

DIVISION 16**ELECTRICAL & COMMUNICATIONS****PART 1 - ELECTRICAL**

- 16.1. General Information** - This Division defines general design criteria that apply to the design of electrical systems at DFW Airport. Division 1 should be consulted for specific Airport regulations and standards that also apply.

The electrical design criteria in this section are organized into three (3) distinct divisions: interior electrical, exterior electrical and airfield electrical.

- 16.1.1. Short Circuit Study** - The available short circuit current shall be calculated using the "direct method" by IEEE 242 on all projects having services greater than 100 kVA at 480 volts or 50 kVA at 208 volts. The fault current shall be shown on the drawings at each applicable bus and should include the contributions from all premises motors, stand-by generators, and the utility power source.

- 16.1.2. Preservation of Power Quality** - All low voltage power and distribution system designs of facilities with computers and other sensitive electronic loads shall comply with IEEE 1100.

- 16.1.3. Harmonic Current Limits** - The harmonic current distortion of any individual device or piece of equipment specified in the design documents shall not exceed values given in IEEE 519.

- 16.2. Interior Electrical** - The information contained within this section applies to all electrical work inside of the building limit lines.

- 16.2.1. Conduit** - Conduit shall be galvanized rigid metal (RMC) or intermediate metal (IMC) steel except as follows:

- 16.2.1.1.** Electrical Metallic Tubing (EMT) may be used where permitted by code except where subject to mechanical or physical damage 6'-0" above floor, if exposed. EMT may not be used in concrete or underground. EMT fittings shall be steel compression type only.

- 16.2.1.2.** Direct buried metallic conduits require PVC coating or approved equal coating to protect against corrosion.

- 16.2.1.3.** PVC conduit, Schedule 40 or thicker, may be used underground, direct buried or concrete encased. Conduit bends shall be IMC, PVC coated except as follows:

- 16.2.1.3.1.** Two (2) inches or less, and runs less than 150 feet long, with two (2) or less ninety degree (90 degree) bends.

- 16.2.1.4.** Steel flex or liquid-tight flex (for damp or wet locations) shall be used for connection to all movable, rotating or vibrating equipment, including dry type transformers. Flex connection shall not be used as equipment grounding conductor.

- 16.2.1.5.** Flex metal or MC type cable, 6 feet or less in length, shall be used for connection of light fixtures above ceilings.

- 16.2.1.6.** All concrete encased PVC schedule 40 conduits shall have a minimum of 1 #3 rebar in each corner of duct, running parallel to the conduit runs.

16.2.1.7. Minimum conduit size shall be:

- ¾ inch for home runs and feeders
- ½" for branch runs

16.2.1.8. All RMC and IMC conduit couplings shall be threaded type only.

16.2.2. Wire - Copper shall be used for all wiring, except aluminum wire 1/0 and larger may be used for temporary service conductors.

16.2.2.1. Minimum size #12 AWG, except control wiring may be #16-#20 AWG depending on the application. All conductors #10 AWG and smaller shall be solid type unless used for control wiring. Wire sizes #8 AWG and larger shall be stranded construction. Control wiring shall be stranded.

16.2.2.2. Total voltage drop shall be less than five (5%) percent. Limit feeder drop to less than two (2%) percent and branch circuit drop to less than three (3%) percent.

16.2.2.3. All circuits serving "HID" lighting fixtures shall be limited to a loading of sixty (60%) percent or less of the "Full Load" capacity of the circuit (including circuit breakers, switches, relays, etc.). HID fixtures include high pressure sodium, metal halide and mercury vapor lamps.

16.2.2.4. All direct buried counterpoise group wire used at the Airport shall be #6 or stranded, tinned, soft drawn, copper wire conforming to ASTM #B-33.

16.2.2.5. Interior power wiring for power and lighting shall be color coded as follows:

<u>480Y / 277V, 3Ø, 4W</u>	<u>208Y / 120V, 3Ø, 4W</u>	<u>240 / 120V, 1Ø, 3W</u>
AØ - Brown	AØ - Black	AØ - Black
BØ - Orange	BØ - Blue	CØ - Red
CØ - Yellow	CØ - Red	N - White
N - Gray	N - White	Grnd - Bare
Grnd - Bare	Grnd - Bare	Iso. Grnd - Green
Iso Grnd - Green	Iso. Grnd - Green	

16.2.3. Panels and Switchgear - Panel main bus may be copper or aluminum. Panels shall have conductor color code identification.

16.2.3.1. Panel circuit breakers shall be bolt on type.

16.2.3.2. Fused switches shall utilize current limiting fuses with "rejection" type pins where applicable. A spare fuse panel and a set of three (3) spare fuses of each size used on a project will be furnished.

16.2.3.3. Freestanding switchboard construction shall be specified for bus sizes larger than 1200 amp.

16.2.3.4. Redundant services are available from the Airport electrical distribution system and are normally provided for Terminal Buildings, FAA Buildings, Emergency Facilities, Crash/Fire/Rescue Stations, Airport Trains, Central Utilities Plant and other critical use facilities. Other alternate emergency sources may be considered for true uninterruptible power supply. Terminal building service entrance switchgear is double ended drawout air circuit breaker type. Transformers, main breakers and bus on each side of the tie breaker is sized to serve the total service load. T.U. Electric provides the main services switches and transfer switch (circuit breakers). The owner and/or

tenant provide all distribution switchgear from this point to the building electrical systems.

16.2.3.5. Buildings not consisting of critical loads shall be served with single radial feed. The Designer should verify service type with Airport Maintenance Engineering.

16.2.3.6. Freestanding equipment shall be installed on concrete pad.

16.2.4. Service Entrance - Primary and Secondary service entrance conduits shall be concrete encased. Verify requirements for service entrance with Electric Company. The primary duct bank shall be marked with red dye.

16.2.5. Notify Electric Company if access to manholes or vaults is required.

16.2.6. Light Fixtures - Shall include interior, exterior attached to buildings, exterior steps, stairways and parking structures.

16.2.6.1. The Designer shall obtain a list of lamps from Airport Maintenance that are in stock and limit design to lamps that are currently being used for interior lighting. Requirement may be waived if special design warrants, subject to DFW Contact approval.

16.2.6.2. Do not specify ballasts that are manufactured exclusively for a particular fixture, or fixtures that require a particular ballast. Avoid use of unusual fixtures, tubes, voltages, et cetera.

16.2.6.3. Lighting system shall be designed in accordance with IES recommendations to provide an energy efficient system with minimum maintenance.

16.2.6.4. Battery (sealed, recombination lead calcium type) operated emergency lights and exit lights will be used to illuminate all means of egress, unless other stand-by power or redundant power systems are available.

16.2.6.5. Exit lights shall be installed on a dedicated circuit with no other equipment connected to it. Provide constant un-switched hot to keep battery charged if battery backup is provided. All exit lights shall be "LED" types with a minimum twenty (20) - year warranty.

16.2.6.6. Consider use of occupancy sensor controls and dimming for energy management.

16.2.6.7. Use double twin tube type compact florescent lamps in lieu of incandescent where low level down-lighting is required, and dimming is not required.

16.2.6.8. Long term lamp and fixture maintenance should be considered in location of all fixtures. Use very long life lamps in areas difficult to re-lamp and areas along roadways.

16.2.7. Metering - Revenue metering is provided by T.U. Electric. Provide a metering equipment enclosure in accordance with T.U. Electric requirements. Provide a voltmeter and ammeter for incoming services 1200 amp and larger.

16.2.7.1. In Terminal buildings, provide sub-metering for approximately each 30,000 square foot area (approximately one (1) gate). Provide two (2) sub-meters for each area, one (1) for lighting and one for remainder of load.

16.2.7.2. Meters shall be kilowatt-hour and kilowatt demand with pulse transmitter.

16.2.8. Distribution Transformers - Distribution transformers will be three (3) phase, 25 kVA, 120/208 volt or 277/480 volt, provided by T.U. Electric. Furnish equipment pads in accordance with T.U. Electric requirements.

16.2.9. Grounding - Consideration shall be given to local conditions affecting grounding methods. Ground resistance shall not exceed limits as established by IEEE for type of facility.

16.2.9.1. Ground rods shall be ¾" x 10' stainless steel, minimum.

16.2.9.2. All ground connections shall be bolted (where accessible) or by the exothermic process.

16.2.9.3. Exothermic welds shall be coated against corrosion where direct buried.

16.2.9.4. All premises ground rods or other NEC approved grounding electrodes shall be bonded together to form the grounding electrode system to limit the potential differences between them and their associated wiring system.

16.2.10. Lightning Protection - A Lightning Protection System shall be provided for all building structures on the Airport. The lightning protection system shall comply with the 1995 Edition of NFPA 780, Standard for the Installation of Lightning Protection Systems of the National Fire Protection Association. Installation shall be made under the direct supervision of a Certified Master Installer, whose certification has been granted by the Lightning Protection Institute (LPI). Except for cable fasteners, all components of the lightning protection system shall be listed and labeled by Underwriters Laboratories, Inc.

16.2.10.1. For additions to buildings already having a lightning protection system, provide lightning protection in the new construction only and bond to the existing system.

16.2.10.2. Upon completion of the work, the prime contractor is required to transmit on his letterhead an affidavit bearing the notarized signature of the LPI Certified Master Installer that the lightning protection system complies with NFPA 780 and, in building additions, that it has been bonded to the existing system.

16.3. Exterior Electrical - The information contained within this section applies to all electrical work outside of the building limit lines, excluding airfield lighting.

16.3.1. Exterior Lighting Systems - All airport light sources shall be aimed in a manner that will not interfere with FAA Air Traffic Control Tower operations or piloting activities. Where lighting sources are directed toward runway ends or FAA towers, they shall be shielded as may be necessary to deflect the light source down and away from those areas. Lighting systems shall be designed in accordance with IES recommendations to provide an energy efficient system with minimum maintenance.

16.3.1.1. Poles shall be located to provide adequate working clearance for maintenance without disrupting roadway traffic. Poles required to be installed in areas not accessible with bucket truck shall be equipped with mechanical fixture lifting device in accordance with Airport Standards. All high poles modified with fixture lowering devices shall be inspected by the manufacturer of the device. This manufacturer shall issue a certificate as to the proper installation to factory specification with an appropriate warranty period to cover installation and factory defects. The Board prefers a five (5) year warranty period.

16.3.1.2. Building or pole mounted fixtures shall be spherical shaped and have a bronze finish. All exterior lighting shall be high pressure sodium. The Designer shall obtain a list of lamps from Airport Maintenance that are in stock and limit design to lamps that are currently being used for exterior lighting. Requirement may be waived if special

design warrants, subject to DFW Contact approval.

- 16.3.1.3.** New underground lighting systems shall be installed in direct buried Schedule 40 PVC. Splices shall be made in pole base or concrete splice box with heavy duty traffic cover.
- 16.3.1.4.** Conduit bends shall be IMC, PVC coated, except as follows:
- Two (2) inches or less, and runs less than 150 feet long, with two (2) or less ninety degree (90 degree) bends.
- 16.3.1.5.** Do not specify ballasts that are manufactured exclusively for a particular fixture, or fixtures that require a particular ballast. Ballasts shall be located at the base of high poles rather than at fixture. Avoid use of unusual fixtures, tubes, voltages, et cetera.
- 16.3.1.6.** Conductor shall be copper and sized based on NEC recommended maximum allowable voltage drop.
- 16.3.1.7.** All ground connections shall be bolted (where accessible) or by the exothermic process. Considerations shall be given to local conditions affecting grounding methods. Ground resistance shall not exceed limits as established by IEEE Standard 142. All ground rods shall be stainless steel, 3/4" x 10' 0" minimum.
- 16.3.1.8.** An equipment grounding conductor shall be routed with the phase conductors and bonded to each lighting pole to facilitate the operation of the upstream over-current protective device. The earth shall not be used as the sole equipment grounding conductor.
- 16.3.1.9.** Fixture and system voltage shall match existing for maintenance purposes.
- 16.3.1.10. Anchor Bolts and Poles – Design Standards:**
- 16.3.1.10.1.** ACI 318, most current edition.
- 16.3.1.10.2.** AISC, most current edition.
- 16.3.1.10.3.** AASHTO, Specification for Design and Construction of Structural Supports for Highway Luminaries
- 16.3.1.10.4.** Corrosion Protection - Nuts and top ten (10) inches of anchor bolts shall be hot dipped galvanized. All base plates shall be exposed to air, no grout allowed.
- 16.3.1.10.5.** Anchorage - Anchor bolts shall have full embedment as required by ACI. Specify nut torque requirement.
- 16.3.1.11. Roadways** - The existing roadway lighting system is 480 volt, single phase, with power extending to pole bases underground in duct. Sleeves have been installed in anticipation of future Airport growth.
- 16.3.1.11.1.** Poles shall be weathering steel to match existing. Fixtures shall be spherical or for pre-arranged locations may be of the "Cobra Head" design similar to State Highway fixtures, except with a painted finish, base coat shall be zinc chromate. Provide conductor for each lighting circuit to facilitate remote control of street light circuits from central automation system in order to override photocell and reduce demand when time-of-day electrical rate is applied.
- 16.3.1.11.2.** Roadway lighting shall be per IES Type II or Type III with distribution obtained by reflectors or in some cases by refractors if approved by DFW Contact.

16.3.1.12. Parking Lot and International Parkway - Between taxiway bridges, lighting is supplied by 480/277 volt, 3 phase, distribution system. High mast poles (70 - 100 feet) are supplied with 3 phase, 480 volt, up the pole with 480 volt fixture load balanced between phases. For outside taxiway bridges, lighting is supplied by 480 volt, single phase, distribution system (i.e. 480 volt, 2 wire and ground wire).

16.3.1.13. Apron Lighting - This lighting shall be in accordance with IES Recommended Practice RP-14 "Airport Service Area Lighting" with the following exceptions:

16.3.1.13.1. The Airport design shall provide four (4) to eight (8) fixtures mounted on one (1) or two (2) precast cross members between two standards, sixty (60) feet above the apron, spaced at approximately one hundred (100) feet along the airside face of the Terminal building. Currently used fixtures are 1000 watt metal halide and 1000 watt high pressure sodium. New fixtures shall utilize high pressure sodium lamps. The floodlights are enclosed in spheres with wide and medium horizontal beam spread (up to 100 degrees). Vertical beam spread is minimum with cutoff.

16.3.1.13.2. General lighting near the Terminal buildings is specified at approximately two (2) maintained foot-candles.

16.3.1.13.3. In the service areas, approximately fifty (50) feet to three hundred (300) feet from Terminal buildings, average illumination levels, at five (5) feet above the apron are specified at three (3) to four (4) foot candles horizontal and seven (7) to nine (9) foot candles vertical. The uniformity ratio is in the range of 3:1 (average/minimum) and 6:1 (maximum/minimum). The fixtures have a specified cutoff at four hundred (400) feet from the Terminal building to prevent direct spill onto the taxiways. In addition, internal louvers shall be provided for maximum bare lamp shielding.

16.3.1.13.4. The Designer shall call for submittals of the manufacturer's lighting analysis to include point by point foot-candle calculations to demonstrate the proposal meets the design criteria. In addition, prior to the final acceptance, the Contractor must submit a report, of testing accomplished by an IES certified agency, showing that the installation complies with the specified criteria and the proposal calculated values. These tests shall indicate areas of unacceptable glare as indicated by FAA Air Traffic Controllers or pilots. All testing shall comply with IES recommendations. All adjustments in fixture aiming shall be accomplished by the Contractor at no additional cost to the Board.

16.3.2. Exterior Electrical Systems

16.3.2.1. Standard Lock Out Procedures - Standard electrical circuit lockout procedures are available from Airport Maintenance.

16.3.2.2. Utilities - Airport 25 KV, 3 Phase, Medium Voltage Distribution System is owned and maintained by Oncor Electric. The Designer shall confer with the DFW Contact and Oncor Electric to determine service arrangement for each project.

16.3.2.2.1. Redundant services are available and are normally provided for Terminal Buildings, FAA Buildings, Emergency Facilities, Crash/Fire/Rescue Stations, Airport Trains, and other critical use facilities. Other alternate emergency sources may be considered for true uninterruptible power supply.

16.3.2.2.2. All electrical distribution shall be underground.

16.3.2.2.3. Provide all ductwork, equipment pads and metering enclosures in accordance

with Oncor Electric specifications and standards.

16.3.2.3. Underground Electrical Circuits shall be installed in Schedule 40 PVC. Service entrance conduits shall be encased in concrete.

16.3.2.4. Conductors shall be copper with insulation suitable for wet locations, sized based on NEC recommended maximum allowable voltage drops.

16.3.2.5. Ground Connections shall be bolted (where accessible) or by the exothermic process. Considerations shall be given to local conditions affecting grounding methods. Ground resistance shall not exceed limits as established by IEEE Standard 142. Ground rods shall be $\frac{3}{4}$ " x 10' stainless steel.

16.3.2.6. Manholes and Handholes shall be provided with heavy duty traffic covers. All circuits shall be labeled with stamped brass tags.

16.4. Airfield Lighting - Runway and taxiway lighting and visual aids shall be designed based on the design standards and requirements of the FAA Advisory Circulars, as appropriately supplemented by the National Electric Code (NEC) as it pertains to vault work and the commercial power side of the vault equipment.

16.4.1. Lighting and Visual Aid Systems and Fixtures - System layout configuration and fixture utilization and design shall be specified by all current applicable FAA Advisory Circulars. Airport operated lighting systems shall be designed for the most critical operational criteria (CAT II/III).

16.4.1.1. In all specifications for lighting and electrical equipment, the item and manufacturer must be listed as approved for use by the FAA. In some instances, requirements above those required for FAA approval will be stipulated. These must be specified precisely; for example "Signs (L-858) - To withstand high wind velocity up to 200 mph regardless of location."

16.4.1.2. Fixtures and lamps shall be specified to match existing equipment whenever possible. Fixtures shall be installed on deep bases (cans) housing the isolation transformers. Inset (shallow) bases shall not be used unless approved by the DFW Contact. Runway Distance Remaining Signs and Taxiway Guidance Signs shall be internally lighted to match existing equipment.

16.4.2. Cable and Conduit - Direct burial cable is not permitted. All cables shall be placed in conduit (PVC Schedule 40 as minimum). Bends in underground conduit system are not permitted without a junction box. All cables shall be tagged in manholes with heat sealing tags, Scotch HB-21 or approved equal, imprinted with the circuit number on each side of L-823 connectors. 5KV series circuit cables shall be color coded as to circuit type (i.e. Runway CKT, Taxiway CKT, Sign CKT, etc.). Verify color coding with the Airport Maintenance Department.

16.4.3. Electrical Manholes, Junction Boxes, and Pull Boxes - These structures shall be located outside of runway and taxiway safety areas (as defined in AC 150/5300-13) where DFW Maintenance personnel can service them without closing runways or taxiways, if possible. They shall sufficiently be raised, where allowed, above the surrounding grade to prevent ponding water on the structure and the top cover sloped to drain. A concrete apron shall be constructed around all electrical manholes located in turfed areas. Particular attention must be given to storm water drainage plans to prevent placement of electrical structures in areas of channeled for drainage. They shall have all joints and openings completely sealed and vermin proof. Secure covers with bolts. Structures, covers and frames in the runway and taxiway safety areas shall be heavy duty designed for aircraft at 250 psi tire pressures and wheel loads of at least 40,000 pounds. Homerun manholes and pull boxes shall be located at a maximum spacing of six hundred (600) feet.

16.4.4. Saw Kerfs - Saw kerfs are discouraged. However, where saw kerfs are required, only one 1" conduit per saw kerf is allowed.

16.4.5. Circuit Lockouts – No construction or maintenance shall be allowed on Airfield lighting circuits while the circuits are energized. The published circuit "Lock-out and Lock-in" procedures will be required to be followed for all work performed on the airfield. Confirm with DFW Operations Department the need for temporary circuits for extended outages (more than 1 work period, 8 to 12 hours).

PART 2 - COMMUNICATIONS

16.5. General Information. This section defines general design criteria that apply to the design of communication systems at Dallas/Fort Worth International Airport. This design should be prepared by a registered RCDD and follow guidelines set forth in the most recent BICSI TDMM. Chapter 1 should be consulted for specific airport regulations and standards that also apply.

16.5.1. Overview. The typical telecommunications infrastructure in a campus environment centers upon telecommunications rooms located throughout the facility. These rooms house wiring cross-connect panels as well as network electronics needed for voice, data, video, etc. Each building has one Main Distribution Frame (MDF) room, and possibly one or more Intermediate Distribution Frame (IDF) rooms located elsewhere in the building. The MDF serves as the connection point between the entrance and riser cabling systems. IDF'S serve as the connection point between the riser and horizontal cabling systems. Each IDF serves as the hub for a particular geographic zone of the building (i.e. floor or wing). In most cases the MDF also serves as an IDF (an originating point of horizontal cabling serving its own geographic zone). Therefore, this section also describes all equipment in the MDF associated with the typical IDF functions. The MDF and/or IDF should be void of drop ceilings. Please see Figure 1, Product List, for a list of some approved products.

16.5.2. Plan View. The designer should include a floor plan for each IDF within the project drawings. This floor plan should show type and locations (dimensioned) of equipment cabinets, overhead ladder racks, and all wire ways and conduits that enter the room.

16.5.3. Cabinet Views. The designer should also include an elevation (front) view of each equipment cabinet denoting the equipment to be installed, pertinent termination and numbering information, and labeling instructions. Considerations should be given for a 25% growth when designing the MDF, IDF'S and all associated hardware. See Attachment A - DFW Rack Elevation, for DFW's standard rack elevation configuration for data cabinets.

16.5.4. Ladder Racks. A system of horizontal and vertical ladder racks shall be installed in the MDF and each IDF to support and distribute all cabling from where it enters and exits the room or to its appropriate termination location.

16.5.5. Grounding. In order to protect personnel and equipment from hazardous voltages and reduce electro-magnetic interference (EMI), a proper bonding and grounding system is required for the telecommunications infrastructure in campus buildings. The designer should specify this system within the project design for new or completely renovated buildings. This system should comply with the most recent BICSI TDMM, appropriate codes, industry standards, and these guidelines.

16.5.6. Patching. Installation of patch cords between two cross-connect panels or between network electronics and cross-connect panels in the IDF'S should be performed in accordance with these guidelines. The provision and installation of patch cords will fall within the scope of work for contractors so total channel testing can be performed. Contractor will provide (1) three foot and (10) ten-foot patch cable for each data channel. This installation will be accomplished while testing is being performed. However, the designer should position equipment racks such as to allow patch cord installation to be performed with maximum efficiency using the shortest length patch cords possible. When more than one cabinet is needed they will be attached with the adjacent side panels removed.

16.6. Conduit.

- 16.6.1. Conduit shall be rigid or intermediate galvanized steel when exposed. EMT can be utilized with in the building for horizontal distribution.
- 16.6.2. Electrical Metallic Tubing (EMT) may be used in sizes through two (2) inches where used inside dry locations where not subject to mechanical damage, six (6) feet AFF, if exposed. EMT may not be used outside, in concrete or underground. EMT fittings shall be steel compression type.
- 16.6.3. Minimum conduit size shall be $\frac{3}{4}$ inch.
- 16.6.4. Increase conduit one size when flex conduit is used in place of EMT.
- 16.6.5. Conduit size and quantity should be designed according to BICSI TDMM fill ratios.

16.7. Cabling and Terminations.

- 16.7.1. **General.** All new and reworked cable installations will follow the latest BICSI TDMM installation methods unless specified otherwise within this document or local, state and federal codes supersedes. Each work area outlet (WAO) will consist of four (4) Cat5E cables as defined below. Station wiring, fixtures and patch panel equipment shall be of quality and quantity sufficient to meet current Category 5E standards, and support current and future technology. Renovated areas and new construction independent conduit and/or approved Category 5E cable pathway system shall be provided to organize all network and voice cables. Data and voice shall be identified, bundled and terminated separately. Routing and coordination of all cable trunks and cable systems shall be approved by ITS Department.
- 16.7.2. **Cable Standards.** All cable shall be Cat5E, must meet TDMM standards and be UL approved. Data premise cable jacket shall be red. Voice premise cable jacket shall be white. Cable type and specifications will be permanently marked on the cable at least every twelve (12) inches with the ability to terminate the cable without destroying or disfiguring the markings. Acceptable cable is Belden 1701 or equivalent.
- 16.7.3. **Non-Recommended systems.** While a variety of pathway system technologies are commercially available, some are not generally recommended for use. These include under floor duct systems, trench duct systems, cellular floor systems, under-floor conduit systems, multi-drop conduit systems, and access (raised) floor systems. Also, use of floor outlet boxes and “tombstone” is not usually recommended unless certain criteria are met. None of the above systems should be used without approval from the DFW ITS department.
- 16.7.4. **Horizontal Pathways and Station Cabling.** All communication wiring in new or rebuilt walls will be installed in EMT conduit, and shall not be stapled or secured within inaccessible portions of the wall, floor or overhead. Communications wires installed in existing wall may be run in approved flexible duct. Cables installed in modular furniture raceways do not require conduit: however, conduit or equivalent protection is required between the wall plate or junction box and the raceway. All cables will be run to a standard duplex wall box or modular furniture equivalent, unless minimum bend radius or other requirements require surface-mount or other arrangement acceptable to DFW ITS Department. Surface mounting should be avoided if at all possible. All Wall Area Outlet installations require four (4) 4-Pair Category 5E cables per station or termination point. No electrical power or RF signal sources allowed in the same pathway as communication cables. Horizontal link will not exceed two hundred ninety (290) feet (90 meters), per TDMM. Total channel length from a network switch to station equipment will not exceed three hundred thirty (330) feet (100 meters), including patch and drop cables. Ten-foot service loop will be maintained at each end of the station cable. At the cable ends, the length of the untwisted section at the

connector or patch panel shall not exceed manufactures specifications. For renovated areas and new construction independent conduit and/or approved Category 5E cable support system shall be provided to organize all network and voice cables. Routing, approval and coordination of all cable trunks and cable support systems shall be approved and directed by DFW ITS Department.

16.7.5. Station Wall Outlets. Wall plate selection shall accommodate the simultaneous physical installation (not necessarily simultaneous electrical connection) of four (4) 8-position receptacles - two (2), red, RJ-45 clearly marked for data, and two (2), white, RJ-45 clearly marked for voice. Unless otherwise directed all jacks shall be terminated according to 568A wiring scheme. Acceptable termination hardware is Panduit Mini-Com CJ5E88Txx or equivalent.

16.7.6. Data Telecommunications Room Standards. Contractor shall provide patch cable and patch panel equipment meeting the same CAT5E specifications as above for the cable. Data patch cables shall be stranded and red. Data patch panels shall be placed in wall or floor mounted lockable cabinets approved by DFW ITS Department. Cabinet considerations should include: quantity of Wall Area Outlets, electronics, cable management, environment, room security access control. The cabinet shall also comply with TDMM standards regarding grounding, cable routing and accessibility. In general a full size cabinet should accommodate ninety-six dual data stations, wire management and associated electronics. In order to determine the specific rack unit requirements refer to Attachment A. Acceptable termination hardware is Panduit CFFL24WBL W/ Panduit Mini-Com CJ5E88Txx inserts or equivalent.

16.7.7. Voice Telecommunications Room Standards. Contractor shall provide all voice cable and cross connect pathways, meeting the same specifications as above for the cable. Voice will be terminated on Panduit PVK3004 110-style blocks using C4's and C5's. All hardware will be provided by contractor to facilitate termination, cross connect pathways and connections. Voice cross connects will be performed by DFW personnel. A separate 100-pr 110-block will be used for special circuits (wall phones, elevator phones fire circuits, etc.) so not to interrupt labeling continuity.

16.7.8. Copper Testing. Contractor will test all Cat5E cable with certified Cat5E tester.

16.8. Fiber Optic Cabling Standards. Fiber optic cable specifications (type and quantity) are dependent on specific project needs. Close coordination needs to be made with the DFW ITS Department when designing fiber optic infrastructure.

16.8.1. Fiber Optic Cable Installation.

16.8.1.1. All fiber optic cable shall be installed and terminated in compliance with manufacturer's recommendations regarding maximum pull tension, minimum bend radius, working and resting tension and protection. Splicing should be avoided whenever possible and should only be performed after consulting with DFW ITS Department. Inner-duct and/or approved fiber optic cabling systems shall be incorporated into any plans for any facility requiring fiber optic connections. Building entry shall be considered regarding placement of termination equipment, so to eliminate splice conversion panels and/or patch panels, cable management, environment, security and accessibility. Routing, approval, and coordination of all fiber trunks and cable systems shall be approved and directed by ITS Department (itsinfrastructure@dfwairport.com, 972-574-9000).

16.8.1.2. The Contractor shall perform cable-pulling calculations based on the actual field routing of the cables prior to installation. The calculations shall demonstrate that cable pulling tensions and sidewall pressures are within Manufacturer requirements. The

calculations shall be submitted to the ITS Department for approval (itsinfrastructure@dfwairport.com, 972-574-9000). Do not exceed maximum allowable pulling tensions. Contractor will be responsible for any damage to the fiber cable prior to acceptance.

16.8.1.3. All fiber optic cable will be installed to have a minimum service loop length of one meter behind the patch panel and ten meters in ceiling or mounted to wall. If fiber optic cable is used as station wiring, bend radius considerations may require surface-mount fixtures; this will be addressed on a case-by-case basis. Fiber optic cables may be co-located with electrical power or RF signal sources if all other options have been exhausted and provided other compatibility considerations are maintained. All fiber optic cable will meet applicable fire and other safety ratings.

16.8.1.4. Cables shall be neatly trained and laced within junction boxes and patch panels. Cable terminations shall be installed in accordance with Manufactures instructions.

16.8.2. Fiber Optic Testing Procedures - Pass / Fail Criteria.

16.8.2.1. Testing will be performed by the Contractor. The Contractor shall provide all tools and equipment required to perform the tests. The tests shall be conducted in the presence of the DFW Board Representative. Contractor shall provide forty-eight (48) hours notice to DFW ITS Department prior to conducting tests (972-574-9000). The Contractor shall provide at least one written and one electronic copy of the test results to the DFW ITS Department or authorized representative.

16.8.2.2. Cables shall be tested by OTDR on the spools prior to installation. Cables having attenuation at either wavelength greater than factory specifications shall be rejected and replaced at no cost to the DFW Board.

16.8.2.3. Cables shall be tested bi-directionally at both wave lengths using an OTDR and a Light Meter after installation and termination. Cables having attenuation at either wavelength greater than maximum factory specifications, or having total loss including splice and connector greater than formulas specified in BICSI TDMM will be rejected by DFW ITS Department. Any fiber strands exceeding maximum db loss allowed will be re-tested with OTDR to determine cause. DFW ITS personnel will be present during any re-testing. The tests will be submitted to DFW ITS Department for review. A rejected test will be grounds for either replacement or repair at DFW ITS Department's discretion at no additional cost to the DFW Board.

16.8.3. Fiber Optic Patch Panel.

16.8.3.1. Fiber optic patch panel configurations are dependent on project needs Close coordination needs to be made with the DFW ITS Department when designing fiber optic infrastructure. FJ style jacks/modules shall be used for new fiber installations. Consult with DFW ITS Department when renovating existing fiber optic cables. All extra fiber cable and patch panel connectors will be fitted with a dust/dirt cover sized for the connector arrack. This will ensure that the fiber element will not become dirty or contaminated. The contractor will supply a reasonable amount of extra covers for existing or newly installed panels and cables. These extra covers shall be located at each patch panel in a box, plastic bag or other container selected by the contractor

16.8.3.2. Fiber optic equipment connectors may be of either the SC, SJ, MT-RJ or ST type The contractor shall be responsible to verify and provide the correct patch cable connection, if necessary, supply adapters to convert the connector type required for existing and newly installed equipment and patch panels.

16.8.3.3. Patch Panels will be labeled with fiber count, type of fiber, date Installed, origination and destination of cable

16.8.4. Fiber Optic Splicing. It is the intent of the Board that fiber optic cable splicing is not allowed. Exceptions shall be directed in writing to DFW ITS Department for review. In the event of an accidental severed cable, the DFW ITS Department shall direct the method and means for repair or replacement. When fibers are spliced a complete end-to-end testing shall be performed. Appropriate splice enclosures shall be used depending on the environment. Without exception splice enclosures shall be installed and secured according to the manufactures installation guidelines and to the satisfaction of the Boards representative.

16.9. Equipment and Cable Labeling. All cables shall be labeled at both ends for identification purposes. All exposed cable trunks (in duct banks, tunnel trays, outside plant trunk cables, etc.) including fiber, shall be identified every five (5) feet and at major intersections, all penetrations, and at turns greater than 45 degrees, with a water-proof label permanently affixed to the cable stating "PROPERTY OF DFW AIRPORT, CONTACT DFW ITS DEPT. (972)-574-9000". Patch panels and wall receptacles shall also be labeled as appropriate. Materials used for labeling shall be indelible, meet applicable fire codes, and be in compliance with BICSI TDMM guidelines and DFW ITS Department direction. The labeling system will use pre-printed or computer-generated labels and not hand written. The labeling system for cables and patch cables shall incorporate a clear covering over the label characters. Cables shall be labeled at both ends. Patch panels and Wall Area Outlet (WAO) labeling shall comply with ANSI/TIA/EIA-606 standards. See Figure 2 thru 5 for DFW ITS Department Labeling Standards.

16.10. Electrical Power and Electrical Noise. Facilities designed or modified to be data communications areas shall comply with regard to electrical noise and availability of an adequate signal reference ground/grid. Special attention needs to be given to EMI devices. Appropriate distances and/or shields should be maintained in accordance with BICSI TDMM standards.

16.11. Telecommunication and Network Systems.

16.11.1. Telephone Riser Cable. The riser cable is to be a riser rate AR Series with 24 AWG Solid Un-tinned Copper Conductors with a dual insulation of semi-rigid PVC over foamed polyethylene The pairs are assembled into a cable core and wrapped with a polyester film core wrap They are sheathed with corrugated aluminum tape bonded to a gray PVC Jacket This product is available In 25-pair to 1800-pair sizes for 24 AWG for telephone cabling.

16.11.2. Telephone Termination Hardware. All telephone riser cable shall be terminated with 110 style cross connect system wiring blocks using C5 connectors and necessary hardware for cross connect paths. Cross connect system wiring blocks are one-piece units made of fire-retardant molded polycarbonate plastic with horizontal Index strips that secure 25 pairs of 22 through 26 gauge cable conductors These wiring blocks are designed with legs to mount away from the wall to provide space for cable routing behind the block and are available in 100- and 300-pair sizes.

16.11.3. Grounding. A bonding and grounding system devoted to the telecommunications system is required and shall be independent of the electrical outlet grounding system. The purpose is to protect personnel, cabling, and equipment from unwanted electrical currents associated with the telecommunications infrastructure and equipment. This system shall be designed according to the BICSI TDMM standards. Building steel, water pipes, or metallic conducts will NOT serve as a substitute for the grounding conductor.

16.11.4. Fire Stop. Fire stopping helps limit the spread of fire and smoke through a building by route of the cable or pathway. A DFW approved fire stop method and material shall be used to fire stop or seal the opening in a wall or floor where a riser cable, horizontal cable,

conduit, sleeve, or other such objects protrude. The fire stop method and material shall at a minimum meet the fire rating of the material penetrated. Use 3M fire stop or approved equal per NEC/NFPA/DFW Code.

16.12. Paging/Intercom/Sound Reinforcement Systems. System requirements will be determined by Tenants.

16.12.1. System wiring and components shall be installed in order not to cause any interference with Airport communication facilities and other tenant facilities.

16.12.2. Ceiling type speakers shall be equipped with properly sized back box and independent support free of the ceiling tile.

16.13. Radio Communications System for Department of Public Safety.

16.13.1. Coordinate radio system requirements with the DFW Airport Department of Public Safety.

16.13.2. Existing repeater stations are located on the top floor of the hotels and each terminal building.

16.14. Emergency Telephones for Installation in Elevators. Viking Electronics, model E-1600-02A.

16.15. Documentation.

16.15.1.General. Both electronic and hard copies of required cable test results, As-Built drawings, and warranty information will be submitted to the Owner or Owner's representative at least ten (10) working days before Certificate of Occupancy is awarded. CAD files will be submitted in Micro Station (.dgn) format. When proprietary software is needed to view cable test results, the contractor will provide a licensed copy for DFW ITS Department.

16.15.2.Cable Management Software. The cable management software database is maintained by DFW ITS Department. The Contractor is responsible for providing the installed wiring infrastructure data on a CD in Microsoft Excel (.xls) format. The Contractor shall coordinate the specific document requirements with DFW ITS Department.

Figure 1 - Product List: Materials listed in this document are from preferred manufactures. Alternates or equivalent products must be submitted for approval. All alternates must be approved by DFW ITS Department Infrastructure Team prior to acceptance of bid packages. The performance and assurance warranty associated with these alternates must meet or exceed the preferred manufactures 25-year warranty.

<u>MFG</u>	<u>Description</u>	<u>Part Number</u>
Generic	4' Grid wire w/clip, hook & shot	-
Caddy	J Hook	CAT32
Belden	DataTwist 350 Plenum UTP Cable-Red (Data)	1701A
Belden	DataTwist 350 Plenum UTP Cable-White (Voice)	1701A
Panduit	6-Port Executive Series Faceplate-White	CFPE6WH
Panduit	4-Port Executive Series Faceplate-White	CFPE4WH
Panduit	4 Port Furniture Faceplate-Black-Herman Miller	CFFPHM4BL
Panduit	CAT 5E Inserts-Red (Data)	CJ588RD
Panduit	CAT 5E Inserts-White (Voice)	CJ588WH
Panduit	24 Port Open Style Modular Patch Panel (Data)	CPPL24WBL
Panduit	Horizontal Wire Management Panel	WMPSE
Panduit	300Pair 110 Block w/Legs and C4 Kit	P110KB3004
Panduit	100Pair 110 Block w/Legs and C5 Kit	P110KB1005
Panduit	CAT 5e Patch Cables-Red-10FT (Data)	UTPCH-10-RD
Panduit	CAT 5e Patch Cables-Red-3FT (Data)	UTPCH-3-RD
CPI	M-Series MegaFrame Cabinet (optional fan kit required top & bottom when room does not have its own conditioned air)	M1050-731
CPI	Deluxe Filtered Fan Kit	12511-501
CPI	Vertical Power Strip	12470-006
CPI	Mounting Rails	12460-205

Typical DFW Labeling Standards:

Notes:

- TC Identifiers are not unique across the campus
- Facility is the building identifier
- X – Indicates alphanumeric value
- Y – Indicates numeric value

Figure 2 - Faceplate Label.

Label				
Top Row	TC	Faceplate		
	XXXX	YYY		
Each Jack	Rack	ChassisPort	(for data)	
	YY	YY	YY	
Each Jack	Wall Field	Row	Port	(for voice)
	XX	YY	YY	(01 to 06)

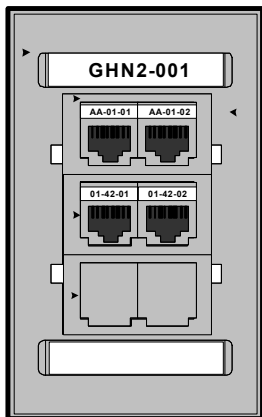


Figure 3 - Horizontal Cable Label.

Label	TC	Faceplate	Rack/WF	Chassis/Row	Port
	XXXX	YYY	YY/XX	YY YY	

Figure 4 - Patch Panel Label.

Label	Line 1	TC	Rack	Chassis
		XXXX	YY	YY
	Line 2	Port		
		YY		

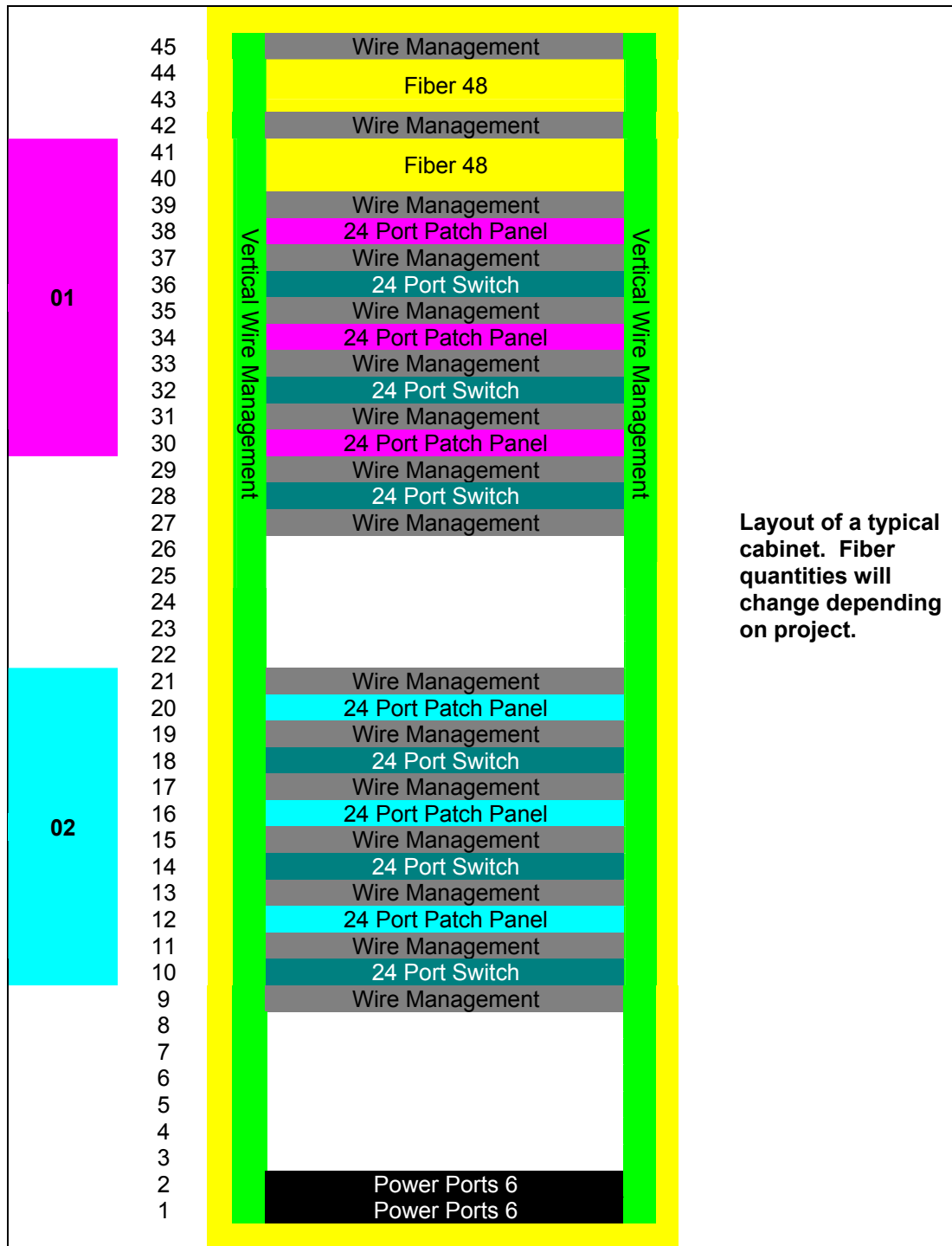


Figure 5 - Wall Field.

Label	TC XXXX	Wall Field XX	Row YY	Port YY (01 to 06)
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Figure 6 – Vertical Rack Layout:



Layout of a typical cabinet. Fiber quantities will change depending on project.

Attachment A - Network Design Criteria, Policies, and Requirements

Description – This Attachment contains requirements, criteria, and standards for basic design and installation of network infrastructure electronics for the DFW Board Data Network referred to as **DFW ITS Department Network Design Standards**.

1. Network Infrastructure Electronics.

- 1.1.** The network infrastructure shall be designed so that each end system (computer, printer, etc.) or host will be connected to a switched 100BaseT Ethernet port (Edge switch) at a minimum. Switch ports designated for servers or large storage arrays such as SAN or NAS shall be capable of 1000Mb speeds over either copper or fiber depending on the server. It is the System Integrator's responsibility to insure adequate and correct port types for all hosts, servers, special equipment, etc. connecting to the edge access layer switches.
- 1.2.** The DFW Board Data Network is designed as a large multi-layer hierarchical campus TCP/IP-based Ethernet network consisting of Cisco Core, Distribution, and Access layer electronics.
 - 1.2.1.** Core Layer switches currently consists of Cisco Catalyst 6509 chassis located at four different locations at the airport. These fully meshed devices provide connectivity for distribution layer switches only.
 - 1.2.2.** Distribution Layer switches when required by the design specifications will consist of a pair of Cisco switches (such as Cisco Catalyst 6509, 4506, 4006, or 3750 models) with multi-layer capabilities connected to two Core layer switches via single-mode fiber if located in a separate location, or multi-mode fiber if located in the same location. It is the responsibility of the System Integrator to obtain written approval from the DFW ITS Department for any exceptions to this standard prior to implementation.
 - 1.2.3.** Access Layer switch (Edge) design shall be adequate in numbers of switches so as to provide the correct quantity and type of ports, plus an additional 50% for future expansion. Acceptable access layer switches are the Cisco models 2950, 3550, and 3750 switches. It is the responsibility of the System Integrator to insure that this design criterion is met. Any deviations from this design criterion require written approval from DFW ITS Department.
 - 1.2.4.** External Telecommunication connections to the DFW data network, such as T1, DS3, or frame-relay circuits, originating from an external source other than DFW network, will be terminated at a minimum to a DFW owned and managed network security appliance. This security appliance shall be capable of performing firewall and security policy duties. The appliance shall also be capable of performing strong-levels of encryption such as 3DES and AES. The device should also support high-availability to provide redundancy. This is a fast changing technology so no specific security appliance is required; however, the specific appliance must be approved in writing by DFW ITS Department prior to implementation. This will ensure that it seamlessly fits into the current security models.

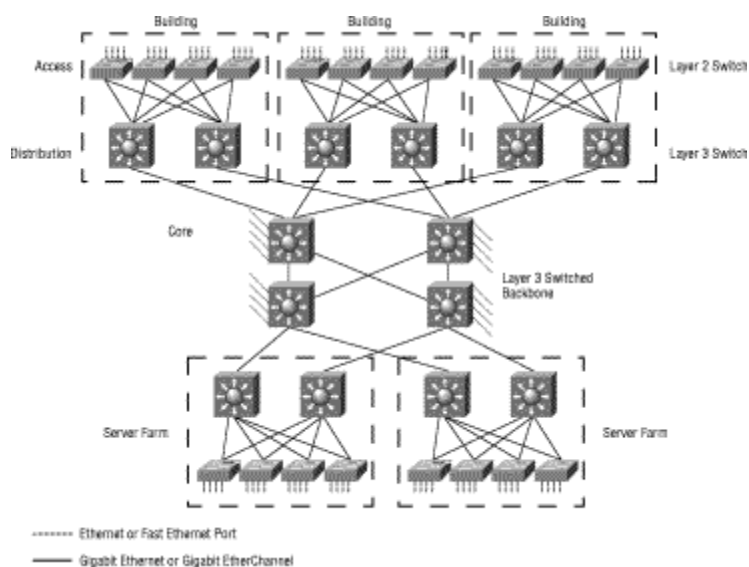
2. Network Infrastructure Connectivity and Topology.

- 2.1.** Gigabit EtherChannel fiber links are currently utilized between Core and Distribution layer switches to provide added reliability and a 4-Gigabit backbone. This provides 'redundant paths' to the rest of the data network yielding reliability and fail-over capabilities for that particular switch or stack of switches.
- 2.2.** A typical Access layer stack consists of three (3) Cisco switches such as the current Cisco 2950, 3550 and 3750 models. The maximum acceptable number of switches in a stack is four (4) with three (3) recommended. Typically, the top Access switch in a stack is connected to Distribution switch number 1 using the 2nd Gigabit fiber port (Gi0/2), and the bottom Access switch in the stack is connected to Distribution switch number 2 using the 2nd Gigabit fiber port (Gi0/2). The middle switch of that stack (if installed) is connected to the switch above and below it using Gigastack GBIC technology (Gig copper) installed in the first Gigabit port (Gi0/1). Other stacking

technology is acceptable if it meets or exceeds the performance of the Gigastack design. It is DFW ITS Department network design standard that every Core, Distribution, and Access layer switch placed in service on the DFW data network will be designed and configured with redundant connectivity (fiber or copper) to the rest of the network. This standard only addresses redundant physical layer connectivity, and not redundant electronics such as Supervisor Modules in the Catalyst 6500 series switches.

- 2.3. DFW ITS Department network design standard is to design and configure all fiber link connections between backbone switches utilizing routed point-to-point links, not VLAN trunks across the network.
- 2.4. The DFW ITS Department network design standard is to limit or restrict the propagation of any failure or electrical problem associated with a host workstation or server to a single Layer 2 switch or stack of Layer 2 switches in a wiring closet. In order to do this, the deployment of VLANs and VLAN trunking is restricted to one wiring-closet switch or stack of switches. Each wiring-closet or group of wiring-closets installed for the purpose of providing network connectivity to a building, or a section or floor of the building, is assigned to a unique VLAN. Further, a VLAN will not span into multiple wiring-closets from separate geographical locations unless approved in writing by DFW ITS Department. Restricting one VLAN to a single Layer 2 switch or stack of switches per wiring closet also minimizes the spanning-tree complexity and greatly increases network convergence should an forwarding link fail and the connection fail-over to the backup or redundant link.
- 2.5. DFW also recommends limiting broadcast traffic on layer 2 networks. Furthermore, in the instance of a bi-directional fiber link failure the port should be automatically disabled. The network design should support these efforts as much as possible.
- 2.6. Deploying pervasive (geographically diverse) VLANs throughout the campus adds to the complexity and causes spanning-tree convergence problems and thus is not allowed. DFW ITS Department network design standard is to utilize one IP subnet per VLAN, which then maps to a single switch or stack of switches per wiring closet.
- 2.7. Figure 1 depicts a typical Layer 3 Switched Campus Backbone which the DFW network design standard is based on.

Figure 1. Large-scale Layer 3 Switched Campus Backbone.



- 2.8. Determinism is an important design goal of DFW ITS Department network design criteria. For the network to be deterministic, the design must be as simple and highly structured as possible. Recovery mechanisms must be considered as part of the design process. Recovery timing is determined in part by protocol messages such as hellos and keepalives, and these may need to be tuned to achieve recovery goals.
- 2.9. Quality of service (QoS) for voice over IP (VoIP) consists of providing low-enough packet loss and low-enough delay so that voice quality is not affected by conditions in the network. A reasonable design goal for end-to-end network delay for VoIP is 150 milliseconds. At this level, delay is not noticeable to the speakers. To achieve guaranteed low delay for voice at campus speeds, it is sufficient to provide a separate outbound queue for real-time traffic. The bursty data traffic such as file transfers is placed in a different queue from the real-time traffic. Because of the relative high speed of switched Ethernet trunks in the campus, it does not matter much whether the queue allocation scheme is based on weighted round robin, weighted-fair, or strict-priority.

3. Remote Access and Internet Standards.

- 3.1. Currently DFW has several T1 connections to the data network in several locations. Any additional external network connections, such as T1, frame-relay, etc., will be aggregated into a "Common Demarcation" electronic appliance as defined by the DFW ITS Department Networks section. This will allow for improved security and management of remote access to the DFW network. Any external data or telecommunication connections to the DFW data network will be approved and coordinated through the DFW ITS Department Infrastructure Team.

4. Network Management.

- 4.1. Any network electronics such as switches, routers, firewalls, VPN concentrators, wireless access points, etc. that are installed on DFW network must be able to be managed by the currently installed network management software. CiscoWorks 2000 is the current network management software in use. These devices must also be able to send SNMP traps to and be able to respond to Secure SNMP queries by the network management server. DFW must be able to limit management access to network devices via built in control mechanisms.

5. Equipment Specifications.

- 5.1. Where specific products are referenced, products that are substituted must be electronically, mechanically, and functionally interchangeable with the product specified. A copy of the specifications of the proposed substitution must be submitted with the vendor's response. Substitutions will only be allowed by written approval by the DFW ITS Department. Any substitutions made without written approval are done at the risk of the vendor. Unacceptable substitutions will be rejected without explanation or appeal. The proposed switches, routers, firewalls, VPN concentrators, network management software, etc. must be approved by the same manufacturer.
- 5.2. Each electronic network device must have at least a one (1) year, advanced replacement warranty equivalent to the Cisco SMARTnet Maintenance package. Advanced replacement is defined as receiving replacement equipment within one (1) business day after obtaining a TAC case number from Cisco. If the standard warranty does not meet this requirement, the vendor must include a service or maintenance contract that does. The Proposer must also include pricing for providing extended warranty for years two and three.

6. Physical Security.

- 6.1. All network electronics such as switches, routers, firewalls, VPN concentrators, wireless access points, etc. must be physically installed into a cabinet per manufacturer's recommendations, and the cabinet must be able to be physically secured and lockable in order to prevent unauthorized access to that device.