made to the access floor system and all equipment racks, cabinets, etc. are in place, it is recommended that the AC system be properly balanced.

8.5.5 Cable types under access floors

Cable fire-rating requirements vary by installation conditions and jurisdiction. Consult the AHJ before deciding on the type of cable to use under access floors.

> NOTE – Consider the selection of cable types (e.g. plenum-rated) and fire suppression practices that minimize damage to equipment and the facility in the event of fire

8.6 Overhead cable trays

8.6.1 General

Overhead cable tray systems may alleviate the need for access floors in data centers that do not employ floor-standing systems that are cabled from below.

Overhead cable trays may be installed in several layers to provide additional capacity. Typical installations include two or three layers of cable trays, one for power cables and one or two for telecommunications cabling. One of the cable tray layers may employ brackets on one side that hold the data center grounding infrastructure. These overhead cable trays may be supplemented by a duct or tray system for fiber patch cables. The fiber duct or tray may be secured to the same hanging rods used to support the cable trays.

During the design phase, the weight of fully occupied cable pathways should be calculated and coordinated with a structural engineer.

Cable pathways should not be located where they interfere with proper operation of fire suppression systems such water distribution from sprinkler heads. Overhead cable pathways should not block airflow into or out of cabinets (e.g., not block air exiting the hot aisle or cabinet vents if located at the top of cabinets).

Cables shall not be left abandoned in overhead cable trays. Cables shall be terminated on at least one end in an MDA, IDA, or HDA, or shall be removed.

In aisles and other common spaces in internet data centers, co-location facilities, and other shared tenant data centers, overhead cable trays should have solid bottoms or be placed at least 2.7 m (9 ft) above the finished floor to limit accessibility or be protected through alternate means from accidental and/or intentional damage.

The maximum recommended depth of cable in any cable tray is 150 mm (6 in).

Typical cable tray types for overhead cable installation include telco-type cable ladders, center spine cable tray, or wire basket cable tray. The cable tray system shall be bonded and grounded per ANSI/TIA-607-B.

8.6.2 Cable tray support

Overhead cable trays should be suspended from the ceiling. Where building structural characteristics make overhead suspension of a cable tray impossible, the tray can be suspended from a structural grid that is supported by other means. If all racks and cabinets are of uniform height, the cable trays may be attached to the top of racks and cabinets, but this is not a recommended practice because suspended cable trays provide more flexibility for supporting cabinets and racks of various heights, and provide more flexibility for adding and removing cabinets and racks.

8.6.3 Coordination of cable tray routes

Planning of overhead cable trays for telecommunications cabling should be coordinated with architects, mechanical engineers, and electrical engineers that are designing lighting, plumbing, air ducts, power, and fire protection systems. Lighting fixtures and sprinkler heads should be placed between cable trays, not directly above cable trays. Cable trays should be located above cabinets and racks instead of above the aisles, where lighting should be located.

9 DATA CENTER REDUNDANCY

9.1 Introduction

Data centers that are equipped with diverse telecommunications facilities may be able to continue their function under unplanned or adverse conditions that would otherwise interrupt the data center's telecommunications service. This Standard includes information on the planned availability of the data center facility infrastructure in annex F. Figure 12 illustrates various redundant telecommunications infrastructure components that can be added to the basic infrastructure.

The reliability of the telecommunications infrastructure can be increased by providing redundant cross-connect areas and pathways that are physically separated. It is common for data centers to have multiple access providers providing services, redundant routers, redundant core distribution and edge switches. Although this network topology provides a certain level of redundancy, the duplication in services and hardware alone does not ensure that single points of failure have been eliminated.

The proximity and response time of technicians required to perform repairs may affect reliability depending on the redundancy and architecture of the network and information technology infrastructure.

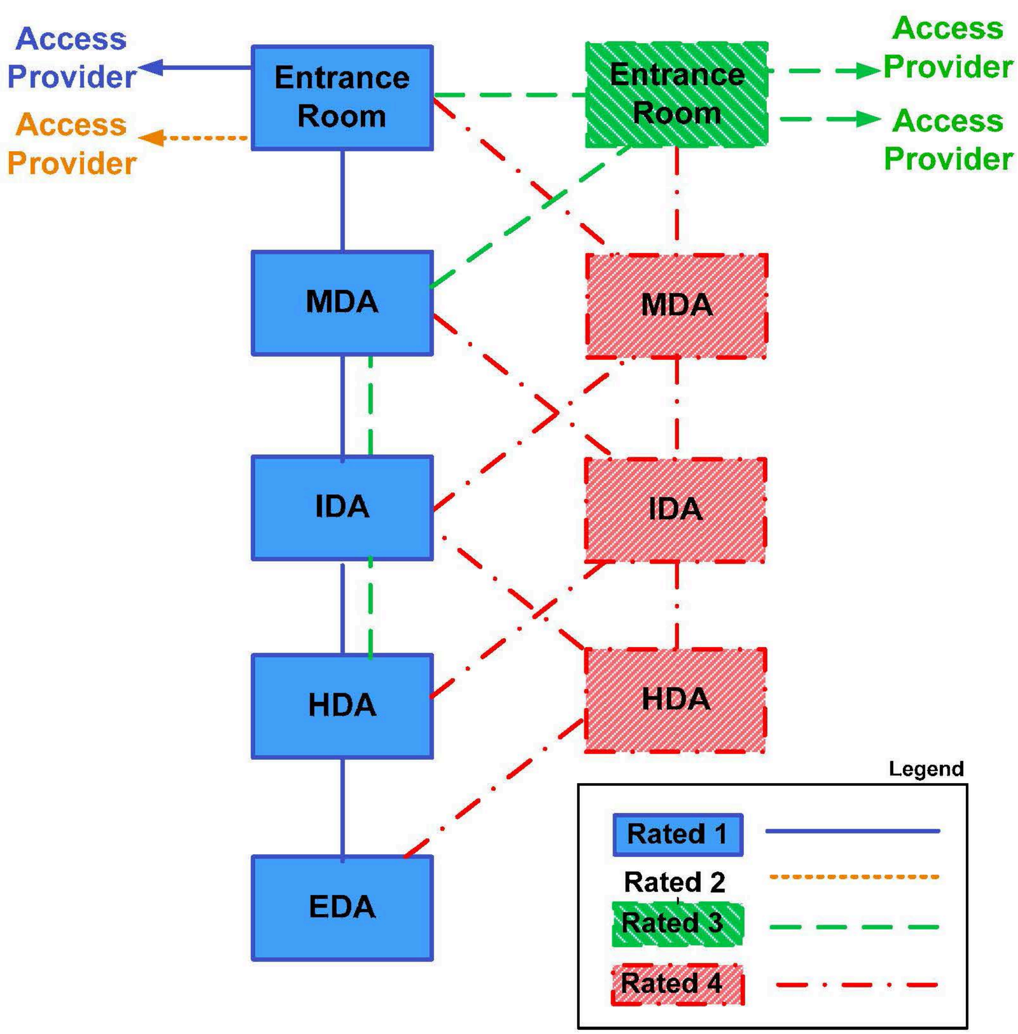

Figure 12: Telecommunications cabling pathway and space redundancy

9.2 Redundant maintenance holes and entrance pathways

Multiple entrance pathways from the property line to the entrance room(s) eliminate a single point of failure for access provider services entering the building. These pathways will include customer-owned maintenance holes where the access provider conduits do not terminate at the building wall. The maintenance holes and entrance pathways should be on opposite sides of the building and be at least 20 m (66 ft) apart.

In data centers with two entrance rooms and two maintenance holes, it is not necessary to install conduits from each entrance room to each of the two maintenance holes. In such a configuration, each access provider is typically requested to install two entrance cables, one to the primary entrance room through the primary maintenance hole, and one to the secondary entrance room through the secondary maintenance hole. Conduits from the primary maintenance hole to the secondary entrance room and from the secondary maintenance hole to the primary maintenance hole provide flexibility, but are not required.

In data centers with two entrance rooms, conduits may be installed between the two entrance rooms to provide a direct path for access provider cabling between these two rooms (for example, to complete a SONET or SDH ring).

9.3 Redundant access provider services

Continuity of telecommunications access provider services to the data center can be ensured by using multiple access providers, multiple access provider central offices, and multiple diverse pathways from the access provider central offices to the data center.

Utilizing multiple access providers may increase service reliability in the event of an access provider-wide outage or access provider financial failure that impacts service.

Utilizing multiple access providers alone does not ensure continuity of service, because access providers often share space in central offices and share rights-of-way.

The customer should ensure that its services are provisioned from different access provider central offices and the pathways to these central offices are diversely routed. These diversely routed pathways should be physically separated by at least 20 m (66 ft) at all points along their routes.

9.4 Redundant entrance room

Multiple entrance rooms may be installed for redundancy rather than simply to alleviate maximum circuit length restrictions. Multiple entrance rooms improve redundancy, but complicate administration.

Access providers should install circuit provisioning equipment in both entrance rooms so that circuits of all required types can be provisioned from either room. Care should be taken to distribute circuits between entrance rooms. The access provider provisioning equipment in one entrance room should not be subsidiary to the equipment in the other entrance room. The access provider equipment in each entrance room should be able to operate in the event of a failure in the other entrance room.

The two entrance rooms should be at least 20 m (66 ft) apart and be in separated fire protection zones. The two entrance rooms should not share power distribution units or air conditioning equipment.

9.5 Redundant main distribution area

A secondary main distribution area (MDA) provides additional redundancy, but at the cost of complicating administration. Core routers and switches should be distributed between the two MDAs. Circuits should also be distributed between the two spaces.

The two MDAs should be in different fire protection zones, be served by different power distribution units, and be served by different air conditioning equipment.

9.6 Redundant backbone cabling

Redundant backbone cabling protects against an outage caused by damage to backbone cabling. Redundant backbone cabling may be provided in several ways depending on the degree of protection desired.

Backbone cabling between two spaces, for example, a HDA and a MDA, can be provided by running two cables between these spaces, preferably along different routes. If the data center has redundant MDAs or redundant IDAs, redundant backbone cabling to the HDA from each higher level distributor (IDA or MDA) is not necessary. However, the routing of cables from the HDA to the redundant IDAs or MDAs should follow different routes.

9.7 Redundant horizontal cabling

Horizontal cabling to critical systems can be diversely routed to improved redundancy. Care should be taken not to exceed maximum horizontal cable lengths when selecting paths.

Critical systems can be supported by two different HDAs as long as maximum cable length restrictions are not exceeded. The two HDAs should be in different fire protection zones for this degree of redundancy to provide maximum benefit.

ANNEX A (INFORMATIVE) CABLING DESIGN CONSIDERATIONS

This annex is informative only and is not part of this Standard.

A.1 Application cabling lengths

The maximum supportable lengths in this annex are application and media dependent.

See table 6 in ANSI/TIA-568-C.0 for balanced twisted pair applications and table 7 in ANSI/TIA-568-C.0 for optical fiber applications.

A.1.1 T-1, E-1, T-3 and E-3 circuit lengths

Table 2 provides the maximum circuit lengths for T-1, T-3, E-1, and E-3 circuits with no adjustments for intermediate connections or outlets between the circuit demarcation point and the end equipment. These calculations assume that there is no customer DSX panel between the access provider demarcation point (which may be a DSX) and the end equipment. The access provider DSX panel is not counted in determining maximum circuit lengths.

Table 2: Maximum circuit lengths with no DSX panel

Circuit type	Category 3	Category 5e, 6 & 6A	734 Type Coaxial	735 Type Coaxial
T-1	159 m (520 ft)	193 m (632 ft)	-	-
CEPT-1 (E-1)	116 m (380 ft)	146 m (477 ft)	332 m (1088 ft)	148 m (487 ft)
T-3	-	-	146 m (480 ft)	75 m (246 ft)
CEPT-3 (E-3)	-	-	160 m (524 ft)	82 m (268 ft)

NOTE: The lengths shown in table 2 are for the specific applications used in data centers and may be different from the lengths supported for various applications in ANSI/TIA-568-C.0.

Repeaters can be used to extend circuits beyond the lengths specified above.

These circuit lengths should be adjusted for insertion loss losses caused by a DSX panel between the access provider demarcation point (which may be a DSX panel) and the end equipment. Table 3 provides the reduction caused by DSX panels in maximum circuit lengths for T-1, T-3, E-1, and E-3 circuits over the recognized media type.

Table 3: Reduction in circuit lengths for DSX panel

Circuit type	Category 3	Category 5e, 6 & 6A	734 Type Coaxial	735 Type Coaxial
T-1	11 m (37 ft)	14 m (45 ft)	-	-
CEPT-1 (E-1)	10 m (32 ft)	12 m (40 ft)	64 m (209 ft)	28 m (93 ft)
T-3	-	-	13 m (44 ft)	7 m (23 ft)
CEPT-3 (E-3)	-	-	15 m (50 ft)	8 m (26 ft)

Maximum circuit lengths should be adjusted for insertion loss losses caused by intermediate connections and outlets. Table 4 provides the reduction in maximum circuit lengths for T-1, T-3, E-1, and E-3 circuits over the recognized media type.

Table 4: Reduction in circuit lengths per connection or outlet

Circuit type	Category 3	Category 5e, 6, & 6A	734 Type Coaxial	735 Type Coaxial
T-1	4.0 m (13.0 ft)	1.9 m (6.4 ft)	-	-
CEPT-1 (E-1)	3.9 m (12.8 ft)	2.0 m (6.4 ft)	4.4 m (14.5 ft)	2.0 m (6.5 ft)
T-3	-	-	0.9 m (3.1 ft)	0.5 m (1.6 ft)
CEPT-3 (E-3)	-	-	1.1 m (3.5 ft)	0.5 m (1.8 ft)

In the typical data center, there are a total of 3 connections in the backbone cabling, 3 connections in the horizontal cabling and no DSX panels between the access provider demarcation point and the end equipment.

Backbone cabling:

- one connection in the entrance room;
- two connections in the main cross-connect;
- no intermediate cross-connect.

Horizontal cabling:

- two connections in the horizontal cross-connect;
- an outlet connection at the equipment distribution area.

This "typical" configuration corresponds to the typical data center with an entrance room, main distribution area (MDA), one or more horizontal distribution areas (HDAs), and no zone distribution areas. Maximum circuit lengths for a typical data center configuration with six connections are shown in table 5. These maximum circuit lengths include backbone cabling, horizontal cabling, and all patch cords or jumpers between the access provider demarcation point and the end equipment.

Table 5: Maximum circuit lengths for the typical data center configuration

Circuit type	Category 3	Category 5e, 6, & 6A	734 Type Coaxial	735 Type Coaxial
T-1	135 m (442 ft)	184 m (603 ft)	-	-
CEPT-1 (E-1)	92 m (303 ft)	134 m (439 ft)	305 m (1001 ft)	137 m (448 ft)
T-3	-	-	141 m (462 ft)	72 m (236 ft)
CEPT-3 (E-3)	-	-	153 m (503 ft)	78 m (257 ft)

With maximum horizontal cable lengths, maximum patch cord lengths, no customer DSX, no intermediate distribution area (IDA), and no consolidation point, the maximum backbone cable lengths for T-1, E-1, T-3, or E-3 circuits are shown in table 6. This "typical" configuration assumes that the entrance room, MDA, and HDAs are separate rather than combined, and that there is no IDA. The maximum backbone cabling length is the sum of the length of cabling from the entrance room to the MDA and from the MDA to the HDA.

Table 6: Maximum backbone length for the typical data center configuration

Circuit type	Category 3	Category 5e, 6, & 6A	734 Type Coaxial	735 Type Coaxial
T-1	<1 m (<3 ft)	46 m (150 ft)	-	-
CEPT-1 (E-1)	<1 m (<3 ft)	<1 m (<3 ft)	190 m (624 ft)	29 m (95 ft)
T-3	-	-	26 m (85 ft)	0 m (0 ft)
CEPT-3 (E-3)	-	-	38 m (126 ft)	0 m (0 ft)

These calculations assume the following maximum patch cord lengths in the "typical" data center:

- 10 m (32.8 ft) for balanced twisted-pair and fiber in the entrance room, MDA, and HDA;
- 5 m (16.4 ft) for 734-type coaxial cable in the entrance room, MDA, and HDA;
- 2.5 m (8.2 ft) for 735-type coaxial cable in the entrance room, MDA, and HDA.

Due to the very short lengths permitted by category 3 balanced twisted-pair cabling and 735 type coaxial cable for T-1, T-3, E-1, and E-3 circuits, category 3 balanced twisted-pair and 735-type coaxial cables are not recommended for supporting these types of circuits.

Backbone cabling lengths can be increased by:

- limiting the locations where T-1, E-1, T-3, and E-3 circuits are provisioned (for example only in the MDA or horizontal cabling originating from the MDA);
- provisioning circuits from multiplexers or other circuit provisioning equipment located in the MDA, IDA, or HDA;
- provisioning circuits using horizontal cabling from the MDA, reducing the number of connections from six to two, and reducing the number of patch cords.

A.1.2 Baluns E-3 and T-3 circuits

Baluns permit E-3 and T-3 circuits to use twisted-pair cabling instead of 75-ohm coaxial cabling.

Lengths for E-3 and T-3 circuits over twisted pair cabling depends on a number of factors, including the electrical characteristics of the baluns, which are beyond the scope of this standard. However, lengths for E-3 and T-3 circuits over twisted-pair cabling using baluns will be considerably shorter than the lengths for these circuits over 734 type coaxial cabling.

Taking into account only the insertion loss of the cabling and two twisted pair connections, the maximum lengths for E-3 and T-3 circuits with baluns over twisted-pair cabling is:

Table 7: Maximum circuit lengths over baluns NOT including insertion loss of baluns

Circuit type	Category 5e Cable & Panels	Category 6 Cable & Panels	Category 6A Cable & Panels
T-3	60.0 m (196.8 ft)	67,8 m (222.5 ft)	69.3 m (227.4 ft)
CEPT-3 (E-3)	66.2 m (217.2 ft)	74.5 m (244.2 ft)	75.9 m (249.1 ft)

These calculations assume that the baluns are attached directly to the access provider DSX panel, that there is no customer DSX panel, and that there are two twisted-pair connections. The lengths above need to be reduced by the following lengths for each decibel of insertion loss for the pair of baluns:

Table 8: Reduction in maximum circuit length for each 1 dB insertion loss for a pair of baluns

Circuit type	Category 5e Cable & Panels	Category 6 Cable & Panels	Category 6A Cable & Panels
T-3	10.2 m (33.4 ft)	11.1 m (36.6 ft)	11.4 m (37.4 ft)
CEPT-3 (E-3)	11.7 m (38.3 ft)	12.8 m (41.9 ft)	13.0 m (42.7 ft)

If the circuit is to pass through more than two connections, the circuit lengths will need to be reduced as described in table 9.

Table 9: Reduction in maximum circuit length for each additional twisted pair connection (after the 1st two)

Circuit type	Category 5e Cable & Panel	Category 6 Cable & Panel	Category 6A Cable & Panel
T-3	1.9 m (6.3 ft)	1.1 m (3.5 ft)	1.1 m (3.5 ft)
CEPT-3 (E-3)	1.9 m (6.4 ft)	1.1 m (3.5 ft)	1.1 m (3.5 ft)

A.1.3 TIA-232 and TIA-561 console connections

The recommended maximum lengths for TIA-232-F and TIA-561/562 console connections up to 20 kb/s are:

- 23.2 m (76.2 ft) over category 3 balanced twisted-pair cable;
- 27.4 m (89.8 ft) over category 5e or higher balanced twisted-pair cable.

The recommended maximum lengths for TIA-232-F and TIA-561/562 console connections up to 64 kb/s are:

- 8.1 m (26.5 ft) over category 3 balanced twisted-pair cable;

- 9.5 m (31.2 ft) over category 5e or higher balanced twisted-pair cable.

A.2 Cross-connections

In the entrance room, MDA, IDA, and HDA, jumper and patch cord lengths used for cross-connection to backbone cabling should not exceed 20 m (66 ft).

The only exception to these length restrictions should be in the case of 75-ohm coaxial cables, for DS-3 patching, the maximum length should be 5 m (16.4 ft) for type 734 coaxial and 2.5 m (8.2 ft) for type 735 coaxial in the entrance room, main cross-connect, intermediate cross-connect, and horizontal cross-connects.

A.3 Separation of functions in the main distribution area

The MDA should have separate racks for balanced twisted-pair, coaxial cable, and optical fiber distribution unless the data center is small and the main cross-connect can fit in one or two racks. Separate patching bays for balanced twisted-pair cables, coaxial cables, and optical fiber cables simplify management and serves to minimize the size of each type of patching bay. Arrange patching bays and equipment in close proximity to minimize patch cord lengths.

A.3.1 Twisted-pair main cross-connect

The twisted-pair main cross-connect (MC) supports twisted-pair cable for a wide range of applications including low speed circuits, T-1, E-1, consoles, out-of-band management, KVM, and LANs.

Consider installing category 6A twisted-pair cabling for all balanced twisted-pair cabling from the MC to the intermediate cross-connects (ICs) and HCs, as this will provide maximum flexibility for supporting a wide variety of applications. Cabling from the E-1/T-1 demarcation area in the entrance room should be 4-pair category 5e or higher.

The type of terminations in the MC (IDC connecting hardware or patch panels) depends on the desired density and where the conversion from 1- and 2-pair access provider cabling to 4-pair computer room structured cabling occurs:

- if the conversion from 1- and 2-pair access provider cabling occurs in the entrance room, then balanced twisted-pair cable terminations in the MC are typically on patch panels. This is the recommended configuration;
- if the conversion from 1- and 2-pair access provider cabling occurs in the MC, then balanced twisted-pair cable terminations in the MC should be on IDC connecting hardware.

A.3.2 Coaxial main cross-connect

The coaxial MC supports coaxial cable for T-3 and E-3 cabling (two coaxial cables per circuit). For smaller data centers and shorter cable runs, 735-type coaxial cable may be considered. All other coaxial cabling should be 734-type coaxial cable.

Termination of coaxial cables should be on patch panels with 75-ohm BNC connectors. The BNC connectors should be female-BNC on both the front and back of the patch panels.

A.3.3 Optical fiber main cross-connect

The fiber MC supports optical fiber cable for local area networks, storage area networks, metropolitan area networks, computer channels, and SONET circuits.

Termination of fiber cables should be on fiber patch panels.

A.4 Separation of functions in the horizontal distribution area

HDAs should have separate cabinets or racks for balanced twisted-pair, coaxial cable, and optical fiber distribution unless the horizontal cross-connect is small and only requires one or two racks. Separate patching bays for balanced twisted-pair cables, coaxial cables, and optical fiber cables simplify management and minimize the size of each type of patching bay. Arrange patching bays and equipment in close proximity to minimize patch cord lengths.

The use of a single type of cable simplifies management and improves flexibility to support new applications. Consider installing only one type of balanced twisted-pair cable and only one type of optical fiber cable for horizontal cabling (for example all category 6 or all category 6A, and all OM4 cable or all OM3 cable).

A.5 Cabling to end equipment

Equipment cord lengths from the ZDA should be limited to a maximum of 22 m (72 ft) in the case of balanced twisted-pair or fiber optic cabling.

If individual equipment outlets are located on the same equipment rack or cabinet as the equipment served in lieu of a ZDA, equipment cord lengths should be limited to 5 m (16 ft).

A.6 Fiber design consideration

High termination density can be achieved using multi-fiber increments and the use of MPO connectors. If cable lengths can be accurately pre-calculated, pre-terminated multi-fiber cable assemblies can reduce installation time. In these cases, the effects of additional connections should be considered to ensure overall fiber system performance. High data-rate end equipment may accommodate multi-fiber connectors directly (e.g., 40/100G Ethernet with multimode fiber).

A.7 Balanced twisted-pair design consideration

The patch panels should provide adequate space for labeling of each patch panel with its identifier as well as labeling each port as per ANSI/TIA-606-B requirements.