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Data Center Design and Implementation Best Practices

DEMONSTRATION VERSION
NOT FOR RESALE

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PREFACE

Revision History

June 18, 2010 First publication of this standard, titled BICSI 002-2010, *Data Center Design and Implementation Best Practices*

March 15, 2011 Revision of BICSI 002-2010 published as ANSI/BICSI 002-2011, *Data Center Design and Implementation Best Practices*

Major revisions include:

- Addition of Section 9, *Electrical*
- Addition of Section 14, *Telecommunications*

Minor revisions include: definitions, updating of graphics for printing and readability, other editorial corrections

December 9, 2014 Revision of ANSI/BICSI 002-2011 published as ANSI/BICSI 002-2014, *Data Center Design and Implementation Best Practices*

Major revisions include:

- Revision of Class F0 – F4 electrical infrastructure, including the removal of the requirement for a second power utility connection in Section 9, *Electrical*.
- Revised telecommunications Availability Classes C3 and C4 concerning the redundancy of main and horizontal distributors in Section 14, *Telecommunications*.
- Added, expanded and revised Availability Class structure to mechanical, telecommunications and network infrastructure (see Sections 9, 14, and 15 respectively).
- Addition of Appendix C, Alignment of Data Center Services Reliability with Application and System Architecture.
- Addition and revision of content for modular and containerized data centers in Section 6, *Space Planning* and Section 9, *Electrical*.
- Introduced content on DCIM and renamed Section 13 to *Data Center Management and Building Systems.*
- Expanded content regarding DC power and safety in Section 9, *Electrical.*
- Addition of hot and cold aisle containment in Section 6, *Space Planning* and Section 11, *Fire Protection*.
- Added and expanded content regarding designing for energy efficiency in multiple sections and added Appendix G, *Design for Energy Efficiency.*
- Addition of Appendix D, Data Center Services Outsourcing Models.
- Addition of Appendix E, Multi-Data Center Architecture.
- Updated cabinet door air flow and cable capacity calculations in Section 14, *Telecommunications.*

Minor revisions include:

- Moved former Section 5, *Space Planning* to directly after former Section 6, *Site Planning.*
- Restructuring of Section 5, *Site Planning*, Section 14, *Telecommunications*, and Section 16, *Commissioning.*
- Expansion of content to reflect both new and international design practices.
- Revisions to Appendix B, *Reliability and Availability*, to accommodate extension of availability classes.
- Update Section 8, *Structural*, to align with revisions to the *IBC* and related standards.

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- Updated Section 10, *Mechanical*, to reflect expanded ASHRAE guidelines for temperature and humidity.
- Updated Section 11, *Fire Protection* section to reflect changes in NFPA 75 and NFPA 76.
- Updated Section 14, *Telecommunications*, to reflect updates to ISO, TIA, and CENELEC data center cabling standards including cable types (removed OM1 and OM2, recommend OM4, added Category 8) and addition of intermediate distributor.
- Revised content regarding zinc whiskers and moved to Section 7, *Architectural*.
- Added content on testing equipment, system testing, acceptance testing, equipment operations and maintenance manuals, and system training to Section 16, *Commissioning*.
- Revised and moved system availability information to Appendix B, *Reliability and Availability*. (content formerly in Section 17, *Maintenance*).
- Added new content on maintenance plans and service contracts in Section 17, *Maintenance.*
- General content relocation and editorial corrections to improve readability and reduce ambiguity.

May 1, 2019 Revision of ANSI/BICSI 002-2014 published as ANSI/BICSI 002-2019, *Data Center Design and Implementation Best Practices*

Notable content relocation to BICSI 009-2019 includes:

- Operational security topics within Section 12*, Security*
- Operational maintenance topics within Section 17*, Data Center Maintenance*

Major revisions include:

- Title change of Section 13 to *Facility, Ancillary and IP-enabled Systems*, with addition of applicable content
- Restructured and expanded content within Section 10, *Mechanical Systems* related to heating and cooling
- Addition of Appendix H, *Colocation Technical Planning*
- Revision of Section 16, *Commissioning*
- Addition of content for Open Compute Project® infrastructure

Minor revisions include:

- Additions or revsions to airports volcanoes, and microgrids in Section 5, *Site Selection*
- Exapnsion of network topologies and fabirics in Section 15, *Information Technology*
- Addtion of litihium ion (Li-ion) batter information within multiple sections
- General content relocation and editorial corrections to improve readability and reduce ambiguity

Document Format (Usability Features)

This standard has the following usability features as aids to the user:

- Additions and changes, other than those for editorial purposes, are indicated with a vertical rule within the left page margin.
- Deletion of one or more paragraphs is indicated with a bullet (•) between the content that remains

NOTE: The relocation of content within or between sections (e.g., Section 12, *Security*) related to structure, readability, or content alignment changes is not indicated.

Translation Notice

This standard may have one or more translations available as a reference for the convenience of its readers. As that act of translation may contain inconsistencies with the original text, if differences between the translation and the published English version exist, the English text shall be used as the official and authoritative version.

1 Introduction

1.1 General

This standard is written with the expectation that the reader is familiar with the different facets of the design process (See Appendix A). The reader should understand from which role and point of view he or she intends to use this document (e.g., information technology, facilities, other corporate internal or external to the owner). Refer to Sections 1.2.1 – 1.2.3 below.

1.2 Purpose

This standard provides a reference of common terminology and design practice. It is not intended to be used by architects and engineers as their sole reference or as a step-by-step design guide, but may be used by such persons to determine design requirements in conjunction with the data center owner, occupant, or consultant.

This standard is intended primarily for:

- Data center owners and operators
- Telecommunications and information technology (IT) consultants and project managers
- Telecommunications and IT technology installers

Additionally, individuals in the following groups are also served by this standard.

1.2.1 Users Within IT

1.2.1.1 IT and Telecommunications Designers

IT and telecommunications designers and consultants may use BICSI 002 in conjunction with the appropriate local telecommunications infrastructure standard (e.g., ANSI/TIA-942-B, AS/NZS 2834-1995 Computer Accommodation, CENELEC EN 50173 Series, ISO/IEC 24764) to design the telecommunications pathways, spaces, and cabling system for the data center. The telecommunications designer/consultant should work with the data center architects and engineers to develop the IT and telecommunications equipment floor plan using guidelines specified in this standard.

1.2.1.2 IT and Telecommunications Management

IT and telecommunications management may use BICSI 002 as an aid in defining initial data center design requirements based on required levels of security, reliability, and availability. IT and telecommunications should work with information protection management, the business continuity group, and end user departments to determine the required levels of security, reliability, and availability.

1.2.1.3 IT Operations Management

Working with facilities groups, IT operations managers may use BICSI 002 to guide the requirements they specify to outsource suppliers who provide computing services and server room IT operations.

1.2.1.4 Information Security

Information security personnel may use BICSI 002 as a guide in defining and implementing information protection and security and assisting in the development of standard policies and operating procedures.

1.2.2 Users Within Facilities Group

1.2.2.1 Technical Representatives Within Facilities Group Capital Projects

Facilities group technical representatives may use BICSI 002 as a guide during the project planning phase as they estimate costs, prepare preliminary design and construction schedules, and prepare requests for professional services (RFPS) for the design and construction of new or renovated IT facilities. Thus, after the method of project delivery is determined, BICSI 002 becomes a referenced document in the RFPS that the facilities group prepares and issues to architecture and engineering (A/E) and design-build (D/B) firms. These companies, in turn, bid on the design and construction of the IT facilities.

1.2.2.2 Facilities Management Representatives Within Facilities Group

Facilities operations and management may use BICSI 002 as a guide in planning the operation and maintenance of corporate IT facilities so that these facilities maintain defined levels of reliability and availability. For example, BICSI 002 provides guidance in defining training needs and maintenance schedules of critical equipment for operations and maintenance personnel.

1.2.3 Staff Outside IT and Facilities Groups

1.2.3.1 Physical Security Management

Security staff responsible for physical security management may use BICSI 002 as a guide in determining physical security and fire protection system requirements for IT facilities.

1.2.3.2 External Resources

1.2.3.2.1 Telecommunications Consulting Firms

BICSI 002 is useful to telecommunications consulting firms or design/build installation firms by providing guidance in the design and construction of IT facilities for the corporation.

1.2.3.2.2 A/E and Construction Firms

BICSI 002 is useful to A/E and construction firms to guide them in the process of design and construction of IT facilities. It provides a reference of common terminology and reliability topologies. It is not intended to be used by A/E and construction firms as their sole reference, and it is not meant to provide a step-by-step design guide for the A/E or D/B firms; however, it may be used by such persons to guide design requirements in conjunction with the data center owner, occupant, or consultant.

1.3 Categories of Criteria

Two categories of criteria are specified — mandatory and advisory:

- Mandatory criteria generally apply to protection, performance, administration and compatibility; they specify the absolute minimum acceptable requirements.
- Advisory or desirable criteria are presented when their attainment will enhance the general performance of the data center infrastructure in all its contemplated applications.

Mandatory requirements are designated by the word *shall*; advisory recommendations are designated by the words *should*, *may*, or *desirable*, which are used interchangeably in this standard. Where possible, requirements and recommendations were separated to aid in clarity.

Notes, cautions and warnings found in the text, tables, or figures are used for emphasis or for offering informative suggestions.

2 Scope

This standard provides best practices and implementation methods that complement TIA, CENELEC, ISO/IEC and other published data center standards and documents. It is primarily a design standard, with installation requirements and guidelines related to implementing a design. The standard includes other installation requirements and guidelines for data centers where appropriate.

3 Required Standards and Documents

The following standards and documents contain provisions that constitute requirements listed within this standard. Unless otherwise indicated, all standards and documents listed are the latest published version prior to the initial publication of this standard. Parties to agreement based on this standard are encouraged to investigate the possibility of applying a more recent version as applicable.

Where equivalent local codes and standards exist, requirements from these local specifications shall apply. Where reference is made to a requirement that exceeds minimum code requirements, the specification requirement shall take precedence over any apparent conflict with applicable codes.

Alliance for Telecommunication Industry Solutions (ATIS)

- ATIS 0600336, *Engineering Requirements for a Universal Telecommunications Framework*

American Society of Civil Engineers (ASCE)

- ASCE/SEI 7, *Minimum Design Loads for Buildings and Other Structures*

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)

- ANSI/ASHRAE 62.1, *Ventilation for Acceptable Indoor Air Quality*
- *Best Practices for Datacom Facility Energy Efficiency*
- *Datacom Equipment Power Trends and Cooling Applications*
- *Design Considerations for Datacom Equipment Centers*
- *Particulate and Gaseous Contamination in Datacom Environments*
- *Structural and Vibration Guidelines for Datacom Equipment Centers*
- *Thermal Guidelines for Data Processing Environments*

ASTM International

- ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*

BICSI

- ANSI/BICSI 005, *Electronic Safety and Security (ESS) System Design and Implementation Best Practices*
- ANSI/BICSI 006, *Distributed Antenna System (DAS) Design and Implementation Best Practices*
- ANSI/BICSI 007, *Information Communication Technology Design and Implementation Practices for Intelligent Buildings and Premises*
- ANSI/BICSI 008, *Wireless Local Area Network (WLAN) Systems Design and Implementation Best Practices*

Electronic Components Industry Association (ECIA)

- EIA/ECA-310-E, *Cabinets, Racks, Panels, and Associated Equipment*

European Committee for Electrotechnical Standardization (CENELEC)

- CENELEC EN 50173-1, *Information technology – Generic cabling systems – Part 1: General requirements*
- CENELEC EN 50173-5, *Information technology – Generic cabling systems – Part 5: Data centres*
- CENELEC EN 50174-2, *Information technology – Cabling installation – Installation planning and practices inside buildings*

European Telecommunications Standards Institute (ETSI)

- ETSI EN 300-019, *Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment*

International Code Council (ICC)

- *International Building Code (IBC)*
- *International Fuel Gas Code (IFGC)*
- *International Mechanical Code (IMC)*
- *International Plumbing Code (IPC)*

Institute of Electrical and Electronics Engineers (IEEE)

- IEEE 142 (The IEEE Green Book), *IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems*
- IEEE 450, *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Application*
- IEEE 484, *IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications*
- IEEE 1100 (The IEEE Emerald Book), *IEEE Recommended Practice for Powering and Grounding Electronic Equipment*
- IEEE 1106, *IEEE Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications*
- IEEE 1115, *IEEE Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications*
- IEEE 1184, *IEEE Guide for Batteries for Uninterruptible Power Supply Systems*
- IEEE 1187, *IEEE Recommend Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications*
- IEEE 1188, *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications*
- IEEE 1189, *IEEE Guide for the Selection of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications*
- IEEE 1491, *IEEE Guide for Selection and Use of Battery Monitoring Equipment in Stationary Applications*
- IEEE 1578, *IEEE Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management*

International Electrotechnical Commission (IEC)

- IEC 61280-4-1, *Fibre-optic communication subsystem test procedures - Part 4-1: Installed cable plant - Multimode attenuation measurement*
- IEC 61280-4-2, *Fibre optic communication subsystem basic test procedures - Part 4-2: Fibre optic cable plant - Single-mode fibre optic cable plant attenuation*
- IEC 61300-3-35, *Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-35: Examinations and measurements - Fibre optic connector endface visual and automated inspection*
- IEC 61935-1, *Specification for the testing of balanced and coaxial information technology cabling - Part 1: Installed balanced cabling as specified in ISO/IEC 11801 and related standards*
- IEC 62305-3, *Protection against lightning - Part 3: Physical damage to structures and life hazard*

International Organization for Standardization (ISO)

- ISO 7240, *Fire detection and alarm systems*
- ISO/IEC 11801-1, *Generic cabling for customer premises – Part 1: General requirements*
- ISO/IEC 11801-5, *Generic cabling for customer premises – Part 1: Data centres*
- ISO/IEC 11801-6, *Generic cabling for customer premises – Part 6: Distributed building services*
- ISO 14520, *Gaseous fire-extinguishing systems – Physical properties and system design*
- ISO/IEC 14763-2, *Information technology – Implementation and operation of customer premises cabling – Part 2: Planning and installation*
- ISO/IEC 14763-3, *Information technology – Implementation and operation of customer premises cabling – Part 3: Testing of optical fibre cabling*

List continues on the next page

- ISO/IEC 18598, *Information technology – Automated infrastructure management (AIM) systems – Requirements, data exchange and applications*
- ISO/IEC 24764, *Information technology – Generic cabling systems for data centres*
- ISO/IEC 30129, *Information Technology – Telecommunications bonding networks for buildings and other structures*

National Electrical Contractors Association (NECA)

- ANSI/NECA/BICSI 607, *Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings*

National Fire Protection Association (NFPA)

- NFPA 12, *Carbon Dioxide Fire Extinguishing Systems*
- NFPA 12A, *Halon 1301 Fire Extinguishing Systems*
- NFPA 13, *Standard for the Installation of Sprinkler Systems*
- NFPA 20, *Installation of Stationary Pumps for Fire Protection*
- NFPA 70®, *National Electrical Code® (NEC®)*
- NFPA 70E, *Standard for Electrical Safety in the Workplace*
- NFPA 72®, *National Fire Alarm and Signaling Code*
- NFPA 75, *Standard for the Protection of Information Technology Equipment*
- NFPA 76, *Recommended Practice for the Fire Protection of Telecommunications Facilities*
- NFPA 1600, *Standard on Disaster/Emergency Management Business Continuity Programs*
- NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*
- *NFPA Fire Protection Handbook*

Telcordia

- Telcordia GR-63-CORE, *NEBS Requirements: Physical Protection*
- Telcordia GR-139, *Generic Requirements for Central Office Coaxial Cable*
- Telcordia GR-3028-CORE, *Thermal Management in Telecommunications Central Offices*

Telecommunications Industry Association (TIA)

- ANSI/TIA-568.0-D, *Generic Telecommunications Cabling for Customer Premises*
- ANSI/TIA-568.2-D, *Balanced Twisted-Pair Telecommunications Cabling and Components Standard*
- ANSI/TIA-568.3-D, *Optical Fiber Cabling Components Standard*
- ANSI/TIA-569-D, *Telecommunications Pathways and Spaces*
- ANSI/TIA-606-C, *Administration Standard for Telecommunications Infrastructure*
- ANSI/TIA-607-C, *Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises*
- ANSI/TIA-862-B, *Structured Cabling Infrastructure Standard for Intelligent Building Systems*
- ANSI/TIA-942-B, *Telecommunications Infrastructure Standard for Data Centers*
- ANSI/TIA-1152-A, *Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling*
- TIA TSB-155-A, *Guidelines for the Assessment and Mitigation of Installed Category 6 Cabling to Support 10GBASE-T*

Underwriters Laboratories (UL)

- ANSI/UL 497, *Standard for Safety Protectors for Paired-Conductor Communications Circuits*
- UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*
- UL 1449, *Surge Protective Devices*
- UL 60950-1, *Information Technology Equipment - Safety - Part 1: General Requirements*

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4 Definitions, Acronyms, Abbreviations, and Units of Measurement

4.1 Definitions

For the purposes of this document, the following terms and definitions apply. Some terms and definitions may also be represented by an acronym as listed in Section 4.2.

A-C-rated fire-retardant plywood	Plywood treated with a fire-retardant that has a well-finished A grade side that typically faces outward and a less finished C grade side that typically faces the wall.
abandoned cable	Installed cables that are not terminated at both ends at a connector or other equipment and not identified 'For Future Use' with a tag.
access block	A single access switch or group of switches sharing one trunk/uplink or set of redundant uplinks to the distribution layer. Generally confined to one telecommunications room (TR). In a large TR, it is possible to have more than one access block.
access floor	A system consisting of completely removable and interchangeable floor panels (tiles) that are supported on adjustable pedestals or stringers (or both) to allow access to the area beneath the floor (also known as raised floor).
access layer	The point at which local end users are allowed into the network. In a LAN environment, this connection point is typically a switched Ethernet port that is assigned to a VLAN.
access provider	The operator of any facility that is used to convey telecommunications signals to and from a customer premises.
adapter	A device that converts attributes of one device or system to those of an otherwise incompatible device or system. The use of an adaptor may allow actions such as (a) the connection of different sizes or types of plugs (b) the rearrangement of leads or segmentation of cables with numerous conductors into smaller group (c) interconnection between cables (d) connection of systems with differing voltage, polarity or waveform.
administration	The method for labeling, identification, documentation and usage needed to implement moves, additions and changes of the telecommunications infrastructure
alarm	An electrical, electronic, or mechanical signal that serves to warn of danger or abnormal condition by means of an audible sound or visual signal.
alien crosstalk	Unwanted coupling of signals into a balanced twisted-pair in a given cable from one or more balanced twisted-pair(s) external to the given cable.
alien far-end crosstalk	The unwanted signal coupling from a disturbing pair of a 4-pair channel, permanent link, or component to a disturbed pair of another 4-pair channel, permanent link or component, measured at the far end.
alien near-end crosstalk	Unwanted signal coupling from a disturbing pair of a 4-pair channel, permanent link, or component to a disturbed pair of another 4-pair channel, permanent link, or component, measured at the near end.
asset	Anything tangible or intangible that has value.
attenuation	The decrease in magnitude of transmission signal strength between points, expressed in units of decibels (dB) from the ratio of output to input signal level. See also *insertion loss*.
attenuation to crosstalk	Crosstalk measured at the opposite end from which the disturbing signal is transmitted normalized by the attenuation contribution of the cable or cabling.

automatic transfer switch See *transfer switch, automatic*.

availability The probability that a component or system is in a condition to perform its intended function, which is calculated as the ratio of the total time a system or component is functional within a specified time interval divided by the length of the specified time interval.

backboard A panel (e.g., wood or metal) used for mounting connecting hardware and equipment.

backbone (1) A facility (e.g., pathway, cable, conductors) between any of the following spaces: telecommunications rooms (TRs), common TRs, floor-serving terminals, entrance facilities, equipment rooms, and common equipment rooms. (2) In a data center, a facility (e.g., pathway, cable, conductors) between any of the following spaces entrance rooms or spaces, main distribution areas, horizontal distribution areas, and TRs.

backbone bonding conductor A telecommunication bonding connection which interconnects telecommunications bonding backbones.

NOTE: Formerly known as the grounding equalizer (GE)

backbone cable See *backbone*.

battery backup unit An energy storage device connected to an AC to DC power supply unit (PSU) or power shelf that serves as an uninterruptible power supply (UPS). Battery backup units are typically used within open rack configurations.

blanking panel (or filler panel) (1) A panel that may be plastic or finished metal and is not integral to any discrete electronic component or system. (2) A barrier installed in information technology equipment cabinets, racks, or enclosures for maximizing segregation for optimized cooling effectiveness.

bonding The permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed.

bonding conductor (jumper) A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected.

bonding network A set of interconnected conductive elements that provide functional equipotential bonding for telecommunications equipment

building commissioning In the broadest sense, a process for achieving, verifying, and documenting that the performance of a building and its various systems meet design intent and the owner and occupants' operational needs. The process ideally extends through all phases of a project, from concept to occupancy and operations.

building systems The architectural, mechanical, electrical, and control system along with their respective subsystems, equipment, and components.

built-in-place A traditional construction method that may be employed for the data center space or supporting infrastructure. It can be extrapolated to also indicate hand-configured cabinets, networks and information technology equipment and systems. It is synonymous with the phrase stick built.

bundled cable An assembly consisting of two or more cables, of the same or different types of cable media, continuously bound together to form a single unit. Bundled cable may be created by the original cable manufacturer, a third-party facility, or during installation. See also *hybrid cable.*

bus topology (1) Networking topology where each communications device or network has a single connection to a shared medium that serves as the communications channel. Also called a point-to-multipoint topology. (2) A linear configuration where all network devices are connected using a single length of cable. It requires one backbone cable to which all network devices are connected.

cabinet A container with a hinged cover that may enclose telecommunications connection devices, terminations, apparatus, wiring, and equipment.

cable (1) An assembly of one or more insulated conductors or optical fibers within an enveloping sheath. (2) An assembly of one or more cable units of the same type and category in an overall sheath. It may include overall screen. (3) The act of installing cable.

cable management Physical structures attached to, within, or between cabinets and racks to provide horizontal and vertical pathways for guiding and managing cabling infrastructure.

cable plant Cable, raceways, vaults, junction/pull boxes, racks, equipment, patch bays/blocks, and other infrastructure required to provide physical, electrical, optical connectivity between buildings of the owner or between buildings on the owner's property.

cable sheath A covering over the optical fiber or conductor assembly that may include one or more metallic members, strength members, or jackets.

cable tray A support mechanism used to route and support telecommunications and other cable. Cable trays may be equipped with side walls or barriers to constrain a cable's horizontal placement or movement.

cable tray system A cable tray unit or assembly of cable tray units or sections and associated fittings forming a rigid structural system used to securely fasten or support cables and raceway.

cabling A combination of all cables, jumpers, cords, and connecting hardware.

campus (1) The buildings and grounds having legal contiguous interconnection (e.g., college, university, industrial park, military installation). (2) A premise containing one or more buildings.

central office A building that functions as a network or telecommunication service provider's switching center. A central office typical serves a defined geographical area and utilizes outside plant cabling infrastructure to connect the central office to one or more customers. A central office may also be termed a *telco exchange* or *public exchange.*

centralized cabling A cabling configuration from the work area to a centralized cross-connect using pull through cables and an interconnect or splice in the telecommunications room.

change of state A change from the normal operating stance of a system, whether required by maintenance or a failure, resulting from an automatic or a manual response to some form of system input or response.

channel The end-to-end transmission path between two points at which application-specific equipment is connected.

Class An abbreviation of Data Center Facility Availability Class—the characteristic uptime performance of one component of the critical IT infrastructure. A quantitative measure of the total uptime needed in a facility without regard to the level of quality required in the IT functions carried on during that uptime. As used in this standard, it applies to scheduled uptime. Class is expressed in terms of one of five Data Center Facility Availability Classes. This classification reflects the interaction between the level of criticality and the availability of operation time.

clean agent An electrically nonconductive, volatile, or gaseous fire extinguishant that does not leave a residue upon evaporation.

clean agent fire suppression	A fire extinguishing system using a total flooding clean agent.
clear zone	An area separating an outdoor barrier from buildings or any form of natural or fabricated concealment.
client	(1) An internal or external customer. (2) A hardware or software entity, as in “client/server.”
closed transition	A change of state or transfer where the electrical circuit connection is maintained during the transfer. This is also known as “make before break”.
colocation	A data center, managed by a vendor, that provides one or more services (e.g., space, power, network connectivity, cooling, physical security) for the server, storage, and networking equipment of one or more customers. A colocation data center is often called a colo.
command center	A location where network and IT systems are managed and monitored. A command center is commonly referred to as a network operations center (NOC).
commissioning authority	The qualified person, company, or agency that plans, coordinates, and oversees the entire commissioning process. The Commissioning Authority may also be known as the commissioning agent.
commissioning plan	The document prepared for each project that describes all aspects of the commissioning process, including schedules, responsibilities, documentation requirements, and functional performance test requirements.
commissioning test plan	The document that details the prefunctional performance test, functional performance test, and the necessary information for carrying out the testing process for each system, piece of equipment, or energy efficiency measure.
common bonding network	The principal means for effecting bonding and grounding inside a telecommunication building. It is the set of metallic components that are intentionally or incidentally interconnected to form the principal bonding network (BN) in a building. These components include structural steel or reinforcing rods, plumbing, alternating current (AC) power conduit, AC equipment grounding conductors (ACEGs), cable racks, and bonding conductors. The CBN always has a mesh topology and is connected to the grounding electrode system.
common equipment room (telecommunications)	An enclosed space used for equipment and backbone interconnections for more than one tenant in a building or campus.
common grounding electrode	(1) An electrode in or at a building structure that is used to ground an AC system as well as equipment and conductor enclosures. (2) A single electrode connected to separate services, feeders, or branch circuits supplying a building. (3) Two or more grounding electrodes that are bonded together.
compartmentalization	The segregation of components, programs, and information. This provides isolation and protection from compromise, contamination, or unauthorized access.
component redundancy	A configuration designed into a system to increase the likelihood of continuous function despite the failure of a component. Component redundancy is achieved by designing and deploying a secondary component so that it replaces an associated primary component when the primary component fails.
computer room	An architectural space with the primary function of accommodating information technology equipment (ITE).
concurrently maintainable and operable	A configuration where system components may be removed from service for maintenance or may fail in a manner transparent to the load. There will be some form of state change, and redundancy will be lost while a component or system is out of commission. This is a prime requirement for a Class 3 facility.

conduit	(1) A raceway of circular cross section. (2) A structure containing one or more ducts.
connecting hardware	A device providing mechanical cable terminations.
connectivity	Patch panels, cabling, connectors, and cable management used to create and maintain electrical and optical circuits.
consolidation point	A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.
construction manager	An organization or individual assigned to manage the construction team and various contractors to build and test the building systems for the project.
containerized	An information technology equipment (ITE) or infrastructure solution offered in a cargo shipping container, typically 12 m long by 2.4 m wide by 2.4 m high (40 ft by 8 ft by 8 ft). A container solution may offer combined electrical, mechanical and data center space as part of the solution or may offer space for a singular service (e.g., electrical or mechanical solutions).
cord	A length of cable with connectors on one or both ends used to join equipment with cabling infrastructure (i.e., patch panel or cross-connect), a component of cabling infrastructure to another component of cabling infrastructure, or active equipment directly to active equipment.
core layer	The high-speed switching backbone of the network. Its primary purpose is to allow the distribution layer access to critical enterprise computing resources by switching packets as fast as possible.
countermeasures	The procedures, technologies, devices or organisms (e.g., dogs, humans) put into place to deter, delay or detect damage from a threat.
critical distribution board	A power distribution board that feeds critical loads.
criticality	The relative importance of a function or process as measured by the consequences of its failure or inability to function.
cross-connect	A facility enabling the termination of cable elements and their interconnection or cross-connection.
cross-connection	A connection scheme between cabling runs, subsystems, and equipment using patch cords or jumpers that attach to connecting hardware on each end.
dark fiber	Unused installed optical fiber cable. When optical fiber cable is carrying a light signal, it is referred to as lit fiber.
data center	A building or portion of a building with the primary function to house a computer room and its support areas.
data center infrastructure efficiency	Typically expressed as *DCiE*, data center infrastructure efficiency is a metric for an entire data center, calculated as the reciprocal of power usage effectiveness (PUE), where 1/PUE = IT equipment power/Total facility power x 100%.
delay skew	The difference in propagation delay between the pair with the highest and the pair with the lowest propagation delay value within the same cable sheath.
demarc	See *demarcation point.*
demarcation point	A point where the operational control or ownership changes, typically between the service provider and the customer.
design document	The record that details the design intent.
design intent	Design intent is a detailed technical description of the ideas, concepts, and criteria defined by the building owner to be important.

designation strips A type of label designated for insertion into a termination frame, comprised of paper or plastic strips, which are usually contained in a clear or color-tinted plastic carrier. Designation strips are usually imprinted with the adjacent terminal number and are used to aid in locating a specific pair, group of pairs, or information outlet or for delineating a termination field.

detection, (fire protection) The means of detecting the occurrence of heat, smoke or other particles or products of combustion.

distribution layer Collection of switches between the core and access layer. Distribution switches may be a switch and external router combination or a multilayer switch.

domain A portion of the naming hierarchy tree that refers to general groupings of networks based on organization type or geography.

double ended A power distribution switchboard with two power source inputs with an interposing tiebreaker between the sources where either input source of the switchboard can supply 100% of the load. The double-ended system constitutes an N + 1 or 2N system. This type of system may be used for dual utility systems or a single utility system split into redundant feeds and may possess the circuit breaker transfer system with the generator.

earthing See *grounding.*

electromagnetic interference Radiated or conducted electromagnetic energy that has an undesirable effect on electronic equipment or signal transmissions.

emergency systems Those systems legally required and classed as emergency by municipal, state, federal, or other codes or by any governmental agency having jurisdiction. These systems are intended to automatically supply illumination, power, or both to designated areas and equipment in the event of failure of the normal supply or in the event of accident to elements of a system intended to supply, distribute, and control power and illumination essential for safety to human life.

energy efficiency measure Any equipment, system, or control strategy installed in a building for the purpose of reducing energy consumption and enhancing building performance.

entrance conduit Conduit that connects the outside underground infrastructure with the building's entrance room.

entrance facility (telecommunications) (1) An entrance to a building for both public and private network service cables (including wireless), including the entrance point of the building and continuing to the entrance room or space. (2) A facility that provides all necessary mechanical and electrical services for the entry of telecommunications cables into a building and that complies with all relevant regulations.

entrance point (telecommunications) The point of emergence for telecommunications cabling through an exterior wall, a floor, or from a conduit.

entrance room or space (telecommunications) A space in which the joining of inter or intra building telecommunications backbone facilities takes place. Examples include computer rooms and server rooms.

equipment cord See *cord*.

equipment distribution area The computer room space occupied by equipment cabinets or racks.

equipment grounding conductor The conductive path installed to connect normally non-current carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor or both.

equipment room (telecommunications) An environmentally controlled centralized space for telecommunications and data processing equipment with supporting communications connectivity infrastructure.

equipotential bonding	Properly designed and installed electrical connections(s) putting various exposed conductive parts and extraneous conductive parts at a substantially equal potential, especially during normal (non-transient) conditions.
event	Typically, a message generated by a device for informational or error purposes.
failure mode	A system state resulting from an unanticipated system outage and typically an automatic system response to that failure.
Faraday cage	A metallic enclosure that is designed to prevent the entry or escape of electromagnetic fields. An ideal Faraday cage consists of an unbroken perfectly conducting shell. This ideal cannot be achieved in practice but it can be approached.
fault tolerant	The attribute of a concurrently maintainable and operable system or facility where redundancy is not lost during failure or maintenance mode of operation.
fiber management	Hardware designed and manufactured for keeping optical fiber patch cords neat and orderly. Most termination frame manufacturers provide optical fiber management components designed to work in conjunction with their termination frames. Fiber management may also refer to other types of hardware for securing optical fiber cable to the building.
fiber optic	See *optical fiber.*
fire	The presence of a flame.
fire detection	The means of detecting the occurrence of heat, smoke or other particles or products of combustion.
fire protection	The active means of detecting and suppressing fires.
fire suppression	The means of extinguishing an active fire.
flexibility	A design's ability to anticipate future changes in space, communications, power density, or heat rejection and to respond to these changes without affecting the mission of the critical IT functions.
frame	A special purpose equipment mounting structure (e.g., IDC blocks, fiber termination hardware not meant to be mounted in standard 19 inch or 23-inch racks).
functional performance test	The full range of checks and tests carried out to determine whether all components, subsystems, systems, and interfaces between systems function in accordance with the design documents.
ground	A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth or to some conducting body that serves in place of earth.
ground fault circuit interrupter	A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the established value.
grounding	The act of creating a ground.
grounding conductor	A conductor used to connect the grounding electrode to the building's main grounding busbar.
grounding electrode	A conducting object through which a direct connection to earth is established.
grounding electrode conductor	The conductor used to connect the grounding electrode to the equipment grounding conductor or to the grounded conductor of the circuit at the service equipment or at the source of a separately derived system.
grounding electrode system	One or more grounding electrodes that are connected together.
hanging load	The weight that can be suspended from the underside of the floor or structure above.
hardening	Protection from physical forces, security breaches, and natural disasters.

heat (fire protection)	The existence of temperatures significantly above normal ambient temperatures.
high resistance/impedance grounding system	A type of impedance grounded neutral system in which a grounding impedance, usually a resistor, limits the ground-fault current.
higher Class	Within this standard, a higher Class data center is a data center that meets the requirements of either Class 3 or Class 4.
horizontal cabling	(1) The cabling between and including the telecommunications outlet/connector and the horizontal cross-connect. (2) The cabling between and including the building automation system outlet or the first mechanical termination of the horizontal connection point and the horizontal cross-connect. (3) Within a data center, horizontal cabling is the cabling from the horizontal cross-connect (in the main distribution area or horizontal distribution area) to the outlet in the equipment distribution area or zone distribution area.
horizontal cross-connect	A cross-connect of horizontal cabling to other cabling (e.g., horizontal, backbone, equipment).
horizontal distribution area	A space in a computer room where a horizontal cross-connect is located and may include LAN switches, SAN switches, and keyboard/video/mouse (KVM) switches for the equipment located in the equipment distribution areas.
hot spot	A temperature reading taken at the air intake point of equipment mounted in a cabinet or rack in excess of the design standard or equipment requirement.
human events	Man-made incidents, including economic, general strike, terrorism (e.g., ecological, cyber, nuclear, biological, chemical), sabotage, hostage situation, civil unrest, enemy attack, arson, mass hysteria, accidental and special events.
hybrid cable	A manufactured assembly of two or more cables of the same or differing types of media, categories designation, covered by one overall sheath. See also *bundled cable.*
identifier	An unique item of information that links a specific element of the telecommunications infrastructure with its corresponding record.
impact of downtime	One of three characteristics used to determine the performance requirements and associated redundancy of the critical systems within a data center. The impact of downtime characteristic integrates the multiple effects that a disruption in computer processing services has on an organization's ability to achieve its objectives. See also *operational level* and *operational availability*.
incipient	The early or beginning stage of a fire where combustion particulates may be emitted from materials developing inherently high heat, but no smoke is visible and are low in density and below the level of detection capabilities of conventional smoke detectors.
inductive/reactance-grounded power system	A method of grounding in which the system is grounded through impedance, the principle element of which is inductive reactance.
information technology equipment	Electronic equipment used for the creation, processing, storage, organization, manipulation and retrieval of electronic data.
information technology equipment power	The power consumed by ITE to manage, monitor, control, process, store, or route data within the data center, excluding all infrastructure equipment.
infrastructure (telecommunications)	A collection of those telecommunications components, excluding equipment, that together provides the basic support for the distribution of all information within a building or campus.
input source transfer	The function of and the location in the electrical system where the transfer occurs between two sources.

insertion loss	The signal loss resulting from the insertion of a component or link between a transmitter and receiver. Insertion loss is often referred to as attenuation.
inside plant	Communication systems inside a building (e.g., wire, optical fiber, coaxial cable, equipment racks, and information outlets). Telecommunications companies refer to this as inside wire or intrafacility cabling.
interconnection	(1) A connection scheme that employs connecting hardware for the direct connection of a cable to another cable without a patch cord or jumper. (2) A type of connection in which single port equipment connections (e.g., 4-pair and optical fiber connectors) attach to horizontal or backbone cabling by means of patch cords or jumpers.
intermediate cross-connect	A cross-connect between first level and second level backbone cabling. Also referred to as the horizontal cross-connect (HC).
intersystem bonding conductor	A conductor used to connect grounding systems for diverse (e.g., electrical, telecommunications) or multiple electrical services to a common building grounding electrode system (e.g., building ground [electrode] ring).
isolated bonding network	Typically expressed as IBN, an isolated bonding network is a bonding and grounding subsystem in which all associated equipment cabinets, frames, racks, cable trays, pathways and supplementary bonding grids designated to be within that IBN are bonded together at a single point of connection (SPC). The SPC is also bonded to either the common bonding network (CBN) or another IBN. All IBNs have a connection to ground through the SPC.
isolation	A design strategy that mitigates the risk of concurrent damage to some components in a facility using physical, logical, or system separation.
jumper	(1) An assembly of twisted pairs without connectors used to join telecommunications circuits/links at the cross-connect. (2) A length of optical fiber cable with a connector plug on each end. (3) A length of twisted-pair or coaxial cable with connectors attached to each end, also called a patch cord.
label	A piece of paper or other material that is fastened to something and gives predefined information about it. Describes its identity, path, location, or other important information about the product or material.
ladder rack	A cable tray with side stringers and cross members, resembling a ladder, which may support cable either horizontally or vertically.
layering	In security, the use of many layers of barriers, other countermeasures, or a mixture of both used to provide the maximum level of deterrence and delay to intruders.
link	A transmission path between two points, not including equipment and cords.
linkage	A connection between a record and an identifier or between records in a database.
Listed	Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction (AHJ), maintaining periodic inspection of production of listed equipment or materials or periodic evaluation of services and whose listing states either the equipment, material, or services meets appropriate standards or has been tested and found suitable for use in a specified manner
load bank	A device to simulate actual equipment consisting of groups of resistive and reactive elements, fans, and controls. The load bank is an electrical load that is connected to power distribution unit (PDU) systems, uninterruptible power supply (UPS) systems or generators in load test situations.

local distribution point A connection point within the zone distribution cabling subsystem between a zone distributor and an equipment outlet as described in CENELEC EN 50173-5 and ISO/IEC 24764. An LDP is equivalent to the consolidation point (CP) in a zone distribution area (ZDA) as described ANSI/TIA-942-B.

luminaire An electric light and its components; an electrical lighting fixture.

M13 multiplexer Consolidates T-1 and E-1 signals into a T-3 or E-3 circuit. A cost-effective device for combining independent T-1s, E-1s, or a combination of the two over the same T-3 or E-3 circuit.

main cross-connect A cross-connect for first level backbone cables, entrance cables, and equipment cords.

main distribution area The space in a computer room where the main cross-connect is located.

main distributor A distributor used to make connections between the main distribution cabling subsystem, network access cabling subsystem, cabling subsystems and active equipment. Equivalent to the main cross-connect.

main electrical grounding busbar The busbar within the building at which electrical service grounding electrode conductor(s) and other grounding and bonding conductors are interconnected to establish the main equipotential location for the building.

maintenance mode A system state resulting from an anticipated system outage or routine maintenance activity and typically a manual system response to that activity.

management information base Within the simple network management protocol (SNMP), defines objects and attributes to be managed.

manual transfer switch See *transfer switch, non-automatic.*

mechanical room An enclosed space, which serves the needs of mechanical building systems.

media (telecommunications) Wire, cable, or conductors used for telecommunications.

medium voltage Any electrical voltage above the normal utilized value and below transmission-level system voltages. The utilization voltage varies from country to country. In the United States, medium voltage is considered to be between 1001 V and 35,000 V, whereas in the European Union and other parts of the world, the utilization voltage level can be significantly higher than in the United States.

meet me room A place within a colocation data center where telecommunications service providers can physically connect to each other and where customers in the data center can connect to the telecommunications service providers. The meet me rooms may be the same or different rooms as the telecommunications entrance rooms.

mesh bonding network A non-insolated bonding network to which all associated equipment cabinets, frames racks, cable trays, and pathways are connected by using a bonding grid. This grid is connected at multiple points to the common bonding network.

mission critical Any operation, activity, process, equipment, or facility that is essential to continuous operation for reasons of business continuity, personnel safety, security, or emergency management.

modular As applied to a data center, a factory-built or pre-fabricated data center space, infrastructure or combination of data center space and infrastructure that is constructed away from the actual data center site and is delivered as a complete solution. A modular data center may utilize or require some final site assembly or fabrication.

modular jack The receptacle ("female") element of a telecommunications connector that may be keyed or unkeyed, typically has six or eight contact positions, of which not all the positions need to be equipped with contacts.

NOTE: The element inserted into a modular jack is named a modular plug.

module The incremental development size of a storage or computer node, electrical or mechanical system, or data center area.

multimode optical fiber An optical fiber that carries many paths (modes) of light.

natural barrier Any object of nature that impedes or prevents access, including mountains, bodies of water, deserts, and swamps.

natural events Natural disasters, including drought, fire, avalanche, snow/ice/hail, tsunami, windstorm/tropical storm, hurricane/typhoon/cyclone, biological, extreme heat/cold, flood/wind-driven water, earthquake/land shift, volcanic eruption, tornado, landslide/mudslide, dust/sand storm, and lightning storm.

near-end crosstalk (1) The unwanted signal coupling between pairs. It is measured at the end of a cable nearest the point of transmission. (Contrast with far-end crosstalk, which is measured at the end farthest from point of transmission). (2) The signal transfer between circuits at the same (near) end of the cable.

network operation center See *command center*.

normal mode The steady-state system configuration while under load.

open rack A rack that has the following characteristics: 1) two busbars in the rear of the rack that supply power to mounted equipment, 2) a width that allows the mounting of 528 mm (21 inch) wide equipment, 3) a larger vertical spacing of 48 mm (1.89 in) for equipment, termed an open rack unit or OU, and 4) cable connections are accessed from the front of the rack.

NOTE: Open racks typically do not conform to the specifications of EIA/ECA-310-E.

open transition A change of state or transfer where the electrical circuit connection is not maintained during the transfer. This is also known as "break before make".

operational availability One of three characteristics used to determine the performance requirements and associated redundancy of the critical systems within a data center. The operational availability integrates the multiple effects of an organization's expected uptime of the computer processing systems during normal operations. See also *operational level* and *impact of downtime*.

operational level One of three characteristics used to determine the performance requirements and associated redundancy of the critical systems within a data center. The operational level integrates the multiple effects of an organization's ability, or inability, to suspend all computer processing operations for planned maintenance. See also *impact of downtime* and *operational availability*.

optical fiber Any filament made of dielectric materials that guides light.

optical fiber cable An assembly consisting of one or more optical fibers.

outside plant Communications system outside of the buildings (typically underground conduit and vaults, exterior/underground, aerial, and buried rated wire and cable).

panelboard (electrical) A single panel, or groups of panel units, designed for assembly in the form of a single panel, including buses and automatic overcurrent devices such as fuses or molded-case circuit breakers, accessible only from the front.

passive damper An unpowered device that is utilized in structures to mitigate the effects of vibration due to seismic or wind loading.

patch cord See *cord*.

patch panel A connecting hardware system that facilitates cable termination and cabling administration using patch cords.

pathway A facility for the placement of telecommunications cable.

performance test A series of tests for specified equipment or systems, which determines that the systems are installed correctly, started and are prepared for the functional performance tests. Often these tests are in a checklist format.

performance verification The process of determining the ability of the system to function according to the design intent.

permanent link (1) The permanently installed portion of horizontal cabling, excluding cords (e.g., test, equipment, patch). (2) A test configuration for a link excluding test cords and patch cords.

plenum A compartment or chamber that forms part of the air distribution system.

power distribution unit Typically expressed as PDU, this is a floor- or rack-mounted enclosure for distributing branch circuit electrical power via cables, either overhead or under an access floor, to multiple racks or enclosures of information technology equipment (ITE). A PDU includes one or more distribution panelboards and can include a transformer, monitoring, and controls. PDUs may also be called a computer power center or a power distribution center.

power strip A device mounted onto or within an information technology equipment (ITE) rack or enclosure, supplied by a single branch circuit, and containing power receptacles into which multiple IT devices can be plugged. A power strip can include metering, controls, circuit protection, filtering, and surge suppression. A power strip is identified within IEEE 1100 as a power outlet unit or POU. A power strip may also be called a rack-mount PDU, rack power distribution unit, ITE-PDU, cabinet distribution unit, or plug strip.

power sum alien far-end crosstalk The power sum of the unwanted signal coupling from multiple disturbing pairs of one or more 4-pair channels, permanent links, or components to a disturbed pair of another 4-pair channel, permanent link, or component measured at the far end.

power sum alien near-end crosstalk The power sum of the unwanted signal coupling from multiple disturbing pairs of one or more 4-pair channels, permanent links, or components to a disturbed pair of another 4-pair channel, permanent link, or component measured at the near end.

power sum attenuation to alien crosstalk ratio at the far end The difference in dB between the power sum alien far-end crosstalk (PSAFEXT) from multiple disturbing pairs of one or more 4-pair channels, permanent links, or components and the insertion loss of a disturbed pair in another 4-pair channel, permanent link, or component.

power sum attenuation to crosstalk ratio, far-end A computation of the unwanted signal coupling from multiple transmitters at the near end into a pair measured at the far end and normalized to the received signal level.

power sum near-end crosstalk A computation of the unwanted signal coupling from multiple transmitters at the near end into a pair measured at the near end.

power usage effectiveness Typically expressed as PUE, power usage effectiveness is an efficiency metric for an entire data center calculated as the total facility power usage divided by the information technology equipment power usage. PUE is the reciprocal of data center infrastructure efficiency (DCiE).

primary bonding busbar A busbar placed in a convenient and accessible location and bonded by means of the telecommunications bonding conductor to the building service equipment (power) ground.

NOTE: Formerly known as a telecommunications main grounding busbar (PBB)

primary side	The high-voltage side of the electrical power service transformer (above 600V), the electrical power service line side of the UPS, and the electrical power service line side of the PDU transformer or the input side of the static switch.
private branch exchange	A private telecommunications switching system allowing private local voice (and other voice-related services) switching over a network.
propagation delay	The time required for a signal to travel from one end of the transmission path to the other end.
protected circuit	A communication circuit in which a second path automatically activates when the primary path fails.
psychological barrier	A device, obstacle or lack of obstacle that by its presence alone discourages unauthorized access or penetration.
pull box	A housing located in a closed raceway used to facilitate the placing of wire or cables.
quality control	One of the four major strategies for increasing reliability by ensuring that high quality is designed and implemented in the facility, thus reducing the risk of downtime because of new installation failures or premature wear.
raceway	An enclosed channel of metal or nonmetallic materials designed expressly for holding wires or cables. Raceways include, but are not limited to: rigid metal conduit, rigid nonmetallic conduit, rigid nonmetallic conduit, intermediate metal conduit, liquid tight flexible conduit, flexible metallic tubing, flexible metal conduit, electrical nonmetallic tubing, electrical metallic tubing, underfloor raceways, cellular, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways, and busways. NOTE: Cable tray is not considered a type of raceway.
rack	An open structure for mounting electrical and electronic equipment.
rack unit	The modular unit on which panel heights are based. One rack unit is 45 mm (1.75 in) and is expressed in units of U or RU
radio frequency interference	Electromagnetic interference within the frequency band for radio transmission.
raised floor	See *access floor.*
record	A collection of detailed information related to a specific element of the infrastructure.
record drawing	A plan, on paper or electronically, that graphically documents and illustrates the installed infrastructure in a building or portion thereof. Also known as an as-built drawing.
redundancy	Providing secondary components that either become instantly operational or are continuously operational so that the failure of a primary component will not result in mission failure. See also *component redundancy*.
reliability	The probability that a component or system will perform as intended over a given time period.
remote power panel	A power distribution cabinet downstream from a PDU or UPS, typically containing circuits and breakers, without a transformer, located near the load. A remote power panel may be referred to as a RPP, power distribution panel, or PDP.
report	Presentation of a collection of information from various records.
resistively grounded power system	A method of grounding in which the system is grounded through impedance, the principle element of which is resistance.

return loss A ratio, expressed in dB, of the power of the outgoing signal to the power of the reflected signal. When the termination (load) impedance does not match (equal) the value of the characteristic impedance of the transmission line, some of the signal energy is reflected back toward the source and is not delivered to the load; this signal loss contributes to the insertion loss of the transmission path and is called return loss.

return on investment The ratio of money gained or lost on an investment relative to the amount of money invested.

ring topology A physical or logical network topology in which nodes are connected in a point-to-point serial fashion in an unbroken circular configuration. Each node receives and retransmits the signal to the next node.

riser (1) Vertical sections of cable (e.g., changing from underground or direct-buried plant to aerial plant). (2) The space used for cable access between floors.

riser cable Communications cable that is used to implement backbones located on the same or different floors.

risk The likelihood that a threat agent will exploit a vulnerability, creating physical or technological damage.

risk management The process of identifying risks and developing the strategy and tactics needed to eliminate, mitigate, or manage them.

scan Within local area networks, a nonintrusive analysis technique that identifies the open ports found on each live network device and collects the associated port banners found as each port is scanned. Each port banner is compared against a table of rules to identify the network device, its operating system, and all potential vulnerabilities.

screen A thin metallic wrapping (e.g., aluminum foil) used to isolate cable pairs from interference.

screened twisted-pair cable A balanced twisted-pair cable with one or more pairs of individual unscreened balanced twisted-pairs having an overall foil screen shield and may contain a drain wire. The entire assembly is covered with an insulating sheath (cable jacket). It may also be called *foil twisted-pair cable*.

secondary side The low-voltage side of the electrical power service transformer, the load side of the UPS, the load side of the PDU transformer, or the output side of the static switch.

seismic snubber Mechanical devices, when anchored to the building structure and placed around vibration-isolated equipment, are intended to limit motion by containing the supported equipment. Snubbers are designed for use in locations subject to earthquakes, high winds, or other external forces that could displace resiliently supported equipment.

separately derived system A premise wiring system in which power is derived from a source of electric energy or equipment other than a service. Such systems have no direct electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another system.

service gallery Space adjacent to a computer room where electrical and mechanical equipment that supports the computer room may be located.

service provider The operator of any service that furnishes telecommunications content (transmissions) delivered over access provider facilities.

sheath See *cable sheath*.

shield A metallic sheath (usually copper or aluminum) applied over the insulation of a conductor or conductors for the purpose of providing means for reducing electrostatic coupling between the conductors.

shielded twisted-pair cable — Cable made up of balanced metallic conductor pairs, each pair with an individual shield. The entire structure is then covered with an overall shield or braid and an insulating sheath (cable jacket).

simplicity — The application of irreducible functionality to achieve the intended goal with the corresponding understanding that complexity introduces additional risk.

single-mode optical fiber — An optical fiber that carries only one path (mode) of light.

smoke — Visible products of combustion prior to and concurrent with a fire.

solidly grounded — Connected to ground without inserting any resistor or impedance device.

space (telecommunications) — An area whose primary function is to house the installation and termination of telecommunications equipment and cable (e.g., MDA, IDA, HDA, TR, entrance room).

splice — A joining of conductors, which is meant to be permanent.

star topology (telecommunications cabling) — A topology in which telecommunications cables are distributed from a central point.

static switch — See *transfer switch, static.*

storage area network — A high-speed network of shared storage devices. A SAN permits storage devices attached to the SAN to be used by servers attached to the SAN.

structural barrier — Defined as something that physically deters or prevents unauthorized access, movement, destruction, or removal of data center assets.

supervisory control and data acquisition system — A control system composed of programmable logic controllers (PLCs), data input to the PLCs, custom software, and electrically operated circuit breakers in the distribution gear. All these combine to form a unique system that allows automatic operation and monitoring of the electrical system through control panel workstations.

supplementary bonding grid — A set of conductors or conductive elements formed into a grid or provided as a conductive plate and becomes part of the bonding network to which it is intentionally attached.

- **surge protection device** — A protective device for limiting transient voltages by diverting or limiting surge current. It has a nonlinear voltage-current characteristic that reduces voltages exceeding the normal safe system levels by a rapid increase in conducted current.

  NOTE**:** A surge protection device may also be known as a voltage limiter, overvoltage protector, (surge) arrestor, or transient voltage surge suppressor (TVSS).

switch (device) — (1) A device designed to close, open, or both one or more electrical circuits. (2) A mechanical device capable of opening and closing rated electrical current. (3) A device for making, breaking, or changing the connections in an electric circuit. (4) An electronic device connected between two data lines that can change state between open and closed based upon a digital variable.

NOTE**:** A switch may be operated by manual, mechanical, hydraulic, thermal, barometric, or gravitational means or by electromechanical means not falling with the definition of *relay*.

switch (equipment) — A voice communications device that uses switching technology to establish and terminate calls.

switch (network) — A network access device that provides a centralized point for LAN communications, media connections, and management activities where each switch port represents a separate communications channel.

switchboard A single-panel frame or assembly of panels, typically accessed from the front, containing electrical disconnects, fuses, and circuit breakers used to isolate electrical equipment. Switchboards are typically rated 400 A to 5,000 A and are characterized by fixed, group-mounted, molded case, or insulated case circuit breakers, but they may include draw-out circuit breakers and usually require work on de-energized equipment only.

switchgear An electrical enclosure, typically having both front and rear access, containing overcurrent protective devices, such as fuses and circuit breakers, used to isolate electrical equipment. Switchgear is typically rated 800 A to 5,000 A and is characterized by segregated, insulated-case, or low-voltage power circuit breakers, usually draw-out, and frequently contains monitoring and controls as well as features to permit addition or removal of switching devices on an energized bus.

switching (1) The action of opening or closing one or more electrical circuits. (2) The action of changing state between open and closed in data circuits. (3) A networking protocol in which a station sends a message to a hub switch, which then routes the message to the specified destination station.

system redundancy A strategy for increasing reliability by providing redundancy at the system level.

targeted availability A positive expression of allowable maximum annual downtime

technological events Technological incidents, including hazardous material release, explosion/fire, transportation accident, building/structural collapse, power/utility failure, extreme air pollution, radiological accident, dam/levee failure, fuel/resource shortage, strike, business interruption, financial collapse, and communication failure.

telecommunications Any transmission, emission, and reception of information (e.g., signs, signals, writings, images, sounds) by cable, radio, optical, or other electromagnetic systems.

telecommunications bonding backbone A conductor that interconnects the primary bonding busbar (PBB) to the secondary bonding busbar (SBB).

telecommunications bonding conductor A conductor that interconnects the telecommunications bonding infrastructure to the building's service equipment (power) ground.

NOTE: Formerly known as a bonding conductor for telecommunications (BCT)

telecommunications entrance point See *entrance point (telecommunications).*

telecommunications entrance room or space See *entrance room or space (telecommunications).*

telecommunications equipment room See *equipment room (telecommunications).*

telecommunications infrastructure See *infrastructure (telecommunications).*

• **telecommunications media** See *media (telecommunications).*

telecommunications room A telecommunications space that differs from equipment rooms and entrance facilities in that this space is generally considered a floor-serving or tenant-serving (as opposed to building- or campus-serving) space that provides a connection point between backbone and horizontal cabling.

telecommunications space See *space (telecommunications).*

termination The physical connection of a conductor to connecting hardware.

test procedures The detailed, sequential steps to set the procedures and conditions necessary to test the system functionality.

threats The agents by which damage, injury, loss, or death can occur. Threats are commonly classified as originating from temperature extremes, liquids, gases, projectiles, organisms, movement, or energy anomalies. See also vulnerability.

topology The physical or logical arrangement of a system.

total facility power The power dedicated solely to the data center, including all infrastructure equipment that supports the information technology equipment (ITE) such as power delivery components, cooling and environmental control system components, computer network and storage nodes, and miscellaneous other components necessary for the operation of the data center.

transfer switch, automatic Self-acting equipment that transfers a load from one power source to an alternate power source through the use of electrically operated mechanical moving components, (e.g., switch, breaker).

NOTE: Automatic transfer switches with open transition transfer times exceeding 20 milliseconds will result in a reboot or restart cycle of any loads with electronics or controls utilizing switch-mode power supplies. Automatic transfer switches with open transition transfer times of 16 milliseconds or less will not result in a reboot or restart cycle of any loads with electronics or controls utilizing switch-mode power supplies.

transfer switch, non-automatic Equipment that enables an operator to transfer a load from one power source to an alternate power source through the use of manually operated mechanical moving components (e.g., switch or breaker).

NOTE**:** The transfer time consists of an open transition greater than 20 milliseconds, which results in a reboot or restart cycle of any loads with electronics or controls (also commonly referred to as manual transfer switch).

transfer switch, static Self-acting equipment that transfers a load from one power source to an alternate power source through the use of semiconductors devices (e.g., silicon controlled rectifiers).

NOTE**:** Because there are no mechanical moving components the transfer time is typically less than 6 milliseconds, which will not result in a reboot or restart cycle of any loads with electronics or controls that utilize switch-mode power supplies.

tree topology A LAN topology that has only one route between any two nodes on the network. The pattern of connections resembles a tree or the letter "T".

trunk cables Cables bundled together to form a single unit.

trunk cabling assemblies A type of bundled cable consisting of two or more preconnectorized cabling links of the same or different types cabling media, which may either be covered by one overall sheath or be continuously bound together to form a single unit.

trunking (1) A combination of equipment, software and protocols that allows many clients to share relatively few telecommunications channels as opposed to each channel being dedicated to an individual client. In radio systems, the channels are frequencies and repeaters. In wireline systems, the channels are copper wire pairs or fiber optic strands. Trunking greatly expands the efficiency of resource usage, making limited resources (channels) available to many more clients. (2) In networking protocols, combining (multiplexing) frames from multiple VLANs across a single physical link (trunk) by using an encapsulation protocol such as IEEE 802.1Q. The protocol modifies the frame to identify the originating VLAN before the frame is placed on the trunk. The reverse process occurs at the receiving end of the trunk.

uninterruptible power supply A system that provides a continuous supply of power to a load, utilizing stored energy when the normal source of energy is not available or is of unacceptable quality. A UPS will provide power until the stored energy of the system has been depleted or an alternative or the normal source of power of acceptable quality becomes available.

uninterruptible power supply, rotary	A UPS consisting of a prime mover (such as an electric motor), a rotating power source (such as an alternator), a stored energy source (such as a battery), associated controls and protective devices, and a means of replenishing the stored energy (such as a rectifier/charger).
uninterruptible power supply, static	A UPS consisting of nonmoving (solid state) components, usually consisting of a rectifier component, an inverter component, a stored energy component, associated controls and protective devices.
unshielded twisted-pair	A balanced transmission medium consisting of a pair of electrical conductors twisted to provide a level of immunity to outside electrical interference without the use of metallic shielding. Typical construction has four such pairs of conductors contained with a common outer sheath.
uplink	Referring to data processing, a connection between layers (switches) in a hierarchical network. Uplinks are usually optical fiber links configured on Gigabit Ethernet (GbE) ports. (Fast Ethernet uplinks can also be configured using optical fiber or balanced twisted-pair cabling). An uplink can be referred to as a trunk.
uptime	The period of time, usually expressed as a percentage of a year, in which the information technology equipment (ITE) is operational and able to fulfill its mission.
validation	The establishment of documented evidence that will provide a high degree of assurance the system will consistently perform according to the design intent.
verification	The implementation and review of the tests performed to determine if the systems and the interface between systems operates according to the design intent.
virtual local area network	A networking protocol that allows the overlay of logical topologies onto a separate physical topology. VLANs provide traffic separation and logical network partitioning. A VLAN forms a broadcast domain and, to communicate between VLANs, a routing function is required.
vulnerability	A physical, procedural, or technical weakness that creates an opportunity for injury, death, or loss of an asset. See also threats.
wire	An individual solid or stranded metallic conductor.
wire management	See *cable management.*
wireless	The use of radiated electromagnetic energy (e.g., radio frequency and microwave signals, light) traveling through free space to convey information.
X-O bond	The point in the electrical system where a separately derived ground is generated. This point generates a power carrying neutral conductor or 4th wire for the electrical power system. The X-O bond point is typically used as the ground reference for the downstream power system.
XaaS	A generic representation of services provided by external vendors and data centers. Examples of usages include Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS).
zero U space	A space for mounting accessories in cabinets that does not consume any rack mount spaces, typically between the side panel and the sides of equipment mounted in the rack unit mounting space.
zone distribution area	A space in a computer room where a zone outlet or a consolidation point is located.
zone distributor	Distributor used to make connections between the main distribution cabling subsystem, zone distribution cabling subsystem, network access cabling subsystem, and cabling subsystems specified in ISO/IEC 11801-5 or EN 50173-1 and active equipment (CENELEC EN 50173-5 and ISO/IEC 24764). Equivalent to the horizontal cross-connect (HC) in ANSI/TIA-942-B.

zone outlet A connecting device in the zone distribution area terminating the horizontal cable enabling equipment cord connections to the equipment distribution area.

4.2 Acronyms and Abbreviations

Abbreviations and acronyms, other than in common usage, are defined as follows:

24/7	twenty-four hours a day, seven days a week
A/E	architectural/engineering
AC	alternating current
ACEG	alternating current equipment grounding conductor
ACRF	attenuation to crosstalk ratio, far-end
ACS	access control system
ADA	Americans with Disability Act
AFEXT	alien far-end crosstalk
AHJ	authority having jurisdiction
AHU	air handling unit
AISS	automated information storage system
ANEXT	alien near-end crosstalk
APC	angle physical connector; angle polished connector
ASTS	automatic static transfer switch
ATM	asynchronous transfer mode
ATS	automatic transfer switch
AWG	American wire gauge
BAS	building automation system
BBU	battery backup unit
BMS	building management system
BN	bonding network
BNC	Bayonet Neill-Concelman
CATV	community antenna television
CBN	common bonding network
CBRNE	chemical, biological, radiological, nuclear, or explosive
CD	construction document
CFD	computational fluid dynamics
CM	construction management
CO	central office
CP	consolidation point; critical power
CPE	customer premises equipment
CPU	central processing unit
CPVC	chlorinated polyvinyl chloride
CRAC	computer room air conditioner; computer room air conditioning
CRAH	computer room air handler; computer room air handling
DC	direct current
DCEG	direct current equipment grounding conductor
DCiE	data center infrastructure efficiency
DCIM	data center infrastructure management
DP	data processing; distribution panel
DS-1	digital signal level 1
DS-3	digital signal level 3
DSX	digital signal cross-connect
DWDM	dense wave division multiplexer
E-1	European trunk level 1
E-3	European trunk level 3
EAC	electronic access control
EAP	electronic asset program
EDA	equipment distribution area
EGC	equipment grounding conductor
EGS	equipment grounding system
EMD	equilibrium mode distribution
EMI	electromagnetic interference
EMS	energy management system
EO	equipment outlet
EPMS	electrical power management system
EPO	emergency power off
ESCON	enterprise system connection
ESD	electrostatic discharge
ESS	electronic safety and security
EU	European Union
F/UTP	foil screened unshielded twisted-pair
FDDI	fiber distributed data interface
FE	Fast Ethernet
FICON	fiber connection
GbE	Gigabit Ethernet
GEC	grounding electrode conductor
GES	grounding electrode system
GFCI	ground fault circuit interrupter
GUI	graphical user interface
HC	horizontal cross-connect
HCP	horizontal connection point
HDA	horizontal distribution area
HEPA	high-efficiency particulate air

HMI	human machine interface
HR	human resources
HVAC	heating, ventilating, and air conditioning
IBN	isolated bonding network
IC	intermediate cross-connect
IDC	insulation displacement contact
IIM	intelligent infrastructure management
ISDN	integrated services digital network
ISP	inside plant
IT	information technology
ITE	information technology equipment
KVM	keyboard/video/mouse
LAN	local area network
LDP	local distribution point
LED	light-emitting diode
LPS	lightning protection system
LSZH	low smoke zero halogen
MC	main cross-connect
MD	main distributor
MDA	main distribution area
MDF	main distribution frame
MEGB	main electrical grounding busbar
MERV	minimum efficiency reporting value
mesh-BN	mesh-bonding network
MIB	management information base
MMR	meet me room
MPLS	multiprotocol label switching
MTBF	mean time between failures
MTTR	mean time to repair
NC	noise criterion
NEBS	network equipment building system
NEC®	*National Electrical Code®*
NEXT	near-end crosstalk
Ni-Cd	nickel-cadmium
NRTL	nationally recognized testing laboratory
O&M	operation and maintenance
OC	optical carrier
OCP	Open Compute Project

NOTE: OCP is a registered trademark of the Open Compute Project Foundation and is used with permission.

OLTS	optical loss test set
OSP	outside plant
OTDR	optical time domain reflectometer
PBB	primary bonding busbar
PBX	private branch exchange
PC	personal computer
PD	propagation delay
PDU	power distribution unit
PLC	programmable logic controller
PM	preventive maintenance
PoE	power over Ethernet
POU	power outlet unit
PPE	personnel protection equipment
PQM	power quality monitoring
PSAACRF	power sum attenuation to alien crosstalk ratio at the far end
PSACRF	power sum attenuation to crosstalk ratio, far-end
PSAFEXT	power sum alien far-end crosstalk
PSANEXT	power sum alien near-end crosstalk
PSNEXT	power sum near-end crosstalk
PSU	power supply unit
PUE	power usage effectiveness
PVC	polyvinyl chloride
QoS	quality of service
RAID	redundant array of independent (or inexpensive) disks
RC	room cooling
RCI	rack cooling index
RF	radio frequency
RFI	radio frequency interference
RFP	request for proposal
RH	relative humidity
RJ48X	registered jack with individual 8-position modular jacks with loopback
ROI	return on investment
RPP	remote power panel
RU	rack unit
SAN	storage area network
SBB	secondary bonding busbar
SBG	supplementary bonding grid
SC	supplemental cooling
SCADA	supervisory control and data acquisition
SCSI	small computer system interface
ScTP	screened twisted-pair
SD	schematic design
SDH	synchronous digital hierarchy
SNMP	simple network management protocol
SONET	synchronous optical network
SPC	single point of connection
SPD	surge protection device

SPG	single point ground
STM	synchronous transport module
STP	shielded twisted-pair
STS	static transfer switch
T-1	trunk level 1
T-3	trunk level 3
TBB	telecommunications bonding backbone
TBC	telecommunications bonding conductor
TLE	telecommunications load equipment
TR	telecommunications room
TVSS	transient voltage surge suppression
UPS	uninterruptible power supply
UTP	unshielded twisted-pair
VAV	variable air volume
VBIED	vehicle borne improvised explosive device
VCSEL	vertical cavity surface emitting laser
VFD	voltage and frequency dependent, variable frequency drive
VFI	voltage/frequency independent
VI	voltage independent
VLA	vented lead-acid
VLAN	virtual local area network
VoIP	voice over Internet protocol
VPN	virtual private network
VRLA	valve-regulated lead-acid
VSS	video surveillance system
WAN	wide area network
ZD	zone distributor
ZDA	zone distribution area

4.3 Units of Measurement

The units of measurement used in this standard are metric. Approximate conversions from metric to U.S. customary units are provided in parentheses; e.g., 100 millimeters (4 inches).

Units of measurement used in this standard are defined below:

°C	degree Celsius
°F	degree Fahrenheit
µm	micrometer
A	ampere
BTU	British thermal unit
dB	decibel
CFM	cubic foot per minute
fc	foot-candle
ft	foot, feet
ft^2	square foot
ft/min	foot per minute
ft^3/min	cubic foot per minute
ft/s	foot per second
Gbps	gigabit per second
GHz	gigahertz
gpd	gallons (U.S.) per day
gpm	gallons (U.S.) per minute
Hz	hertz
in	inch
in WC	inches of water column
K	kelvin
kb/s	kilobit per second
kg	kilogram
kg/m^2	kilogram per square meter
kHz	kilohertz
km	kilometer
kN	kilonewton
kPa	kilopascal
kVA	kilovolt-ampere
kW	kilowatt
lb	pound
lbf	pound-force
lbf/ft^2	pound force per square foot
lbf/in^2	pound force per square inch
lx	lux
m	meter
m/s	meter per second
m^2	square meter
m^3/min	cubic meter per minute
MCM	thousand circular mils
MHz	megahertz
MHz•km	megahertz kilometer
mm	millimeter
MPa	megapascal
mph	mile per hour
MW	megawatt
N	newton
nm	nanometer
OU	open rack unit

NOTE: 1 OU is equivalent to 48 mm (1.89 in).

Pa	pascal
psi	pound per square inch
RU	rack unit
V	volt
VA	volt-ampere
V_{AC}	volt alternating current
V_{DC}	volt direct current
W	watt
W/ft^2	watt per square foot
W/m^2	watt per square meter

5 Site Selection

5.1 Introduction

This section outlines the considerations that should be reviewed and provides recommendations when selecting a location for a data center, whether the location is for a "green field" site that involves the construction of a new data center, reviewing the location of an existing building that will function as a data center, or the ranking of data centers when considering closure or consolidation.

NOTE: When evaluating the suitability of existing buildings and data centers, additional areas (e.g., building structure and architecture, mechanical and electrical systems) should be considered and can be found in other sections of this standard.

The guidance and examples provided are applicable in a wide range of jurisdictions and locations; however, when determining the suitability of a specific site, it is recommended that all applicable local and region guidelines and codes are also reviewed prior to final selection.

In the case that a redundant or disaster recovery data center site selection process is in place, it is important to minimize the likelihood that both the main data center and the redundant data center are affected by the occurrence of the same event.

5.2 Site Evaluation

5.2.1 General Requirements

The suitability of a site shall be determined by a site survey and evaluation and a risk analysis.

5.2.2 General Recommendations

When comparing alternative sites, the feasibility and cost of measures to mitigate the risks identified should be considered as part of the site selection process. An existing site survey should only be referred to if the documents are not older than 6 months. An existing risk analysis for a specific site should only be referred to if it was conducted for a similar objective.

A risk assessment should include the following hazards to be evaluated:

- Natural hazards (e.g., geological, meteorological, and biological)
- Human-caused events (e.g., accidental and intentional)
- Technologically caused events (e.g., accidental and intentional)

NOTE: NFPA 1600, ISO 22301, and ISO 31000 contain additional information on risk analysis and business continuity planning.

5.2.3 Risk Assessment

Risk can form from one or more factors or potential events, and when not identified and planned for, can lead to relatively minor to major impacts of equipment, systems, personnel and operations. Performing a data center risk assessment provides value as it allows the identification, estimation, and communication of the different risk events and their severity that are present at the data center.

Risk can be defined as the product of the probability of occurrence of an event and its impact. Evaluating the impact of an event requires considering the event's ability to disrupt an organization's entire IT operations or a smaller subset of IT operations, and the potential duration of the disruption.

A systematic analysis and evaluation of threats and vulnerabilities is recommended to understand the risk involved. Organizations and stakeholders may be tolerant to different risk levels for a variety of reasons, such as the impact on the facility, the probability of occurrence of the threat, and the perception of a specific threat, risk attitudes and tolerances.

Multiple international standards and guidelines (e.g., ISO/IEC 27001, ISO/IEC 27002, ISO/IEC 27005, ISO/IEC 31000, and NIST SP 800-30) can be used to support the risk management process.

5.2.4 Cost Evaluation Recommendations

The site selection process should include a detailed analysis of all the costs associated with any particular location. Costs that should be considered when comparing available sites are listed below:

- One-time costs that may be significant such that any one may drive the site selection process are:
  - Real estate costs.
  - Local tax incentives.
  - Environmental assessment consulting costs.

    This could include an environmental impact study if wetland or other environmentally sensitive areas are impacted or if the site has any contaminants present. Some sites may require a significant effort to develop the assessment and attend required meetings with the AHJ.
  - Cost to bring adequate utilities infrastructure (e.g., power, water, sewer, gas, telecommunications) to the site in order to support the critical load, both initial and future anticipated growth.
  - Cost to provide redundant utilities (e.g., power, water, gas, telecommunications) to the site as required.

    Determine the additional costs associated with redundant site utilities and any impact that the implementation may have on the schedule. Costs for diverse underground service from an alternate access provider office may be quite high.
  - Demolition costs for any existing structures; site preparation costs.
- Cost and availability of permanent telecommunications service and temporary telecommunications services to support the migration of data from existing data center(s).
- Costs associated with the temporary circuits for movement of data, including:
  - Consider temporary telecommunications circuits that may be needed to support the migration of data from the existing data center(s) to the new data center.
  - Cost of relocation of systems into the new data center:

    Develop a high-level move strategy so that appropriate funds can be allocated for the move of systems and networks into the new data center. Identify any needs for consultants, temporary labor, media, network, server, and storage hardware to support the move and their associated costs.
  - Impact of data center constructability:

    Determine if there are any conditions at a particular site that will affect the constructability of the new data center. A particular site may require a longer approval, permitting, or construction schedule. An extended schedule may affect feasibility because of decommissioning requirements of the existing data center.
- Recurring costs that will have long-term effects on the feasibility of the proposed site:
  - Usage costs for utility services (power, water, sewer, gas)
  - Cost of telecommunications services
  - Prevailing wage for skilled labor in local area
  - Lease costs
  - Taxes
- Intangible costs:
  - Proximity to other corporate facilities (travel time)
  - Proximity of skilled staff

5.2.5 Existing Facilities Requirements

If the data center is moving into an existing building, determine if the building is up to current code and industry standards. It may actually be less desirable to move into a building with an existing electrical and mechanical plant as it may be unsuitable for use in the data center. The existing systems may need to be removed and replaced at considerable expense. See Appendix A for additional items which may need to be assessed.

5.3 Natural Hazards

5.3.1 Introduction

While many things can be determined to be a "natural hazard", this section covers specifically those natural events that are typically major adverse events and may be known as "natural disasters." Locations with high probability of occurrence of natural disasters or environmental threats should be avoided when selecting a site for a data center, as they may affect the structure of the building itself, power, telecommunication and water supply, roads of access to the site and public transportation, and other operational concerns.

5.3.2 General Requirements

The risk from natural hazards identified in this section shall always be evaluated and considered during the site selection process.

5.3.3 Seismic Activity

5.3.3.1 Introduction

Seismic activity (earthquakes) is typically associated with the presence of a geological fault or volcano. Earthquakes can range from a low-level vibration lasting less than a second to a catastrophic event lasting over 20 seconds, severely damaging or destroying structures in the event area.

5.3.3.2 Recommendations

Seismically active areas should be avoided whenever possible. If this is not possible, appropriate seismic equipment supports and structures shall be provided to meet or exceed the requirements of the local AHJ.

In a seismically active area, the equipment within the data center, including the ITE cabinets and racks, should be designed for the level of seismic activity that the data center is designed to resist and have corresponding structural anchorage. Additionally, the building will have higher structural requirements. If one is not already required by the AHJ, consider working with a professional structural engineer to meet the appropriate seismic criteria of the data center facility.

Refer to seismic charts and other seismic activity information for the specific proposed data center site. An example of a global seismic activity map is shown in Figure 5-1.

5.3.4 Volcanic Activity

5.3.4.1 Introduction

Many active volcanoes are located on or near a geological fault but can occur in other areas. (See Figure 5-2). However, volcanoes pose additional risk from the event of an eruption and subsequent lava flow, ash fall, lahars, or flooding.

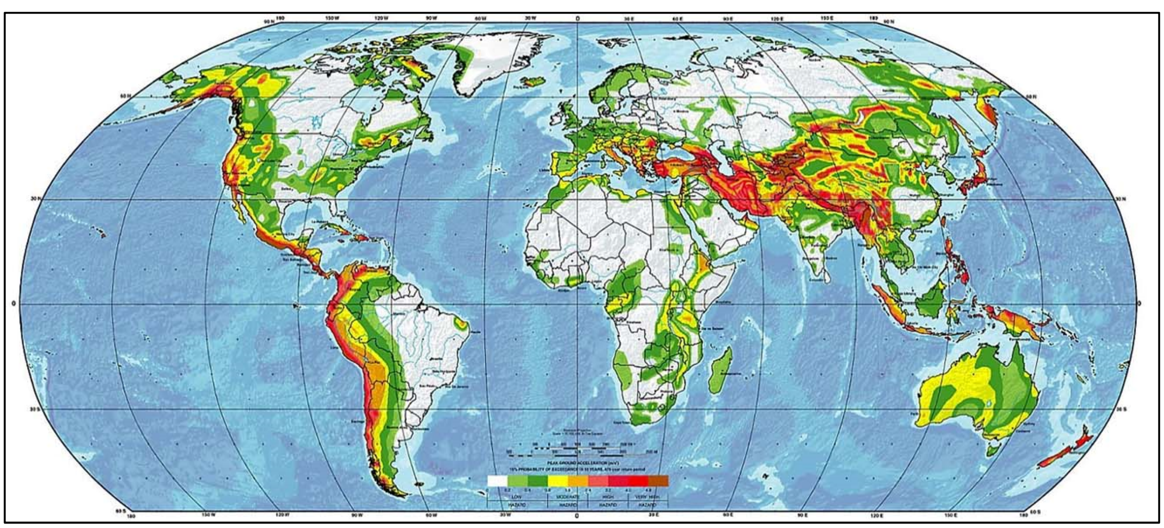

Figure 5-1
Example of a Global Seismic Hazard Map

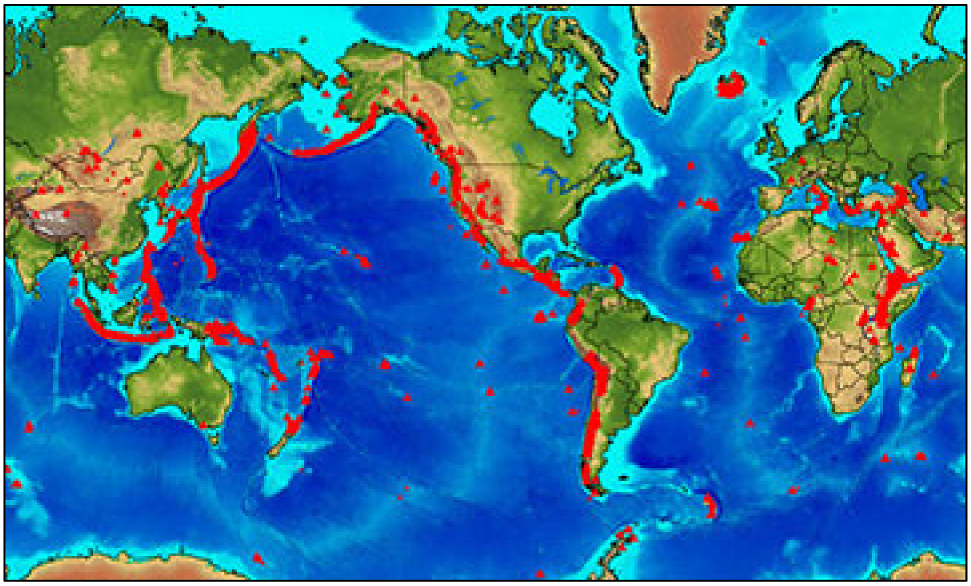

Figure 5-2
Example of a Global Volcano Hazard Map

5.3.4.2 Recommendations

Data centers should be located outside the immediate risk (buffer) area of an active volcano. The hazard zone(s) for a volcano are unique, even when two more volcanoes are in relative proximity. (See Figure 5-3 for an example). Hazard maps for each volcano in the vicinity of the data center should be obtained and evaluated.

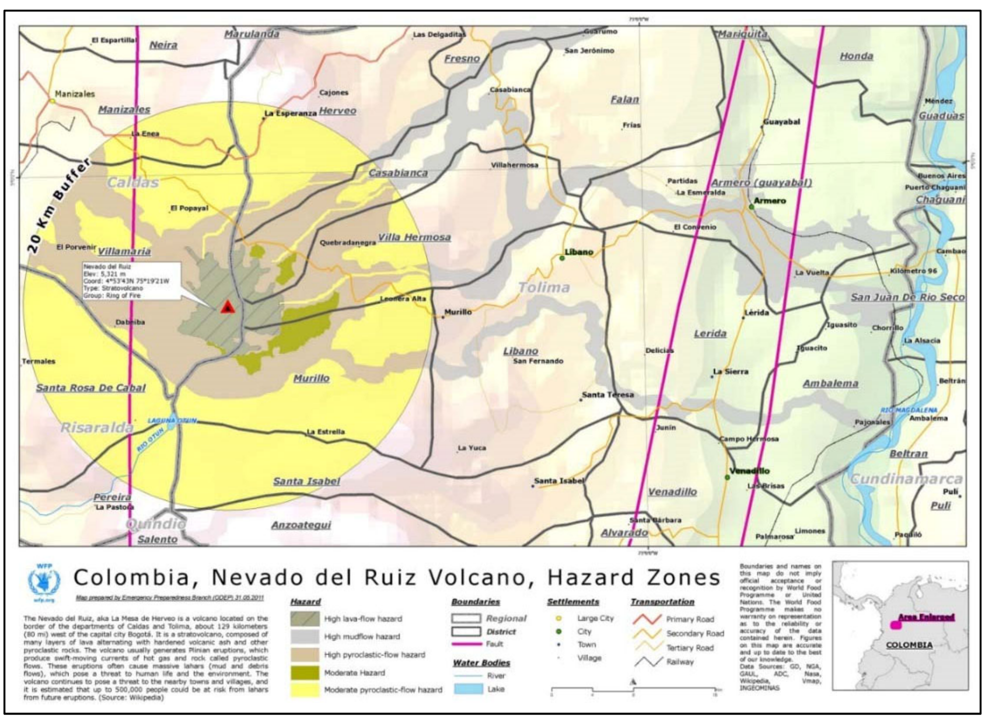

Figure 5-3
Example of a Volcano Hazard Map

5.3.5 Wildfire

5.3.5.1 Introduction

Wildfires can easily spread to 60 km^2 (15,000 acres) or larger. While a site may not be in immediate danger, large wildfires that occur 80 km (50 mi) or farther away from the site can affect an access provider's transmission infrastructure being used by the data center.

Wildfires typically occur away from urban environments. However, depending on the topography of the area and the amount of other development in the area, some sites are susceptible to operational interruption or structural damage from wildfires.

5.3.5.2 Recommendations

Data centers should not be placed on the edge of urban development or near protected natural areas. Data center sites within areas that have historical wildfire events should review all access providers' records for service disruptions because of wildfires.

If a data center is to be placed within an area with moderate to high wildfire risk, redundant access routes should be made available to provide both data center operators and fire suppression crews access to the site. Security and disaster recovery plans should detail procedures for evacuation and continued data center operation in event of required wildfire evacuation.

5.3.6 Flood Plains

5.3.6.1 Introduction

Flooding may occur in a number of areas and may occur in areas not known for significant annual rain or snowfall.

5.3.6.2 Recommendations

The site should be free of flood risk from river flood plain proximity, tidal basin proximity, dam failure, tsunami, or levee failure. The site should not be within the flood hazard and tsunami inundation area as defined in the *IBC*, be within 91 m (300 ft) of a 500-year flood hazard area, or be less than 3 m (10 ft) above the highest known flood level. The site should also have multiple access roads with elevations above the flood recommendations along their entire route.

NOTE: Some locations may warrant a site-specific flood study.

An example of available flood information is Figure 5-4, which shows global flood risk. Information is also available on a region or country basis.

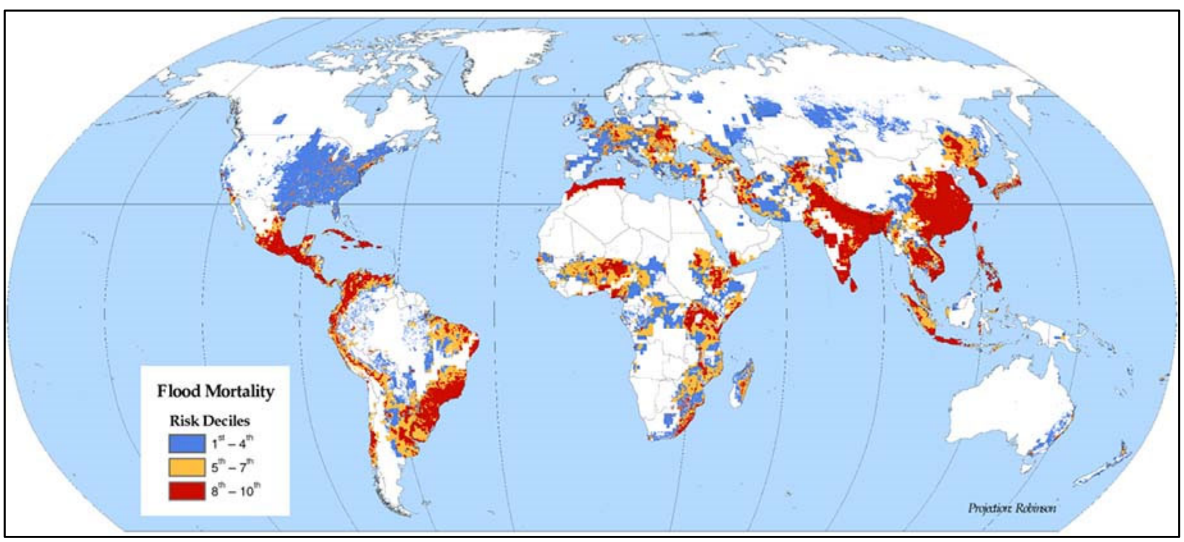

Figure 5-4
Example of a Global Flooding Hazard Chart

5.3.7 Wind

5.3.7.1 Introduction

While wind is prevalent in every area of the Earth, extreme winds because of storms (e.g., tornado, hurricane, cyclone, derechos) can affect a data center's operation.

5.3.7.2 Recommendations

The most desirable location should be an area with winds less than or equal to 53.6 m/s (120 mph) per ASCE 7. When business drivers dictate that a data center be located in an area with greater wind velocity, specific detail in the "hardening" of the facility should be incorporated into the design.

Class 2 and lower data centers should be designed to meet Risk Category I (USA) or designed to withstand at a minimum wind speeds of 4.8 m/s (10 mph) above the highest 100 year mean recurrence interval wind speed. Class 3 data centers should be designed to meet Risk Category II (USA) or designed to withstand at a minimum wind speeds of 8.9 m/s (20 mph) above the highest 100 year mean recurrence interval wind speed, and Class 4 data centers should be designed to meet Risk Category III-IV (USA) or designed to withstand at a minimum wind speeds of 13.4 m/s (30 mph) above the highest 100 year mean recurrence interval wind speed.

Refer to wind charts and other wind activity information for the specific proposed data center site. While wind/windstorm risk maps are typically specific to region or country, Figure 5-5 is an example of a global tornado risk map.

5.4 Natural Environment

5.4.1 Introduction

The natural environment has its own set of risks that while they may not cause the potential destruction of that of an earthquake or hurricane, still have the potential to cause adverse effects to a data center's construction or operation.

5.4.2 Ground Stability

5.4.2.1 Landslides

5.4.2.1.1 Introduction

Landslides occur when the stability of the slope changes from a stable to an unstable condition. A change in the stability of a slope can be caused by a number of factors. Landslides do not need a dramatic difference of elevations as a landslip can occur over a seemingly flat area because of the ground structure underneath.

5.4.2.1.2 Recommendations

For new building locations, the suitability of the site should be verified by current documents, recent geological records, or by appropriate analytical measures.

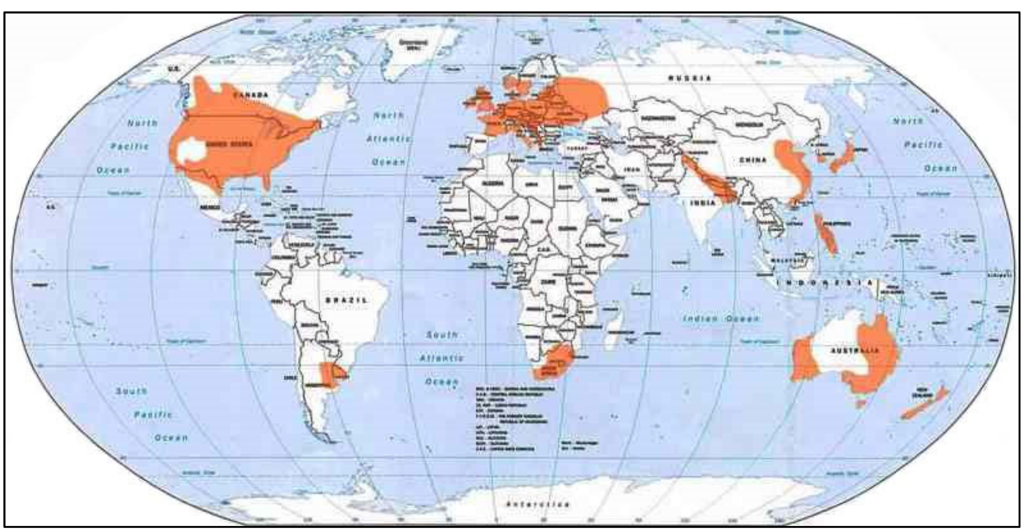

Figure 5-5
Example of a Global Tornado Risk Area Map

5.4.2.2 Soil Stability

5.4.2.2.1 Introduction

While the most dramatic effect of insufficient ground stability is the formation of sinkholes, even minimal instability can cause a building to not uniformly "settle", leading to structure issues and damage.

5.4.2.2.2 Requirements

The ground shall be suitable to support the loads of the facility. The suitability of the site shall be verified by current documents or by appropriate analytical measures.

5.4.2.2.3 Recommendations

The following criteria should be used in determining a site's suitability:

- Avoid the potential for quick, unstable, or expansive soils.
- Ensure that there is no known subsurface contamination from either on-site hazardous waste storage or other adjacent site.
- Ensure that there is no potential of underlying solution-formed cavities common in limestone formations or the source of potential sinkhole problems.

Consider working with a professional geotechnical engineer to meet the appropriate criteria of the data center and to provide a formal written geotechnical report.

5.4.3 Lightning

5.4.3.1 Recommendations

Sites with a flash rate of 10 or less are preferred.

The type and duration of service provider failures should be researched for potential site locations with a flash rate greater than 1 and integrated into the overall site selection and design criteria.

5.4.3.2 Additional Information

Areas with a flash rate of 0.6 or less are typically seen as "lightning free". However, lightning may occur at almost any point on the globe, and a single lightning flash has the potential to cause a downtime event.

Examples of lightning flash data can be found in Figure 5-6.

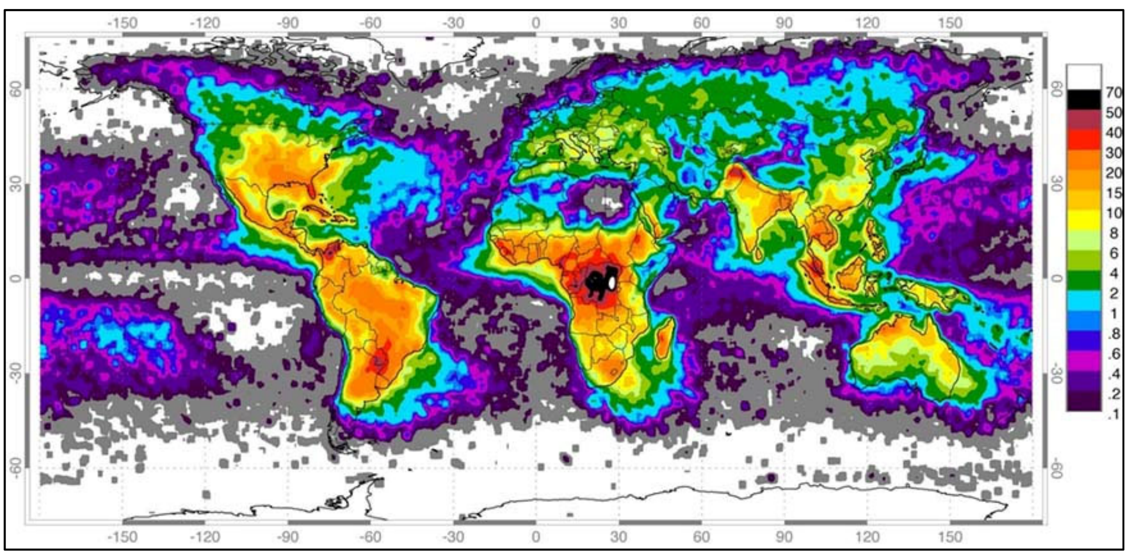

Figure 5-6
Example of a Lightning Flash Data Map

5.4.4 Groundwater

5.4.4.1 Introduction

Groundwater is water located beneath the earth's surface in soil pore spaces and in the fractures of rock formations. The depth at which soil pore spaces or fractures and voids in rock become completely saturated with water is called the water table. Groundwater is recharged from, and eventually flows to, the surface naturally; natural discharge often occurs at springs and seeps and can form oases or wetlands.

5.4.4.2 Recommendations

The site should have a water table that is as low as possible; it should be below the utility ducts and below the lowest level of the building at a minimum.

If the data center is a "slab on grade", then placing it at the top of a hill or in a relatively flat topographical area should minimize ground water issues.

If the building has one or more subgrade floors or is located at the bottom of a hill, additional efforts may be required to protect the data center from seepage or the effects of seasonal variances in the water table. If the data center is located at the bottom of a hill, there should be great concern for ground water issues.

Refer to ground water charts and other ground water activity information, such as shown in Figure 5-7, for the specific data center site.

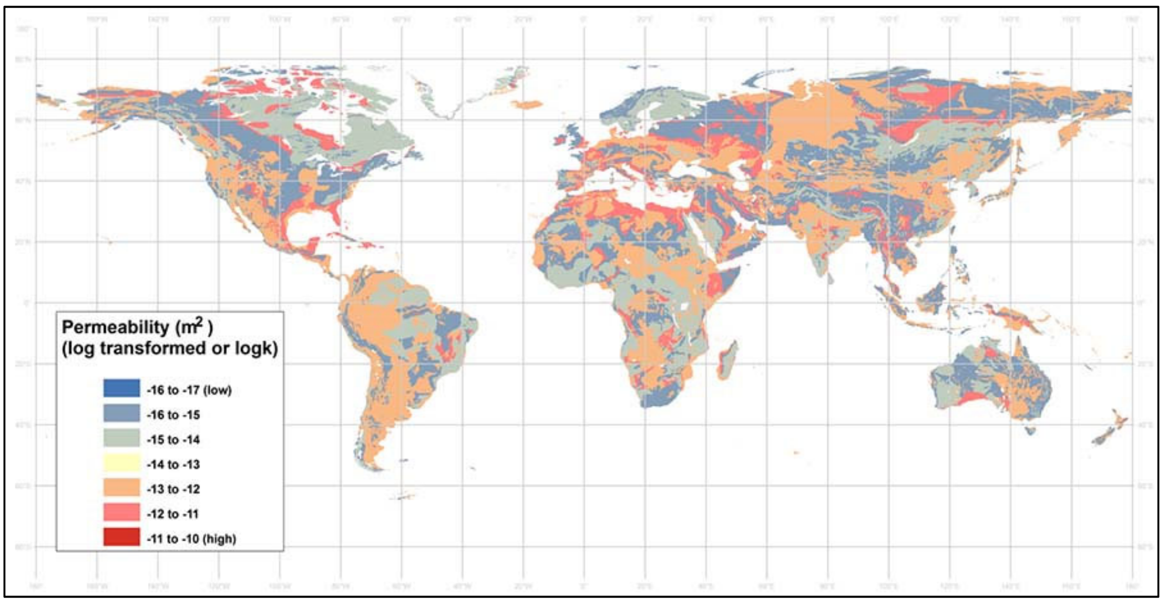

Figure 5-7
Example of a Ground Permeability Chart

5.4.5 Air Quality

5.4.5.1 Intake Recommendations

Air quality issues (e.g., ashes, sand) should be considered for the data center's fresh air intake and for external mechanical components like cooling towers and heat exchangers, as well as anything that may be emitted from the site. Fresh air intake requirements are usually regulated by the local AHJ. Provide appropriate air intake filtration systems as required.

When data centers must be located in densely populated areas or metropolitan areas, consider the effects of noise and emissions from the data center exhausts on neighbors and surroundings. Although usually regulated, it is common to have restaurants, dry cleaners, and other similar businesses requiring venting of chemicals and contaminants into the immediate environment. Special air intake filtration systems may be required for the data center in addition to any regulations.

5.4.5.2 Emission Recommendations

An area with clean air quality is preferred so that emission of gases and particles does not cause a new air quality problem or worsen an existing problem.

In areas with existing air quality problems, regulations may be very stringent regarding emissions produced from fossil fuel consumption.

Ensure that generator run time permitting documents are issued in a timely manner to the jurisdiction overseeing air quality control and other local environmental authorities. In most cases, annual operation hours will be restricted, and compliance must be verified.

If the owner wants to consider cogeneration of electricity, there may be stricter air quality requirements and special permits required.

5.4.6 Noise

5.4.6.1 Introduction

Wind will carry sound long distances. Even the slightest breeze can carry the sound of a facility well beyond the property line.

5.4.6.2 Recommendations

It is recommended to verify acceptable noise levels at the property line and determine the noise levels produced by equipment.

Critical silencers on generator exhausts and sound attenuated enclosures on outdoor equipment, such as generators and cooling towers, should be always considered.

Outdoor equipment located on the ground and on rooftops may require screening for architectural aesthetics or building codes. Consider incorporating sound barriers within the architectural screening.

5.4.7 Other Topography and Natural Environment Recommendations

Avoid sites with larger than a 15% ground slope if possible; otherwise, this may limit the developable area. Sites with steep slopes may be difficult to access in adverse weather conditions.

The site topographical features should not restrict the line of sight to geosynchronous satellites and location of ground dish arrays if required. Line of sight issues may also affect the location of wireless access equipment such as microwave, infrared, and directional antennas.

Sites with wetlands and protected habitat should be avoided because construction in these areas can be delayed, have higher costs, and may create unwanted public awareness of the facility.

A maximum elevation of 3050 m (10,000 ft) is recommended as the effectiveness of air-cooling systems degrades significantly at higher elevations where air density is lower. Generator radiator cooling systems are severely limited at higher altitude (above 450 m/1500 ft), affecting both operating times for prime, standby, or continuous duty engines in addition to the derating of the kW output to maintain a generator system's prime, standby, or continuous rating.

5.5 Man-Made Hazards

5.5.1 Introduction

Man-made hazards from accidents and incidents typically have a greater impact on a data center's operational availability than natural events.

5.5.2 Recommended Separation Distances

The following distances shown in Table 5-1 should be observed when selecting a data center.

NOTE: Each element on the list has its own risk factors and rating dependent on the specific site.

5.5.3 Other Recommendations

Locations that are adjacent to or accessed via routes that could be subject to protest or blockade because of their antisocial nature should be avoided.

When placing a data center in close proximity to a railroad, measurement of vibration and EMI at the site should be conducted over the period of several days to aid in the assessment and mitigation requirements, if any, required at the site.

Risk of terrorist attack can be a significant reason for avoiding a location close to an underground train station. Additionally, underground train traffic can create vibration and provide EMI within a building located directly above the train tunnel.

Table 5-1 Recommended Distances from Man-Made Elements

Man-Made Element	*Minimum Distance*
Airports	8 km (5 mi)
Auto body or other paint shops	1.6 km (1 mi)
Canals	3.2 km (2 mi)
Chemical plants and storage (e.g., fuel, fertilizer)	8 km (5 mi)
Conventional power plants (e.g., coal, natural gas)	8 km (5 mi)
Embassies and political group properties	5 km (3 mi)
Foundries and heavy industry operations	8 km (5 mi)
Gas stations and distributors	1.6 km (1 mi)
Grain elevators	8 km (5 mi)
Harbors and ports	3.2 km (2 mi)
Lakes, dams, and reservoirs	3.2 km (2 mi)
Landfills and waste storage facilities	3.2 km (2 mi)
Military installations and munitions storage	13 km (8 mi)
Municipal water and sewage treatment plants	3.2 km (2 mi)
Nuclear power plants	80 km (50 mi)
Overflow areas for reservoirs and man-made lakes	1.6 km (1 mi)
Quarries	3.2 km (2 mi)
Radio/television transmitters/stations	5 km (3 mi)
Railroads	1.6 km (1 mi)
Research laboratories	5 km (3 mi)
Self-storage facilities	1.6 km (1 mi)
Stockyards and livestock feedlots	3.2 km (2 mi)
Transportation corridors where hazardous material could be transported	1.6 km (1 mi)
Water storage towers	1.6 km (1 mi)
Weather or other radar installations	5 km (3 mi)

Within risk analysis, airports typically represent a low probability but high impact threat. In addition to maintaining a minimum 8 km (5 mi) radial distance from an airport, the length and location of takeoff and landing flight paths should also be considered as part of site selection and risk analysis. Figure 5-8 provides a generic example of takeoff and landing paths for an airport. However, every airport will be different, based on factors such as type of airport (e.g., civilian, commercial, military), natural terrain in the vicinity, regulation (e.g., restricted air space), and proximity to other hazards (e.g., other air traffic).

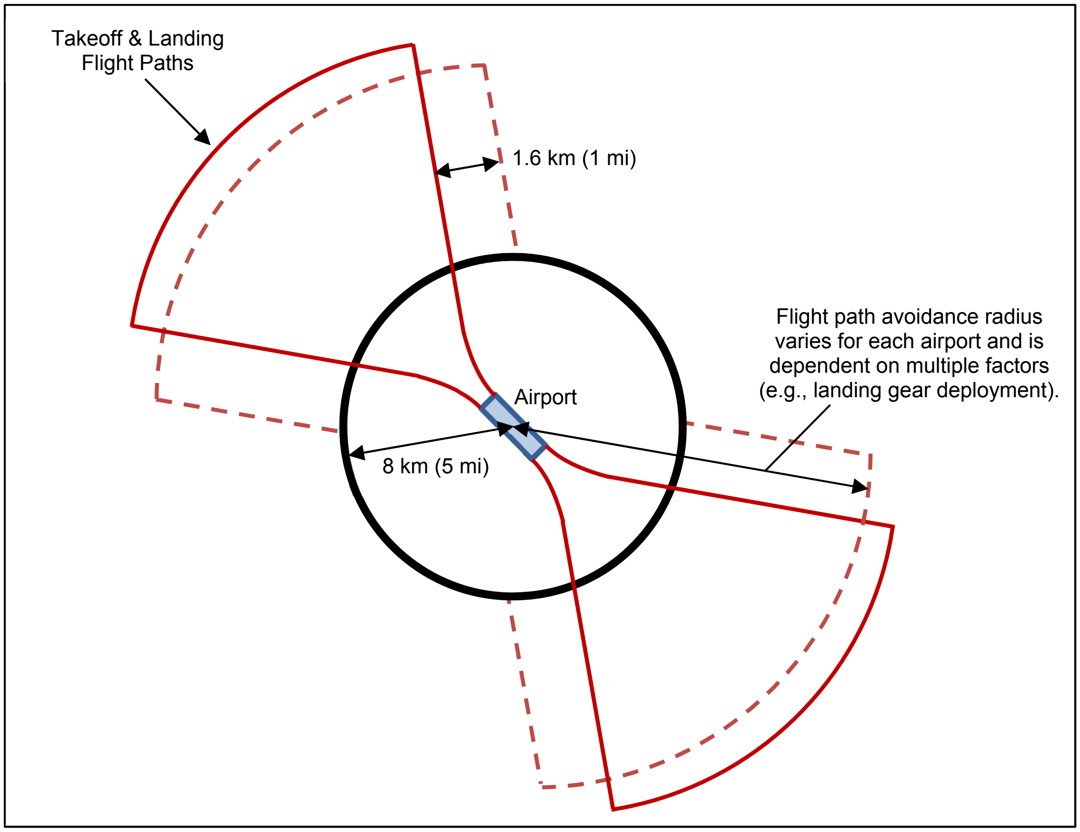

Figure 5-8
Example of Radial and Flight Path Zones for an Airport

5.6 Site Access and Location

5.6.1 Public Road Access Recommendations

The site should allow the placement of the building so that it is not close enough to the road that an adjacent road traffic accident could result in vehicular contact with the building fabric or any external component of the data center's mechanical or electrical systems and the potential for resulting structural damage or the potential for fire.

The site should allow the placement of the building so that it is not close enough to the road that an adjacent road traffic accident could result in the spillage of a toxic or flammable load coming into contact with the building fabric and resulting in structural damage or the potential for fire.

The site should be within reasonable distance—3.2 km (2 mi) to 16 km (10 mi)—to a freeway or other major arterial road. However, it is generally not desirable for the data center to be within 1.6 km (1 mi) of a freeway, railroad, or other major thoroughfare to minimize exposure to contaminants in the event of an accident.

The site should have two or more access roads from the nearest major arterial road with each road having a minimum of 4.3 m (14 ft) height clearance for vehicles throughout. Utilizing a single access road with bridges or tunnels should be avoided.

The sub-structure and surface of the access roads should be designed in a way so that in any weather condition deliveries (e.g., heavy components of the technical building systems, including mobile cranes required for unloading) can be made.

If the data center is on a campus, then the campus should have redundant access roads with either a security checkpoint at the access point to the data center facility or at each access point to the campus.

5.6.2 Adjacent Property

5.6.2.1 Recommendations

The data center should be built far from any other buildings and facilities that may pose a fire threat or that could cause damage to the data center should the other buildings or structures collapse.

A facility located adjacent to a large campus or manufacturing plant may suffer from traffic issues at certain times of the day (e.g., at the start and end of the working day; if adjacent to a 24-hour facility, this could be three times a day or more, depending on shift patterns).

5.6.2.2 Additional Information

The following is a partial list of adjacent properties that have an increased potential to affect data center operations:

- Embassy/consulate
- Military
- Police
- Fire station
- Hospital
- Chemical plant
- Political target
- Research lab
- Publishing house/foreign press

Adjacent vacant lots may cause future issues because of:

- Possible future development and disruption during construction
- Unknown tenant(s)

5.6.3 Proximity to Existing or Redundant Data Center

For disaster backup sites, consider the issue of distance from the primary data center. Distance will be determined by the use of the primary site and whether the backup site must have synchronous or asynchronous replication with the primary data center.

5.6.4 Security and Emergency Services

5.6.4.1 Requirements

Avoid high crime areas. Refer to Section 12 for additional threats and concerns to be considered.

5.6.4.2 Recommendations

Having emergency services reasonably accessible can be a valuable lifesaving resource for site occupants. Ideally, a staffed (or at least volunteer) fire station and police station should be within 8 km (5 mi) of the candidate site and a hospital emergency room within 16 km (10 mi).

Consideration should be made for level and type of perimeter security required for the site, depending on an initial risk and threat analysis. This would include building type, site location, fenestration, and neighborhood. These factors will vary based on the users need.

5.6.5 Proximity to Skilled Labor

If the site is in a rural location, skilled personnel to staff the data center may not be available locally, and skilled people may not be willing to relocate from urban locations. A location close to technical colleges and universities is desirable. The site should be close to the location of vendor technicians that perform maintenance and repair of ITE and facility equipment.

5.7 Utility Services

5.7.1 Introduction

It is of utmost importance for the data center location to have access to reliable high-power quality and high speed telecommunications services. Access to other services such as water, sewage, and other energy sources of conventional (e.g., natural gas, propane, diesel) or renewable energy (e.g., wind, solar) must also be taken into consideration.

5.7.2 Power and Electrical Service

5.7.2.1 Introduction

Figure 5-9 shows an overview of electrical transmission and distribution.

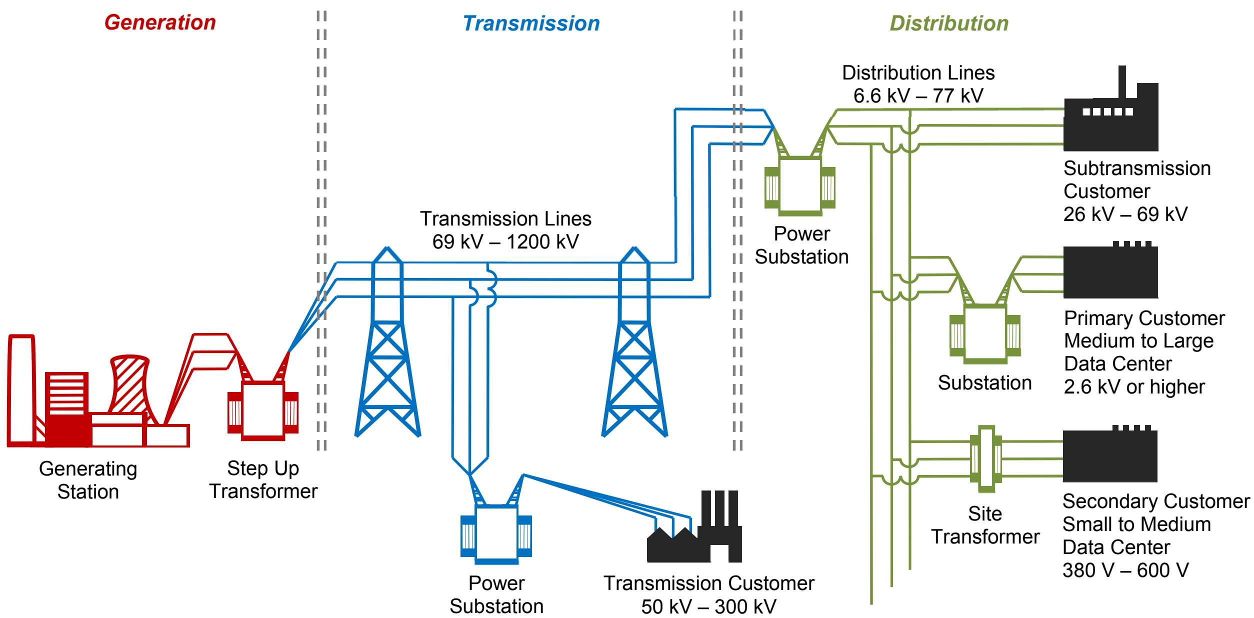

Figure 5-9
AC Electricity Distribution from Generation Stations to Data Centers

5.7.2.2 Capacity Available to Site

5.7.2.2.1 Requirements

Adequate electrical utility capacity to the site shall be provided to meet both current and projected needs of the entire site and depends on the data center Availability Class requirements (as described in Appendix B).

5.7.2.2.2 Recommendations

Consider using multiple electrical utility circuits, each with enough capacity, to handle the entire site requirements.

Circuit capacity to the site should be planned and implemented very carefully. If the data center is designed for minimal initial capacity with large future capacity requirements, careful consideration should be given to the amount of initial power requested to be delivered to the site by the utility company.

Work with a professional electrical engineer and the electrical utility or utilities serving the site. A cost benefit analysis and progressive circuit capacity design/implementation may benefit the site.

5.7.2.3 Unit Substations

5.7.2.3.1 Introduction

Unit substations are usually medium voltage switchgear that is used to parallel electrical utility circuits or to transfer between redundant electrical utility circuits feeding the data center site. Unit substations are generally located outdoors on pads within fenced areas, but in some cases, may be found inside of the data center building (e.g., data centers located in metropolitan settings).

Depending on the size, Availability Class, and location of the data center, a unit substation may be required on the site. Very large data centers typically have substations on the premises. In most cases, the unit substations are owned and maintained by the electric utility. The largest data centers may prefer to have control over the unit substations for security and availability reasons.

Unit substations generally connect to utility transformers sized to meet the building voltage and amperage requirements.

5.7.2.3.2 Recommendations

Data centers should be located in an area with easy sustainable circuit access to utility substations with preference toward an area with utility circuits provided by two or more utility substations.

When selecting a site, consider space for an electrical unit substation and its associated transformers and electrical utility circuit paths. It is preferable that these are located on the data center site in a secure and aesthetically pleasing manner.

5.7.2.4 Utility Transformers

5.7.2.4.1 Introduction

For small data centers, the utility transformer might be pole-mounted or pad-mounted outside of the facility. For most data centers, depending on the data center's size, class, and location, the utility transformer will be onsite. Utility transformers are generally located outdoors, but in some cases, may be found inside the data center building (e.g., data centers located in metropolitan settings).

The utility transformer is usually the last utility-provided device prior to the electric meter, which marks the demarcation between the electric utility and the electricity consumer. In many cases, this transformer is owned by the power consumer, in which case, it is located on the load side of the electric meter.

Utility transformers usually transform the utility's medium distribution voltage to a lower voltage for utilization by the data center. For example, for a large data center, the unit substation might transform voltage in excess of 13 kV to a voltage up to 1 kV. An on-site utility transformer might then transform the voltage to a lower voltage utilized by the building or facility. Consumption voltages vary around the world and will typically be defined by the regulatory authority in the country or region where the data center is located.

5.7.2.4.2 Recommendations

When selecting a site, consider space for one or more electrical utility transformers and their associated electrical utility circuit paths. It is preferable that these are located on the data center site in a secure and aesthetically pleasing manner.

5.7.2.5 Proven Utility Reliability (Percentage Availability)

5.7.2.5.1 Introduction

For critical data centers, there may be benefit in providing a second, independent utility service to the data center site.

5.7.2.5.2 Requirements

A second power utility connection is not required for any Class of data center.

5.7.2.5.3 Recommendations

The benefit of installing a second utility feed should be analyzed based on the mean time between failure (MTBF) rate, mean time to repair (MTTR), and the power quality of the service to the data center.

A second diverse power utility feed is only recommended when all of the following are true:

1) The operational requirements of the data center results in an Operational Level 4
2) The availability requirements of the data center results in an Availability Ranking Level 4
3) The impact of downtime of the data center results in a Catastrophic classification
4) The reliability of the utility, based on the specific MTBF rates of the utility and the required mission time of the data center, is greater than 50%.

For the electrical feed, determine if there are other customers, such as manufacturing plants, that can create electrical noise. An electrical feed that also serves a hospital is generally desirable because such feed is less prone to shutdown by a utility.

5.7.2.5.4 Additional Information

Table 5-2 shows reliabilities of a utility, given examples of MTBF, and the mission times expressed in years. In the table shown, the only scenario that achieves greater than 50% reliability is where the mission time is 5 years with a utility MTBF of 10 years. Within this scenario, the second utility with an example reliability of 50% will result in between 1/10% and 1% of an increase in the overall power systems, assuming the power systems meet a Class 4 topology. The increase in capital expenditures (CapEx) and operational expenditures (OpEx) costs for the second utility must be weighed against the value of increasing the overall reliability by 0.1% to 1%.

The power utility services in the United States average 1.86 outages annually (MTBF equals 1/1.86 = 0.5376 years). For a 2(N+1) electrical topology where the number of generators required to meet the load is N=2, the resulting overall increase in the power systems reliability with a second utility would be approximately 1/100000000% compared to a 2(N+1) backup power generation topology combined with a single power utility connection. This insignificant increase in reliability would not normally be considered worth the significant increase in CapEx and OpEx of the second utility connection.

Table 5-2 Utility Reliability Examples

		Mean Time Between Failure (MTBF) - Years				
		0.5	*1*	*2*	*5*	*10*
Mission Time (Yrs)	*5*	0.004539992976%	0.673794699909%	8.208499862390%	36.787944117144%	60.653065971263%
	10	0.000002206115%	0.004539992976%	0.673794699909%	13.533528326610%	36.787944117144%
	15	0.000000000009%	0.000030590232%	0.055308437015%	4.978706836786%	22.313016014843%
	20	0.000000000000%	0.000000206115%	0.004539992976%	1.831563888873%	13.533528326610%
	25	0.000000000000%	0.000000000139%	0.000372665310%	0.673794699909%	8.208499862390%

5.7.2.6 Utility Service

5.7.2.6.1 General Recommendations

Electrical service entrance feeds should have a minimum separation of 1.2 m (4 ft) from other utilities along the entire route. If redundant feeds are provided to the data center, it is recommended that the electrical service entrances to the facility have a minimum separation of 20 m (66 ft) from the other electrical service entrances along the entire route.

5.7.2.6.2 Overhead Utility Service Recommendations

Overhead utility service to the facility should be avoided whenever possible. Underground utility service to the facility is recommended. This will reduce the potential for system failure caused by overhead utility line damage. Vehicle accidents, wind, snow, and other weather conditions are known factors for utility line damage.

5.7.2.6.3 Underground Utility Service Recommendations

It is recommended that all electrical service entrances and feeds to the facility be underground.

5.7.2.7 On-Site Generation

5.7.2.7.1 Introduction

Backup generators are used to backup data center equipment in case of utility power failure. Emergency generators (as opposed to backup generators) are used to power data center life safety systems (e.g., emergency lighting, fire pumps) if utility power fails.

Backup generators can be as small as a compact car and as large as a full-sized truck. Some generator solutions utilize a space as large as a shipping container or larger. These may be either indoors or outdoors, and it is common to find building rooftop-mounted generators.

5.7.2.7.2 Requirements

For buildings to be occupied for extended power outages, areas of the building outside the data center must provide basic life safety and building occupancy requirements, including but not limited to, lighting, fire alarm, restrooms, elevators, security, and ventilation.

5.7.2.7.3 Recommendations

When selecting a site, consider space for one or more backup and one or more emergency generators and their associated electrical utility and life safety circuit paths. It is preferable that these are located on the data center site in a secure and aesthetically pleasing manner.

Space considerations for generators should also include the necessary fuel pumps, piping, and on-site storage required. For some data center applications, the space required can be quite extensive as operational requirements may dictate performance for a minimum of 48 hours without outside services or deliveries.

5.7.2.7.4 Microgrids

A microgrid is a combination of power generation, storage and a connection point to the primary power delivery system (grid), allowing a site to utilize the primary power system or "disconnect" and run independently. Microgrids are commonly associated with alternative power generation (e.g., thermal, wind, solar), but may also be used by end-users who have sufficient on-site power generation.

Microgrid concepts and techniques may be utilized to manage on-site back-up and emergency power generation, assist with power reliability, and used as a transition mechanism between systems because of maintenance processes, shortages/outages in the primary delivery systems, or operational and financial considerations.

Microgrids can be of any size and their presence may not be readily noticeable during a site visit.

5.7.3 Communications

5.7.3.1 Capacity Available to Site Recommendations

Adequate copper conductor and optical fiber capacity to the site should be provided to meet the current and projected needs of the entire site, and depending on the data center Class requirements, provide one or multiple connectivity paths, each with enough capacity, to handle the entire site requirements.

Connectivity capacity to the site should be planned and implemented very carefully. If the data center is designed for minimal initial capacity with large future capacity requirements, careful consideration should be given to the amount of capacity requested to be delivered to the site by the access providers.

Work with a professional IT consultant and the access providers serving the site. A cost benefit analysis and progressive connectivity capacity design/implementation may benefit the site.

5.7.3.2 Proven Access Provider Reliability (Percentage Availability) Recommendations

The reliability of the primary access provider should be determined to ensure that the required availability requirements can be achieved.

Reliability of the communication services can be improved by either adding redundant circuits from the primary access provider or adding services from alternate access providers. The reliability of the overall communications services can be further increased if the redundant circuits are serviced from separate access provider offices following diverse routes.

5.7.3.3 General Service Recommendations

If redundant telecommunications service cabling is desired or required, telecommunications service cabling pathways should maintain a minimum separation of 20 m (66 ft) along the entire route.

The following is a list of preferences (in successive order) of communication service sources:

1) At least two diversely routed telecommunications service feeds from different access provider central offices with each access provider central office connected to multiple higher-level access provider and multiple long-distance carrier offices.
2) At least two diversely routed telecommunications service feeds from different access provider central offices with both access provider central offices connected to the same higher-level access provider and long-distance carrier offices.
3) At least two diversely routed telecommunications service feeds from one access provider central office.
4) One telecommunications service feed from one access provider central office.

5.7.3.4 Underground Service to Facility

5.7.3.4.1 Requirements

Determine if the site can accommodate customer-owned maintenance holes and if elevation of maintenance holes (utility or customer owned) can cause problems with water infiltration into data center.

5.7.3.4.2 Recommendations

It is recommended that all telecommunications service cabling to the facility be underground with a minimum separation of 1.2 m (4 ft) from other utilities along the entire route.

Provide underground utility service to the facility whenever possible.

5.7.3.5 Overhead Service to Facility

5.7.3.5.1 Introduction

Overhead utility service to the facility is not desirable, especially if there is only one service entrance.

5.7.3.5.2 Requirements

If overhead utility lines to the site cannot be avoided, provide multiple source paths. Ensure that the entrance cables are well protected from physical damage at the drop pole.

5.7.3.5.3 Recommendations

If cables drop from service poles to underground, the drop pole should provide 100 mm (4 in) rigid conduits from below grade up to the elevation where the cables are suspended to protect the entrance cables from physical damage.

5.7.3.6 Proximity to Service Providers or Other Data Centers

Data centers should be located in an area with easy sustainable connectivity to the access provider central offices. Locating a data center in an area with connectivity provided by two or more access provider central offices is recommended for Class 2 and higher data centers.

Redundant data centers for disaster recovery (DR) purposes should be located with sufficient physical separation to reduce single modes of failure (natural or manmade) to within acceptable limits for the critical data. The two locations should be on separate distribution systems to minimize the occurrence of one outage affecting both locations.

5.7.4 Water Service

5.7.4.1 Introduction

The data center may need to have access to reliable significant quantities (e.g., 0.75 – 1.1 m^3/min [200-300 U.S. gallon/min]) of quality water, depending on cooling system design. However, not all areas are able to provide this quantity of quality water continuously independent of long-term weather conditions.

Data centers may require large volumes of water for other uses. Some uses of water that may be required are as follows:

- Domestic water (e.g., drinking water, restrooms, kitchens)
- Irrigation (e.g., lawn watering)
- Fire suppression (e.g., sprinkler systems)
- HVAC (e.g., cooling towers, air humidification)

5.7.4.2 Municipal Water Supply

5.7.4.2.1 Capacity Available to Site Requirements

Provide adequate municipal water delivery to the site to meet the requirements of the data center. For Class F3 or F4 data centers, the ability of the water supply pumping station(s) to deliver water when there is a major power outage must be documented or mitigated.

5.7.4.2.2 Water Quality Recommendations

Although water delivered to sites by most municipalities is generally considered to be potable (drinkable), the water should be tested for contaminants and particulates. Water filtration systems may be required for some or all of the various water uses listed above. It is common to find a water filtration system specific to the domestic water system in a building.

5.7.4.3 Non-potable Water Systems (Greywater)

5.7.4.3.1 Introduction

Non-potable (waste water that doesn't contain serious or hazardous contaminants) systems can be municipally provided or project generated and can be used to minimize a project's impact on the surrounding community and potentially reduce operating costs.

5.7.4.3.2 Requirements

Non-potable water systems shall be used according to the local AHJ.

5.7.4.3.3 Recommendations

Greywater systems should not store grey water for longer than one day to minimize the risk of microbial growth. Greywater storage tanks should be designed to drain completely upon use and have minimal to no anaerobic corners or pockets.

5.7.4.4 Private Well Supply (Well Water)

5.7.4.4.1 Capacity Available to Site

5.7.4.4.1.1 Requirements

If well water is to be utilized, make sure that there is adequate well water delivery on the site to meet the requirements of the data center. It is first necessary to determine the volume and quality of water that will be consumed for all purposes (data center cooling, building plumbing and occupant use, lawn irrigation, etc.) and how much can be recycled.

5.7.4.4.1.2 Recommendations

A hydrogeological risk assessment may be required. The assessment should be conducted by a licensed hydrology engineering firm. An environmental impact study might be required. A hydrogeological report can include information on:

- Groundwater
- Infiltration
- Soil moisture
- Surface water flow
- Precipitation and evaporation
- Uncertainty analysis
- Water quality
- Remote sensing
- Integrating measurement and modeling
- Prediction

5.7.4.4.2 Quality Recommendations

The available on-site water (well water) should be tested for contaminants and particulates. Water filtration systems may be required for some or all of the various water uses listed above. It is common to find a water filtration system specific to the domestic water system in a building.

5.7.4.4.3 Dual Water Supply (Municipal Water Supply and Well Water Supply)

Occasionally, a data center site will require both a municipal water feed to the site as well as using an on-site well. A domestic water system and fire suppression system may be connected to the municipal water source while having the HVAC and irrigation systems connected to the on-site well. An on-site well can also be used as a backup water source for HVAC water systems connected to a municipal water source.

5.7.4.5 Backup Water Supply

5.7.4.5.1 Introduction

Backup systems could be multiple water sources or onsite water storage.

5.7.4.5.2 Requirements

A backup water supply of at least 8 hours at any time shall be provided for data centers with Class F3 or F4 that use evaporative cooling towers for heat rejection.

5.7.4.5.3 Recommendations

Review need and availability of a backup water supply for the facility for domestic uses as well as water cooled cooling systems.

Backup water supply should be provided that meets the minimums listed in Table 5-3.

Table 5-3 Recommended On-Site Supply of Services for Data Center Facility Classes

Class F0	*Class F1*	*Class F2*	*Class F3*	*Class F4*
No requirement	8 hours minimum	24 hours minimum	72 hours minimum	96 hours minimum

5.7.5 Sanitary Sewer

5.7.5.1 Municipal Sanitary Waste Sewer System

5.7.5.1.1 Capacity Available to Site Requirements

Provide adequate sanitary waste capacity from the site to the municipal sanitary waste sewer system. A private sanitary waste system will be required in regions where no municipal sanitary waste sewer system is available.

Sanitary systems or storm drainage systems (depending on local requirements) need to be sized for the amount of expected water usage by cooling systems, including cooling tower blow down or filtration systems, which could be greater than 0.75 m^3/min (200 gpm).

5.7.5.1.2 Remediation Requirements

Coordinate with the local AHJ and provide all remediation as may be required by code and standards. Holding tanks, traps, and the like may be required and need to be planned into the site design.

5.7.5.1.3 Recommendations

A private sanitary waste system is recommended for critical facilities that require on-site operations personnel 24/7 to maintain uninterrupted services. This will help mitigate having to vacate the facility in the event the municipal sanitary waste sewer system fails.

5.7.5.2 Private Sanitary Waste System

5.7.5.2.1 Capacity Available to Site Requirements

Provide adequate sanitary waste capacity from the building to the on-site sanitary waste system (septic system).

5.7.5.2.2 Remediation Requirements

Coordinate with the local AHJ and provide all remediation as may be required by code and standards. Holding tanks, traps, and similar facilities may be required and need to be planned into the site design.

5.7.6 Natural Gas and Other Fuels

5.7.6.1 Introduction

Fuels (e.g., natural gas, propane, diesel) may be used to support primary or back-up systems of a data center. On-site fuel (e.g., propane, diesel) storage tanks are usually located outdoors on the ground and are sometimes buried below grade.

5.7.6.2 Requirements

If natural gas is selected to support the heating systems, cooling systems, or backup electricity generation that the site requires, provide properly sized natural gas feed from the local utilities.

Make sure that the utility company assures full capacity natural gas delivery to the site for the duration of any prolonged power outage or disaster situation.

5.7.6.3 Recommendations

Redundant gas feeds from redundant gas sources is the most desirable, although rarely available, method for natural gas delivery to a site. Natural gas in combination with diesel fuel may also be considered if dual-fuel generators are incorporated into the design. Dual-fuel generators start on diesel but can run on either diesel or natural gas. For sites with natural gas generators sized 25 kW or less, on-site storage of natural gas should be considered. The number of hours or days of reserve should be based upon a risk analysis or meet the recommendations listed in Table 5-3.

The data center site should be carefully planned to support on-site fuel storage when it is required. On-site fuel storage should be located on the data center site in a secure and aesthetically pleasing manner. Fuel should be stored as far away from the data center as practical. Blast containment (proximity to building or actual structure) should always be planned into the site.

Special containment or controls are usually required in case of fuel leaks.

Controls for fuel transfer should be in a secure location, above worst-case flood levels, and protected from other natural disasters.

5.7.6.4 Alternative Fuel Source Recommendations

Other fuel or energy sources (e.g., wind, solar) may be used to support the site. Consider their continuous availability to determine if they can be primary or secondary energy sources. If other energy sources are used, their requisite equipment and system infrastructure (wind generator, photovoltaic panels) will require additional space and may affect building and structural requirements.

Careful consideration should be given to the visual intrusion on neighbors and any effects on the surrounding environment. Zoning, codes, and other governmental/municipal restrictions may not allow for alternate fuel/energy sources.

5.8 Regulations (Local, Regional, Country)

5.8.1 Air Quality Requirements

Determine if local air quality regulations exist such as generator emission restrictions. These regulations may restrict the acceptable hours of operating backup generators.

Particular concerns that data centers may have for local authorities are the emissions of oxides of nitrogen (NOx), carbon monoxide (CO), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), ionic pollutants such as chlorides, and particulate matter (PM-10).

NOTE: The United States government enacted a law through the 1990 Clean Air Act that mandated individual states are required to only meet the minimum requirements of the Act. However, individual states were, and continue to be, permitted to enforce stricter requirements.

5.8.2 Noise Requirements

Determine if there are any local, regional, or federal regulations that identify acceptable levels of noise from equipment operating within the data center facility or campus or that cannot be exceeded at or beyond the property line.

5.8.3 Towers and Tall Structures Requirements

Determine if there are any local regulations that will restrict the height or proximity to other facilities for communication towers, water tanks, cooling towers, and other tall structures.

Determine if there are any federal or local requirements to hide these structures from public view.

5.8.4 Fuel Tanks Requirements

Determine if there are any local regulations that will require double-walled tanks or restrict the size or proximity to other facilities for fuel tanks.

Determine if there are local regulations that will allow above ground fuel tanks only.

Evaluate security of the fuel tanks.

5.8.5 Generator Requirements

Emission levels need to meet state and local emission requirements. Generator hours may be limited by local codes because of air quality emission control or noise abatement.

5.8.6 Site Access and Required Parking

Determine if there are any road restrictions (permanent or seasonal) on the size of vehicular traffic or time of day restrictions for truck traffic.

Determine how the AHJ determines the required number of parking stalls for a new facility. Negotiations with the AHJ may be necessary to try to reduce the number of required stalls if the AHJ treats the data center as typical commercial office space.

Consideration should be given to disaster recovery scenarios, which may require additional parking for the respective personnel.

5.8.7 Setbacks and Sight Lines

Determine the required setbacks from the property line for the building, parking, or perimeter security. Verify with the AHJ that the target location does not have sight line restrictions that must be mitigated or that they can be done so economically.

5.8.8 Environmental Assessment

An environmental assessment could include an environmental impact study if wetlands are impacted or if the site has any contaminants present. An environmental impact study may be required by the AHJ. Ensure sufficient time prior to proceeding with the detailed design phase to allow completing the study and attend AHJ meetings as required to obtain approval.

NOTE: The United States Environmental Protection Agency and the European Commission (i.e., Environmental Impact Assessment Directive 2011/92/EU) may provide further relevant information specific to the site or project.