Campus Network Cabling: Installation Best Practices

Campus Network Design & Operations Workshop

UNIVERSITY OF OREGON

Last updated 30th September 2024

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Network Startup Resource Center

Cabling Installation Hints

- UTP Copper Installation
- Outdoor Conduit Planning/Installation
- Fiber Optic Cabling Installation
- Network Racks

Unshielded Twisted Pair

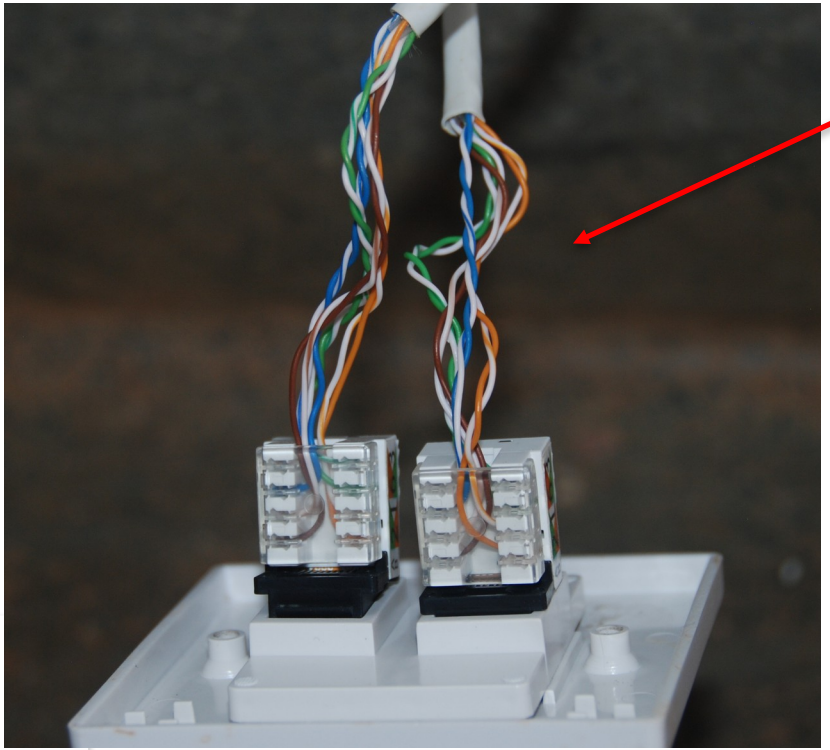
- Cable Construction
  - 24 AWG, 4-Pair cable
  - Be aware: counterfeit/fake cable is common in Asia
- Installation Mistakes
  - 90 Meters maximum installed cable distance
  - No more than 1cm unsheathed cable at terminations
  - Termination should be in jacks, not RJ45 plugs
  - Labeling should include both ends of wire run

https://en.wikipedia.org/wiki/American_wire_gauge

Various types of UTP Jacks

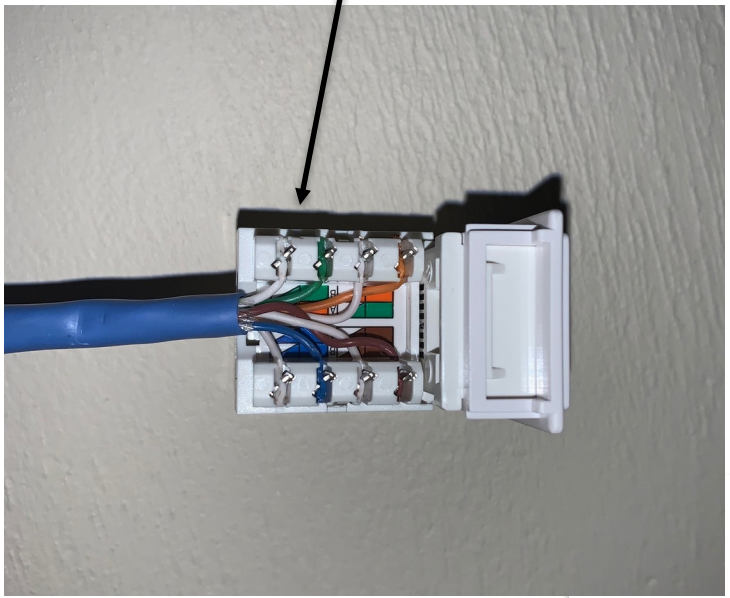
Beware of Poorly Done Terminations

- Remember, only 1cm of unsheathed cable



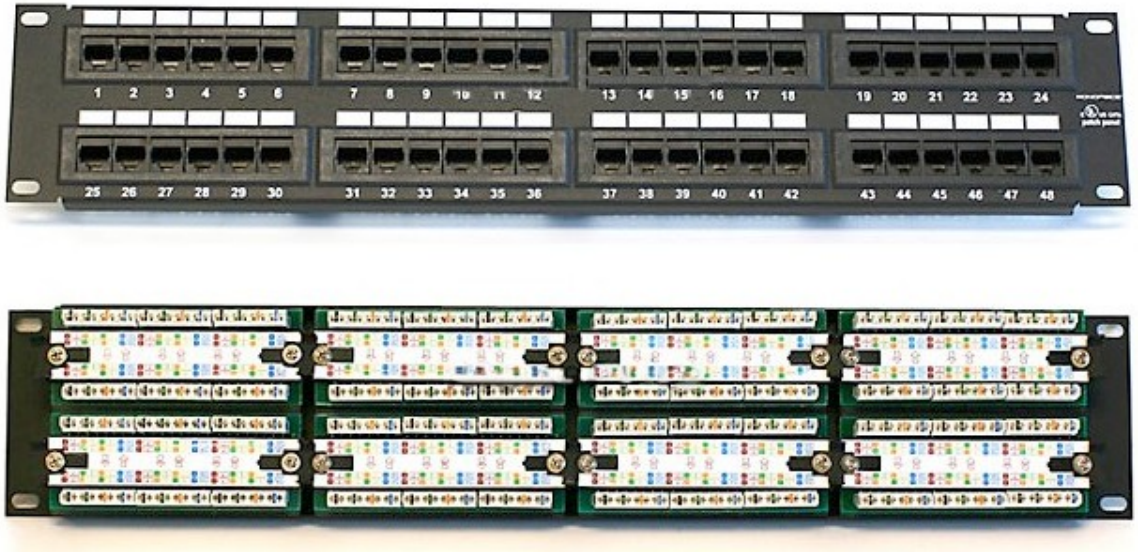
No

Yes

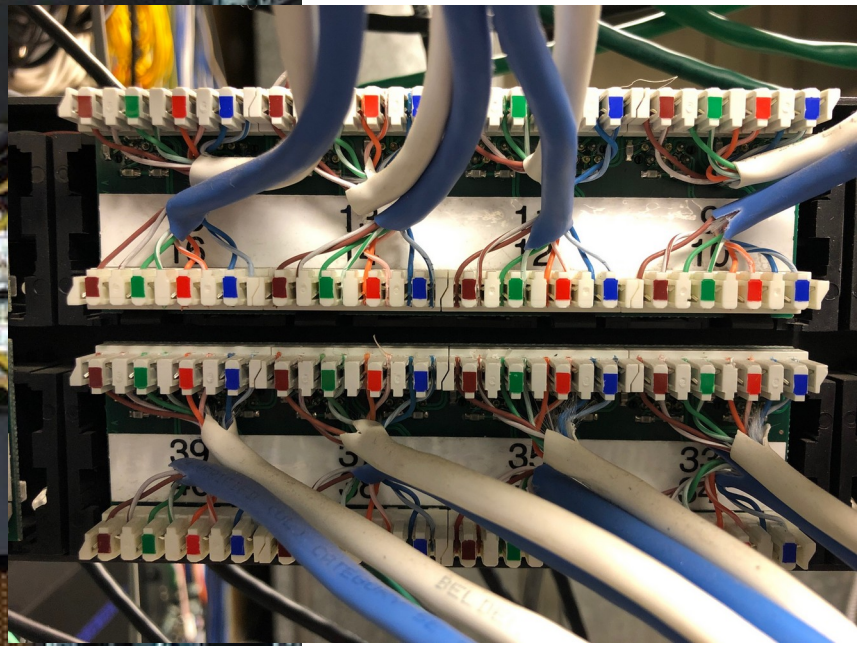


Patch (or Jack) Panels

- Always terminate cabling in patch/jack panels at rack locations

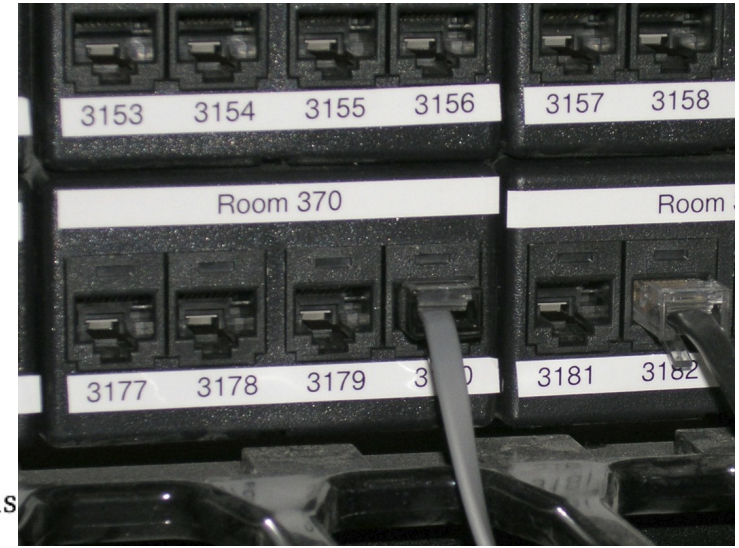


Properly Terminate Jack Panels



Unshielded Twisted Pair Cable (UTP)

- Always terminate in a Jack Panel and in device plates
- Labeling is a key to reducing work later
- Pull more than one cable



UTP Cable Tools

Tone and Trace Tool

RJ45 & RJ11 cable tester

Punch down tool

RJ45 & RJ11 crimp tool

- The tone and trace and RJ45 tester are required
- If you are going to install your own cabling or make your own ethernet patch cables then you need the punch down and crimp tools

Underground Conduit

- Often used to route cabling between buildings
- Not simple to design and very easy to make mistakes which make conduits hard to use
- Common mistakes
  - Not enough conduit
  - Conduit too small
  - Missing pull rope
  - Too many bends between places you can pull

Underground Conduit Rules

- No more than 200m between pull points
- Reduce distance by 50m for every 90 degrees of bend
- Do not exceed 270 degrees without a pull point
- Survey the site, do the layout, place hand holes

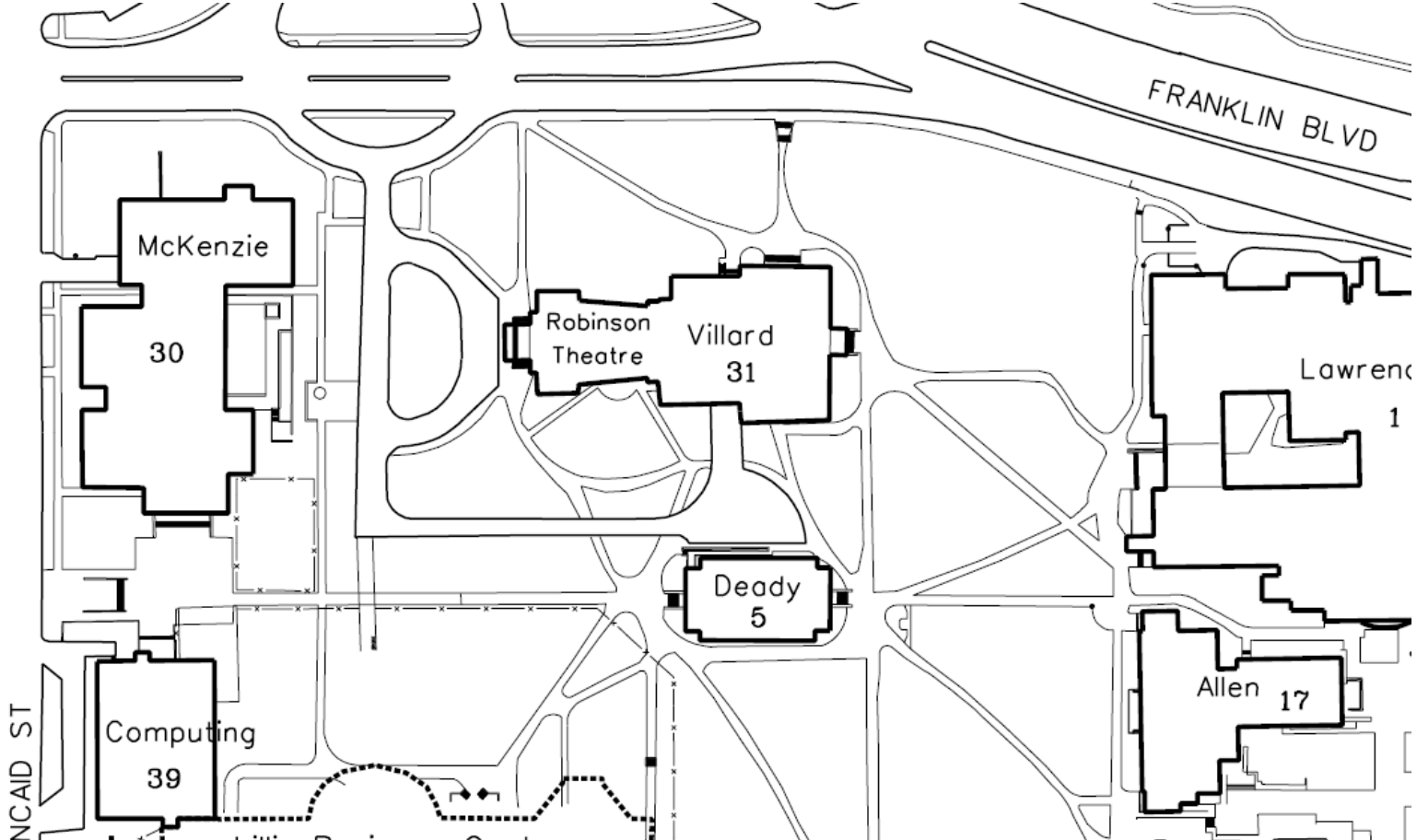
Underground Conduit Hints

- Bigger conduit better than little conduit
  - Recommended installation: at least one 100mm or two 50mm conduits to each building
- Conduit for fiber optic cable is different than water pipe.
- Always install a pull rope in all conduits, including empty ones
- Label the Conduits

Planning Underground Conduit

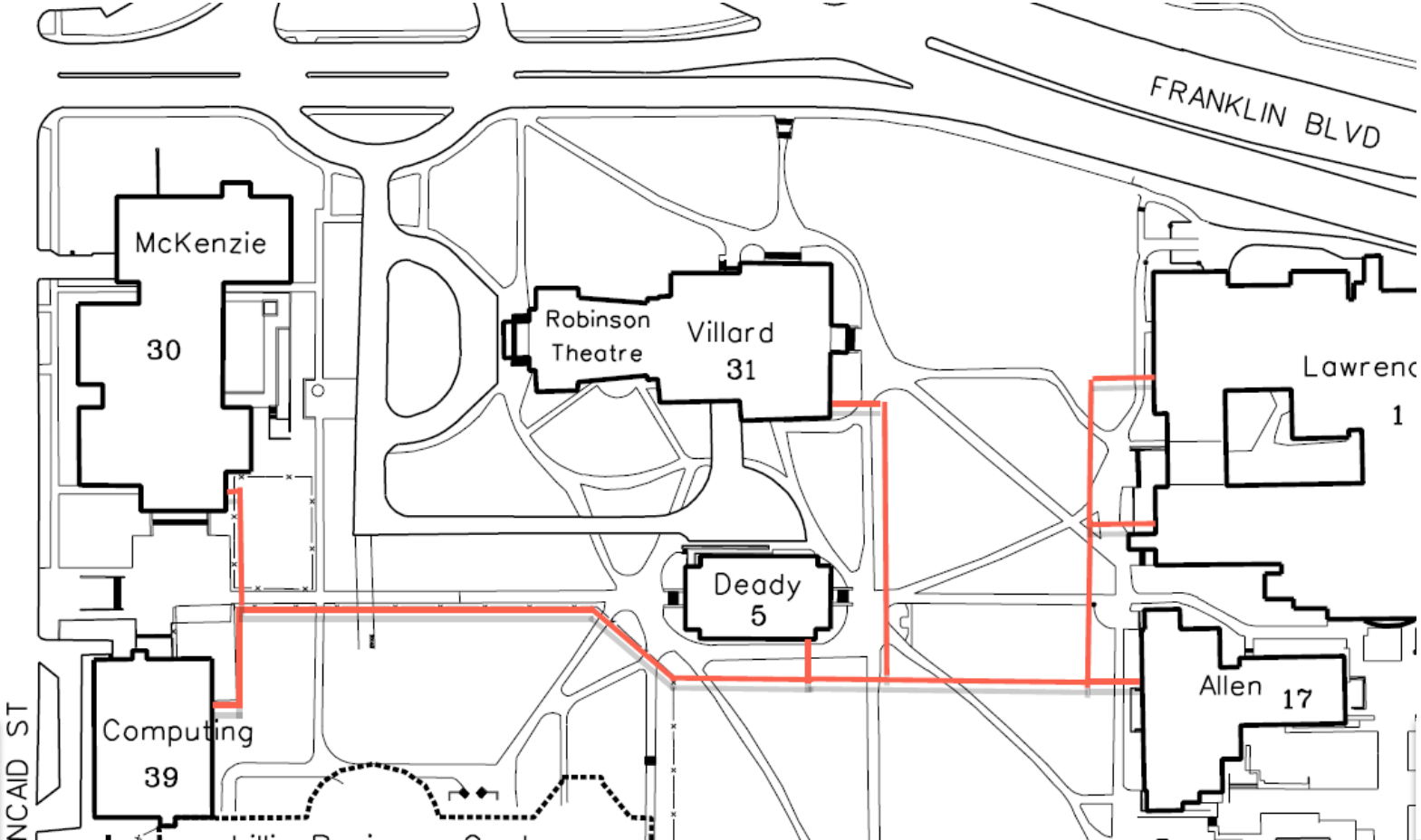
- Get a map of your campus (can use google earth if you don't have a map)
- Layout conduit paths
- Plan for vaults
- Don't forget to think about future expansion

A Simple Campus

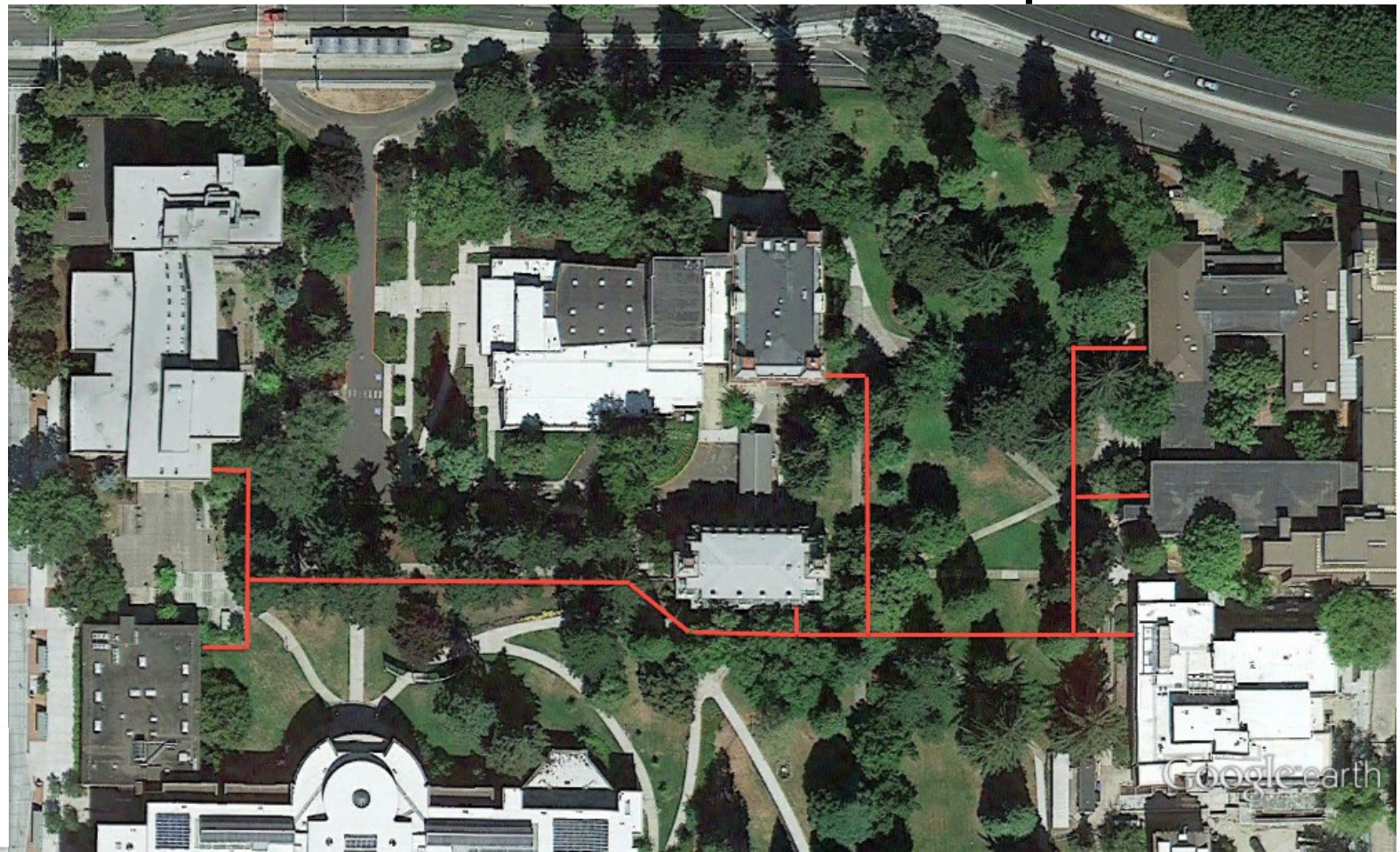


A Simple Campus

Conduits on Small Campus



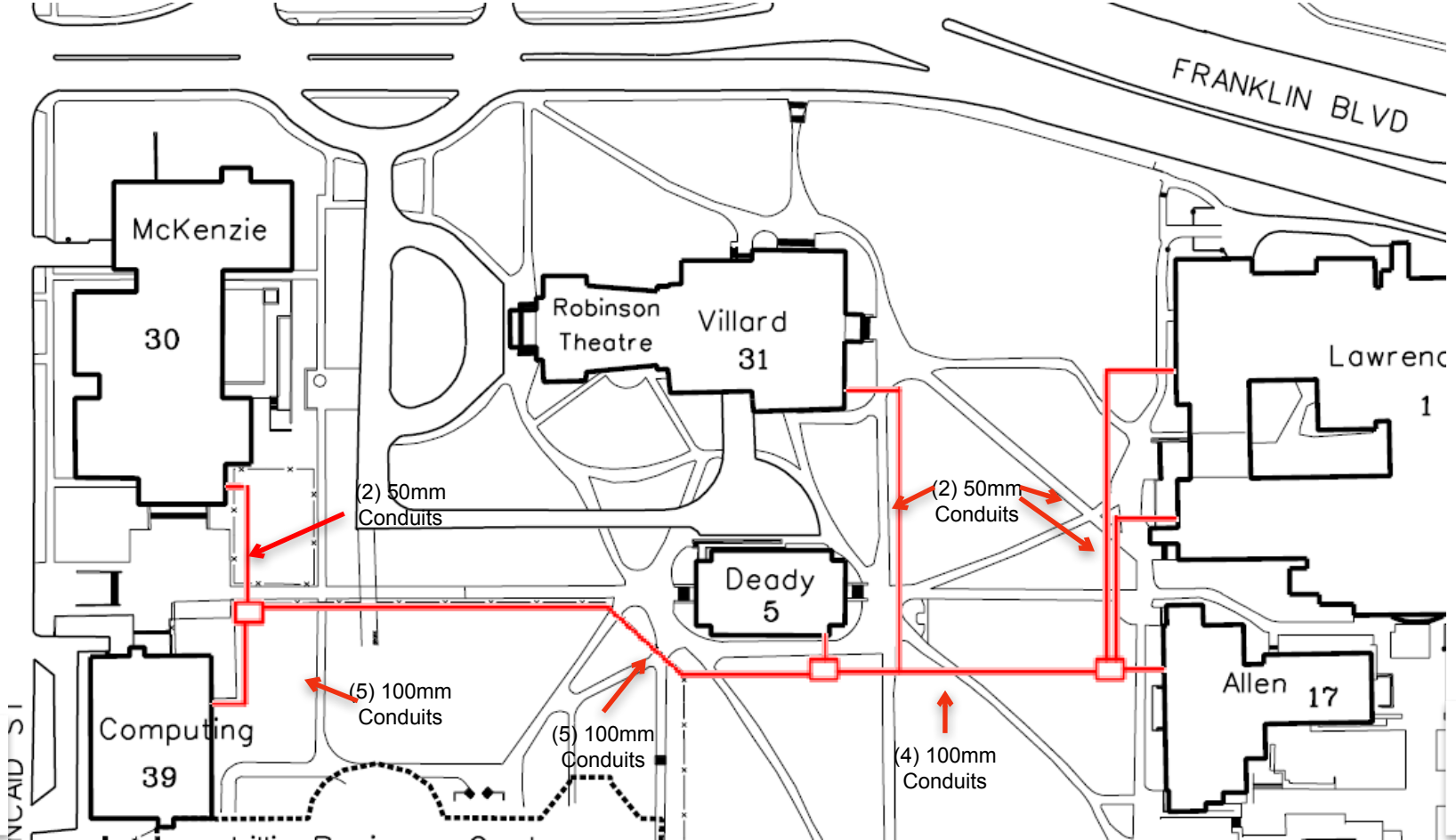
Conduits on Small Campus



But What about Vaults?

- Things to Consider
  - The conduit distance and number of bends
    - Vaults (Hand Holes) provide a pull point, so they reset the 200M rule.
    - How do you come out of building? Do you have a 90 degree bend at the transition?
  - Places where you might branch and go different directions
  - Future locations

Suggested Vault Placement



But What About Hub and Spoke Configuration

- Typically, underground conduit is installed in a very linear fashion
  - This doesn't help with redundancy. A single cut can take out your entire campus network
  - Think about alternate paths and install two fiber cables to each building, one from each direction
  - Redundancy is something to consider **after** you've gotten a network installed and operational

Underground Conduit

Some Regions Use Roll Pipe

Conduit versus Water Pipe

If you use Roll Pipe

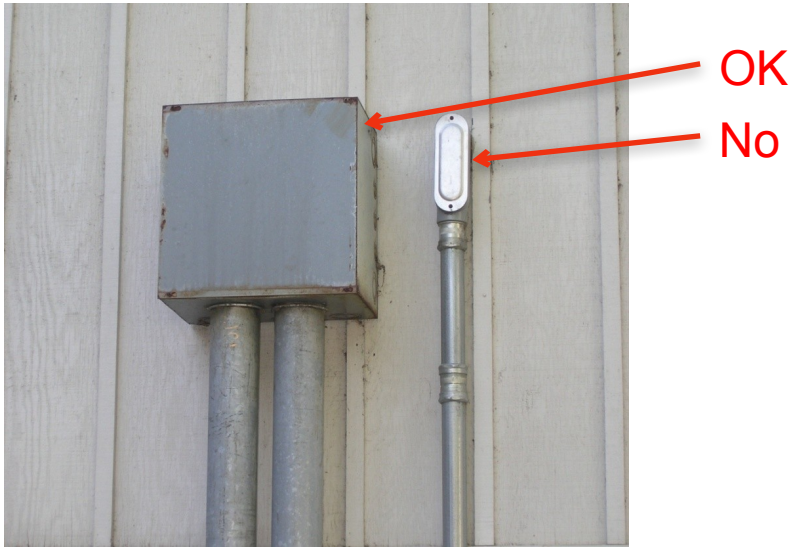
- The same rules apply on length and the number of bends
  - No more than 200 meters
  - No more than 270 degrees bend
  - Reduce distance by 50 meters for every 90 degrees bend

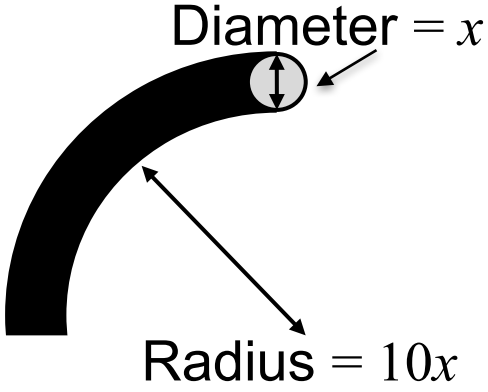
Getting Conduit out of Building

Examples of correct conduit connections

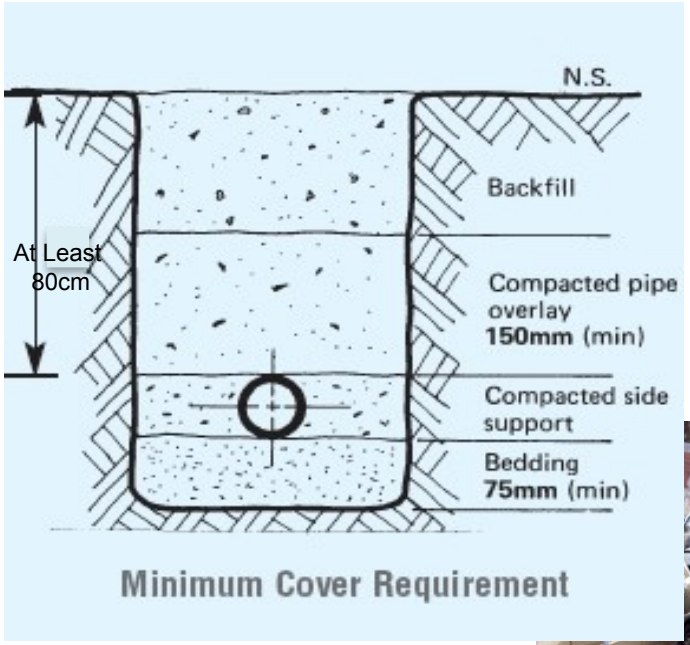
Don’t Bend Fiber Too Tight

- Fiber has bend radius issues
- Keep bends ≥ 10x cable diameter





Buried Conduit Trenching



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Conduit Fill

- USA National Electric Code recommends only 40% of the volume of a conduit can be filled
- For low voltage cabling this is important for installing extra cables.
- If the conduit is too full you can damage existing cables by pulling cable past others.
- Pay attention to how full conduits are to help avoid damaging cables.

Labeling Conduit and Cables

Seal Conduits

- Conduit plugs prevent water from using conduits as a water pipe
- Seal conduits with cables in them
- This also prevent rodents from using the conduits as a path into your buildings

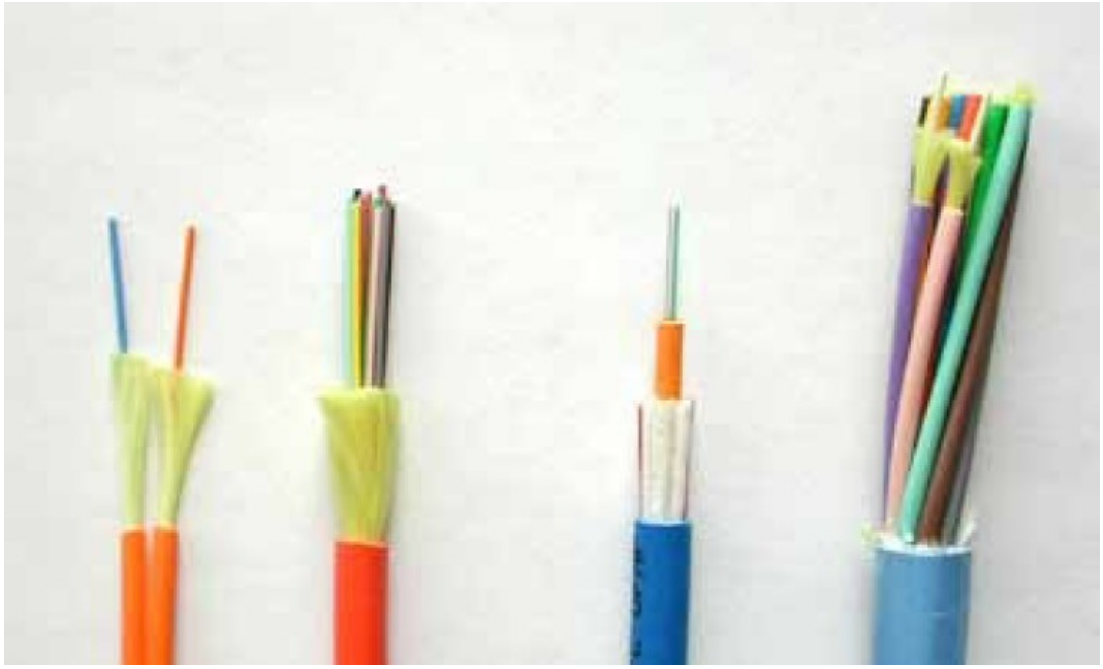
Fiber Optic Cable Installation

- Installing your own fiber optic cable is very possible
- It requires specialized training and lots of experience
- Probably best to utilize contractors to install cable

Indoor versus Outdoor Fiber

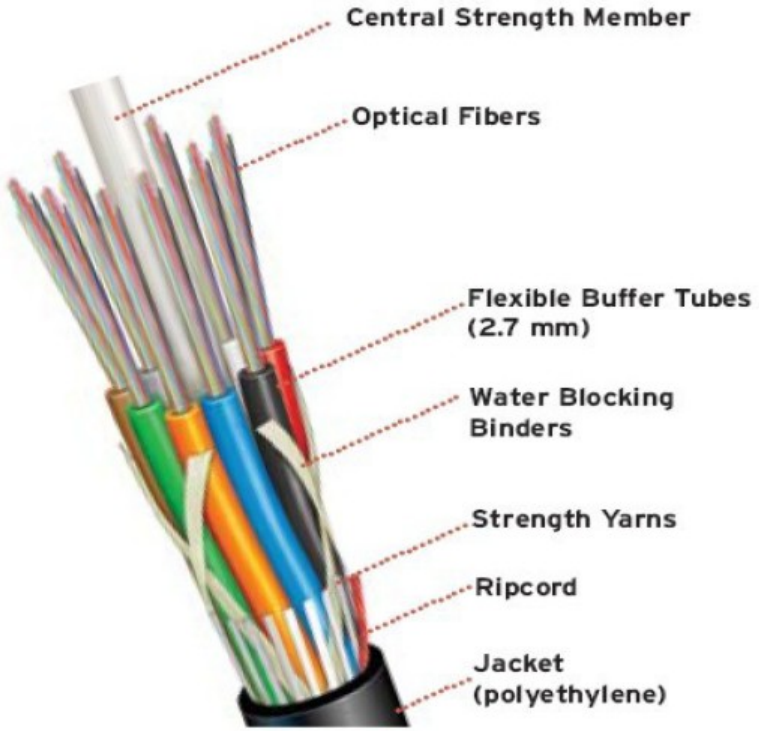
- Always use outdoor rated cable outside of buildings
  - It must be warranted for outdoor use by the manufacturer
- Loose tube versus tight buffer
  - Loose tube is typically cheaper, tight buffer is easier to terminate
- Armor versus all dielectric
  - Armor protects against rodent damage
  - Armor requires grounding

Indoor Fiber Packages

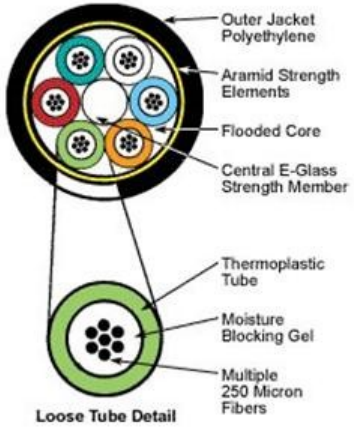


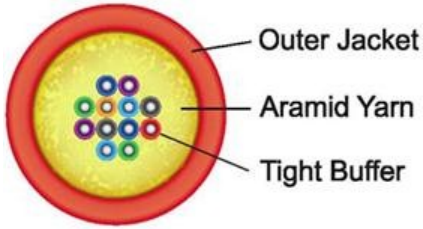
Outdoor Loose Tube Armored Cable

96 Fiber Loose Tube Outdoor Non-Armored



Loose Tube vs. Tight Buffer



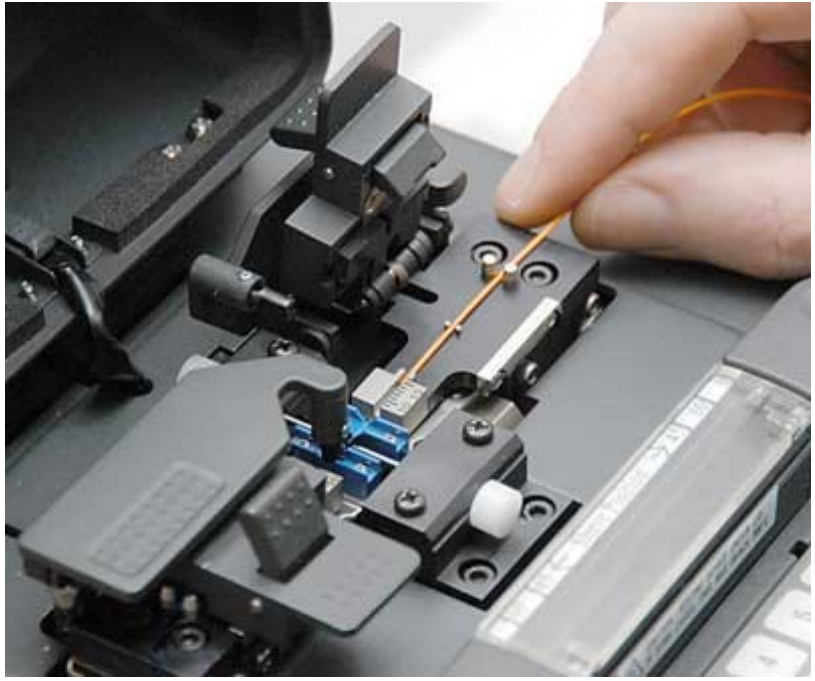


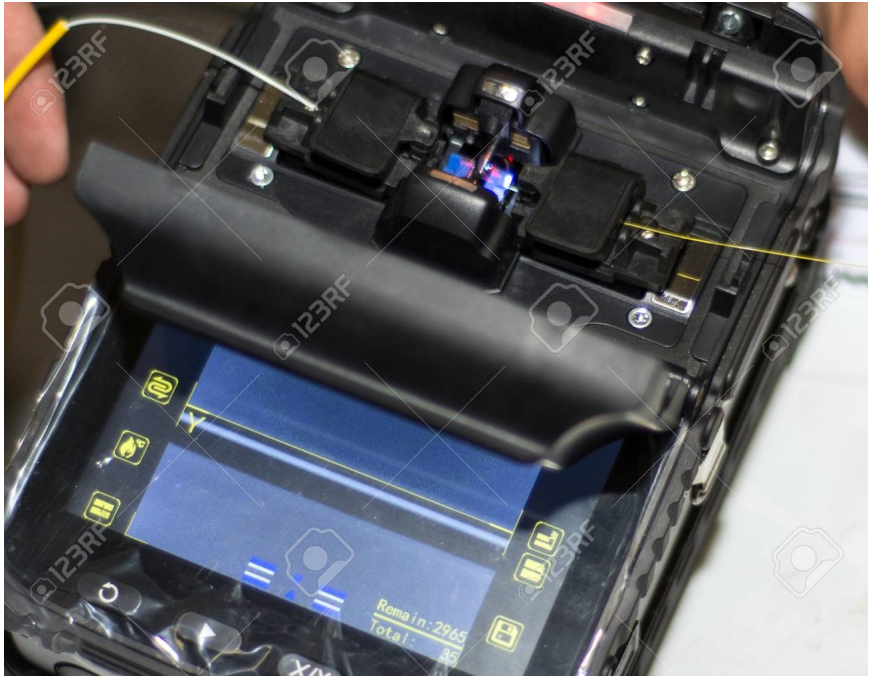
- Loose Tube: several fibers 250 micron in a buffer tube, gel filling, more compact, fragile, outdoor, very water resistant.
- Tight Buffer: one fiber in a 0.9mm buffer, no gel, bigger, sturdier, in/outdoor.

Fiber Termination

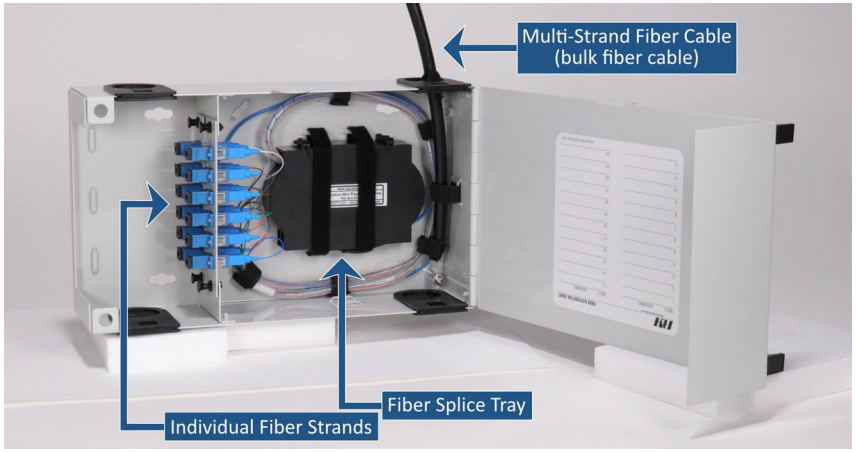
- Tight buffer fiber can be terminated directly with a connector although this is not recommended for single mode fiber
- Single mode fiber should be terminated by fusion splicing a factory pre-polished connector onto the individual fiber strands
  - This works for both loose tube and tight buffer cable
  - Best practices are to place splices into a splice tray

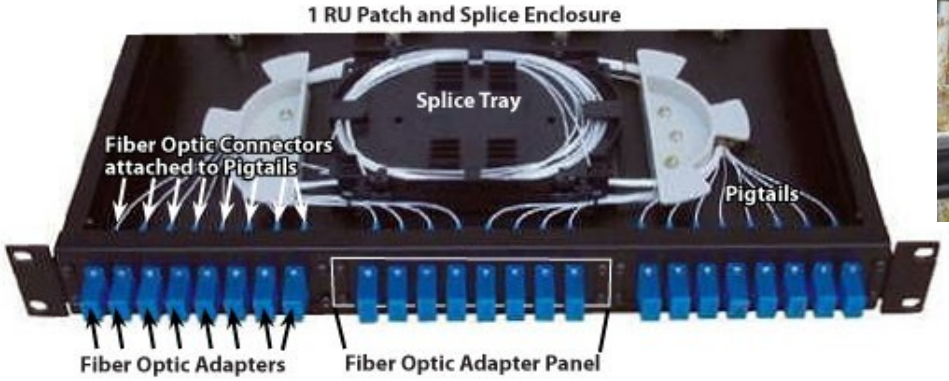
Fusion Splicing Fiber





Fiber Optic Splice Enclosures





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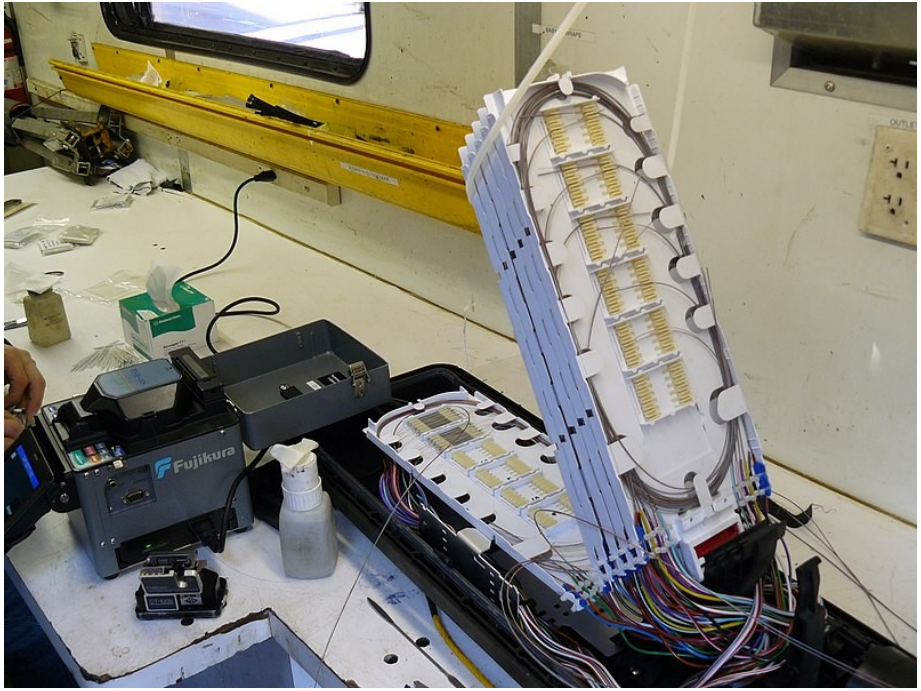
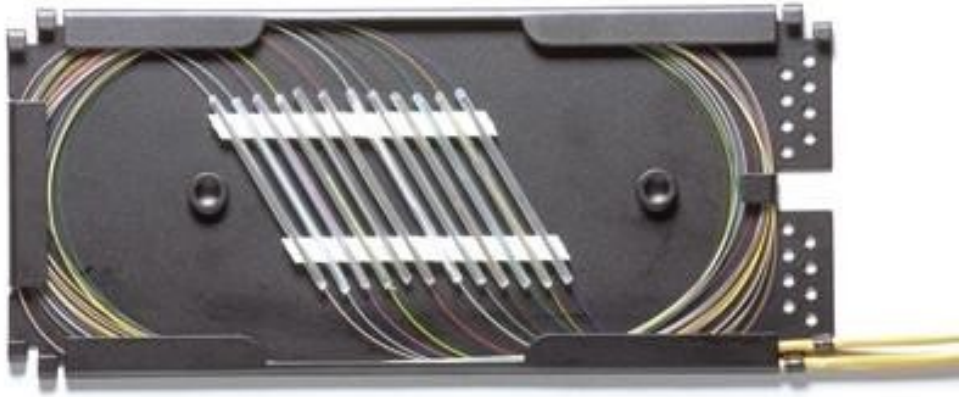
Fiber Optic Splice Trays





Fiber Optic Testing Tools

Visual Fault Locator

Optical Light Source

Optical Power Meter

- The visual fault locator is required and they are cheap. It is tone and trace for fiber.
- The light source and power meter aren't required, but are useful as it is used to measure the optical loss through fiber cabling.

Fusion Splicer

- Fusion splicer:
  - Used to join (splice) fiber optic cables
    - To terminate single mode fiber
    - Installing new fiber runs
    - To repair fiber cable cuts
- Picture shows example of a simple portable fusion splicer, as sold on eBay
- Not required unless you are installing your own fiber cabling

Additional Fiber Testing Tools

Optical Time Domain Reflectometer

150m spool of fiber in a “launch box” for OTDR

- These are used to take a “picture” of a run of optical fiber to find places where the fiber has been partially damaged or where you have dirty connectors
- Only required if you install your own fiber cable

Labeling Fiber Cabling

- Identifying Fiber
  - Label at each end, strand count, type and destination
  - Label slack loops, Where from? Where to?

Fiber Slack Loops

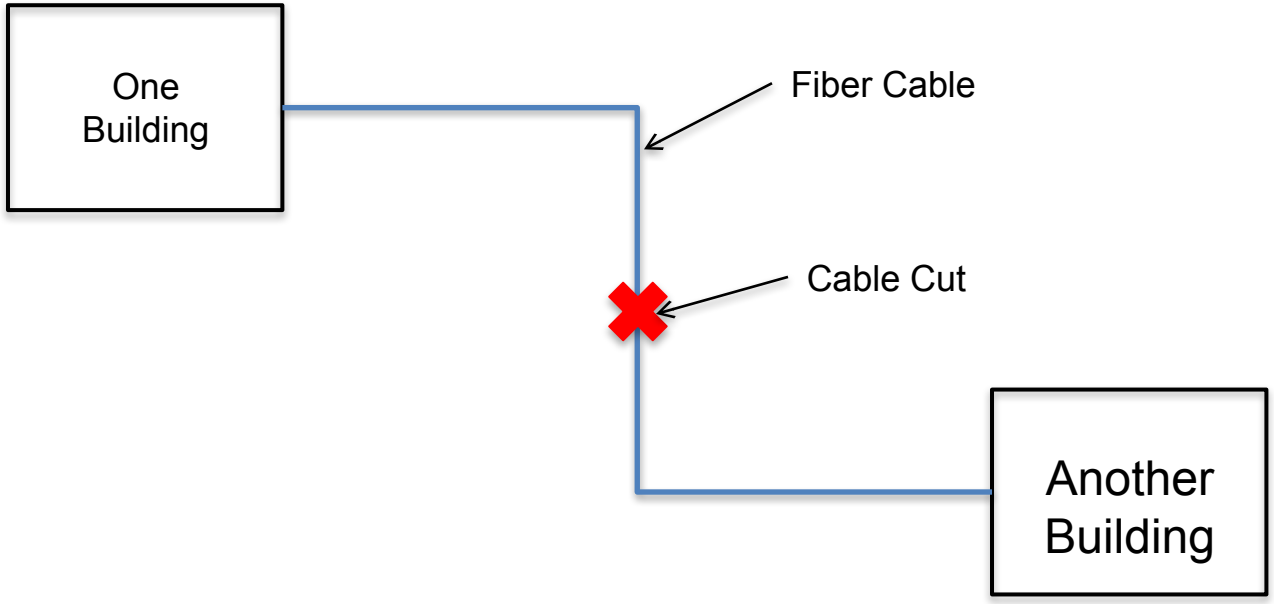
- You need to install fiber with extra lengths stored along the path
  - These are called slack loops
  - 10m slack every 100m of distance
  - 20m slack at each end

Slack Loops in the USA

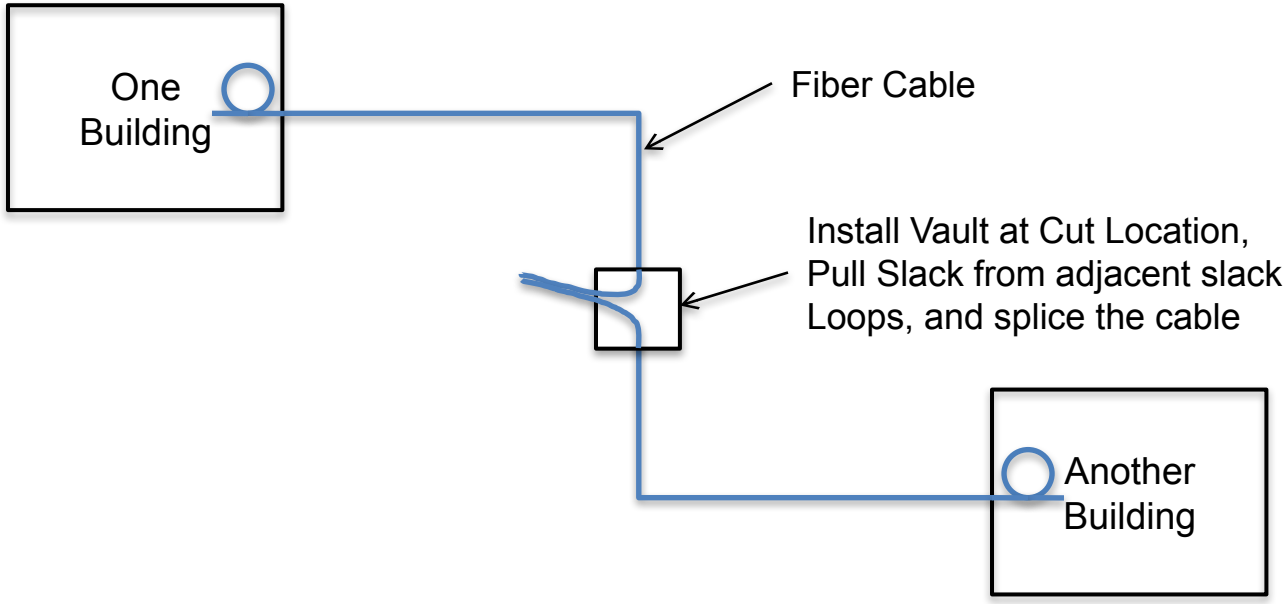
Small Vault Slack Loop

Slack Loops in Thailand

How Do You Repair a Fiber Cut?



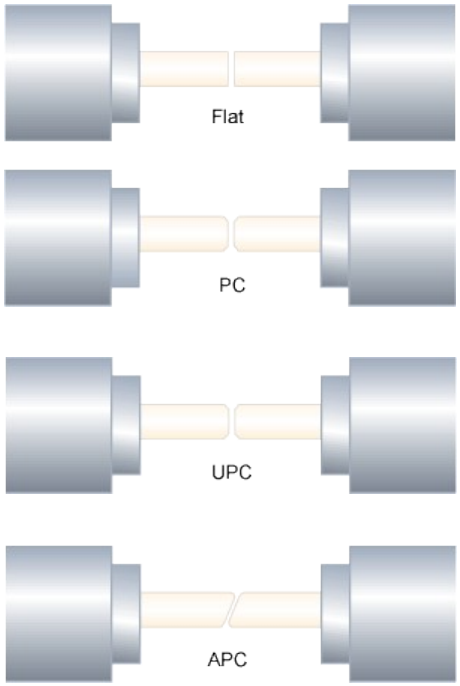
Easy, If you Have Slack



Fiber Optic Connectors

- Single mode fiber should only use SC or LC connectors
  - Best practice is to fusion splice a factory built UPC pigtail onto installed fiber cable
- Type of fiber can be indicated by connector bodies
  - Blue denotes Single Mode
  - Tan or Beige denotes Multi-Mode
  - Metallic Connectors can be either Single Mode or Multi-Mode. Check cable color or packaging.

Connector tip



- Flat: air between surfaces, back reflection -14dB
- Physical Contact: slanted end, no air, back reflection -40dB
- Ultra Physical Contact: more polishing, back reflection -55dB
- Angled Physical Contact: back reflection -70dB, analog signal

Fiber Patch Cords

- Multi-mode:
  - OM1 62.5µ is recommended to be Orange
    - (possibly other colors as well)
  - OM2 50µ is Orange as well
  - OM3 & OM4 50µ are recommended to be Aqua (blue)
    - Some “OM4+” vendors use Violet (OM4+ is not an official designation)
  - OM5 50µ is officially Lime-Green
- Single-mode:
  - OS2 cords are always yellow
- Lengths from 0.5m to 30m

LC and SC Connectors on Patch Cords

- Simplex and duplex LC (small RJ45-like tab) and SC (square) single mode connectors (blue) on single mode (yellow) cable

Fiber Patch Panels

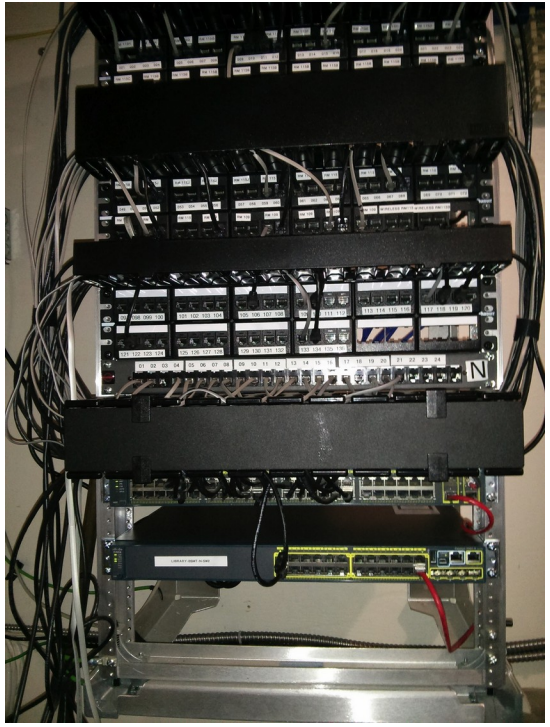
Wall Mount Fiber Optic Panel

Rack Mount Fiber Optic Panel

Network Racks

- There are a few different types of network racks
  - Free standing or wall mount
  - Enclosed or not enclosed
  - In US and Europe, network racks tend to be in rooms dedicated for that function
  - Buildings with concrete walls makes it better to use more and smaller (wall mount) network racks

Wall Mount Network Rack



Free Standing Network Racks

Instructions to Contractors

- Please refer to the web site for this workshop to retrieve a document that gives complete instructions to contractors for
  - Category 6 cabling
  - Single Mode Fiber optic cabling
  - Installation of underground conduit and vaults
- Download and edit this document to meet your needs

Questions?