IU Building Telecommunications Design Guidelines

COMMUNICATIONS (Includes Information Outlets and Telecommunications Rooms)

This guideline is intended for architectural design as it pertains to telecommunications infrastructure on at Indiana University. The telecommunications system herein specified provides for voice, data, video and other low voltage signaling functions (such as for energy management and security systems) through twisted pair, fiber optic, and coaxial cable. The system shall provide acceptable outlets for any telecommunication device, which requires connection to other devices, networks or information services serving general university needs.

These requirements are stated generally because of rapid changes in technology; University Information Technology Services Telecommunications and Networks staff must be actively involved in a review and advisory capacity from inception through construction with contacts available through the University Architect's Office and through commreq@iu.edu. Greater detail is provided in the Appendices to this document and in the Division 27 Communications specifications document.

The building telecommunications room (MDF/IDF-1/BDF) houses the necessary hardware to provide cross connection between the outside plant cables and the inside backbone cabling and may also serve as an IDF-2. Floor telecommunications rooms (IDF-2) house horizontal wiring and network equipment in climate controlled secured spaces. Main and floor telecommunications rooms room should be sized at a minimum of 100 sf with no dimension less than eight (8) feet. However, depending on the amount of stations served and equipment required, the room may need to be significantly larger. All telecommunications rooms should be vertically stacked within multi-floor buildings.

Station communications design is based on 'one Information Outlet per workstation', as defined under "Information Outlet Types at IU" in Appendix J. Therefore the components selected for an individual workstation information outlet should reflect the port needs, by type and quantity, of the intended and possible future users of a given outlet. All equipment working from a given information outlet must be located in the same room as the outlet.

The horizontal (station) cabling extends from the work area information outlet/connector to the horizontal cross-connect in the telecommunications room. The maximum horizontal data cable length shall be 90 m (295 ft). The maximum horizontal cable link length is based on a maximum length of 5 m (16 ft) of work area line cord; therefore no information outlet will be installed such that the intended workstation or device cannot be reasonably reached by a 16 ft cord.

==========

IU Building Telecommunications Design Guidelines

APPENDIX J

PURPOSE

This document is intended to serve as a guideline for architectural design as it pertains to telecommunications infrastructure at Indiana University. Greater detail is provided in the University Information Technology Services document which is downloadable from the University Architects office website at http://www.indiana.edu/~uao/, labeled under "Contracts/Standards" as "Communications Systems – Structured Cabling - Division 27".

GENERAL

Telecommunications and computing requirements as described herein for each area have been reviewed and approved by representatives of the technologies at both the campus and system levels. In some cases these requirements are stated generally due to rapid changes in technology. Therefore, University Information Technology Services Telecommunications and Networks staff must be actively involved in a review and advisory capacity from inception through construction.

Design architects, engineers, and eventually, contractors are expected to propose designs and build in accordance with the guidelines and requirements stated herein. Exceptions to any of the guidelines and the Division 27

The design architect shall schedule regular design progress meetings with the University Information Technology Services Telecommunications Plant representative, a University Information Technology Services Network representative, and a university Engineering Services representative. These linkages shall be made through the University Architect's Office and through commreq@iu.edu.

Telecommunication system herein specified provides for voice, data, video and other low voltage signaling functions (such as for energy management and security systems) through twisted pair, fiber optic, and coaxial cable. The system shall provide acceptable outlets for any telecommunication device, which requires connection to other devices, networks or information services serving general university needs.

Telecommunication design shall comply with Federal and State codes, regulations, and standards with variances adopted as standards by Indiana University and the State of Indiana. Applicable state and national standards include the latest editions of:

ANSI/NFPA 70 National Electrical Code with Indiana Amendments, latest edition
BICSI CO-OSP Customer Owned Outside Plant Manual
BICSI 11thth Edition Telecommunications Distribution Methods Manual
BICSI 2nd Edition Customer Owned Outside Plant Design Manual
EIA Standard EIA-230 - Color Marking of Thermoplastic Wire
FCC Rules and Regulations

Indiana Administrative Code, Title 675, Article 22, Indiana Fire Prevention Codes
Joint Commission Accreditation of Hospitals Code
J-STD-607-A Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
National Electrical Safety Code
NFPA 101: Life Safety Code
REA Standards for Engineering, Construction, and Installation
TIA 526-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant – OFSTP-7
TIA 526-14-A Optical Power Loss Measurements for Installed Multimode Fiber Cable Plant – OFSTP-7
TIA 568-C Commercial Building Telecommunications Cabling
TIA 569-B Commercial Building Standard for Telecommunications Pathways and Spaces
TIA 598-C - Optical Fiber Cable Color Coding
TIA Standard ANSI/TIA/EIA-607-A - Commercial Building Grounding and Bonding Requirements for Telecommunications
TIA 604 Standards on Fiber Optic Connector Intermateability
TIA 606-A Administration Standard for Commercial Telecommunications Infrastructure Standard
TIA 758-A Customer Owned Outside Plant Telecommunications Cabling Standard
TIA Telecommunication Systems Bulletin TSB67 - Transmission Performance Specifications for Field Testing of Unshielded Twisted-Pair Cabling Systems
TSB-140 Additional Guidelines for Field Testing Length, Loss and Polarity of Optical Fiber Cabling Systems

TOPOLOGY

Horizontal cabling shall be installed in a star topology, with each work area information outlet terminated to a horizontal cross-connect in a telecommunications room via horizontal cable.

Station communications design is based on ‘one information outlet per workstation’, as defined under “Information Outlet Types at IU”. Therefore the components selected for an individual workstation information outlet should reflect the needs of the intended and considered future users of a given outlet.

Due to the need to maintain a secure and manageable campus network, as well as the need to maintain location records of information outlets and equipment associated with them for E911 response databases, all equipment working from a given information outlet must be located in the same room as the outlet; a switch may not serve equipment in more than one room.

Large classrooms should be routed to Telecommunications Rooms or served with wireless facilities where practical.

Communications data switching can under certain circumstances be supplied from an in-room switch to individual stations, or run back to a wiring closet via horizontal cabling

(preferred). In-room switches are allowed only for lab-type settings or temporary work clusters. Any application of an in-room switch must be approved prior to design and implementation by the Indiana University Technology Services (UITS) Network group. Those not approved will not be connected to the University data network. Further information on this topic may be obtained the Indiana University Bloomington Network Operations Center at noc@indiana.edu.

TELECOMMUNICATIONS ROOMS, GENERAL

Architects/engineers must prepare detailed layout diagram/drawing(s) for the telecommunications equipment rooms in each building in a project, such drawings to be included in bid and construction documents. Drawings should include locations, footprints, and identification of all telecom related and non-telecom related materials, equipment, devices, and structures which occupy space in the telecommunications equipment rooms, high voltage electrical gear adjacent to the telecommunications equipment rooms, and indicate clearances of telecom items from all such objects. Such drawing(s) must be included as part of the bid and construction documents. A simple example of a layout drawing is included in this document and indicates minimum clearance requirements allowed for worker convenience and safety.

All telecommunications rooms should be designed to the two rack standard, whether one or two racks are initially installed, with the exception of small buildings where the installation of large quantities of wiring and devices is not possible. In such small buildings, design would be handled on a case by case basis, with approval required by the appropriate Indiana University UITS representative.

Telecom rack layout drawings must also be included in bid and construction documents. The rack layout drawings provided in this document, and on the Division 27 document provided on the University Architect's website, illustrate the specified arrangement of components in the telecom equipment racks. With over 800 such rooms to manage on the largest IU campus, the uniform arrangement is an important step in efficiency for those who provide ongoing service orders, repair, and upgrades to the University telecommunications systems. Examples of rack layout drawings are included in this document, and may be requested in CAD form.

Very small buildings with fewer than 20 stations may have another option than a large telecom room. Such option may be discussed the appropriate UITS representative during design.

In order to maintain network security, all telecommunications rooms must be able to be locked with a telecommunications key core and cardkey system and must not be accessible to any individuals who are not granted access to telecommunications equipment rooms.

Telecommunications rooms should not house systems other than telecom systems; servers, security system monitors, fire alarm monitors, IP camera monitoring systems, and similar systems requiring access by non-UITS personnel must be located in other non-telecom spaces.

Access panels for other building systems should not be located in telecommunications room.

Conduit placement with telecommunications rooms must not interfere with working space clearances.

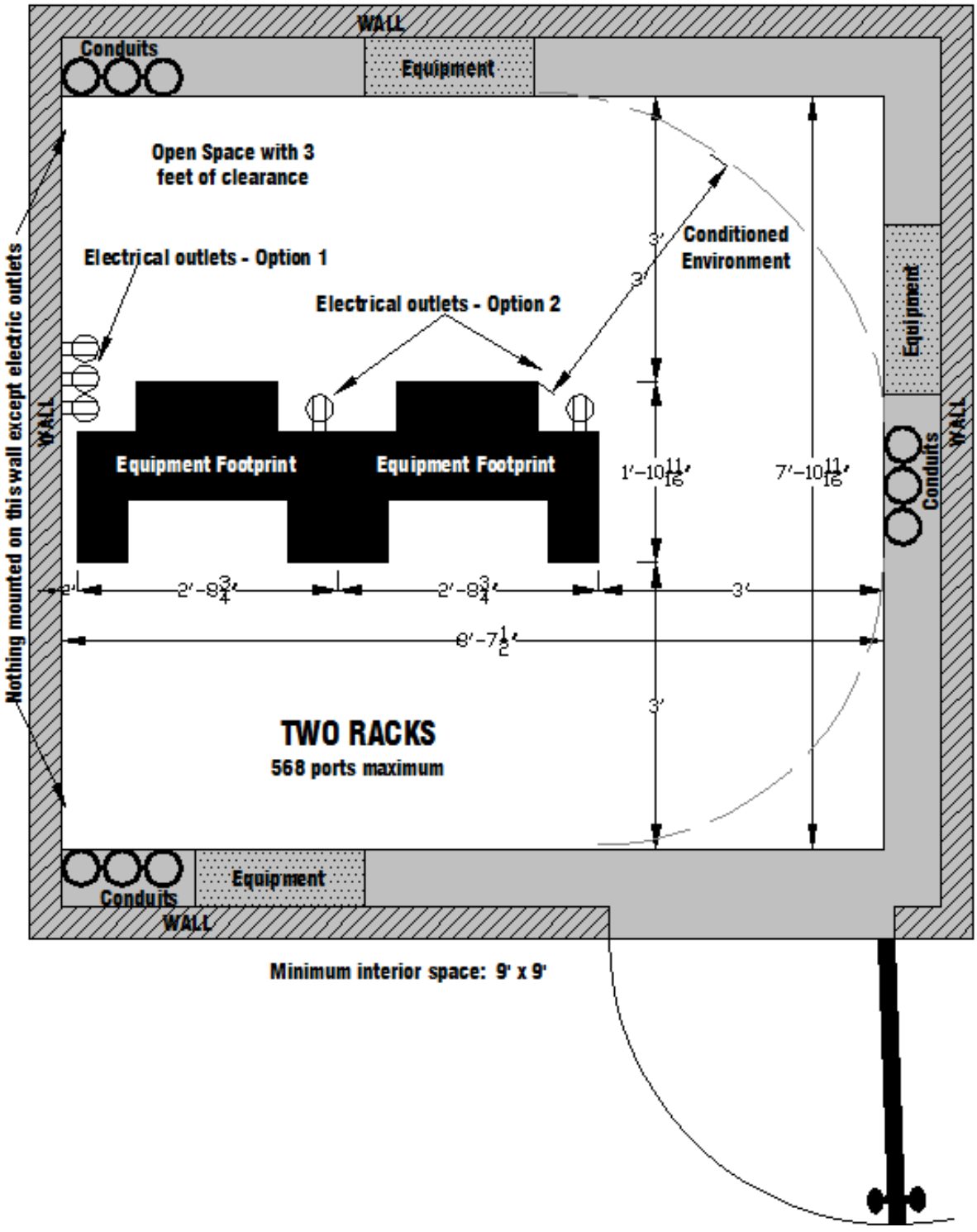
MAIN BUILDING TELECOMMUNICATIONS ROOM (MDF/IDF-1/BDF)

The primary function of the main building telecommunications room is to house the necessary hardware to provide cross connection between the outside plant cables that enter the building from the campus communication distribution network and the inside backbone cabling. Room should be sized at a minimum of 100 sf with no dimension less than eight (8) feet; this minimum space requirement is not negotiable.

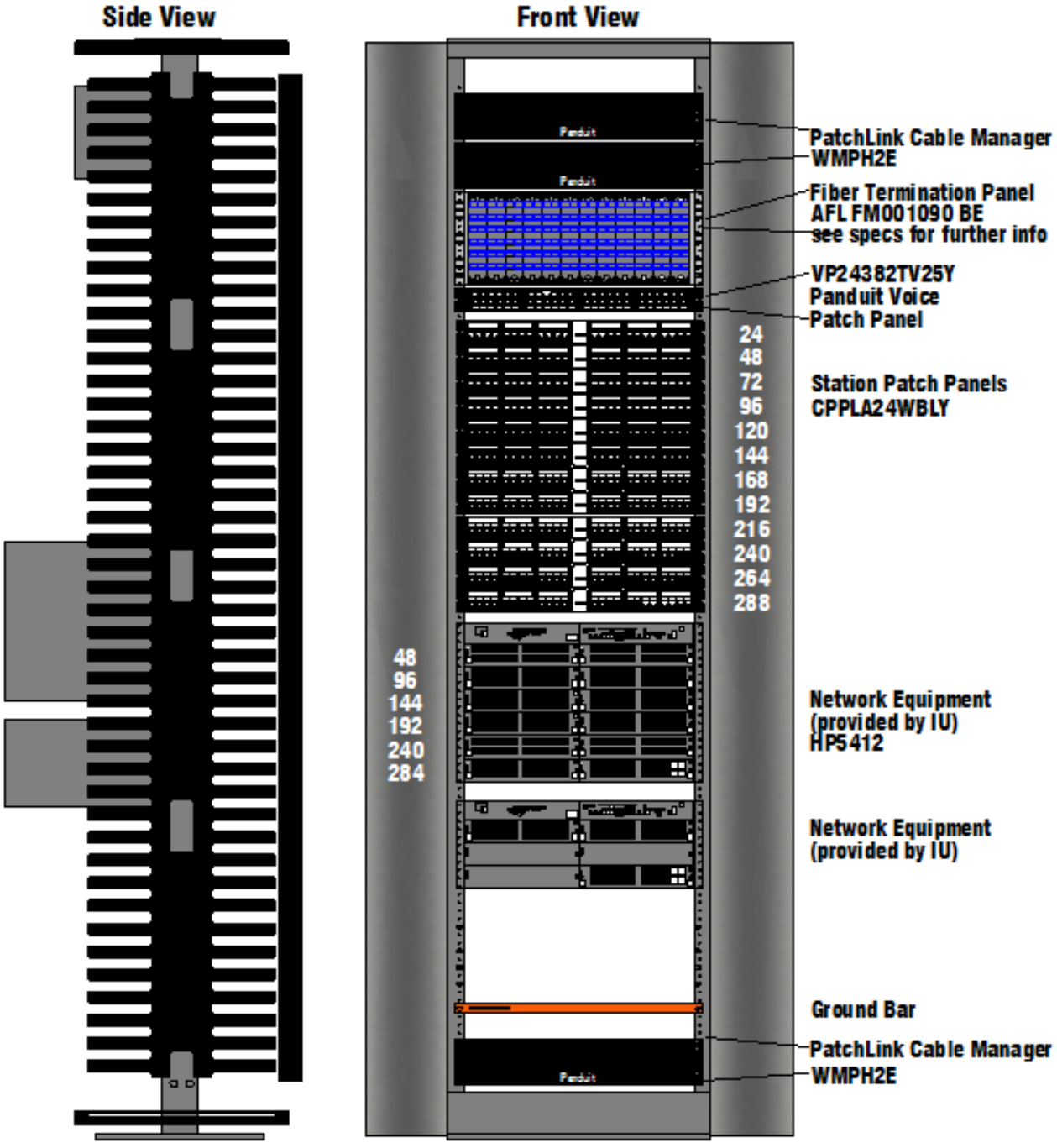
The main telecommunications room may also serve as a floor telecommunications room (IDF-2). If so, then the room should be sized by appropriate UITS Telecommunications personnel on a case-by-case basis, but with no dimension less than nine (9) feet. If additional equipment, such as coaxial cable amplifiers and splitters are to be housed in the room, then additional floor and wall space must be added according to the space requirements of that equipment and associated cabling and mechanical requirements.

The design must comply with ANSI/TIA/EIA-569 standard regarding the requirements and recommendations for separation of copper telecommunication cabling from sources of electromagnetic interference.

IDF ROOM - RACK LAYOUT

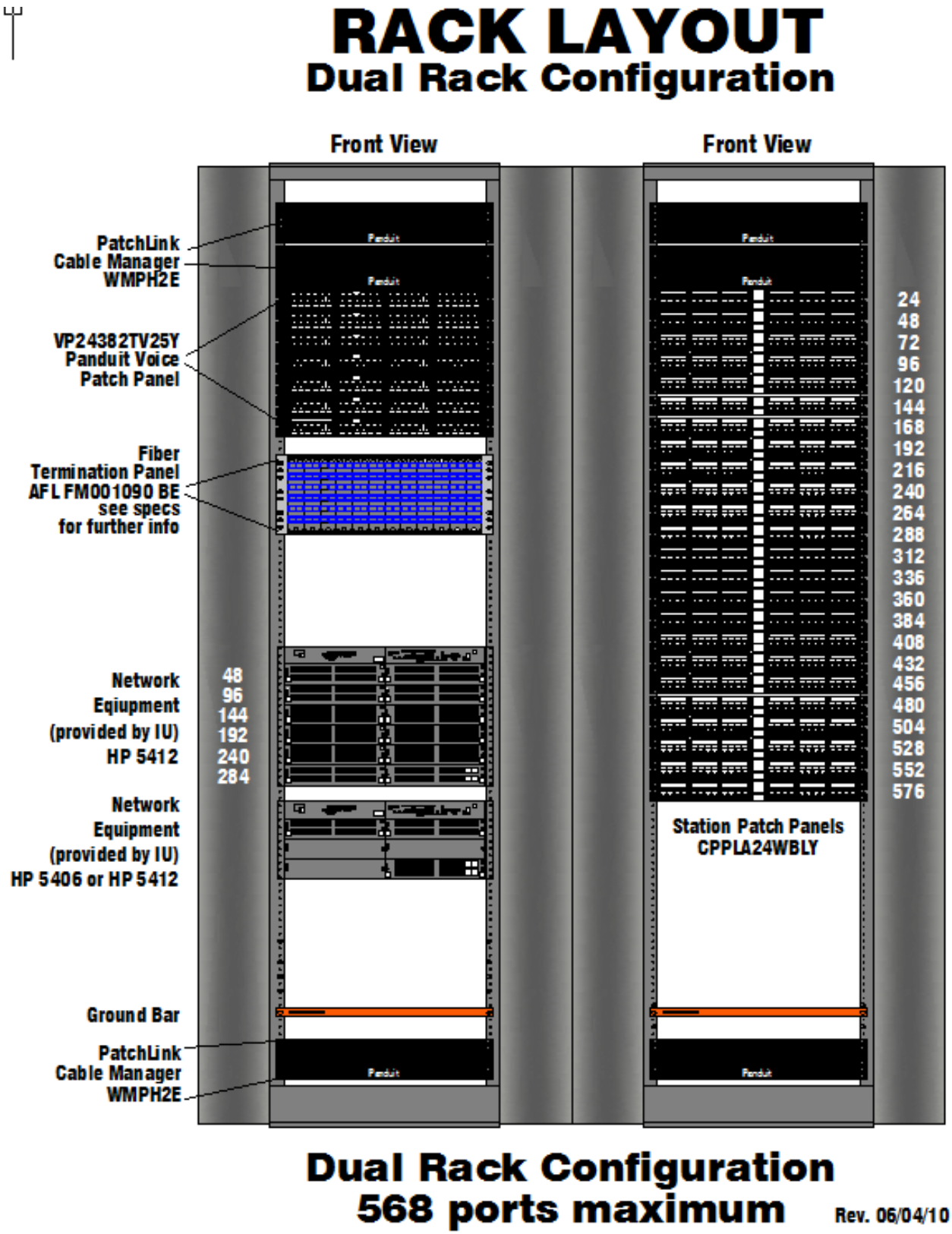


RACK LAYOUT
Single Rack Configuration



Single Rack Configuration
284 ports maximum

Rev. 06/04/10


RACK LAYOUT
Dual Rack Configuration
Front View
Front View
PatchLink
Cable Manager
WMPH2E
VP24382TV25Y
Panduit Voice
Patch Panel
Fiber
Termination Panel
AFL FM001090 BE
see specs
for further info
Network
Eqiupment
(provided by IU)
HP 5412
48
96
144
192
240
284
Network
Equipment
(provided by IU)
HP 5406 or HP 5412
Ground Bar
PatchLink
Cable Manager
WMPH2E
Panduit
24
48
72
96
120
144
168
192
216
240
264
288
312
336
360
384
408
432
456
480
504
528
552
576
Station Patch Panels
CPPLA24WBLY
Dual Rack Configuration
568 ports maximum
Rev. 06/04/10

FLOOR TELECOMMUNICATIONS ROOM (IDF-2)

The primary function of a floor telecommunications room is the termination of horizontal and backbone cables onto compatible connecting hardware, as well as splice closures, grounding and bonding facilities, and protection apparatus where applicable.

A floor telecommunications room must also provide a controlled environment to house telecommunications equipment such as data networking electronic equipment, campus video, carrier equipment and Voice Over Internet Protocol (VOIP) equipment. The telecommunications room provides for the administration and routing of equipment cables/cords from the horizontal cross-connect to the telecommunications equipment.

A floor telecommunications room should be sized at a minimum of 100 sf with no dimension less than eight (8) feet; this minimum space requirement is not negotiable. If additional equipment, for example coaxial cable amplifiers and splitters, are to be house in the room, then additional floor and wall space should be added according to the space requirements of that equipment and associated cabling and mechanical requirements.

The floor telecommunications room should be located on the same floor as and centrally located to the work areas served. In a large building, more than one telecommunications room may be necessary to keep horizontal cabling runs within the specified lengths. In small buildings, a telecommunications room may serve multiple small floors if approved on a case-by-case basis by the appropriate UITS design representative, with the requirement that all other design criteria are met.

All telecommunications rooms should be vertically stacked within multi-floor buildings.

The design must comply with ANSI/TIA/EIA-569 standard regarding the requirements and recommendations for separation of copper telecommunication cabling from sources of electromagnetic interference.

TELECOMMUNICATIONS ROOMS SECURITY

Telecommunications rooms will utilize the following security devices to provide controlled access and video/audio monitoring. Complete design should be coordinated with the appropriate UITS representative. Associated costs are project costs and are to be provided as part of the project.

Access Control

The following devices support multiple card formats:

Open Option, Inc. SSP-D2 Intelligent Two Door Controller
Open Option, Inc. RSC-1 Single Reader
Open Option, Inc. RSC-2 Dual Reader

XceedID XF2100 Mid-Range Reader

Telecom room door security components and installations must be approved by and coordinated with the appropriate Indiana University Building Systems division representative. See http://www.indiana.edu/~phyplant/building_systems.html for contact information.

Network Cameras

A network based security camera will be mounted inside Telecommunications Rooms, mounted on ceiling or on the wall to monitor persons entering and leaving the room. Each device will require a Category 6e station wire terminated on a single port Information Outlet for each device, mounted at 7'2" aff unless noted otherwise. Cameras may be requested for other locations within the building as well. Examples of acceptable cameras are:

Axis 216FD/216FD-V Network Cameras (power over Ethernet)
For use in normal lighting conditions

Axis P3301/-V Fixed Dome Network Cameras (power over Ethernet)
For use in areas where extreme light changes can cause picture wash out, such as might be experienced around glass entryways or opened overhead doors

Axis 225FD Network Camera (power over Ethernet)(outdoor camera)
An environmental mini-dome camera for outdoor use

Exterior cameras mounted within 6 feet of a lightning ground or mounted on metal that can conduct lightning are required to be protected.

PATHWAYS

The size of station device boxes are defined in the specifications available on the UAO website. The telecommunications raceway system must be specified such that during installation, cable is not subject to sharp or binding edges, as well as large enough to accommodate all of the intended telecommunication services materials plus 30% growth.

The pathways and spaces shall be designed and installed to support horizontal cabling in accordance with the requirements of ANSI/TIA/EIA-569-A.

BACKBONE CABLING

Cabling from the Main Telecommunications Room (MDF, BDF, IDF-1) to each Telecommunications Room (IDF-2) is considered as backbone/riser cable.

Splices in backbone cable runs are not permitted. Wiring must be continuous from connecting block to connecting block.

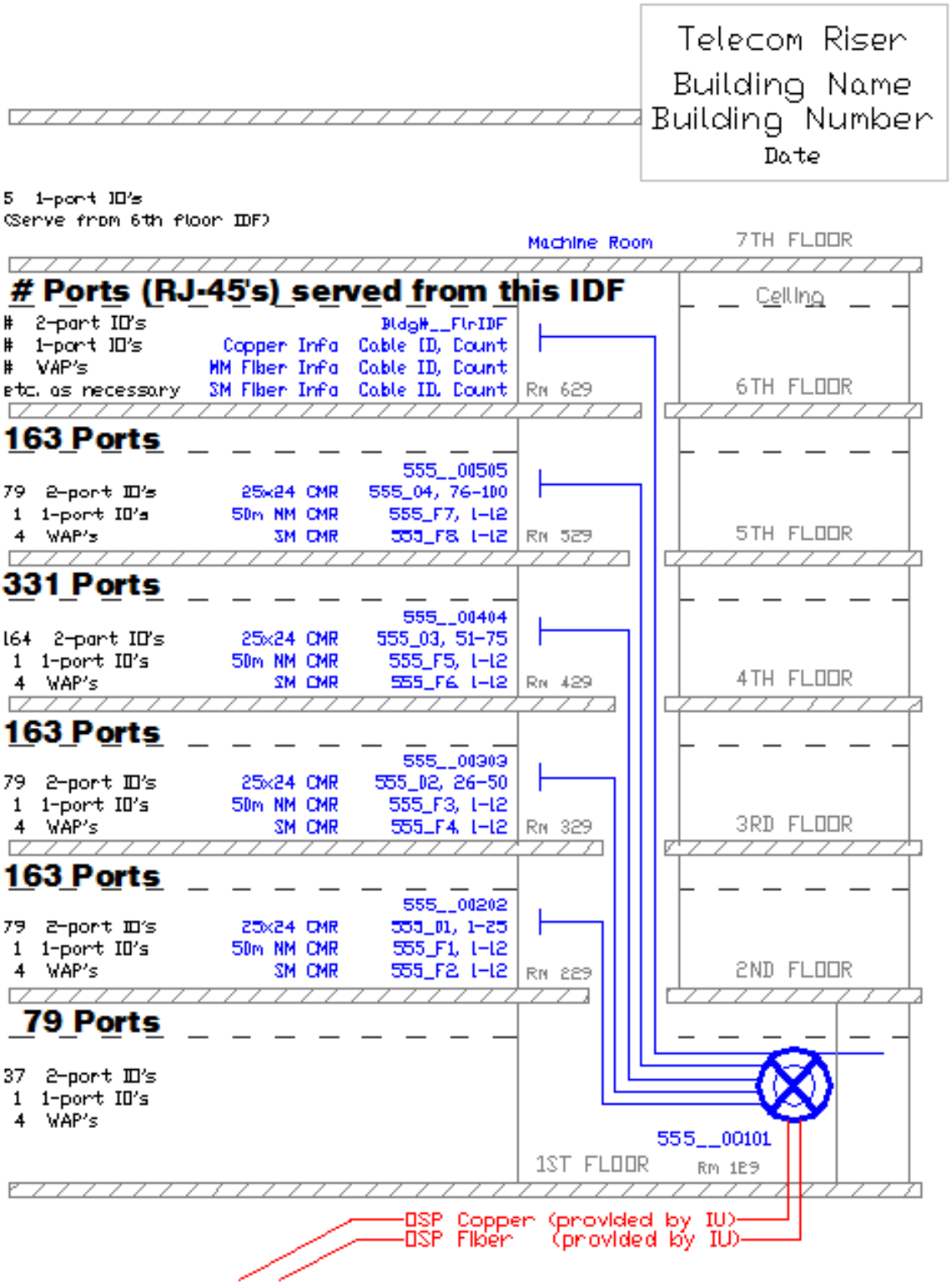
The copper intra-building cabling and the riser cabling shall be in agreement with ANSI/TIA/EIA-568 Category 3 requirements.

The design architect/engineer will prove a summary sheet with Information Outlet counts by type, port counts by type, and total ports per serving IDF, as shown in the following example.

A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
					*= D * E*	*= SUM(F)*	
FLOOR	**SERVED FROM**	**IO TYPE**	**IO TYPE (# ports)**	**# IO's**	**# PORTS**	**IDF TOTAL PORTS**	**INSTALLED RACKS**
7	00606	ELEV	1	5	5	-----	-----
6	00606	STD	2	79	158	-----	-----
6	00606	WALL	1	1	1	-----	-----
6	00606	WAP	1	4	4	-----	-----
SUM	-----	-----	-----	-----	-----	**168**	1
5	00505	STD	2	79	158	-----	-----
5	00505	WALL	1	1	1	-----	-----
5	00505	WAP	4	1	4	-----	-----
SUM	-----	-----	-----	-----	-----	**163**	1
4	00404	STD	2	163	326	-----	-----
4	00404	WALL	1	1	1	-----	-----
4	00404	WAP	4	1	4	-----	-----
SUM	-----	-----	-----	-----	-----	**331**	2
3	00303	STD	2	79	158	-----	-----
3	00303	WALL	1	1	1	-----	-----
3	00303	WAP	4	1	4	-----	-----
SUM	-----	-----	-----	-----	-----	**163**	1
2	00202	STD	2	79	158	-----	-----
2	00202	WALL	1	1	1	-----	-----
2	00202	WAP	4	1	4	-----	-----
SUM	-----	-----	-----	-----	-----	**163**	1
1	00101	STD	2	37	74	-----	-----
1	00101	WALL	1	1	1	-----	-----
1	00101	WAP	4	1	4	-----	-----
SUM	-----	-----	-----	-----	-----	**79**	1

"IO" = Information Outlet

The design architect/engineer will provide a riser diagram which indicates port counts, along with cable types, sizes and counts, developed in conjunction with the appropriate UITS representative. This diagram will be part on the bid documents and construction specification drawings.



HORIZONTAL CABLING

The horizontal cabling is the portion of the telecommunications cabling system that extends from the work station information outlet/connector to the horizontal cross-connect in the telecommunications room. The horizontal cabling includes horizontal cables, information outlet/connectors in the work area, and mechanical termination equipment in the telecommunications room.

In addition to satisfying today's telecommunications requirements, the horizontal cabling should be planned to reduce on-going maintenance and relocation, and should also accommodate future equipment and service changes. After construction of the building, the horizontal cabling is often much less accessible than the backbone cabling. The time, effort, skills and subsequent costs required for changes can be extremely high. In addition, access to the horizontal cabling frequently causes disruption to occupants and their work.

These factors make the choice and layout of horizontal cabling structures very important to the design of the associated building structures. Consideration should be given to accommodating a diversity of user applications in order to reduce or eliminate the probability of requiring changes to the horizontal cabling as user needs evolve.

Horizontal cable length is the distance termination to termination, that is, from the mechanical termination of the media at the horizontal cross-connect in the telecommunications room, to the terminations on the information outlet/connector in the work area. Hence path layout for horizontal cabling should be made with reference to total cable length, rather than simply linear measurements.

The maximum horizontal cable distance for a Category 6e system shall be 90 m (295 ft). Any horizontal station wiring run longer than this will not be accepted by the University. Splices in horizontal cable runs are not permitted. Wiring must be continuous from outlet to connecting block.

All horizontal cabling from a given room shall terminate in the same telecommunications Room.

INFORMATION OUTLETS (IO’s)

An Information Outlet as described below and used in this document is defined as "providing access to all available communication media: twisted pair, coaxial cable, and in the future fiber. Thus voice and data are the basics of an outlet; if optional video and fiber optic services are required, they shall be so indicated in individual room or area descriptions.

The maximum horizontal cable length is based on a maximum length of 5 m (16 ft) of work area cord. Therefore no information outlet will be installed such that the intended workstation or device cannot be reasonably reached by a 16 ft cord.

Information outlet assemblies shall be located in fully accessible, permanent locations such as building columns and permanent walls. Multi-user information outlet assemblies shall not be located in ceiling spaces or in any obstructed area.

Gang assemblies will require minimum 2-1/8" deep boxes to accommodate the IO assemblies and bending radius of horizontal wiring.

See the list of "Information outlet Types at IU" in this appendix.

DESIGN DRAWINGS

Design drawings shall include, but not be limited to:

1. Backbone cable routing and schematic riser diagram, including:
   1.1. Backbone cable types and sizes
   1.2. Information Outlet count, by type, by IDF
   1.3. Total port count (RJ45's) by IDF
   (see example)
   (telecom plans will not be approved without this diagram, updated as necessary)
2. Telecommunication room locations, layouts, and details
3. Conduit / cable tray routing, elevations in relation to other mechanicals and building structures, sizes, and pull box and access point locations
4. Other supporting structures for telecommunications cabling
5. Grounding schematic for telecommunications rooms
6. Information Outlet locations and types

SPECIFIC TELECOM ROOM REQUIREMENTS

1. Rooms should be located such that horizontal station cabling runs from mechanical termination at the information outlet to mechanical termination in the serving equipment room will not exceed a maximum cable length of 295 feet.

2. Rooms must be clear of mechanicals such as ventilation ducts, water, sewer, or steam pipes, and high voltage electric

3. Do not locate near alternating current (AC) switch gear as defined in NEC Article 110 and referenced sections.

4. Minimum room height: 8'6"; no ceiling (clear to deck)

5. Minimum door dimensions: 36"w and 80"h

6. 4' x 8' plywood backboard, 3/4" thick, painted with a light colored fire retardant paint, shall be mounted 4" AFF on all walls.

7. Control of heat and humidity essential, to be maintained between 64^{o}F and 75^{o}F and between 25%RH and 55%RH non-condensing.
7.1. Current network equipment generates an average 575 btu per 24 data ports installed to a maximum 6800 btu per HP5412 chassis.
7.2. Design cooling to maximum number of current and future data ports that can be installed, in addition to other heat generating equipment to be installed in the telecommunications room.
7.3. HP5406 chassis may be used in smaller applications or as supplement to the 5412 chassis; design cooling to accommodate the cooling requirements of all equipment expected to be installed in the room.
7.4. Consideration should be given to the critical nature of extended telecommunications services to the building, to determine if telecommunications room(s) cooling should be connected to the building emergency power source(s).

8. Telecommunications Room key cores and security systems shall be included as part of the project.
8.1. Floor Telecommunications Rooms and Main Building Telecommunications Room key sets and security systems should be the same.
8.2. Campus telecommunications personnel shall approve key/locking arrangements.

9. Fluorescent lighting with a minimum of two fixtures should provide a minimum lighting level of 30-40 fc.
9.1. Emergency lighting should be provided for telecommunications rooms.

10. Provide duplex outlets for task lighting and tools.

11. Depending on the size of the project and the number of stations served from each telecommunications room, provide one or two (or more) equipment racks with vertical wire management, 7' high and to accommodate 19" bay-mounted equipment in each telecommunications room.
11.1. Equipment racks must be attached to floor with an overhead runway to a wall; additional racks may be required on specific projects.

12. At the network equipment rack location, standard 18” height, provide one 120v 20 amp duplex outlet (surge suppression type) on circuit; isolate feed from motors, AC switch equipment, lighting circuits; minimize noise and interference.
12.1. This outlet should be connected to the building emergency power source(s).

13. At the network equipment rack location, standard 18” height, provide two (2) 208v circuits, each terminated on NEMA L6-20R outlets.
12.1. These outlets should be connected to the building emergency power source(s).

14. The riser system (Main Telecommunications Room to each Telephone Room, or, IDF-1/BDF to IDF-2) will contain any combination of the following:
14.1. Category 3 shielded UTP for voice, fax and modem use
14.2. Fiber optic 50 micron multimode cable
14.3. Singlemode 8.3 micron cable for data and video use
14.4. and possibly coaxial cable for video use. The amount of each type cannot be stated until the design stage of the riser system.

15. Provide ladder type cable tray to surround room at a minimum height of 7' 2"AFF from the bottom of the tray, and with a minimum clearance of 12" above the tray
15.1. Include a section of 12" wide or wider ladder rack extending from the cable tray to each individual equipment rack.
15.2. All equipment racks and raceways shall be bonded per NEC.

16. A TGB (Telecommunications Ground Bus bar) shall be located in each Telecommunications Room and shall be tied back to the TMGB (Telecommunication Main Bus bar located in Main Telecommunications Room).

INFORMATION OUTLET (IO) TYPES AT IU

STANDARD IO: Two Category 6e station cables terminated onto two Category 6e RJ-45 modules in a double or single gang configuration installed at the same height as 120 volt AC outlets (normally 18" above finished floor).

Standard IO with Video: Two Category 6e station cables terminated onto two Category 6e RJ-45 modules for voice, and one RG-6 coaxial cable terminated on a F connector module in a double gang configuration installed at the same height as 120 volt AC outlets (normally 18" above finished floor.

Emergency Phone Jack: One station cable (inside building) or one multi-pair buried drop (outside, protected) terminated on an RJ-45 surface mount jack, mounted inside of phone base.

Elevator Phone Jack: One station cable terminated to one RJ-11 or RJ-45 (to be coordinated between UITS and elevator installer) surface mount jack, mounted in outlet box adjacent to elevator control box.

Wall Jack: One Category 6e station cable terminated on one (1) RJ-45 jack for voice. Wall mounted telephones require a special wall telephone jack that provides mounting lugs for the telephone and an eight position jack. The outlet box for this installation is a 2 gang box with a single gang plaster ring and will be positioned 54" A.F.F. to the center of the outlet box

WAP Jack (Wireless Access Point): One Category 6e data station cable terminated onto one RJ-45 module, in a single or double gang configuration, typically installed 7’ in height.

Modular Furniture IO: Category 6e data cables installed into Category 6 data modules installed into a modular furniture bezel. Quantities to be determined by individual needs. Height will be determined by the furniture. Contact commreq@iu.edu for additional information.

Advanced User IO: Multiple Category 6e station cables terminated into Category 6 RJ-45 jacks, designed to meet TIA/EIA-568-B.2-1 Category 6 standard, in single gang or double gang configurations installed at the same height as 120 volt AC outlets (normally 18" above finished floor). Quantity of RJ-45 jacks and configurations to be determined as part of the design process and in conjuction with the proper UITS Telecommunications representative.

Note: *RJ45 jack outlets are to be wired to the TIA/EIA 568A wire map standard.*

APPENDIX: OUTSIDE PLANT CONDUIT SYSTEM

For convenience, this section references information from the Telecommunications Industry Association TIA-758 Customer-Owned Outside Plant Telecommunications Infrastructure Standard. Please refer to the document for further details.

Conduits: Typically, Schedule 40 nonmetallic that meets NEMA standard TC-2. The outside of conduits installed into manholes should be sealed against moisture and dirt penetration.

Where possible, conduits should penetrate manhole at precast knockout locations or at same height. Conduits should NOT penetrate manholes in the collars, in the middle of side walls, or in the case of existing manholes, at locations blocked by existing cables. Conduit terminations should not extend beyond the manhole walls. Conduit penetration locations should allow for easy racking of cables around the walls.

Conduits should be installed at a minimum depth of 30", surrounded with granular backfill material for a minimum of 2" all sides and capped with a minimum of 4" of concrete. An orange warning tape should be placed above the concrete cap and 18" from ground level. Mule tape should be installed in all conduits.

One conduit per run should have a conductive wire install for the purpose utility locates.

Pulling points: A manhole or handhole. Pulling points should be located for safe and easy access by personnel and equipment; the location should allow for necessary water pumping operations.

Manhole: Standard manhole size is 12'x6'x7' Type A for inline, Type J for corners in manhole runs, with 32" lid. Manholes are typically used for splice points and pulling points. Manholes shall have corrosion-resistant pulling irons, grounded cable racks, and ladder. The floor should have a sump for drainage.

Handhole: Standard handhole size is a 4'x4'x4'concrete precast unit with sumphole; a 30"x4'x4' handhole may be used for one or two duct runs only and with prior approval by the appropriate University representative. Handholes are typically used as pulling points only. Handholes should be installed in a manner to provide adequate drainage.

Lengths: The section length of conduit between pulling points should not exceed 600 ft without prior approval of the appropriate University representative. Friction and tension design should not allow for pulling tensions on fiber optic cables of greater than 600 lbs.

Bends: Sharp bends, that is a bend with a radius of less than 10 times the diameter of the conduit, must NOT be utilized for conduits that will carry communications cables. Bends which reduce the inner diameter of the conduit are not permitted. The number of bends should be minimized; the total degrees of bend in conduit(s) between pulling points should not exceed 180 degrees.

Slope: Conduits should be installed to slope away from buildings and toward pulling points.

Duct Plugs: Conduits must be sealed to resist liquid and gas infiltration at all building entrance points and maintenance holes.

Innerduct: Innerducts will not be used unless specifically requested by the appropriate University representative.

Bridge crossings: Route design should avoid attachments to bridges and similar structures unless approved by the appropriate University representative.