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Data Center Design and Implementation Best Practices

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TABLE OF CONTENTS

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INDEX OF FIGURES

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INDEX OF TABLES

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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 Annex 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 information technology (IT)

1.2.1.1 Information technology (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, 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 Information technology (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 Information technology (IT) operations management

Working with facilities group, 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/or design-build (D/B) firms. These companies, in turn, bid on the design and/or 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 information technology (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/or 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/or 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, nor is it meant to provide a step-by-step design guide for the A&E or D/B firms, but 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 d*esirable*, 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 References

The following standards and documents are referenced within this standard and contain provisions that constitute provisions of this standard.

Alliance for Telecommunication Industry Solutions (ATIS)

- ATIS 0600336, *Engineering Requirements for a Universal Telecommunications Framework* (2003)

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

- ASHRAE 62.1, *Ventilation for Acceptable Indoor Air Quality* (2007);
- ASHRAE *Best Practices for Datacom Facility Energy Efficiency* (2009);
- ASHRAE *Datacom Equipment Power Trends and Cooling Applications* (2005);
- ASHRAE *Design Considerations for Data and Communications Equipment Centers* (2009);
- ASHRAE *Gaseous and Particulate Contamination Guidelines for Data Centers* (2009);
- ASHRAE *Structural and Vibration Guidelines for Datacom Equipment Centers* (2008);
- ASHRAE *Thermal Guidelines for Data Processing Environments* (2009);

Consumer Electronics Association (CEA)

- CEA-310-E, *Cabinets, Racks, Panels, and Associated Equipment* (2005);

European Committee for Electrotechnical Standardization (CENELEC)

- CENELEC EN 50173-1, *Information technology - Generic Cabling Systems – Part 1: General Requirements* (2007);
- CENELEC EN 50173-5, *Information technology - Generic Cabling Systems - Part 5 Data Centres* (2007);
- CENELEC EN 50174-2, *Information technology - Cabling installation - Installation planning and practices inside buildings* (2009);

European Telecommunications Standards Institute (ETSI)

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

Institute of Electrical and Electronics Engineers (IEEE)

- IEEE 142-2007 (The IEEE Green Book), *Recommended Practice for Grounding for Industrial and Commercial Buildings*;
- IEEE 450-2002, *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Application*;
- IEEE 484-2002, *IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications*;
- IEEE 493-2007 (The IEEE Gold Book), *Recommended Practice for Design of Reliable and Commercial Power Systems*;
- IEEE 1100-2005 (The IEEE Emerald Book), *Recommended Practice for Powering and Grounding Electronic Equipment*;
- IEEE 1106-2005, *IEEE Recommended Practice for Maintenance, Testing and Replacement of Nickel-Cadmium Batteries for Stationary Applications*;
- IEEE 1115-2000, *IEEE Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications*;
- IEEE 1184-2006, *IEEE Guide for the Selection and Sizing of Batteries for Uninterruptible Power Systems*;
- IEEE 1187-2002, *IEEE Recommend Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications*;
- IEEE 1188-2005, *IEEE Recommended Practice for Maintenance, Testing and Replacement of Valve Regulated Lead-Acid Batteries (VRLA) for Stationary Applications*;
- IEEE 1189-2007, *IEEE Guide for the Selection of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications*;
- IEEE 1491-2005, *IEEE Guide for Selection and Use of Battery Monitoring Equipment in Stationary Applications*;
- IEEE 1578-2007, *IEEE Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management*;

International Electrotechnical Commission (IEC)

- IEC 61280-4-1:2009(E), *Fibre-optic communication subsystem test procedures - Part 4-1: Installed cable plant - Multimode attenuation measurement*;
- IEC 61280-4-2:1999, *Fibre Optic Communication Subsystem Basic Test Procedures - Part 4-2: Fibre Optic Cable Plant - Single-Mode Fibre Optic Cable Plant Attenuation*;
- IEC 61935-1:2005, *Generic cabling systems-Communication cabling in accordance with ISO/IEC 11801-Part 1: Installed cabling*;
- IEC 62305-3: 2006, *Protection against lightning - Part 3: Physical damage to structures and life hazard*;

International Organization for Standardization (ISO)

- ISO/IEC 11801:2002, *Information technology - Generic cabling for customer premises*;
- ISO/IEC TR 14763-2:2000, *Information technology – Implementation and operation of customer premises cabling – Part 2: Planning and installation of copper cabling*;
- ISO/IEC 14763-3:2006, *Information technology—Implementation and operation of customer premises cabling-Part 3: Testing of optical fibre cabling*;
- ISO/IEC 24764:2010, *Information technology - Generic cabling systems for data centres*;

National Electrical Contractors Association (NECA)

- ANSI/NECA/BICSI 607, *Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings* (2010);

National Fire Protection Association (NFPA)

- NFPA 12, *Carbon Dioxide Fire Extinguishing Systems* (2008);
- NFPA 12A, *Halon 1301 Fire Extinguishing Systems* (2009);
- NFPA 13, *Standard for the Installation of Sprinkler Systems* (2010);
- NFPA 20, *Installation of Stationary Pumps for Fire Protection* (2010);
- NFPA 70, *The National Electrical Code®* (NEC®) (2008);
- NFPA 70E, *Standard for Electrical Safety in the Workplace* (2004);
- NFPA 72, *National Fire Alarm Code* (1999);
- NFPA 75, *Standard for the Protection of Information Technology Equipment* (2009);
- NFPA 76, *Recommended Practice for the Fire Protection of Telecommunications Facilities* (2009)
- NFPA 1600, *Standard on Disaster/Emergency Management Business Continuity Programs* (2007);
- NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems* (2008);
- *NFPA Fire Protection Handbook* (2003);

Telcordia

- Telcordia GR-63-CORE, *NEBS Requirements: Physical Protection* (2006);
- Telcordia GR-139, *Generic Requirements for Central Office Coaxial Cable* (1996);
- Telcordia GR-3028-CORE (2001), *Thermal Management in Telecommunications Central Offices: Thermal GR-3028-CORE*;

Telecommunication Industry Association (TIA)

- ANSI/TIA TSB-155-A, *Guidelines for the Assessment and Mitigation of Installed Category 6 Cabling to Support 10GBASE-T* (2010);
- ANSI/TIA-526-14-A OFSTP-14 *Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant* (1998);
- TIA-569-B, *Commercial Building Standard for Telecommunications Pathways and Spaces* (2004).
- ANSI/TIA/EIA-606-A, *Administration Standard for Commercial Telecommunications Infrastructure* (2002);
- ANSI-J-STD-607-A, *Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications* (2002);
- ANSI/TIA-862, *Building Automation Cabling Standard for Commercial Buildings* (2002);
- ANSI/TIA-942, *Telecommunications Infrastructure Standard for Data Centers* (2005);

Underwriters Laboratories (UL)

- ANSI/UL 497-2001, *Standard for Safety Protectors for Paired-Conductor Communications Circuits*;
- UL 60950-1 2003, *Information Technology Equipment - Safety - Part 1: General Requirements*;

Other Standards and Documents

- *Americans with Disabilities Act* (ADA) (1990);
- *EU Code of Conduct on Data Centres Energy Efficiency*, Version 1.0 (2008);
- *EU Best Practices for EU Code of Conduct on Data Centres*, version 1.0 (2008);
- *International Building Code* (IBC), 2009;
- *International Fuel Gas Code* (IFGC), 2009;
- *International Mechanical Code* (IMC), 2009;
- *International Plumbing Code* (IPC), 2009;

At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

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.

4 Definitions, acronyms, abbreviations, and units of measurement

For the purpose of this standard the following definitions, acronyms, abbreviations and units of measurement apply.

4.1 Definitions

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 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 access layer is the point at which local end users are allowed into the network. In the 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 enables any or all of the following: (1) different sizes or types of plugs to mate with one another or to fit into a telecommunications outlet, (2) the rearrangement of leads, (3) large cables with numerous conductors to fan out into smaller groups of conductors, (4) interconnection between cables, (5) limited voltage and/or polarity and/or DC rectification conversion.

administration: The method for labeling, identification, documentation and usage needed to implement moves, additions and changes of the telecommunications infrastructure

alarm: A visual and audible signal indicating the presence of heat, smoke, other products of combustion or systems malfunctions or security breach within a facility.

alien 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.

alien far-end crosstalk (AFEXT): 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 neared crosstalk (ANEXT): 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: An employee, contractor, or any physical, technological or intellectual possession.

attenuation: The decrease in magnitude of transmission signal strength between points, expressed in dB as the ratio of output to input signal level. See also *insertion loss*.

attenuation to crosstalk ratio, far-end (ACRF): Crosstalk measured at the opposite end from which the disturbing signal is transmitted normalized by the attenuation contribution of the cable or cabling.

availability: (1) the probability that a system or component is operating at a specified time; (2) the ratio of the total time a system or component is functional divided by the length of the time interval for which availability is being determined.

backboard: Backboard generally refers to the A-C rated, fire retardant, plywood sheeting on walls typically for telecommunications facilities. Backboards may also refer to the entire wall-mounted assembly, including wire management and termination frames.

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 cable: See *backbone*.

barrier: A fabricated or natural obstacle used to control access to something, or the movement of people, animals, vehicles or any material-in-motion or the spread of fire.

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 an information technology equipment (ITE) cabinet, rack, or enclosure 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: An insulated, bare, tinned or untinned copper conductor that puts various exposed conductive parts and extraneous conductive parts at a substantially equal potential especially during normal (non-transient) conditions.

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

bonding network (BN): A set of interconnected conductive structures that provides, in varying degrees based upon the design topology and installation, an electromagnetic shield for electronic systems and personnel at frequencies to tens of MHz. NOTE: the term "electromagnetic shield", denotes any structure used to divert, block or impede the passage of electromagnetic energy. In general, a BN need not be connected to ground but all BNs considered in the Standard will have a ground connection. Typical energy sources of concern are lightning, and ac and dc power faults. Of generally lesser concern are quasi steady-state sources such as ac power harmonics, and "function sources" such as clock signals from digital 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.

bundled cable: Assembly consists of two or more cables, of the same or different types or categories, continuously bound together to form a single unit.

bus topology: (1) Networking topology, in which 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 that may enclose connection devices, terminations, apparatus, wiring, and equipment.

cabinet (telecommunications): An enclosure with a hinged cover used for terminating telecommunications cables, wiring and connection devices.

cable: An assembly of one or more insulated conductors or optical fibers, within an enveloping sheath.

cable management: Physical structures attached to and/or within cabinets and racks to provide horizontal and vertical pathways for guiding and managing cabling infrastructure. Similar to pathways as defined in TIA-569-B, horizontal and vertical pathways within cabinets and racks guide cabling infrastructure in an engineered and orderly fashion when connecting to equipment and connectivity housed within the racks and/or cabinets.

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 rack: Hardware designed and manufactured for horizontal pathway distribution of cable and inside wiring inside the MDF, TR, or TR rooms.

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 ladder, trough, spline, solid-bottom, or channel raceway system intended for, but not limited to, the support of telecommunications cable.

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

campus: A building or collection of buildings located within a limited geographic area – typically one contiguous piece of property.

centralized cabling: A cabling configuration from the work area to a centralized cross-connect using pull through cables, 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 nonconducting, 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."

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 (CBN): 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/or 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 isolation or segregation of assets from threats using architectural design or countermeasures, including physical barriers.

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 is to accommodate data processing equipment.

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 F3 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.

core layer: the core layer is 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.

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.

countermeasures: The procedures, technologies, devices or organisms (dogs, humans) put into place to deter, delay or detect damage from a threat.

dark fiber: Unused installed optical fiber cable. When it 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 (DCIE): An efficiency metric for an entire data center calculated as the reciprocal of PUE: 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: Demarcation point between carrier equipment and customer premises equipment (CPE).

demarcation point: A point where the operational control or ownership changes.

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: Paper or plastic strips, usually contained in a clear or color tinted plastic carrier, designated for insertion into a termination frame. 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 inserted into the termination frame, 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, a single utility system split into redundant feeds, and may possess the circuit breaker transfer system with the generator.

earthing: See *grounding*.

electromagnetic interference (EMI): 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): 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.

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.

equipment cable: cord: A cable or cable assembly used to connect equipment to horizontal or backbone cabling.

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

equipment grounding conductor (EGC): 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 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: The ability of a design 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: special purpose equipment mounting structure (for example, IDC blocks, fiber termination hardware not meant to be mounted in standard 19” or 23” 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 (GFCI): 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 values established for a Class A device.

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 (GEC): 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.

grounding equalizer (GE): The conductor that interconnects elements of the telecommunications grounding infrastructure.

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-order mode transient losses: Losses in optical signal level power caused by the attenuation of weakly guided high-order modes of multimode optical fiber.

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.

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) in 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 (HC): A cross-connect of horizontal cabling to other cabling (e.g., horizontal, backbone, equipment).

horizontal distribution area (HDA): 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 end equipment located in the equipment distribution areas.

hot spot: A temperature reading taken at the air intake point of equipment mounted in a rack or cabinet in excess of the design standard or equipment requirement.

human events: Man-made disasters, including economic, general strike, terrorism (ecological, cyber, nuclear, biological, chemical), sabotage, hostage situation, civil unrest, enemy attack, arson, mass hysteria, accidental, special events.

hybrid cable: Assembly consists of two or more cables, of the same or different types or categories, covered by one overall sheath.

identifier: An item of information that links a specific element of the telecommunications infrastructure with its corresponding record.

impact of downtime: Specified as local, regional, or enterprise wide.

incipient products of combustion: Particles emitted from materials developing inherently high heat but from which no smoke is yet visible.

inductive/reactance-grounded power system: method of grounding in which the system is grounded through impedance, the principle element of which is inductive reactance

information technology equipment (ITE) 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, or channel, between a transmitter and receiver (often referred to as attenuation).

inside plant (ISP): Communications system inside a building (wire, optical fiber, coaxial cable, equipment racks, and information outlets). Telecommunications companies refer to this as inside wire (IW) or intrafacility cabling (IFC).

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 cord or jumper.

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 in conjunction with an intersystem bonding termination device.

isolated bonding network (IBN): An insulated bonding network in which all associated equipment cabinets, frames racks, trays, pathways and supplementary bonding grids that are designated to be within that IBN are bonded together (such as in a functional system block) that has a single point of connection (SPC) to either the common bonding network or another isolated bonding network. The IBN indirectly augments the CBN via a single point connection. All IBNs considered here will have a connection to ground through the SPC window.

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: The use of many layers of barriers, other countermeasures, or a mixture of both, used to provide the maximum level of deterrence and delay.

link: A transmission path between two points, not including terminal equipment, work area cables, and equipment cables.

linkage: A connection between a record and an identifier or between records.

load bank: A device to simulate actual equipment consisting of groups of resistive and/or reactive elements, fans and controls. The load bank is an electrical load that is connected to PDU systems, UPS systems or generators in load test situations.

local distribution point (LDP): (CENELEC EN 50173-5 and ISO/IEC 24764) Connection point in the zone distribution cabling subsystem between a zone distributor and an equipment outlet. Equivalent to the consolidation point (CP) in a zone distribution area (ZDA) in ANSI/TIA-942.

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 (MC): A cross-connect for first level backbone cables, entrance cables, and equipment cables.

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

main distributor (MD): (CENELEC EN 50173-5 and ISO/IEC 24764) distributor used to make connections between the main distribution cabling subsystem , network access cabling subsystem and cabling subsystems specified in ISO/IEC 11801 or EN 50173-1 and active equipment. Equivalent to the main cross-connect in ANSI/TIA-942.

main electrical grounding busbar (MEGB): The main electrical ground busbar for 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 (MIB): Within simple network management protocol (SNMP), defines objects and attributes to be managed.

mechanical room: An enclosed space serving 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 US, medium voltage is considered to be between 601 V and 35,000V, where as in the EU or other parts of the world, the utilization voltage level can be significantly higher than in the United States.

meshed bonding network (mesh-BN): A non-insulated bonding network to which all associated equipment cabinets, frames racks, trays, pathways are connected by using a bonding grid. This grid is connected to 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 jack: A female telecommunications connector that may be keyed or unkeyed and may have 6 or 8 contact positions, but not all the positions need to be equipped with jack contacts.

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 (NEXT): (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. (2) The signal transfer between circuits at the same (near) end of the cable.

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

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 level: Defined for a given facility by assigning one of four levels, according to the amount of time that will be available in the facility for testing and maintenance.

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

overall availability range: Defined by combining a given facility's availability requirement "while running" with the operational classification defined for the facility.

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.

patch cord: A length of cable with a plug on one or both ends.

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 determine that the systems are installed correctly, start up, and are prepared for the functional performance tests. Often these tests are in a checklist format. The prefunctional test checklists may be completed as part of the normal contractor startup test.

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

permanent link: 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 (PDU): Sometimes called a computer power center or a power distribution center—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 panel boards and can include a transformer, monitoring, and controls.

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. Also known in IEEE 1100 as a power outlet unit (POU). Sometimes called rack-mount PDU, rack power distribution unit, ITE-PDU , cabinet distribution unit, or plug strip.

power sum alien far-end crosstalk (PSAFEXT): 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 (PSANEXT): 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 (PSAACRF): 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 (PSACRF): 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 (PSNEXT): 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 (PUE): An efficiency metric for an entire data center calculated as: Total facility power usage/information technology equipment (ITE) power usage.

primary side: The high-voltage side of the electrical power service transformer (above 600V), the electrical power service line side of the UPS, the electrical power service line side of the PDU transformer or the 480V side of the static switch.

private branch exchange (PBX): A private telecommunications switching system.

propagation delay (PD): The time required for a signal to travel from one end of the transmission path to the other end that limits the voltage between the conductors and shield of a cable.

protection, fire: The active means of detecting and suppressing fires occurring within the data processing facility;

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 pathway run 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 due to 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.

rack: An open structure for mounting electrical and/or electronic equipment.

rack unit (U or RU): The modular unit on which panel heights are based. One rack unit is 45 mm (1.75 in).

radio frequency interference (RFI): Electromagnetic interference within the frequency band for radio transmission.

raised floor: See *access floor*.

record drawing: Plan, on paper or electronically, that graphically documents and illustrates the installed infrastructure in a building or portion thereof.

record: Collection of detailed information related to a specific element of the infrastructure.

records: A logical collection of data fields consisting of characters (bytes or bits).

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 (RPP): power distribution cabinet downstream from a PDU or UPS, typically containing circuits and breakers, without a transformer, located near the load.

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 (ROI): 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.

SAN: Storage Area Network (SAN) is 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.

SCADA system: SCADA is the acronym for "Supervisory Control and Data Acquisition." This is 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.

scan: Scan is 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: An element of a cable formed by a shield.

screened twisted-pair (ScTP) cable: A balanced metallic conductor or pair cable with an overall screen.

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 premises 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 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 (STP) 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 used for housing the installation and termination of telecommunications equipment and cabling.

splice: A joining of conductors, meant to be permanent.

star topology: A topology in which telecommunications cables are distributed from a central point.

static switch: Automatic transfer switch capable of electronically sensing power deviations and transferring load conductor connections from one power source to another without interruption of the connected load.

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

supplementary bonding grid (SBG): 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.

suppression, fire: The means of extinguishing an active fire.

surge protection device (SPD): A protective device for limiting transient voltages by diverting or limiting surge current, has a nonlinear voltage-current characteristic that reduces voltages exceeding the normal safe system levels by a rapid increase in conducted current. Surge protection device is the preferred term. Also called a voltage limiter, overvoltage protector, (surge) arrestor, or transient voltage surge suppressor (TVSS).

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

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

switchgear: An electrical enclosure, typically both front and rear access, containing overcurrent protective devices such as fuses and/or circuit breakers used to isolate electrical equipment. Switchgear is typically rated 800A to 5,000A and is characterized by segregated, insulated-case or low-voltage power circuit breakers, usually draw-out, and frequently containing 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.

system redundancy: Strategy for increasing reliability by providing redundancy at the system level.

targeted availability: A positive expression of allowable maximum annual downtime

technological events: Technological disasters, 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 signs, signals, writings, images, and sounds, that is, information of any nature by cable, radio, optical, or other electromagnetic systems.

telecommunications bonding backbone (TBB): A conductor that interconnects the telecommunications main grounding busbar (TMGB) to the telecommunications grounding busbar (TGB).

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 main grounding busbar (TMGB): A busbar placed in a convenient and accessible location and bonded by means of the bonding conductor for telecommunications, to the building service equipment (power) ground.

telecommunications media: See *media (telecommunications).*

telecommunications room: An enclosed architectural space for housing telecommunications equipment, cable terminations, and cross-connect 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.

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 (ATS): Self-acting equipment for transferring load conductor connections from one power source to another.

transfer switch, nonautomatic: Equipment operated manually and initiated either locally or remotely, for transferring load conductor connections from one power source to another (also commonly referred to as manual transfer switch).

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: Consist of two or more preconnectorized, cabling links, of the same or different types or categories that may either be covered by one overall sheath or individual units may be continuously bound together to form a single unit.

trunking: 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 (UPS): 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, and until the stored energy is all used up or the normal source of power returns to acceptable quality, whichever happens first.

unshielded twisted-pair (UTP): A balanced transmission medium consisting of a pair of electrical conductors twisted to provide a level of immunity to outside electrical interference. 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 fiber optic links configured on Gigabit Ethernet (GE) 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".

UPS, 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).

UPS, 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.

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 (VLAN): Virtual networking 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. To communicate between VLANs a routing function is required.

vulnerability: Defined as a physical, procedural, or technical weakness that creates and opportunity for injury, death, or loss of an asset.

wire: An individual solid or stranded metallic conductor.

wire management: Hardware designed and manufactured for keeping cross-connect wire and patch cables neat and orderly. Wire management may also refer to other types of hardware for securing wire and cable to the building.

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 were 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.

zero U space: 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 (ZDA): A space in a computer room where a zone outlet or a consolidation point is located

zone distributor (ZD): (CENELEC EN 50173-5 and ISO/IEC 24764) 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 or EN 50173-1 and active equipment. Equivalent to the horizontal cross-connect (HC) in ANSI/TIA-942.

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

4.2 Acronyms and abbreviations

Abbreviations and acronyms, other than in common usage, are defined below.

A/E	architectural/engineering
AHJ	authority having jurisdiction
AHU	air handling unit
AISS	automated information storage system
ASTS	automatic static transfer switch
ATM	asynchronous transfer mode
ATS	automatic transfer switch
AWG	American wire gauge
BAS	building automation system
BCT	bonding conductor for telecommunications
BMS	building management system
BNC	Bayonet Neill-Concelman
CATV	community antenna television
CBN	common bonding network
CCTV	closed-circuit television
CD	construction document
CFD	computational fluid dynamics
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
DCIE	data center infrastructure efficiency
DD	design development
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
EGS	equipment grounding system
EMD	equilibrium mode distribution
EMI	electromagnetic interference
EMS	energy management system
EO	equipment outlet
EPO	emergency power off
ESCON	Enterprise System Connection
ESD	electrostatic discharge
F/UTP	foil screened unshielded twisted-pair
FDDI	fiber distributed data interface
FE	Fast Ethernet
FICON	fiber connection
GbE	Gigabit Ethernet
GE	grounding equalizer
GUI	graphical user interface
HC	horizontal cross-connect
HCP	horizontal connection point
HDA	horizontal distribution area
HEPA	high-efficiency particulate air
HVAC	heating, ventilating, and air conditioning
IBC®	International Building Code®
IBN	isolated bonding network
IC	intermediate cross-connect
IDC	insulation displacement contact
IFGC®	International Fuel Gas Code®
IIM	intelligent infrastructure management
IMC®	International Mechanical Code®
IPC®	International Plumbing Code®
IT	information technology
ITE	information technology equipment
KVM	keyboard/video/mouse
LAN	local area network
LDP	local distribution point
LED	light-emitting diode
LSZH	low smoke zero halogen
MC	main cross-connect
MD	main distributor
MDA	main distribution area
MERV	minimum efficiency reporting value

Mesh-BN	mesh-bonding network
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
NRTL	Nationally Recognized Testing Laboratory
OC	optical carrier
OLTS	optical loss test set
OTDR	optical time domain reflectometer
PBX	private branch exchange
PC	personal computer
PDU	power distribution unit; protocol data unit
PEMCS	power and environmental monitoring and control system
PLC	programmable logic controller
PM	preventive maintenance
PoE	power over Ethernet
POU	power outlet unit
PQM	power quality monitoring
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
RPP	remote power panel
SAN	storage area network
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
SPD	surge protection device
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
TGB	telecommunications grounding busbar
TMGB	telecommunications main grounding busbar
TR	telecommunications room
TVSS	transient voltage surge suppression
UL®	Underwriters Laboratories Inc.®
UPS	uninterruptible power supply
UTP	unshielded twisted-pair
VRLA	valve-regulated lead-acid
WAN	wide area network
ZD	zone distributor
ZDA	zone distribution area

4.3 Units of measurement

The majority of dimensions in this standard are metric. Soft 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.

A	ampere
°C	degree Celsius
ft^3/min	cubic foot per minute
dB	decibel
°F	degree Fahrenheit
fc	foot-candle
ft	foot
ft/min	foot per minute
ft/s	foot per second
Gb/s	gigabit per second
GHz	gigahertz
gpd	gallons (U.S.) per day
gpm	gallons (U.S.) per minute
Hz	hertz
in	inch
in Hg	inches of mercury (pressure)
in WC	inches of water column
in WG	inches water gauge
kb/s	kilobit per second
kg	kilogram
kHz	kilohertz
km	kilometer
kN	kilonewton
kPa	kilopascal
kVA	kilovolt-ampere
kW	kilowatt
lb	pound
lbf	pound-force
lx	lux
m	meter
Mb/s	megabit per second
MHz	megahertz
MHz•km	megahertz kilometer
mm	millimeter
mph	mile per hour
m/s	meter per second
MW	megawatt
N	newton
nm	nanometer
Pa	pascal (pressure)
psi	pound per square inch (pressure)
RU	rack unit
µm	micrometer
V	volt
VA	volt-ampere
W/ft^2	watt per square foot
W	watt
W/m^2	watt per square meter

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5 Space planning

5.1 Overall facility capacity

The capacity of a data center is based on the size of the computer room space (floor space available for IT and telecommunications equipment), and the capacity of the power and cooling systems per unit of computer room floor space. High-density data centers have a higher capacity of power and or cooling per unit of computer room floor space.

A balance between space and capacity needs to be determined at the outset when designing a new data center and when modifying an existing data center space. The balance will depend on the type of IT and telecommunications systems the data center is to support and the number/combination of those systems which are to be placed within each cabinet or rack.

When planning for the overall facility:

- design to accommodate a defined load (N) over a defined area.
- consider current and future platforms for servers and storage when identifying the design load and area requirements.
- determine percentages for mainframe high-end processing, mid-range processing, small-form or blade servers, communications networks, and storage.
- identify potential growth rates not only within business units, but also identify growth rates across platforms , as these effect capacity and space plans.

If it is perceived that to meet the performance balance will require delivery of both high levels of power and large amounts of cooling to the cabinet or rack, it may be more cost-effective to design and build a more moderate density data center by designing the data center into a space that can accommodate a larger computer room. Resulting space utilization and power / cooling density limitations should be clearly communicated and documented.

5.2 Power systems

5.2.1 Introduction

The primary considerations when developing the space plan for the power systems are as follows:

- minimizing the distance of electrical feeders between various distribution equipment; excessive distances require increased feeder sizes and additional costs.
- providing sufficient space for the conduit runs with minimal bends; as the routing of the electrical feeders can be very complex in a data center, coordination with all other disciplines is required.
- in power configurations that have redundant systems, dedicated space should be provided for each system to provide physical separation between the systems.

5.2.1.2 Requirements

Sufficient clearances shall be provided for safety, access and maintenance for all electrical equipment, as specified by the manufacturer, applicable codes and standards, and/or the applicable AHJ.

Sufficient access shall be provided to the electrical equipment spaces to remove components or systems for maintenance or replacement, as specified by the manufacturer, applicable codes and standards, and/or the applicable AHJ.

5.2.1.3 Recommendations

Subsystems of the electrical distribution systems (e.g., main switch gear, generator switch gear, UPS and batteries) should be installed in dedicated electrical rooms or located outside of the data center computer room space, separated by a fire-rated wall. See Table 4 regarding fire-rated construction.

The electrical infrastructure for the data center should be isolated and separate from the base building electrical systems if the building is not exclusively dedicated to the data center function.

5.2.1.4 Additional information

The space required for the power systems will be proportional to the required capacity and level of redundancy/reliability of the electrical systems. It is not proportional to the square footage of the computer room alone. For example, a power system for a 1,000 m^2 (10,000 ft^2) computer room with a total critical capacity of 1 MW will require roughly the same physical space as a 500 m^2 (5,000 ft^2) computer room with a total critical capacity of 1 MW.

The following is a partial list of electrical equipment, components and systems that should be included in the space plan:

Equipment typically installed in dedicated electrical rooms outside the main computer area:

1) service entrance switchgear (medium or low voltage, metal enclosed, or metal clad);
2) unit substation (medium voltage);
3) tie breaker section for dual entrance configurations;
4) generators (indoor/outdoor);
5) generator paralleling switchgear;
6) automatic transfer switches (ATS);
7) load banks (permanently installed or portable load banks on trailers requiring connection to electrical systems);
8) distribution boards (critical loads, noncritical loads, life safety loads);
9) transformers;
10) uninterruptible power system (UPS—static system or rotary system);
11) UPS battery room (static or rotary system with flooded cell batteries);

Equipment typically installed in the computer room spaces:

1) power distribution units (PDUs), with or without transformers and static transfer switches depending on the UPS design and load requirements;
2) remote power panels (RPPs)—rack or cabinet mounted panels used to provide a concentration of breakers, typically close to the load;
3) power strips within each server cabinet that provide power dedicated to the specific cabinet.
4) PDU equipment may be located outside the computer room, in adjacent space. The benefit to locating the PDU equipment outside the computer room is that the electrical operations and maintenance activities are outside the critical computer room space.

5.2.2 Electric utility service feeds

5.2.2.1 Single entrance single pathway

5.2.2.1.1 Recommendations

The electric utility service feeds and associated switchgear should be located in a dedicated space that is adjacent or in close proximity to the main data center electrical distribution space.

5.2.2.2 Single entrance/dual pathway

5.2.2.2.1 Recommendations

The electric utility service feeds and associated switchgear should be located in a dedicated space that is equally distanced between or in close proximity to the dual data center electrical distribution spaces.

5.2.2.3 Dual entrance/dual pathway

5.2.2.3.1 Recommendations

The electric utility service feed and associated switchgear should be located in dedicated spaces separate from each other. Utility entrance space A should be located adjacent to electrical distribution space A, and utility entrance space B should be located adjacent to electrical distribution space B.

5.2.3 Generator power

5.2.3.1 Indoor/outdoor installations

5.2.3.1.1 Introduction

Locating the generators either indoors or outdoors is based on site and client specific requirements.

While there may not be a large difference in cost between locating the generators indoors or outdoors, factors to consider during the evaluation of generator location include:

Indoor generators

- placement of indoor generators in an area of the building with the lowest cost per square meter to construct;
- additional costs for items associated with an indoor implementation, such as automated louvers and noise reduction/mitigation;
- requirements for weight, vibration, lateral structure, and fire rating of surrounding surfaces of the space intended for a generator;
- fuel tank capacity and location;
- local and building regulations, codes, or standards.

Outdoor generators

- increased exposure to physical and weather related damage;
- requirements for weight, vibration, lateral structure, and fire rating of surrounding surfaces of the space intended for a generator;
- fuel tank capacity and location;
- local and building regulations, codes, or standards.

5.2.3.1.2 Requirements

Generators installed outdoors shall be installed within shelters.

Generator exhaust systems shall be located so they do not flow into building ventilation air intakes, preferably on the prevailing downwind side from building ventilation air intakes

5.2.3.1.3 Recommendations

It is recommended that generators are installed indoors. With sufficient clearances, indoor generators are easier to monitor and maintain, especially during extreme weather conditions when their operation may be required.

5.2.3.2 Onsite fuel storage

5.2.3.2.1 Introduction

Space planning will need to account for onsite fuel storage. The quantity of fuel that is required and can be stored will be affected by the following:

- proximity of the data center to locations or services which provide fuel replenishment;
- priority status of the organization and response time for fuel replenishment, during regional disasters such as earthquakes, floods and hurricanes;
- criticality of applications, regulatory requirements;
- business drivers requiring self sustaining operations;
- availability of backup or disaster recovery site for applications supported by the data center and expected time required to recover applications at the backup site;
- local codes and acceptance by the AHJ.
- environmental requirements

Storage of large amounts of fuel onsite may trigger extensive jurisdictional and/or environmental permit reviews, and the permitting process may be more stringent for underground storage tanks (UST) than for aboveground storage tanks (AST).

5.2.3.2.2 Recommendations

The minimum amount of generator fuel storage required should be between 8 and 96 hours running at full load depending on the data center availability requirements.

Depending on specific owner needs, the amount of fuel storage required may be far greater than 4 days.

5.2.4 Power distribution

5.2.4.1 Recommendations

Power distribution design should have sufficient flexibility and scalability to allow the load to increase or decrease in any rack, cabinet, or IT equipment zone within acceptable design limits. If the total anticipated data processing load has a capacity criteria of N, the multipliers for each subsystem within the electrical distribution system (as shown in Table 1) will provide sufficient capacity to meet normal equipment layout diversity and scalability, thereby preventing the creation of areas where the power available is insufficient to support the connected load..

Table 1: Multipliers For Electrical Distribution System Components

Distribution system component	*Multiplier (N = IT load design criteria)*
UPS and UPS critical distribution	N x 1.25
Remote power panels (RPP)	N x 2.0 to 3.0
Power strips (POU)	NC x 1.25
UPS and UPS critical distribution	N x 1.25

Figure 1 shows a single path electrical system to represent system capacities at various stages of the electrical distribution system.

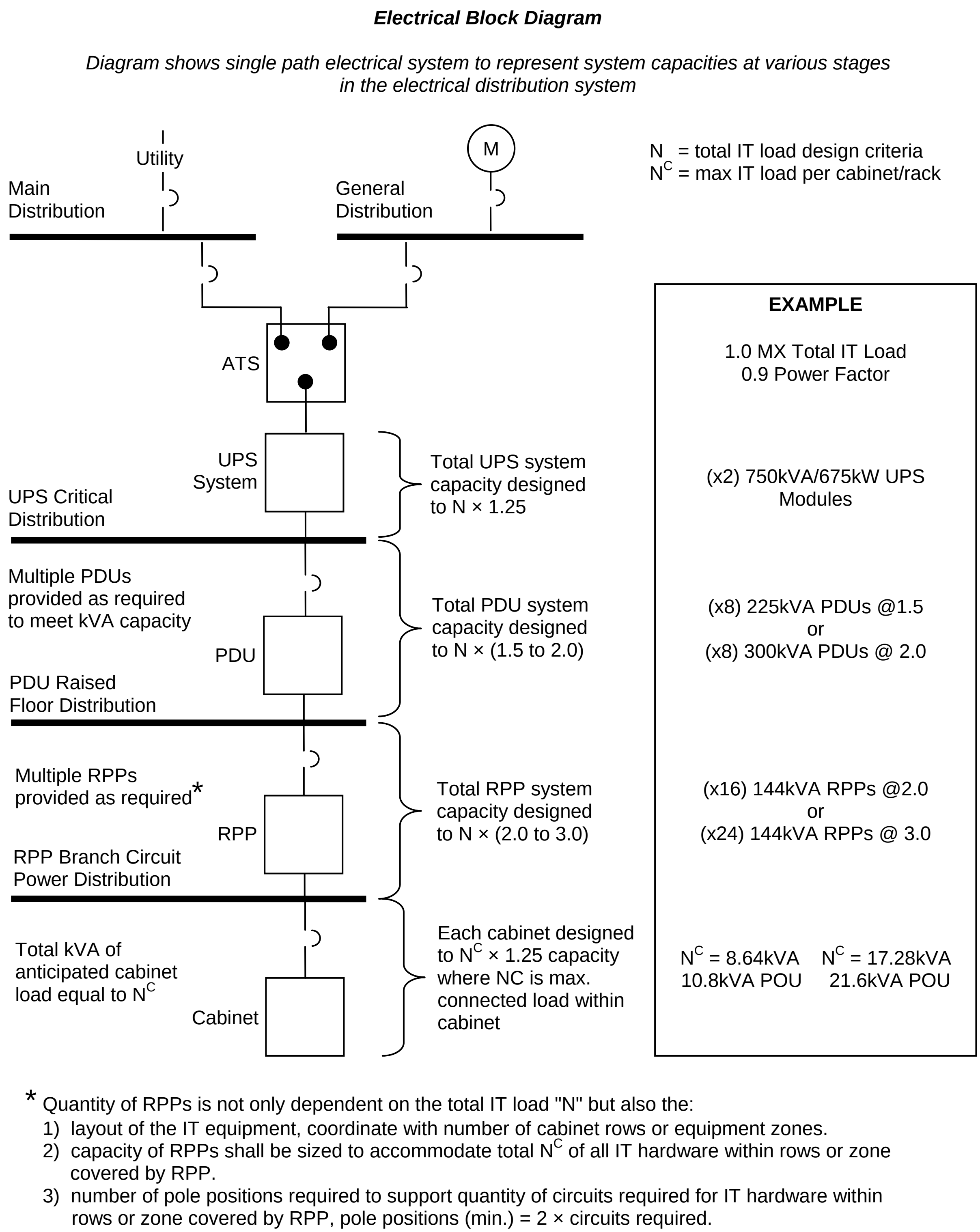

Figure 1: System Capacities At Various Stages Of The Electrical Distribution System

5.3 Cooling capacity

5.3.1 Introduction

The space required to support the cooling systems will vary depending on the type of cooling system selected. Items to consider include:

- central air handlers versus CRAC units,
- chilled water versus air-cooled systems,
- liquid-cooled cabinets in the computer processing area,
- cooling tower (chilled water system),
- thermal storage (chilled water system),
- piping and pumps,
- other required equipment or resources.

5.3.2 Recommendations

Mechanical infrastructure for the data center should be isolated and separate from the base building mechanical systems if the building is not exclusively dedicated to the data center function.

The cooling system design capacity should be sufficient to support the electrical distribution system and subsystem cooling requirements within each rack, cabinet or IT equipment zone.

5.4 Data center supporting spaces

5.4.1 Adjacencies of functional spaces

5.4.1.1 Introduction

The appropriate adjacencies of spaces can be determined by performing an exercise of required staff and material flow. Figure 2 shows an example of staff and material flow through a data center; it is not meant to show the physical adjacencies, but can be used to assist in identifying required adjacencies.

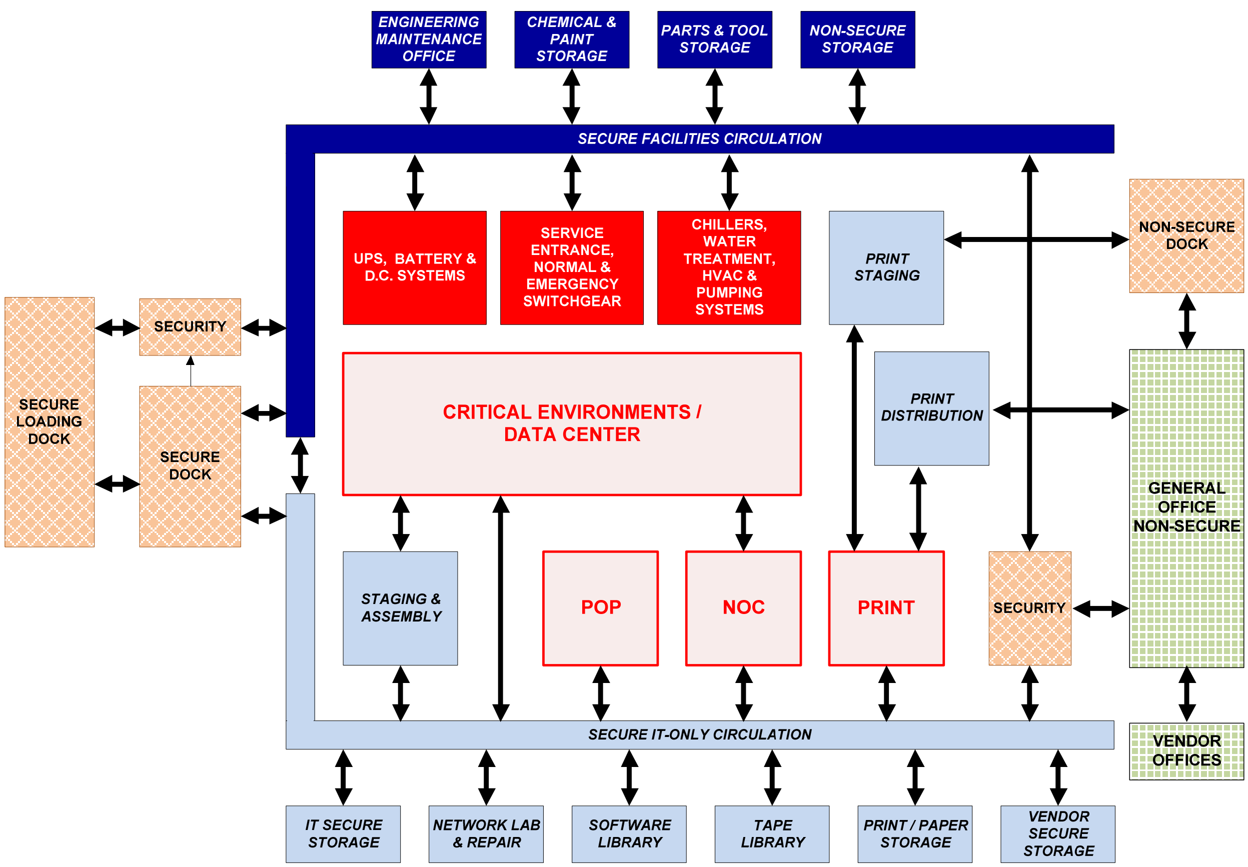

Figure 2: Space Adjacencies

5.4.2 Security

5.4.2.1 Recommendations

Security should be located at or adjacent to the main personnel entrance to facility.

Visitor sign-in area should be physically separate from security operations facility.

The security room should include the security operations facility, including video monitoring and access control system database and front end user interface. When planning this space consider:

- video monitoring space requirements,
- access control system space requirements,
- access control storage requirements,
- unobstructed access to key storage,
- unobstructed access to access-card (temporary and blank) storage;
- fire/smoke alarm monitoring systems.

5.4.3 Telecommunications entrance room

5.4.3.1 Introduction

The function of the entrance room is twofold:

1) Provide a secure point where entering media from access providers can be converted from outdoor cable to indoor cable.
2) House the access provider-owned equipment such as their demarcation, termination, and provisioning equipment.

5.4.3.2 Location

5.4.3.2.1 Recommendations

The location of the entrance room with respect to the computer room needs to be designed to accommodate the distance limitations of circuits to be provisioned from the entrance room. Where possible, the entrance room should be adjacent to or be in a secured space within the computer room.

Pay particular attention to distance limitations for T-1, T-3, E-1, and E-3 circuits, the type of media these circuits utilize, and the number of DSX panels and patch panels in the channel. See the applicable cabling standard (e.g., ANSI/TIA-942-1 for coaxial circuits) for guidance on the maximum distances allowed for T-3 and E-3 circuits in data centers.

The entrance room with the telecommunications main grounding busbar (TMGB) should be close to the main electrical ground bar to minimize the length of the bonding conductor for telecommunications (BCT), the conductor that interconnects the main electrical ground bar to the TMGB. The BCT shall be sized per applicable standards (e.g., ANSI/NECA/BICSI 607).

5.4.3.3 Access provider considerations

5.4.3.3.1 Recommendations

Where access provision is contracted for the delivery of a service, the access provider’s equipment and any associated cabling must be provided with space and the required services. Separate and/or secured cable routes may be required between the entrance room and the access provider’s equipment.

Where a separate entrance room is provided, access to the entrance room will be required by both the data center network operations staff and the access provider’s technicians. Customer-owned equipment in the entrance room and the computer room should be secure from access provider technicians.

The entrance room may be divided into separate areas to provide separation between access provider-owned and customer-owned equipment. If the room is subdivided, there are typically only two spaces – one for the data center owner and one shared by all access providers. However, if there are multiple access providers, they may each request their own space. These requested spaces may be provided within the same room by using secure fencing, or can be created through the use of walls

Where required by access provision contract, each access provider will terminate its entrance cables and connect its equipment in racks or cabinets separate from the other access providers.

The customer may ask all carriers to place demarcation equipment (patch panels, DSX panels, and IDC blocks) in shared meet-me or demarcation racks. Consolidating all patching to carrier circuits into meet-me racks and locating patch panels for cabling to the computer room in the same racks or adjacent ones simplifies cabling in the entrance room. Placing the demarcation panels and blocks adjacent to the patch panels that support cabling to the computer room allows circuits to be cross connected to the computer room cabling system using short patch cords.

The entrance room should be sized to accommodate each anticipated access provider. The designer should meet with each carrier to determine its space requirements before sizing the entrance rooms. Additionally rack and cabinet space will be required for customer-owned equipment and termination of cabling to the computer room and rest of the building.

Carrier equipment included in the entrance room consists of carrier-owned patch panels, digital cross-connect (DSX) panels, routers, SONET, DWDM, and circuit provisioning equipment. The power requirement for the entrance room typically ranges from 500 to 1500 watts per access provider. However, the designer should meet with each access provider to determine its electrical, space, interface, and other facility requirements.

5.4.4 Operations center

5.4.4.1 Recommendations

The telecommunications room (TR) that supports the operations center and other nearby data center support spaces should be outside the computer room.

The work area communications devices within the operations center may need connectivity back to two different supporting cross-connect fields. Network monitoring may need connectivity directly to the core network hardware located in the MDA space. Corporate LAN and telephony will need connectivity to the general telecommunications cross-connect serving noncomputer room communications.

Some applications may require installation of large video displays easily visible to all operations center personnel.

Depending on the data center, there may be need for CATV systems (local cable provider and satellite service).

5.4.5 Helpdesk

5.4.5.1 Recommendations

The helpdesk does not need to be located near the computer room and may be integrated into the general office space adjoining the data center. Additionally, it may be acceptable to build helpdesk and other general office space in a different building, when there is no need for its location within the hardened portion of the data center facility.

Operator workstations for the helpdesk should be provided with critical electrical circuits fed from the backup generator and UPS systems to ensure that support functions are not disrupted by power fluctuations or blackouts.

5.4.6 Print

5.4.6.1 Recommendations

Printers should be located within a dedicated print room separate from the main computer room. The print room should have its own dedicated air handling system.

Power and cooling systems supporting the print functions should be considered critical, and supported by the backup generator and UPS systems.

Both a separate paper storage room near the print room and a suitable route from loading dock to print room and paper storage room, to facilitate pallets of bulk paper products, should be provided. Ensure that printer manufacturers' environmental criteria are included in the design parameters of the facility. Typical environmental parameters that are unique for a print room are humidity and temperature.

5.4.7 Loading dock

5.4.7.1 Recommendations

Location of the loading dock should provide a step free route through to the computer spaces with sufficient floor loading capacity to withstand material and equipment weights.

A non-secure loading dock should be provided for general building deliveries.

For all high-value equipment, a secure loading dock should be provided. Some considerations when planning a secure loading dock include:

- provision of an enclosed area for the delivery truck to protect deliveries from extreme weather;
- use of a dock leveler so that equipment can be safely moved from any type of delivery truck;
- monitoring of the area by the building CCTV security system, with preference for security guards from the building's guard station to be able to visually monitor all activity;
- Controlling access to the loading dock by the facility access control system, with the system able to generate a history of all access attempts.

5.4.8 Storage

5.4.8.1 Secured high value

5.4.8.1.1 Recommendations

A secured storage area for high-value equipment should be located adjacent to a secured loading dock.

The space required for secured high-value storage is recommended to be a ratio of 1:10 in comparison to the computer room space. The minimum space recommended is 23 m^2 (250 ft^2). The ratio may be reduced for large data centers depending on the specific operational practices.

The secured storage area should be monitored by the building CCTV security system and/or access controlled by the facility access control system. The system should generate a history of all access attempts.

5.4.8.2 Staging

5.4.8.2.1 Recommendations

All storage and unpacking activities should occur outside the computer room space, either in storage rooms or in staging areas. Preferably, a staging area should be located adjacent to the computer room. For high-value equipment, a staging area should be provided for unpacking, and should be separate from any test-bench or lab space.

A staging area should have an air conditioning system separate from the computer room, as cardboard boxes and packing materials can generate large amounts of particulates

Due to limited space within a lab, the staging area may be used to test and burn-in equipment for larger mainframe or high-end servers space. However, this should not be a regular occurrence and alternatives should be considered.

The staging area should be monitored by the building CCTV security system and/or access controlled by the facility access control system. The system should generate a history of all access attempts.

5.4.8.3 Vendor storage

5.4.8.3.1 Recommendations

A secured storage area should be provided for vendors' equipment. The space needed depends on the number and type of vendors that will be storing equipment onsite.

The vendor storage area should be monitored by the building CCTV security system and/or located near or adjacent to a secured loading dock.

The security requirements for vendor storage should be the same as the staging area.

5.4.8.4 Print storage

5.4.8.4.1 Recommendations

Print storage may be located adjacent either to a loading dock or preferably, the print room.

5.4.9 Engineering offices

5.4.9.1 Recommendations

The engineering offices should be located near the electrical switchgear, UPS, generator, chiller and HVAC rooms, with sufficient space provided for power and cooling engineers and support staff

For offices, at least 10 m^2 (100 ft^2) of office floor space should be provided with sufficient noise baffling from adjacent equipment rooms to meet ASHRAE NC rating of not more than 35.

5.4.10 Administrative

5.4.10.1 Recommendations

The administrative or general office space may not require the same level of detailed construction as the data center and supporting back-of-house areas.

Factors affecting administrative space requirements include:

- disaster recovery and business continuity plans;
- operational policy during extreme weather conditions

  Example: the facility and have only minimal required staff to ensure the data center remains operational, allowing administrative and general office space to be constructed to standard office design criteria
- future administrative space requirements, either as an expansion to the overall data center or as a stand-alone project
- special function rooms, such as a large conference or "war room" with wall-to-wall, floor-to-ceiling white boards

5.4.11 Waste/recycle

5.4.11.1 Recommendations

As these facilities generate a large amount of boxes, packing material, and other waste, adequate space should be allocated for its handling. Frequency of removal, fire prevention/protection, local AHJ requirements, and dumpster requirements, such as size, access, and location, should also be considered.

Recycling and/or compliance with local environmental initiatives (e.g., United States Green Building Council [USGBC], Leadership in Energy and Environmental Design [LEED], Building Research Establishment Environmental Assessment Method [BREEAM]) is recommended.

5.5 Non-IT equipment on access floor

5.5.1 Cooling

5.5.1.1 Floor vents/perforated tiles

5.5.1.1.1 Recommendations

While the exact locations of the required floor vents or perforated tiles are not typically known at the time the construction documents are issued for the flooring system, the general layout and approximate locations should be identified. The HVAC designer should coordinate the anticipated quantities with the technology consultant or end user and ensure that the construction documents require the appropriate number and type of cutouts for floor vents and quantity of perforated floor tiles. The exact locations can be validated prior to installation of the flooring system.

It is recommended that a computational fluid dynamics (CFD) model of the floor design be produced to ensure proper placement of floor tiles and that the cooling design will meet the design requirements.

Tile cutouts should have a means of restricting airflow for cutouts that are not fully populated with cabling. Open cutouts can cause more than 50% of the air supplied by the air handlers or CRAC units to bypass the perforated tiles.

The location of the tile cutouts and perforated tiles need to be coordinated with the specific design of the equipment racks and cabinets. Open frame racks should have the floor cutouts positioned directly below the back half of the vertical cable management between each rack. Cabinets should have the floor cutouts positioned below the vertical channel that will be used for power and communications cabling within the cabinet.

When placing floor cutouts below open rack vertical cable managers, ensure that the grommet system used does not protrude above the access floor and interfere with proper installation and leveling of the vertical cable managers and racks.

Consider positioning cabinets with the front or back edges aligned with the edge of the floor tiles. The adjacent clear floor tile can then be removed without interference from the rack or cabinet.

Do not install perforated floor tiles until they are required. The efficiency and performance of the air distribution system will be affected by additional perforated floor tiles.

5.5.1.2 Ducting

5.5.1.2.1 Recommendations

Ducting may be required, particularly for computer rooms without access floors.

5.5.1.3 Air-handling units

5.5.1.3.1 Recommendations

The exact location of the air-handling units should be coordinated with the mechanical engineer, technology consultant and/or end user to ensure that an optimal equipment layout can be determined without hindering airflow requirements or utilization of floor space.

If air handlers are required to be located within the computer room area due to the size and density of the data center, coordination is required to ensure that the technology equipment layout and/or low-voltage cable routing is not constrained.

5.5.2 Power distribution

5.5.2.1 Remote power panels (RPP)

5.5.2.1.1 Recommendations

RPP locations should be coordinated with the technology equipment layout. The preferred RPP configuration is to place the RPPs at one or both ends of equipment cabinet rows.

5.5.2.2 PDU placement

5.5.2.2.1 Recommendations

The preferred location for PDUs is in a service gallery (a space outside but adjacent to the computer room). This location is subject to the approval by the AHJ and if the feeder distances to the remote power panels allow such a placement. Security for this space should be the same as for other critical electrical and mechanical spaces.

NOTE: This is the preferred approach because it removes a maintenance item from the computer room, removes a source of heat (if provided with transformers), and allows the PDUs to be located in less expensive space.

5.5.3 Fire protection systems

5.5.3.1 General

Space for fire protection system detection and protection equipment in the data center space should be coordinated with the fire protection system engineer.

Sufficient aisle space should be provided and coordinated with ceiling mounted fire detection and protection devices. Ceiling heights that are in excess of 3.7 m (12 ft) may require additional aisle space to maneuver support lifts in the computer room.

For computer rooms with an access floor, the placement of fire detection and protection devices which are installed below the access floor (including sprinkler or gaseous suppression piping and tanks) should be coordinated with all power and communications underfloor pathways and placement of technology equipment situated on the access floor.

For automatic protection information, See Section 11, as well as NFPA 75, NFPA 76, and AHJ requirements for additional information.

Manual fire extinguishing methods include handheld extinguishers and fire blankets. See Section 11 and NFPA 75 for additional information on manual methods.

5.6 Information technology equipment placement in a computer room with an access floor

5.6.1 Telecommunications spaces

NOTE: See Section 14.2 and ANSI/TIA-942 for more information on telecommunications spaces.

5.6.1.1 Introduction

The computer room will support one or two main distribution areas (MDA) and can support several horizontal distribution areas (HDAs). Some computer rooms require only a single MDA, however a second MDA is often deployed to provide redundancy.

The main distribution area will support the main cross-connect for the computer room, network equipment for the computer room (e.g., core routers, core LAN switches, core SAN switches, firewalls), and can support a horizontal cross-connect for portions of the computer room near the MDA.

The horizontal distribution areas support horizontal cabling to equipment areas (e.g., server cabinets) and LAN, SAN, console, or KVM (keyboard/video/mouse) or other edge switches.

The entrance rooms, MDAs, and HDAs need to be carefully situated to ensure that maximum cable lengths for applications to be used in the data center are not exceeded (e.g., WAN circuits, LAN, SAN).

Whereas a small data center may only have an MDA and no HDAs, TRs, or entrance room, a large data center may require multiple entrance rooms to be able to provision circuits in all locations of the data center.

Larger data centers will require more HDAs not only to ensure that maximum horizontal cable lengths are not exceeded, but also to avoid cable congestion. HDAs should not be so large as to completely fill all raceways feeding the HDAs during initial occupancy. Due to the high density of cabling in data centers, HDAs are more often required in data centers to avoid cable congestion than to avoid maximum cable length restrictions.

5.6.1.2 Recommendations

If the computer room has two MDAs, they should be physically separated. It may not necessary to place the MDAs on opposite ends of the computer room, if such a configuration causes cable lengths for distance-limited applications, such as T-1, T-3, E-1, E-3, and SANs, to be exceeded.

5.6.2 Racks, frames, and equipment

NOTE: Section 14.3 contains additional information regarding racks and cabinets.

5.6.2.1 Rack unit capacity

5.6.2.1.1 Recommendations

The amount of IT equipment (ITE) that should be placed within a cabinet will depend on many factors that vary for each hardware platform, data center, and organization. For example, each organization has its own practices for populating cabinets, and some may prefer not to install servers in all positions, leaving room for patch panels or switches, or for ease of maintenance.

ITE implementation planning should consider occupying cabinets based upon:

- Platforms (e.g., appliance servers, mid-range, blade servers).
- Departments, independent of platforms.
- Occupancy to the desired density independent of platform or departments.

Adequate space should be allocated for patch panels, switches, power strips, and cabling for the cabinet when it is at its desired maximum capacity. Patch panels and power strips should not be placed directly behind servers, as this may impede access and airflow to the rear of these systems.

The availability of power and cooling, rather than space, may limit the amount of ITE per cabinet or rack. As equipment power densities continue to increase, it is recommended to design the data center so that space constraints are realized before power and cooling constraints.

To ensure that the initial and ultimate power and cooling system capacities will meet the anticipated demands, validate power consumptions either by performing measurements or by obtaining actual power consumption data from manufacturers.

Any unused rack space should be filled with blanking devices to reduce any nonfunctional airflow migration through the equipment rack.

Initial and ultimate system weight loads should be used when verifying the structural design parameters of the various platforms that will be installed within the computer room.

5.6.2.2 Network racks

5.6.2.2.1 Recommendations

When arranging the computer room space and organizing the hot/cold aisle locations with respect to the cabling and cabinets, consider future changes. For example, it may be desirable to locate the cabinets or racks in which cabling is terminated in the hot aisle, so that a hot and/or cold aisle containment system may be installed in the future.

If redundant network equipment is located in equipment racks that are physically separated, these network racks should be separated to ensure facility infrastructure (power, cooling) diversity. This also provides physical separation of the cabling pathways and cabling from the redundant network equipment to the servers that are connected.

The areas in the computer room where the entrance rooms, MDAs, and HDAs are located may be secured with caging. This may be an end user requirement, dependent on internal operating procedures and security requirements.

5.6.2.3 End equipment cabinets and racks

5.6.2.3.1 Requirements

For new installations, a preliminary layout of the equipment cabinets and racks shall be completed prior to establishing the reference point for the access floor grid in computer rooms, entrance rooms, and TRs. The preliminary layout should anticipate logical groupings of equipment, flush front alignment of equipment rows, heat and energy density proximity to ducting and cooling, and worst-case cabinet depth.

The required clearances for the equipment cabinets, access floor grid, and internal columns will determine where the front alignments of rows of cabinets and racks are best located. The access floor grid shall line-up with the preferred layout of the rows of cabinets and allow for easy removal of tiles. Rear access (or hot aisle width when deployed in hot aisle/cold aisle arrangement) must allow for minimum service clearance appropriate to the voltage of the equipment per applicable local codes and regulations. Because all equipment may not be known at the time of initial layout, a final layout with adjustments may be required after the access floor grid has been established.

For existing installations, the access floor grid has already been determined. An equipment layout and alignments shall be made with the same considerations as in the previous paragraph, based upon the existing floor grid.

5.6.2.3.2 Recommendations

High density of servers within cabinets, higher density port counts per server, and the number of power cords per server create significant cable and cooling management issues within the server cabinets, particularly those with a 600 mm (24 in) width. Since most blade server chassis and emergent storage and rack-mounted server chassis are more than 800 mm (32 in) deep, cabinets should be 1200 mm (48 in) deep. This also provides adequate space to install redundant power strips and vertical cable management in the back of the cabinets. Prior to committing to a standard server cabinet size, the end users should review, and have the vendors provide mock-ups of, the various server cabinet configurations that they will implement. A mock-up of the worst-case configuration with maximum number of anticipated servers and cabling should also be provided. Upon completion of the mock-up, power and heat loads should be recalculated to ensure adequate power and cooling are delivered to the cabinet.

Additional room for cable management can be gained by increasing the depth or width of the cabinet. However, increasing the width of the cabinets will reduce the number of cabinets that can be installed in the computer room.

When equipment cabinets or racks are installed adjacent to each other, thus forming a continuous aisle, the number of cabinets or racks within one row should not exceed twenty. Where one end of an aisle is closed off or has no personnel exit, the number of cabinets and racks within one row should not exceed ten racks/cabinets. There may be AHJ restrictions on the length of an aisle, which will take precedence over these guidelines.

The layout of the computer equipment, electrical equipment, and air conditioning equipment should be done concurrently. One recommended method is to place the RPPs on the ends of the server cabinet rows.

Cabinets and racks should be placed to permit access floor tiles in front and in back to be lifted. It is a good practice to align one edge of the cabinets flush with one edge of the floor tiles, preferably the front edge to maximize cold aisle airflow by leaving at least two tile positions for perforated tiles.

In hot/cold aisle floor layouts, there should not be any gaps in the cabinet row. All gaps should be eliminated to minimize hot air migration into the cold aisle.

5.6.2.4 Large frame servers

5.6.2.4.1 Requirements

The layout of the large frame servers shall be coordinated with respect to weight loads, cooling airflow, power and connectivity requirements, as they will not fit within the standard server cabinet space.

5.6.2.5 SAN equipment

5.6.2.5.1 Requirements

The layout of the SAN equipment shall be coordinated with respect to weight loads, cooling airflow, power and network connectivity requirements, as they may not fit within the standard server cabinet space.

5.6.2.5.2 Additional information

Some SAN implementations require centralization of SAN storage and switches. Other SAN implementations use core-edge SAN architecture with core switches in the MDA and edge switches in the HDA.

5.6.2.6 SAN frames

5.6.2.6.1 Recommendations

SAN frames are network racks that provide the infrastructure to terminate the media that provide connectivity to the servers. SAN frames should be located within the SAN equipment area and typically consist of large quantities of high-density optical fiber termination panels.

The SAN frames need to provide proper optical fiber cable management to facilitate the interconnects from the patch panels to the SAN equipment.

Where the SAN frames consist of fabric core switches and edge layer switches, the edge layer switches and core switches should be installed in separate racks because the number of edge switches may increase. In addition, the amount of moves, adds, and changes at the edge layer is typically much higher than at the core layer.

5.6.3 Aisles

5.6.3.1 Orientation

5.6.3.1.1 Recommendations

For rectangular computer rooms, equipment rows may be run parallel or perpendicular to the long walls. The optimum configuration should be determined by examining both options.

5.6.3.2 Clearances

5.6.3.2.1 Requirements

The minimum width of an aisle shall be 0.9 m (3 ft), depending on local code requirements and voltage level present in cabinet.

5.6.3.2.2 Recommendations

There should be at least a 1.2 m (4 ft) clearance at the front of racks and cabinets to permit unobstructed access, equipment movement, and maintenance.

Aisle widths may need to be 3 or 4 tiles depending on HVAC engineer's analysis, requirements for planned equipment, and the design of the cooling system.

As equipment is typically installed within cabinets from the front, the front aisle width should, at a minimum, be equal the greatest value of the following:

- the anticipated depth of equipment to be installed within the cabinets;
- the current or planned cabinet depth to permit replacement of cabinets;
- the width required by local code(s) requirements and/or the AHJ;
- 0.9 m (3 ft).

NOTE: Additional allowance should be provided if moving equipment (e.g., hand truck) will be used

Clearance in front of racks and patching frames should provide for safe access and clearance to work. When the swing of a door encounters an obstruction such as a building support column, double (wardrobe) doors may be considered in place of a single door to facilitate full access to the cabinet content.

If the end user has an environment that changes equipment between server cabinets and floor standing equipment frequently, it may be desirable to designate two rows of floor tiles for equipment and two rows of floor tiles for aisles (both hot and cold). This will reduce the floor space utilization of the computer room, but will provide the flexibility that this particular environment requires.

5.6.3.3 Hot/cold aisles

5.6.3.3.1 Recommendations

The front of the racks and cabinets should be oriented toward the cold aisle. The cold aisle should have at least two rows of floor tiles that can be configured with perforated tiles, providing the required flexibility in airflow management. Additional front (cold) aisle clearance may be required subject to HVAC and operational considerations.

A minimum of least two complete rows of floor tiles that can be removed in the hot aisles at the rear of the cabinets and racks should be provided. This allows the designer to make use of two rather than one row of tiles for cable trays.

With 1100 mm (42 in) deep server cabinets and the front of the cabinets aligned with the edge of a 600 x 600 mm (24 in x 24 in) floor tile in the cold aisle, there would be 100 mm (4 in) of under lap provided in the hot aisle, which would necessitate two further rows of floor tiles that can be removed. (See Figure 3)

If cabinets or equipment have a depth that is greater than 1.1 m (42 in), there will need to be coordination with the hot and cold aisle configuration to ensure that the required clearances are provided.

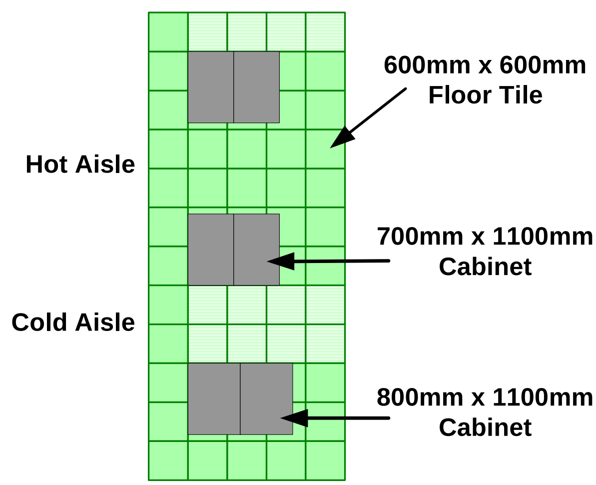

Figure 3: Examples Of Aisle Width With Different Cabinet Sizes

5.6.3.4 Location

5.6.3.4.1 Recommendations

The equipment cabinets and racks should have a minimum of 1.2 m (4 ft) and preferably 1.8 m (6 ft) of clearance from the server cabinets to air conditioning equipment and power distribution equipment along the perimeter wall. This provides a large aisle for the movement of large equipment such as electrical distribution equipment and air conditioning equipment within the computer room.

In the more traditional model, air conditioning equipment and power distribution equipment are placed along the perimeter walls for distribution under raised, perforated tiles. When subfloor air distribution is used, there should be a minimum of 1.2 m (4 ft) and, preferably, 1.8 m (6 ft) of clearance between the server cabinets and the air conditioning equipment. The cold aisle should be a minimum of 2.4 m (8 ft) from the cooling units. This will help reduce the possibility of the effect in which air is drawn from above the access floor through the perforated floor tile due to low pressure caused by the high-velocity air below the floor near the discharge of the air conditioning equipment. These distances are dependent on mechanical considerations such as the depth of the access floor, the absence or presence of turning vanes on the discharge of the CRAC unit, the speed of the air discharge, or the deployment of fans that are recessed under the access floor. Equipment cabinet and server row lengths may be limited by the maximum distance that the air conditioning equipment can provide adequate air pressure for delivering cold air. This distance is a function of the CRAC unit blower, the access floor depth, and the distribution of the perforated tiles.

When overhead or in-row cooling is provided, the CRAC units should be close coupled to the racks to be cooled, meaning that the cooling equipment should be as close as possible to the heat source. Close coupling minimizes hot and cold air mixing and improves efficiency because it minimizes the volume of air that must be cooled.

5.6.4 Power and telecommunications cable distribution

5.6.4.1 Introduction

Various configurations can be used to distribute power and telecommunications cables. See Section 14.4.8 for considerations of overhead versus under-floor cable routing.

5.6.4.2 Requirements

A telecommunications cable pathway (such as cable trays or other containment) shall contain a maximum depth of cable of 150 mm (6 in) when fully populated.

The bottom of the access floor tiles shall be:

- a minimum of 50 mm (2 in) from the top of the cable tray (if cables exit the cable tray from the top of the tray)
- a minimum of 200 mm (8 in) from the bottom of the cable tray if the cable tray is expected to be filled to the capacity of 150 mm (6 in) depth.

Cable pathways shall meet the clearance requirements of fire detection, suppression, and prevention systems, and these systems must be coordinated with other systems (e.g., electrical, mechanical, telecommunications) and meet the requirements of the manufacturer and the AHJ.

5.6.4.3 Recommendations

Raceways should be sized for the maximum number of cable expected, with a 50% additional capacity to allow for future growth. Raceway size should be calculated in areas of maximum density, such as near MDAs and HDAs.

Where fiber optic cabling is installed under the floor, it should be protected from damage by placing it within a cable tray or other containment. There is no separation requirement between power and fiber optic cabling, except that which is required by the AHJ.

If both power and telecommunications cabling are distributed from below the access floor then:

- the power cabling should be routed either adjacent to or within the cold aisle;
- the telecommunications cabling should be routed adjacent to or within the hot aisle.

This ensures that the telecommunications cabling does not interfere with airflow in the cold aisles.

If both power and fiber optic telecommunications cabling are distributed from overhead and copper telecommunications cabling is distributed from below the access floor then:

- the fiber optic telecommunications cabling should be routed above the power cabling on separate containment, and should be coordinated with mechanical and electrical systems above the cabinets;
- the copper telecommunications cabling should be routed adjacent to or within the hot aisles.

Power and communication pathways should be positioned at different heights off the floor so that they can cross each other without interference. Alternatively, at every point where the power and copper cabling cross the path of each other, the crossing should be at a right (90 degree).angle

5.6.4.4 Additional information

Patch cabling within a row of cabinets and racks is often routed overhead to maximize space underfloor for horizontal and backbone cabling. This routing also separates patch cabling, which changes often, from horizontal and backbone cabling, which should be more permanent.

The data cabling standards used in the design provide guidance as to the recommended separation between power and copper telecommunications cabling to maintain signal integrity (e.g., ANSI/TIA-942, CENELEC EN 50174-2, ISO/IEC 14763-2). Separation and segregation for safety shall be in accordance with the requirements of the AHJ.

5.6.5 Airflow circulation and equipment placement coordination

5.6.5.1 Recommendations

Consider the following items when coordinating placement of equipment, airflow, and cable routes:

On-floor equipment:

- Equipment type and dimensions
- Orientation with respect to airflow direction

Underfloor services:

- Electrical services:
  - Dimensions and clearances
  - Orientation with respect to airflow direction
- Data cabling:
  - Dimensions and clearances
  - Orientation with respect to airflow direction
- Ducting:
  - Dimensions and clearances
  - Orientation with respect to airflow direction
- Fire suppression system:
  - Dimensions and clearances
  - Orientation with respect to airflow direction
- Fire detection system:
  - Dimensions and clearances
  - Orientation with respect to airflow direction
- Air conditioning pipes:
  - Dimensions and clearances
  - Orientation with respect to airflow direction

5.6.6 Information technology (IT) equipment adjacencies

5.6.6.1 Proximity to EMI and RFI energies

5.6.6.1.1 Recommendations

Where possible , exposure to sources of EMI and RFI should be avoided. Transformers, other than those in PDUs, should be placed a minimum of 600 mm (24 in), and preferably at least 1.2 m (4 ft) from ITE and data cabling.

5.6.6.2 Information technology equipment (ITE) access space requirements

5.6.6.2.1 Recommendations

The equipment access space for ITE and non-ITE should be coordinated so that access space can be shared whenever possible, maximizing computer room utilization.

5.6.7 Access floor grid layout and reference point

5.6.7.1 Recommendations

The access floor reference point should be coordinated with the technology equipment layout, PDUs, CRAHs, chilled water piping and associated valving.

The reference point should not be selected simply at one of the corners of the computer room without coordinating the placement of the technology equipment. While having the reference point at one of the corners is the most cost effective from an installation cost perspective as it results in the fewest partial floor tiles, it may not provide the most optimized technology layout. The best long-term solution may be to position the reference point some distance away from a corner to accommodate the maximum number of server cabinet rows while still maintaining the required clearances.

5.7 Network architecture

Network architecture considerations include:

- centralized/decentralized location and its impact on space planning;
- copper communications cabling distance limitations and their impact on space planning;
- optical fiber distance limitations and their impact on space planning.