PHYSICAL LAYER
TELECOMMUNICATIONS CONSULTING, LLC

Information Technology Systems Tables and Figures

Table 1. Conduit Size and Cable Capacity

Conduit Size		Cable Outside Diameter mm (in.)							
Inside Diameter (mm)	**Trade Size**	**3.3 (0.13)**	**4.06 (0.18)**	**506 (0.22)**	**601 (0.24)**	**7.4 (0.29)**	**7.9 (0.31)**	**904 (0.37)**	**13.5 (0.53)**
16	1/2	1	1	0	0	0	0	0	0
21	3/4	6	5	4	3	2	2	1	0
27	1	8	8	7	6	3	3	2	1
35	1-1/4	16	14	12	10	6	4	3	1
41	1-1/2	20	18	16	15	7	6	4	2
53	2	30	26	22	20	14	12	7	4
63	2-1/2	45	40	36	30	17	14	12	6
78	3	70	60	50	40	20	20	17	7
91	3-1/2	—	—	—	—	—	—	22	12
103	4	—	—	—	—	—	—	30	14

Table 2. Copper Cable Characteristics in a Horizontal Application

TIA/ISO Category [1]	ISO Class [2]	Max. Frequency	Recommended Color [3]	Minimum Field Tester Level
Category 3	**Class C**	16 MHz	Gray	
Category 5e	**Class D**	100 MHz	Blue	Level IIe
Category 6	**Class E**	250 MHz	Yellow/Blue	Level III
Category 6A	**Class E_A**	500 MHz	White/White	Level IIIe
Category 7	**Class F**	600 MHz	none	Level IV
Category 7A	**Class F_A**	1,000 MHz	none	Level IVe

1. Per TIA and ISO specifications. Categories 6A, 7 and 7A are not approved by the TIA specifications.
2. Per ISO/IEC 11801
3. Colors for Cat 3 and 5e cables refer to backbone cable. Others are for horizontal cable. The 2nd color shown is for patch cords. OSP cable color may be black, regardless of category, to accommodate environmental requirements.

Table 3. Optical Fiber Transmitter Characteristics

	LED	Short Wavelength Laser (CD)	VCSEL	Laser (LD)
Cost	Less expensive	Less expensive	Less expensive	More expensive
Primary optical fiber type	Multimode	Multimode	Multimode	Singlemode
Center Wavelength	850 nm and 1300 nm	780 nm	850 nm	1300 nm and 1550
Modulation Frequency	Usually under 200 MHz	Can exceed 1 GHz	Up to 10 GHz	Can exceed 10 GHz
Average launched power level	–10 to -30 dBm	+1.0 to -5 dBm	+1 to -3 dBm	+1 to -3 dBm

Table E-4. Optical Fiber Cable Characteristics

	50/125 µm Multimode		50/125 µm Multimode Laser Optimized		62.5/125 µm Multimode		Singlemode	
Core Diameter (µm)	50		50		62.5		8-9	
Cladding Diameter (µm)	125		125		125		125	
Wavelength (nm)	**850**	**1300**	**850**	**1300**	**850**	**1300**	**1310**	**1550**
Max. Insertion Loss (dB/km)	3.5	1.5	3.5	1.5	3.5	1.5	1.0	1.0
Max. Distance (m) for:								
100BASE-FX (Fast Ethernet)	n/a	2,000				2,000	NST(1)	NST(1)
1000BASE-SX(2) (Gigabit Ethernet)	550	n/a	550	n/a	220	n/a	n/a	n/a
1000BASE-LX(2) (Gigabit Ethernet)	n/a	550	550	n/a	n/a	550	5,000	5,000
10GBASE-S	82	n/a	300	n/a	26	n/a	NST(1)	NST(1)
10GBASE-L	NST(1)	NST(1)	NST(1)	NST(1)	NST(1)	NST(1)	10,000	n/a
10GBASE-E	NST(1)	NST(1)	NST(1)	NST(1)	NST(1)	NST(1)	n/a	40,000
10GBASE-LX4	n/a	300	n/a	300	n/a	300	10,000	n/a
Modal Bandwidth (MHz•km)(3)	500	500	2000	500	160(4)	500	n/a	n/a
Backbone Distance(5):								
MC to HC	2000	2000	2000	2000	2000	2000	3,000	3000
MC to IC	1700	1700	1700	1700	1700	1700	2,700	2700
IC to HC	300	300	300	300	300	300	300	300

1. NST (nonstandard) entries indicate where this standard does not specify support for the media, but where equipment is commonly available to convert the native application signals to a form compatible with the non-native media.
2. This is a laser-based application. When not so noted, multimode applications are LED-based.
3. A measure of the spreading of a light signal caused by photons traveling through the fiber using different paths. MHz•km is a unit developed to allow consistent product comparison. It means that the bandwidth number provided was specified at a 1 km length. Optical bandwidth decreases with increasing distance. Not applicable to single mode fiber.
4. ISO/IEC 11801 Ed.2:2002 and other cabling standards specify 200 MHz•km.
5. MC = Main Cross-Connect
   IC = Intermediate Cross-Connect
   HC = Horizontal Cross-Connect
6. Includes backbone cable, patch cords or jumpers, and equipment cable.

Table 5. General Physical Interface Naming Convention for 10 Gigabit Ethernet

Prefix	First Suffix = Media Type or Wavelength	Second Suffix = PHY Encoding Type	Third Suffix = Number of WWDM Wavelengths or XAUI Lanes
10GBASE-	Examples: C = Copper (twin axial) S = Short (850 nm) L = Long (1310 nm) E = Extended (1550 nm) Z = Ultra extended (1550 nm)	Examples: R = LAN PHY (64B/66B) X = LAN PHY (8B/10B) W = WAN PHY (64B/66B)	Examples: If omitted, value = 1 (serial) 4 = 4 WWDM wavelengths or 4 XAUI lanes

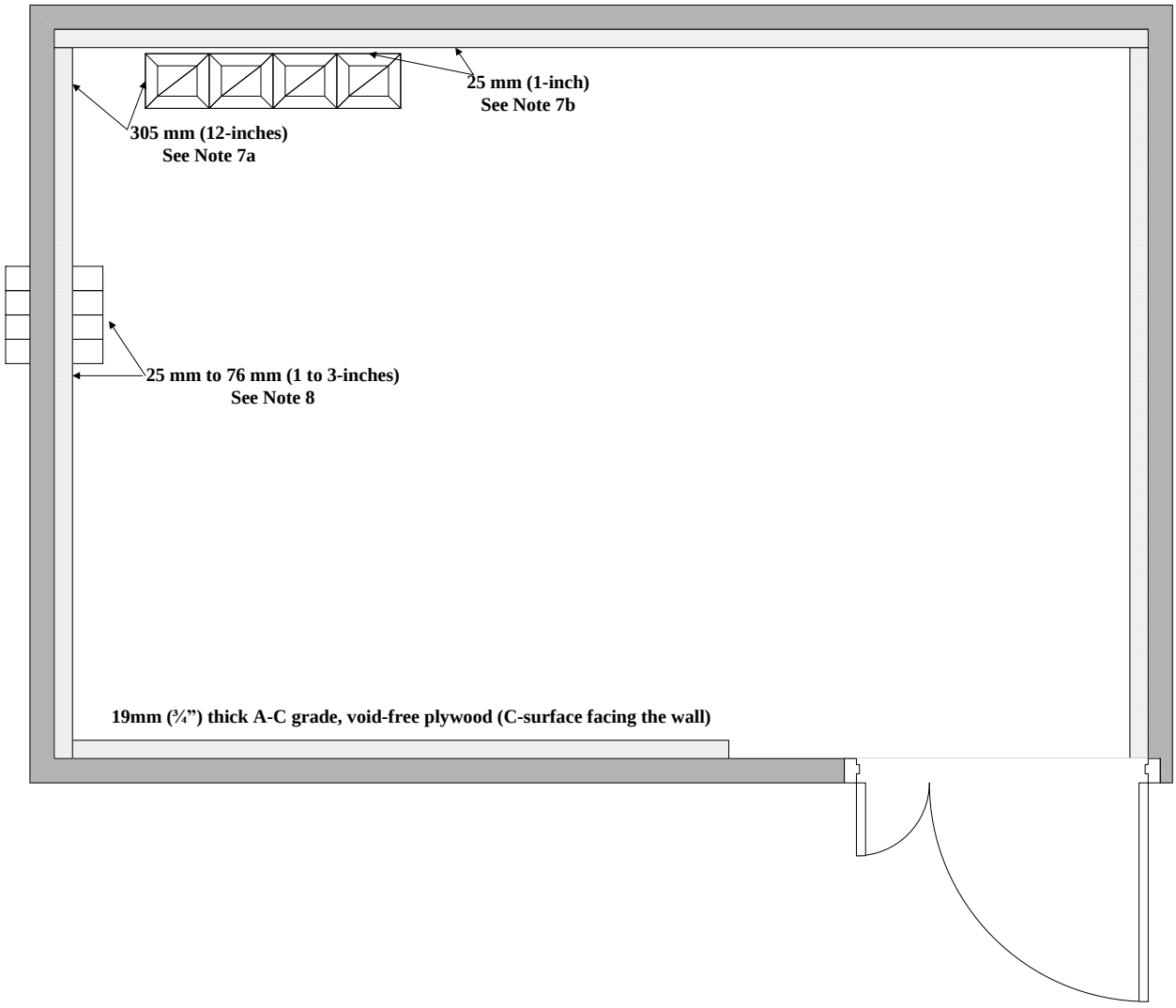
1. Per IEEE 802.3ae
2. PHY = Physical layer device. OSI Layer 1.
3. WWDM = Wide wavelength division multiplexing
4. XAUI = Gigabit Ethernet Attachment Unit Interface. The "X" represents the Roman numeral for ten and implies ten gigabits per second.
5. 8B/10B = An IBM patented encoding method used for encoding 8-bit data bytes to 10-bit transmission characters.
6. 64B/66B = encoding method used for encoding a 64-bit data string into a 66-bit transmission character string.

Table 6. 10 Gigabit Ethernet Operating Ranges

10 GE Physical Interface	Typical Deployment	Operating Range Over:			
		62.5 micron Multi-Mode Fiber	50 micron Multi-Mode Fiber	10 micron Single Mode Fiber	Twinaxial Copper
10GBASE-CX4	Data Center	-	-	-	15m
10GBASE-SR	Data Center	26m-33m	66m-300m	-	-
10GBASE-LX4	Campus Or Data Center	300m	240m-300m	-	-
10GBASE-LR	Campus Or Metro	-	-	10 km	-
10GBASE-ER	Metro	-	-	40 km	-
10GBASE-ZR	Metro Or Long-Haul	-	-	80 km	-
DWDM	Metro Or Long-Haul	-	-	80 km- 32 wavelengths over single-strand SMF	-

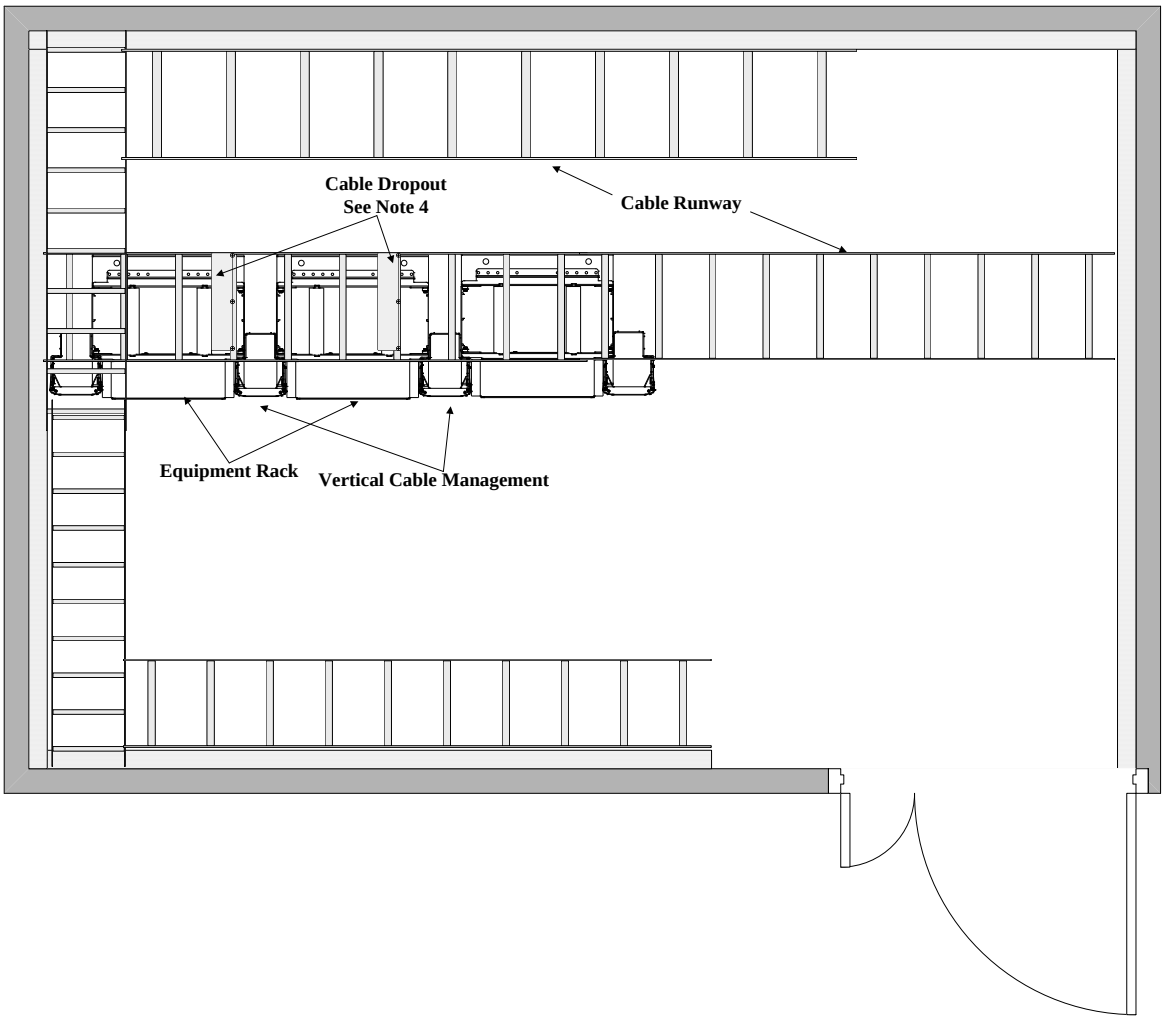
Per Cisco document: "10 Gigabit Ethernet Switching For Enterprises",
http://www.cisco.com/en/US/prod/collateral/switches/ps5718/ps708/prod_white_paper0900aecd802a648b.html

Figure 1. Typical Telecommunications Room Layout – Walls and Cable Entrances



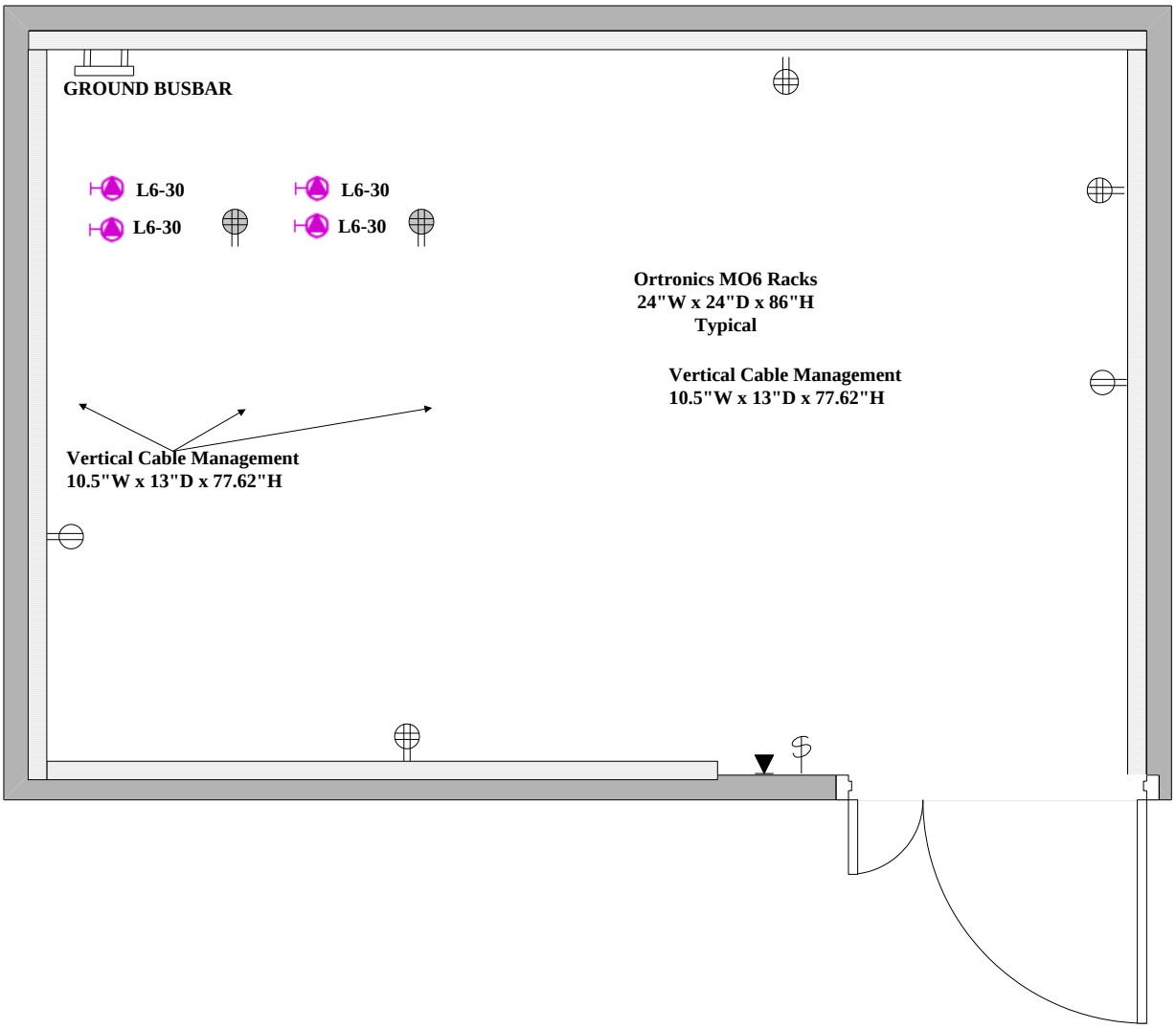
1. Telecommunications Room recommended Size is 3 m W x 5 m L x 3 m H (10' W x 15'L x 10'H)
2. "Off-set Doors" are preferred. Size 1.2 m W x 2.3 m H (48" W x 91"H). Door should open out from room.
3. Plywood is 19 mm (¾") thick A-C grade, void-free (C-surface facing the wall). Plywood should be mounted 305 mm (12-inches) from finished floor to the ceiling.
4. Room should be painted with two coats of fire-retardant semi-gloss or eggshell white enamel.
5. Lighting fixtures should be at least 2.6 m (8.5 ft) above finished floor.
6. Room should have a minimum light level of 500 lux (50 footcandles) measured at 1 m (3 ft.) above the finished floor throughout the room.
7. Edge of pathways that enter TR or ER from the floor should:
    a. Terminate approximately 305 mm (12 in.) from the corner of the room to allow for proper cable sweep bends. Terminate the pathway approximately 25 mm (1-inch) from the wall underneath the plywood backboard.
    b. Terminate pathways that protrude through the structural floor 75 mm to 100 mm (3 to 4-inches) above finished floor.
8. Cable Trays and cable runways within the ceiling shall protrude into the room 25-75 mm (1-3 in), without a bend, and above the 2.4 m (8-ft) level.

Figure 2. Typical Telecommunications Room Layout – Overhead Cable Trays



1. Cable Runway 610 mm W x 64 63.5 mm H x 3 m H (24" x 2. 5" x 10'L) Sections.
2. Equipment Rack is 610 mm W x 610 mm D x 2.2 m H (24"W x 24"D x 86"H).
3. Vertical Cable Manager is 254 mm W x 330 mm D x 2.1 m H (10"W x 13"D x 84"H).
4. Cable Runway shall have a Cable Dropout (Waterfall) where the cable exits the runway.

Figure 3. Typical Telecommunications Room Layout – Power Systems



208V AC at 30 amps with L6 Type Receptacle. Each circuit should be from separate source. Outlets should be mounted on Rack 1 m (36-inches) from finished floor.

120v AC at 20 amps. Each circuit should be from separate source. Outlets should be mounted on Rack 1 m (36-inches) from finished floor.

120v AC at 20 amps. Each circuit should be from separate source. Outlets should be mounted 1.8 m (72-inches) from finished floor.

120v AC at 15 amps service outlet. Each circuit should be from separate source. Outlets should be mounted 457 mm (18-inches) from finished floor.

Wall Phone should be mounted 1.2 m (48-inches) from finished floor.

Ground all Equipment Racks, and Cable Runway to the Ground Busbar. Ground busbar shall be connected to the building grounding electrode and structural steel.

Bonding Conductor (BC) shall be 6 AWG and must be routed with minimum bends or changes in direction.