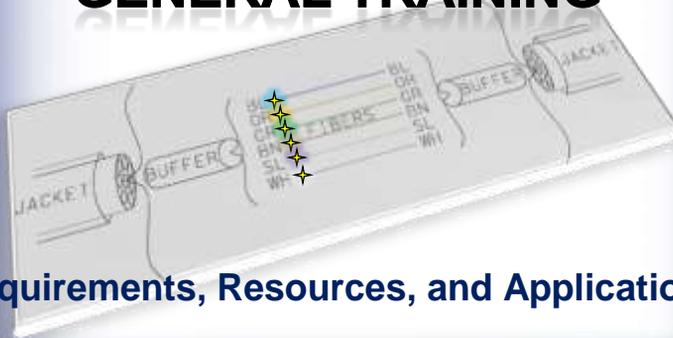


Florida Department of Transportation

Traffic Engineering and Operations

ITS FIBER OPTIC CABLE GENERAL TRAINING



Requirements, Resources, and Application

PRESENTER:

R. "Carlo" Adair, P.E.

ATKINS - Central Florida ITS (Orlando)

ITS Engineer

- 10 Years Experience
- 5 Years with ATKINS
- ITS Design
- Signal Design
- Technical Writer
- Utility/Power/Stakeholder Coordination
- Project Management



PURPOSE:

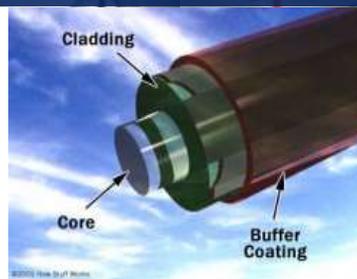
Provide insight into practices associated with fiber optic cable design including: specifications, pay-items, Design Standards, and industry practices.

- Standard Specifications for Road and Bridge Construction**
- Minimum Specifications for Traffic Control Signals and Devices (MSTCSD)**
- FDOT Design Standards**
- Basis of Estimates (BOE)**
- Plans Preparation Manual (PPM)**



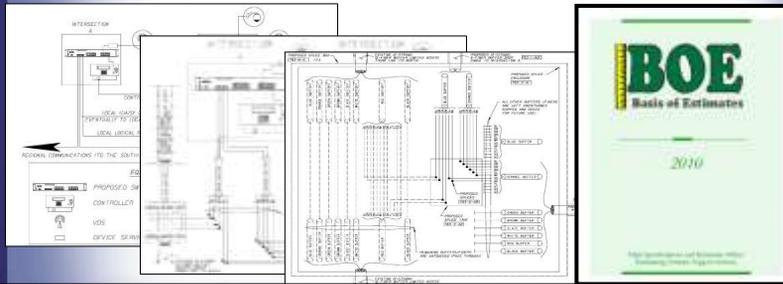
AGENDA: Fiber Optic Cable

- What it is**
- How it works**
- Why we use it**
- Regulations important to our industry**



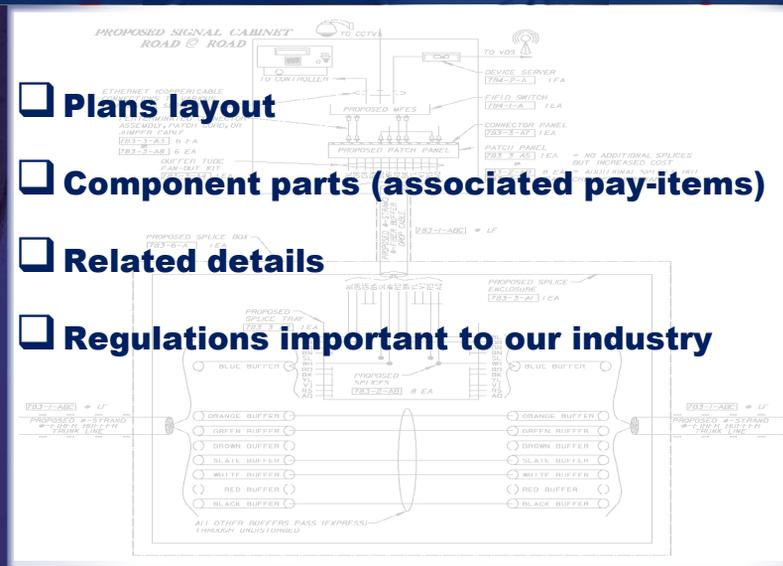
AGENDA: Design Concepts

- Layout from high-level
- Layout from mid-level
- Layout for specific conditions
- Regulations important to our industry



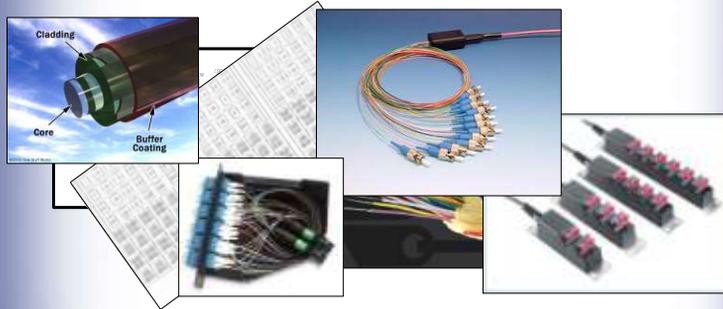
AGENDA: Design Plans

- Plans layout
- Component parts (associated pay-items)
- Related details
- Regulations important to our industry



AGENDA: Examples

- Various devices
- Connections to one another
- Associated pay-items (as applicable)



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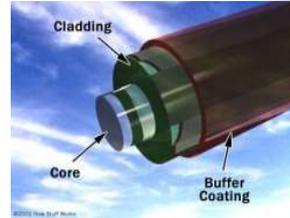
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FIBER OPTIC CABLE:

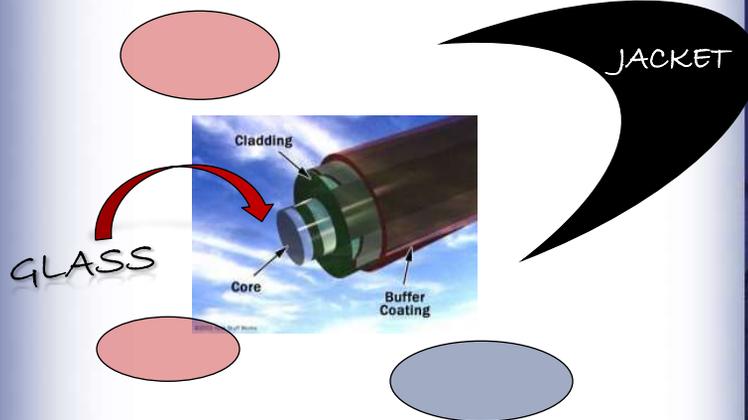


FIBER OPTIC CABLE:

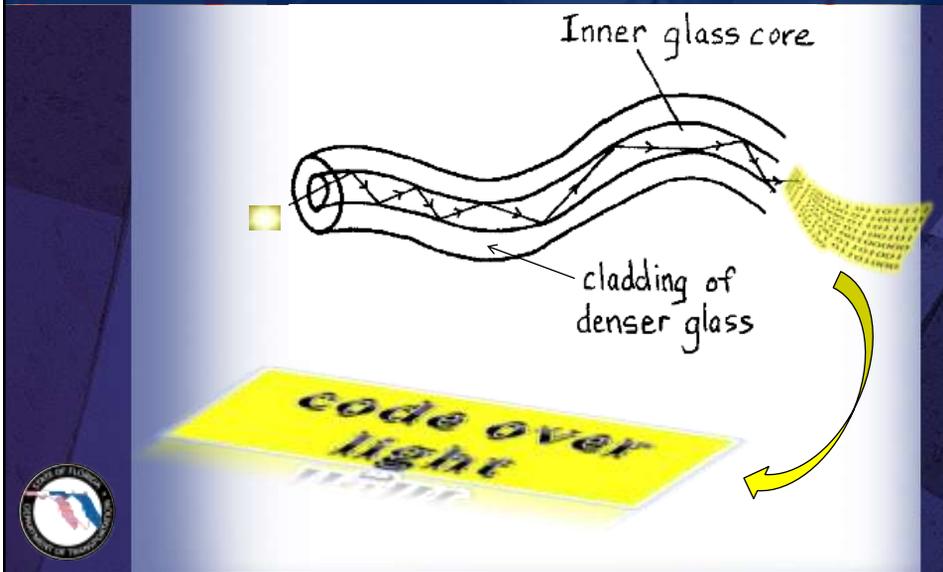
- What it is
- How it works
- Why we use it



FIBER OPTIC CABLE: What it is



FIBER OPTIC CABLE: How it works



FIBER OPTIC CABLE: Why we use it

- Speed of Light = 186,000 miles/second
- Circumference of the earth = ~24,900 miles
- FS = ~49,800 miles
- 1/4sec to "safely" transmit a signal to opposite end of earth and back!



FIBER OPTIC CABLE: Regulations

TERMINOLOGY



COLOR CODE

Position	Jacket color
1	Blue
2	Orange
3	Green
4	Brown
5	Slate
6	White
7	Red
8	Black
9	Yellow
10	Pink
11	Rose
12	Light Blue

RULE OF SEPARATION

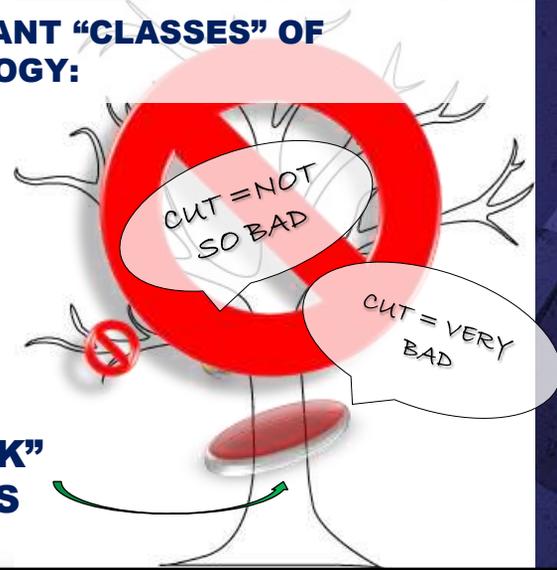


FIBER OPTIC CABLE: Terminology

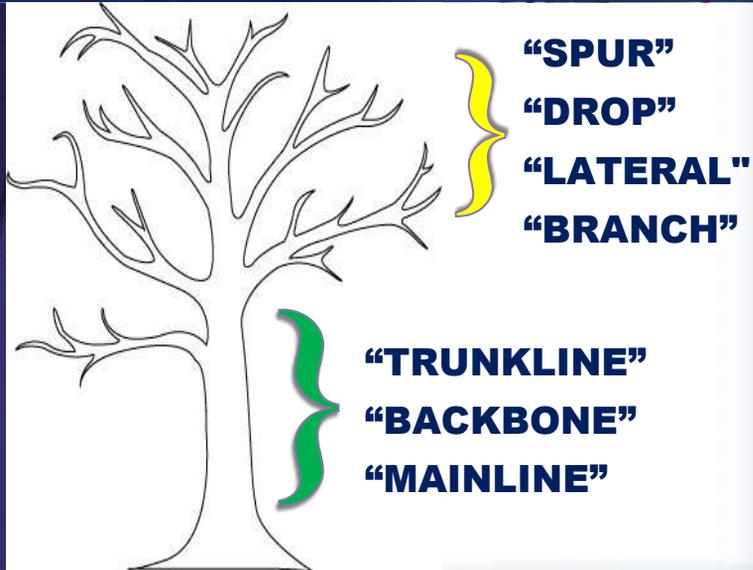
TWO IMPORTANT "CLASSES" OF TERMINOLOGY:

"BRANCH" CLASS

"TRUNK" CLASS



FIBER OPTIC CABLE: Terminology



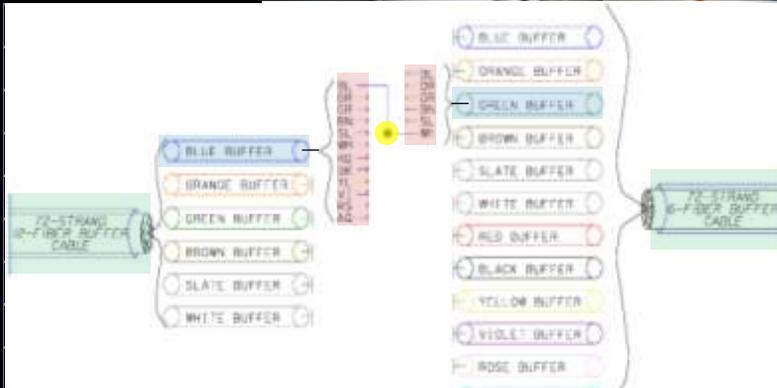
FIBER OPTIC CABLE: Color Code

EIA / TIA – 598 STANDARD:
"Optical Fiber Cable Color Coding" schema

Position	Jacket color
1	Blue
2	Orange
3	Green
4	Brown
5	Slate
6	White
7	Red
8	Black
9	Yellow
10	Violet
11	Rose
12	Aqua

VERY
IMPORTANT
TO KNOW!!!

FIBER OPTIC CABLE: Color Code



WAYS TO SAY THE SAME THING:

CABLE	BUFFER	FIBER	-----	FIBER	BUFFER	CABLE	COMMENTS:
12-STRAND PER BUFFER 72- COUNT CABLE	BLUE	BLUE	-----	WHITE	GREEN	6-STRAND PER BUFFER 72- COUNT CABLE	COLORS ONLY
	1	1	-----	6	3		NUMBERS ONLY
	1	BLUE	-----	6	GREEN		MIXED
	BLUE	1	-----	WHITE	3		

FIBER OPTIC CABLE: Separation

TWO WIDELY SOURCED REASONS:

1. GLASS CAN MELT:



FIBER OPTIC CABLE: Separation

TWO WIDELY SOURCED REASONS:



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Traffic Engineering and Operations

**FIBER DESIGN
HIGH-LEVEL CONCEPTS:**



HIGH LEVEL FIBER DESIGN:



HIGH LEVEL FIBER DESIGN: Exposure

"TO BETTER ENSURE COMMUNICATIONS INTEGRITY IS TO LIMIT EXPOSURE OF YOUR MOST CRUCIAL COMMUNICATIONS COMPONENTS."

TRUNK
CLASS

~Me (CARLO)

HIGH LEVEL FIBER DESIGN: Path'ing

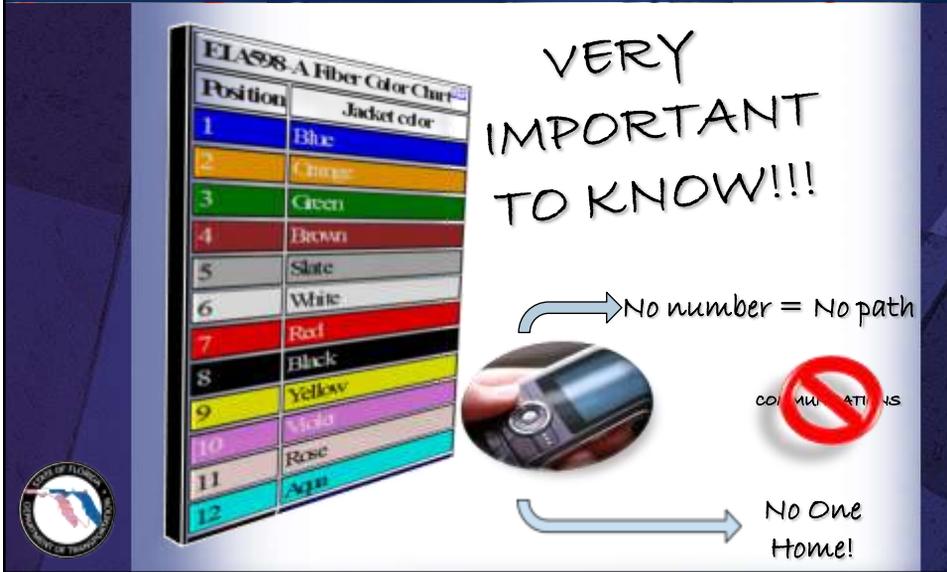
VERY IMPORTANT TO KNOW!!!

Position	Jacket color
1	Blue
2	Orange
3	Green
4	Brown
5	Slate
6	White
7	Red
8	Black
9	Yellow
10	Violet
11	Rose
12	Aqua

→ No number = No path

COMMUNICATIONS

→ No One Home!



HIGH LEVEL FIBER DESIGN: Capacity

CAPACITY IS BANDWIDTH

code over light

10

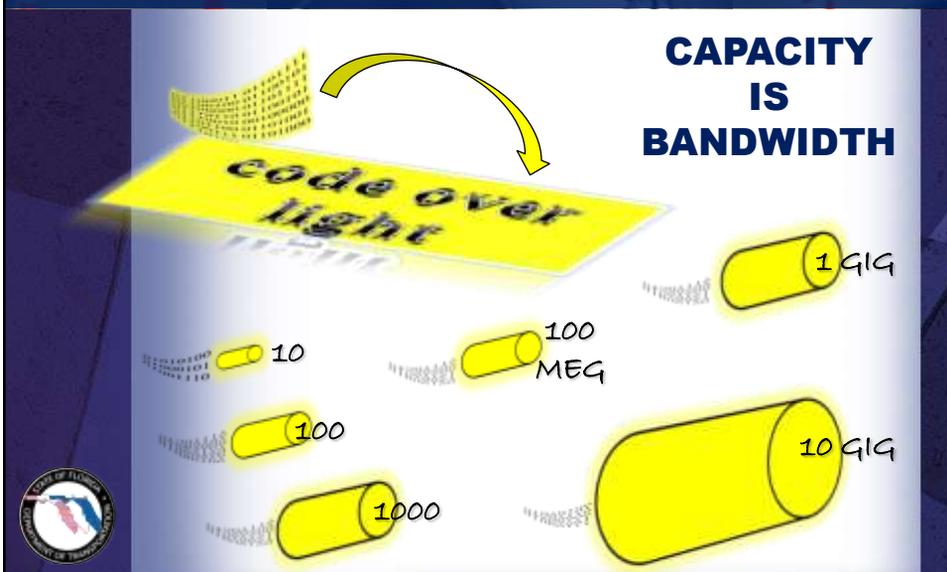
100 MEG

100

1000

1 GIG

10 GIG



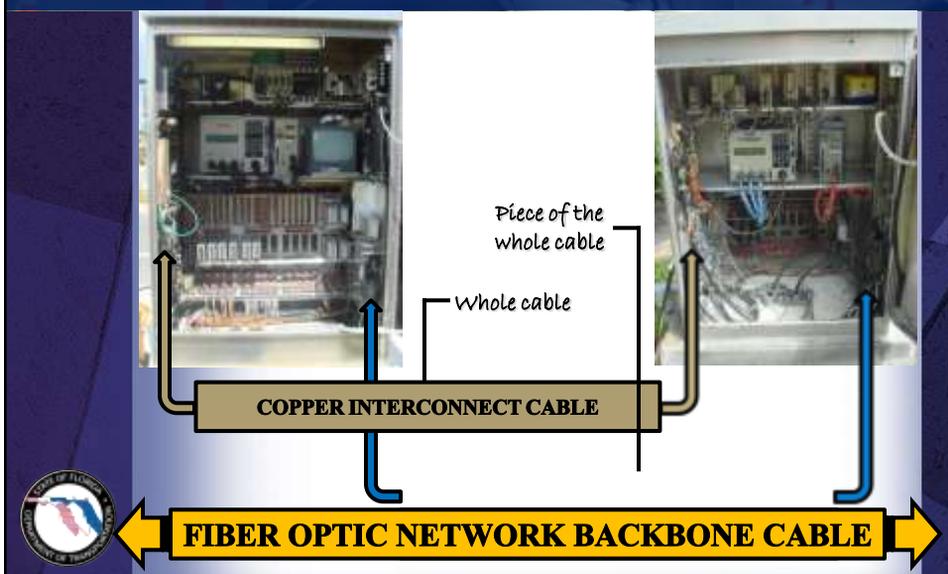
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FIBER DESIGN MID-LEVEL CONCEPTS:



FIBER DESIGN: How To Limit Exposure



FIBER DESIGN: How To Limit Exposure

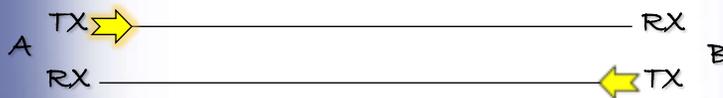


FIBER DESIGN: How To Verify Path'ing

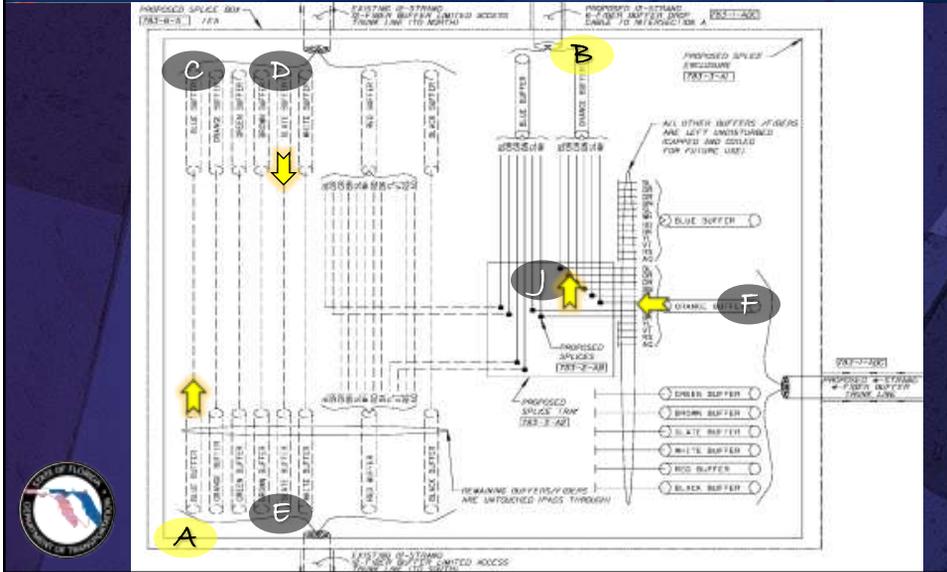
PATH'ING = TRACING



FULL DUPLEX = SIMULTANEOUS TRANSMIT AND RECEIVE



FIBER DESIGN: How To Verify Path'ing



FIBER DESIGN: How To Check Capacity

783-1.4.2.1 End to End Attenuation Testing: Perform testing on all fibers to ensure that end to end attenuation does not exceed allowable loss (0.4 db/km for 1310nm wavelength, 0.3 db/km for 1550nm wavelength, plus 0.5 db for any connectors and 0.1 db for splices). Repair or replace cable sections exceeding allowable attenuation at no cost to the Department.

GIVEN:

- Known Distances
- Known number and type of connections
- With associated loss values

FIBER DESIGN: How To Check Capacity

GIVEN:

- Known Distance..... 5**
- Known number and type of connections**
 - Fusion..... 3**
 - Mechanical..... 2**

SAMPLE LINE-LOSS BUDGET SPREAD SHEET								
Distance (km)	Allowable loss over length per wavelength (dB)		Number of connection types		Allowable loss per connection Type (dB)		Total allowable loss (dB)	
	1310nm	1550nm	Fusion	Mechanical	Fusion	Mechanical	1310nm	1550nm
5	2	1.5	3	2	0.3	1	3.3	2.8

CHECK WITH ITS NETWORK MANAGERS!!!



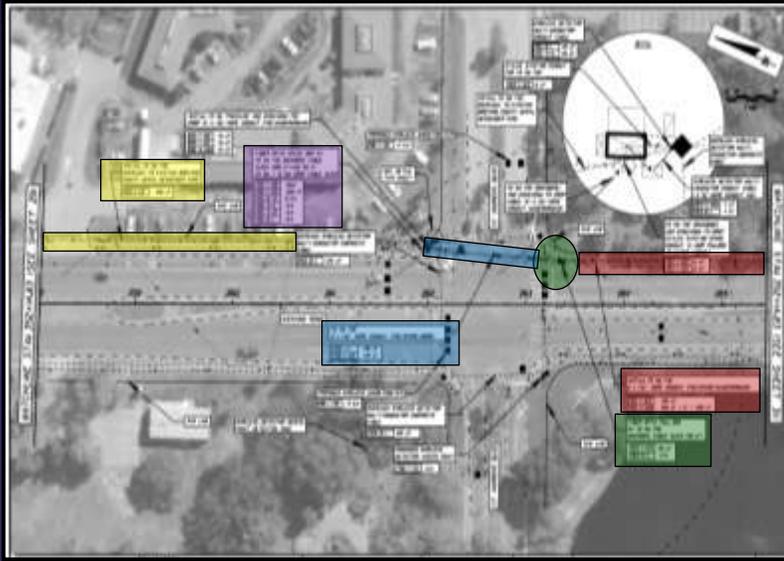
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FIBER DESIGN PLANS:



FIBER DESIGN IN PLANS: Plan Sheets



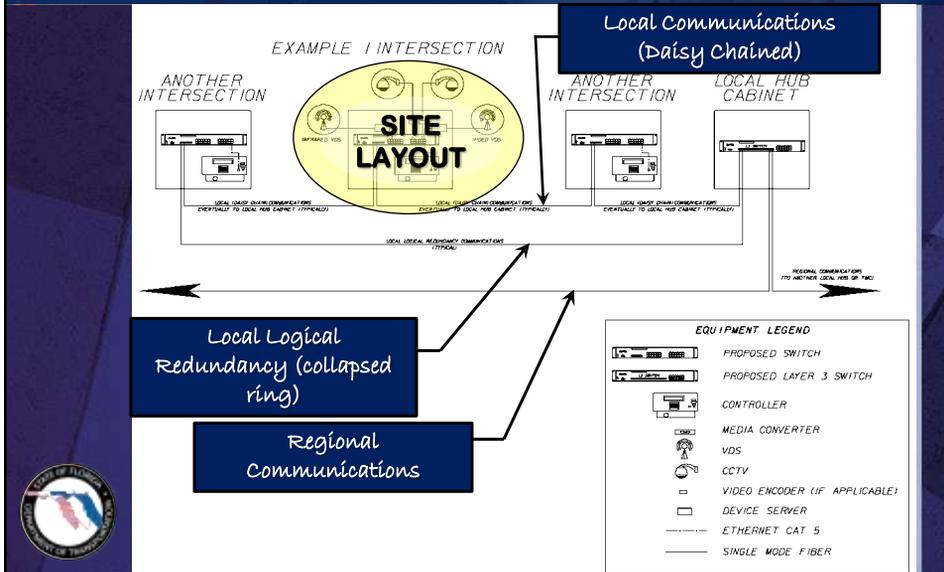
FIBER DESIGN IN PLANS: Details

FOUR PRIMARY DETAILS:

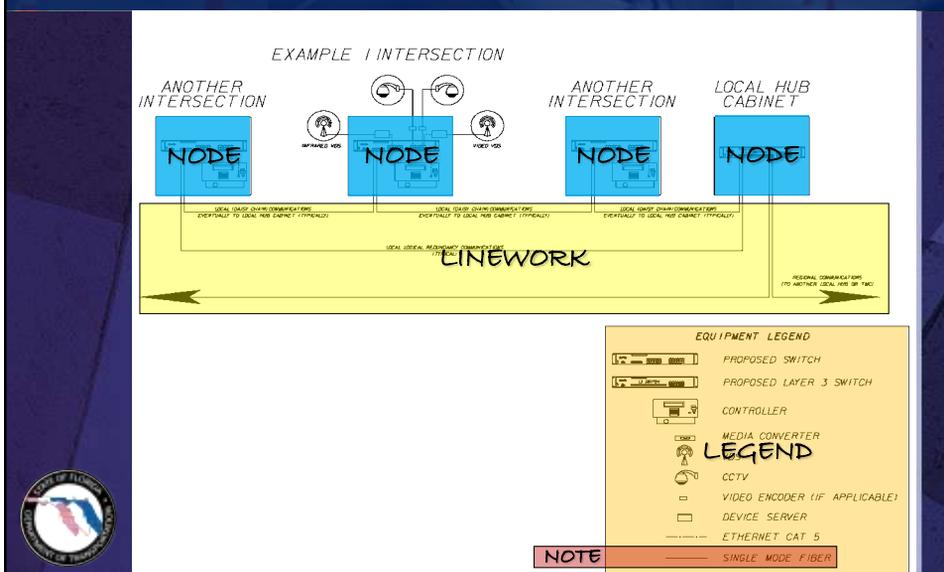
- Network Block Diagram
- Splicing Diagram
- Port Assignment
- Link-loss Budget



FIBER DESIGN IN PLANS: Block



FIBER DESIGN IN PLANS: Block



FIBER DESIGN IN PLANS: Ports

PORTS

ASSIGNMENTS

FIBER DESIGN IN PLANS: Links

SAMPLE LINK-LOSS BUDGET SPREADSHEET

Distance (km)	Allowable loss over length per wavelength (dB)		Number of connection types		Allowable loss per connection Type (dB)		Total allowable loss (dB)	
	1310nm	1550nm	Fusion	Mechanical	Fusion	Mechanical	1310nm	1550nm
3	2	1.5	3	2	0.3	1	3.3	2.8

SAMPLE LINK-LOSS BUDGET SPREADSHEET

Typical Route	Distance (km)	Allowable loss over length per wavelength (dB)		Number of connection types		Allowable loss per connection Type (dB)		Total allowable loss (dB)	
		1310nm	1550nm	Fusion	Mechanical	Fusion	Mechanical	1310nm	1550nm
1	5	2	1.5	3	2	0.3	1	3.3	2.8
2	1	0.4	0.3	1	1	0.1	0.5	1	0.9
3	2	0.8	0.6	2	2	0.2	1	2	1.8
4	3	1.2	0.9	3	3	0.3	1.5	3	2.7
5	4	1.6	1.2	4	4	0.4	2	4	3.6

FIBER DESIGN IN PLANS: Links

SAMPLE LINK-LOSS BUDGET SPREADSHEET

Typical Route	Distance (km)	Allowable loss over length per wavelength (dB)		Number of connection types		Allowable loss per connection Type (dB)		Total allowable loss (dB)	
		1310nm	1550nm	Fusion	Mechanical	Fusion	Mechanical	1310nm	1550nm
1	5	2	1.5	3	2	0.3	1	3.3	2.8
2	1	0.4	0.3	1	1	0.1	0.5	1	0.9
3	2	0.8	0.6	2	2	0.2	1	2	1.8
4	3	1.2	0.9	3	3	0.3	1.5	3	2.7
5	4	1.6	1.2	4	4	0.4	2	4	3.6



Florida Department of Transportation

Traffic Engineering and Operations

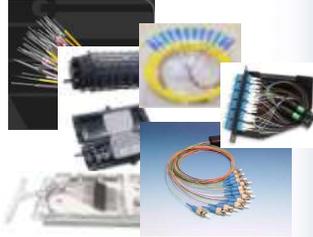
**EXAMPLES
(STAGE I):**



EXAMPLES: Agenda

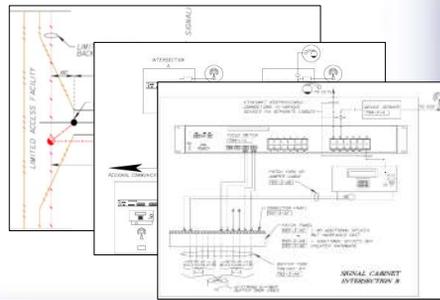
STAGE I:

Components



STAGE II:

Mock Design



EXAMPLES: Stage I

BASIC COMPONENTS:

Fiber Optic Cable

Connection Types

Hardware for FOC

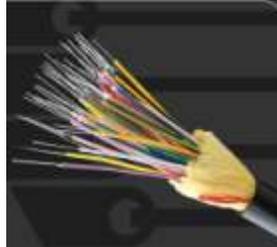
Infrastructure for FOC



EXAMPLES: Stage I: FOC

Struct. 783- 1-ABC ITS FIBER OPTIC CABLE LF

- A= Operation
 1 (Furnish & Install)
 3 (Install)
 4 (Relocate)
 5 (Adjust /Modify)
 6 (Remove) BC=00
 7 (Remove and Stockpile) BC=00
- B= Location
 1 (Overhead)
 2 (Underground)
- C= Number of Fibers in Cable
 1 (2 to 12)
 2 (13 to 48)
 3 (49 to 96)
 4 (97 to 144)



Notes *Remove item may require plan details and/or tech spec

- As required in the Standard Specs:

783-1 Fiber Optic Cable System.

783-1.1 Description. Furnish and install a fiber optic cable system as shown in the plans

- The general notes or design tags should specify the fiber count within each buffer tube of the fiber optic cable (FOC)

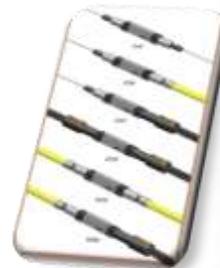
- Typical specifications include:
 - 12-count, 6-fibers per buffer
 - 12-count, 12-fibers per buffer



EXAMPLES: Stage I: FOC Connection

Struct. 783- 2- AB ITS FIBER OPTIC CONNECTION EA

- A= Operation
 3 (Install)
 4 (Relocate)
 5 (Adjust /Modify)
- B= Type
 1 (Splice)
 2 (Termination)



- As required in the Standard Specs:

783-1.3.2 Splicing: Perform all optical fiber splicing using the fusion splicing technique, and according to the latest version of the manufacturer's cable installation procedures; industry-accepted installation standards, codes, and practices; or as directed by the Engineer.

- Use of "relocate" (A=4) and "adjust/modify" (A=5) options is rare
 - Additional work associated with relocate and adjust/modify efforts typically covered under "adjust/modify" of splice tray or enclosure:
 - 783-3-51 or 783-3-52 (see following slides)



EXAMPLES: Stage I: FOC Hardware

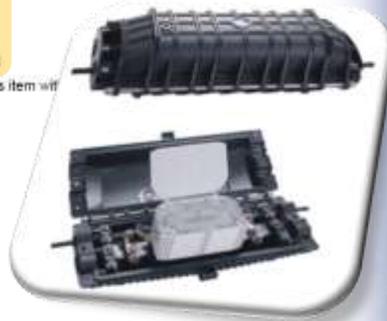
Struct. 783- 3- AB ITS FIBER OPTIC CONNECTION HARDWARE EA

- A= Operation
 1 (Furnish & Install)
 2 (Furnish)
 3 (Install)
 4 (Relocate)
 5 (Adjust /Modify)

- B=Component
 1 (Splice Enclosure)
 2 (Splice Tray)
 3 (Preterminated Connector Assembly)
 4 (Buffer Tube Fan Out Kit)
 5 (Patch Panel, Preterminated)
 6 (Patch Panel, Field Terminated)
 7 (Connector Panel)
 8 (Patch Cord)" Tech Spec needed; see BOE detail

Notes: *B=8: Tech Spec needed. Coordinate the use of this item with

B = 1; Splice Enclosure:



EXAMPLES: Stage I: FOC Hardware

B = 2; Splice Tray



B = 3; Pre-terminated Connector Assembly (Pigtails):



EXAMPLES: Stage I: FOC Hardware

B = 4; Buffer Tube Fan-out Kit:



B = 5; Patch Panel (Pre-terminated):



EXAMPLES: Stage I: FOC Hardware

B = 6; Patch Panel (Field terminated):



B = 7; Connector Panel:



Type LC

Type SC



Type ST

Type FC

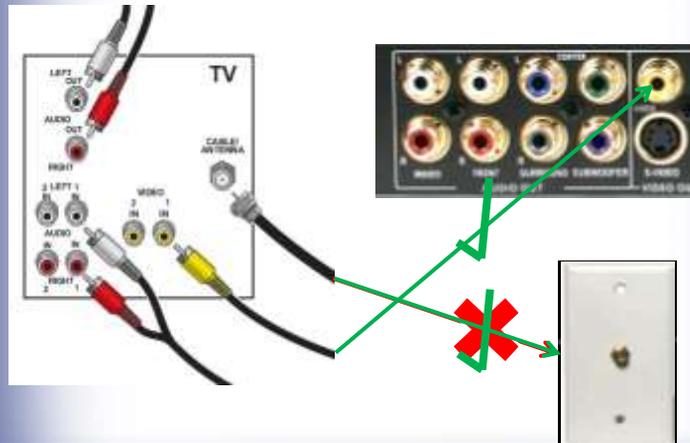
B = 8; Patch Cord:



COMMUNICATIONS INFRASTRUCTURE

Design 101

- Physical design is understanding what connects to what:



EXAMPLES: Stage I: Conduit

Struct. 783- 4-1AB ITS CONDUIT

LF

- A= Operation
 1 (Furnish & install)
 2 (Furnish) B=0
 3 (Install)
 4 (Relocate)
 5 (Adjust /Modify)
 6 (Remove and Dispose) B=0

- B= Location
 1 (Aboveground)
 2 (Underground)
 3 (Underpavement Sawcut) Note: to be used only when sawcutting is necessary
 9 (Special)"

Notes *Special to be used only with approval of the ITS Office
 Plan Details and/or Tech Specs needed for Install, Relocate, Adjust/Modify, and Remove items.



783-2 Conduit and Locate System.

783-2.1 General: Furnish and install conduit and a locate system for fiber optic cable. Ensure that the conduit complies with the requirements of Section 630.

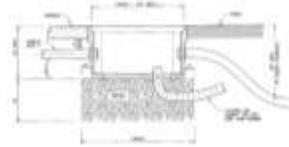
Place the locate system along any underground conduit installation. Ensure that the locate system includes aboveground route markers, warning tape, tone wire, and electronics that allow detection of buried conduit and other related underground facilities.



EXAMPLES: Stage I: Pull Boxes

Struct. 783- 5- A ITS PULL BOX FOR FIBER OPTIC EA

- A= Operation:
 1 (Furnish & Install)
 2 (Furnish)
 3 (Install)
 4 (Relocate)
 5 (Adjust /Modify)



- As required in the Standard Specs:

783-3 Pull Boxes and Splice Boxes for Fiber Optic Cable.

783-3.1 Description: Furnish and install pull boxes and splice boxes of the type, size, and quantity as shown in the plans. Ensure that pull boxes and splice boxes also conform to the requirements of Section 635. Use only equipment and components that meet the requirements of these minimum specifications, and are listed on the Department's Approved Product List (APL).

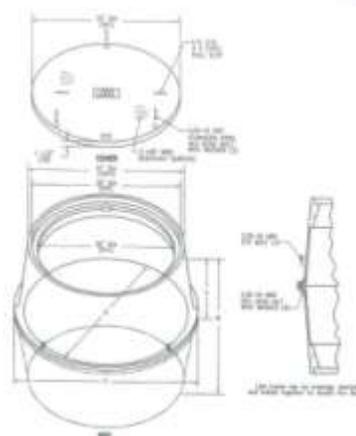
- Not completely descriptive however, it is noted that pull boxes must be on the APL and dimensions are to be specified in the design plans...



EXAMPLES: Stage I: Pull Boxes

Struct. 783- 6- A ITS SPLICE BOX FOR FIBER OPTIC EA

- A= Operation:
 1 (Furnish & Install)
 2 (Furnish)
 3 (Install)
 4 (Relocate)
 5 (Adjust /Modify)
 6 (Remove & Dispose)



- The same standards governing pull boxes for fiber optic apply here:
 - Refer to previous slides for guidance...
- Details required



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Traffic Engineering and Operations

EXAMPLES (STAGE II):



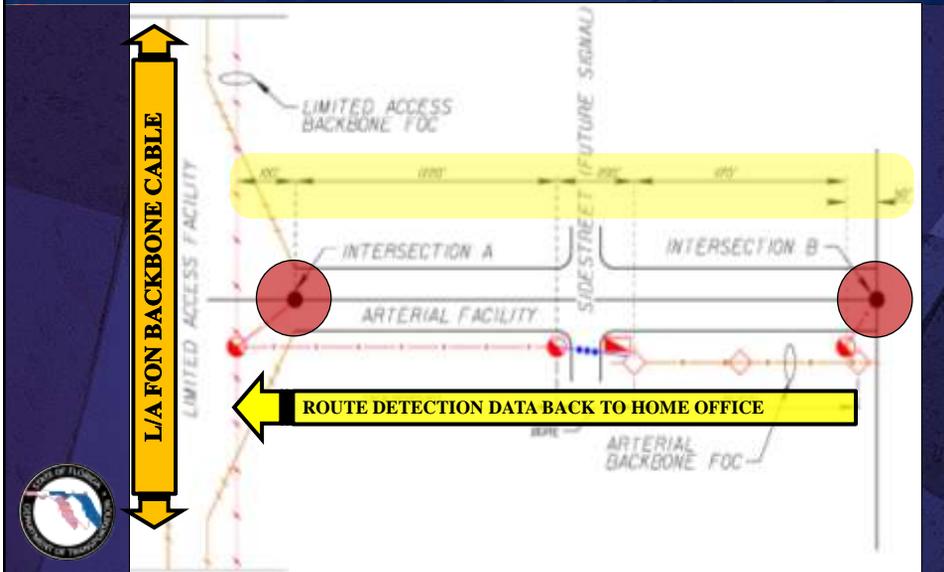
EXAMPLES: Stage II

COMPONENTS:

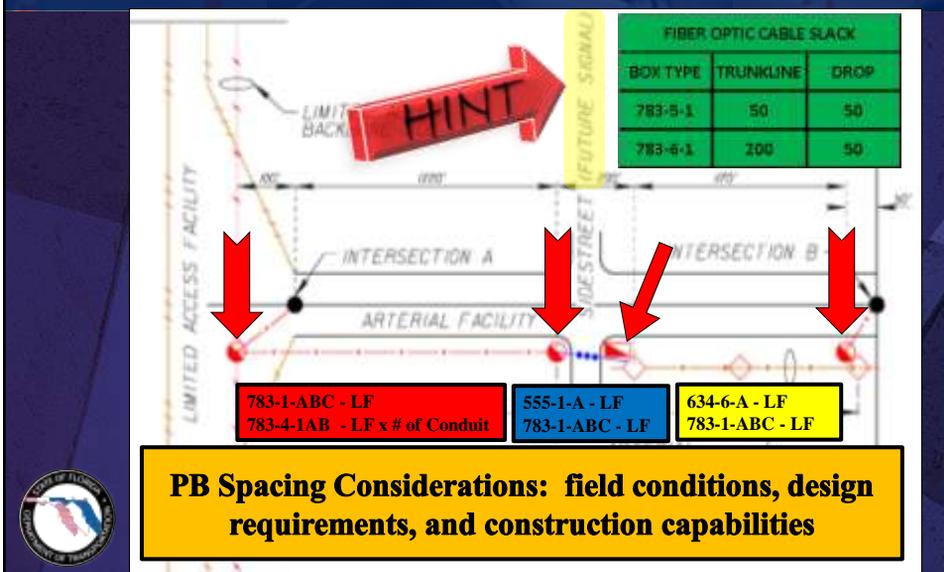
- Minimize backbone exposure**
- Verify Path'ing**
- Checking Capacity**



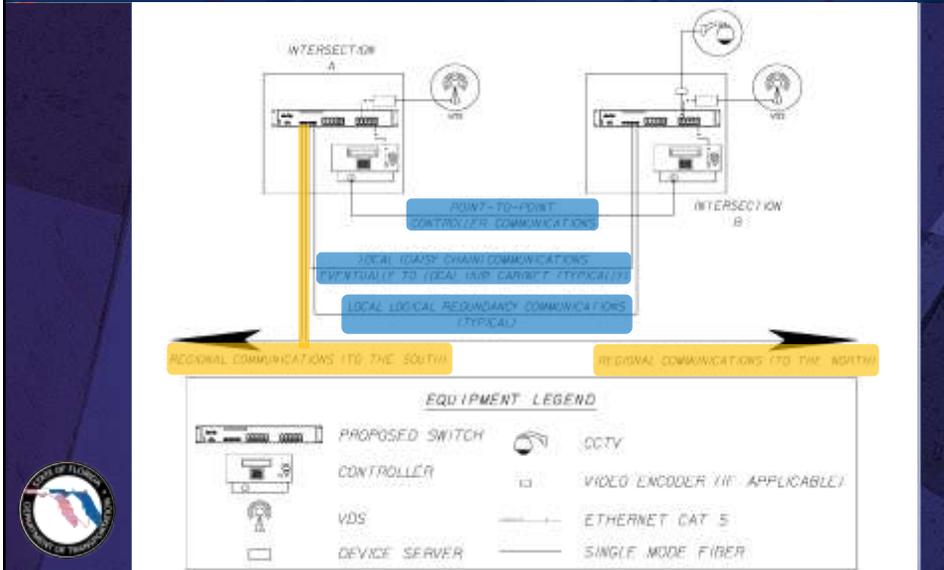
EXAMPLES: Stage II - Overview



EXAMPLES: Stage II - Overview



EXAMPLES: Stage II - Overview

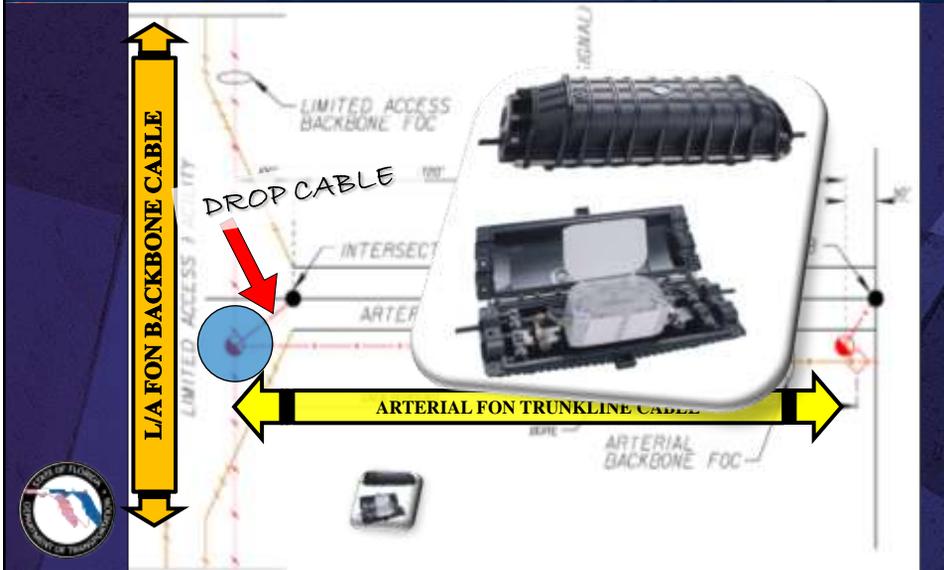


EXAMPLES: Stage II - Overview

Mock Fiber Allocation:

CABLE	BUFFER	FIBER	FIBER	BUFFER	CABLE	COMMENTS
Location: Intersection A						
Limited Access Trunkline	[Red Buffer]	1	1	1	Drop Cable to Intersection	Regional Communications North
		2	2			Regional Communications South
		3	3			Point-to-Point Controller Technology
		4	4			Arterial local communications
Arterial Trunkline	2	5	5	2	Drop Cable to Intersection	Spare
		6	6			Arterial redundant communications
		1	1			Arterial local communications
		2	2			Spare
		3	3			Arterial redundant communications
		4	4			Point-to-Point Controller Technology
Location: Intersection B						
Arterial Trunkline	2	1	1	2	Drop Cable to Intersection	Arterial local communications
		2	2			Spare
		3	3			Arterial redundant communications
		4	4			Arterial local communications
		5	5			Spare
		6	6			Arterial redundant communications
		7	7			Point-to-Point Controller Technology
		8	8			

EXAMPLES: Stage II – Limiting Exposure



EXAMPLES: Stage II – Limiting Exposure

Mock Fiber Allocation:

CABLE	FIBER	FIBER	BUFFER	CABLE	COMMENTS
Location: Intersection A					
Limited A		1			Regional Communications North
		2			
		3	1		Regional Communications South
Arterial Trunkline	2	7	5	Drop Cable to Intersection	Point-to-Point Controller Technology
		8	6		Arterial local communications
		1	1		Spare
		2	2		Arterial redundant communications
		3	3		
		4	4		
Location: Intersection B					
Trunkline	2	1	1	Drop Cable to Intersection	Arterial local communications
		2	2		Spare
		3	3		Arterial redundant communications
		4	4		
		5	5		
		6	6		
		7	7		
		8	8		Point-to-Point Controller Technology

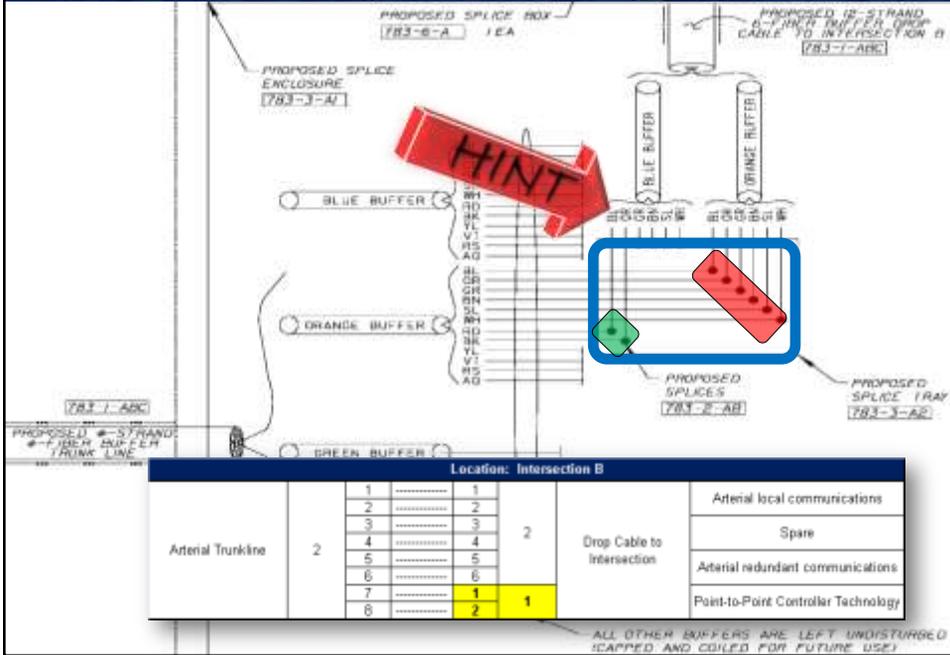
EXAMPLES: Stage II - Overview

Mock Fiber Allocation:							
CABLE	BUFFER	FIBER	-----	FIBER	BUFFER	CABLE	COMMENTS:
Location: Intersection A							
Limited Access Trunkline	7	1	-----	1	1	Drop Cable to Intersection	Regional Communications North
		2	-----	2			Regional Communications South
		9	-----	3			Point-to-Point Controller Technology
		10	-----	4			Arterial local communications
Arterial Trunkline	2	7	-----	5	2		Spare
		8	-----	6			Arterial redundant communications
		1	-----	1			
		2	-----	2			
		3	-----	3			
		4	-----	4			
		5	-----	5			
		6	-----	6			
Location: Intersection B							
Arterial Trunkline	2	1	-----	1	2	Drop Cable to Intersection	Arterial local communications
		2	-----	2			Spare
		3	-----	3			Arterial redundant communications
		4	-----	4			
		5	-----	5			
		6	-----	6			
		7	-----				
		8	-----				Point-to-Point Controller Technology

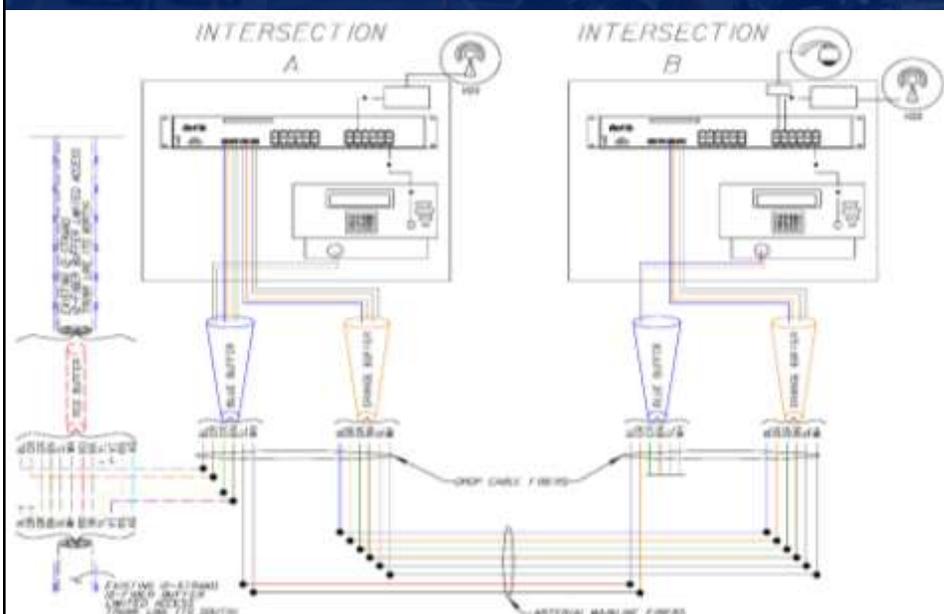
EXAMPLES: Stage II – Limiting Exposure

Mock Fiber Allocation:							
CABLE	BUFFER	FIBER	-----	FIBER	BUFFER	CABLE	COMMENTS:
Location: Intersection A							
Limited Access Trunkline			-----	1	1	Drop Cable to Intersection	Regional Communications North
			-----	2			Regional Communications South
			-----	3			Point-to-Point Controller Technology
			-----	4			Arterial local communications
Arterial Trunkline	2	7	-----	5	2		Spare
		8	-----	6			Arterial redundant communications
		1	-----	1			
		2	-----	2			
		3	-----	3			
		4	-----	4			
		5	-----	5			
		6	-----	6			
Location: Intersection B							
Arterial Trunkline	2	1	-----	1	2	Drop Cable to Intersection	Arterial local communications
		2	-----	2			Spare
		3	-----	3			Arterial redundant communications
		4	-----	4			
		5	-----	5			
		6	-----	6			
		7	-----				
		8	-----				Point-to-Point Controller Technology

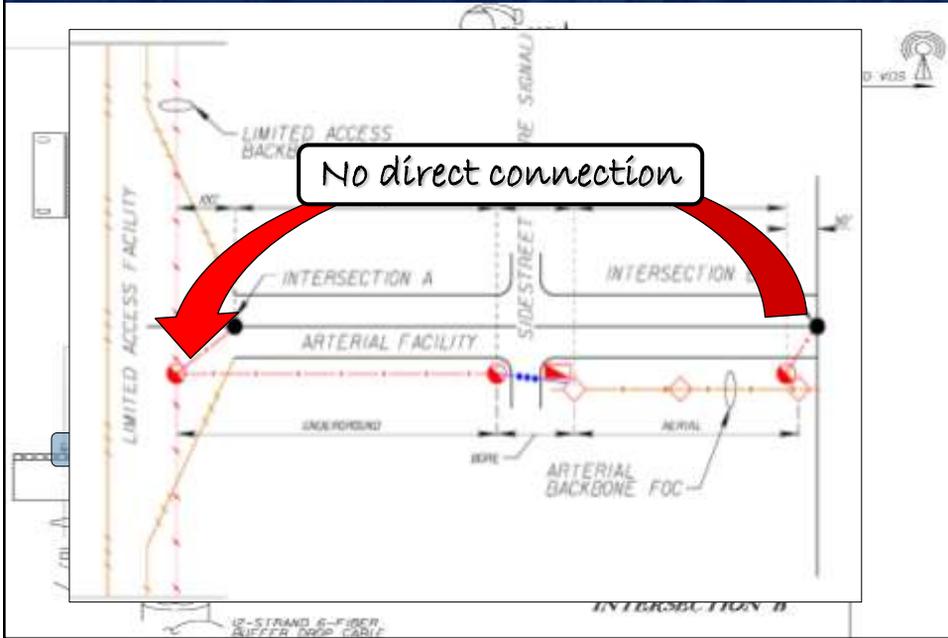
EXAMPLES: Stage II – Limiting Exposure



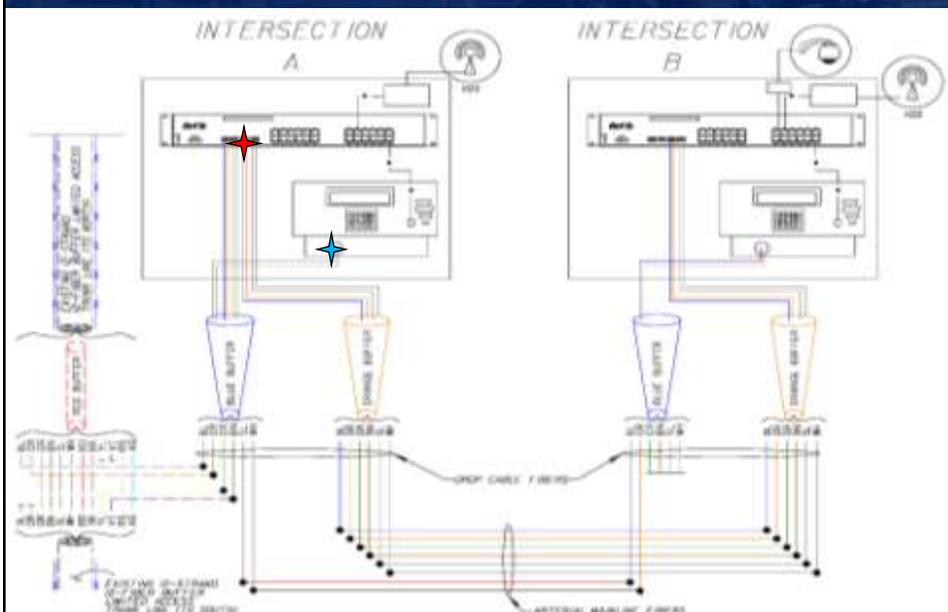
EXAMPLES: Stage II – Verifying Path'ing



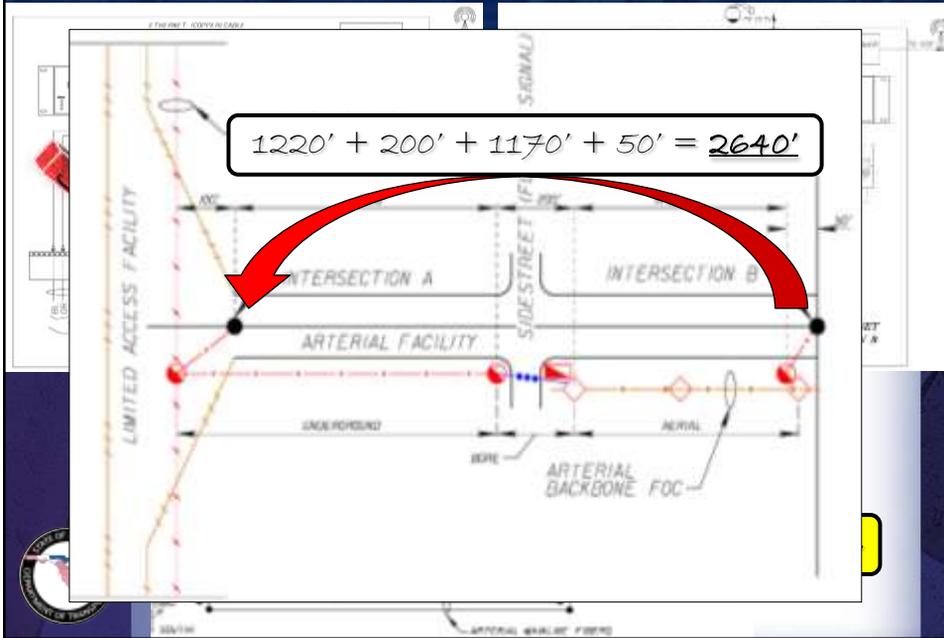
EXAMPLES: Stage II – Verifying Path'ing



EXAMPLES: Stage II – Verifying Path'ing



EXAMPLES: Stage II – Checking Capacity



EXAMPLES: Stage II – Checking Capacity

GIVEN:

- Known Distance..... .5 Miles in Km
- Known number and type of connections
 - Fusion..... 2
 - Mechanical..... 2

SAMPLE LINK-LOSS BUDGET SPREADSHEET

Typical Route	Distance (km)	Allowable loss over length per wavelength (dB)		Number of connection types		Allowable loss per connection Type (dB)		Total allowable loss (dB)	
		1310nm	1550nm	Fusion	Mechanical	Fusion	Mechanical	1310nm	1550nm
1	0.804672	0.322	0.241	2	2	0.2	1	1.522	1.441



783-1.4.2.1 End to End Attenuation Testing: Perform testing on all fibers to ensure that end to end attenuation does not exceed allowable loss (0.4 db/km for 1310nm wavelength, 0.3 db/km for 1550nm wavelength, plus 0.5 db for any connectors and 0.1 db for splices). Repair or replace cable sections exceeding allowable attenuation at no cost to the Department.

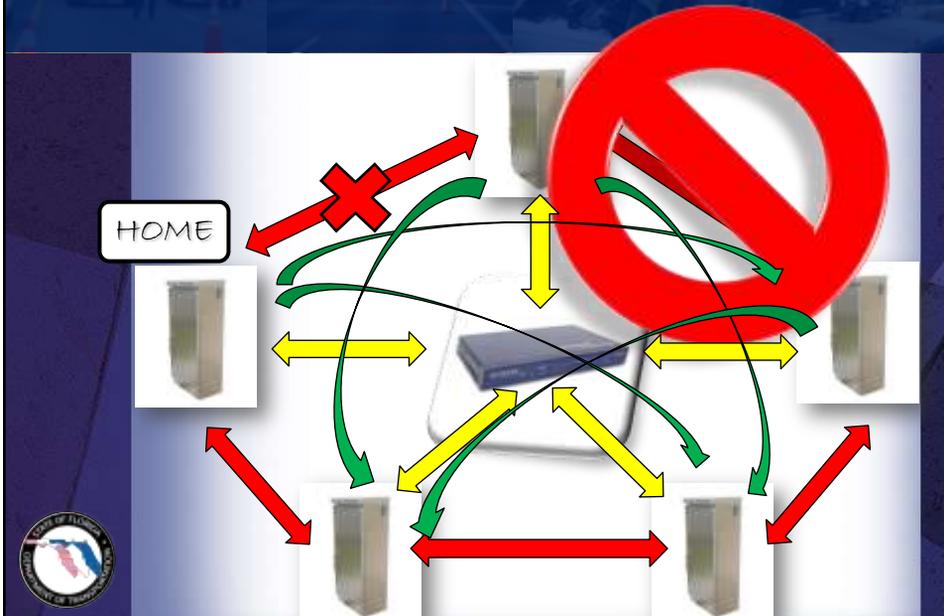
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NEARLY THERE...



FIBER DESIGN: Types of FONs



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CONCLUSION



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REFERENCES AND RESOURCES



RESOURCES:

- *Division II - Signalization and ITS*
 - *Section 780 – General Requirements*
 - *Blanket references to general Equipment and Material requirements*
 - *Cross-references to applicable “600-series” specs*
 - *603, General Requirements*
 - *608, Guaranties*
 - *611, Acceptance Procedures*
 - *General mention of Grounding and TVSS*
 - *620, Signal Installation Grounding*
 - *785*
 - *ITS Electrical Power Service*
 - *639, Electrical Power Service Assemblies*
 - *Current content ultimately destined for consolidation or relocation to other sections*



Links / References

- **FDOT Traffic Engineering and Operations**
<http://www.dot.state.fl.us/trafficoperations/>
- **FDOT Specifications and Estimates**
<http://www.dot.state.fl.us/specificationsoffice/>
- **FDOT Design Standards**
<http://www.dot.state.fl.us/rddesign/DesignStandards/Standards.shtml>
- **Approved Product List**
<http://www3.dot.state.fl.us/trafficcontrolproducts/>
- **Traffic Engineering Manual (TEM)**
<http://www.dot.state.fl.us/trafficoperations/Operations/Studies/TEM/TEM.shtml>



Links / References

- Florida Intersection Design Guide
www.dot.state.fl.us/rddesign/FIDG-Manual/FIDG2007.pdf
- Plans Preparation Manual
<http://www.dot.state.fl.us/rddesign/PPMManual/PPM.shtm>
- Master Pay Item List / WebGate
- FHWA Manual on Uniform Traffic Control Devices (MUTCD)
http://mutcd.fhwa.dot.gov/pdfs/2009/pdf_index.htm



Future Questions?

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