Fiber Optic Network/Topology Design on State Highways

Presented by:

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Presentation Outline

- Conduit Layout
  - Layout, Conduit construction placement methods, Conduit detection system
- Fiber Optics
  - Single Mode, dB losses, 1310/1550nm Wavelengths, Connector types

Presentation Outline

- Network Topologies
  - Daisy Chain, Ring and Star networks
  - Case Study – Fresno Metro Area Fiber Optic System

Conduit Layout

- Some Conduit Terminology
  - Schedule 40 PVC (Polyvinyl chloride)
    - Caltrans Type 3 conduit
  - High-density polyethylene (HDPE)
  - Standard Dimension Ratio (SDR)
  - Standard Internal Dimension Ratio (SIDR)

Conduit Layout (continued)

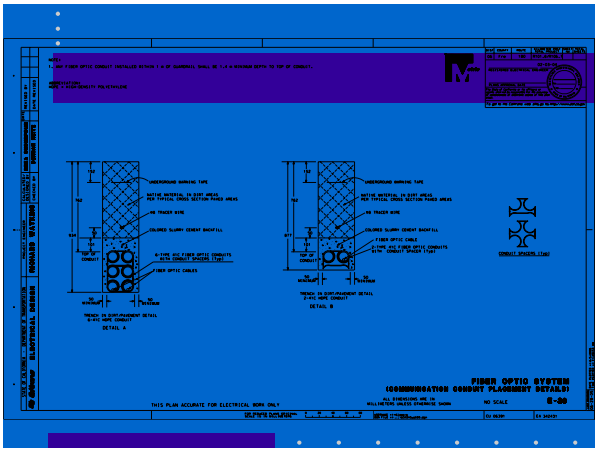
- Six pack – Six 1 ½ direct burial
- 4” PVC w/ three 1 ¼ innerduct
- Conduit sweeps
- HDPE Conduit types:
  - Smooth wall, Ribbed, and Corrugated innerduct
  - Standard Dimension Ratio (SDR) / Standard Internal Dimension Ratio (SIDR)

Conduit Layout (continued)

- Six Pack
  - Six 1 ½ rigid steel
  - CalTrans Type 1

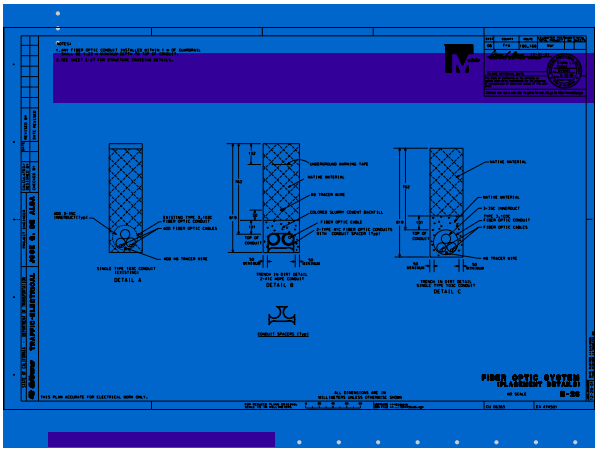
Conduit Layout (continued)

Conduit Layout (continued)



Conduit Layout (continued)

- Other methods
  - 4" PVC – Three 1-¼" innerduct



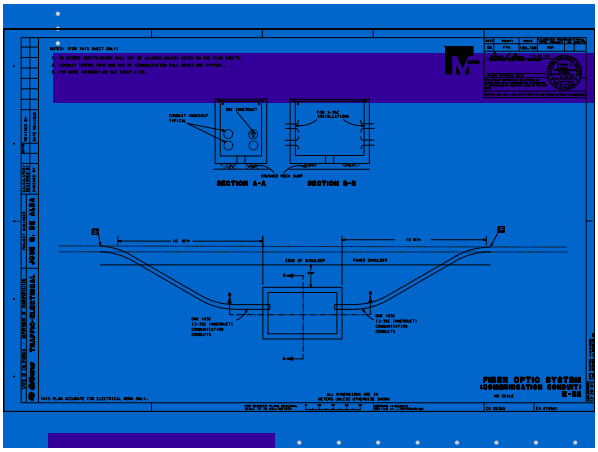
Conduit Layout (continued)

- 4" PVC No innerduct

Conduit Layout (continued)

Conduit Layout (continued)

- Conduit sweeps
  - Avoid 90 degree conduit turns
  - Conduit transitions should be smooth flowing
    - Reduces friction on cable
    - Eases cable placement
    - Continuous installation runs
    - Expedites job!



Conduit Layout (continued)

Conduit Layout (continued)

- HDPE Conduit types:
  - Smoothwall Innerduct
  - Ribbed Innerduct
  - Corrugated Innerduct
  - Standard Dimension Ratio (SDR)
    - The lower the number, the thicker the wall
  - Standard Internal Dimension Ratio (SIDR)
    - The lower the number, the thicker the wall

Conduit Layout (continued)

- For Example
  - 1 1/4" SDR 11 Duct has a wall thickness of 0.151, multiplied by 11 (SDR 11) = an outside diameter of 1.66"
  - 1" SIDR 7 Duct has a wall thickness of 0.150, multiplied by 7 (SIDR 7) = an inside diameter of 1.05"

Conduit Layout (continued)

What's better Sch. 40 PVC or HDPE?

- PVC
  - Internal wall typically smooth
  - PVC primarily for electrical conductor usage
  - Wall thickness is standard
  - PVC standard lengths (Sticks of conduit)
    - 10 and 20 foot standard lengths

Conduit Layout (continued)

- HDPE
  - Wall thickness can vary depending on application
  - Internal and External wall specifically designed for reducing friction
  - Conduit can be pressurized

Conduit Layout (continued)

- HDPE (continued)
  - HDPE standard lengths
    - Typically, duct will be delivered on spools
    - Standard lengths:
      - 1" 10,000 foot reel
      - 1 1/4" 7,000 foot reel
      - 1 1/2" 4,500 foot reel

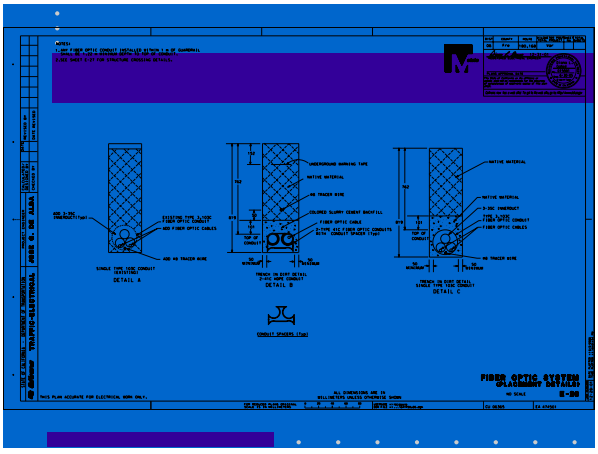
Conduit Layout (continued)

- Pull Tape
  - footage markings
  - polyester material
  - pre-lubricated
- Pull Rope
  - No foot markings
  - polyester material
  - pre-lubricated

Conduit Layout (continued)

Conduit Placement Methods

- Trenching
  - Native material backfill
  - 3 sack cement slurry backfill



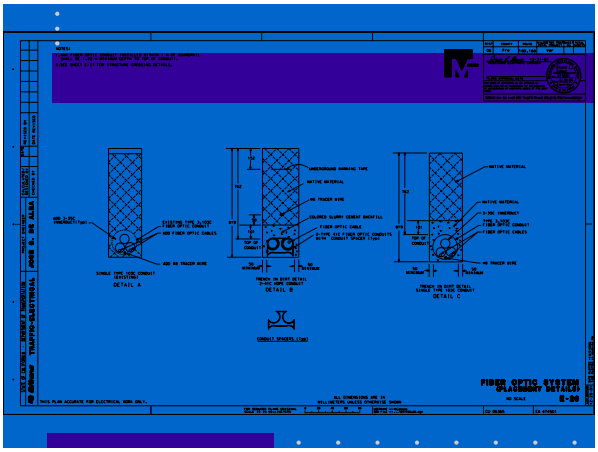
Conduit Layout (continued)


Conduit Layout (continued)



Conduit Layout (continued)

- Bore/Jacking
  - Hardpan
  - Sandy areas
  - Dependent on As-built, Underground Service Alert (USA)



Conduit Layout (continued)

- Conduit Detection Systems
  - Warning tape
  - Colored slurry cement backfill
  - Tracer wire
  - Conduit w/ tracer wire
  - Fabric duct w/ tracer wire
  - Detectable pull tape

Conduit Layout (continued)

- Fiber Optic Splice Vaults
  - Concrete pull boxes
    - Caltrans #6
    - P48

Conduit Layout (continued)


Conduit Layout (continued)

Conduit Layout (continued)

- Fiber Optic Splice Vaults
  - Fiber vaults
    - Full size vaults (6.5'W x 4'L x 4'D)
    - Mini vaults (4'W x 2.5'L x 4'D)
    - Installation/Construction
      - Conduit termination
      - Labeling/ID
      - Sump

Conduit Layout (continued)


Conduit Layout (continued)


Fiber Optic System

Fiber Optic Hubs

- ITS Cabinet Type

Fiber Optic System (continued)

Fiber Optic System (continued)

Fiber Optic System (continued)

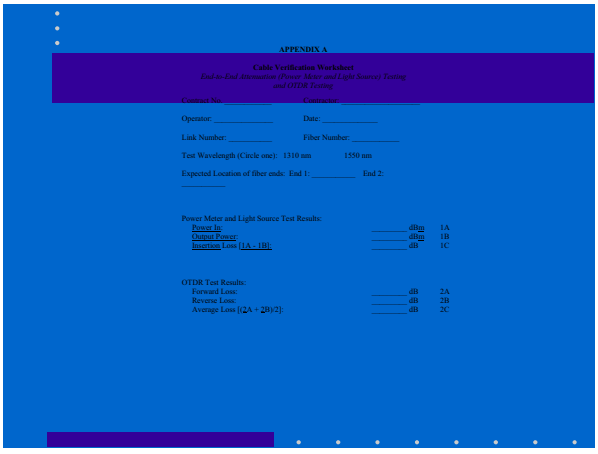
Fiber Optic Hubs

- Walk-ins Type
  - Pre-fabricated/Onsite
  - HVAC

Fiber Optic System (continued)

Fiber Optic System (continued)

- Fiber Optics cable types
  - – Multi-mode – LAN networks
    - Loose tube cables – Outside plant environments
  - – Single mode – WAN/MAN's network
    - Tight-buffered cables – Inside plant environments



APPENDIX A

Cable Verification Worksheet

End-to-End Attenuation (Power Meter and Light Source) Testing and OTDR Testing

Contract No. _____ Contractor: _____

Operator: _____ Date: _____

Link Number: _____ Fiber Number: _____

Test Wavelength (Circle one): 1310 nm 1550 nm

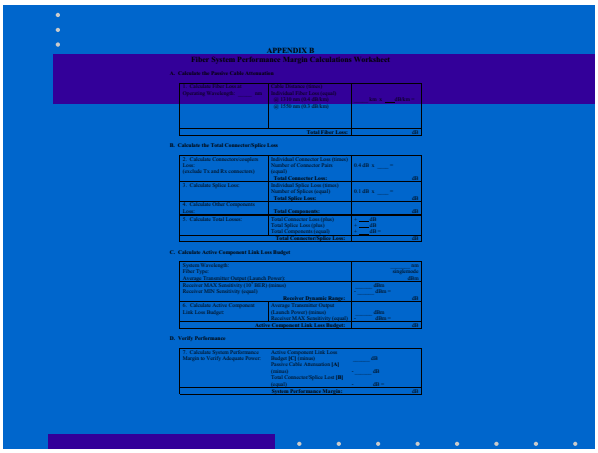
Expected Location of fiber ends: End 1: _____ End 2: _____

Power Meter and Light Source Test Results:

Power In:	_____ dBm	1A
Output Power:	_____ dBm	1B
Insertion Loss [1A - 1B]:	_____ dB	1C

OTDR Test Results:

Forward Loss:	_____ dB	2A
Reverse Loss:	_____ dB	2B
Average Loss [(2A + 2B)/2]:	_____ dB	2C



APPENDIX B

Fiber System Performance Margin Calculations Worksheet

A. Calculate the Passive Cable Attenuation

1. Calculate Fiber Loss at Operating Wavelength: _____ nm	Cable Attenuation (dB/km) Multiplied Fiber Loss (typical) @ 1310 nm (0.4 dB/km) @ 1550 nm (0.3 dB/km)	loss x ___ dB/km =
	Total Fiber Loss:	dB

B. Calculate the Total Connector/Splice Loss

2. Calculate Connector/coupler Loss (include Tx and Rx connectors)	Individual Connector Loss (times) Number of Connector Pairs (equal)	0.4 dB x ___ =
	Total Connector Loss:	dB
3. Calculate Splice Loss:	Individual Splice Loss (times) Number of Splices (equal)	0.1 dB x ___ =
	Total Splice Loss:	dB
4. Calculate Other Components Loss:	Total Components:	dB
5. Calculate Total Losses:	Total Connector Loss (plus) Total Splice Loss (plus) Total Components (equal)	___ dB ___ dB + ___ dB =
	Total Connector/Splice Loss:	dB

C. Calculate Active Component Link Loss Budget

System Wavelength:		nm
Fiber Type:		single/multi
Average Transmitter Output (Launch Power):		dBm
Receiver MAX Sensitivity (-10^-BER) (minus)		- _____ dBm =
Receiver MIN Sensitivity (equal)		- _____ dBm =
	Receiver Dynamic Range:	dB
6. Calculate Active Component Link Loss Budget:	Average Transmitter Output (Launch Power) (minus)	_____ dBm
	Receiver MAX Sensitivity (equal)	- _____ dBm =
	Active Component Link Loss Budget:	dB

D. Verify Performance

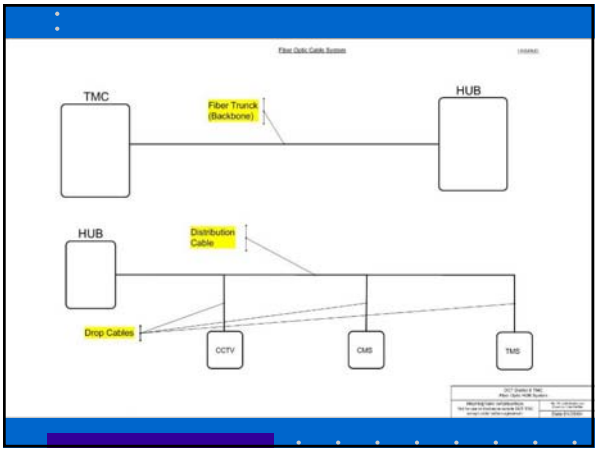
7. Calculate System Performance Margin to Verify Adequate Power:	Active Component Link Loss Budget [C] (minus)	_____ dB
	Passive Cable Attenuation [A] (minus)	- _____ dB
	Total Connector/Splice Loss [B] (equal)	- _____ dB =
	System Performance Margin:	dB

Fiber Optic System (continued)

- All-Dielectric, Armored, Self-Supporting, Direct Buried
- Other considerations
  - Riser – Floor to floor
  - Plenum areas– Use in return air attics/false ceilings/etc
  - PVC jacket cables – If used indoors, use in conduit for plenum areas
  - NEC requirements

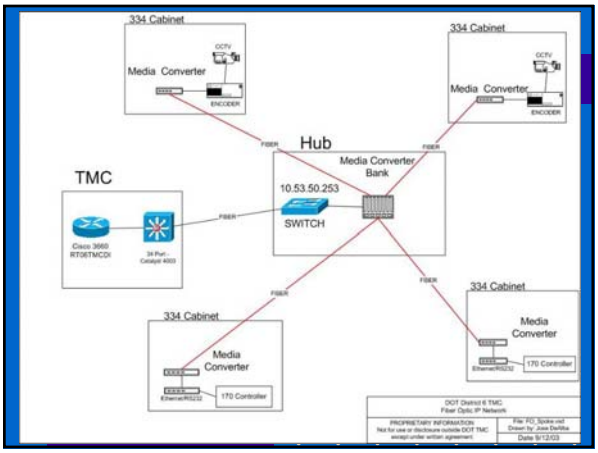
Fiber Optic Topologies

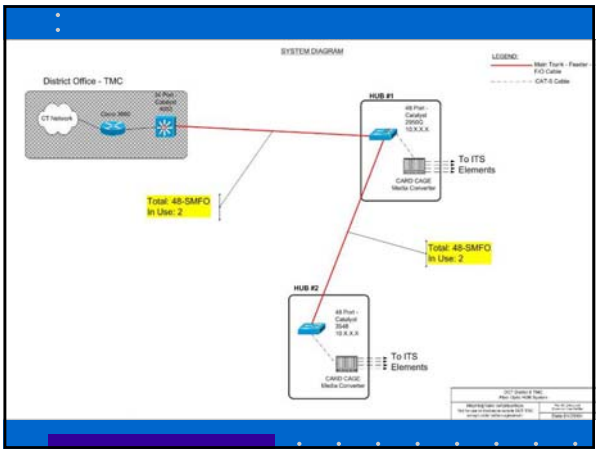
- Fiber Optic Network Topologies
  - Fiber Optic cable system design types
    - Trunk cables (a.k.a. Fiber Backbone)
    - Distribution cables
    - Drop cables
    - Reduction cables

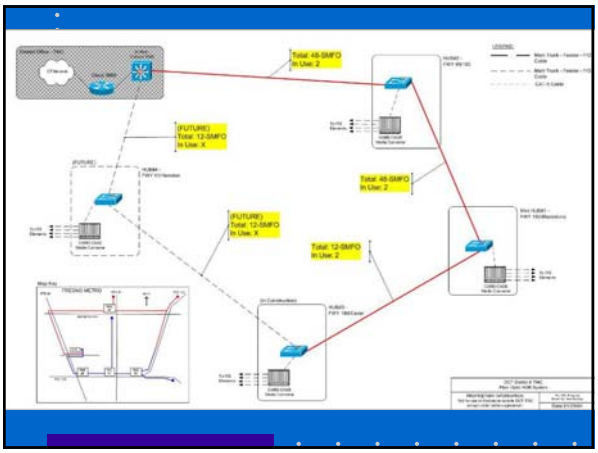


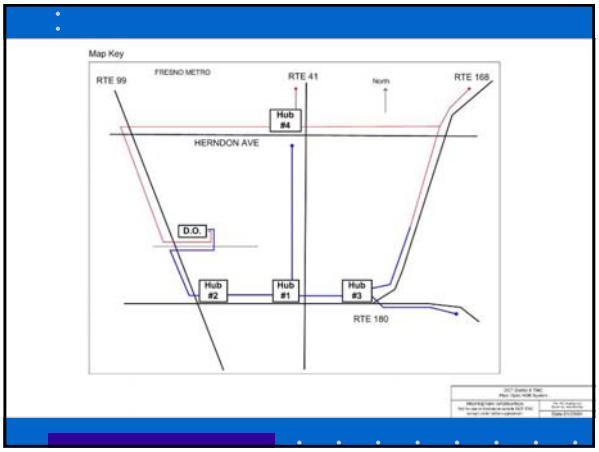
Fiber Optic Topologies

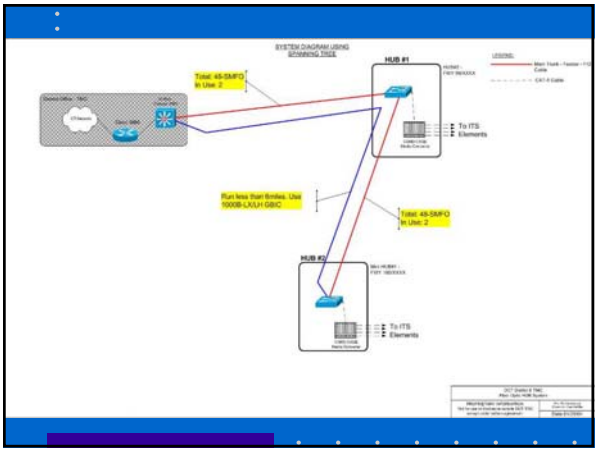
- Fiber Optic Network Topologies
  - Spoke, Ring, Hybrid
    - Case study
      - Fresno Metro Area Fiber Optic System











Final Comments

- Inter-agency cooperation – Funding !!!
- Regional Agencies/Join forces
- Build in pieces, not the whole

References

- CalTrans 1999 Standard Plans
- CalTrans 2004 Standard Plans
- CalTrans 1999 Standard Plans
- 1999 National Electric Code (NEC)
- 2002 National Electric Code (NEC)
- Web