - For 2 inches or less, six times the internal conduit diameter.
  - For greater than 2 inches, 10 times the internal conduit diameter.
- All conduit pathways shall have no more than two 90 degree bends between pull boxes.
- The minimum conduit size running to each individual work area outlet will be determined to accommodate all four individual runs in support of a quad outlet.
- Ream all conduit ends and fit them with insulated bushings to eliminate sharp edges.
- All horizontal pathways shall have a maximum fill ratio of 40 percent.
- When pathways must cross sources of electromagnetic interference (EMI), they shall be perpendicular to the source, not gradual over a long distance.

- A communications pathway may not be affixed to other pathways or supported fixtures.
- An open cable tray system will be used in all buildings in order to facilitate expansion (e.g., additions, moves, changes). When conditions exist that prohibit the use of a cable tray system, J-hooks, and/or conduit may be used with G-6 approval. When J-hooks are used, they must be placed in a manner to support the cable spaced irregularly at 4- to 5-foot intervals. **NOTE:** J-hooks are not authorized with new construction.
- Sharp metal edges in cable trays shall be smoothed, with cabling dressed away from these edges.
- Horizontal pathways and supports shall not be used for the attachment of conduit or cable containing line voltage conductors, to include branch wiring.
- When cable is installed in a false ceiling space that is not readily accessible, access hatches shall be provided at 10-foot intervals (nominal).
- Communications cable shall not be installed in the same stud cavity as electrical.
- Each office space will have a minimum of four work area outlets, one per wall. In large office areas or conference rooms, the outlets must be placed so there is no more than 10 feet of separation between outlets. Outlets are to be placed 16 inches above the finished floor unless directed otherwise by the G-6. All outlets shall be clearly labeled IAW paragraph 2.12.8.
- Provide grounding and bonding IAW Chapter 3.

5.1.2 Modular Furniture

Modular furniture pathways shall comply with UL 1286 and will be installed IAW manufacturers' instructions.

5.1.3 Pull Boxes

Constructed of galvanized sheet steel with screw-fastened covers, the minimum size of pull boxes shall be as follows:

- For individual 1-inch diameter conduit, a minimum of 4 by 4 by 3 inches.
- For 4-inch conduit, a minimum of 24 by 24 by 8 inches.

Provide pull boxes where the conduit length exceeds 100 feet or where there are more than two 90 degree bends or equivalent. Align conduit ends on opposite sides of pull boxes. Provide pull boxes in straight lengths of conduit; neither pull boxes nor conduit bodies shall be permitted in lieu of bends. All pull boxes must be accessible. Table 5-1 lists pull box sizes IAW TIA-569.

Table 5-1. Pull Box Sizing

Metric Designator (trade size)	Width in Inches (mm)	Length in Inches (mm)	Depth in Inches (mm)	Width Increase for Additional Conduit in Inches (mm)
1 (27)	4 (102)	16 (406)	3 (76)	2 (51)
1-1/4 (35)	6 (152)	20 (508)	3 (76)	3 (76)
1-1/2 (41)	8 (203)	27 (686)	4 (102)	4 (102)
2 (53)	8 (203)	36 (914)	4 (102)	5 (127)
2-1/2 (63)	10 (254)	42 (1067)	5 (127)	6 (152)
3 (78)	12 (305)	48 (1219)	5 (127)	6 (152)
3-1/2 (91)	12 (305)	54 (1372)	6 (152)	6 (152)
4 (103)	15 (381)	60 (1524)	8 (203)	8 (203)

5.1.4 Bend Radius

The inside radius of a conduit bend shall be at least six times the internal diameter of conduit.

5.1.5 Telecommunications Outlet Box Installations

Telecommunications outlet box installations shall be:

- standard-type,
- 4 inches square by 2 1/8 inches deep with 1-inch diameter side knock-outs, and
- equipped with a single gang plaster ring.

Mount boxes flush in finished walls at the height indicated as follows:

- For wall-mounted telephones, outlet boxes shall be 2 by 4 by 2 1/8 inches, and mounted 60 inches above the finished floor.
- For handicapped telephone stations, outlet boxes shall be mounted at a height of 48 inches above the finished floor.

5.1.6 Under Floor Pathway Installations

Under floor pathway installations shall be used in a raised floor application only with G-6 approval. Cabling and under floor ducts shall be install IAW manufacturers' instructions.

5.1.7 Under Floor Slab Conduit Installations

Under floor conduit installations shall be located a minimum of 12 inches (300 mm) below the vapor barrier with G-6 approval. Seal around conduits at penetrations through the vapor barrier. Conduits shall be installed IAW manufacturers' recommendations.

5.1.8 Service Entrance Conduit Installations - Overhead

Service entrance conduit installations shall be of galvanized rigid steel or intermediate metal conduit (IMC) from service entrance-to-service entrance fitting or weather head outside of the building with G-6 approval.

5.1.9 Service Entrance Conduit Installations - Underground

The underground portion of service entrance conduit shall be:

- encased in a minimum of 3 inches (75 mm) of concrete extending from the building entrance to 5 feet (1,500 mm) out from the building, and
- a minimum of 18 inches (450 mm) below slab or grade using polyvinyl chloride (PVC)-type Electrical Plastic Conduit-40, galvanized-rigid steel, or steel IMC.

5.1.10 Cable Tray Installation

Cable trays shall be designed to accommodate a maximum calculated fill ratio of 50 percent. The inside of the cable support system shall be free of burrs, sharp edges or projections that can damage cable insulation. Openings in fire-rated walls, floors, and ceilings shall be fire-stopped. Install cable tray components IAW TIA-569.

5.2 Telecommunications Cabling

Indoor/outdoor cable is not authorized for use unless directed by the G-6.

5.2.1 Horizontal Copper

Horizontal copper cable shall comply with Insulated Cable Engineers Association (ICEA) S-80-576, National Electrical Manufacturers Association (NEMA) Standards Publication WC 63.1-2005, NFPA 70, TIA-492AAAA, TIA-568.1-D, TIA-568-C.2, TIA-568-C.3, UL 444, and UL 1666. General purpose riser-rated cable and plenum-rated cable shall be installed IAW NFPA 70.

All cable will be ordered from the same lot. One hundred feet of cable will be provided to the G-6 at least 30 calendar days prior to testing and Quality Control (QC) inspections. This cable will allow the G-6 to test it and establish the baseline. Install cable between main distribution frame (MDF), building distribution frame (BDF), and intermediate distribution frame (IDF) equipment as indicated on the drawings. The following standards apply:

- All cable will be 24 AWG solid copper UTP rated at Cat 6 or higher. Each work area outlet will consist of a minimum of two cables (one white for voice and one red for data).
- Do not untwist Cat 6 UTP cables more than a half inch (12 mm) from the termination point.

- Provide a service loop on each end of the cable as follows:
  - In the TR, 10 feet (3 meters).
  - In the work area outlet, 3.25 feet (1 meter) for fiber optic and 6 inches (150 mm) for UTP.

  NOTE: Service loops will not be coiled. Apply Figure 8 or S configuration.
- For cable pulling tensions, do not exceed manufacturers' specifications.
- Use lubricants approved by cable manufacturers only.
- Use Velcro®-type cable straps only.
- For UTP cable, the bend radii shall not exceed manufacturers' specifications.
- All Cat 6 cabling will be terminated on the patch panel installed in the Comm rack(s). **NOTE:** The white cabling will be terminated on the patch panel(s) designated as voice and the red cabling will be terminated on the patch panel(s) designated as data.
- All horizontal cable runs will be continuous with a maximum of 295 feet (cable length) from the station outlet to the termination point (e.g., patch panel).
- Each cable at the station outlet will be terminated on Cat 6-rated Registered Jack 45 (RJ45) jacks using the T568A configuration.
- Screw terminals shall not be used.

For testing, see Chapter 4.

5.2.2 Fiber Optic

All fiber optic cable shall be terminated with fusion splices on factory-terminated, single-mode pigtails with SC connectors unless directed by the G-6.

5.2.3 Backbone Cable

5.2.3.1 Copper

Copper backbone cable shall be solid-conductor, 24 AWG, 100 ohm (Ω), 100-pair UTP Cat 5e formed into 25-pair binder groups covered with a thermoplastic jacket.

5.2.3.2 Fiber Optic

Fiber optic cable shall be single-mode fiber. Do not exceed manufacturer's recommended specifications for bending radii and pull tensions.

5.3 Distribution Frames

For terminating and cross-connecting permanent cabling, the MDFs, BDFs, and IDFs shall be provided as depicted on the approved design drawings.

5.4 Backboards

Provide void-free, AC-grade plywood backboards (4 by 8 feet by 3/4 inch) IAW the design. Backboards shall be fire-rated or fully painted with two coats of white, nonconductive, fire-retardant paint. The plywood shall be fixed to the wall starting at the finished floor level. If painted, supply the manufacturer and product label on the backboard. **NOTE:** All fire-rated markings will be left unpainted.

5.5 Building Entrance Terminal

Building entrance terminals (BETs), also known as protected entrance terminals, shall be self-contained and have interconnecting hardware for connecting to exterior cabling at full capacity. Provide the following:

- Manufacturer's instructions for BET installation.
- Copper cable interconnecting hardware as specified in UFGS Section 27 10 00.
- Protector modules IAW UL 497 (3-element gas tube-type or solid state-type, 5-pin-rated for the application).
- Gas tube protection modules IAW RUS Bull 345-83, which shall be heavy-duty 400 V where A is the maximum single-impulse discharge current, B is the impulse life, and C is the ac (alternating current) discharge current IAW NEMA ANSI C62.61. The gas modules shall shunt high voltage to ground, fail short, and be equipped with an external spark gap and heat coils IAW UL 497.

The quantity of protector modules will match the termination capacity of the BET. In addition, the BET will be mounted to a backboard.

5.6 Patch Panels and Patch Cords

Patch panels and patch cords shall meet the minimum performance requirements IAW TIA-568.1-D, TIA-568-C.2, and TIA-568-C.3. Panels shall be compatible with a standard 19-inch Comm rack.

5.6.1 Copper

All copper patch panels shall be RJ45 Cat 6, 110-style, and terminated using the T568A standard. The size and number shall be determined by the design specifications. Patch panels shall accommodate all wiring plus 25 percent open for spares. When terminating voice backbone, terminate pairs using pins 4 and 5. For copper patch panel labeling, see paragraph 2.12.3.1. For grounding and bonding, see Chapter 3. **NOTE:** Provide factory-terminated Cat 6 patch cords to match the quantity of ports on the patch panel.

5.6.2 Fiber Optic

All fiber optic patch panels shall have single-mode SC-to-SC adapters to accommodate design specifications. **NOTE:** Provide fiber optic patch cord jumpers to match the quantity of ports on the LIU.

Adapters shall utilize metallic alignment sleeves. Provide dust covers for all unused adapters. The rear of each panel shall have a cable management tray a minimum of 8 inches (203 mm) deep with a removable cover, incoming cable strain relief, and routing guides. Panels shall have each adapter factory-numbered and be equipped with laminated plastic nameplates above each adapter. For fiber patch panel labeling, see paragraph 2.12.3.2.

5.7 Telecommunications Outlet/Connector Assemblies

5.7.1 Outlet/Connector Copper

Outlet/connectors shall comply with Federal Communications Commission (FCC) Part 68.5, TIA-568.1-D, and TIA-568-C.2. UTP outlet/connectors shall:

- be UL 1863-listed, non-keyed, 4-pair constructed of high impact-rated thermoplastic housing;
- be third party-verified and comply with Electronic Industries Alliance (EIA)/TIA Cat 6 requirements; and
- comply with TIA-455-21 for 500 mating cycles.

Each cable at the station outlet will be terminated on Cat 6-rated RJ45 jacks using the T568A configuration. Jacks will be color-coded (white for voice, red for data).

5.7.2 Faceplates

Telecommunications faceplates shall comply with UL 514C, TIA-568.1-D, TIA-568-C.2, and TIA-568-C.3. Faceplates shall be flush or of an oversized design, constructed of a high-impact thermoplastic material, and be white in color. For faceplate labeling, see paragraph 2.12.5.

5.8 Firestopping Material

Provide firestopping material for all penetrations of fire-rated walls. Provide an asbestos-free firestopping system capable of maintaining a barrier against flame and gases. The system shall be UL-listed and comply with ASTM E814. Include the UL system number/UL-listed print from the manufacturer for each type of floor, wall, and ceiling penetration. All firestopping systems shall be installed IAW manufacturers' instructions. Specifications will be provided upon request. For an example of firestopping, see Figure 5-1.

Figure 5-1. Firestopping – Example

For firestopping labeling, see paragraph 2.12.7.

5.9 Modular Furniture

Modular furniture is not part of the permanent facility; therefore, no horizontal infrastructure will terminate as part of the furniture. All service shall be provided via a wall outlet mounted on the finished wall that is part of the facility. A telecommunications cable will be provided to extend service from the work area outlet to the outlet mounted on the furniture. At no time will power cabling be installed in the same tray, path or trough with telecommunications cabling. All cabling within modular furniture shall be labeled on each end for traceability. **NOTE:** A multiuser telecommunications outlet assembly may be installed to support modular furniture arrays as directed by the G-6.

5.10 Records

For records, see paragraph 2.9.

5.11 Grounding and Bonding

For grounding and bonding, see Chapter 3.

5.12 Labeling

For label naming conventions and standards, see paragraph 2.12.

CHAPTER 6. TELECOMMUNICATION ROOMS AND ENTRANCE FACILITIES

6.1 Telecommunications Room

Each building shall have a minimum of one TR on every floor, serving a maximum floor space of 9,000 square feet (ft^2). For multi-story buildings, the TRs are preferred to be vertically aligned, located at the bottom of the telecommunications riser system on the first floor, and located as close as practical to the center of the floor area being served. The maximum horizontal cable length to the farthest outlet shall not exceed 295 feet. If these limits need to be exceeded to provide service to any area of the building, additional TRs shall be required.

These additional TRs shall be tied to the main TR with copper and fiber backbone cables terminated at each end to an appropriately sized patch panel. The minimum copper cable count is 50 pair and the minimum fiber count is 24 strands of single mode; however, these requirements are subject to change depending on the project requirements defined by the G-6.

All TRs will be sized according to the requirements for the service being provided and the size of the facility; however, TRs will be a minimum of 10 by 8 by 8.5 feet. **NOTE:** TRs shall be located within the building to avoid possible flooding as well as to reduce proximity to hazardous material storage and exposure to sources of EMI (e.g., transformers, generators, electrical motors, transmitters).

6.2 Entrance Facility

The EF is required to provide signal paths from the closest point of presence to the new facility, including free-standing frames or backboards, interconnecting hardware, terminating cables, and lightning and surge protection modules. With G-6 approval, the EF may also serve as the TR. Any building that is multi-storied or exceeds 9,000 ft^2 requires an EF.

The entrance or outside building cables shall be terminated and protected on a listed primary protector within 50 feet of entering the building IAW NEC Article 800, Section 800-50, Exception No.3. The work consists of providing, testing, and making operational cabling, interconnecting hardware, and lightning and surge protection necessary to form a complete OSP telecommunications system for continuous use.

All EFs must provide the correct interface (cabling and infrastructure) between OSP and ISP. Equipment housed therein is considered distinct from a TR because of the nature of its complexity. All telecommunications work must be coordinated with the G-6 concerning layout and configuration of the EF infrastructure. The Contractor may be required to coordinate its work effort with the G-6 for access to EF telecommunications and OSP. All EFs will be sized according to the requirements for the service being provided and the size of the facility; however, EFs will be a minimum of 10 by 8 by 8.5 feet.

6.3 Access

TRs and EFs shall be accessible from a public corridor; however, they shall not contain windows or be ceiling-accessible from adjacent rooms except via approved connectivity pathways.

6.4 Backboard

TRs and EFs shall be equipped with at least one backboard. For backboard requirements, see paragraph 5.4.

6.5 Building Entrance Terminal

All BETs shall be MS$^{2™}$ in, 110 out.

6.6 Lighting

TRs and EFs will be equipped with independent lighting that provides a minimum of 50 foot-candles (500 lux) measurable at 3 feet (1 meter) above the finished floor, within 1 meter of any racking. False ceilings shall not be provided.

6.7 Doors

Doors will open outward, be a minimum of 36 inches wide, and be equipped with Schlage-compatible, base-standard, electronic cipher locks. All TR/EF/Comm room door locks shall be keyed to MR4. For an example of the lock, see Figure 6-1.

Figure 6-1. Door Cypher Lock – Example

NOTE: For all new construction, the contractor shall provide these locks.

6.8 Signage

Provide signage for equipment rooms and TR doors IAW the requirements displayed on the design drawings or as directed by the G-6.

6.9 Electrical Power

For equipment power, the TR shall be equipped with a minimum of two duplex, 3-wire, 20 A DDC, 120 Vac (non-switchable), quadraplex electrical outlets. For labeling, see paragraph 2.12.8.

6.10 Grounding and Bonding

For grounding and bonding, see Chapter 3.

6.11 HVAC Services

Heating, ventilation, and air conditioning (HVAC) services shall not use the TR space for pathways of ducts and pipes other than those needed directly for environmental control of the room.

6.12 Environmental Control

The TR will be equipped with an environmental control to maintain temperatures between 65 and 75 °F (18 to 24 °C) at a relative humidity between 30 and 55 percent, 24 hours a day, 7 days a week.

6.13 Painting

TR walls and ceilings shall receive two coats of a light-colored, anti-static paint. **NOTE:** Sanding between coats is a mandatory requirement to achieve a static- and dust-free environment.

6.14 Flooring

TR flooring shall be a light-colored, static-free covering (linoleum tile-recommended). No carpet.

6.15 Comm Racks and Ladder Racking

The TR will be equipped with at least one Comm rack (Chatsworth Products Inc. [CPI] 46353-503 or approved equal) 7 feet tall by 19 inches wide and mounted to the floor. When installation is on concrete flooring, an isolation kit will be used. The rack will be mounted in such a manner to allow 48 inches of working space both front and back. Each Comm rack will be equipped with two vertical cable management organizers (CPI 11729-503 or approved equal). The TR also will be equipped with ladder-racking to provide wire management and 3-point seismic stability.

For Zone 4 compliance, see the installation instructions to comply with manufacturers' specifications. All equipment racks and ladder-racking shall be secured to the building in at least three separate points. **NOTE:** All installations shall conform to current seismic regulations as directed by Federal, State, and County codes.

6.16 Copper Patch Panels

For copper patch panels, see paragraph 5.6.1.

6.17 Connecting Satellites

In facilities that require more than one TR, there shall be at least two 4-inch IMCs connecting each satellite TR to the main TR. For grounding and bonding, see Chapter 3.

CHAPTER 7. OUTSIDE PLANT AND SUPPORTING INFRASTRUCTURE

7.1 General

Install all system components IAW manufacturers' instructions, IEEE C2, NFPA 70, and as indicated. Provide all necessary interconnections, services, and adjustments required for a complete and operable turn-key telecommunications system. If there is no existing or there is insufficient central office copper or fiber optic OSP cable to the facility, new cable and pathways must be provided from a point of connection to be determined by the G-6.

7.2 Pathways

Telecommunications vaults, maintenance holes, hand holes, and pathways shall not be shared with other utilities.

7.2.1 Conduits

Provide conduit as specified in UFGS Section 33 71 02. A minimum of two Schedule 40, 4-inch, buried entrance conduits must be provided to the TR and connect to the nearest point of connection as designated by the G-6. A pull tape is to be placed inside each of conduit. One of the two conduits will contain a 4-inch, 3-cell MaxCell or equivalent inner duct. Conduits will extend 4 inches above the finished floor.

All unused conduits will be capped with the appropriate duct plugs. No caps will be installed using any type of glue, epoxy or like materials. All conduits containing cables will be plugged with the appropriate plugs as to not interfere with the performance of cables. The intent is to block dirt, moisture, and other debris from entering conduits. All conduit systems shall have conduit spacers. In addition, all conduit systems shall be installed a minimum of 3 feet below grade because of the unique conditions that exist aboard the Combat Center (e.g., tank traffic, environmental erosion). Detectable marking tape shall be placed 1 foot below grade.

7.2.2 Vaults and Maintenance Holes

All vaults and maintenance holes shall be spaced no greater than 450 feet apart as measured center to center of the maintenance hole. The minimum sizing shall be determined by the design specifications. The minimum maintenance hole interior size is 12 by 6 by 7 feet (3.7 by 1.8 by 2 meters). Other sizes may be used with G-6 approval only. Splayed maintenance holes shall be provided near central offices where future duct expansion is expected.

To accommodate heavy vehicular traffic, maintenance holes shall have a load rating of HS-20. Maintenance holes shall be installed on a leveled, crushed, and washed gravel base of sufficient depth (i.e., a minimum thickness of 6 inches [150 mm] under the entire maintenance hole) to allow for drainage and stability. Where maintenance holes are installed in roadways, the structure and lid (cover) shall support heavy vehicular traffic. Each new maintenance hole shall be equipped with a lid, sump, pulling-in irons, bonding ribbon, cable racks, ladder, and hooks. A 5/8-inch-by-10-foot copper-clad ground rod that extends 4 inches above the floor, plus or minus a half inch, shall be installed in any available corner.

7.2.3 Hand Holes

The minimum hand hole size is 6 by 4 by 4 feet (1.8 by 1.2 by 1.2 meters). Larger hand holes are acceptable. Hand holes installed where vehicle traffic may be present shall be both load-rated as H-20 and equipped with round maintenance hole lids. Hand holes in duct systems located in sparsely populated areas or at the end of runs that will have fiber cables or small copper cables (not to exceed 100 pair) only in them can be spaced up to 1,000 feet apart. A 5/8-inch-by-10-foot copper-clad ground rod (that extends 4 inches above the floor, plus or minus a half inch), bonding ribbon, cable racks, and hooks shall be installed in any available corner.

7.2.4 Bollards

Bollards shall be installed in areas where vaults, maintenance holes, hand holes, and pedestals are subject to vehicle traffic. Bollards shall be 6-foot-by-6-inch Schedule 80 steel pipe buried in concrete 3 feet deep by 18 inches wide. Bollards shall be filled with concrete and painted brilliant yellow.

7.2.5 Direct Burial System

Installation shall be IAW RUS Bull 1751F-640. Install cable in conduit encased in concrete underneath railroad tracks, paved areas, and roadways. Slope the ducts 1 inch per 10 feet to ensure proper drainage. Excavate trenches by using hand or mechanical trenching equipment. Provide a minimum cable cover of 3 feet (915 mm) below finished grade. Trenches shall be a minimum of 6 inches (155 mm) wide and in straight lines between cable markers. Do not use cable plows. Bends in trenches shall have a minimum radius of 3 feet (915 mm). Where two or more cables are laid parallel in the same trench, space them laterally a minimum of 3 inches (78 mm) apart. When rock is encountered, remove it to a minimum depth of 3 inches (78 mm) below the cable and fill the space with sand or clean earth free from particles larger than a quarter inch (6 mm). Do not unreel and pull cables into the trench from one end. Cable may be unreeled on grade and lifted into position.

7.2.6 Aerial Pathway/Suspension Strand

Provide poles IAW design specifications. Place a suspension strand as indicated. Tension IAW the data indicated. When tensioning a strand, loosen cable suspension clamps enough to allow free movement of the strand. Place suspension strand on the road side of the pole line. In tangent construction, point the lip of the suspension strand clamp toward the pole. At angles in the line, point the suspension strand clamp lip away from the load. In level construction, place the suspension strand clamp in such a manner that it will hold the strand below the through-bolt. At points where there is an up-pull on the strand, place clamp so that it will support strand above the through-bolt. Make suspension strand electrically continuous throughout its entire length, bond to other bare cables suspension strands, and connect to pole ground at each pole.

7.2.7 Backfill for Rocky Soil

When placing cable in a trench in rocky soil, the cable shall be cushioned by a fill of sand or selected soil at least 2 inches (53 mm) thick on the floor of the trench before placing the cable or wire. The backfill for at least 4 inches (103 mm) above the wire or cable shall be free from

stones, rocks, or other hard or sharp materials which might damage the cable or wire. If the buried cable is placed less than 2 feet (610 mm) in depth, a protective cover of concrete shall be used.

7.2.8 Cable Protection

Provide direct burial cable protection IAW NFPA 70. Galvanized conduits which penetrate concrete (slabs, pavement, and walls) shall be PVC-coated and shall extend from the first coupling or fitting outside either side of the concrete a minimum of 6 inches per foot (155 mm per 305 mm) burial depth beyond the edge of the surface where cable protection is required. **NOTE:** All conduits shall be sealed on each end.

Where additional protection is required, cable may be placed in galvanized iron pipe sized on a maximum fill 40 percent of cross-sectional area, or in concrete-encased, 4-inch (103 mm) PVC pipe. Conduit may be installed by jacking or trenching. Trenches shall be backfilled with earth and mechanically tamped at 6 inches (155 mm) lift so that the earth is restored to the same density, grade, and vegetation as the adjacent, undisturbed material.

7.2.9 Cable End Caps

Cable ends shall be sealed at all times with coated heat-shrinkable end caps when the cable is delivered to the job site, while the cable is stored, and during installation of the cable. The caps shall remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat-shrinkable end caps. Cable not sealed at all times in the specified manner will be rejected.

7.2.10 Penetrations

Caulk and seal cable access penetrations in walls, ceilings, and other parts of the building. Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings. For firestopping systems, see paragraph 5.8.

7.3 Cable

7.3.1 Cable Placement

Prior to the design and installation of any copper or optical fiber cable systems, cable routes and pathways must be approved by the G-6. Separate cables crossing other cables or metal piping from the other cables or pipe by a minimum of 3 inches (78 mm) of well-tamped earth. Do not install circuits for communications under or above traffic signal loops. Cables shall be in one piece without splices between connections except where the distance exceeds the lengths in which the cable is furnished.

Do not exceed the manufacturer’s bend radius for the cable. Leave a horizontal slack of approximately 3 feet (915 mm) in the ground on each end of cable runs, on each side of connection boxes, and at points where connections are brought above ground. Where cable is brought above ground, leave additional slack to make necessary connections.

7.3.2 Cable Pulling

Before pulling cables, test duct lines with a mandrel and swab to remove foreign material. Do not exceed the manufacturer's bend radius or pull tension specifications.

7.3.3 Pulling Eyes

Equip cables 1 1/4 inch (32 mm) and larger in diameter with cable the manufacturer's factory-installed pulling-in eyes. Provide cables with diameter smaller than 1 1/4 inch (32 mm) with heat shrinkable-type end caps or seals on cable ends when using cable pulling grips. Rings used to prevent grip slippage shall not be beaten into the cable sheath. Use a swivel of quarter-inch (19 mm) links between pulling-in eyes or grips and the pulling strand.

7.3.4 Maintenance Holes, Hand Holes, and Vaults

Do not install cables utilizing the shortest route, but route them along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls—not to interfere with duct entrances—and support cables on brackets and cable insulators at a maximum of 4 feet (1,220 mm). Install cable or cables in corresponding ducts entering and exiting the maintenance holes. In existing maintenance holes, hand holes, and vaults where new ducts are to be terminated, or where new cables are to be installed, modify the existing installation of cables, cable supports, and grounding as required with cables arranged and supported as specified for new cables. Identify each cable with plastic tags.

7.3.5 Aerial Cable

Where physical obstructions make it necessary to pull distribution cable-vice-wire along the line from a stationary reel, use cable-stringing blocks to support the cable-vice-wire during placing and tensioning operations. Do not place ladders, cable coils, and other equipment on or against the distribution wire. Protect cable installed outside of a building less than 8 feet (2.5 meters) above finished grade against physical damage. Cables crossing main roads shall be a minimum of 18 feet, 4 inches at the center point of the span.

Keep cable ends sealed at all times using cable end caps. Take cable from reel only as it is placed. During placing operations, do not exceed the manufacturer's bend radius or pulling tension. Place temporary supports sufficiently close together and properly tension the cable where necessary to prevent excessive bending. In those instances where spiraling of cabling is involved, mount enclosures for the purposes of loading, splicing, and distribution after the spiraling operation has been completed. Provide filled cable meeting the requirements of ICEA S-99-689, ICEA S-98-688, and 7 CFR 1755.390.

7.3.6 Figure 8 Distribution Cable

Perform spiraling of the cable within 24 hours of the tensioning operation. Perform spiraling operations at alternate poles with the approximate length of the spiral being 15 feet (4,575 mm). Do not remove insulation from support members except at bonding and grounding points and at points where ends of support members are terminated in splicing and dead-end devices. Ground the support member at poles to the pole ground.

7.3.7 Copper Conductor Cable

Solid copper conductors shall be covered with an extruded solid-insulating compound. Insulated conductors shall be twisted into pairs which are then stranded or oscillated to form a cylindrical core. For special high-frequency applications, the cable core shall be separated into compartments. Cable shall be completed by the application of a suitable core-wrapping material, a corrugated copper or a plastic-coated aluminum shield, and an overall extruded jacket. The gauge of conductor shall determine the range of the numbers of pairs as specified in Table 7-1.

Table 7-1. Gauge of Conductor-to-Range of No. of Pairs

Gauge	Pairs
19	6 to 400
22	6 to 1,200
24	6 to 2,100
26	6 to 3,000

Copper conductors shall be PE-89 type to meet the requirements of ICEA S-99-689 and 7 CFR 1755.390. Provide 20 feet of slack in each maintenance hole and hand hole unless directed otherwise by the G-6.

7.3.8 Fiber Optic Cable

Provide armored single-mode, 8/125-µm, 0.10 aperture, 1310 and 1550 nm fiber optic cable IAW TIA-492CAAA, TIA-472D000, and ICEA S-87-640, including any unique requirements made necessary by a specialized design. Fiber optic cable shall be specifically designed for outside use with a loose-tubed buffer construction. Provide fiber optic cable with optical and mechanical performance requirements IAW ICEA S-87-640. Provide 20 feet of slack in each maintenance hole and hand hole unless directed otherwise by the G-6. **NOTE:** Indoor/outdoor cable is prohibited unless authorized by the G-6.

7.3.9 Grounding and Bonding Conductors

All conductive cable shall be bonded, grounded, and protected. For grounding and bonding standards, see Chapter 3.

7.4 Closures

7.4.1 Copper

The splice closure for copper cable-splicing operations shall consist of two foam-filled endplates (two-section, three-section, or multiple-section [up to seven-section endplates for fire-retardant applications]) custom-drilled by the installer for cable entries specific to the measured outer diameter of the cable(s) to be spliced. There will be a maximum of two bolts to close the endplate sections around the cables to provide a gasket seal. There shall be a minimum of two

torque bars attachable to the two endplates to prevent the torqueing of the end plates during the application. These torque bars shall be a permanent part of the splice case.

The outer two-piece shell system shall be constructed of stainless steel with a neoprene rubber liner that is molded into the shells. The outer shells will not require sealing tapes or cords to close the shells. Endplate sections must be sealable with ultraviolet-stabilized rubber tape and C-cement compound. The endplate seal around the cable sheath must also be sealable in the same manner as the endplate sections.

Outer stainless steel shell halves must also be constructed as to provide an option from the manufacturer to include a filling flange on one half of the top shell to permit the introduction of a two-part, re-enterable encapsulant compound into the interior of the splice cavity. When installed, the non-fillable version of the splice case must be airtight to an operating pressure rating of 15 pounds per square inch (psi).

7.4.1.1 Aerial

Provide cable closure assembly consisting of a stainless steel re-enterable closure suitable for the aerial splicing of PVC-insulated copper cable.

7.4.1.2 Aboveground (Pedestals)

Provide aboveground closures constructed of a minimum 14 gauge steel and acceptable pole- or stake-mounting IAW 7 CFR 1755.910. Closures shall be sized and contain a marker as indicated. Covers shall be secured to prevent unauthorized entry. All pedestals shall contain a minimum 8-foot-by-5/8-inch copper-clad ground rod.

7.4.1.3 Direct Buried

Provide buried stainless steel closure suitable for enclosing a straight, butt, and branch splices, which can be poured with an encapsulating compound. Closure shall have adequate strength to protect the splice and maintain cable shield electrical continuity in the buried environment. All metallic shields shall be bonded and tested to ground.

7.4.2 Fiber Optic

The splice closure for fiber optic cable-splicing operations shall consist of a dome-style closure which permits butt-style splices that can be field-converted into an in-line splice closure configuration. The endplate shall consist of three to seven isolated (segmented) cable entry ports. The manufacturer must provide the option of either an in-line or a butt splice enclosure kit. Components of the kit must also be orderable separately.

The sealing method for the entry of cables to be spliced shall consist of a silicone-based grommet that provides for single or multiple cable entries. Also, the silicone-based grommets can be field split to allow for expressing cables. When installed, the fiber optic splice enclosure shall be of an airtight (flash test) rating of 5 psi for the smallest closure and 10 psi for larger units. The fiber optic cable splice closure will be equipped with a built-in air valve for pressure-testing purposes.

7.4.2.1 Aerial

Provide aerial closure that is constructed of stainless steel or PVC and suitable for a housing splice organizer of non-pressurized cables.

7.4.2.2 Aboveground (Pedestals)

Aboveground fiber closures shall be NEMA 6-rated because of the sandy environment of the Combat Center.

7.4.2.3 Direct Buried

Provide buried closure suitable to house a splice organizer in a protective housing. The closure shall have adequate strength to protect the splice and maintain cable shield electrical continuity—when metallic—in the buried environment. All metallic shields shall be bonded and tested.

7.5 Cable Splices and Connectors

Direct buried cable splices shall be installed in a pedestal, hand hole, or maintenance hole.

7.5.1 Copper Cable Splices

Provide multi-pair inline foldback or single-pair inline splices of a moisture-resistant, 3-wire insulation displacement connector held rigidly in place to assure maximum continuity IAW RUS Bull 1753F-401. Cables greater than 25 pairs shall be spliced using MS$^{2™}$, which accommodate 25 pairs of conductors at a time. Provide the correct connector size to accommodate the cable gauge of the supplied cable. All OSP cables shall be spliced using MS$^{2™}$ modules (4000-G/TR or 4005-G/TR [Gel]). Half taps will use MS$^{2™}$ modules (4008-G/TR [Gel]).

7.5.2 Fiber Optic Cable Splices

Provide fiber optic cable splices and splicing materials for fusion methods at locations shown on the construction drawings. The splice insertion loss shall be 0.3 dB maximum when measured IAW TIA-455-78 using an OTDR. Physically protect each fiber optic splice by applying a splice protector specially designed for the splice.

7.5.3 Fiber Optic Splice Organizers

Provide a splice organizer suitable for housing fiber optic splices in a neat and orderly fashion. The splice organizer shall allow for a minimum of 3 feet (1 meter) of fiber for each fiber within the cable to be neatly stored without kinks or twists. The splice organizer shall accommodate individual strain relief for each splice and allow for future maintenance or modification without damage to the cable or splices. Provide splice organizer hardware such as splice trays, protective glass shelves, and shield bond connectors in a splice organizer kit. When splicing in a fiber optic patch panel, the installation of connectors shall be IAW paragraph 5.2.2.

7.5.4 Shield Connectors

Provide connectors with a stable, low-impedance electrical connection between the cable shield and the bonding conductor IAW RUS Bull 345-65.

7.5.5 Plastic Insulating Tape

Plastic insulating tape must comply with UL 510.

7.6 Tags and Nameplates

Provide tags for each telecommunications cable or wire located in maintenance holes, hand holes, and vaults. Cable tags shall be made of polyethylene as described in paragraph 7.6.1 and labeled IAW paragraph 2.12.6 and TIA-606. Handwritten tags and nameplates are unacceptable.

7.6.1 Polyethylene Cable Tags

Provide tags of manufactured of polyethylene that have an average tensile strength of 3,250 psi (22.4 megapascals) and are a minimum 0.08-inch (2 mm) thick, non-corrosive and non-conductive; resistive to acids, alkalis, organic solvents, and saltwater; and distortion-resistant to 170 °F (77 °C). Provide a black polyethylene tag holder that is a minimum 0.05 of an inch (1.3 mm) thick. Provide a single-piece, self-locking nylon tie at each end of the cable tag. Ties shall have a minimum loop tensile strength of 175 pounds (778.75 newtons). The cable tags shall have black block letters, numbers, and symbols that are 1 inch (25 mm) high on a yellow background. Letters, numbers, and symbols shall not fall off or change positions regardless of cable tag orientation.

7.6.2 Manufacturer’s Nameplate

Each piece of equipment shall have a nameplate securely affixed in a conspicuous place and include the manufacturer’s name, address, model number, and serial number. The nameplate of the distributing agent will not be acceptable.

7.6.3 Field-Fabricated Nameplates

Provide laminated plastic nameplates IAW ASTM D709 for each patch panel, protector assembly, rack, cabinet and other equipment or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 of an inch (3 mm) thick, and white with a black center core. The surface shall be of a matte finish. Corners shall be square. Accurately align lettering and engrave them into the core. The minimum size of nameplates shall be 1 inch by 2.5 inches (25 by 65 mm). Lettering shall be a minimum of a quarter inch (6.35 mm) high and of normal block style.

7.7 Pad-Mounted Cross-Connect Terminal Cabinets

Pad-mounted cross-connect terminal cabinets (outdoor cross-connects) shall be provided IAW 7 CFR 1755.910 and constructed of 14 gauge steel and include the following:

- A double set of hinged doors with closed-cell foam weather-stripping. **NOTE:** Doors shall be locked and contain a marker as indicated.
- A spindle bracket, mounting frames, a binding post log, a jumper instruction label, and load coil mounting provisions.
- Cross-connect modules to terminate number of pairs as indicated.

The cabinets shall also be sized as required to support all terminations.

7.8 Record Documentation

For record documentation, see paragraph 2.9.

7.9 Grounding and Bonding

For grounding and bonding, see Chapter 3.

7.10 Cutover

All necessary transfers and cutovers shall be accomplished by the Contractor. All cutovers will be scheduled with the G-6 a minimum of 30 days in advance.

7.11 Labeling

Label IAW paragraph 2.12 and TIA-606.

7.12 Spare Parts and Warranties

Spare parts shall be provided no later than the start of field testing. This action will initiate QC and acceptance testing prior to end of the contract. All parts will be submitted 90 days prior to end of contract. The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract. All spare parts and warranties shall be turned over to the appropriate G-6 division.

CHAPTER 8. RADIO FREQUENCY SPECTRUM MANAGEMENT

8.1 Equipment Certification and Spectrum Supportability

8.1.1 General

DoD Instruction (DoDI) 4650.01, *Policy and Procedures for Management and Use of the Electromagnetic Spectrum*, requires that all communications electronics systems obtain spectrum certification and guidance from the Military Communications Electronics Board (MCEB) as early as possible in the acquisition process.

8.1.2 Program Manager

Program Managers are responsible for initiating DD-1494, *Application for Equipment Frequency Allocation*, for all newly developed equipment and prior to the acquisition of new equipment intended to be added to the USMC inventory.

8.1.3 Contracting Officer

Contracting Officers are required by DoD 5000 series guidance to ensure acquisitions of new equipment obtain approved frequency allocation within the intended area of operation prior to activation IAW DoDI 4650.01. The equipment certification process reviews the DD-1494 submittal to ensure spectrum is available prior to the equipment being fielded. Once certification is obtained, the MCEB assigns a J/F-12 number for the equipment. The certification process ensures that all spectrum-dependent systems are certified and authorized to operate within specific parameters. The parameters must conform to all international, national, state, and local laws and regulations.

8.1.4 DD-1494 Development

Organizations, activities, or commands developing and/or procuring the spectrum-dependent equipment shall develop the DD-1494 submittal via the supporting Program Manager. The application for allocation must begin during the conceptual stage or as soon as an electromagnetic frequency band of operation is identified. The organization, activity, or command involved is also responsible for ensuring the initial application for allocation is updated whenever significant changes are made to the equipment which affect or change the transmitter, receiver or antenna. When the equipment is no longer in the inventory, the application must be deleted via Headquarters Marine Corps (HQMC) Command, Control, Communications, and Computers (C4) Cybersecurity.

8.2 Frequency Assignment

8.2.1 General

Requests for frequency assignments for equipment to be installed or used aboard the Combat Center require that the equipment has received spectrum supportability certification during the equipment acquisition process and prior to equipment activation within the intended area of operation IAW Marine Corps Order (MCO) 2400.2A, *Marine Corps Management and Use of the Electromagnetic Spectrum*. The intent is to eliminate unauthorized use of radio frequencies

within the USMC. This guidance does not change or nullify any applicable DoD publications or Department of the Navy (DoN) policy that pertains to frequency assignment. USMC frequencies/allocations shall be based on proper authority and the level of the operation/exercise.

8.2.2 Frequency Request Process

Requests for frequencies/assignments within the U.S. and possessions will follow procedures as directed IAW all guidance, regulations, and authority within MCO 2400.2A and the *National Telecommunications and Information Agency (NTIA) Manual of Regulations and Procedures for Federal Radio Frequency Management*, hereinafter referred to as the *Redbook*. An approved frequency allocation or assignment within the U.S. must be coordinated with the NTIA via the Navy-Marine Corps Spectrum Center.

8.2.3 Frequency Requests and Assignments

Frequency requests shall be submitted 60 days prior to usage within the Contiguous U.S (CONUS) and 120 days for frequencies used outside of CONUS IAW the *Redbook*. Generally, requests for international spectrum support, unmanned vehicles, RADARS (i.e., RAdio Detection And Ranging System), electronic-counter countermeasures, and equipment under development or evaluation will require the longest lead times. Lead times for frequency assignment requests vary depending on their geographical location, type of equipment, frequency, etc.

All USMC equipment that transmits or receives electromagnetic radiation must have an approved frequency assignment or allocation, with the exception of equipment that operates on frequencies in bands above 3,000 gigahertz. Frequency assignments authorize equipment to operate within its allocated frequency band, at a designated location, and within the constraints of the authorized assignment parameters. Frequency assignments may be temporary or permanent. An approved frequency assignment or allocation acknowledges that development and/or procurement of equipment can be supported within the constraints of the authorized assignment parameters.

8.3 Part 15, Non-Licensed, and FRS Devices

Part 15 devices are low power-emitter equipment approved by the FCC for government and non-government use. IAW the *Redbook*, devices such as Family Radio Service (FRS) or the Multi-Use Radio Service have an increased probability of causing or receiving interference to/from similar devices used by government or non-government personnel, agencies or organizations. Interference to USMC Part 15 devices must be accepted without recourse. These devices must share each channel and no user is assured protection from interference caused by another user. Furthermore, these devices are unencrypted. IAW guidance within the *Redbook*, paragraph 7.5.8, “Because FRS users must share each channel and no user is assured protection from interference caused by another authorized user, federal entities may not purchase and operate FRS radios for planned communications operations that safeguard human life or property.”

8.4 Spectrum Manager

Spectrum Managers are those personnel who are trained and responsible for requesting, maintaining, processing, and assigning spectrum to support equipment and operations. All use of frequencies by USMC commands, organizations or activities, and other services, agencies, contractors, and foreign country services aboard USMC installations will be coordinated with the applicable USMC Installation Spectrum Manager.

8.5 Spectrum User Tasks and Responsibilities

A user is considered any person or personnel who activate equipment that requires spectrum or frequencies to operate. Users will:

- ensure all frequencies are used IAW MCO 2400.2A and the *Redbook*,
- submit frequency requests to the appropriate Frequency Management Office for processing,
- report frequency interference immediately to the appropriate Frequency Management Office for resolution,
- ensure all equipment that emits an electromagnetic signal has an approved frequency to operate on, and
- ensure all equipment—which is appropriated at the unit level—is properly spectrum-certified prior to requesting frequencies and operating the system.

APPENDIX A ABBREVIATIONS, ACRONYMS, AND SYMBOLS

Acronym	Definition
ac	alternating current
AC/S	Assistant Chief of Staff
ACRF	attenuation-to-crosstalk ratio, far-end
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
ATC	authority to connect
ATO	authority to operate
AWG	American Wire Gauge
BDF	building distribution frame
BET	building entrance terminal
BICSI	Building Industry Consulting Service International
C4	Command, Control, Communications and Computers
CCO	Combat Center Order
CFR	Code of Federal Regulations
CD	campus distributor
CFOT	Certified Fiber Optic Technician
CNCI	Certified Network Cable Installer
CNET	Centre National d'Études des Télécommunications
CONUS	Contiguous United States
CPI	Chatsworth Products Inc.
DAA	Designated Approving Authority
dc	direct current
DDC	dedicated data circuit
DoD or DD	Department of Defense
DoDIN	Department of Defense Information Network
DoN	Department of the Navy
ECA	Environmental Consultants Association
ECIA	Electronics Components Industry Association
EDP	electronic distribution panel
EF	entrance facility

Acronym	Definition
EIA	Electronic Industries Alliance
ELFEXT	equal-level far-end crosstalk
EMI	electromagnetic interference
ER	entrance room
ETA	Electronics Technicians Association
FAA	Federal Aviation Administration
FAA-STD	Federal Aviation Administration-Standard
FCC	Federal Communications Commission
FISMA	Federal Information Security Management Act
FOA	Fiber Optic Association
FOTP	Fiber Optic Test Procedure
FRS	Family Radio Service
GBB	grounding busbar
HVAC	heating, ventilation, and air conditioning
HQMC	Headquarters Marine Corps
IA	information assurance
IAW	in accordance with
ICEA	Insulated Cable Engineers Association
IDF	intermediate distribution frame
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMC	intermediate metal conduit
INT	Interpretation
ISP	inside plant
IT	Information Technology
ITS	Information Technology Systems
LIU	light interface unit
MAGTFTC	Marine Air Ground Task Force Training Command
MCAGCC	Marine Corps Air Ground Combat Center
MCEB	Military Communications Electronics Board
MCEN	Marine Corps Enterprise Network

Acronym	Definition
MCO	Marine Corps Order
MDF	main distribution frame
MIL-STD	Military Standard
NACE	National Association of Corrosion Engineers
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NEXT	near-end crosstalk
NFPA	National Fire Protection Association
NTIA	National Telecommunications and Information Agency
O&M	operation and maintenance
OSP	outside plant
OTDR	Optical Time Domain Reflectometer
PC	printed circuit
PDF	Portable Document Format
PSACRF	power-sum attenuation-to-crosstalk ratio, far-end
PSELFEXT	power-sum equal-level far-end crosstalk
PSNEXT	power-sum near-end crosstalk
PVC	polyvinyl chloride
PWD	Public Works Division (AC/S G-4)
QC	Quality Control
R	Reaffirmation Notice (for tabular notation)
RCDD	registered communications distribution designer
RJ45	Registered Jack 45 (8-pin, 8-connector)
ROM	read-only memory
RUS	Rural Utility Services
SP	service provider
SSPC	Society for Protective Coatings
Std or STD	Standard
TBB	telecommunication bonding backbone
TEBC	telecommunications equipment bonding conductor
TGB	telecommunications grounding busbar

Acronym	Definition
TIA	Telecommunications Industry Association
TMGB	telecommunications main grounding busbar
TR	telecommunications room
UC	Unified Capabilities
UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guide Specification
UL	Underwriter Laboratories
USMC	United States Marine Corps
USN	United States Navy
UTP	unshielded twisted pair
Abbreviation	**Definition**
A	ampere
Add	Addendum
Bldg.	Building
Bull	Bulletin
Cat	Category
cu	cubic
dB	decibel
dc	direct current
Ed.	Edition
ft^2	square feet
ft^3	cubic feet
kcmil	A symbol for 1,000 circular mils
kN	kilonewton
lbf	pound-force
m	meter
m^3	cubic meter
mm	millimeter
nm	nanometer
No.	number
psi	pounds per square inch

Acronym	Definition
U.S.	United States
V	volt
XD	cut dead
Symbol	**Definition**
°C	degrees Celsius
°F	degrees Fahrenheit
µm	micrometer (micron)
Ω	ohm

APPENDIX B GLOSSARY

building distribution frame (BDF)	A structure with terminations for connecting backbone, campus, and horizontal cabling. The BDF generally includes a cross-connect, an equipment support frame, and either a wooden backboard or terminal cabinet. When used for campus backbone or service provider (SP) cabling, the BDF shall include building protector assemblies.
building distributor	A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made.
campus distributor	A distributor from which the campus backbone cabling emanates.
conduit sleeve	A conduit that only penetrates a single wall for the purpose of providing a pathway for communications cabling into adjacent rooms.
entrance facility	An entrance to the building for both private and public network service cables (including wireless) including the entrance point to the building and continuing to the entrance room or space.
equipment room	An environmentally controlled, centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.
information systems	A set of information resources organized for the collection, storage, processing, maintenance, use, sharing, dissemination, disposition, display, or transmission of information. This includes automated information system applications, enclaves, outsourced information technology (IT)-based processes, and platform IT interconnections.
infrastructure	A collection of those telecommunications components (excluding equipment) that together provides the base support for the distribution of information within a building or campus. The substructure of all systems used to support the physical plant being installed. This can also include transport layers and other electronics for information distribution (i.e., voice, video, and data).
inside plant	A collection of those telecommunications components and equipment which together provides the base support for the distribution of all information within a building. This includes telecommunications electronics, patch panels, distribution frames, power supplies, telecommunications rooms, outlets, horizontal cabling, and wireless devices.
intermediate distribution frame	An intermediate termination point for horizontal wiring and cross-connections within telecommunications rooms or wiring closets.

main distribution frame (MDF)	A physical structure at a central location for terminating permanent backbone cables to interconnect with SP equipment at the activity-minimum point of presence. The MDF generally includes vendor-specific components to support voice and data circuits, building surge protector assemblies, main cross-connect blocks, equipment support frames, and wooden backboard (if the MDF is wall-mounted). Depending on local site conditions, the MDF and BDF may be identical.
outside plant (OSP)	A collection of those telecommunications components, including equipment, which together provides the base support for the distribution of all information within a campus. The substructure of all systems used to support the physical plant being installed. The OSP also includes cables, conduits, poles, and other supporting structures, building entrance terminals, pedestals, telecommunications huts, and cable vaults.
pathway	A physical infrastructure utilized for the placement and routing of telecommunications cable.
telecommunication room	An enclosed space for housing telecommunications equipment, cable, terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and the horizontal cabling.
unified capabilities	The integration of voice, video, and/or data services delivered ubiquitously across a secure and highly available network infrastructure, independent of technology, to provide increased mission effectiveness to the warfighter and business communities.