UNIFIED FACILITIES CRITERIA (UFC)

COMMAND, CONTROL, COMPUTERS, COMMUNICATIONS, CYBER-DEFENSE, INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE (C5ISR) FACILITIES

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Indicate the Military Department Preparing Activity responsible for the document.

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING SYSTEMS COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER CENTER

Record of Changes (changes are indicated by **1**\ ... /**1**/)

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FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States, its territories, and possessions is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA). Therefore, the acquisition team must ensure compliance with the most stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Military Department's responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Systems Command (NAVFAC), and Air Force Civil Engineer Center (AFCEC) are responsible for administration of the UFC system. Technical content of UFC is the responsibility of the cognizant DoD working group. Defense Agencies should contact the respective DoD Working Group for document interpretation and improvements. Recommended changes with supporting rationale may be sent to the respective DoD working group by submitting a Criteria Change Request (CCR) via the Internet site listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide website https://www.wbdg.org/dod.

Refer to UFC 1-200-01, *DoD Building Code*, for implementation of new issuances on projects.

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CHAPTER 1 INTRODUCTION

1-1 BACKGROUND.

This UFC provides criteria for new and renovated C5ISR facilities to adopt and align industry best practices for critical facility redundancy and Resilience with the Core UFCs and other DoD criteria for data centers. Industry best practices such as Uptime Institute's *Data Center Site Infrastructure Tier Standard; Topology*, ANSI/TIA-942-B *Telecommunications Infrastructure Standard for Data Centers*, and ANSI/BICSI 002 *Data Center Design and Implementation Best Practices* provide multiple paths to achieve a redundant and resilient facility. These best practices do not always align with the Core UFCs or provide a complete set of criteria to allow for prescriptive designs that can be executed with a degree of commonality across the DoD.

The planners, designers, and Functional Authorities must use this UFC in conjunction with service-specific requirements for planning to develop the program for the facility. The planning and design process must include development of the sponsor and user operational requirements statement and technical description of the infrastructure required to support the mission. Refer to Paragraph 2-3 for additional requirements for developing the Mission Engineering Systems Execution Plan (MESEP).

1-2 PURPOSE AND SCOPE.

This Unified Facilities Criteria (UFC) provides requirements for evaluating, planning, programming, and designing new construction and renovations of existing Command, Control, Computers, Communications, Cyber-Defense, Intelligence, Surveillance, and Reconnaissance (C5ISR) Facilities. This UFC provides prescriptive criteria to achieve the required redundancy and Resilience for C5ISR facilities.

1-3 APPLICABILITY.

This UFC follows the same applicability as UFC 1-200-01, paragraph 1-3 Applicability for C5ISR facilities.

1-3.1 Facility Types.

This UFC applies to the following DoD facility types and provides prescriptive criteria for the facility to meet the required reliability and availability:

- DoD Real Property Categorization System (RPCS) Basic Category Code 131: Communications Buildings
- DoD RPCS Facility Analysis Category (FAC) Code 1444: Miscellaneous Operations Support Buildings with C5ISR missions
- DoD RPCS FAC Code 1452: Missile Guidance Facility
- DoD RPCS FAC Code 6104: Automated Data Processing Center

Refer to the DoDI 4165.03 RPCS for cross reference between the three-digit DoD Basic Category Code, four-digit FAC Code, and the five- or six-digit Military Department Category Codes.

1-3.2 Users of this Document.

1-3.2.1 Planning/Programming Personnel.

Planning and programming personnel must use this UFC in conjunction with the applicable Service-specific governing document for pre-design planning or to assess the extent of improvements required in an existing facility to achieve the standard established herein.

1-3.2.2 Assessment of Existing Facilities.

Use UFC 3-520-02 to assess existing facilities' reliability and availability.

1-3.2.3 Design Services.

Professional architects, engineers, and interior designers must provide design services under the direction of the individual design agencies and this UFC.

1-3.2.4 Service-specific Users and Distribution of Responsibilities.

When Service criteria vary from standard criteria, it is noted in the text as a "Service Exception" or a "Service-specific" criteria. Since numerous and different program offices and functions may be housed in C5ISR Facilities, refer to the appropriate overseeing program office for the specific users and distribution of responsibilities to be housed in the facility. For more general planning questions, refer to the following Service-specific governing documents:

- Army — AR 405-70, IMCOM Space Planning And Criteria Manual
- Navy and Marine Corps — FC 2-000-05N
- Air Force — DAFMAN 32-1084

1-4 FUNCTIONAL AUTHORITIES.

Each facility user or service must appoint a Component Technical Representative (CTR). The CTR represents the project sponsor or customers and exercises authority to establish project requirements on behalf of the user or facility owner as described in UFC 1-200-01. The CTR must identify additional criteria above these requirements during the planning process and MESEP development.

Where Sensitive Compartmented Information Facilities (SCIFs) and Special Access Program Facilities (SAPFs) are included in the C5ISR facility space program, the planning, design, and construction teams must work closely with the supported command, designated Site Security Manager (SSM), and the Certified TEMPEST Technical Authority (CTTA) to determine the requirements for each SCIF. Refer to UFC 4-010-05 for additional requirements.

1-4.1 Planning Process and Facility Grading.

All C5ISR facilities must be at least Grade 3 (concurrently maintainable facility) and can be elevated to Grade 4 (fault-tolerant facility) or lowered to Grade 2 (Redundant Component) based on the mission. During the planning/1391 development phase, the CTR must validate the facility Grade. Justification for facility grades other than Grade 3 must be captured in the planning documents to pass along to the designers. Justification for other than Grade 3 is a service- and mission-specific determination. DoD IEA DC RA requires DoD Core Data Centers (CDCs) to target ANSI/TIA 942-B III Data Center requirements for availability which is equivalent to Grade 3 in this UFC. Refer to DoD IEA DC RA for requirements for other types of DoD Data Centers such as Component Enterprise Data Centers (CEDCs), Installation Processing Nodes (IPNs), Special Purpose Processing Nodes (SPPNs), Installation Services Node (ISN), Geographically Separated Unit (GSU), and Tactical Processing Nodes (TPNs). Refer to Paragraph 2-2 for description of Facility Grading.

Table 1-1 Grade Criteria Based on DoD IEA DC RA

	Data Centers					Other Nodes	
	CDC	CEDC	IPN	SPPN	TPN	ISN	GSU
Grade 1[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grade 2	N/A	N/A	●[2]	●[2]	N/A	●[2]	●[2]
Grade 3	●	●	●	●	●	●	N/A
Grade 4	●	●	●	●	●	●	N/A

Notes:
1. Grade 1 is not acceptable for any DoD Communication Facility
2. Grade 2 is acceptable as minimum with exception.
N/A = Not Applicable

1-5 GENERAL BUILDING REQUIREMENTS.

Comply with UFC 1-200-01, *DoD Building Code*. UFC 1-200-01 provides applicability of model building codes and government unique criteria for typical design disciplines and building systems, as well as for accessibility, antiterrorism, security, high performance and sustainability requirements, and safety. Use this UFC in addition to UFC 1-200-01 and the UFCs and government criteria referenced therein.

1-6 CYBERSECURITY.

All facility-related control systems (including systems separate from a utility monitoring and control system) must be planned, designed, acquired, executed, and maintained in accordance with UFC 4-010-06, and as required by individual Service Implementation Policy.

1-7 INFORMATION SECURITY.

Where SCIFs and SAPFs are included in the C5ISR facility space program, refer to UFC 4-010-05 for planning, design, and construction requirements. In accordance with ICS 705-1, the designated SSM must develop a Construction Security Plan (CSP). Construction plans and all related documents must be handled and protected following the CSP.

1-8 GLOSSARY.

APPENDIX B contains acronyms, abbreviations, and terms.

1-9 REFERENCES.

APPENDIX C contains a list of references used in this document. The publication date of the code or standard is not included in this document. Unless otherwise specified, the most recent edition of the referenced publication applies.

CHAPTER 2 PLANNING AND LAYOUT

2-1 RESILIENCE AND REDUNDANCY.

The continued operation of the facility is contingent upon the systems that maintain the operations. Systems must be reliable and provide both Resilience and redundancy. Refer to Table 1-1 for Grading criteria. C5ISR facilities are to have a minimum facility Grade of 3. Facilities that can operate at a decreased availability and reliability may be designed to have an infrastructure Grading of 2. Facilities that require increased mission availability and reliability may be designed to have an infrastructure Grading of 4. The decision to design a facility for Grade 2 or 4 must be made during the planning/DD1391 development phase. Data Center Infrastructure ratings are driven by the Resilience and redundancy of the systems as defined by Appendix A-2. Refer to UFC 3-520-02 for further definition and descriptions of Resilience.

2-1.1 Resilience.

Systems must be able to continue to support critical equipment in the event of unforeseen circumstances. System Resilience includes maintainability, survivability, and adaptability. Conceptually straightforward systems are easier to operate and maintain. Consider proximity to skilled labor and replacement parts. Systems must be designed to survive natural disasters and other unforeseen circumstances. Systems must be designed for the appropriate risk category to withstand seismic events and wind loads from storms common to their location. Design must comply with the antiterrorism requirements and consider other physical security preventive measures. Identify any other facility requirements with the mission owner, including but not limited to Chemical, Biological, Radiological, Nuclear, and Explosives, or electromagnetic shielding during the planning/DD1391 development phase.

Resilient systems provide an ability to adapt or recover from an event quickly. Work with mission owner engineering and maintenance personnel during the planning/DD1391 development and design process to incorporate resilient features. Resilient features may require higher first cost and increased maintenance. Carefully weigh and discuss resilient features, understanding that no facility can be designed for all unforeseen events.

2-1.2 Redundancy.

Redundancy in a facility is the ability to have multiple paths of system operation allowing for a component or components to be inoperable, while maintaining system function. For mission critical systems, it is important for the mechanical & electrical systems to allow facility operators to maintain equipment or replace faulty equipment while maintaining the mission operations with minimal or no downtime. Both mechanical and electrical can be configured with multiple redundant system architectures ranging from simplistic to more complex. More complex systems feature more components and equipment and may be less reliable. Simpler systems often feature fewer components and less equipment but may suffer from the ability to provide adequate support paths.

See mechanical and electrical discussions of redundancy in Chapter 3 for further discussion. Redundancy must focus on providing highly reliable operations.

System redundancy must be outlined during the planning/DD1391 development phase. Redundancy requirements carry a significant cost. If costs are not accounted for in the development phase, the project cost may be significantly larger than the enacted DD1391 cost.

2-2 FACILITY MISSION CLASSIFICATION (GRADING).

Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance, and Reconnaissance (C5ISR) facilities are mission critical facilities for multiple branches of the Department of Defense. They support the reception, processing, distribution, and/or transmission of classified and unclassified voice, data, and video communications. Refer to the individual services applicable policies and regulations for space types within these facilities based on their Military Department Category Code. Due to the redundancy and Resilience requirements for the C5ISR missions, non-mission space and users should be minimized and limited to the space and users required to execute the C5ISR mission. This requirement to limit space types and users in the C5ISR facility is to reduce risk to the mission (outside and insider threats), facility construction, and facility maintenance costs. The CTR identifies any spaces that must be part of the facility, but do not have the highest level of mission criticality. The CTR can allow these spaces to have a lower infrastructure Grade than the rest of the C5ISR facility.

All C5ISR facilities must be at least Grade 3. Facilities that can operate at a decreased availability and reliability may be designed to have an infrastructure Grading of 2. Facilities that require increased mission availability and reliability may be designed to have an infrastructure Grading of 4. The decision to design a facility for Grade 2 or 4 must be made during the planning/DD1391 development phase. During the planning phase, the CTR must validate the facility Grade. Grades are defined as the following:

2-2.1 Grade 1.

Not applicable to C5ISR facilities. A facility that has no redundant capacity components and no redundant distribution pathways. Maintenance or failures result in facility down time. For cross reference, this Grade 1 definition is a DoD specific definition that is similar in scope to Uptime Institute’s Tier I Data Center, ANSI/TIA-942-B I Data Center, and ANSI/BICSI 002 Class F1.

2-2.2 Grade 2.

A facility that contains single path(s) to critical loads while having some component redundancy. Component redundancy includes added equipment to exceed N requirements but not system level redundancy. This type of system would be vulnerable to component level faults with no added path around failures. It is possible to have planned component level maintenance but only on those components with the added redundancy. In most cases, maintenance or failures would cause downtime to the critical loads supporting the mission. For cross reference, this Grade 2 definition is a DoD specific definition that is similar in scope to Uptime Institute's Tier II Data Center Topology, ANSI/TIA-942-B II Data Center, and ANSI/BICSI 002 Class F2.

2-2.3 Grade 3.

A concurrently maintainable facility with redundant components to service critical operations. The facility must maintain operations for any scheduled maintenance routine without loss in availability. Major features of these facilities include mechanical and electrical systems with N+1 design architectures at a minimum. These architectures may be 50 percent higher in cost compared to a similar-sized facility with no redundancy. For cross reference, this Grade 3 definition is a DoD specific definition that is similar in scope to Uptime Institute's Tier III Data Center Topology, ANSI/TIA-942-B III Data Center, and ANSI/BICSI 002 Class F3.

2-2.4 Grade 4.

A fault-tolerant facility with independent systems that provide redundant paths to critical operations of the facility and automatic response to faults. Equipment associated with redundant paths are physically isolated to prevent catastrophic events from impacting the operations. This facility can maintain availability during a single component, system, or infrastructure failure by initiating an automatic sequence of operations. It may suffer from loss of operations if a component fails during a scheduled maintenance event. Major features of these facilities include mechanical and electrical systems with 2N design architectures at a minimum. These architectures may cost 100-300 percent more than a similar-sized facility with no redundancy. Cost will increase significantly with additional full capacity (N) redundant paths. For cross reference, this Grade 4 definition is a DoD specific definition that is similar in scope to Uptime Institute's Tier IV Data Center Topology, ANSI/TIA-942-B IV Data Center, and ANSI/BICSI 002 Class F4.

2-3 ENGINEERING SYSTEMS GRADING CHECKLIST.

The following checklist is adopted from ANSI/TIA-942-B, Annex F and aligned to DoD-specific requirements. Discipline designations reflect ANSI/TIA-942-B, Annex F and do not necessarily align with the discipline alignments of Chapter 3.

Engineering Systems Grading Checklist			
	Grade 2	**Grade 3**	**Grade 4**
TELECOMMUNICATIONS			
General			
Cabling, racks, cabinets, & pathways meet TIA specs.	IAW UFC 3-580-01	IAW UFC 3-580-01	IAW UFC 3-580-01
Racks & Cabinets	IAW UFC 3-580-01	IAW UFC 3-580-01	IAW UFC 3-580-01
Diversely routed access provider entrances and maintenance holes with minimum 20 m separation	Required	Required	Required
Redundant access provider services – multiple access providers, central offices, access provider rights-of-way	Not Required	Required	Required
Redundant Entrance Room	Not Required	Required	Required
Redundant Distribution Area	Not Required	Not Required	Optional
Redundant Backbone Pathways	Not Required	Required	Required
Redundant Horizontal Cabling	Not Required	Not Required	Optional
Routers and switches have redundant hot-swappable power supplies and processors	Required	Required	Required
Multiple routers and switches for redundancy	Not Required	Required	Required

	Grade 2	Grade 3	Grade 4
Patch panels, outlets, and cabling to be labeled per ANSI/TIA-606-D. Cabinets and racks to be labeled on front and rear.	Required	Required	Required
Patch cords and jumpers to be labeled on both ends with the name of the connection at both ends of the cable	Required	Required	Required
Patch panel and patch cable documentation compliant with ANSI/TIA-606-D.	Not Required	Required	Required
ARCHITECTURAL			
Parking			
Separate visitor and employee parking areas	IAW UFC 3-201-01	IAW UFC 3-201-01	IAW UFC 3-201-01
Separate from loading docks	IAW UFC 3-201-01	IAW UFC 3-201-01	IAW UFC 3-201-01
Proximity of visitor parking to data center perimeter building walls	IAW UFC 4-020-01	IAW UFC 4-020-01	IAW UFC 4-020-01
Multi-tenant occupancy within building	IAW UFC 4-020-01	IAW UFC 4-020-01	IAW UFC 4-020-01

	Grade 2	Grade 3	Grade 4
Fire Resistive Requirements			
Exterior bearing walls	IAW UFC 1-200-01. Minimum Type II construction.	IAW UFC 1-200-01. Minimum Type II construction.	IAW UFC 1-200-01. Minimum Type II construction.
Interior bearing walls	IAW UFC 1-200-01. Minimum Type II construction.	IAW UFC 1-200-01. Minimum Type II construction.	IAW UFC 1-200-01. Minimum Type II construction.
Exterior nonbearing walls	IAW UFC 1-200-01. Minimum Type II construction.	IAW UFC 1-200-01. Minimum Type II construction.	IAW UFC 1-200-01. Minimum Type II construction.
Structural frame	IAW UFC 1-200-01. Minimum Type II construction.	IAW UFC 1-200-01. Minimum Type II construction.	IAW UFC 1-200-01. Minimum Type II construction.
Interior non-computer room partition walls	IAW UFC 1-200-01. Minimum Type II construction.	IAW UFC 1-200-01. Minimum Type II construction.	IAW UFC 1-200-01. Minimum Type II construction.
Interior computer room partition walls	2 hour minimum	2 hour minimum	2 hour minimum
Shaft enclosures	IAW UFC 1-200-01.	IAW UFC 1-200-01.	IAW UFC 1-200-01.
Floors and floor-ceilings	IAW UFC 1-200-01. Minimum Type II construction.	IAW UFC 1-200-01. Minimum Type II construction.	IAW UFC 1-200-01. Minimum Type II construction.
Roofs and roof-ceilings	IAW UFC 1-200-01. Minimum Type II construction.	IAW UFC 1-200-01. Minimum Type II construction.	IAW UFC 1-200-01. Minimum Type II construction.
Meet requirements of NFPA 75	Required.	Required.	Required

	Grade 2	Grade 3	Grade 4
Building Components			
Vapor barriers for walls and ceiling of computer room	Required for walls, add floors as well	Required, add floors as well	Required, add floors as well
Multiple building entrances with security checkpoints	IAW UFC 4-020-01 & 4-010-05	IAW UFC 4-020-01 & 4-010-05	IAW UFC 4-020-01 & 4-010-05
Floor panel construction	No Requirement	Computer grade all steel	Computer grade all steel or computer grade steel with concrete fill
Understructure	No Requirement	Bolted stringer access flooring	Bolted stringer access flooring with 48 in. x 48 in. (1200 mm x 1200 mm) basket weave pattern
Ceilings Within Computer Room Areas			
Ceiling Construction	If provided, suspended with clean room tile	If provided, suspended with clean room tile	If provided, suspended with clean room tile
Ceiling Height	9 feet (2.7 m) minimum	10 feet (3 m) minimum (not less than 18 in. (460 mm) above tallest piece of equipment)	10 feet (3 m) minimum (not less than 24 in. (610 mm) above tallest piece of equipment)
Roofing			
Class	**Class A**	**Class A**	**Class A**
Type	Non-redundant with non- combustible deck (no mechanically attached systems)	Non-redundant with non- combustible deck (no mechanically attached systems)	Double redundant with concrete deck (no mechanically attached systems)
Wind uplift resistance	Greater of FM I-90 or UFC 3-110-03	Greater of FM I-90 or UFC 3-110-03	Greater of FM I-120 or UFC 3-110-03
Roof Slope	IAW UFC 3-110-03	IAW UFC 3-110-03	IAW UFC 3-110-03

	Grade 2	Grade 3	Grade 4
Doors and Windows			
F Fire rating	IAW UFC 1-200-01	IAW UFC 1-200-01	IAW UFC 1-200-01
Door size	Minimum code requirements and not less than 36 in. (910 mm) wide and 96 in. (2400 m) high	Minimum Code requirements (not less than 36 in. (910 mm) wide into computer, electrical, & mechanical rooms) and not less than 96 in. (2400 m) high	Minimum Code requirements (not less than 48 in. (1200 mm) wide into computer, electrical, & mechanical rooms) and not less than 96 in. (2400 m) high
Windows on perimeter of computer room	IAW UFC 1-200-01, 4-010-05 & 4-020-01	IAW UFC 1-200-01, 4-010-05 & 4-020-01	IAW UFC 1-200-01, 4-010-05 & 4-020-01
Entry Lobby			
Physically separate from other areas of data center	Required	Required	Required
Fire separation from other areas of data center	IAW UFC 1-200-01	IAW UFC 1-200-01	IAW UFC 1-200-01
Security counter	Not Required	Required	Required (physically separated from other areas of data center)
Single person interlock, portal or other hardware designed to prevent piggybacking or pass back	Not Required	Required	Required

	Grade 2	Grade 3	Grade 4
Administrative Offices			
Physically separate from other areas of data center	Required	Required	Required
Fire separation from other areas of data center	IAW UFC 1-200-01	IAW UFC 1-200-01	IAW UFC 1-200-01
Security Office			
Physically separate from other areas of data center	Not Required	Required	Required
Fire separation from other areas of data center	IAW UFC 1-200-01	IAW UFC 1-200-01	IAW UFC 1-200-01
180-degree peepholes on security equipment and monitoring rooms	IAW UFC 4-010-05 & 4-020-01	IAW UFC 4-010-05 & 4-020-01	IAW UFC 4-010-05 & 4-020-01
Dedicated and hardened security equipment and monitoring room with 16 mm (5/8 in) plywood-lined walls and solid core door	IAW UFC 4-010-05 & 4-020-01	IAW UFC 4-010-05 & 4-020-01	IAW UFC 4-010-05 & 4-020-01
Operations Center			
Physically separate from other areas of data center	IAW MESEP or Planning Criteria	IAW MESEP or Planning Criteria	IAW MESEP or Planning Criteria
Fire separation from other non-computer room areas of data center	IAW UFC 1-200-01	IAW UFC 1-200-01	IAW UFC 1-200-01
Proximity to computer room	IAW MESEP or Planning Criteria	IAW MESEP or Planning Criteria	IAW MESEP or Planning Criteria

	Grade 2	Grade 3	Grade 4
Restrooms and Break Room Areas			
Proximity to computer room and support areas	If immediately adjacent, provided with leak prevention barrier	If immediately adjacent, provided with leak prevention barrier	Not immediately adjacent and provided with leak prevention barrier
Fire separation from computer room and support areas	IAW UFC 1-200-01	IAW UFC 1-200-01	IAW UFC 1-200-01
UPS and Battery Rooms			
Aisle widths for maintenance, repair, or equipment removal	IAW UFC 1-200-01 and not less than 36 in. (910 mm) clear	IAW UFC 1-200-01 and not less than 36 in. (910 mm) clear	IAW UFC 1-200-01 and not less than 36 in. (910 mm) clear
Proximity to computer room	IAW MESEP or Planning Criteria	IAW MESEP or Planning Criteria	IAW MESEP or Planning Criteria
Fire separation from computer room and other areas of data center	IAW UFC 1-200-01	IAW UFC 1-200-01	IAW UFC 1-200-01
Required Exit Corridors			
Fire separation from computer room and support areas	IAW UFC 1-200-01	IAW UFC 1-200-01	IAW UFC 1-200-01
Width	IAW UFC 1-200-01 and not less than 48 in. (1200 mm) clear	IAW UFC 1-200-01 and not less than 48 in. (1200 mm) clear	IAW UFC 1-200-01 and not less than 60 in. (1500 mm) clear

	Grade 2	Grade 3	Grade 4
Shipping and Receiving Area			
Physically separate from other areas of data center	IAW MESEP or Planning Criteria	IAW MESEP or Planning Criteria	IAW MESEP or Planning Criteria
Fire separation from other areas of data center	IAW UFC 1-200-01	IAW UFC 1-200-01	IAW UFC 1-200-01
Physical protection of walls exposed to lifting equipment traffic	Required (minimum 3/4 in. (19 mm) plywood wainscot)	Required (minimum 3/4 in. (19 mm) plywood wainscot)	Required (steel bollards or similar protection)
Number of loading docks	IAW MESEP or minimum of 1 per 25,000 square feet (2300 sm) (1 minimum)	IAW MESEP or minimum of 1 per 25,000 square feet (2300 sm) (2 minimum)	IAW MESEP or minimum of 1 per 25,000 square feet (2300 sm) (2 minimum)
Loading docks separate from parking areas	No Requirement	Required	Required (physically separated by fence or wall)
Security counter	No Requirement	Required	Required (physically separated)
Generator and Fuel Storage Areas			
Proximity to computer room and support areas	IAW UFC 1-200-01	IAW UFC 1-200-01	IAW UFC 1-200-01
Proximity to publicly accessible areas	IAW UFC 4-020-01 & 3-460-01	IAW UFC 4-020-01 & 3-460-01 and a 30 feet (9.1 m) minimum	IAW UFC 4-020-01 & 3-460-01 and a 30 feet (9.1 m) minimum
Security			
System CPU UPS capacity	IAW MESEP & UFC 4-021-02	IAW MESEP & UFC 4-021-02	IAW MESEP & UFC 4-021-02
Data Gathering Panels (Field Panels) UPS Capacity	IAW MESEP & UFC 4-021-02	IAW MESEP & UFC 4-021-02	IAW MESEP & UFC 4-021-02
Field Device UPS Capacity	IAW MESEP & UFC 4-021-02	IAW MESEP & UFC 4-021-02	IAW MESEP & UFC 4-021-02
Physical security staffing per shift	IAW UFC 4-020-01 & 4-010-05	IAW UFC 4-020-01 & 4-010-05	IAW UFC 4-020-01 & 4-010-05

	Grade 2	Grade 3	Grade 4
Security Access Control/Monitoring			
Generators	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
UPS, Telephone & MEP Rooms	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
Fiber Vaults	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
Emergency Exit Doors	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
Accessible Exterior Windows / opening	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
Security Operations Center	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
Network Operations Center	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
Security Equipment Rooms	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
Doors into Computer Rooms	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
Perimeter building doors	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
Main door onto computer room floor	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01

	Grade 2	Grade 3	Grade 4
Bullet Resistant Walls, Windows, and Doors			
Security Counter in Lobby	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
CCTV Monitoring			
Building perimeter and parking	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
Generators	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
Access Controlled Doors	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
Computer Room Floors	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
UPS, Telephone & MEP Rooms	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
CCTV Recording			
CCTV Recording of all activity on all cameras	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01
Recording rate (frames per second)	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01	Requirement determined by study IAW UFC 4-020-01

	Grade 2	Grade 3	Grade 4
Structural			
Facility designed to International Building Code (IBC) Seismic Design category (SDC) requirements	Requirement determined IAW UFC 3-301-01	Requirement determined IAW UFC 3-301-01	Requirement determined IAW UFC 3-301-01
Site Specific Response Spectra - Degree of local Seismic accelerations	Requirement determined IAW UFC 3-301-01	Requirement determined IAW UFC 3-301-01	Requirement determined IAW UFC 3-301-01
Importance factor - assists to ensure greater than code design	Requirement determined IAW UFC 3-301-01	Requirement determined IAW UFC 3-301-01	Requirement determined IAW UFC 3-301-01
Telecommunications equipment racks/cabinets anchored to base or supported at top and base	Requirement determined IAW UFC 3-301-01	Requirement determined IAW UFC 3-301-01	Requirement determined IAW UFC 3-301-01
Deflection limitation on telecommunications equipment within limits acceptable by the electrical attachments	Requirement determined IAW UFC 3-301-01	Requirement determined IAW UFC 3-301-01	Requirement determined IAW UFC 3-301-01
Bracing of electrical conduits runs and cable trays	Requirement determined IAW UFC 3-301-01	Requirement determined IAW UFC 3-301-01	Requirement determined IAW UFC 3-301-01
Bracing of mechanical system major duct runs	Requirement determined IAW UFC 3-301-01	Requirement determined IAW UFC 3-301-01	Requirement determined IAW UFC 3-301-01
Floor loading capacity superimposed live load	250 lbf/sq ft (12 kPa) minimum	250 lbf/sq ft (12 kPa) minimum	250 lbf/sq ft (12 kPa) minimum
Floor hanging capacity for ancillary loads	50 lbf/sq ft (2.4 kPa) minimum	50 lbf/sq ft (2.4 kPa) minimum	50 lbf/sq ft (2.4 kPa) minimum

	Grade 2	Grade 3	Grade 4
Concrete Slab Thickness at ground	5 in. (127 mm) minimum	5 in. (127 mm) minimum	5 in. (127 mm) minimum
Minimum concrete topping over flutes for equipment anchorage when concrete filled metal deck structure used for elevated floors	4 in. (102 mm) minimum	4 in. (102 mm) minimum	4 in. (102 mm) minimum
Building LFRS (Shear wall/Braced Frame/Moment Frame) indicates displacement of structure	IAW UFC 3-301-01	IAW UFC 3-301-01	IAW UFC 3-301-01
Building Energy Dissipation - Passive Dampers/Base Isolation (energy absorption)	IAW UFC 3-301-01	IAW UFC 3-301-01	IAW UFC 3-301-01
Elevated floor construction. (Steel structures with concrete filled metal decks are more easily upgraded for intense loads in Battery/UPS rooms; and better for installing floor anchors.)	IAW UFC 3-301-01	IAW UFC 3-301-01	IAW UFC 3-301-01

	Grade 2	Grade 3	Grade 4
ELECTRICAL			
General			
System allows concurrent maintenance	Not required but preferred for critical parts of infrastructure	From utility down to but not including power distribution unit	Throughout distribution system
Single Point of Failure	Multiple single points of failure throughout the distribution system	Reduced single points of failure for distribution systems serving electrical equipment. Critical distribution has no single points of failure.	No single points of failure for distribution systems serving electrical equipment or essential load
Power System Analysis	Up-to-date short circuit study, coordination study, arc flash analysis, and load flow study. Selective Coordination provided down to 0.1s	Up-to-date short circuit study, coordination study, arc flash analysis, and load flow study. Selective Coordination provided down to 0.1s	Up-to-date short circuit study, coordination study, arc flash analysis, and load flow study. Selective Coordination provided down to 0.01s
Computer & Telecommunications Equipment Power Cords	Single Cord Feed with 100% capacity	Redundant Cord Feed with 100% capacity on remaining cord(s)	Redundant Cord Feed with 100% capacity on remaining cord(s)
Utility			
Utility Entrance	Single Feed	N+1 Redundant Feed	2N Redundant Feed from different utility substations or generator plant when capable.

	Grade 2	Grade 3	Grade 4
Main Utility Switchboard/Switchgear			
Service	Shared	Dedicated	2N. Two Dedicated from separate substations.
Construction	Switchboard with stationary circuit breakers	Switchboard with draw out circuit breakers	Switchgear with draw out circuit breakers
Surge Suppression	Not Required	Required	Required
Uninterruptible Power Supply (UPS)			
Redundancy	N+1	2N	2N, minimum. Other configurations (3N/2, 2(N+1)) to be evaluated.
Topology	Parallel Modules	Distributed Redundant Modules or Block Redundant System	Distributed Redundant Modules or Block Redundant System
Automatic Bypass	Required, with non-dedicated feeder to automatic bypass	Required, with dedicated feeder to automatic bypass	Required, with dedicated feeder to automatic bypass
Maintenance Bypass Arrangement	Non-dedicated maintenance bypass feeder to UPS output switchboard	Dedicated maintenance bypass feeder to UPS output switchboard	Dedicated maintenance bypass feeder to UPS output switchboard

	Grade 2	Grade 3	Grade 4
Output Power Distribution	Distribution equipment incorporating removable circuit breakers. For equipment main circuit breakers larger than 225 amps provide adjustable long time, short time and instantaneous functions with provision to turn off instantaneous function.	Distribution equipment incorporating removable circuit breakers. For equipment main circuit breakers larger than 225 amps provide adjustable long time, short time and instantaneous functions with provision to turn off instantaneous function.	Distribution equipment incorporating removable circuit breakers. For equipment main circuit breakers larger than 225 amps provide adjustable long time, short time and instantaneous functions with provision to turn off instantaneous function.
Dedicated Battery String for each module	Single or common string for multiple modules modular UPS. Dedicated string for standalone modules	Required	Required
Battery Type	IAW UFC 3-520-05	IAW UFC 3-520-05	IAW UFC 3-520-05
Battery minimum backup time with design load at end of battery life	IAW with MESEP.	IAW with MESEP.	IAW with MESEP.
Battery Monitoring System	String level by UPS system	String level by UPS system	Centralized automated system to check each cell for voltage and impedance or resistance
Power Distribution Unit			
Transformer	Harmonic cancelling, high efficiency	Harmonic cancelling, high efficiency	Harmonic cancelling, high efficiency
Surge Suppression	Required	Required	Required

	Grade 2	Grade 3	Grade 4
Static Transfer Switch (STS)			
Over-current Device	Not Required	Circuit Breaker	Circuit Breaker
Maintenance Bypass Procedure	Not Required	Manual guided with mechanical interlock	Automatic operation
Grounding			
Lightning protection system	Required	Required	Required
Lightning fixtures neutral isolated from service entrance derived from lighting transformer for ground fault isolation	IAW with UFC 3-520-01	IAW with UFC 3-520-01	IAW with UFC 3-520-01
Data center grounding infrastructure in computer room as required by ANSI/TIA-607-D	As required by ANSI/TIA-607-D	IAW MIL-STD-188-124B	IAW MIL-STD-188-124B

	Grade 2	Grade 3	Grade 4
Computer Room Emergency Power Off (EPO) Systems			
Installation	Army and Navy: Provide manual means for electronic equipment EPO as permitted by UFC 3-600-01. Air Force: Automatic EPO is permitted upon sprinkler water flow as guided by TSFPEWG G 3-600-01.01-18. Where provided, provide IAW with NEC 645. A minimum circuit reliability of Performance Level d (PLd) in accordance with ANSI B11.26.	Army and Navy: Provide manual means for electronic equipment EPO as permitted by UFC 3-600-01. Air Force: Automatic EPO is permitted upon sprinkler water flow as guided by TSFPEWG G 3-600-01.01-18. Where provided, provide IAW with NEC 645. A minimum circuit reliability of Performance Level d (PLd) in accordance with ANSI B11.26.	Army and Navy: Provide manual means for electronic equipment EPO as permitted by UFC 3-600-01. Air Force: Automatic EPO is permitted upon sprinkler water flow as guided by TSFPEWG G 3-600-01.01-18. Where provided, provide IAW with NEC 645. A minimum circuit reliability of Performance Level d (PLd) in accordance with ANSI B11.26.
Test Mode	Required	Required	Required
Alarm	Required	Required	Required
Abort Switch	As required by the MESEP	As required by the MESEP	As required by the MESEP

	Grade 2	Grade 3	Grade 4
Central Power Monitoring			
Monitored points	Utility, main transformer, UPS, generator, feeder circuit breakers, automatic static transfer switch, PDU, automatic transfer switches. Limited to circuit breakers 800A or greater.	Utility, main transformer, UPS, generator, feeder circuit breakers, automatic static transfer switch, PDU, automatic transfer switches. Limited to circuit breakers 800A or greater.	Utility, main transformer, UPS, generator, feeder circuit breakers, automatic static transfer switch, PDU, automatic transfer switches. Limited to circuit breakers 800A or greater.
Notification Method	Control Room Console	Engineer of the Watch Workstation via Windows based software.	Engineer of the Watch Workstation via Windows based software.
Battery Room			
Separate from UPS/Switchgear Equipment Rooms	Not Required	Required	Required
Individual Battery Strings contained within their own enclosure.	Not Required	Required	Required
Shatterproof Viewing Glass in Battery Room Door	Not Required	Not required	Required
Standby Generator System			
Generator Sizing	Sized for UPS and mechanical system without redundancy	Sized for station load with N+1 distributed redundancy	Sized for total station load with 2N distributed redundancy. N+1 can be considered if 2N utility is provided.
Generator Configuration	N	N+1 or better	2N on redundant busses

	Grade 2	Grade 3	Grade 4
Loadbank			
Installation	Provision for portable	Provision for portable	IAW with MESEP.
Equipment Tested	Generator	Generator, UPS	IAW with MESEP.
Auto Shutdown	Not Required	Automatic upon failure of utility	IAW with MESEP.
UPS Switchgear	Not Required	Not Required	IAW with MESEP.
Permanently Installed	No - Rental	No - Rental	IAW with MESEP.
Testing			
Factory Accepting Testing	Switchboards, Switchgear, UPS and generator systems, generator controls, STS. Primary injection and contact resistance test of all circuit breakers in critical and essential paths, 225 A and higher IAW UFC 3-560-01	Switchboards, Switchgear, UPS and generator systems, generator controls, STS. Primary injection and contact resistance test of all circuit breakers in critical and essential paths, 225 A and higher IAW UFC 3-560-01	Switchboards, Switchgear, UPS and generator systems, generator controls, STS. Primary injection and contact resistance test of all circuit breakers in critical and essential paths, 225 A and higher IAW UFC 3-560-01
Site Circuit Breaker Testing	Primary injection and contact resistance test of all circuit breakers in critical and essential paths, 225 A and higher IAW UFC 3-560-01	Primary injection and contact resistance test of all circuit breakers in critical and essential paths, 225 A and higher IAW UFC 3-560-01	Primary injection and contact resistance test of all circuit breakers in critical and essential paths, 225 A and higher IAW UFC 3-560-01
Commissioning	Component level, system level, and integrated system including Black Start testing	Component level, system level, and integrated system including Black Start testing	Component level, system level, and integrated system including Black Start testing

	Grade 2	Grade 3	Grade 4
Equipment Maintenance			
Operation and Maintenance Staff	Onsite Day Shift only. On-call at other times	Onsite 24 hrs M-F, on-call on weekends	Onsite 24/7
Preventative Maintenance	Comprehensive preventative maintenance program to include but not limited to Switchgear, switchboards, generators, ATS, STS, automatic sequence exercises and UPS.	Comprehensive preventative maintenance program to include but not limited to Switchgear, switchboards, generators, ATS, STS, automatic sequence exercises and UPS.	Comprehensive preventative maintenance program to include but not limited to Switchgear, switchboards, generators, ATS, STS, automatic sequence exercises and UPS.
Facility Training Programs	Comprehensive training program for normal operation of equipment	Comprehensive training program for normal and emergency operation of equipment.	Comprehensive training program for normal operation of equipment and manual operation of equipment during emergency operation
MECHANICAL			
General			
Redundancy for mechanical equipment (e.g., air conditioning units, coolers, pumps, cooling towers, condensers)	N+1 redundancy for mechanical equipment. Loss of electrical supply path or water supply (where applicable) could lead to loss of cooling	N+1 redundancy for mechanical equipment. Temporary loss of electrical power will not cause loss of cooling, but may cause temperature to elevate within operational range of critical equipment	2N or N+2 redundancy for mechanical equipment. Extended loss of electrical power will not cause loss of cooling outside operational range of critical equipment

	Grade 2	Grade 3	Grade 4
Routing of water or drain piping not associated with the data center equipment in data center spaces	Not permitted	Not permitted	Not permitted
Positive pressure in computer room and associated spaces relative to outdoors and non-data center spaces	Required	Required	Required
Floor drains in computer room for condensate drain water, humidifier flush water, and sprinkler discharge water	Required	Required	Required
Mechanical systems on standby generator	Required	Required	Required
Preventive Maintenance for critical equipment and sensor calibration	Required	Required	Required

	Grade 2	Grade 3	Grade 4
Water-Cooled System			
Indoor Terminal Air Conditioning Units	One redundant air conditioning unit per critical area	Qty. of AC Units sufficient to maintain critical area during loss of one source of electrical power	Qty. of AC Units sufficient to maintain critical area during loss of one source of electrical power. N+1 redundancy is required following loss of one unit.
Humidity Control for Computer Room	De-humidification/humidification, where applicable, provided	De-humidification/humidification, where applicable, provided	De-humidification/humidification, where applicable, provided
Electrical Service to Mechanical Equipment	Single path of electrical power to AC equipment	Multiple paths of electrical power to AC equipment. Connected in checkerboard fashion for cooling redundancy	Multiple paths of electrical power to AC equipment. Provided with ATS/MTS at each piece of equipment.
Heat Rejection			
Piping System	Single path	Headered parallel piped chilled water/ condenser water system or dedicated cooling piping system to ensure concurrent maintainability	Dual path condenser water system
Chilled Water Piping System	Single path	Dual path ladder loop chilled water system with isolation valves	Dual path chilled water system
Condenser Water Piping System	Single path	Headered parallel piped condenser water system	Dual path condenser water system

	Grade 2	Grade 3	Grade 4
Chilled Water System			
Humidity Control for Computer Room	De-humidification/ humidification, where applicable, provided	De-humidification/ humidification, where applicable, provided	De-humidification/ humidification, where applicable, provided
Electrical Service to Mechanical Equipment	Single path of electrical power to AC equipment	Multiple paths of electrical power to AC equipment	Multiple paths of electrical power to AC equipment
Air-Cooled System			
Electrical Service to Mechanical Equipment	Single path of electrical power to AC equipment	Multiple paths of electrical power to AC equipment	Multiple paths of electrical power to AC equipment
Humidity Control for Computer Room	De-humidification/ humidification, where applicable, provided	De-humidification/ humidification, where applicable, provided	De-humidification/ humidification, where applicable, provided
HVAC Control System			
HVAC Control System	Control system failure will not interrupt cooling to critical areas	Control system failure will not interrupt cooling to critical areas	Control system failure will not interrupt cooling to critical areas
Power Source to HVAC Control System	Single path of electrical power to HVAC control system	Redundant, UPS electrical power to BMS control	Redundant, UPS electrical power to BMS control
Plumbing (for Water-Cooled Heat Rejection)			
Dual Sources of Make-up Water	Dual sources of water, or one source + on-site storage with a minimum equal to duration of generator fuel supply	Dual sources of water, or one source + on-site storage with a minimum equal to duration of generator fuel supply	Dual sources of water, or one source + on-site storage with a minimum equal to duration of generator fuel supply
Points of Connection to Condenser Water System	Single point of connection	Two points of connection	Two points of connection

	Grade 2	Grade 3	Grade 4
Fuel Oil System			
Bulk Storage Tanks	Single storage tanks	Multiple storage tanks	Multiple storage tanks
Storage Tank Pumps and Piping	Multiple pumps, single supply pipes, redundant power for fuel control panel.	Multiple pumps, multiple supply pipes, redundant power for fuel control panel.	Multiple pumps, multiple supply pipes, redundant power for fuel control panel.
Fire Suppression			
Fire detection system	Required	Required	Required
Fire sprinkler system	Wet-pipe for Army and Navy. Preaction allowed in certain instances for Air Force per TSFPEWG G 3-600-01.01-18	Wet-pipe for Army and Navy. Preaction allowed in certain instances for Air Force per TSFPEWG G 3-600-01.01-18	Wet-pipe for Army and Navy. Preaction allowed in certain instances for Air Force per TSFPEWG G 3-600-01.01-18
Gaseous suppression system	Clean agent required.	Clean agent required.	Clean agent required.
Early Warning Smoke Detection System	Required	Required	Required
Water Leak Detection System	Required	Required	Required

2-4 MISSION ENGINEERING SYSTEMS EXECUTION PLAN (MESEP).

The MESEP translates the sponsor and user operational requirement statement into a technical description of command, control, communications and intelligence and IT systems and facility infrastructure required to provide the required command, control, communications, and intelligence mission capability. The MESEP must include mission-specific engineering and architecture requirements. The MESEP must include the space planning documents and the electronic equipment engineering requirements document. The requirements of the space planning documents are outlined in the applicable Service-specific governing document.

2-4.1 Minimum MESEP Requirements.

The electronic equipment engineering requirements document must include:

- Technical details related to the station orientation or layout
- Telecommunications equipment rack layouts and rack counts
- Power density per rack
- Network list
- Network Security Requirements (Black/Red/Special Red)
- Preliminary electrical distribution and sizing
- Preliminary mechanical system concept and sizing
- Preliminary fire protection systems (fire alarm, detection, suppression) concepts
- Facility physical security requirements
- Facility cybersecurity requirements
- Systems to be Commissioned.

Rack layouts must include every space that includes telecommunications racks or cabinets. Power density per rack must be provided in a kW per rack unit. The network list must be complete and thorough, giving thought to future networks. Network security must be provided, and verbiage aligned with CNSSAM TEMPEST 1-13. The preliminary mechanical plan is anticipated to assist the Architecture/Engineering (A/E) team in designing the mechanical system. The design process must determine the final mechanical and electrical systems, but it is important to coordinate the electronic equipment engineer’s expectations before design begins. The facility security requirements must be coordinated with the mission and security assessment provided in accordance with UFC 4-020-01. Cybersecurity requirements must be coordinated with mission requirements. At a minimum, include the required C-I-A ratings. This document must be completed during the planning/DD1391 development phase or preliminary project development process to capture required funding.

Navy Facilities: This document is equivalent to the Base Electronic System Engineering Plan (BESEP) for Navy projects, refer to OPNAVINST 11010.20J.

2-5 SITE CONSIDERATIONS.

The primary consideration in selecting a site is its technical adequacy for meeting performance objectives. Generally, the primary considerations are maximum signal-to-noise ratios at the receivers and maximum effective power radiated in the desired direction from the transmitters. Additional considerations include suitability for construction at a reasonable cost, link requirements between components of the communication station, land costs, and logistic support requirements. Other site-specific factors for consideration are the availability of utilities, climate, foundation stability, survivability, physical security, and expansion potential. Although other factors enter into the selection of a site, compromises for the sake of economy or logistics convenience must not interfere with performance.

2-5.1 Relationship to Design.

The designer does not select the site, but the considerations leading to its selection must be understood and incorporated into the design. The resulting findings must be incorporated into the final design for the project.

Navy Facilities: Before the designer begins work, the Field Technical Authority of Naval Information Warfare Systems Command (COMNAVWARSYSCOM) conducts a site selection survey and an Electromagnetic Compatibility (EMC) evaluation as part of the preparation of the MESEP.

2-5.2 Site Selection Survey and Risk Assessment.

Perform a site selection survey and risk analysis to determine the suitability of a site.

2-5.3 Natural and Man-Made Site Factors and Constraints.

Do not select project sites with the following site factors and constraints:

- Sites within 5 miles (8.1 km) of a commercial airport or the aircraft takeoff and landing paths.
- Sites within ¼ mile (0.4 km) of a chemical plant, landfill, river, coastline, or dam.
- Sites within one mile (1.6 km) of a nuclear, munitions, or defense plant.

Where feasible, avoid project locations with the following site factors and constraints during the site selection process:

- Sites near a geologic fault, on a hill subject to slide risk, or downstream from a dam or water tower.
- Sites that are within 300 feet (91.5 m) of the 500-year flood hazard area or less than 10 feet (3.1 m) above the highest known flood level.
- Sites within current or future flood hazard areas as defined by UFC 3-201-01. Unless otherwise stipulated in project-specific guidance provided by the using agency or Authority Having Jurisdiction (AHJ), assume that the

C5ISR facility is classified as Flood Design Class 4 (high risk, essential facilities).

- Sites with wetlands and protected habitats.
- Sites with unstable geotechnical conditions, such as expansive soils, subsurface contamination, or potential for sinkholes.
- Sites adjacent to properties with the potential for any development that could interfere with facility operations.
- Sites that may be impacted by vibrations from railroads or that may have access restrictions due to railroad crossings.

Refer to Appendix A-3 – Data Center Facility Grading Requirements for additional site factors based on the facility grade.

2-5.4 Site Accessibility and Infrastructure.

Consider the following site accessibility and infrastructure factors during the site selection process:

- Availability of electrical utility capacity at the site. Electrical utility capacity must be available at the project site to meet the facility's current and projected future needs. Coordinate with the Electrical Engineer to determine the project-specific electrical demands and projected future needs.
- Availability and economics of redundant utility feeders from separate utility substations.
- Availability and economics of redundant telecommunications pathways from separate telecommunications providers.
- Accessibility of the site from major roadway infrastructure. Where feasible, select a site with multiple access roads to the facility from existing major arterial roadways.
- The site's proximity to emergency services such as hospitals, fire stations, and police stations.

2-5.5 Electromagnetic Compatibility (EMC) Evaluation.

Any factor that prevents or degrades the reception of signals also degrades the ability of the site to perform its mission. Locate the receiving and direction-finding site where signal reception is known to be good. All pertinent information must be outlined in the MESEP.

2-5.6 Isolation.

Optimum radio communications depend largely on the site's isolation from sources of interference and the proper dispersion of structures within the site. Minimum separation distances for electromagnetic interference protection of receiver sites are provided in Table 2-1. Tabulated sources interference applies to Direction Finder (DF) stations of any frequency. Specific requirements for each project, including variations required by local conditions, are developed in the MESEP.

Table 2-1 Minimum Separation Distances for Receiver Sites

Facility	Source of Interference	Minimum Distance
Radio Receiver Station	High-power transmitter stations: Very low frequency	25 miles (40 km)
	Low frequency/high frequency	15 miles (24 km)
	Other transmitter stations not under DoD control	5 miles (8 km)
	Airfields and guide paths: general communications transmitting	5 miles (8 km)
	Airfields and guide paths: aeronautical receiving at air stations	1,500 feet (457 m)
	Teletype and other electromechanical systems installed in shielded rooms or level signaling and keying modified	No requirement
	Teletype and other electromechanical systems installed in unshielded rooms or high level signaling and keying operation: Large installation (communication center)	2 miles (3.2 km) from nearest antenna
	Teletype and other electromechanical systems installed in unshielded rooms or high signaling and keying operation: Small installation (one to six instruments)	200 feet (61 m) from nearest antenna
	Main highways	3,000 feet (914 m)
	High-tension overhead power-lines-receiver station feeders	1,000 feet (305 m) from nearest antenna
	Habitable areas (beyond limits of restriction)	1 mile (1.6 km)
	Areas capable of industrialization (beyond limits of restriction) – Light industry	3 miles (4.8 km)
	Areas capable of industrialization (beyond limits of restriction) – Heavy industry	5 miles (8 km)
	Radar installation	1,500 feet (457 m)
Radio Transmitter Stations	Airfield and glide paths: general communications transmitting	3 miles (8 km)
	Airfields and glide paths: aerological transmitting at air stations	1,500 feet (457 m)
	Main highways	1,000 feet (305 m)
	High-tension overhead power lines	1,000 feet (305 m) from nearest antenna

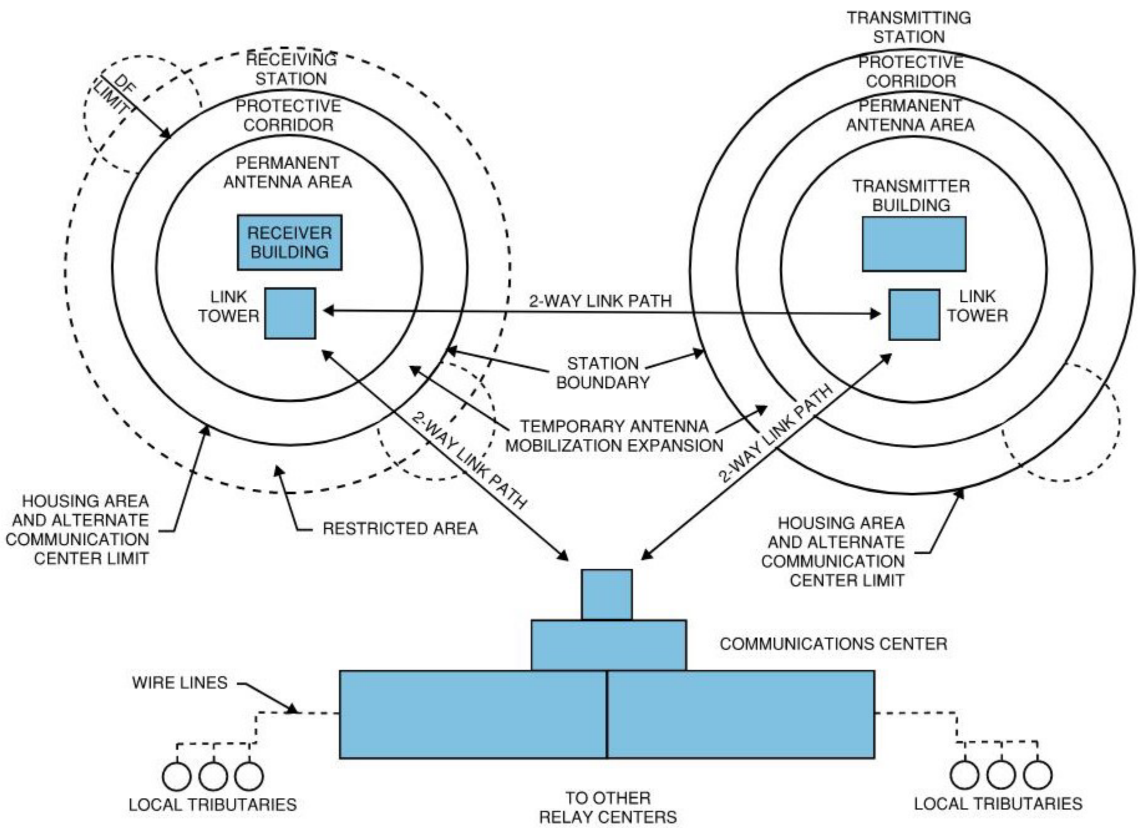
Facility	Source of Interference	Minimum Distance
Direction Finder (DF) Stations (other than Wullenweber type)	Elevated horizontal conductors	Must not subtend a vertical angle exceeding 3° at base of DF antenna
	Railroads	1/4 mile (0.4 km) from antenna
	Rivers and streams	No effect
	Major radio transmitter stations	10 miles (16 km)
	Minor or emergency radio transmitter stations	1 mile (1.6 km)
	Housing areas	1,500 feet (457 m) from DF site
Direction Finder (DF) Stations (other than Wullenweber type)	Ambient interference	Less than 3μV/meter throughout desired frequency range
Communications centers and terminal equipment building	Conform to the minimum separations from Receiver Station as given above	
Control Link Facilities	Separation between RF building and antennas	Max distance 300 feet (91 m)
	Separation between RF building and operations building	Max distance 1,500 feet (457 m)

2-5.7 Layout.

Technical details relating to the location and orientation of buildings are provided in the MESEP and furnished to the designer for adaptation to the site. The arrangement of facilities at a communication station varies according to the mission. Consider the functions of each facility in planning the layout. The locations of buildings are determined in relation to the antenna locations.

Site operating buildings, such as transmitter and receiver buildings, and the terminal point of transmission lines as close to the center of the station or antenna field as possible. Locate support buildings near the station boundary. Where radio interference is a problem, locate roads and parking areas to not have traffic interfere with reception at receiver stations. Orient buildings to provide maximum economy in heating and cooling and to keep paving to a minimum. Site the facility such that adjacent roadway traffic does not result in vehicular contact with the facility perimeter security fence or any external component of the mechanical or electrical systems. Figure 2-1 is a schematic representation of a typical major communication station system.

Figure 2-1 Typical Major Communication Station



2-6 BLACK START SYSTEMS CAPABILITIES.

Black Start capability as defined by National Renewable Energy Laboratory:

> *"Black start is the ability of generation to restart parts of the power system to recover from a blackout. This entails isolated power stations being started individually and gradually reconnected to one another to form an interconnected system again. It is used when the grid experiences a blackout and must be restarted from scratch. As such, black start is a critical resource for maintaining the reliability and resilience of the electric power system and is central to system restoration and recovery plans for system operators."*

For C5ISR facilities, this pertains not only to electrical systems but mechanical systems. The building must be able to be disconnected from its main utility power supply and provide independent power to emergency power system controls, mechanical system controls and start standby power systems. This requirement includes standby generators and UPS systems. Quantity and complexity of systems would be dependent on the Grade required by the mission.

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CHAPTER 3 GENERAL REQUIREMENTS

3-1 PHYSICAL SECURITY AND ANTITERRORISM.

Unless otherwise stipulated in project-specific guidance provided by the using agency or AHJ, assume that the C5ISR facility is an inhabited building in accordance with UFC 4-010-01. For any additional protective design requirements, the installation must establish explicit project-specific Design Basis Threats and Levels of Protection in accordance with UFC 4-020-01.

3-1.1 C5ISR Facilities Enhancements.

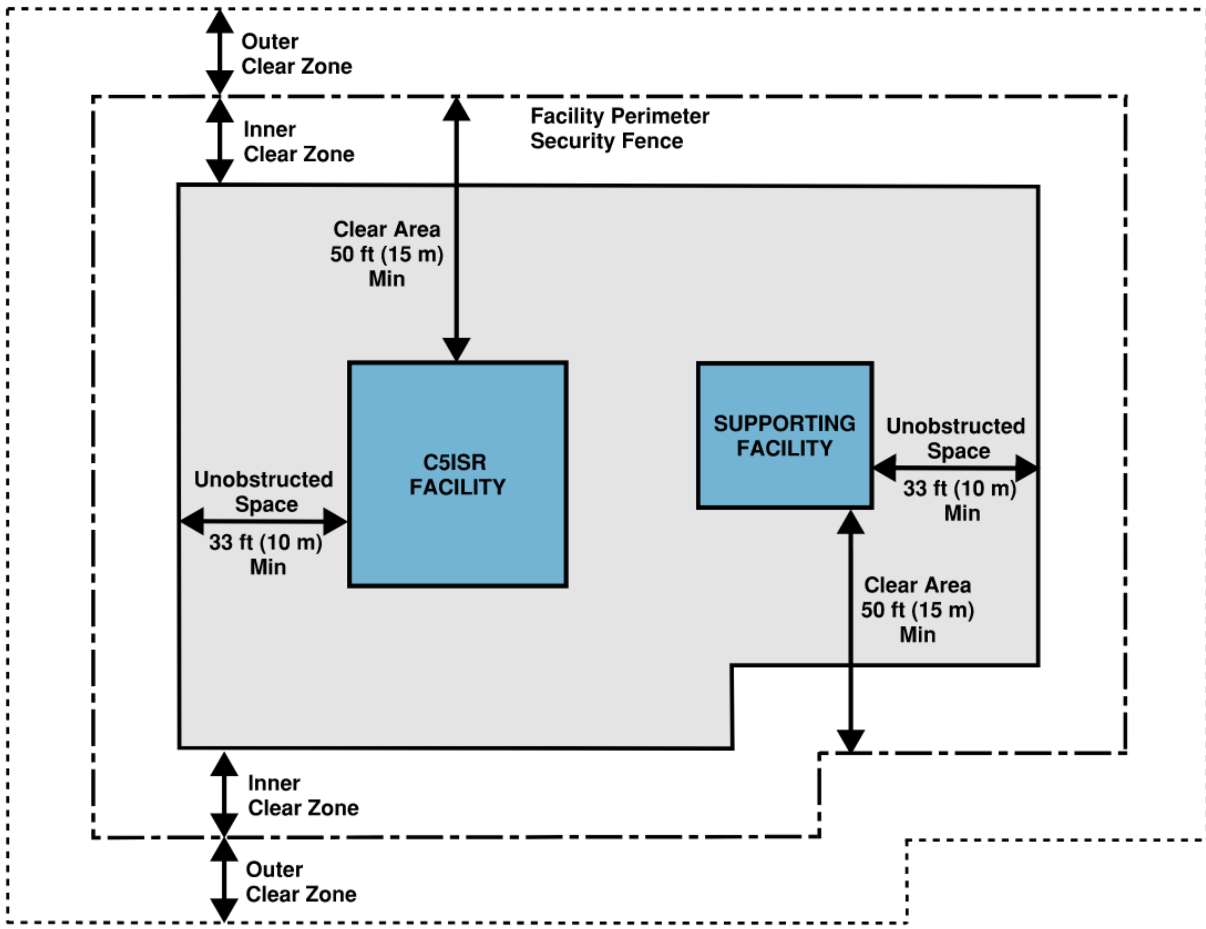
C5ISR facilities contain assets that are critical to the facility's mission and personnel. The Design Basis Threat analysis must consider the criticality of the facility's assets to the success of the facility's mission, including equipment located exterior to the facility, such as transformers and generators. When assets such as transformers or generators are in a standalone supporting facility structure, such as a central utility plant, the standalone structure must meet the same standards as the primary facility.

Due to the enhanced security requirements for C5ISR facilities, establish a minimum clear area around the facility and supporting structures. Clear areas must be free of all obstacles, topographical features, and vegetation exceeding 8 in. (200 mm) in height that could impede observations or provide cover and concealment of an aggressor. Provide a minimum of 50 feet (15 m) from the structures to the facility perimeter security fence. Regardless of the installation's level of security, this requirement provides enhanced detection and assessment of potential threats. This also serves to protect the facility in the case of an insider threat as it establishes a minimum separation between the facility and the remainder of the installation. Provide a minimum unobstructed space of 33 feet (10 m) around the facility in accordance with UFC 4-010-01, Standard 2. Establish requirements for minimum clear zones on the inner and outer perimeter of the security fence in accordance with DoD and Service policy. Refer to Paragraph 3-3.5 for additional information on the perimeter security fence. See Figure 3-1 below.

3-1.2 Secure Facility Requirements.

Facilities with secure requirements must comply with UFC 4-010-05.

Figure 3-1 Facility Clear Zone and Perimeter Fence Requirements



3-2 ARCHITECTURE.

3-2.1

3-2.2 Space Planning.

3-2.2.1 General.

Provide in accordance with MESEP or as required by the individual services applicable policies and regulations.

A computer or equipment room can be defined as any room within the facility where data routing and switching equipment are installed and/or room where cable management is performed to facilitate the mission. When selecting the computer or equipment room site, avoid locations restricted by building components that limit expansion, such as elevators, building cores, outside walls, or other fixed building walls. Provide accessibility, including but not limited to pathways, corridors, and clear door openings for the delivery of large equipment to the equipment room for initial delivery, anticipated service, or replacement (see ANSI/TIA-569-D).

3-2.2.2 Equipment Spaces.

Provide in accordance with MESEP or as required by the individual services applicable policies and regulations.

3-2.2.3 Telecommunications Spaces.

Co-locate telecommunications spaces within the common secure boundaries for the areas being served to the greatest extent practicable.

3-2.3 Basic Construction Criteria.

3-2.3.1 Type of Construction.

Provide minimum Type II Construction for new C5ISR facilities.

Note: The mission can dictate a higher construction type if necessary. Also, depending on location (Outside Continental United States [OCONUS] or expeditionary structures) and for renovations of existing facilities, a lower construction type may be the only option available.

3-2.3.2 Exterior Construction.

3-2.3.2.1 Construction Type.

Facility construction type must be in accordance with Appendix A-3 – Data Center Facility Grading Requirements and the Facility Grade. Reference Section 3-5 STRUCTURAL ENGINEERING for additional requirements.

3-2.3.2.2 Roofs.

Provide Class A roofing as a minimum. Roof penetrations are not permitted in C5ISR mission spaces and telecommunications, mechanical, and electrical rooms that support the C5ISR mission. Antenna doghouses are considered an extension of the facility roof.

Design antenna platforms to be located at a height above the roof to facilitate replacement or repair of roof system without removal of antenna platform structure.

3-2.3.3 Interior Construction.

3-2.3.3.1 Partitions.

At the perimeter of computer rooms and at walls separating computer rooms, provide walls which span from floor slab (true floor) to underside of floor above or roof deck (true ceiling). Coordinate thicknesses to accommodate fully recessed electrical, mechanical and fire safety items (for example, switches, outlets, controllers, fire extinguisher cabinets, piping). Where partitions touch a deck or vertical structural members, provide a joint isolator to prevent the transfer of vibration and structural loads. Design walls and other structural elements for minimum deflection and securely fastened with isolation from all mechanical units and isolation pads or caulking at the top of the partitions.

Coordinate thermal insulation and vapor retarders required for interior partitions with humidity control requirements. Refer to Paragraph 3-6.5.8. Wood stud or other combustible interior framing is prohibited.

3-2.3.3.2 Permanent (Fixed) Flooring.

Provide in accordance with UFC 1-200-01 and UFC 3-101-01 requirements.

3-2.3.3.3 Raised Flooring - Construction.

Raised flooring must conform to the requirements of NFPA 75 and ANSI/TIA-569-D. The flooring system must be a rigid grid bolted grid (stringer) of computer-grade, all steel construction, or as required by the MESEP. Steel or concrete-filled steel flooring panels are acceptable. Galvanized steel components are not permitted. All air supply panels, and similar inserts, must be flush with the flooring surface. Install in accordance with MIL-HDBK-419A, Volumes 1 and 2.

Where under floor cooling is utilized, use floor tile cuts only to accommodate cabinet vents, cooling systems, or route cables from under floor to above floor. In all cases, design floor tile openings to seal, as tight as possible, against the penetrations to minimize loss of under floor air pressure. Use brushes, flaps, or other methods to contain static air pressure. Place floor tile cuts for cabinets under the cabinets or in other locations where the floor tile cut will not create a tripping hazard. Place floor tile cuts for racks either under the vertical cable managers between the racks or under the rack (at the opening between the bottom angles). Generally, placing the floor tile cut under the vertical cable managers is preferable as it allows equipment to be located at the bottom of the rack. Provide access floor tile cuts with edging or grommets along all cut edges. If the edging or grommets are higher than the surface of the access floor, install them so as not to interfere with the placement of racks and cabinets. Do not place the edging or grommets where the racks and cabinets normally contact the surface of the access floor. In the case of down-flow air conditioning (AC) systems where the access flooring is being used as an air distribution plenum, limit floor tile cuts in both size and quantity to ensure proper airflow. In addition, floor tiles with cement cores must have their exposed cut edges sealed to prevent core material from being blown into the computer room. Complete floor installation before mechanical testing and balancing, including all cuts and subsequent sealing.

3-2.3.3.4 Raised Flooring – Depth.

Raised access floor depth must consider future flexibility, with space for future re-configuration and addition of cabling and conduits. The design must ensure ample space is reserved for air distribution if underfloor air distribution is used.

Air Force Facilities: Provide a minimum raised access floor height of 24 in. (610 mm) where underfloor air distribution is utilized.

3-2.3.3.5 Ceilings.

Ceiling design must be consistent with lighting, air conditioning, ventilation, cable tray layout, acoustical treatment, and fire protection requirements. The minimum height of the room is 8.5 feet (2.6 m) from the finished floor to any obstruction, such as sprinklers, lighting fixtures, overhead cable trays, or cameras. Cooling requirements or racks/cabinets taller than 7 feet (2.1 m) may dictate higher ceiling heights. Maintain a minimum of 18 in. (460 mm) vertical and horizontal clearance from sprinklers. In the uninterruptible power supply, transmitter, and similar equipment spaces where heat dissipation is a design factor, a clear height of 10 feet (3 m) is required.

If suspended ceilings are installed, provide clean room tile in all computer rooms. To support the items hanging below the suspended ceiling, provide a structural ceiling grid with a hanging capacity of 25 lb/square foot (1197 N/m^2) and a point load capacity of 132 lb. (60 kg) at a minimum. Structural requirements and systems to be supported off the ceiling grid may require a higher hanging and point load capacity.

3-2.3.3.6 Doors.

For computer rooms and entrance rooms, doors must meet the minimum dimensions of the Engineering Systems Grading Checklist and must be sized to accommodate the largest expected equipment. The door must have no door sills and be hinged to open outward (code permitting). Doors must be fitted with locks and have either no fixed center posts / mullions or be provided with removable center posts / mullions to facilitate access for large equipment.

For computer rooms and entrance rooms, doors and frames must be acoustically treated to provide acoustic separation between computer rooms and program spaces, as required by the MESEP.

3-2.3.3.7 Windows.

No exterior windows are permitted in computer rooms, entrance rooms, equipment rooms, watch floors, or in other spaces defined by the MESEP or applicable security criteria.

3-2.3.3.8 Finishes.

Where wall terminations are to be used for protectors and termination hardware, cover adequate wall space for all anticipated protectors and termination hardware with 3/4 in. (19 mm) fire-retardant-treated plywood. The backboard must be 48 in. (1200 mm) x 96 in. (2400 mm) sheets, mounted vertically, and with the bottom of the plywood mounted 6 in. (150 mm) above finished floor (AFF) with the best side toward the room with markings visible. Plywood must be permanently fastened to the wall using wall anchors utilizing galvanized, zinc-plated, or stainless-steel hardware with a flat head. The finished installation must have a flush appearance with countersunk screw heads to prevent the splitting of the plywood. Drywall screws are not acceptable. Plywood must not be painted, stained, or otherwise finished so that the rating markings remain visible. Finish equipment rooms and related walls with a particulate-free, water-based epoxy paint finish, smooth finish. Before painting, the drywall board must be sealed with a compatible sealing primer.

Completely seal all penetrations in perimeter walls where the wall meets the deck (structure) above, following all security, acoustic, and fire protection requirements. All penetrations in the perimeter walls must be completely sealed, following all security, acoustic, and fire protection requirements.

3-2.3.4 Special Space Requirements.

3-2.3.4.1 Clearances.

Equipment paths from exterior doors and loading areas to computer rooms and equipment spaces must be sized to accommodate the movement of the largest anticipated piece of equipment.

3-2.3.4.2 Acoustical Treatment.

Provide as required by the MESEP.

For Army facilities: Meet the noise abatement requirements of DA PAM 40-501. The noise level must not expose the occupants to sound levels above those shown in MIL-STD-1472, MIL-STD-1474, and DA PAM 40-501. Sound pressure levels within the computer room must not exceed 60 dBA. The facility design and materials must interrelate and optimize the following factors: arrangement and spacing of the engines; acoustical insulation and design of exhaust and intake systems; and acoustical characteristics of the building construction.

3-2.3.4.3 Firestopping.

Provide in accordance with UFC 3-600-01.

3-2.3.4.4 Shielding.

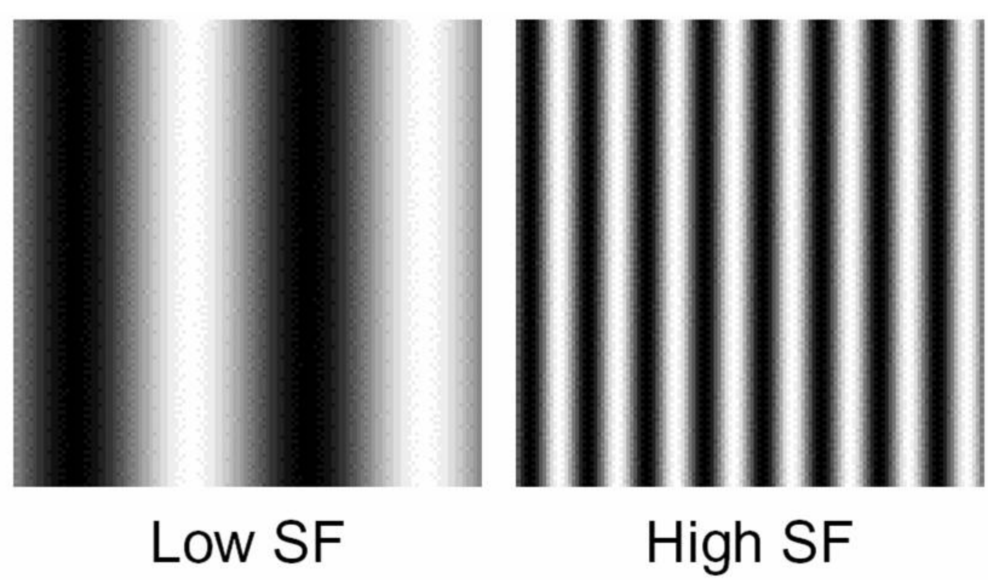
Provide in accordance with TEMPEST Countermeasures Review or as required by the MESEP.

3-2.3.4.5 Windowless Operating Environments (Command and Control / Operations Centers)

C5ISR facilities are mission critical facilities that maintain operations during severe weather and, in worst case, war. Some facilities may be operated and occupied 24 hours a day, 7 days a week. Some facilities support remote wartime operations with operators transitioning from wartime environments (remotely) to a peacetime environment (in person) once they leave the facility. The continuous operation of the facility and transitioning from wartime to peacetime environments makes them a high stress work environment. Many spaces within a C5ISR facility contain sensitive information, and, therefore, may not include windows. This type of environment can be stressful given its claustrophobic nature. Consider providing large frame TVs within the spaces with a continuous, scanning camera feed of the outside. This will allow occupants to maintain their bearings, observe the weather and reduce the stress caused by a confined environment. Visual relief in the form of views of nature may not be possible in the operations area but is highly effective in break areas. Every few hours, analysts need to reset their visual system with long distance viewing (relaxes the eye muscles) ideally with fractal patterns, best provided by views of nature. Visual relaxation is as important as mental relaxation for this high stress visual environment.

For spaces with continuous operation special consideration of interior patterns must be considered to reduce stress. Avoid the use of carpets, art, wall finishes or systems furniture with high spatial frequencies. High spatial frequencies have been associated with exacerbating stress and reducing cognitive functions.

Figure 3-2 Spatial Frequency Example



3-3 CIVIL ENGINEERING.

3-3.1 Siting Procedure.

Developing the optimum site configuration requires civil and electronic equipment engineering coordination. The designer must be provided with preliminary site layouts developed by the electronic system engineering activity showing the site dimensions, schematic building layout, utility requirements, access road layout, direction and number of transmission paths, size, and layout of supporting structures, and unique design considerations for optimum performance of the electronic system.

Provide for future expansion as required by the MESEP. If there are no specific requirements, plan for expansion as a matter of course. Locate support facilities near the boundary of the station to permit expansion without impacting the antenna area. Construction of separate structures or self-contained elements is preferred to expansion by extension of existing facilities.

3-3.2 Site Plan Components.

The designer is responsible for preparing a final site plan using the preliminary site layout prepared by the electronic system engineering activity, information from the site survey, and the criteria herein. In addition to the location of facility components, incorporate the following site components into the final plan as applicable:

- Site boundary and property lines
- Survey base line and benchmarks
- Access roads and parking areas
- Elevation, azimuth, and coordinates for the center of each antenna
- Underground utilities and services
- Existing buildings and facilities

In general, electronic facilities (structures) are similar to other shore facilities, and the criteria in UFC design manuals are applicable.

3-3.3 Surface and Subsurface Drainage.

Utilize surface drainage, such as swales, to the greatest extent possible. Design swales for minimal velocity to avoid erosion to swales or downstream receiving channels. Design storm sewer systems and stormwater management infrastructure based on a storm with a 50-year design frequency. Metallic pipe and reinforced concrete pipe may not be permitted at some sites. Restrictions on pipe material will be indicated in project MESEP. Storm drain piping may not be routed through an antenna ground plane.

Consider water table conditions at the site in the building design. Design the lowest level of the building and any utility piping above the water table. If the building has one or more subgrade floors, additional efforts may be required to protect it from water infiltration or the effects of seasonal variations in the water table.

3-3.4 Vehicular and Pedestrian Circulation.

Provide access roads, parking areas, pedestrian walks, and other traffic areas adjacent to buildings with bituminous concrete (asphalt) or Portland cement concrete surface. Design access roads from the nearest major arterial road to the site having a minimum height clearance of 14 feet (4.3 m). Design access roads to the site to allow for deliveries such as heavy components of the technical building systems, including mobile cranes, in any weather conditions. Avoid using curb and gutter unless necessary based on project or site-specific design constraints.

Provide guardrail where the work area is 4 feet (1.2 m) or more above a lower level.

3-3.5 Site Security Considerations.

Provide a facility layout that is compatible with an overall installation security plan and considers the location of guard posts, patrols, and security response forces; the location and characteristics of intrusion detection systems; facility access control; and natural factors.

External security requirements, in most cases, depend on the internal security measures provided in the facility design and the type of protection required. Normally, external considerations, including building location, orientation, and use of protective barriers and lighting, are developed as part of the facility's security plan and specified in the MESEP. The mode of operation, level of security, and designer's responsibility for particular security elements must be designated in the MESEP.

3-3.5.1 Perimeter Fencing.

Generally, chain-link fencing is used for permanent areas. General-purpose barbed tape and concertina wire are used for temporary installations or where the terrain does not allow the construction of chain-link fencing. The following requirements are the minimum for normal protection:

- Establish clear zones, clear areas, and locate the facility perimeter security fence in accordance with Paragraph 3-1.

- Provide chain-link fence fabric a minimum of 7 feet (1.9 m) high unless project-specific requirements dictate otherwise. Provide a fence topped by a 45-degree outrigger that is 15 to 18 in. (380 to 460 cm) long. Provide three evenly spaced strands of barbed wire strands attached to the outriggers. Provide grounding for all fence fabric and barbed wire strands.

- Protect utility openings, covers, sewers, culverts, tunnels, and other subsurface routes penetrating the fence line.

- Provided the minimum number of gates and perimeter entrances required for safe and efficient operation.

- Where security fencing is adjacent to vehicular travel lanes or parking areas, provide wheel stops, curbs, bollards, or guardrails as required.

- Provide guard shelters where required by the MESEP.

3-3.5.2 Exterior Equipment.

Locate all mechanical equipment, generators, fuel tanks, or other exterior equipment within the perimeter security fence and secure from public access.

3-3.6 Utility Services.

Refer to the MESEP for project-specific restrictions on the use of metallic pipe and reinforced concrete pipe. Refer to Section 3-6.12 for plumbing requirements.

3-4 LANDSCAPE ARCHITECTURE.

Provide landscaping and ground cover only to the extent that they reduce site maintenance. Vegetation must not interfere with antennas and ground mats. Some site areas must be kept free of vegetation. Maintain clear zones free of vegetation on either side of perimeter security fencing in accordance with Paragraph 3-3.1. Consult the electronic system engineering activity for additional restrictions.

Do not provide permanent irrigation for lawn areas or plantings.

3-5 STRUCTURAL ENGINEERING.

3-5.1 Risk Category.

Unless otherwise stipulated in project-specific guidance provided by the using agency or AHJ, assume that the C5ISR facility is a building or other structure having DoD mission-essential command, control, primary communications, data handling, and intelligence functions that are not duplicated at geographically separate locations, as designated by the using agency, and therefore classified as Risk Category IV, as defined by UFC 3-301-01.

3-5.2 Live Loads.

Use a minimum design floor uniform live load of 250 psf (12 kPa). For elevated floors, assume an additional uniform live load of 50 psf (2.4 kPa) minimum to account for the weight of overhead hanging equipment in spaces below. Coordinate with the user to determine if the actual anticipated equipment exceeds these minimum uniform live loads and design the floors accordingly.

3-5.3 Seismic Criteria.

Ensure that non-structural components are laterally braced as required for seismic load stability in accordance with UFC, building code provisions, and as described in this standard. Careful analysis of these requirements must be addressed in the planning/DD1391 development phase. Coordinate additional bracing requirements to avoid interference with items to be installed post construction, such as cabling, conduit raceways, and other infrastructure for electronic equipment.

Assign components required to support and sustain continued operations of the C5ISR mission a component Importance Factor of I_p = 1.5. Refer to UFC 3-301-01 for additional information.

3-5.4 Minimum Concrete Thicknesses.

Provide a minimum concrete thickness of 5 in. (127 mm) for slabs-on-grade. Coordinate minimum concrete thickness with any project security noise reduction requirements. Coordinate minimum concrete thickness with Paragraph 3-7.8 Grounding and Bonding requirements.

For elevated floor construction using a concrete-filled metal deck structure, provide a minimum 4 in. (102 mm) concrete thickness above the flutes of the metal deck to allow equipment anchorage using post-installed anchors.

3-5.5 Raised Flooring Minimum Loading Requirements.

Minimum loading and allowable deflection requirements for raised access flooring are as follows:

- Rolling load (access floor tile): 1,500 lb (680 kg). Local surface deformation 0.02 in. (0.5 mm). Total permanent set 0.04 in. (1 mm).

- Impact Load (access floor tile): 175 lb (80 kg). Drop weight, dropped from 12 in. (305 mm) height on 1 in^2 (645 mm^2) local surface with maximum deformation 0.06 in. (1.5 mm).

- Concentrated Load (access floor tile): 1500 lb (680 kg). Load on 1 in^2 (645 mm^2) point with maximum deflection 0.08 in. (2 mm) anywhere on the panel.

- Uniform Load (access floor system): 250 psf (12 kPa). Load rating of the access floor system, including panels, pedestals, and stringers.

3-5.6 Raised Flooring Seismic Requirements.

Design raised access floors for seismic considerations in accordance with UFC 3-301-01 or UFC 3-301-02 as applicable or ASCE/SEI 7 special access floor requirements, whichever is more stringent. Additionally, perform an in-structure response analysis to compute the coupled response of a raised access floor, then use it to develop response spectra for equipment mounted on the raised access floor. Compute the overturning of equipment mounted on the computer room floor, and if required, provide restraints for Seismic Design Categories C through F. Provide positive mechanical attachments as required to prevent overturning using direct fasteners or adhesive to the substrate. Treat raised access floors as Designated Seismic Systems.

3-6 MECHANICAL ENGINEERING.

All mechanical criteria from UFC 3-401-01 that apply to DoD facilities also apply to C5ISR facilities. Only items specifically applicable to C5ISR facilities are covered in this section.

3-6.1 Outside Design Conditions.

C5ISR spaces must utilize outside design temperature criteria for Specialized Technical Requirements.

3-6.2 Indoor Design Conditions.

C5ISR facilities have spaces with stringent indoor air temperature and humidity requirements.

3-6.2.1 C5ISR Space Temperatures.

C5ISR spaces with data equipment must always comply with ASHRAE Thermal Guidelines for Data Processing Environments. Air temperature and humidity must comply with the “Recommended” requirement. Liquid cooling temperature must comply with Class W17/W27. Heating, Ventilating, and Air-Conditioning (HVAC) systems and controls must account for temperature rise during primary power loss.

Comply with user criteria and MESEP requirements where more stringent.

3-6.2.2 Battery and UPS Space Temperatures.

Temperatures for battery and UPS rooms with batteries must be in accordance with the requirements of UFC 3-520-05.

3-6.2.3 Generator Room Temperatures.

Temperatures for generator rooms must be in accordance with UFC 3-540-01.

3-6.3 Redundancy and Resilience.

Mechanical systems serving C5ISR functions must meet the Facility-required Grade to provide the required level of redundancy and Resilience. Systems that do not serve C5ISR functions are not required to comply with the facilities mission classification.

To increase redundancy in the mechanical plant, use automatic transfer switches (ATS), manual transfer switches (MTS) or static transfer switches (STS) on individual mechanical equipment to provide a dual power path. Dual power feed mechanical equipment is an acceptable solution to reduce the required square footage. An ATS or STS must be provided for Grade 4 facilities to meet the fault tolerant requirements. An MTS is acceptable for Grade 3 facilities.

Air Force Facilities: Manual transfer switches are not allowed.

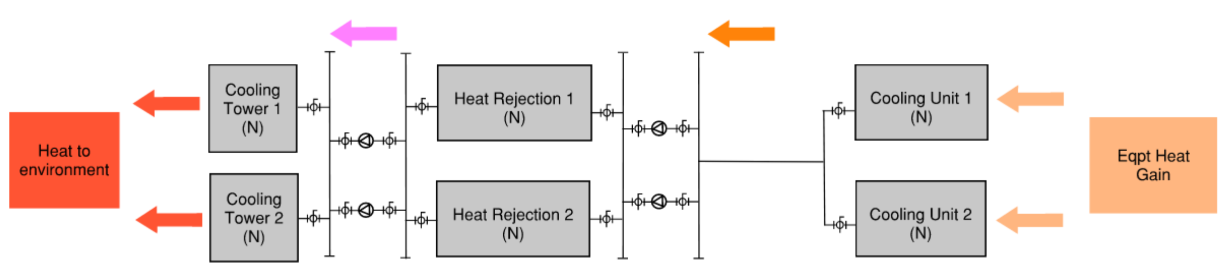
3-6.3.1 Grade 1 Mechanical Systems.

Not applicable.

3-6.3.2 Grade 2 Mechanical Systems.

Grade 2 systems provide critical equipment redundancy. Equipment serving a critical space must feature equipment N+1 redundancy. Redundancy must allow for routine maintenance to any piece of equipment without affecting the critical services being provided with cooling. Refer to Figure 3-3 for a Grade 2 common cooling heat rejection schematic and Figure 3-4 for a Grade 2 dedicated cooling heat rejection schematic. The size of equipment (% of N) can vary, but the system must maintain a minimum of N+1 redundancy. The systems mentioned represent typical cooling approaches but are not an exhaustive list of possible systems. For Grade 2 systems, utilize N+20% redundancy where N is met by five or more components.

Figure 3-3 Grade 2 Common Cooling Heat Rejection Schematic (N+1)



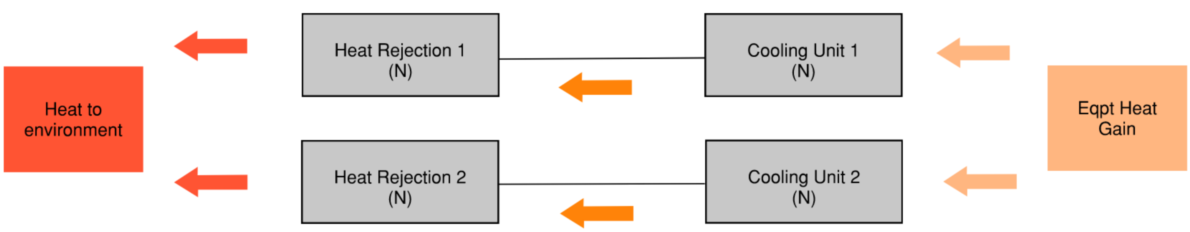
Cooling Tower / Condenser Water (N+1)	Heat Rejection (N+1)	Piping w/ headed pumps*	Cooling Unit (N+1)
Cooling Tower w/ headered pumps	Water Cooled Chiller Plant	Chilled Water	CRAH/Fan Coils
NA	Air Cooled Chiller Plant	Chilled Water	CRAH/Fan Coils
NA	Closed Circuit Cooling Tower	Condenser Water	CRAC/Water Source Heat Pumps
NA	Drycoolers	Cooling Water	CRAC/Water Source Heat Pumps
NA	Drycoolers	Cooling Water	Liquid Cooling

*Figure does not show both supply and return piping for clarity. System requires both supply and return piping.

Availability at Critical Technical Load	
System	Availability
Grade 2 Common Heat Rejection - Water Cooled Chiller (Cooling Tower) w/ CRAH/FCU	0.999999
Grade 2 Common Heat Rejection - Air-Cooled Chiller w/ CRAH/FCU	0.999999
Grade 2 Common Heat Rejection - Evaporatively Cooled w/ CRAC/WSHP	0.999999
Grade 2 Common Heat Rejection - Drycooler w/ CRAC/WSHP	0.999999
Grade 2 Common Heat Rejection - Drycooler w/ Liquid Cooling	0.999999

1. Availability equations are taken from UFC 3-520-02. Calculator utilizes the "block diagram" model.
2. Availability values are taken from IEEE 493-2007, Table 10-4.

Figure 3-4 Grade 2 Dedicated Cooling Heat Rejection Schematic (N+1)



Heat Rejection (N+1)		Piping*		Cooling Unit (N+1)
Drycoolers	←	Cooling Water Piping	←	CRAC/Water Source Heat Pumps
Condenser		Refrigerant Piping		CRAC/DX Split Systems
Drycoolers		Cooling Water Piping		Liquid Cooling

*Figure does not show both supply and return / all required refrigerant piping for clarity. System requires both supply and return / all required refrigerant piping.

Availability at Critical Technical Load	
System	Availability
Grade 2 Dedicated Cooling – Drycooler w/ CRAC/WSHP	0.999999
Grade 2 Dedicated Cooling – Condenser w/ CRAC/DX Split System	0.999999
Grade 2 Dedicated Cooling – Drycooler w/ Liquid Cooling	0.999999

1. Availability equations are taken from UFC 3-520-02. Calculator utilizes the "block diagram" model.
2. Availability values are taken from IEEE 493-2007, Table 10-4.

3-6.3.3 Grade 3 Mechanical Systems.

Grade 3 systems are concurrently maintainable. Concurrently maintainable mechanical systems must maintain critical space temperature and humidity at design conditions while allowing for active maintenance of any unit or utility path. Redundancy must enable the isolation of any item of equipment as required for essential maintenance without affecting the services being provided with cooling. Refer to Figure 3-5 for a Grade 3 common cooling heat rejection schematic and Figure 3-6 for a Grade 3 dedicated cooling heat rejection schematic. The size of equipment (% of N) can vary, but the system must maintain a minimum of N+1 redundancy. The systems mentioned represent typical cooling approaches but are not an exhaustive list of possible systems. For Grade 3 systems, utilize N+20% redundancy where N is met by five or more components.

Figure 3-5 Grade 3 Common Cooling Heat Rejection Schematic (N+1)

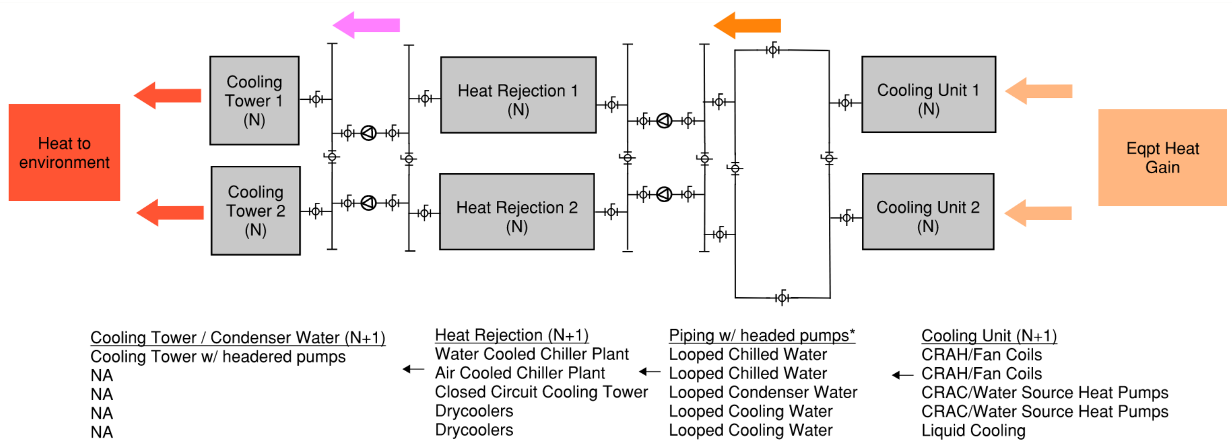


*Figure does not show both supply and return piping for clarity. System requires both supply and return piping.

Availability at Critical Technical Load	
System	Availability
Grade 3 Common Heat Rejection - Water Cooled Chiller (Cooling Tower) w/ CRAH/FCU	0.999999
Grade 3 Common Heat Rejection - Air-Cooled Chiller w/ CRAH/FCU	0.999999
Grade 3 Common Heat Rejection - Evaporatively Cooled w/ CRAC/WSHP	0.999999
Grade 3 Common Heat Rejection - Drycooler w/ CRAC/WSHP	0.999999
Grade 3 Common Heat Rejection - Drycooler w/ Liquid Cooling	0.999999

1. Availability equations are taken from UFC 3-520-02. Calculator utilizes the "block diagram" model.
2. Availability values are taken from IEEE 493-2007, Table 10-4.

Figure 3-6 Grade 3 Dedicated Cooling Heat Rejection Schematic (N+1)

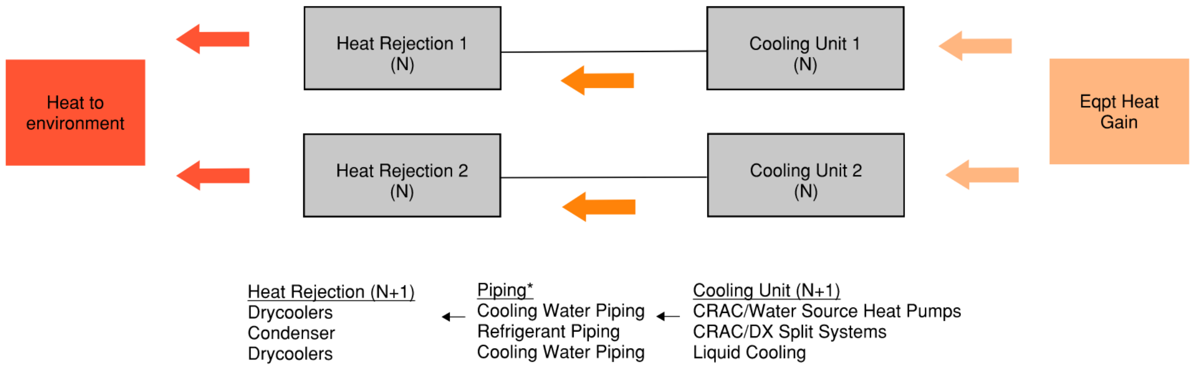


*Figure does not show both supply and return / all required refrigerant piping for clarity. System requires both supply and return / all required refrigerant piping.

Availability at Critical Technical Load	
System	Availability
Grade 3 Dedicated Cooling – Drycooler w/ CRAC/WSHP	0.999999
Grade 3 Dedicated Cooling – Condenser w/ CRAC/DX Split System	0.999999
Grade 3 Dedicated Cooling – Drycooler w/ Liquid Cooling	0.999999

1. Availability equations are taken from UFC 3-520-02. Calculator utilizes the "block diagram" model.
2. Availability values are taken from IEEE 493-2007, Table 10-4.

3-6.3.4 Grade 4 Mechanical Systems.

Grade 4 systems are fault tolerant. Fault-tolerant mechanical systems must maintain critical space temperature and humidity at design conditions while allowing failure of / or service to one electrical switchboard. Redundancy must enable the isolation of any item of equipment as required for essential maintenance or failure without affecting the services being provided with cooling. Refer to Figure 3-7 for a Grade 4 common cooling heat rejection schematic with 2N redundancy, Figure 3-8 for a Grade 4 common cooling heat rejection schematic with N+2 redundancy, Figure 3-9 for a Grade 4 dual path heat rejection schematic, and Figure 3-10 for a Grade 4 dedicated cooling heat rejection schematic. The size of equipment (% of N) can vary, but the system must have a minimum of N+2 redundancy. N+1 redundancy must be maintained if any unit is lost. The systems mentioned represent typical cooling approaches but are not an exhaustive list of possible systems.

For Grade 4 systems with N+2 redundancy, utilize N+40% redundancy where N is met by five or more components.

Figure 3-7 Grade 4 Common Cooling Heat Rejection Schematic (2N)

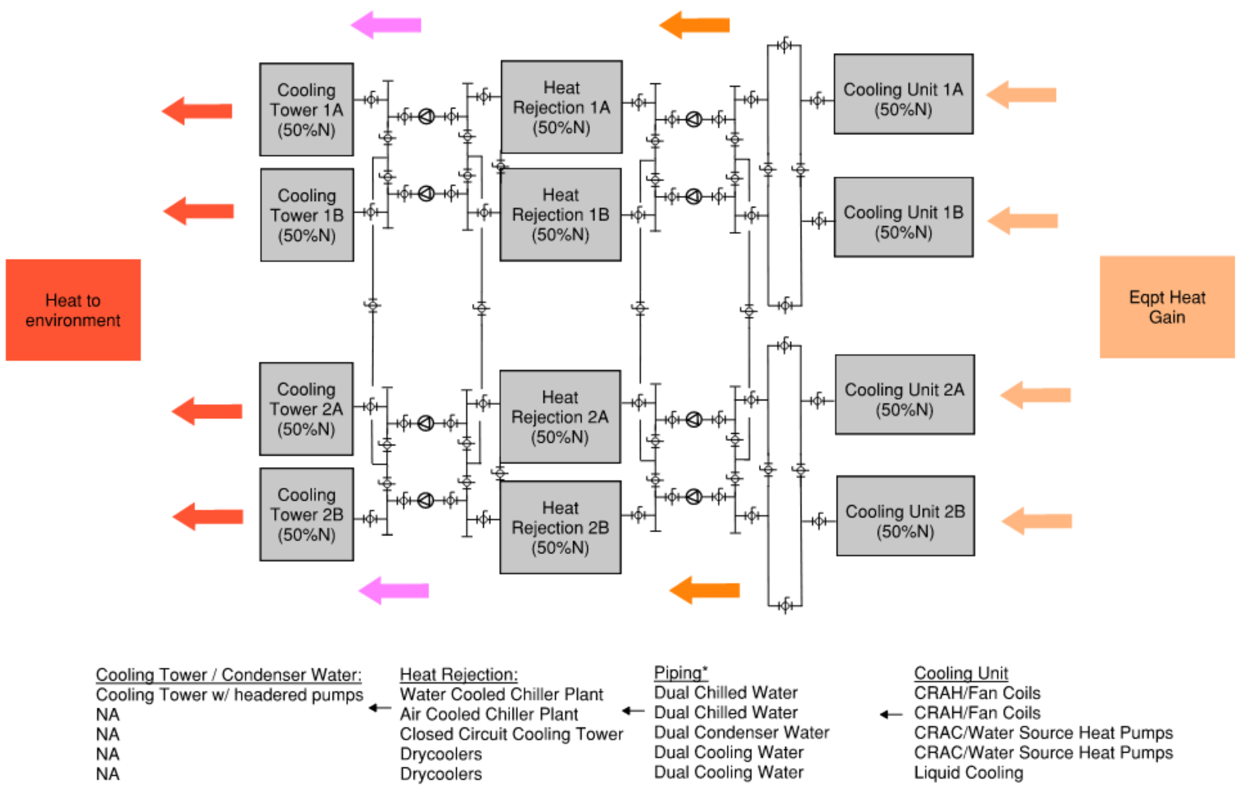


*Figure does not show both supply and return piping for clarity. System requires both supply and return piping.

Availability at Critical Technical Load	
System	Availability
Grade 4 Common Heat Rejection (2N) - Water-Cooled Chiller (Cooling Tower) w/ CRAH/FCU	0.999999
Grade 4 Common Heat Rejection (2N) - Air-Cooled Chiller w/ CRAH/FCU	0.999999
Grade 4 Common Heat Rejection (2N) - Evaporatively Cooled CRAC/WSHP	0.999999
Grade 4 Common Heat Rejection (2N) - Drycooler w/ CRAC/WSHP	0.999999
Grade 4 Common Heat Rejection (2N) - Drycooler w/ Liquid Cooling	0.999999

1. Availability equations are taken from UFC 3-520-02. Calculator utilizes the "block diagram" model.
2. Availability values are taken from IEEE 493-2007, Table 10-4.

Figure 3-8 Grade 4 Common Cooling Heat Rejection Schematic (N+2)

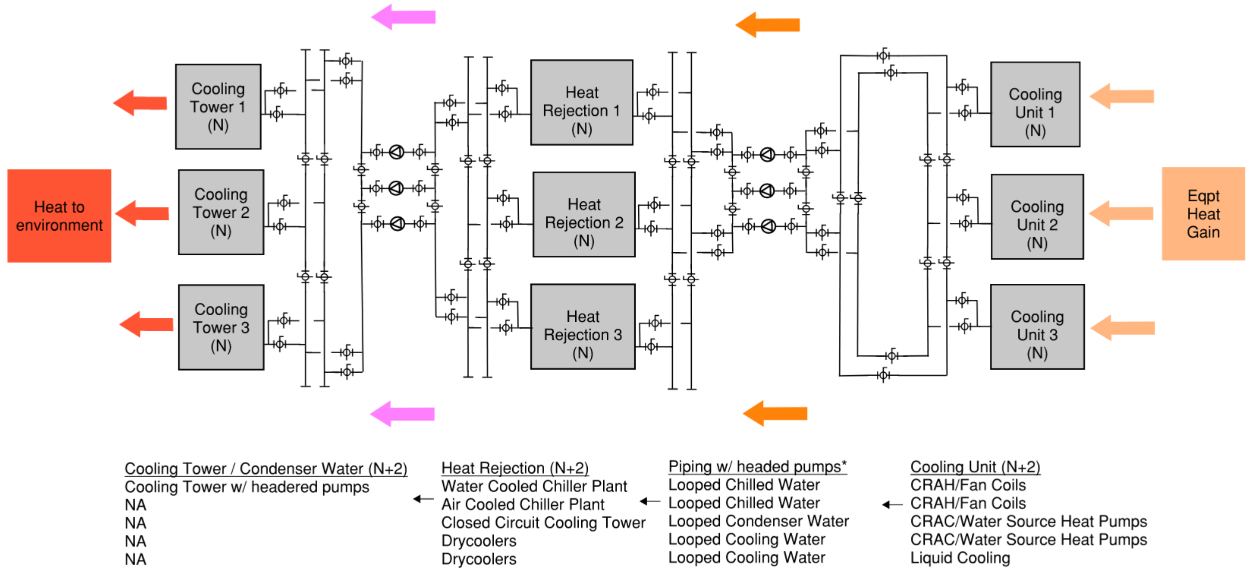
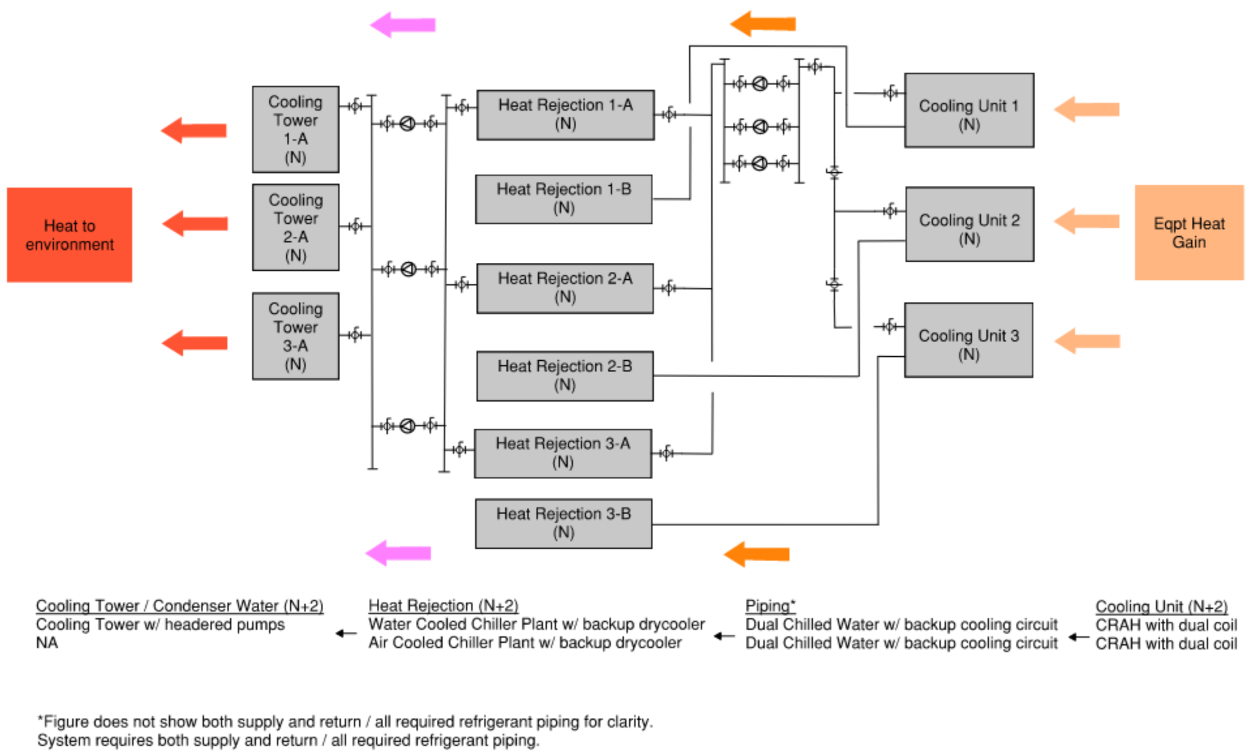


*Figure does not show both supply and return piping for clarity. System requires both supply and return piping.

Availability at Critical Technical Load	
System	Availability
Grade 4 Common Heat Rejection (N+2) - Water-Cooled Chiller (Cooling Tower) w/ CRAH/FCU	0.999999
Grade 4 Common Heat Rejection (N+2) - Air-Cooled Chiller w/ CRAH/FCU	0.999999
Grade 4 Common Heat Rejection (N+2) - Evaporatively Cooled w/ CRAC/WSHP	0.999999
Grade 4 Common Heat Rejection (N+2) - Drycooler w/ CRAC/WSHP	0.999999
Grade 4 Common Heat Rejection (N+2) - Drycooler w/ Liquid Cooling	0.999999

1. Availability equations are taken from UFC 3-520-02. Calculator utilizes the "block diagram" model.
2. Availability values are taken from IEEE 493-2007, Table 10-4.

Figure 3-9 Grade 4 Dual Path Heat Rejection Schematic (N+2)



Availability at Critical Technical Load	
System	Availability
Grade 4 Dual Path Cooling – Water-Cooled CRAC/WSHP	0.999999
Grade 4 Dual Path Cooling – Air-Cooled CRAC/DX Split System	0.999999

1. Availability equations are taken from UFC 3-520-02. Calculator utilizes the "block diagram" model.
2. Availability values are taken from IEEE 493-2007, Table 10-4.

Figure 3-10 Grade 4 Dedicated Cooling Heat Rejection Schematic (N+2)

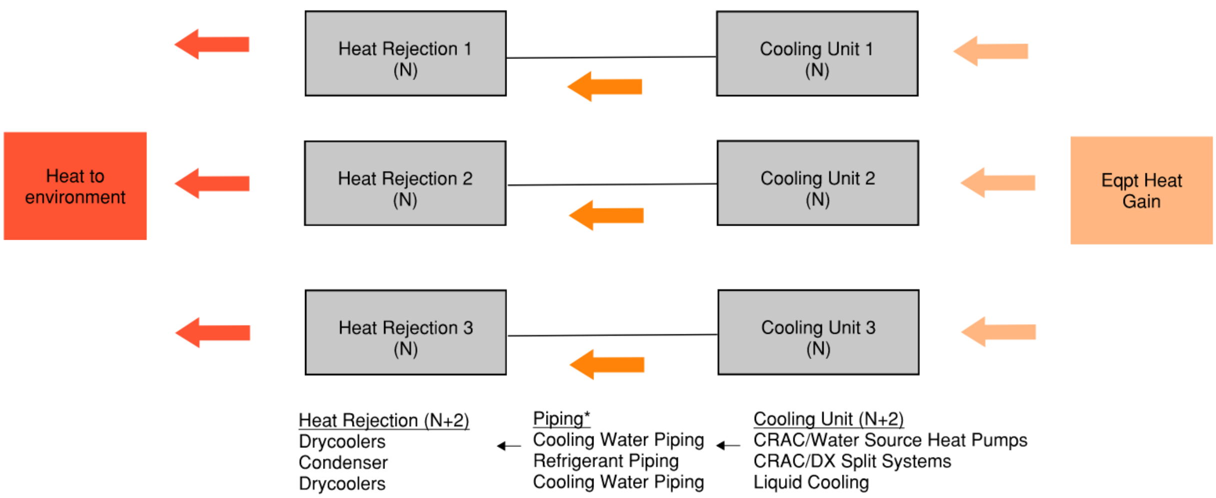


*Figure does not show both supply and return / all required refrigerant piping for clarity.
System requires both supply and return / all required refrigerant piping.

Availability at Critical Technical Load	
System	Availability
Grade 4 Dedicated Cooling – Water-Cooled CRAC/WSHP	0.999999
Grade 4 Dedicated Cooling – Air-Cooled CRAC/DX Split System	0.999999
Grade 4 Dedicated Cooling – Liquid Cooling	0.999999

1. Availability equations are taken from UFC 3-520-02. Calculator utilizes the "block diagram" model.
2. Availability values are taken from IEEE 493-2007, table 10-4.

3-6.4 Air Conditioning Loads.

Equipment heat loads must be established during the planning/DD1391 development process. When a MESEP is available, use it for equipment loads. When a MESEP is not provided, the mission owner must verify, document, and approve electrical equipment loads during design.

3-6.5 HVAC System Design.

HVAC systems selected for C5ISR facilities must consider proximity to service organizations and be maintainable. Equipment requirements must consider the installed environment. Utilize the most life cycle cost effective system considering available utilities, energy consumption, first cost, and maintenance cost over the life of the system. HVAC systems must be capable of meeting the specialized requirements of electronic equipment rooms. Systems must provide air filtration, positive pressurization, and humidity control.

Central utility plants are often used at larger facilities as they are typically more efficient and centralize maintenance. See paragraph 3-6.6 for Central Cooling Equipment. Smaller facilities often utilize packaged/unitary equipment. See paragraph 3-6.7 on Packaged/Unitary Cooling Equipment.

3-6.5.1 Proximity to Service Organizations.

Mechanical equipment must account for facility location and local support resources. Match the level of sophistication with regionally available service personnel expertise and procurement ability. Ensure factory certified service organizations can support the selected systems and equipment to provide regular and emergency service. Organizations must be close to the facility and be able to render service in under 8 hours. Organizations must be capable of obtaining standard replacement parts within 24 hours.

3-6.5.2 Installed Environment.

Mechanical equipment must be configured for the installed environment. Corrosive-prone locations must feature corrosion-resistant materials and coatings in accordance with UFC 1-200-01 and UFC 3-410-01. Equipment in coastal conditions must be rated for wind loads and potential damage from tropical storm wind-borne debris. Equipment in cold environments must be capable of operation in mean extreme winter temperatures and must have features to prevent freezing. Heat rejection equipment must be capable of operating at site specific humidity and dry bulb design temperatures.

3-6.5.3 HVAC System Life Cycle Cost Analysis.

Work with mission owner engineering and service design review engineer to develop three proposed systems. Systems must comply with UFC 3-410-01. Perform Life Cycle Cost Analysis (LCCA) in accordance with UFC 1-200-02 and UFC 3-410-01 of the proposed systems. Utilize system that is life cycle cost effective.

3-6.5.4 Specialized Equipment Room Characteristics.

Equipment rooms typically have high sensible heat gain and require specialized cooling equipment selection. Utilize mechanical equipment capable of operating efficiently with high sensible heat ratios. Also, consider tight temperature and humidity environmental requirements when selecting equipment and controls. Computer Room Air Conditioning Units (CRACs) and Computer Room Air Handling Units (CRAHs) offer a solution, as they are designed to meet stringent equipment room requirements. Units serving electronic equipment rooms must be dedicated to equipment rooms. Units also cannot serve both electronic equipment rooms and non-critical climate cooled rooms, as the sensible heat ratios vary significantly between them.

The use of air-side economizers is not permitted for the primary system serving equipment rooms as they make precise humidity control difficult. Economizers may be allowed for emergency cooling when approved by the mission owner and design authority review engineer.

Air Force Facilities: Economizers for emergency cooling are not allowed.

3-6.5.5 Equipment Room Cooling.

Air distribution and heat management can result in significant energy savings and improved thermal performance of equipment rooms. The design must provide good air distribution across the entire data center or equipment room and must comply with ASHRAE Thermal Guidelines for Data Processing Environments.

Equipment rooms larger than 1000 square feet (92 sm) or with cooling design loads greater than 100kW must be validated using computational fluid dynamics (CFD) modeling. The model must validate all rack inlet temperatures conform with ASHRAE Thermal Guidelines for Data Processing Environments at design load with N capacity components. The model must be submitted for review with the initial design submission or prior to the 50% design completion, whichever is soonest.

3-6.5.5.1 Traditional Equipment Room Cooling Methods.

Below-grade air distribution in the raised access floor and ducted overhead conditioned supply air have traditionally been used. While convenient, both distribution methods have challenges. Unless the equipment is specifically designed to receive raw supply air, avoid the direct connection between the air plenum and the equipment. Instead, supply air to the room through relocatable floor registers and configure equipment to draw tempered air from the room. If overhead distribution is provided, low velocity/low-pressure ductwork is desirable. Systems with overhead and underfloor air distribution air terminal devices must be located to allow the air to reach the area of the loads. When underfloor power distribution is implemented, ensure floor register air flow is not constricted due to power/network cabling. Overhead network and power distribution is preferred when using an underfloor air plenum. When electronic equipment is in a high-bay area with an overhead cable grid network, air outlets must not be located directly above electrical equipment, cabling, or power networks to facilitate good air distribution. Poor air distribution results in thermal hot spots within the space.

Underfloor air distribution with ducted return utilizes traditional underfloor plenum supply air distribution but utilizes a ducted return to eliminate hot spots that develop away from air conditioning units or at high-density racks. This method utilizes cold aisles for rack intake and hot aisles at the discharge of the racks. Locate return inlets over the hot aisles. Air returns must not be located directly above electrical equipment, cabling, or power networks to facilitate good air distribution. The use of containment structures can increase efficiency and thermal performance.

3-6.5.5.2 Alternative Equipment Room Cooling Methods.

Flooded room cool air distribution with rack containment can be used to increase energy efficiency. Flooded rooms utilize a cool air discharge of 60-68°F (15.5-20°C). The equipment room remains cool (65-72°F, [18.3-22.2°C]); air is drawn into racks by server fans which discharge to a hot aisle or directly to the return duct via rack chimneys.

Other cooling strategies, including in-row cooling units and equipment-based cooling, are also used. In-row cooling benefits from dedicated hot and cold aisles and is effective at preventing thermal hot spots caused by uneven rack loading. Equipment or rack-based cooling is gaining more attention due to its ability to remove heat from the source, increasing cooling efficiency and preventing thermal hot spots. Both in-row and equipment-based cooling may result in security concerns if secure networks are present. Secure networks require a physical separation between unsecure and secure networks. The separation requirements for in-row or equipment-based cooling may be overcome by designating the unit control system as a secure network. Secure cooling controls require approval by the mission owner, as the system cannot be tied into a non-secure building Direct Digital Control (DDC) system. All critical controls must be continuously monitored.

3-6.5.5.3 Equipment Room Cooling Coordination.

Rack location must be coordinated with the mission owner, electrical engineer, and telecommunications engineer. Where cold aisles are used, front of racks/cabinets must face each other. The rear of cabinets/racks must face each other to create a hot aisle. Where underfloor supply air is utilized, floor registers/tiles must be installed only in the cold aisles. Utilize blanking plates racks to prevent re-circulation of hot air within racks.

Air Force Facilities: Provide hot or cold aisle containment. Do not duct CRAC/CRAH units; return air chimneys are allowed.

3-6.5.5.4 Clean Agent Fire Suppression Considerations.

Equipment rooms with clean agent systems must be protected with overpressure relief dampers as required and have an exhaust system in accordance with UFC 3-600-01. See Fire Protection and Life Safety Section for smoke exhaust requirements.

3-6.5.6 Air Filtration.

Filter all outside and recirculated air. Equipment providing outside air must have a minimum of Minimum Efficiency Reporting Value (MERV) 8 prefilter with a MERV 13 final filter. Provide equipment room air conditioning units with a minimum of MERV 8 filters. Provide high-performing filters as required by the mission owner or specific equipment requirements. Utilize replaceable media filters. To extend the life of high-performing filters, use prefilters of lower efficiency upstream of higher-efficiency filters. All filter banks must have pressure switches with a dirty filter maintenance alarm when the pressure drop exceeds the maximum recommended loading.

3-6.5.7 Pressurization

Equipment rooms must be slightly positively pressurized relative to the outdoors and surrounding rooms/areas. Positive pressurization limits particulate and moisture infiltration into the equipment room.

3-6.5.8 Humidity Control.

Systems must be capable of maintaining space temperature and humidity. Work closely with the architect during the preliminary design phase to conduct a vapor barrier analysis. The vapor barrier analysis must ensure condensation does not occur in interior partitions or exterior walls.

3-6.5.8.1 Dehumidification.

A Dedicated Outdoor Air System (DOAS) is an acceptable solution to provide filtered dehumidified air to the space in accordance with UFC 3-410-01. Where outside air requirements are not large enough to justify a DOAS, outside air and space latent loads can be met by a dehumidifier controlled by a local humidistat. Do not rely on equipment room cooling units to meet the latent cooling load of outside air. Dehumidification must not rely on full load capacity of equipment as equipment rooms typically operate at part load and are built-out with racks and equipment over several years following construction completion. Avoid reheat where possible and, if required, utilize waste heat.

3-6.5.8.2 Humidification.

Electronic equipment areas require less humidification per thousand British Thermal Units (BTUs) per hour (MBH) of heating than comfort applications. Humidification needs are higher if excessive fresh air is admitted to the space, dehumidification during the cooling process is excessive, or if the humidity ratio of the outside ventilation air is less than the desired humidity ratio. When needed, consider humidifiers mounted integral to the cooling equipment or standalone wall-mounted humidifiers. Humidifiers must have automated controls and report alarms to the building control and automation system. UFC 3-410-01 does not permit atomized water and evaporative humidifiers. Protect domestic water connections to humidifiers with backflow prevention devices.

3-6.6 Central Cooling.

Central cooling is often used at C5ISR facilities. Central cooling equipment has higher efficiencies and centralized maintenance. Since cooling is required year-round, evaluate the life cycle cost effectiveness of condenser heat recovery. Condenser heat recovery can prevent simultaneous heating and cooling, resulting in significant energy savings.

Central cooling plants must include provisions to keep space temperatures within ASHRAE Thermal Guideline “Recommended” requirements for allowable temperature and humidity. Liquid cooling temperature must comply with Class W17/W27. In addition to placing cooling equipment on backup power systems, consider using thermal storage, controls on UPS power, and rapid restart chillers. If space and liquid cooling temperatures cannot be maintained within allowable ranges after primary power is lost and backup power is established, pumps can be placed on the UPS system.

3-6.6.1 Water-Cooled Chiller Plants.

Water-cooled chiller plants often result in the most energy savings. However, water-cooled plants may have a higher overall cost of ownership due to the cost of makeup water, chemical treatment, and replacement cost. Water-cooled plants also require more maintenance. Locate water-cooled chillers and pumps indoors. Consider physical separation of chillers with fire-rated walls to safeguard against the loss of all cooling in the event of a fire in one of the chiller rooms. Chiller rooms must comply with ASHRAE Standard 15 and protective provisions required for Class A2L refrigerants, where used. Chilled water pumps must be headered and match the plant's redundancy scheme. Condenser water pumps must also be headered to allow any pump combination to operate any cooling tower combination. Condenser water cleanliness is critical to the efficiency and reliability of a water-cooled plant. In addition to chemical treatment, a side stream condensing water filter is an acceptable solution to minimize condenser piping and chiller condenser tube fouling. Cooling towers must be specified to conform with NFPA 214 or have a self-extinguishing fill with a flame spread index of 5 or less when tested by ASTM E84.

3-6.6.2 Air-Cooled Chiller Plants.

Air-cooled chiller plants often use more energy than water-cooled plants but often have lower life cycle costs. The cost of makeup water, backup makeup water, reduced maintenance, and replacement can result in air-cooled chiller plants with a lower total cost of ownership than water-cooled plants. Air-cooled chillers are typically located outside, while their pumps can be mounted on the chiller frame or inside a mechanical room. Chilled water pumps must be headered to allow any pump to operate with any chiller. If unit-mounted pumps are used, redundant pumps on each chiller can be used. Redundant pumps cannot share a motor as a shared motor has a single point of failure.

3-6.6.3 Piping and Valves.

Piping must support facility redundancy grade, see Appendix A. Valves on critical Grade 3 and 4 hydronic systems must be installed to allow isolation for maintenance or repairs without disrupting critical loads. Valving must allow isolation of any cooling component.

3-6.7 Packaged/Unitary Cooling.

Packaged/unitary cooling is often used at smaller C5ISR facilities and outlying equipment buildings. Packaged/unitary equipment tends to have lower efficiencies and requires maintenance at the unit. Packaged/unitary equipment includes packaged direct expansion (DX)-cooled floor-mounted or roof-mounted equipment, split system DX, variable refrigerant flow/volume (VRF/VRV), water source heat pumps (WSHPs), and CRACs with a remote condenser or drycooler. Packaged units may have a lower first cost than centralized cooling but are often more expensive over the system's life. Packaged units typically have a shorter service life and a higher overall maintenance burden as they are not centralized. Packaged units are also very dependent on refrigerant and often require factory-trained technicians to maintain refrigerant circuits.

If space temperature cannot be maintained within “Recommended” requirements for temperature range after primary power is lost and backup power is established, unitary equipment can be placed on the UPS system.

3-6.7.1 Packaged/Unitary Design Considerations.

Packaged units can be configured to allow for redundancy and support concurrently maintainable and fault-tolerant configurations. The design must account for dehumidification and part loading, as packaged units may cycle at lower loading and provide inadequate dehumidification.

3-6.8 Controls and Automation Systems.

Mechanical controls and automation systems must be robust and capable of maintaining the equipment room environment within ASHRAE Thermal Guideline “Recommended” temperature and humidity range. Powering the control system from the UPS system allows the system to remain online if main power is lost. Controls must resume programmed operations if power is lost and must be capable of standalone operation if connection to controls is lost.

3-6.8.1 Facility Central Control System.

Central DDC controls systems allow mission owner engineers and maintenance teams to continuously monitor systems from a dedicated engineer watch station. Control systems must report critical and maintenance alarms and be capable of trending data. Work with the mission owner engineering and maintenance team to establish critical control overrides or initiate critical procedures from the watch station. DDC control systems must be in accordance with UFC 3-410-02.

Provide an automated central Power and Environmental Monitoring and Control System (PEMCS). The system must be capable of continuously monitoring the following systems where utilized: utility transformers, main distribution switchboard, switchgear, UPS, batteries, generator, generator fuel tanks, ATS, PDUs, STSs, CRAHs, AHUs, central cooling plant, central heating plant, dampers, fans, and control devices. The system must be capable of providing an external alarm by phone, text, and email. The system must continuously poll using non-proprietary industry standard protocols. Grade 3 PEMCS may utilize a single central processing unit, while Grade 4 PEMCS must have a 2N redundancy.

Army and Navy Facilities: When required by CTR the PEMCS and associated controllers must be on central mission UPS system power, with Grade 4 provided with dual path UPS power.

Air Force Facilities: The PEMCS and associated controllers must be on central mission UPS system power, with Grade 4 provided with dual path UPS power.

3-6.8.2 Cybersecurity.

The controls system must be provided with cybersecurity protections in accordance with UFC 4-010-06. Standalone control networks may be utilized where central DDC controls pose a risk to secure networks. Standalone controls are required to comply with cybersecurity requirements and must be capable of being continuously monitored. Ethernet switches provided in the controls architecture must be an Open Source Interconnection (OSI) layer 2/3 managed switch.

Identify Confidentiality, Integrity, and Availability (C-I-A) rating of controls system during the planning/DD1391 development process.

Air Force Facilities: Controls system must not tie into a non-Classified base wide network.

3-6.8.3 Leak Detection.

Equipment rooms served by hydronic systems must be provided with leak detection. Utilize leak detection at cooling units and floor drains, where provided. Raised Access Floor where utilized, must be provided with leak detection.

3-6.9 UPS/Battery Rooms.

Mechanical systems serving UPS rooms must consider the loss of primary power. Systems must be designed to prevent the temperature in the UPS room from exceeding 104°F (40°C) or manufacturer maximum temperature, whichever is less, when primary power is lost. Mechanical systems serving battery rooms must consider the loss of primary power. Systems must be designed to prevent the temperature in the battery rooms from exceeding UFC 3-520-05 maximum or manufacturer maximum temperature, whichever is less, when primary power is lost. If UPS and/or battery room temperature cannot be maintained within allowable range after primary power is lost and backup power is established, work with CTR to determine which components of the cooling system will be placed on the UPS system.

Army and Navy Facilities: A ventilation fan on UPS power is allowed to serve as a backup system where the outside air temperature and air quality are suitable when acceptable to CTR.

Air Force Facilities: Provide redundant cooling system for UPS rooms. Backup mechanical ventilation of the UPS room is not acceptable.

3-6.10 Physical Security.

Locate critical exterior equipment within the secure perimeter. Facilities with secure requirements must comply with UFC 4-010-05.

3-6.11 Backup Power and Generators.

Mechanical systems serving equipment rooms must be on backup power. Work with the mission owner to identify mechanical equipment and controls that require UPS power.

Design systems supporting generators in accordance with UFC 3-540-01.

3-6.11.1 Fuel Storage and Piping.

Fuel storage systems serving backup power generators must be in accordance with UFC 3-460-01 and meet Environmental Protection Agency (EPA), state, and local environmental requirements.

3-6.11.1.1 Fuel Storage Capacity.

Indoor fuel storage volume must comply with NFPA 30. Grade 2 facilities must have a minimum of 24 hours of fuel storage. Grade 3 facilities must have a minimum of 72 hours of onsite fuel storage with a confirmed delivery source. Grade 4 requires a minimum of 96 hours of onsite fuel storage with a confirmed delivery source. Storage must be based upon full load fuel consumption. The need for additional fuel storage capacity must be established with the mission owner during the planning/DD1391 development process.

Grade 2 facilities may utilize a single storage tank, while Grade 3 and 4 facilities must utilize multiple storage tanks. Grade 3 systems must be concurrently maintainable, while Grade 4 systems must be fault tolerant.

Air Force Facilities: Provide a minimum of 7 days of fuel storage. The Air Force allows Grade 2 and 3 facilities to utilize a fueling agreement provided there is 24 hours of integral/day tank fuel storage. Grade 4 facilities must be provided with N+1 storage tanks.

3-6.11.1.2 Fuel Controls.

The fuel controls must tie into the building control system. The fuel controls must alarm on high fuel level, low fuel levels, and upon leak detection. The fuel system must provide N+1 transfer pump redundancy.

3-6.11.1.3 Fuel Maintenance.

Design for maintenance in accordance with UFC 3-460-03.

3-6.12 Plumbing.

Where plumbing services feed critical systems (cooling tower makeup water or once-through cooling), redundant sources are required.

3-6.12.1 Backup Cooling Water.

Facilities using evaporative heat rejection must be provided with a minimum of 24 hours of makeup water for Grade 2, 72 hours of makeup water for Grade 3, and 96 hours of makeup water for Grade 4. Once through cooling systems can be used as a backup cooling source, but often have drawbacks. Cooling systems typically have high flow requirements. Municipal water is often dependent on electric pumps and may not be reliable if primary electrical power is unavailable. A well can be used to provide backup cooling water. Wells have a higher first cost and recurring maintenance costs. Sustained use of a well for backup cooling may negatively impact the aquifer. Carefully weigh the use of once-through cooling systems. A closed-circuit heat rejection source is an acceptable alternative. When a combination of evaporative cooling and closed-circuit cooling is utilized, a backup water source is not required, provided the heat rejection component has N capacity.

Where water storage is used as a backup cooling source, this water is considered non-potable water and must meet EPA Guidelines for Water Reuse and AWWA M24.

3-7 ELECTRICAL ENGINEERING.

The core UFCs define the minimums for electrical systems. The requirements set forth in this document are more stringent requirements above the core UFCs and are the minimums for C5ISR facilities. If more stringent requirements are presented, beyond the scope of this document by the end users, then the most stringent requirement must be implemented. Analyze stricter user requirements with minimums to determine a cost delta and determine if the implementation is feasible.

C5ISR facilities come in many different types with a large range of electrical requirements. There may be small projects under 250 kVA, medium projects up to 2,500 kVA, and large capacity projects greater than 2,500 kVA. Projects may also contain multi-site facilities that can be as large as 10 MVA with multiple buildings and primary power circuits from a commercial power company. Appropriate electrical distribution architecture must be implemented to meet the facility Grade requirement determined by the mission. For Army projects, refer to TM 5-691 Utility Systems Design Requirements for guidance. Refer to MESEP for more stringent and specific engineering requirements.

3-7.1 Utility Requirements.

Grade 2 and 3 facilities must be provided with independent utility power sources supplied by a commercial power company when available and economically feasible. Grade 4 facilities must be provided with two independent utility power sources supplied by a commercial power company. Investigate the independence of commercial power company feeds; each should originate from an independent substation. Provide a cost for an added utility feeder to assess its economic feasibility to the project overall costs. An added feeder is not economically feasible if it exceeds 10 percent of the total construction budget. Common substation utility feeders for Grade 4 are only acceptable when unavoidable. Each utility feed to the building must be maintained within its own pathway, separate from each other. For new utilities, maintain a 66-foot (20.2 m) separation between feeders along the route and maintain a minimum separation of 4 feet (1.2 m) between other utilities. Redundant feeders must not share duct banks or maintenance holes. When separation requirements cannot be met due to existing utilities and conditions, document the process to resolution in the basis of design narrative. When commercial power is not readily available, an on-station primary power plant must be provided. Generation systems must meet the requirements as outlined in UFC 3-540-01. Utility capacity requirements must be for 100 percent of the station demand load.

3-7.2 Load Categories.

The facility Grade is to be determined in accordance with MESEP. Load categories during design must be labeled and referred to as indicated:

3-7.2.1 Station Load.

Total power requirement of the facility.

3-7.2.2 Operational.

Loads required to maintain continuous operation of the facility.

3-7.2.3 Non-Technical.

Part of the total operational load used for the administration of the facility. Non-technical loads include general lighting, convenience outlets, HVAC, and other normal operation functions and do not require emergency power. These types of loads can be load shed to maintain synchronous operation of the critical technical load.

3-7.2.4 Technical.

Part of the operational load required for the critical technical load and the utilities serving this equipment. Technical load is essential to the facility's mission and must be on emergency power. The project’s electronic equipment engineers must determine this load.

3-7.2.5 Non-critical Technical Load.

Load that is a portion of the technical load not required for synchronous operation. This includes nonsynchronous electronic equipment, test equipment, emergency lighting, and HVAC for critical technical load. The outage time tolerance for specific facilities will vary based on the facility Grade and end user.

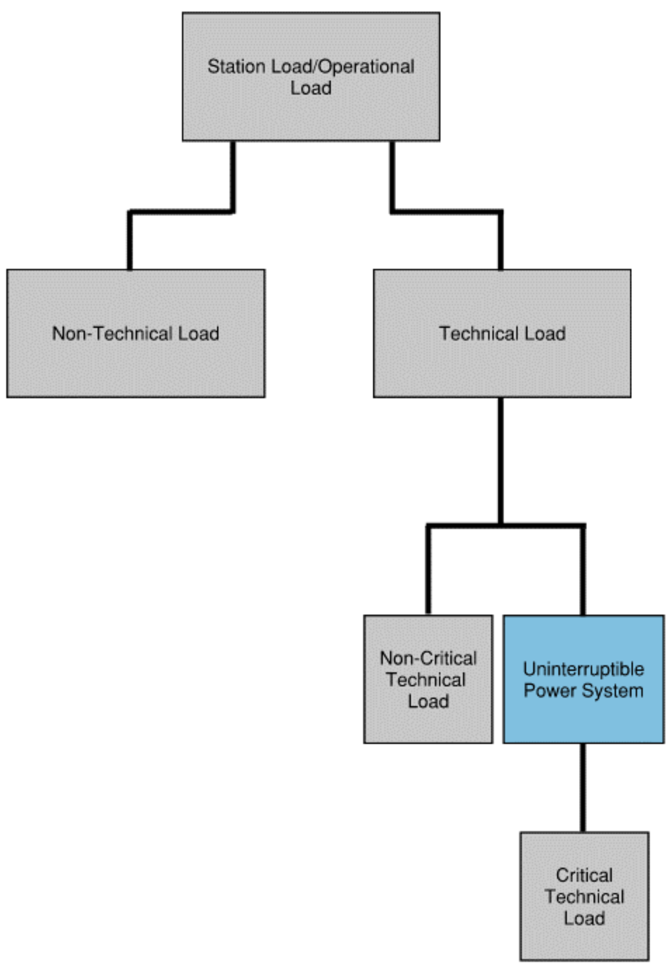
- HVAC Equipment/distribution components supporting critical loads.
- Point-of-use UPS equipment
- Elevators

3-7.2.6 Critical Technical Load.

Part of the total technical load required for continuous synchronous operation of electronic equipment. This includes any equipment malfunctioning during a momentary power dropout and causing additional outages after power is restored due to the need to resynchronize, loss of real-time count by master time sources, or loss of data in Automatic Data Processing (ADP) systems. These loads must be served from a UPS. Some examples of critical technical load include but not limited to:

- Rack-mounted IT Equipment
- Mission communications equipment
- Network equipment
- Facility Related Control Systems
- Key components of security systems

Figure 3-11 Load Categories



3-7.3 Redundancy and Resilience.

Figures associated with Grades are only examples to demonstrate a possible topology. Intent is to show limitations of each grade and help easily navigate pathing to critical loads. Engineered solutions are to be included in the drawing set one-line or riser diagram and demonstrated to meet their intended grade during design development.

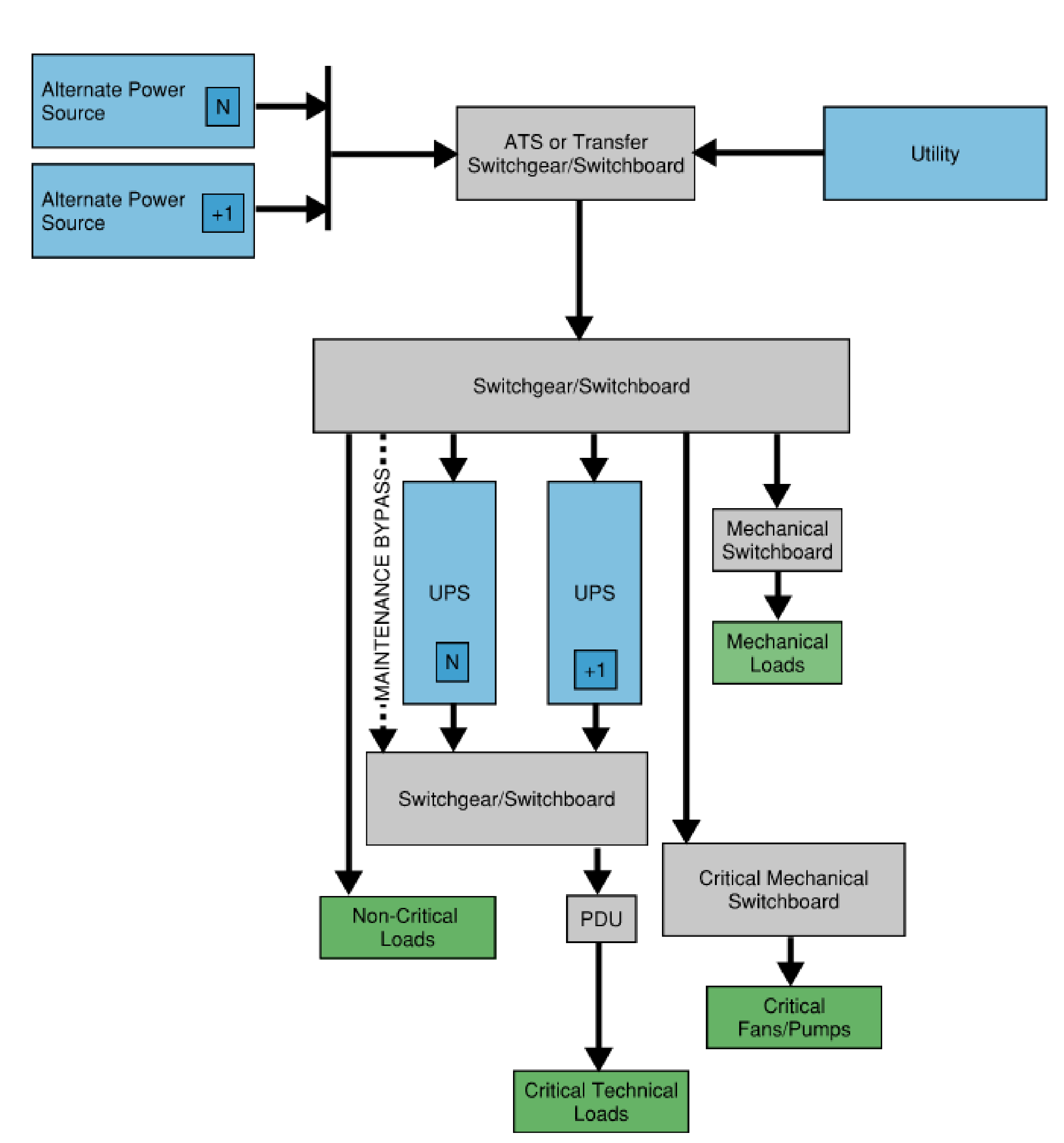
3-7.3.1 Grade 1 Electrical Systems.

Not applicable.

3-7.3.2 Grade 2 Electrical Systems

An electrical system that contains a single path to critical loads while having component redundancy. Component redundancy includes added equipment to exceed N requirements but not system level redundancy. This type of system would be vulnerable to component level faults with no added path around failures. It is possible to have planned component level maintenance but only on those components with the added redundancy. In most cases maintenance or failures would cause downtime to the critical loads supporting the mission. Figure 3-12 is an example of Grade 2 distribution architecture. One-line figures are example solutions only; the final electrical distribution system must meet or exceed the Grade 2 definition.

Figure 3-12 Grade 2 Single Utility with Alternate Power Sources



Availability at Critical Technical Load
0.9999

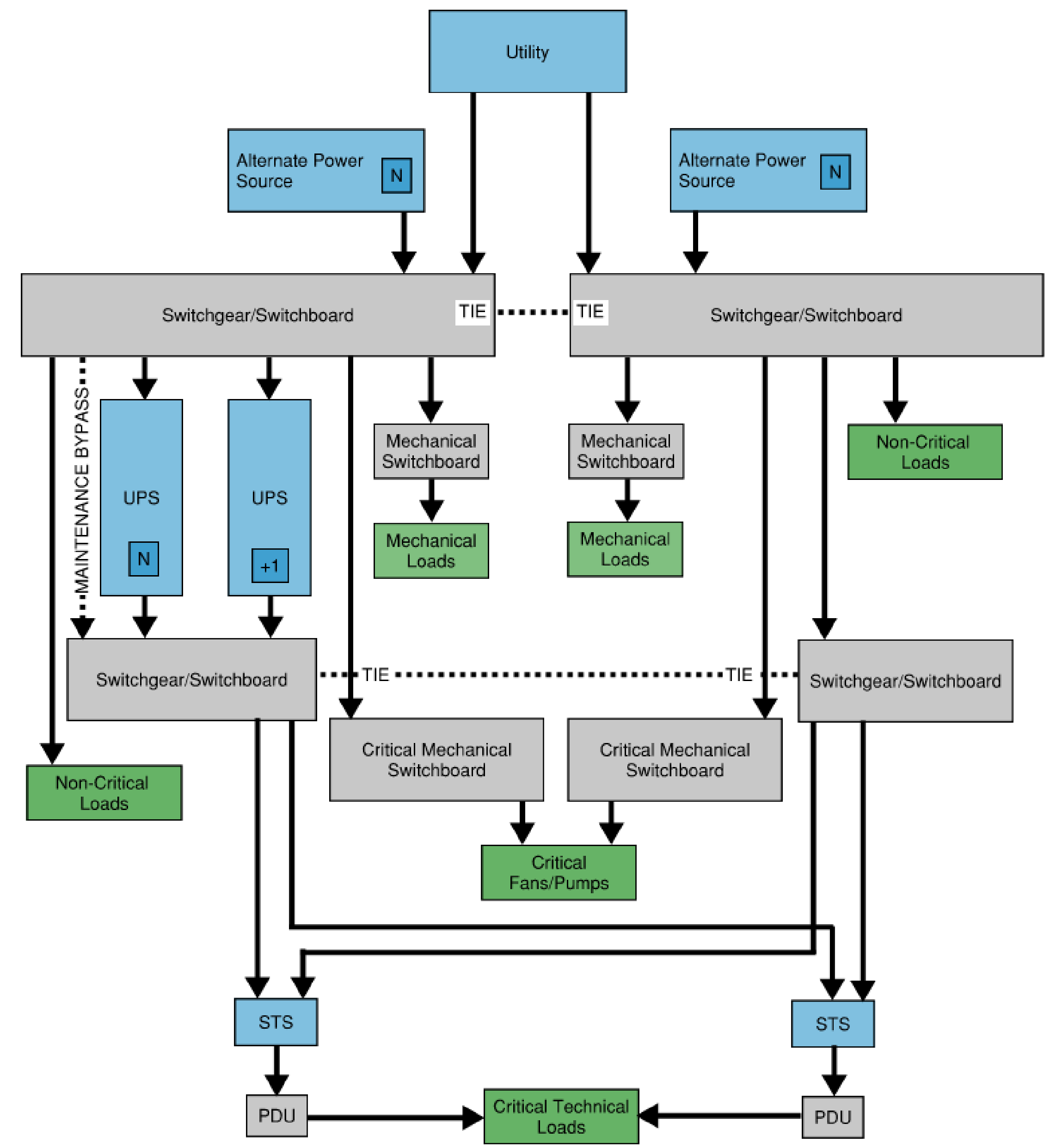
1. Availability equations are taken from UFC 3-520-02. Calculator utilizes the "block diagram" model.
2. Availability values are taken from IEEE 493-2007, Table 10-4.

3-7.3.3 Grade 3 Electrical Systems

An electrical system that is concurrently maintainable with a minimum redundancy of N+1. Concurrently maintainable systems can effectively maintain power during maintenance operations; it is not fault tolerant. It is common for Grade 3 mechanical systems architecture to push electrical into a 2N architecture similar to Grade 4. Analyze requirements with minimums to determine a cost delta and determine if the implementation is feasible. Figure 3-13 and Figure 3-14 are both examples of Grade 3 distribution architectures. One-line figures are example solutions only; the final electrical distribution system must meet or exceed the Grade 3 definition.

Redundant equipment must be physically separated in a redundant architecture to avoid damage due to catastrophic failures. Maintain 3-ft between redundant equipment or the NFPA 70 working clearance; whichever is greater.

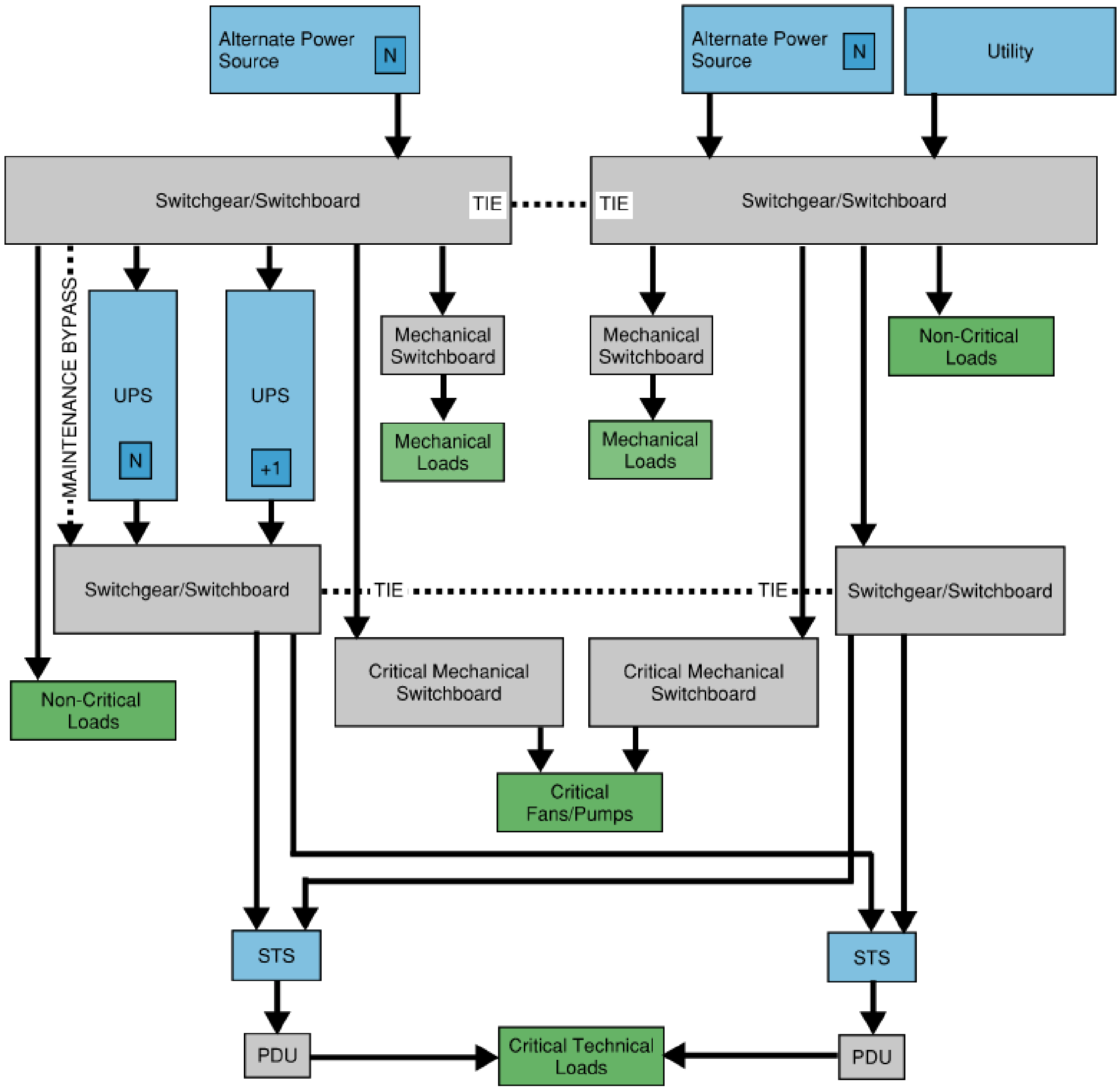
Figure 3-13 Grade 3 Single Utility with Two Utility Inputs



Availability at Critical Technical Load
0.999999

1. Availability equations are taken from UFC 3-520-02. Calculator utilizes the "block diagram" model.
2. Availability values are taken from IEEE 493-2007, Table 10-4.

Figure 3-14 Grade 3 Single Utility Source with Single Utility Input



Availability at Critical Technical Load
0.999999

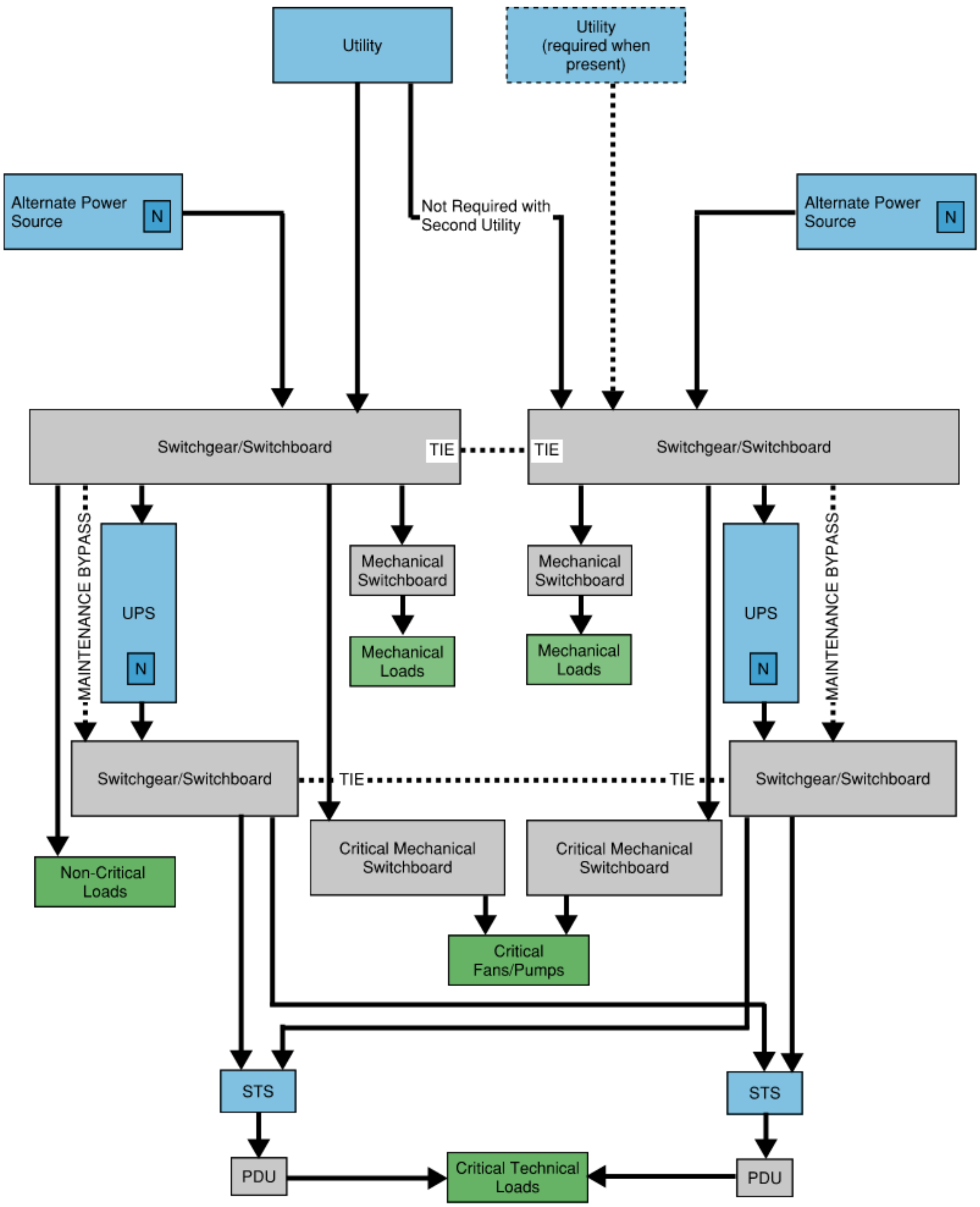
1. Availability equations are taken from UFC 3-520-02. Calculator utilizes the "block diagram" model.
2. Availability values are taken from IEEE 493-2007, Table 10-4.

3-7.3.4 Grade 4 Electrical Systems

An electrical system that is tolerant to faults or unexpected failures of both mechanical and electrical equipment within the distribution system. The electrical distribution network must have a 2N redundancy architecture including two separate utility feeds from independent substations. If 2N utility is provided, an N+1 generator power source may be considered to reduce cost. Provide a 2N uninterruptible alternate power source for critical technical loads.

When multi-path architecture is utilized, all equipment associated with the path is considered a subsystem and must be separated. Electrical subsystems must be separated by a minimum 1-hour fire-rated wall or structure. The critical technical power subsystem must be separated from other subsystems that do not support the data center. If a multi-path architecture is utilized, all equipment associated with the path is considered a subsystem and must be separated. Pathways serving subsystems must be separated by 3 feet (910 mm) when routed in a common space. A reduction to the 3 feet (910 mm) requirement is acceptable when not obtainable. For reference, Figure 3-15 would be considered dual path (2N), Figure 3-16 would be considered dual path (2(N+1)), and Figure 3-17 has three paths (3N). One-line figures are example solutions only; the final electrical distribution system must meet or exceed the Grade 4 definition.

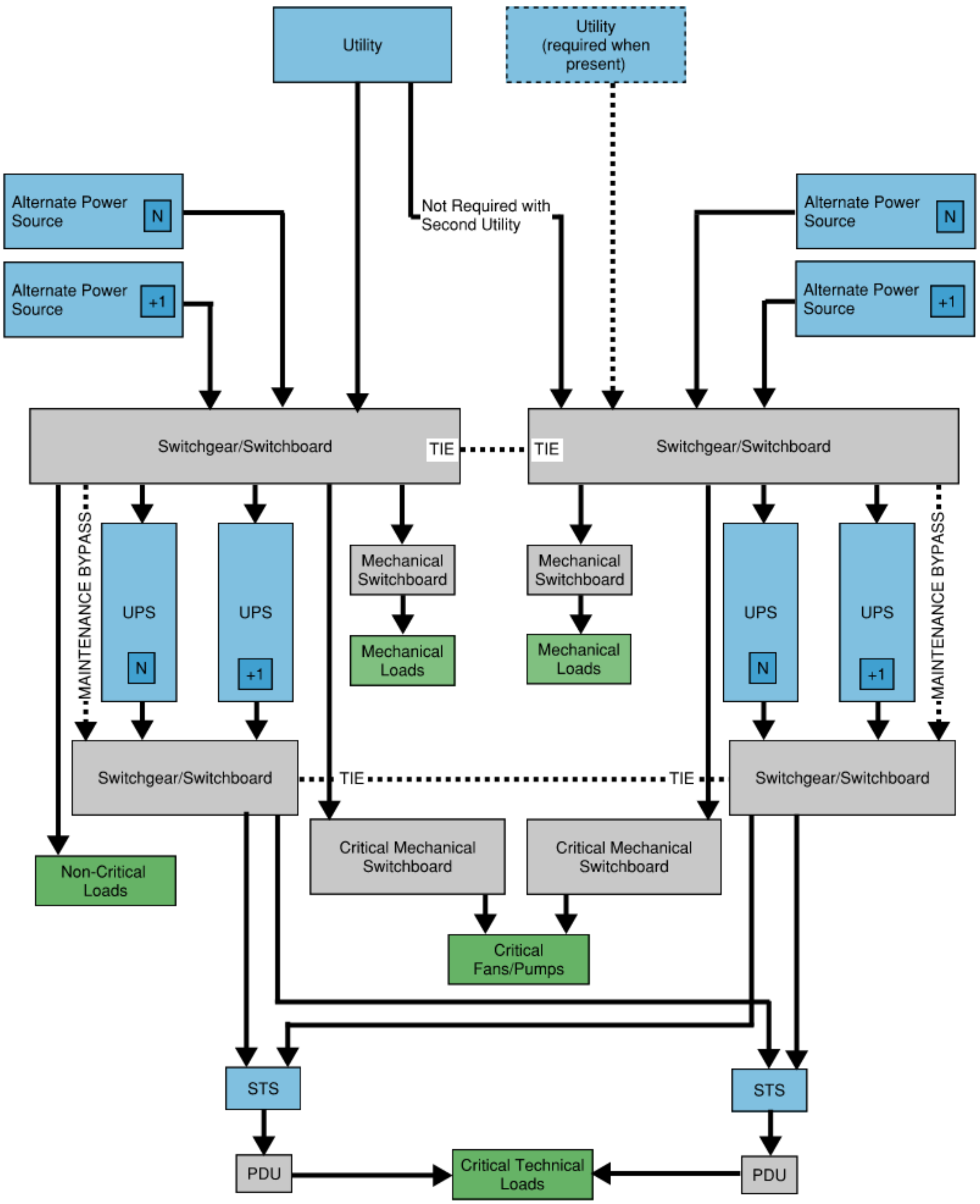
Figure 3-15 Grade 4 2N



Availability at Critical Technical Load
0.999999

1. Availability equations are taken from UFC 3-520-02. Calculator utilizes the "block diagram" model.
2. Availability values are taken from IEEE 493-2007, Table 10-4.

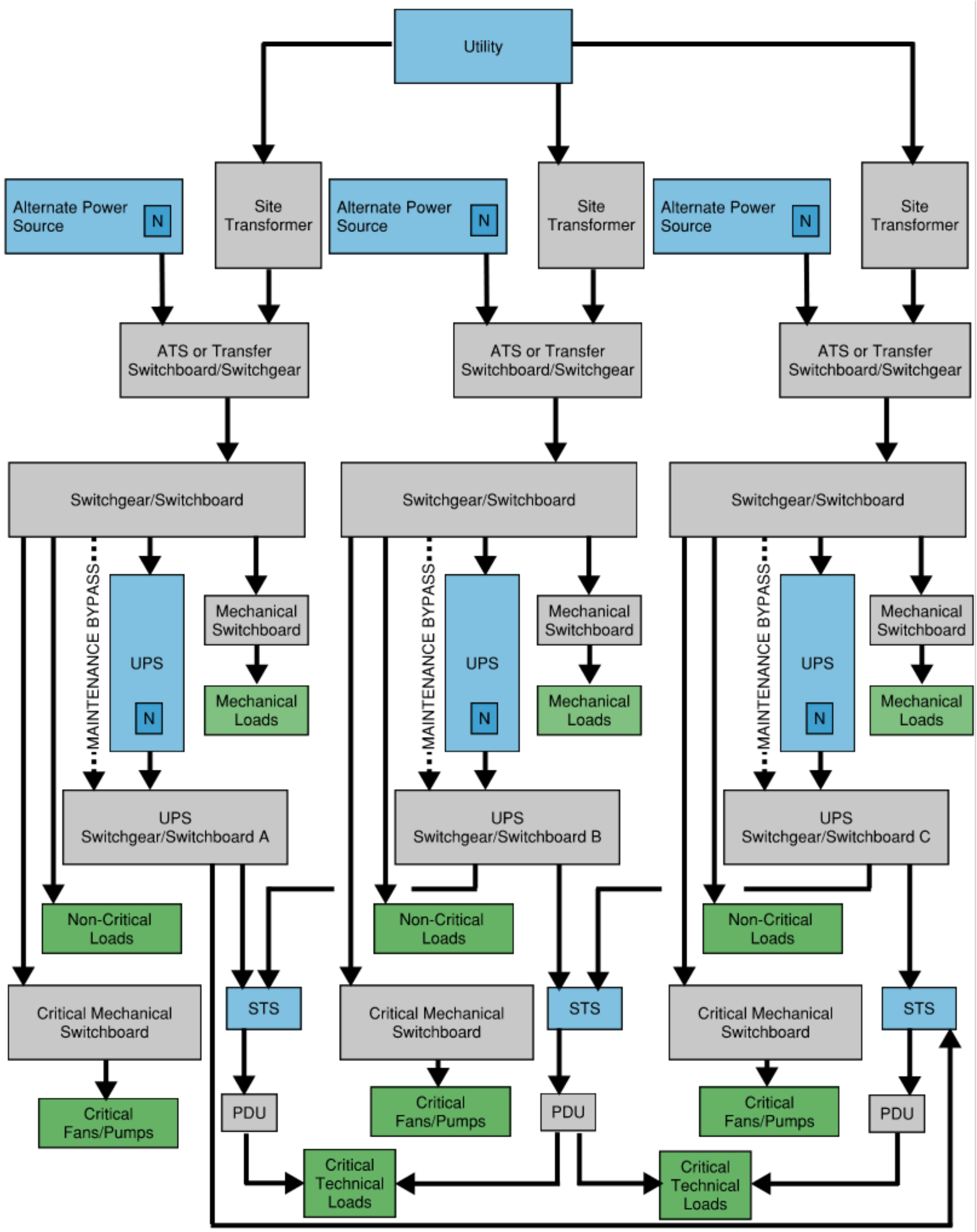
Figure 3-16 Grade 4 2(N+1) (System-Plus-System)



Availability at Critical Technical Load
0.999999

1. Availability equations are taken from UFC 3-520-02. Calculator utilizes the "block diagram" model.
2. Availability values are taken from IEEE 493-2007, Table 10-4.

Figure 3-17 Grade 4 xN or Distributed Redundant



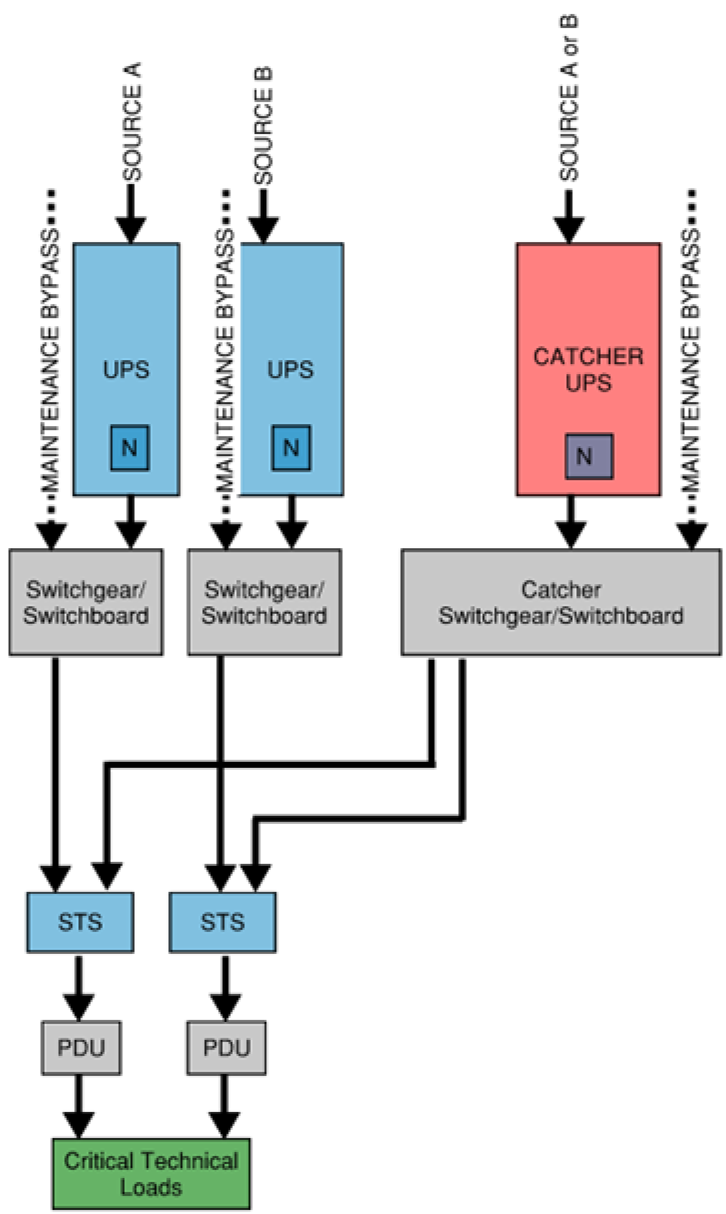
Availability at Critical Technical Load
0.999999

1. Availability equations are taken from UFC 3-520-02. Calculator utilizes the "block diagram" model.
2. Availability values are taken from IEEE 493-2007, Table 10-4.

3-7.3.5 Architectures with Uninterrupted Transfer of Loads

It is possible to provide additional flexibility in the system by utilizing a “catcher” topology. This is when a redundant UPS feeds the static bypass inputs of the normal UPSs (“N” or Need). By having the static bypass feed from the catcher UPS, the normal UPSs sync their outputs with the input from the redundant UPS. This allows switching in the downstream system to be completed much easier and simplifies syncing of UPS outputs. The “catcher” must seamlessly assume the load of a single normal UPS failure. The outputs of the redundant and normal UPSs are tied together allowing for a manual switching between the two sources for maintenance of the normal UPSs. This can be utilized on any distribution paths with UPSs.

Figure 3-18 UPS “Catcher” Topology



3-7.4 Electrical Power Characteristics.

3-7.4.1 Voltage.

Steady-state voltage variation must not exceed plus or minus five percent of the nominal voltage level. The preferred voltage is 480Y/277V for systems above 300 kVA. For systems below 300 kVA, provide 208Y/120V systems.

3-7.4.2 Frequency.

Steady-state variations must not exceed plus or minus 0.5 percent of the nominal frequency. The preferred frequency is 60 hertz (Hz). If 60 Hz is not available overseas, the use of 50 Hz is acceptable. If frequency conversion is required, a synchronous generator or solid-state converter is required. Provide calculations for conversion equipment. Consult UFC 3-510-01 Foreign Voltages and Frequency Guide.

3-7.4.3 Availability.

Availability is the ability for a utility to be ready for use or to maintain its state. Not to be confused with reliability which is the measure of failures of a system or product over a period of time. A system can have poor reliability products in its network, but a given network architecture may provide high availability. Critical loads for C5ISR facilities require high availability to maintain mission operations. Different electrical architectures provide differing levels of availability.

3-7.4.4 Dynamic or Transient Variation.

This is the change of electrical conditions at the operational bus due to system operations, for example, motor starting. Voltage must not exceed minus 15 percent or plus 10 percent. Identify large motors and utilize reduced voltage starters or select a variable speed drive starting operation that reduces voltage requirements. Systems upstream of the Operational load bus may exceed these tolerances.

3-7.4.5 Power Factor.

Provide power factor correction when required. Minimum power factor must not exceed 0.85 lagging.

3-7.5 Medium Voltage (1kV-35.4kV).

Utilize medium voltage distribution within the facility when low voltage service requirements exceed 5 MW or 6000 A at lower utilization voltages (<600V). One-for-one replacement of existing equipment must match existing equipment and not be subject to this requirement.

Where increased safety and reduced footprint are desired, evaluate the use of Gas or Solid Insulated Switchgear (GIS or SIS). Provide all medium voltage circuit breakers with an electronic trip protective relay and when control is required, provide means to open and close the circuit breaker remotely. Protective relays must have the ability to network for advanced control schemes. Protective relays must be compatible with the selected DDC controls or Building Automation System (BAS). Provide connection into the DDC/BAS and monitor relay status at the facility control room. Review available protective relay control points with mission engineering and integrate those into the DDC/BAS.

3-7.5.1 Medium Voltage Controls.

Controls for switchgear operations must be integral to the equipment and have black start capabilities. Black start systems can maintain operations with no external power, carrying their own power supply to regain either primary or standby power. Allocate space for a DC battery supply for operating controls and circuit breakers in the switchgear lineup when located exterior of the facility. Batteries are to be provided in accordance with UFC 3-520-05. Mission central Uninterruptible Power Supply (UPS) circuits to provide power to controls is required. Control operations must be remote from the facility control room.

3-7.6 Low Voltage Electrical Distribution (<1000V).

3-7.6.1 Switchgear, Switchboards, Motor Control Centers, and Panelboards.

For Grade 3 and Grade 4 facilities provide switchgear with the following:

- Overhead lifting means for removing draw out circuit breakers.
- An arc-resistant switchgear assembly tested and certified to IEEE C37.20.7.
- Draw out compartment shutters to protect operators during hot operations.
- Infrared viewing windows for thermal imaging bus and connections without opening equipment doors or access panels.

For main service entrance switchgear and switchboards, consider using 4-pole circuit breakers that can alleviate the use of complicated ground fault schemes. With 4-pole circuit breakers, residual ground fault protection may be utilized in lieu of a modified differential ground fault scheme since the system switches neutrals between sources. When equipment is separated and requires communications connections for proper operation, provide two 4 in. (102 mm) conduits between the equipment to support these communications. When double ended switchgear or switchboards are utilized, they must be configured as Main-Tie-Tie-Main (M-T-T-M). When the utility owns the outdoor transformer, provide disconnecting means ahead of the main service entrance equipment to test black start capabilities.

3-7.6.2 Remote Power Panels (RPP).

Remote power panels (RPPs) can extend a large power capacity into the data center in a small footprint. RPPs have similar footprints to data racks, with some fitting entirely onto a 24in. by 24 in. (610 mm by 610 mm) tile while having the ability to contain four 42-pole panelboards. Consider using RPPs to remove transformers and PDUs, which increase the heat load on the data center floor. When desired, provide branch circuit monitoring capabilities compliant with paragraph 3-7.6.5 for branch circuits less than 800 A.

3-7.6.3 Circuit Breakers and Relays.

The use of low voltage protective relays may be used for better selective coordination on large drawout power circuit breakers over 800 A. For selective coordination purposes, all circuit breakers 225 A or larger must have adjustable long-time, short-time, and instantaneous (LSI) trip settings. Molded case thermal magnetic fixed trip circuit breakers are acceptable up to 225 A.

3-7.6.4 Low Voltage Controls (<600V).

Controls for switchgear and switchboard operations must be integral to the equipment and have black start capabilities. Control operations must also be remote from the facility control room. Black start systems can maintain operations with no external power, carrying their own power supply to regain either primary or standby power. A mission central Uninterruptible Power Supply (UPS) circuits to provide power to controls is required in a 2N configuration with separation of independent pathways. For Grade 3 and above, provide redundant controls with a physical separation, for example, control sections at opposite ends of the gear lineup or in a separate lineup. For Grade 4 provide controllers within separate rooms with 1hr fire barrier. For example, if switchgear A and B are located in different rooms but function together to maintain operations, switchgear A may have the primary controller while switchgear B contains the redundant controls. All controls are to be completely 2N, having automatic failover to the redundant controls system. No controls equipment can be shared for independent operation. Provide a 2N communication path between primary and redundant controls. Provide separate pathways/conduits for each communication link provided. The controls must be provided with cybersecurity protections in accordance with UFC 4-010-06. Ethernet switches provided in the controls' architecture must be an OSI layer 2/3 managed switch.

3-7.6.5 Metering.

Metering is to be provided for all circuit breakers 800 A and above. All digital metering systems must be networked and consolidated at a single Electrical Power Monitoring System (EPMS). Connect consolidation location to DDC/BAS. Provide points to DDC/BAS to monitor phase current, voltage, frequency, crest factor, total harmonic distortion (THD), transient capture, Power (kW, kVA, kVAR), power factor, and energy consumption (kWh) per individual circuit breaker. Ethernet switches provided in the metering architecture must be an OSI layer 2/3 managed switch.

3-7.6.6 Transformers.

Transformers that directly serve critical technical loads must be harmonic mitigating type. Harmonic Analysis must identify which harmonics are the largest in the system and assist in selecting transformer harmonic mitigation techniques. Transformers must have a winding temperature sensor connected to a local and remote alarm system. Local alarms must be visual and audible. Provide connection and integration into the DDC/BAS and monitor the over temperature alarm.

3-7.6.7 Emergency Power/Alternate Power Source.

Categorize loads in accordance with NFPA 70 for Emergency, Legally Required Standby and Optional Standby. Provide a detailed Sequence of Operations (SoO) for generator operations. SoO must include dry contacts or input/output (I/O) blocks for generator running signals to initiate a sequence of operations for other systems. For outdoor generator units 1 MVA and larger, walk-in enclosures are required for ease of maintenance during adverse weather conditions. Size generator sets to their manufactured prime rating in lieu of standby rating to increase generator longevity in extended outages. Provide generators with a nameplate that states “Emergency Standby Use Only.”

Consider providing generator set(s) indoors when space is available. Provide when dictated by the design basis threat analysis. When considered, provide an LCCA comparing indoor and outdoor costs. The LCCA must account for building costs, including architecture, structure, mechanical, and electrical versus outdoor installation costs. The generator transient performance class must be G3 or better.

3-7.6.7.1 Emergency Power System Monitoring (EPSM).

Emergency power system monitoring must be compatible with the selected DDC controls or Building Automation System (BAS). Provide connection into the DDC/BAS and monitor the required Safety Indications and Shutdowns as indicated in NFPA 110 per level type. It is recommended to review optional points with end users for incorporation into the Safety Indications and Shutdowns list. If the EPSM is powered from the generators 12V starting system provide the controls with a power supply buffer that can maintain operating voltages above 9V for a minimum of 0.3 seconds. Multiple buffers can be placed in parallel to increase the duration beyond 0.3 seconds to cover cranking time. It is common during starting to have a large voltage drop which can lead to power issues at the controls. Monitoring system must have a 2N power supply.

3-7.6.7.2 Emergency Power Controls.

Controls for generator operations must be integral to the equipment and have black start capabilities. Allocate space for a DC battery supply for operating controls. If the controls are powered from the generators 12V starting system, provide with a power supply buffer that can maintain operating voltages above 9V for a minimum of 0.3 seconds. Multiple buffers can be placed in parallel to increase the duration beyond 0.3 seconds. It is common during starting to have a large voltage drop which can lead to power issues at the controls. The controls must be provided with cybersecurity protections in accordance with UFC 4-010-06.

3-7.6.7.3 Uninterruptible Power Supplies (UPS).

Provide batteries in accordance with UFC 3-520-05. Provide to meet the transient voltage requirements indicated in 3-7.4.4. Provide monitoring system capable of recording and trending individual battery voltage and impedance. Temperature must be monitored. UPS and monitoring systems must be compatible with the selected DDC controls or BAS. All alarms must be visible at the control room central monitoring station via the DDC or BAS. The use of small DIN rail mounted UPS and batteries is allowable for mechanical and electrical controls and monitoring equipment for ride through until main emergency power is initiated. When calculating runtimes use battery system end-of-life (EOL) runtime. Assume battery system EOL is 80% of initial capacity.

Air Force Only: UPS minimum runtime must be 15 minutes.

3-7.6.8 Loadbanks.

To provide an adequate load to maintain generator(s), provide a loadbank sized at 50 percent minimum of the generator nameplate rating. Loadbanks sized for less than 100 percent of a single generator must be able to be paralleled with the facility loads for full load testing. In facilities with multiple paralleled generator sets, provide a sequence of operations to test each generator set individually to keep the required loadbank size to a minimum. This sequence of operations must be activated via the paralleling switchgear human machine interface (HMI).

For Level 1 generators as defined by NFPA 110, provide a loadbank sized at 75 percent minimum of the generator nameplate rating with the ability to step from 25 percent to 50 percent to 75 percent. This will allow the yearly NFPA 110 required testing to be performed. This will also reduce annual maintenance costs and minimize the logistics of providing a third-party tester onto a secure site.

3-7.6.9 Busway.

The use of continuous open channel busway systems with modular plug-in units is acceptable for providing power to operational racks and cabinets. Coordinate plug-in unit circuit breaker and receptacle types with the facility's electronic equipment engineer. Provide plug-in units with intelligence to monitor the following points: phase current, voltage, frequency, crest factor, THD, Power (kW, kVA, kVAR), Power factor, and energy consumption (kWh) per individual plug-in circuit breaker. Data protocols must be compatible with DDC/BAS system. All points must be integrated into the DDC/BAS and visible at a central monitoring station.

3-7.6.10 Pathways.

For Grade 3 and 4, at a minimum, redundant circuits must not be routed in common duct banks, maintenance holes, conduits, pathways, raceways, or cable trays.

3-7.6.11 Wiring and Wiring Devices.

Coordinate specific wiring device requirements with the facility's electronic equipment engineer. All receptacles other than general purpose, 120V, 20A receptacles must be marked with amperage, voltage, phase, and frequency.

3-7.7 Motors and Motor Control.

Adjustable speed drives must have an Insulated-Gate Bipolar Transistor (IGBT) rectifier or “active front end.” Active front end drives have reduced harmonics that affect the sensitive electronics within the system. Provide adjustable speed drives with three contactor bypasses to allow power to be completely disconnected from the drive during replacement. Locate redundant motor control circuits within their own pathway separate from primary control circuits. Faults on the primary control circuits must not inhibit the operation of the redundant motor.

Modern HVAC equipment utilizes electronically commutated (EC) motors. These motors use a built-in inverter for operation. Inverters add harmonics to the system and therefore include EC motors as non-linear loads in the harmonic analysis.

3-7.8 Grounding and Bonding.

Provide in accordance with NFPA 70, TIA-607-D, and MIL-STD-188-124B. TIA-607 grounding is not required in spaces where MIL-STD-188-124B apply. MIL-STD-188-124B grounding includes an equipotential ground plane (copper mesh) imbedded in the concrete floors/slab which will increase the design thickness. Provide the TIA-607 excluded spaces within the MESEP. Radio equipment with manufacturer warranties require specialized grounding. Provide grounding in accordance with Motorola R56 for Motorola equipment and AE/LZT 123 4618/1 R3A for Harris equipment. Earth electrode subsystem must not exceed 5 ohms.

3-7.8.1 Neutrals.

All neutrals must be fully rated. Coordinate systems furniture circuiting requirements with interiors implementing the built-in electrical through specifications.

3-7.8.2 Screen Rooms and Shielded Enclosures.

Screen rooms/shielding enclosures must be grounded and bonded in accordance with MIL-HDBK-1195.

3-7.8.3 Lightning Protection.

Provide lightning protection for all facilities to include antenna platforms.

3-7.9 Static Transfer Switches (STS).

Static transfer switches are provided to switch power sources with little to no interruption in service. Provide rack-mounted STSs (rSTS) for single-corded network equipment to provide a dual power path. Distribution STSs can be provided for serving mission critical work areas. Distribution level STSs must be provided when required by the MESEP. Do not provide the rSTS with intelligence/ metering capabilities via ethernet.

3-7.10 Power Distribution Units (PDU).

3-7.10.1 Distribution Level PDU.

A distribution level PDU is a single piece of equipment that integrates power distribution and transformer to reduce installation times and costs. When utilized, PDUs must have harmonic mitigating transformers (HMT). PDU must have a main input circuit breaker on the transformer primary. Provide PDUs with sub-feed output sections on the secondary of the transformer. A fully configured HMI display must be provided. Provide with surge suppression device.

3-7.10.2 Rack Level PDU (rPDU).

A rack power distribution unit distributes power to the rack loads and is typically either vertically or horizontally mounted within the rack or cabinet. Provide rPDUs in each rack and coordinate input and output receptacle types with the electronic equipment engineer. Utilize basic non-metered rPDUs unless increased metering is required at the local rPDU level. If remote monitoring is required, provide a monitored rPDU. Monitored rPDUs must be connected to the metering network. Discuss if the facility Operational Technology (OT) network can reside within the cabinet with the mission network(s). Switched rPDUs are an industry option that can remotely switch on/off rPDUs. Switched rPDUs must not be utilized unless specifically required by the electronic equipment engineer. Most rPDUs do not include surge protection; therefore, it is not required at the rPDU level. Coordinate rPDU amperage, voltage and phase requirements with electronics engineer to include in the facility MESEP.

Air Force Only: Provide two 3-phase rPDUs per rack/cabinet with power monitoring in data centers.

3-7.11 Transient Voltage and Surge Protection.

Voltage transient protection must be installed on both transient sources and power distribution equipment serving electronic equipment.

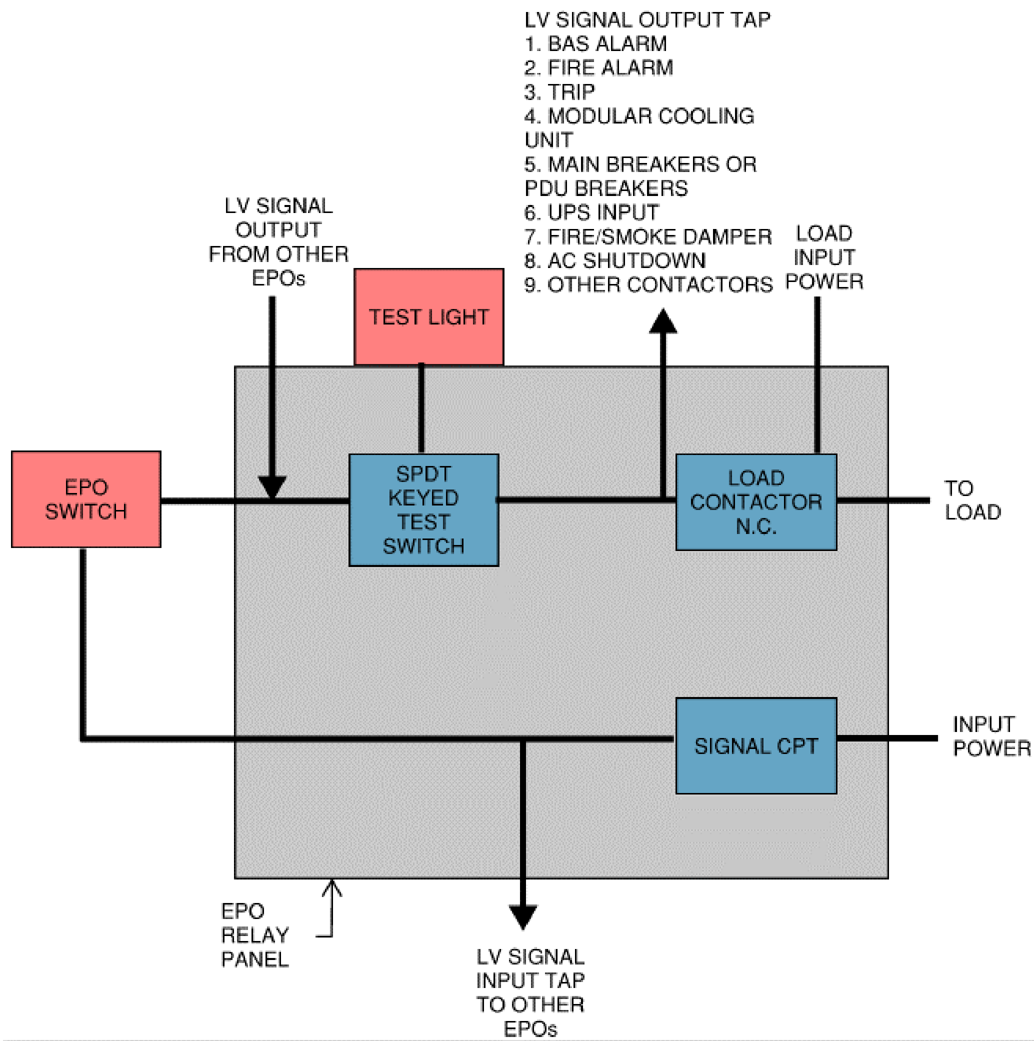
3-7.12 Selective Coordination.

Selective coordination must be provided to 0.1 seconds at a minimum. For instantaneous regions, provide manufacturer test documentation that circuit breakers must operate to open the nearest circuit breaker to the fault based on the calculated fault current. Proper coordination may lead to the deactivation of larger upstream circuit breaker instantaneous operations or instantaneous delay settings above 3 cycles (0.05s). Where this occurs, circuit breakers must be provided within a UL 1558 switchgear designed for a 30-cycle withstand rating. To properly coordinate molded case circuit breakers, consider maintaining a 2:1 or 3:1 ratio of the largest branch to the main rating. Properly document all miscoordinations in the power system study in accordance with UFC 3-501-01.

3-7.13 Emergency Power Off (EPO).

When provided, emergency power off buttons and circuits must have a Performance Level d (PLd) in accordance with ANSI B11.26. This implies structure Category 4 in accordance with ISO 13849-1, adding high diagnostic coverage and common cause failure avoidance techniques. Monitor circuit power at the Fire Alarm Control Unit (FACU) for circuit power failure and EPO activation. EPO system must have a means to test the signal pathway that deactivates the signal to the load contactors and activates a test light.

Figure 3-19 EPO Diagram



3-7.14 Lighting and Lighting Controls.

3-7.14.1 Lighting for Windowless Operating Environments (Command and Control / Operations Centers)

C5ISR facilities are high stress work environments, refer to paragraph 3-2.2.4.5. These high stress work environments are illuminated with two different scenarios; a high and low light environment. For areas of the facility that have high stress associated with them such as Command and Control Operations, Watch Floors, Operations Centers, or War Rooms refer to UFC 3-530-01 section on Command and Control/Operations Centers for the high light environment. The high light scenario will be used for housekeeping of the spaces. The users of these spaces operate in a low light environment much like a movie theater. Therefore, consideration must be given to the amount of light given off by computer screens which adds a measurable amount of usable light to the space. Provide lighting of the low light environment as follows:

- Horizontal Foot-Candles: 1.5 fc at desk
- Vertical Foot-Candles: 6 fc at 6'-0" on walls. 2 fc MAX at screen.
- Correlated Color Temperature: 2700-5500K
- Lighting Orientation: Uplight ON. Downlight OFF.

Use a mixture of direct, indirect and wall washers to meet the requirements and provide flexibility for user comfort. Provide spectral tuning luminaires to enhance operator quality of life in Command and Control/Operations spaces that mimic the natural circadian rhythm of a 24/7 schedule. For additional information refer to U. S. Air Force Lighting for Stressful Environments Report.

3-7.14.2 Lighting Controls

If automatic lighting controls are desired in the data center, provide automatic controls on a per row basis. When a networked system is utilized, integrate it into the DDC/BAS in accordance with UFC 3-530-01. Provide a SoO for lighting controls. SoO must include dry contacts or I/O blocks for outgoing or incoming signals to integrate other systems. Wireless controls are prohibited. The controls must be provided with cybersecurity protections in accordance with UFC 4-010-06. Ethernet switches provided in the lighting controls architecture must be an OSI layer 2/3 managed switch.

When applying lighting controls to secure spaces be mindful of using microphonics due to the microphone used to listen to activity in the space. Secure spaces do not allow the installation of active microphones. Obtain documentation that the sensor is passive and does not transmit intelligible voice data beyond the device. A proper passive device must utilize an op-amp comparator. Provide a lighting control network or lighting control panel inside all common secure areas and connect using fiber optics. For example, if there are multiple compartmentalized secure areas, provide one for each area. Provide location and specifications of all required media conversion equipment to connect control panels by fiber.

3-7.14.2.1 Mission Lighting Controls

Spaces that have continuous 24/7 operations must be provided with a separate control system capable of adjusting individual luminaire spectral color and color shift to meet circadian rhythm requirements. This control system must control the low light scenario of the environment. To meet the low light scenario requirement, provide addressable luminaires and control devices. The color shift must happen over a duration that corresponds to the time of the year of the facility's geographical location. The intent is to maintain the natural circadian rhythm of the operators in 24/7, high stress environments which has shown to reduce stress. The color shift must be adjusted from 2700k as a minimum to 5500K maximum.

3-7.14.3 Security Lighting.

Security lighting for facilities must be provided. Lighting must be installed inside the perimeter security fence to illuminate the fence completely and prevent an intruder from using the light poles and guy wires to gain access to the area. Illuminate areas shadowed by structures. Ensure that the failure of one lamp in a circuit does not affect other lamps in the same circuit. Provide overlapping light distribution to minimize reductions in illumination levels upon lamp failure. Protect all components of the system from vandalism. Provide lights on buildings. The emergency power source must be adequate to sustain security lighting of all critical areas and structures for 8 hours and must go into operation automatically when the primary power fails. The facility must have battery-powered lights at key control points if a failure disables the alternate power supply. Install special-purpose lighting (such as for fog penetration) when climatic or other local factors dictate. Provide additional lighting for (CCTV) security surveillance, as necessary. Vapor type lighting must not be used within 0.5 miles (0.8 km) of antenna receiving areas.

3-7.15 Telecommunications.

Similar to the electrical system, the telecommunications system can be determined using a small, medium, and large scale. Regardless of scale, C5ISR facilities contain large amounts of data processing equipment, typically in a central room or multiple rooms within the facility called data centers. These data centers may process information for multiple missions and must be properly networked for redundancy and flexibility. C5ISR facilities rooms/spaces/areas must be labeled as indicated when applicable:

3-7.15.1 Entrance Facility (EF).

The room or area where the outside plant cabling terminates inside the facility. In some cases, this room will be the same as the main distribution area if the facility provider owns the OSP cabling. When there is an outside service provider, provide a demarcation room to allow separate access for provider cable termination and equipment.

3-7.15.2 Main Distribution Area (MDA).

The room or area that supports customer-owned core equipment, including routers, core switches, firewalls, load balancers, DNS, and possibly core SAN fabric switches. This area is typically found in support of the core data center. MDAs may serve one or more HDAs, IDAs, EDAs, or TRs within a facility. May also be called data center.

3-7.15.3 Intermediate Distribution Area (IDA).

The room or area that supports the intermediate cross connect. Typically used in large facilities when the number of connections between MDAs and HDAs is large and cannot be supported by these rooms or areas. This area is typically found in support of the core data center. IDAs are optional spaces dependent on networking demand.

3-7.15.4 Horizontal Distribution Area (HDA).

The room or area that supports horizontal cabling to ZDAs, EDAs, IT equipment, or equipment outlets. This area is typically found in support of the core data center. HDAs are optional areas that assist with cable decongestion in medium to large scale data centers.

3-7.15.5 Equipment Distribution Area (EDA).

Area that houses IT processing equipment.

3-7.15.6 Zone Distribution Area (ZDA).

An optional interconnection point within the horizontal cabling located between the HDA and the EDA to allow frequent reconfiguration and added flexibility.

3-7.15.7 Telecommunications Room (TR).

A room that supports operations outside of the data center or mission directly serving the data center. This room may also extend the core data center service outside the data center room or area and into the facility for mission use.

In small data centers, a single MDA is required with no supporting area, such as HDAs or IDAs, to provide necessary connections. Provide HDAs and IDAs for larger data centers to support the increased number of cross connects and horizontal cabling. Close coordination with the facility’s electronic equipment engineer is required to determine networking requirements and needs for these specific areas.

3-7.16 Telecommunications Infrastructure Grade.

The Grade is to be determined in accordance with MESEP.

3-7.16.1 Grade 1 Telecommunications System.

Not applicable.

3-7.16.2 Grade 2 Telecommunications System.

The incoming outside plant cabling to the facility must be redundant via two separate paths and maintenance holes. Redundant feeds terminate in a single entrance facility room. Telecommunications equipment for supporting services are to have redundant components such as processors and power supplies. Backbone cabling between telecommunications rooms must have redundant stands or pairs which can be shared within the same sheath of a single cable; independent cabling is not required. It is acceptable to incorporate ring or mesh topologies along with the required star topology.

3-7.16.3 Grade 3 Telecommunications System.

Two separate feeds from separate buildings should serve the facility. Cabling should be separated by 66 feet (20 m) along their entire routes when possible. Document any restrictions of feed separation in the Basis of Design. The facility must have two entrance rooms at preferably opposing ends of the building. A separation distance of 66 feet (20 m) between the two rooms is acceptable if opposing ends are not viable. Sharing entrance feed equipment, fire protection zones, power distribution, and air conditioning equipment between the two entrance rooms is prohibited. The equipment in each entrance room must be able to maintain the mission if the equipment in the opposing entrance room is undergoing planned maintenance. Redundant backbone pathways must be between the entrance rooms, MDA, IDAs, and HDAs. The redundant connections must be in separate pathways or by separate cables.

3-7.16.4 Grade 4 Telecommunications System.

Grade 4 facility must meet all the provisions of Grade 3 plus the following: Backbone cabling and distributor rooms/area must be redundant. Backbones and horizontal cabling between two spaces must be separate paths, with common paths only inside the termination rooms/areas. There should be an automatic backup for all critical telecommunications equipment. The facility must have redundant MDAs. A separation distance of 66 feet (20 m) between the two rooms is acceptable if opposing ends are not viable. Sharing fire protection zones, power distribution units, and air conditioning equipment between MDAs is prohibited. The MDAs must have separate pathways to each entrance room. There must be a telecommunications cabling pathway between the facility MDAs. HDAs must be provided with connections to two different IDAs or MDAs. When provided, each IDA must be provided with connections to both MDAs. Critical systems should have connections to two HDAs.

3-7.17 Telecommunications Cabling, Topology, and Installation.

This section outlines the architecture and product performance requirements of the telecommunications system.

3-7.17.1 Backbone Cabling and Topology.

Maintain backbone cabling outside of horizontal cabling cable trays. When backbones are routed within a large data center space, cabling may be routed inside cable trays or conduits. Backbone topologies will vary based on facility Grade. Refer to project MESEP and Appendix A for exact requirements.

Figure 3-20 Grade 3 Concept Topology

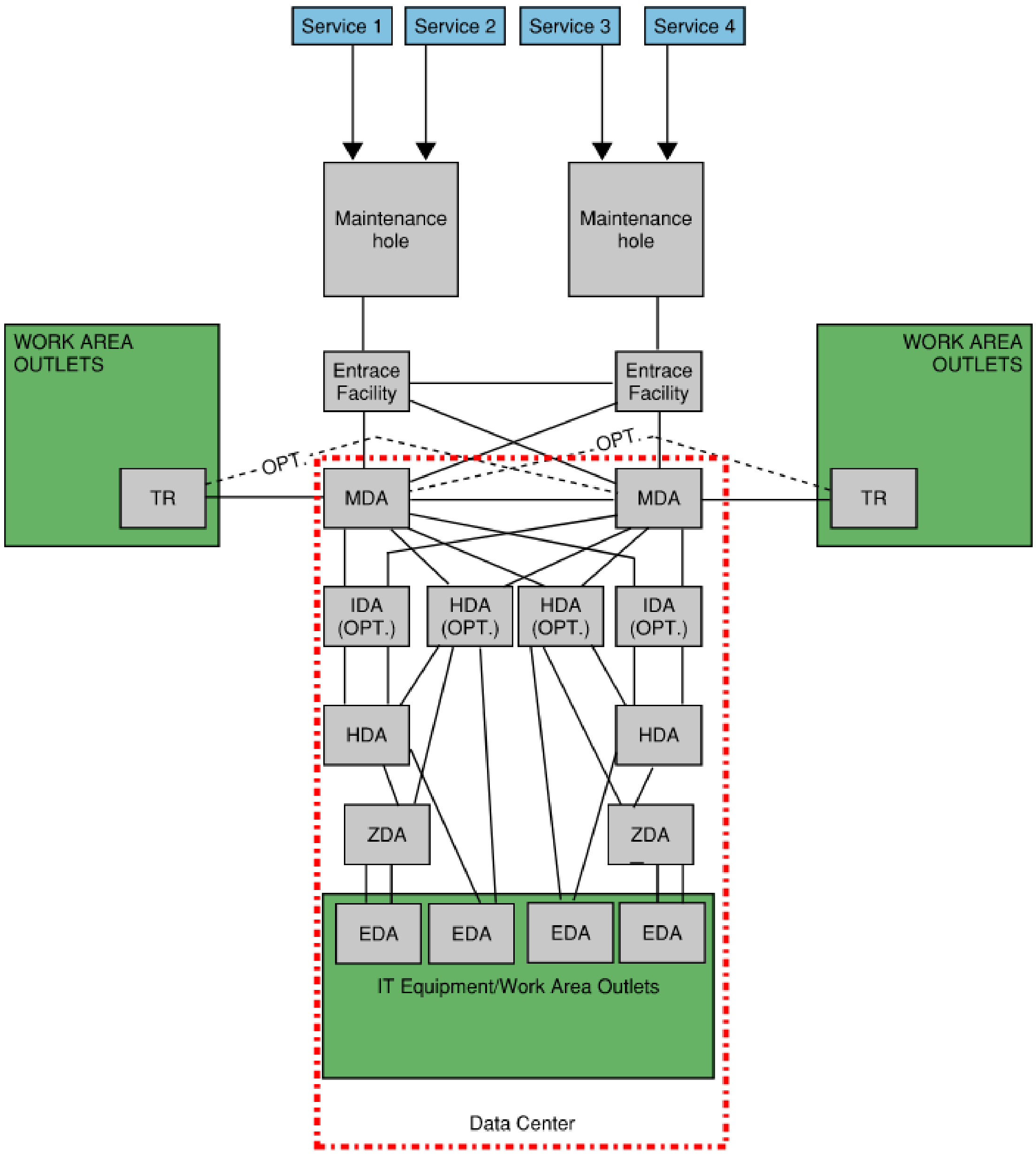
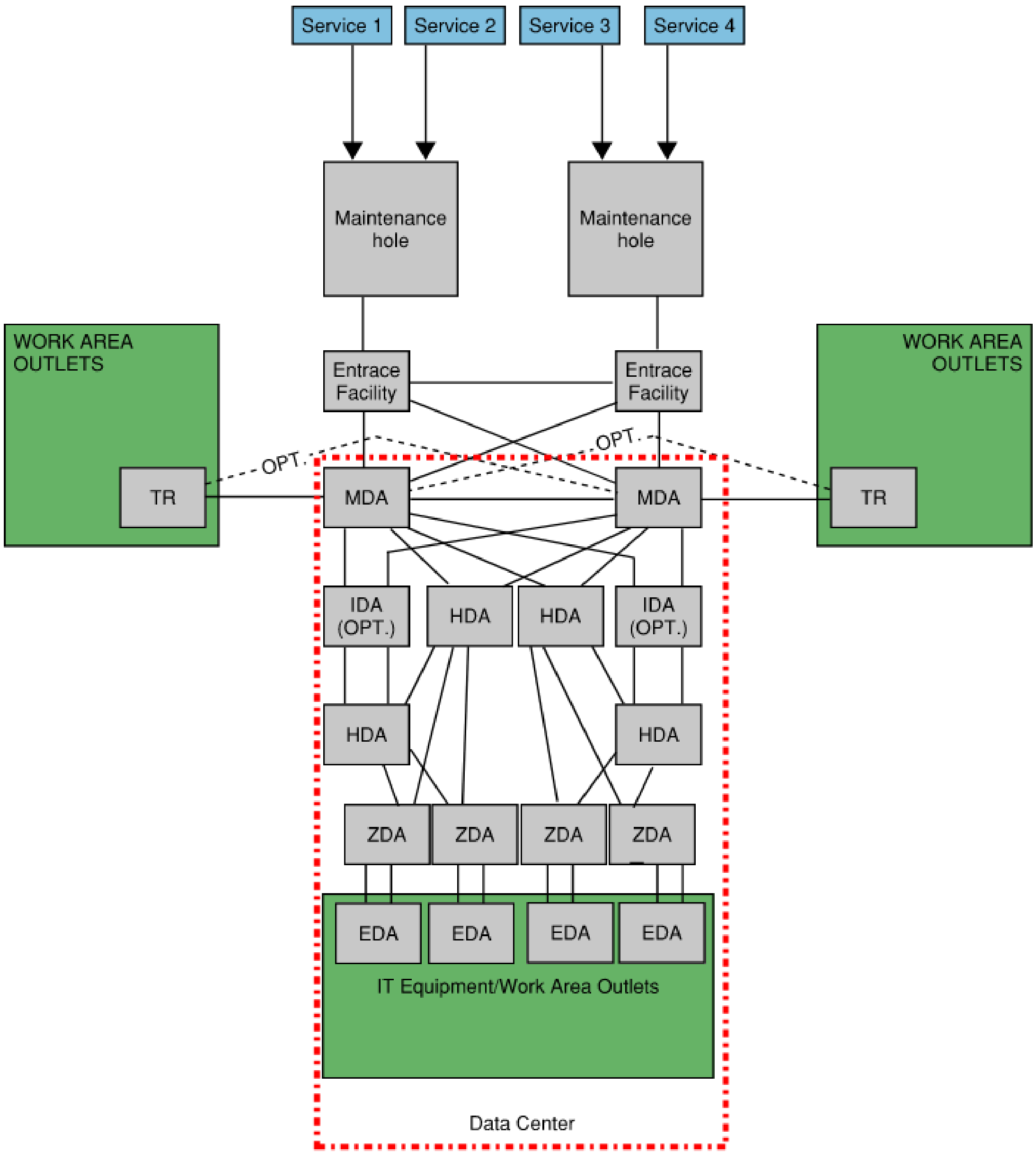


Figure 3-21 Grade 4 Concept Topology



3-7.17.2 Horizontal Cabling and Topology.

Horizontal cabling must be provided in a star topology. Refer to project MESEP and Appendix A for exact requirements. If workstations require redundant horizontal cabling, provide from two separate spaces/rooms. If not possible, route from separate rack/cabinets and provide a cable tray divider between the primary and redundant cabling. Redundant horizontal cabling is not required for workstations serving Grade 3 or 4 facilities. Secure and unsecure networks must maintain separation in accordance with CNSSAM TEMPEST 1-13. The use of cable tray dividers to maintain separation of networks sharing a cable tray is acceptable but not required. This will minimize cable trays within the building reducing overall space required. If dividers are not acceptable special networks with higher security than Red networks must be in their own cable trays.

3-7.18 Telecommunications Spaces and Pathway.

TR spaces should be provided with no ceiling. In facilities with a high structure, a hard ceiling is acceptable 24” above the highest infrastructure within the room.

Data center rooms and areas must be sized for the equipment and mission. Secure and unsecure networks must maintain separation in accordance with CNSSAM TEMPEST 1-13; add square footage for separation requirements. Consider the use of structural grid ceilings in data centers for equipment mounting. Include preferred space sizes in the project MESEP.

For Navy Only: Refer to FC 2-000-05N for guidelines for sizing spaces per rack/cabinet quantities.

3-7.18.1.1 Protected Distribution System (PDS).

Minimize the amount of PDS within the facility as much as possible. Verify with electronics engineer or base communications officer the strategy for decryption within secure spaces. It is not uncommon to have multiple secure areas but a single decryption device provided to support them. PDS is required in this situation to route secure backbones between secure areas. If a decryption device can be located in each secure area, then no PDS would be required between those spaces.

3-7.18.2 Telecommunications Cabinets and Racks.

Coordinate cabinet requirements with the selected mechanical system provided within the data center/equipment room space. Provide blanking panels for empty rack unit spaces when air control is required to maintain hot and cold aisles. If a containment system is required, coordinate the cabinet size/type to maintain proper containment/sealing of the system. Refer to project MESEP for exact requirements.

3-7.18.3 Outside Plant Cabling Infrastructure.

Refer to project MESEP for exact requirements.

3-7.18.3.1 Underground Pathways.

Concrete encase all duct banks providing incoming services to the facility.

3-7.18.3.2 Aerial Pathways.

Do not provide overhead services unless necessary.

3-7.19 Television Systems (CATV).

Provide copper to fiber to copper media conversion for CATV traversing secure boundaries when required.

3-7.20 Electronic Security Systems (ESS).

Provide in accordance with UFC 4-021-02 and coordinate with the security assessment per the design basis threat analysis. Coordinate exact requirements with stakeholders. Provide copper to fiber to copper media conversion for ESS traversing secure boundaries when required. Refer to project MESEP for exact requirements. Ethernet switches in the ESS architecture must be an OSI layer 2/3 managed.

3-7.21 Audio Visual (A/V)

Provide space in accordance with TIA-569 within the telecommunications rooms or local served spaces for A/V equipment.

3-8 FIRE PROTECTION AND LIFE SAFETY.

Provide buildings and systems in accordance with UFC 3-600-01 except where requirements are added/modified by this UFC. Electronic Equipment Areas, as defined by UFC 3-600-01, must follow UFC 3-600-01 requirements except as modified herein.

3-8.1 Physical Security.

For buildings requiring locking arrangements for security purposes, comply with NFPA 101, Life Safety Code locking requirements.

3-8.2 Areas Not Containing Electronic Equipment and Incidental Electronic Equipment Areas.

Comply with UFC 3-600-01.

3-8.3 Electronic Equipment Areas.

3-8.3.1 Electronic Equipment Area Separation.

Provide minimum 2-hour fire barriers to separate Electronic Equipment Areas from the rest of the facility.

3-8.3.2 Vaults, Other Electrical/Telecom Rooms Supplying Electronic Equipment Areas.

All vaults and other telecom and/or electrical rooms within C5ISR facilities that contain communication/data and/or electrical equipment that serve the Electronic Equipment Areas must be protected the same as the Electronic Equipment Areas in the facility and comply with all requirements in 3-8.3. Follow NFPA 70 Article 110. Provide clean agent fire extinguisher(s) sized and spaced in accordance with NFPA 10 in all vaults.

3-8.3.3 Fire Suppression Systems.

3-8.3.3.1 Classification of Hazard.

Follow UFC 3-600-01.

Army Facilities: Minimum sprinkler hazard classification for Electronic Equipment Areas must be Ordinary Hazard.

3-8.3.3.2 Automatic Sprinkler Protection for Electronic Equipment Areas.

Label and identify valves controlling water to Electronic Equipment Areas to indicate the Electronic Equipment Areas they serve.

Army and Navy Facilities: Provide wet-pipe automatic sprinkler protection in these areas of the facility where the facility is fully sprinkled. Use of preaction sprinkler systems is not permitted.

Air Force Facilities: Refer to UFC 3-600-01 and the use of TSFPEWG G 3-600-01.01-18 for automatic sprinkler system guidance, including areas permitting preaction sprinkler systems.

For areas with hot aisle and cold aisle containment, provide sprinklers inside the compartments to comply with NFPA 13 obstruction requirements.

3-8.3.3.3 Clean Agent Systems.

Provide total-flooding clean agent systems in addition to automatic sprinkler protection for all Electronic Equipment Areas in C5ISR facilities regardless of Grade. Comply with UFC 3-600-01 and activate system by a Very Early Warning Fire Detection System (VEWFD).

Note: Additional preventative maintenance requirements are incurred when using a total-flooding clean agent system such as maintaining the enclosure integrity. See UFC 3-601-02 for the required annual, 2-year, 5-year, and other Inspection, Testing, Maintenance requirements.

3-8.3.3.4 Portable Fire Extinguishers

Provide clean agent fire extinguisher(s) sized and spaced in accordance with NFPA 10 in all Electronic Equipment Areas.

3-8.3.4 Fire Alarm Systems.

Provide addressable fire alarm system in accordance with UFC 3-600-01.

3-8.3.4.1 Very Early Warning Fire Detection.

Provide VEWFD port spacing in accordance with NFPA 76 VEWFD port installation requirements. Design system using manufacturer-provided listed criteria, which includes the pipe air pressure, airflow rate through sampling port, percentage of total pipe flow through sampling port, and transport time required for a smoke sample to be drawn from the sampling port to the detector. For areas with hot aisle and cold aisle containment, provide detection inside the compartments. Utilize cross-zoned detection or an equivalent method to minimize potential for false discharges of the clean agent system.

Provide supervisory alert level notification (at lowest smoke obscuration level) with silence switch outside of the protected area in a readily apparent location to notify building occupants. If building occupants do not have access to the protected area, provide signage indicating contact information of personnel who have access to space. Where the protected area is always occupied, outside the space notification is not required.

3-8.3.5 Electronic Equipment Power Disconnect.

Must meet the requirements set forth in section 3-7.13.

Army and Navy Facilities: Provide manual means for electronic equipment EPO as permitted by UFC 3-600-01.

Air Force Facilities: Automatic EPO is permitted upon sprinkler water flow as guided by TSFPEWG G 3-600-01.01-18.

3-8.3.6 Air Handling Equipment Shutdown.

CRAC and CRAH units must not automatically shut down if electronic equipment remains energized and heat generated in the room will be sufficient to activate sprinkler heads. Duct smoke detectors and automatic shutdown are not required where air distribution systems are incapable of spreading smoke beyond the enclosing walls, floors, and ceilings of the room or space in which the smoke is generated.

Clean agent system activation must shut down any equipment cooling system where the airflow passes outside of the clean agent discharge envelope/volume. Equipment cooling systems with airflow completely within the discharge envelope/volume must continue to operate.

3-8.3.7 Smoke Exhaust Systems.

Army and Navy: Smoke exhaust of Electronic Equipment areas is not required in accordance with UFC 3-600-01.

Air Force: Refer to TSFPEWG G 3-600-01.01-18 for smoke exhaust guidance.

CHAPTER 4 SPECIAL REQUIREMENTS

4-1 MAINTENANCE AND COMMISSIONING REQUIREMENTS.

4-1.1 Maintenance.

Design for accessibility and maintenance. Provide egress pathways for all critical equipment to allow removal/replacement without interrupting service. Include in design package drawings indicating travel pathway for equipment removal. Ensure all equipment is readily accessible for inspection and ease of maintenance.

4-1.2 Commissioning.

Provide commissioning in accordance with UFC 1-200-02 and ANSI/NETA ECS. A third party must provide Integrated Systems Testing (IST) for all systems within the facility. Introduce mission critical events that initiate all emergency systems' sequence of operations. Verify that all mechanical, fire protection, and electrical systems operate per the designed sequence of operations and maintain the mission.

For Army only: Provide commissioning in accordance with ER 1110-345-723 and UFC 1-200-02.

4-1.2.1 Grade 1 Facility Scheduled Maintenance Event Test Requirements.

Not applicable.

4-1.2.2 Grade 2 Facility Scheduled Maintenance Event Test Requirements.

Initiate a mission critical scheduled maintenance event by removing equipment from the path of operation that has redundant components. Verify the mission's planned operating procedures by manually shutting down a single piece of equipment requiring maintenance and initiating the redundant mode of operation. Test must be repeated for each piece of equipment in the path of operation for each redundant component. Components are to be tested independently.

4-1.2.3 Grade 3 Facility Scheduled Maintenance Event Test Requirements.

Initiate a mission critical scheduled maintenance event by removing equipment from the intended path of operation. Verify the mission's planned operating procedures by manually shutting down a single piece of equipment requiring maintenance and initiating the redundant mode of operation. Test must be repeated for each piece of equipment in the intended path of operation and each path of operation.

4-1.2.4 Grade 4 Facility Critical Failure Event Test Requirements.

In addition, for Grade 4 facilities, initiate a simulated mission critical failure event by removing equipment from the intended path of operation without a planned procedure. Verify automatic operations of the system to the redundant path equipment for maintaining the critical load. Verify the intended redundant path is operating. Test must be repeated for each piece of equipment or system in the intended path of operation and each path of operation.

4-1.2.5 Systems Manual Requirements.

The Designer of Record (DOR) must incorporate the SM requirements into the construction documents via UFGS 01 91 00.15 Building Commissioning.

For Army only: Provide Systems Manual (SM) for all C5ISR facilities in accordance with ER 1110-345-723 and ER 25-345-1.

4-1.3 Staff Training.

Training of systems must cover the project system Sequence of Operations. It must demonstrate how to maintain facility operations during maintenance or fault conditions.

For Army only: Provide staff training for all C5ISR facilities in accordance with ER 1110-345-723.

4-2 ELECTRICAL.

4-2.1 400 Hz Power.

When 400 Hz is required, provide using either a motor generator or static converter. Provide calculations for conversion equipment in accordance with UFC 3-501-01. Consideration should be given to standby requirements when selecting and locating frequency converters. Both types of converters must be adequately grounded to prevent electromagnetic interference. Power at 400 Hz requires that the distribution system be carefully engineered. Consider using larger conductors, parallel feeders, non-magnetic conduits, and load drop compensators. All cables carrying 400-Hz power must be run in separate raceway systems.

4-2.2 Direct Current (DC) Power Systems.

Electronic facilities often require direct-current power supplies and distribution systems. These power systems utilize 24 to 48-volts DC. The facility’s electronic equipment engineer must provide these systems. Coordinate with the facility’s electronic equipment engineer to support equipment requirements. If others are not providing these systems, determine their impact on project cost and implementation if economically feasible for the project.

4-2.3 Data Center Infrastructure Management (DCIM).

Provide DCIM software integrated with the building's DDC/BAS computer. Integration of Information Technology (IT) and facility management disciplines centralizes monitoring, management, and intelligent capacity planning of a data center's critical systems. It is achieved by implementing specialized software, hardware, and sensors. DCIM enables common, real-time monitoring and management platform for all interdependent systems across IT and facility infrastructures. DCIM allows the user to record equipment installation dates and set maintenance intervals that alarm the user to perform preventative maintenance. The software can also integrate with more advanced sensors to address equipment on the verge of failure due to abnormal operating parameters. For example, a server cabinet operating at a higher temperature may require more frequent replacements of active equipment. DCIM can also track maintenance work orders and perform audits for compliance.

4-2.4 Power Conditioning.

For secure areas requiring filtering or conditioning of power refer to UFC 4-010-05. Any power conditioning equipment must meet the electrical power characteristics stated in Section 3-7.

4-2.5 Antenna Systems.

Size cable entry ports into facilities as required based on quantity and size. Cable boots must be provided and sized according to the cables to enter the entry port. Multi-cable modular-based compression-type transit systems are acceptable. Provide power to exterior antenna systems by underground cable trench with removable covers. Fluorescent and LED lighting can cause interference in radio systems. Consider using incandescent lighting for radio systems easily influenced by EMI. Discuss lighting with radio operators to verify EMI impact on systems.

4-2.6 Audio Visual.

Provide audio visual equipment as required. A/V equipment must utilize all hardwired connections; wireless operability is prohibited.

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APPENDIX A BEST PRACTICES

A-1 GENERAL.

A-1.1 Antiterrorism (AT).

Incorporate AT issues at the initial phase of the design. Coordinate all protection features with the current standards and any additional requirements in place at the time of the design. Ascertain the requirements for protection based on a site-specific survey, or lacking one, and provide the minimum protection standards outlined in the standards. Coordinate all AT issues with the base that may be a part of another project or impact adjacent facilities, such as security fencing and parking.

Design basis threat must consider both the occupants of the building and the equipment within the building necessary for the mission's success.

A-2 ENGINEERING SYSTEMS GRADING.

A-2.1 Grade 1.

Not applicable.

A-2.2 Grade 2.

These facilities have redundant componentry but not system level redundancy. Some maintenance activities will interrupt or impede the performance of the mission.

A-2.3 Grade 3.

These facilities can have any capacity component or distribution element serviced or repaired on a planned basis without interrupting or impeding the performance of the computer equipment.

A-2.4 Grade 4.

The facilities systems can continue operations uninterrupted despite the failure of one or more components.

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APPENDIX B GLOSSARY

B-1 ACRONYMS

A/E	Architecture/Engineering
AC	Air Conditioning
AFCEC	Air Force Civil Engineer Center
AFF	Above Finish Floor
ADP	Automatic Data Processing
AHJ	Authority Having Jurisdiction (See MIL-STD 3007, Change 2, Nov 2018)
ASCE	American Society of Civil Engineers
AT	Antiterrorism
ATS	Automatic Transfer Switch
A/V	Audio/Visual
BAS	Building Automation System
BESEP	Base Electronic System Engineering Plan
BIA	Bilateral Infrastructure Agreement
BTUs	British Thermal Units
C5ISR	Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance, and Reconnaissance
CATV	Television Systems
CDC	Core Data Center
CEDC	Component Enterprise Data Center
CFD	Computational Fluid Dynamics
C-I-A	Confidentiality, Integrity, and Availability
COMNAVWARSYSCOM	Naval Information Warfare Systems Command
CRAC	Computer Room Air Conditioning Units

CRAH	Computer Room Air Handling Units
CSP	Construction Security Plan
CTTA	Certified TEMPEST Technical Authority
CTR	Component Technical Representative
DC	Direct Current
DCIM	Data Center Infrastructure Management
DDC	Direct Digital Control
DF	Direction Finder
DOAS	Dedicated Outdoor Air System
DoD	Department of Defense
DOR	Designer of Record
DX	Direct Expansion
EC	Electronically Commutated
EDA	Equipment Distribution Area
EF	Entrance Facility
EMC	Electromagnetic Compatibility
EPA	Environmental Protection Agency
EPSM	Electrical Power System Monitoring
EPO	Emergency Power Off
ESS	Electronic Security Systems
FAC	Facility Analysis Category
FACU	Fire Alarm Control Unit
GIS	Gas Insulated Switchgear
GSU	Geographically Separated Unit
HDA	Horizontal Distribution Area

HMI	Human Machine Interface
HMT	Harmonic Mitigating Transformers
HNFA	Host Nation Funded Construction Agreements
HQUSACE	Headquarters, U.S. Army Corps of Engineers
HVAC	Heating, Ventilating, and Air-Conditioning
Hz	hertz
in.	Inches
in^2	Square Inches
I/O	Input/Output
IDA	Intermediate Distribution Area
IGBT	Isolated Gate Bipolar Transistor
IPN	Installation Processing Node
ISN	Installation Services Node
IST	Integrated Systems Testing
IT	Information Technology
kg	Kilogram
kPa	Kilopascal
lb	Pounds
LCCA	Life Cycle Cost Analysis
LSI	Long-time, Short-time, and Instantaneous
mm	Millimeter
mm^2	Square Millimeter
MBH	Thousand BTU per Hour
MDA	Main Distribution Area
MERV	Minimum Efficiency Reporting Value

MESEP	Mission Engineering Systems Execution Plan
MTS	Manual Transfer Switch
M-T-T-M	Main-Tie-Tie-Main
NAVFAC	Naval Facilities Engineering Systems Command
OCONUS	Outside Continental U.S.
OSI	Open Source Interconnection
PDS	Protected Distribution System
PDU	Power Distribution Unit
PEMCS	Power and Environmental Monitoring and Control System
PLd	Performance Level d
psf	Pounds per Square Foot
RPCS	Real Property Categorization System
RPP	Remote Power Panel
rPDU	Rack Mounted PDU
rSTS	Rack Mounted STS
SAPF(s)	Special Access Program Facility(ies)
SCIF(s)	Sensitive Compartmented Information Facility(ies)
SEI	Structural Engineering Institute
SIS	Solid Insulated Switchgear
SM	Systems Manual
SOFA	Status of Forces Agreements
SoO	Sequence of Operations
SPPN	Special Purpose Processing Node
SSM	Site Security Manager
STS	Static Transfer Switch

THD	Total Harmonic Distortion
TPN	Tactical Processing Node
TR	Telecommunication Room
UFC	Unified Facilities Criteria
UPS	Uninterruptible Power Supply
USACE	U.S. Army Corps of Engineers
U.S.	United States
VRF/VRV	Variable Refrigerant Flow/Volume
VEWFD	Very Early Warning Fire Detection
ZDA	Zone Distribution Area

B-2 DEFINITION OF TERMS.

Electronics Engineer: Person(s) responsible for the active equipment design of the mission systems to be contained within the facility.

Equipment Rooms: Rooms containing mission active data processing equipment.

Grade: A DoD specific term that is similar to Uptime Institute's Tiering, ANSI/TIA 942 Data Centers, and ANSI/BICSI 002 Class models.

APPENDIX C REFERENCES

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CNSSAM TEMPEST/1-13, *Red/Black Installation Guidance*
https://www.cnss.gov/CNSS/issuances/Memoranda.cfm

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DoDI 4165.03, *DoD Real Property Categorization*

MIL-HDBK-419A, *Grounding, Bonding, and Shielding for Electronic Equipments and Facilities*

MIL-HDBK-1195, *Radio Frequency Shielded Enclosures*

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

MIL-STD-1472, *Human Engineering*

MIL-STD-1474, *Noise Limits*

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https://www.wbdg.org/dod/ufc

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UFC 1-200-02, *High Performance and Sustainable Building Requirements*

FC 2-000-05N, *Facility Planning Criteria for Navy/Marine Corps Shore Installations*

UFC 3-101-01, *Architecture*

UFC 3-110-03, *Roofing*

UFC 3-201-01, *Civil Engineering*

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UFC 3-410-02, *Direct Digital Control for HVAC and Other Building Control Systems*

UFC 3-460-01, *Design: Petroleum Fuel Facilities*

UFC 3-460-03, *Petroleum Fuel Systems Maintenance*

UFC 3-501-01, *Electrical Engineering*

UFC 3-510-01, *Foreign Voltages and Frequencies Guide*

UFC 3-520-01, *Interior Electrical Systems*

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UFC 3-520-05, *Stationary and Mission Batteries*

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UFC 3-540-01, *Engine-Driven Generator Systems for Prime and Standby Power Applications*

UFC 3-560-01, *Operation and Maintenance: Electrical Safety*

UFC 3-580-01, *Telecommunications Interior Infrastructure Planning and Design*

UFC 3-600-01, *Fire Protection Engineering for Facilities*

UFC 3-601-02, *Fire Protection Systems Inspection, Testing, and Maintenance*

UFC 4-010-01, *DoD Minimum Antiterrorism Standards for Buildings*

UFC 4-010-05, *SCIF/SAPF Planning, Design, and Construction*

UFC 4-010-06, *Cybersecurity of Facility-Related Control Systems*

UFC 4-020-01, *DoD Security Engineering Facilities Planning Manual*

UFC 4-021-02, *Electronic Security Systems*

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https://wbdg.org/dod/ufgs/ufgs-01-91-00-15

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TSFPEWG G 3-600-01.01-18, *Air Force Fire Protection Engineering Criteria and Technical Guidance for Mission Continuity of Electronic, Information Technology, and Telecommunications Equipment Installations* https://www.wbdg.org/dod/supp-tech-documents/tsfpewg-g-3-600-01-01-18

AIR FORCE

https://www.e-publishing.af.mil/

DAFMAN 32-1084, *Standard Facility Requirements*

US Air Force Lighting for Stressful Environments, Demonstration Room Lighting Report, 4 January 2016

ARMY

https://armypubs.army.mil/

AR 405-70, *Utilization of Real Property*

DA PAM 40-501, *Army Hearing Program*

ER 1110-345-723, *Total Building Commissioning Procedures*

ER 25-345-1, *Systems Manual*

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ANSI B11.26, *Functional Safety For Equipment: General Principles For The Design Of Safety Control Systems Using ISO 13849-1*

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https://www.asce.org/

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AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR-CONDITIONING ENGINEERS (ASHRAE)

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ASHRAE Standard 15, *Safety Standard for Refrigeration Systems*

Thermal Guidelines for Data Processing Environments

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AMERICAN WATER WORKS ASSOCIATION (AWWA)

https://www.awwa.org/

AWWA M24, *Planning for the Distribution of Reclaimed Water*

BUILDING INDUSTRY CONSULTING SERVICE INTERNATIONAL (BICSI)

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ANSI/BISCI 002, *Data Center Design and Implementation Best Practices*

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)

https://standards.ieee.org/

IEEE C37.20.7, *Guide for Testing Switchgear Rated Up to 52 kV for Internal Arcing Faults*

IEEE 493, *Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems*

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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https://www.iso.org/standard

ISO 13849-1, *Safety of Machinery – Safety-related parts of control systems – Part 1: General principles for design*

MOTOROLA

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NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

https://www.nfpa.org/

NFPA 10, *Standard for Portable Fire Extinguishers*

NFPA 13, *Standard for the Installation of Sprinkler Systems*

NFPA 30, *Flammable and Combustible Liquids Code*

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Note: The NEC must be effective for new design projects awarded after January 1 of the year following the issuance of a revised edition unless specifically identified otherwise in contract documents

NFPA 75, *Standard for the Fire Protection of Information Technology Equipment*

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AE/LZT 123 4618/1 R3A, *Standards, Site Grounding and Lightning Protection*

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UL 1558, *Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear*

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