

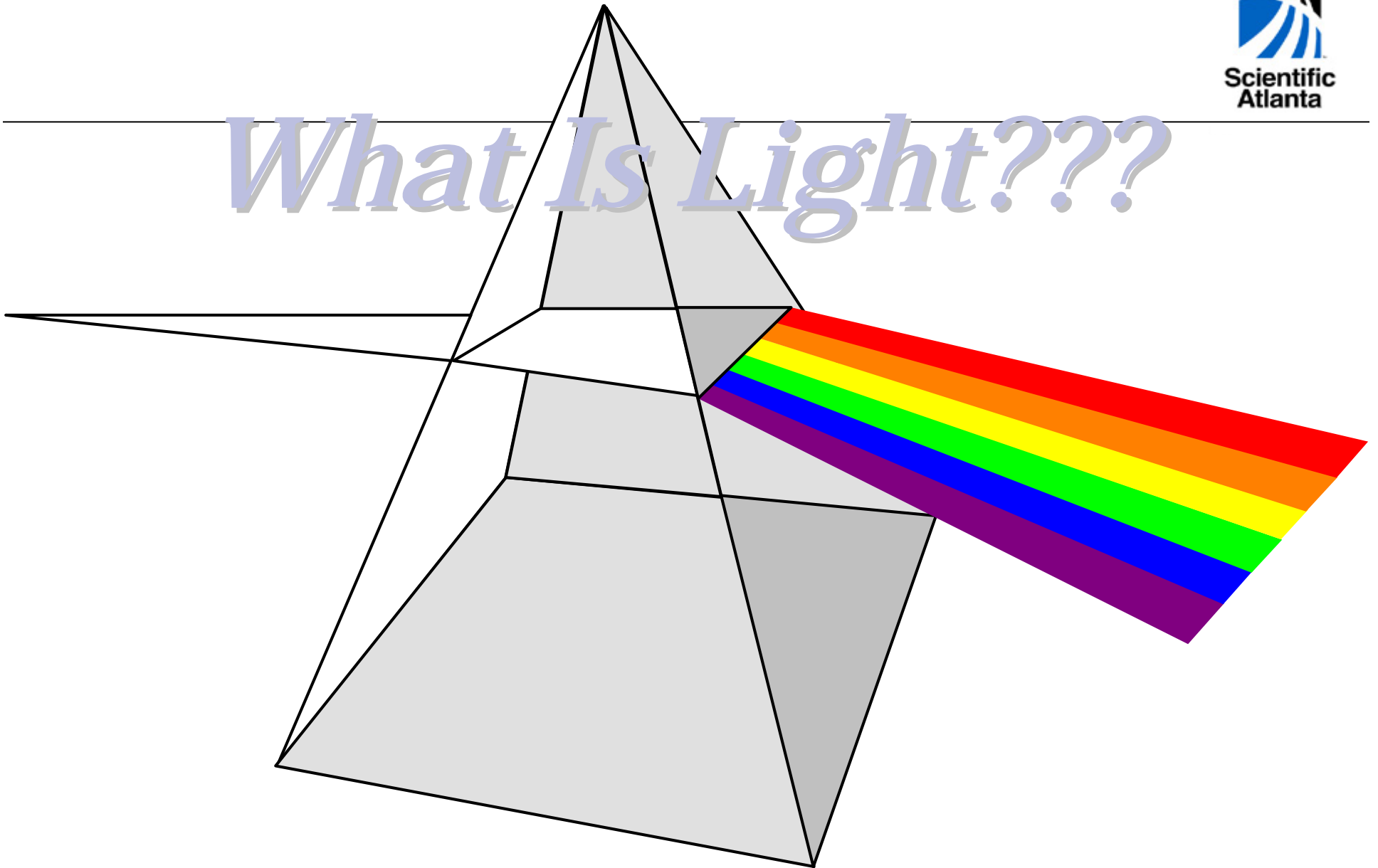
# Analog DWDM Technologies and Design

Frank Eichenlaub  
Senior Staff Engineer

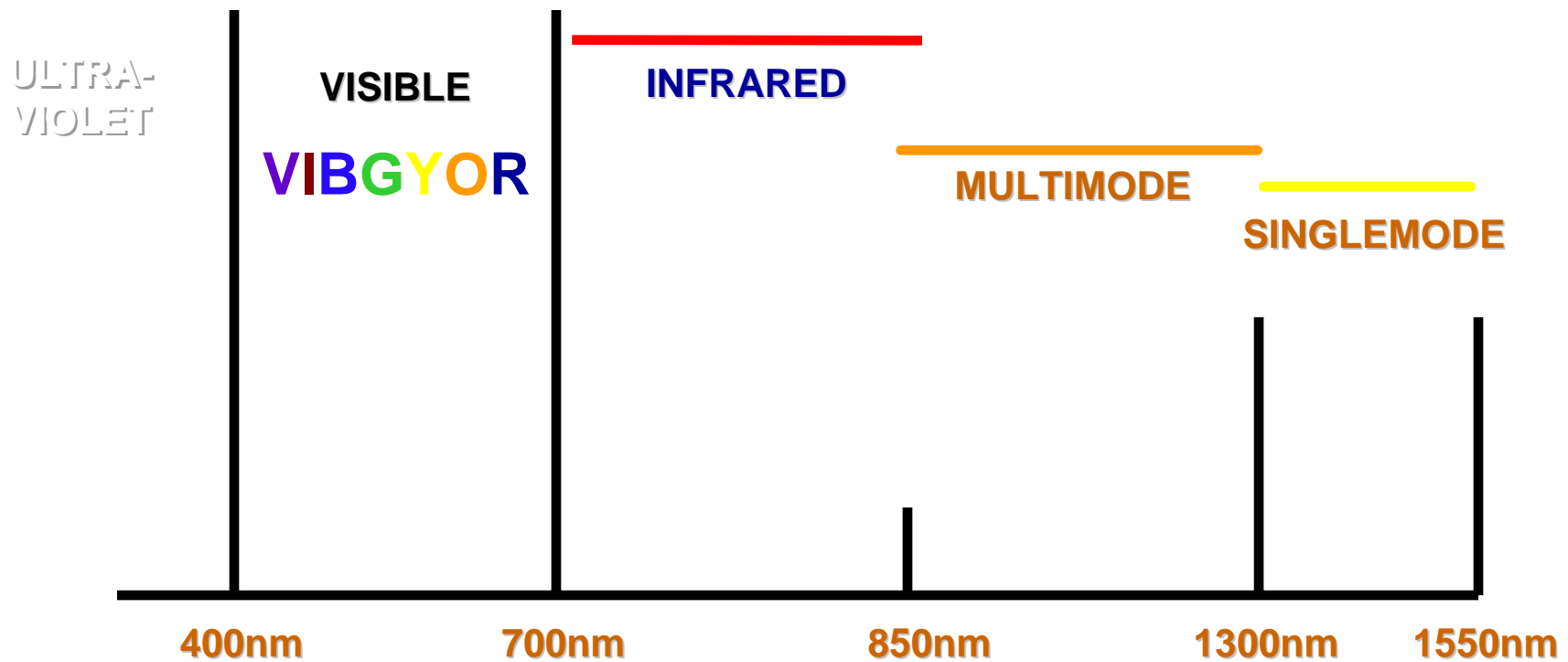


11/30/2007

# *What Is Light???*



# Light and Optical Fibers



# Wavelength Applications

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- 1310 Typical Uses
  - Cascade Reduction
  - Short run Headend Elimination
    - *Less than 37 km path*
  - Narrowcast insertion into 1550 transport
  
- 1550 Typical Uses
  - Headend Eliminations
    - *Paths over 120 km are not uncommon*
    - *DWDM Architectures*
  
- Hybrid Systems
  - 1550 Transport with 1310 Distribution
    - *Headend elimination with cascade reduction*

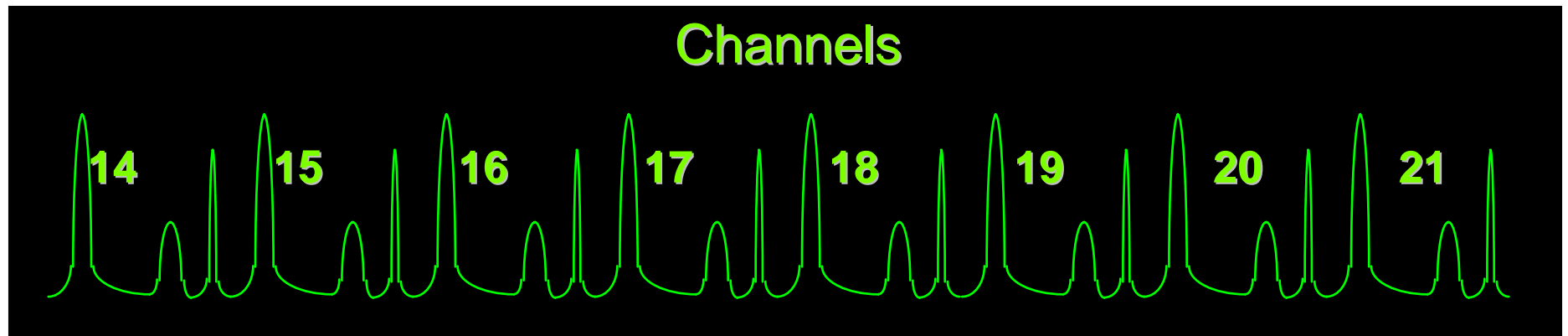
# FDM vs.. WDM

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- In the world of CATV we can place multiple channels onto one piece of cable
  - Frequency Division Multiplexing
  - Each ‘Channel’ has different information
    - *Intelligence*
    - *Audio / Video / Bit Stream*
- With fiber we can do the same thing but with multiple wavelengths.
  - Each wavelength can be considered a ‘Channel’
    - *The intelligence of each channel is what is carried on the RF carriers that were fed into the transmitters.*

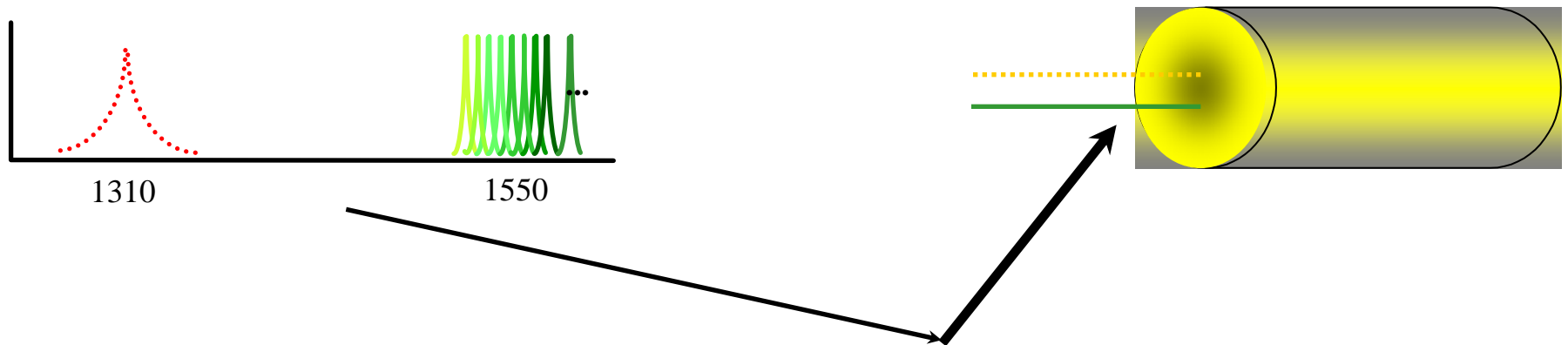
# Frequency Division Multiplexing

- RF Carriers are FDM (Frequency Division Multiplexed) onto one cable.
- The Video and Audio are modulated onto RF carriers to be sent to the TV

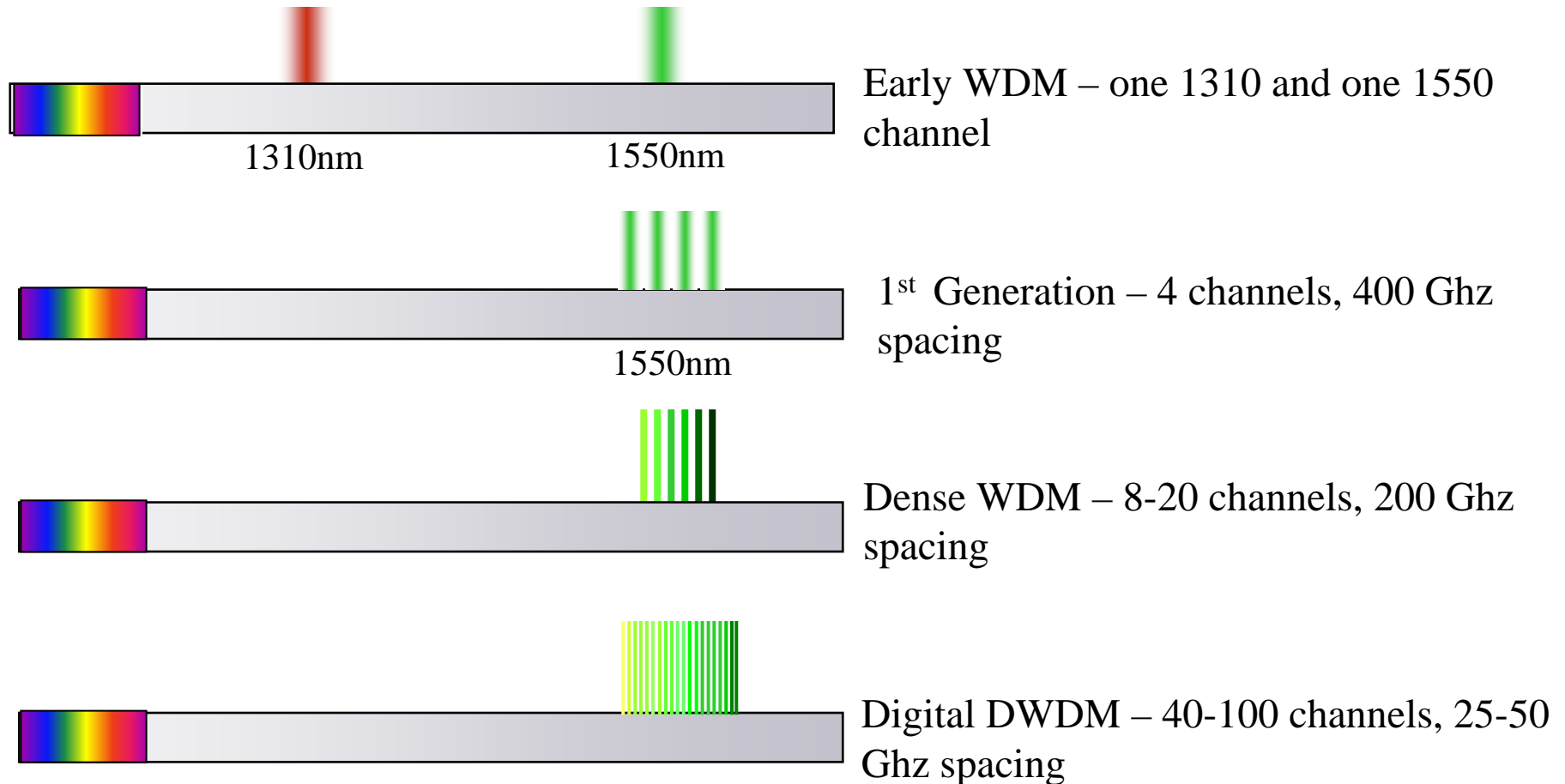


# Wavelength Division Multiplexing

- Optical carriers are WDM into one piece of fiber.
- The CATV spectrum (whatever is on the cable feeding the laser) modulates the laser

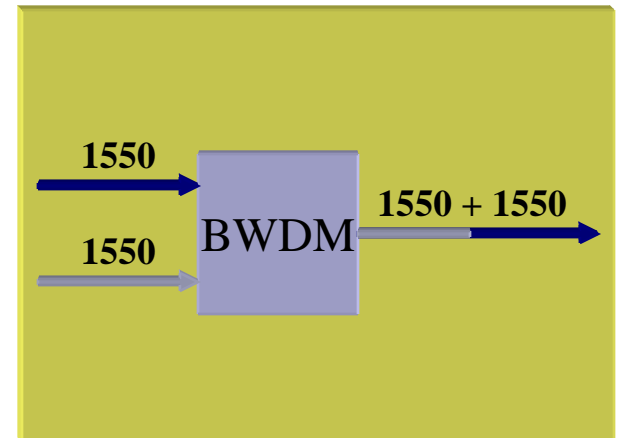
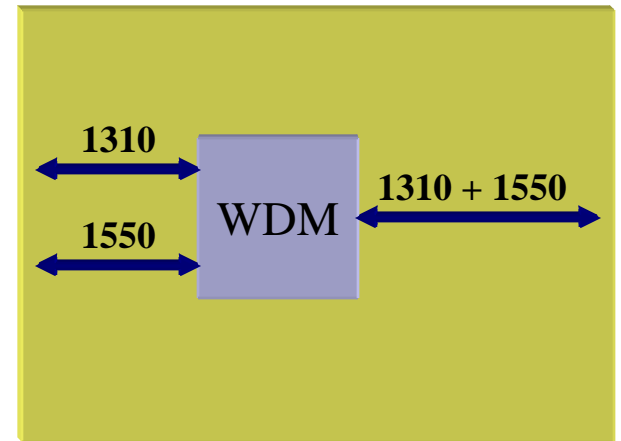


# Evolution of DWDM Systems



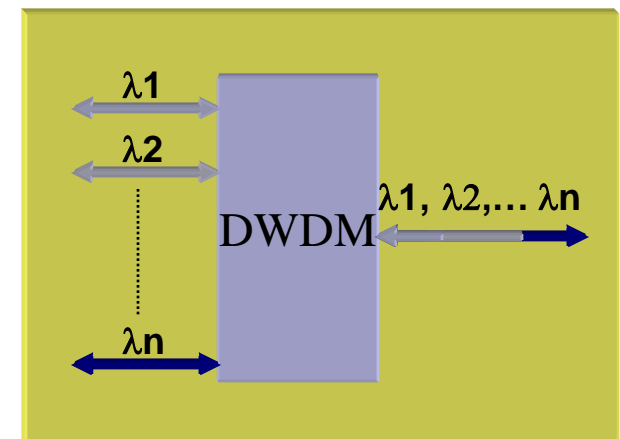
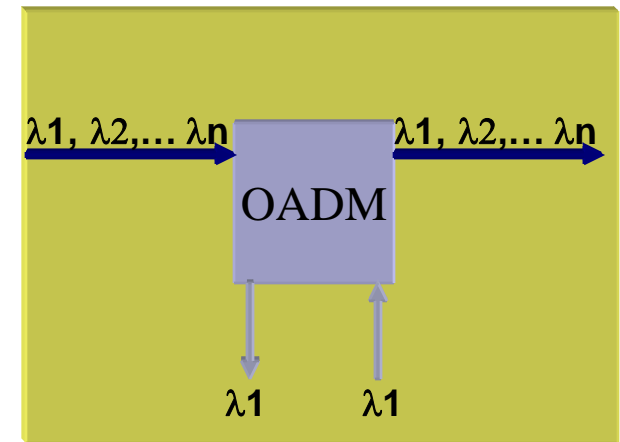
# WDMs, BWDMs, OADM and DWDMs

- WDM (Wave Division Multiplexers)
  - Used to combine or split 1310 and 1550 wavelengths to or from the same fiber
  - Bi-directional
  - Lower insertion loss than standard splitter/combiner, adds about approx. 1.5dB loss to network
- BWDM (Broadband Wave Division Multiplexers)
  - Used to combine specific 1550 color bands onto the same fiber
  - Low Insertion loss, 1.5dB



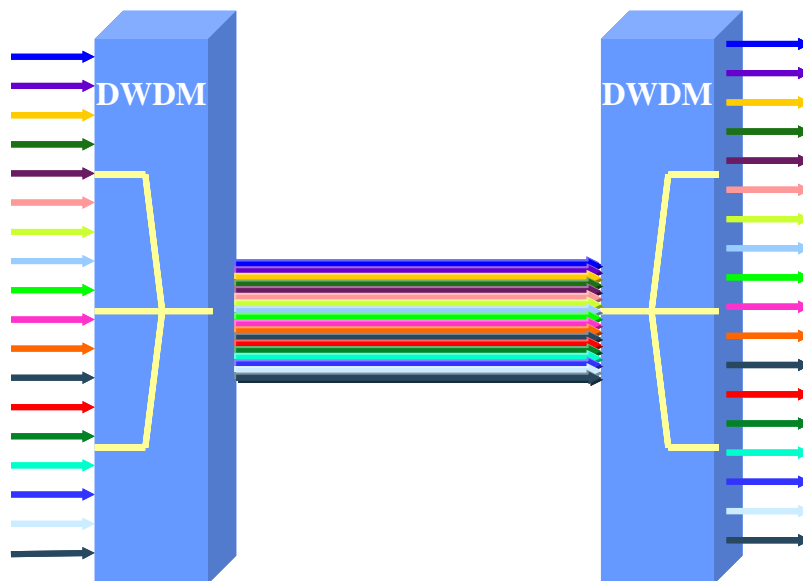
# WDMs, BWDMs, OADMs and DWDMs

- OADM (Optical Add Drop Module)
  - Used to selectively add/drop a specific wavelength or wavelengths from a multiplicity of wavelengths in a fiber, NOTE: Current product is 100GHz spaced, need 200GHz!
- DWDM (Dense Wave Division Multiplexing)
  - Used to Mux or DeMux multiple ITU wavelengths onto a single fiber
    - *20 lambda systems transporting digitally modulated signals are not uncommon*
    - *40 + lambda systems for digital signals are growing*
  - Inputs and Outputs are wavelength specific
  - Lower insertion loss (200GHz options)
    - *See product specifications for actual loss*



# What is DWDM?

- DWDM is a technology that uses multiple 1550 lasers to transmit many wavelengths (colors) of light simultaneously over a single fiber
  - This allows the transport of narrowcast RF signals from the HE to the hub site, where the signals are combined either electrically or optically with the node broadcast signals
  - These RF signals are commonly digitally modulated type signals, 64/256 QAM & QPSK for services types such as.....
    - *HSD, VOD and Telephony*



# DWDM ITU WAVELENGTHS (C - Band)



■CH 21	1560.61 nm	■CH 41	1544.53 nm
■CH 23	1558.98 nm	■CH 43	1542.94 nm
■CH 25	1557.36 nm	■CH 45	1541.35 nm
■CH 27	1555.75 nm	■CH 47	1539.77 nm
■CH 29	1554.13 nm	■CH 49	1538.19 nm
■CH 31	1552.52 nm	■CH 51	1536.61 nm
■CH 33	1550.92 nm	■CH 53	1535.04 nm
■CH 35	1549.32 nm	■CH 55	1533.47 nm
■CH 37	1547.72 nm	■CH 57	1531.90 nm
■CH 39	1546.12 nm	■CH 59	1530.33 nm

# Types of DWDM Architectures

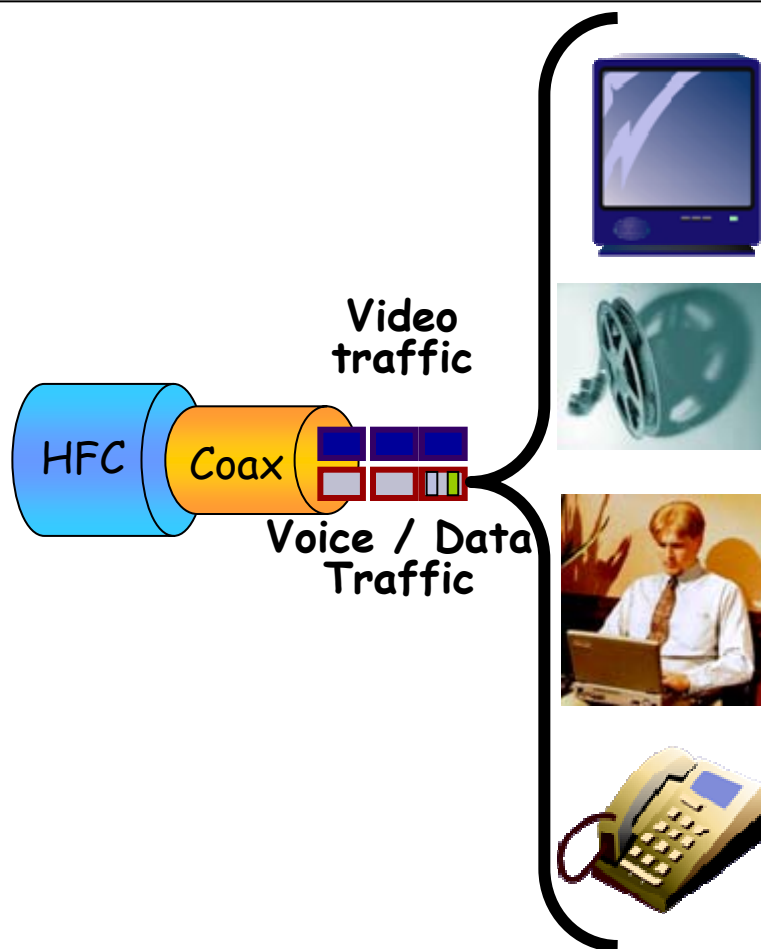
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Point-to-Point  
Forward Transport  
Forward Transport Optical Combining  
Analog DWDM Return Transport  
Digital DWDM Hub Return Transport  
Digital DWDM Node Return Transport

November 30, 2007

# Types of Signals



## ■ Broadcast Signals

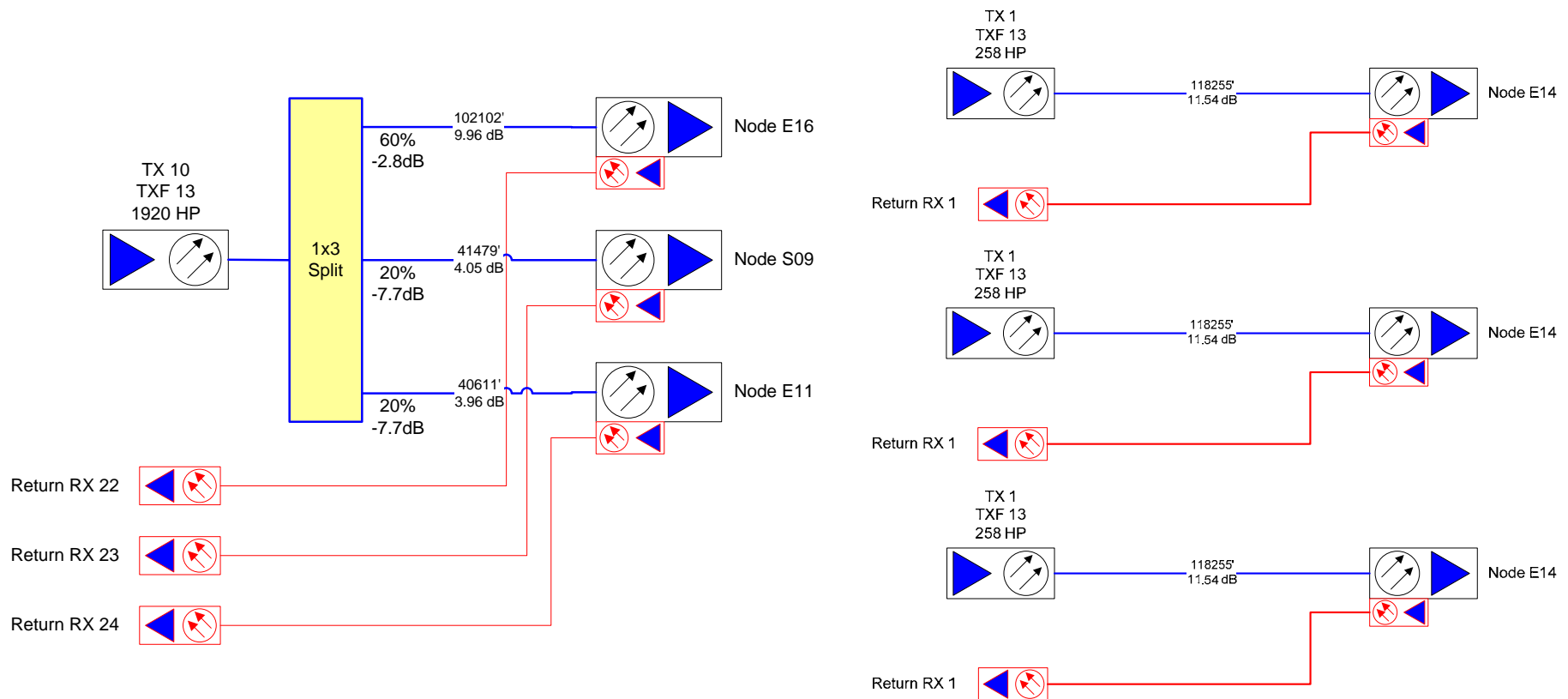
- Analog Video
- Digital Video

## ■ Narrowcast Signals

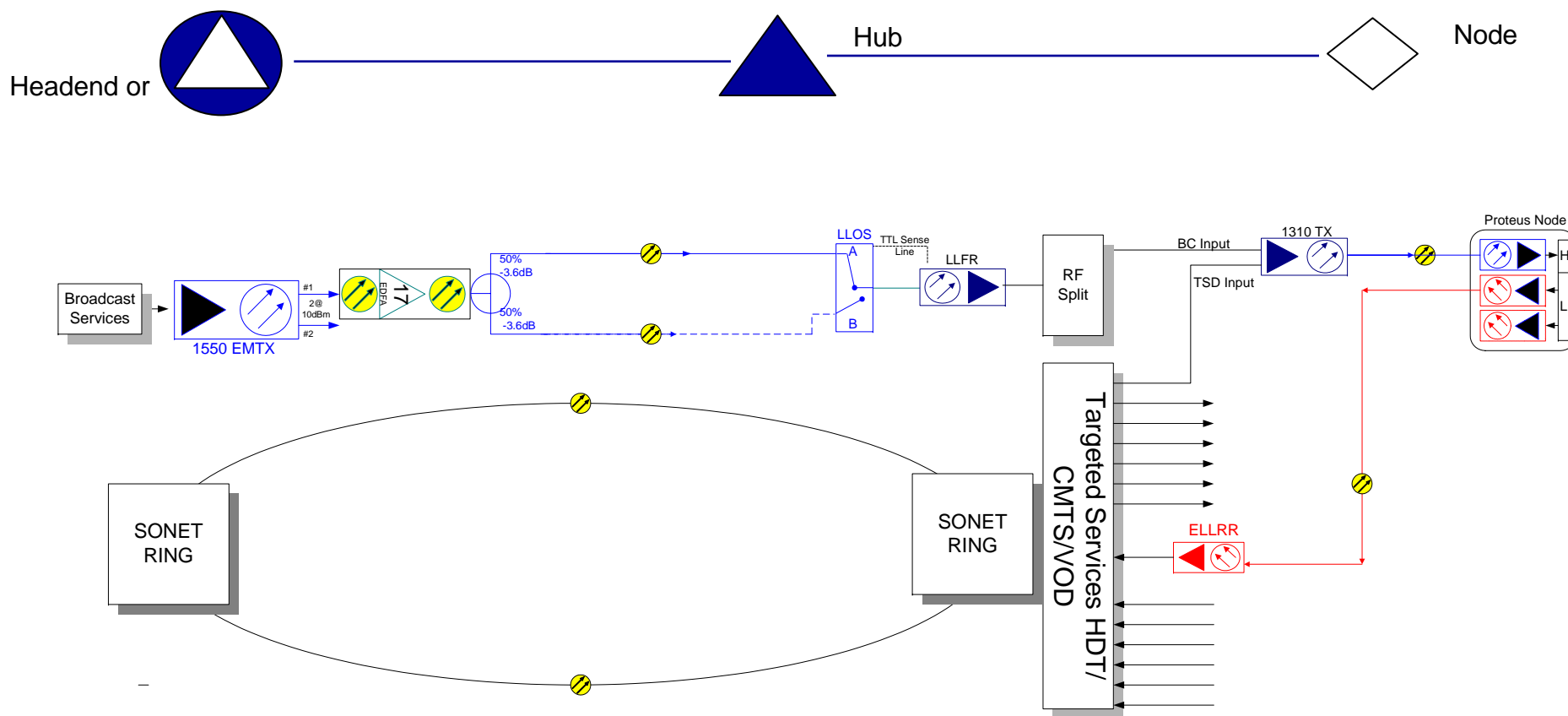
- NVOD, VOD
- Targeted Advertising
- Cable Modem Service
- Telephony Service
- PCS

**Bandwidth Requirements Per Subscriber Increases**

# 1310 Networks

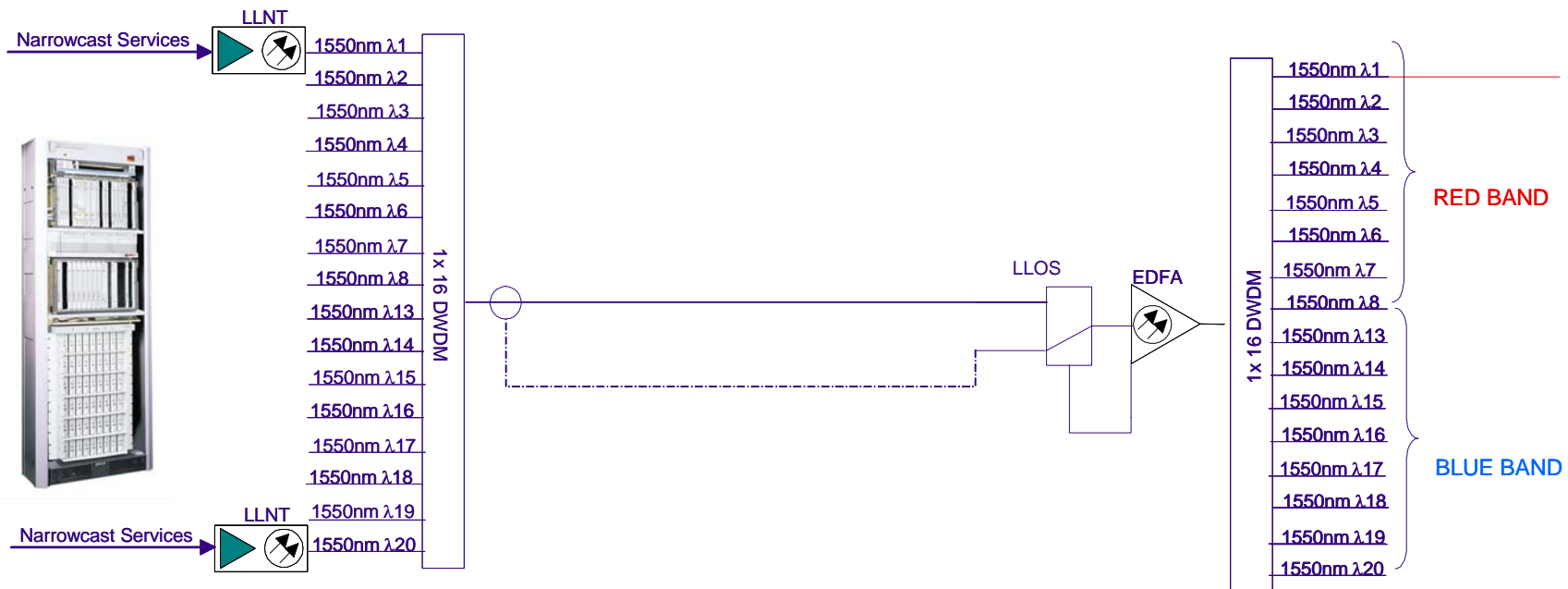
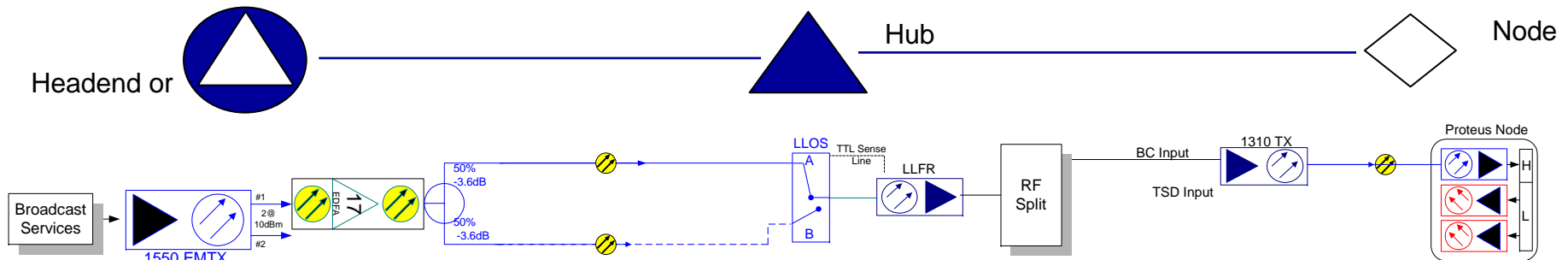


# 1550nm Trunk, 1310nm Distribution Distributed CMTS/Telephony Equipment



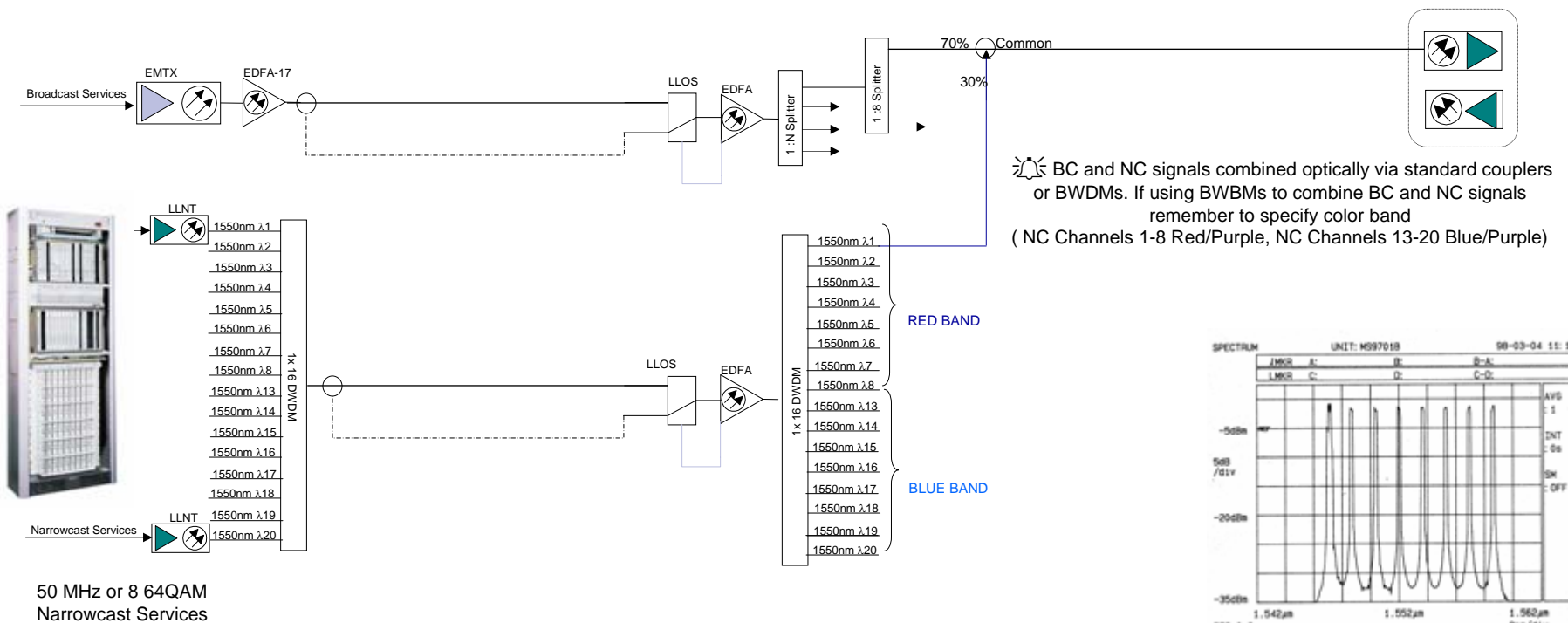
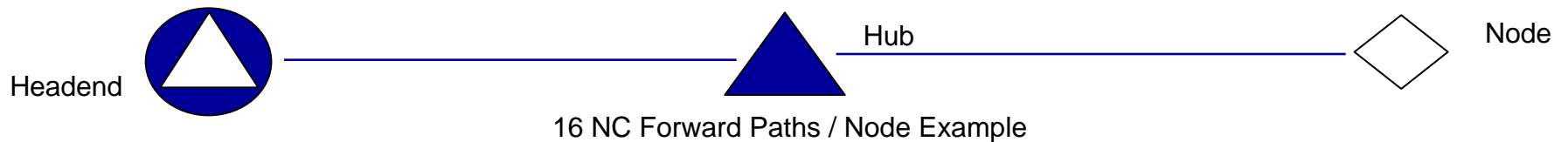
**Expensive equipment located in large  
Secondary hubs with large power systems,  
HVAC and good security**

# 1550nm Trunk, 1310nm Distribution RF Combining of NC



50 MHz or 8 64QAM  
Narrowcast Services

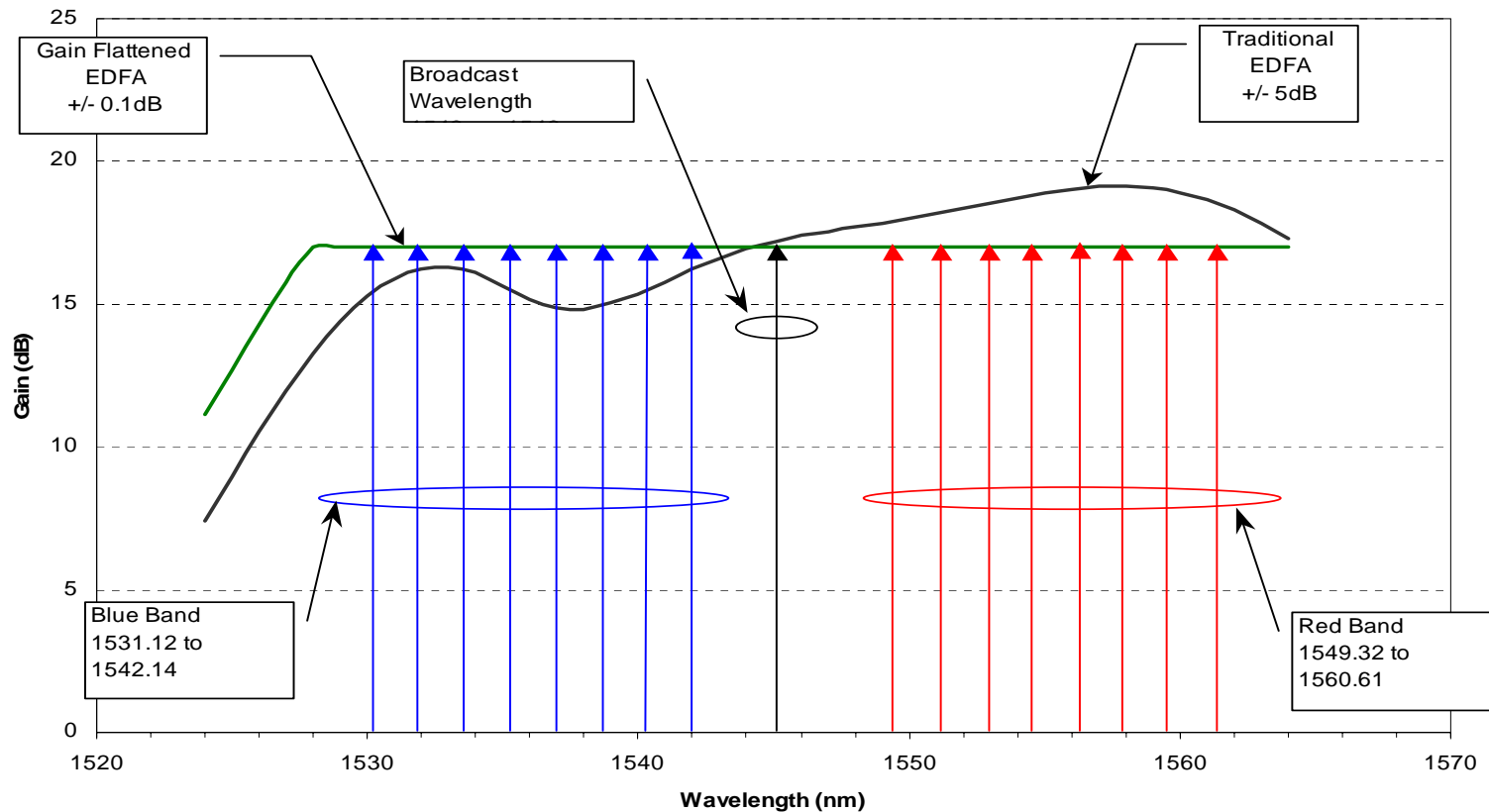
# 1550nm DWDM System Downstream



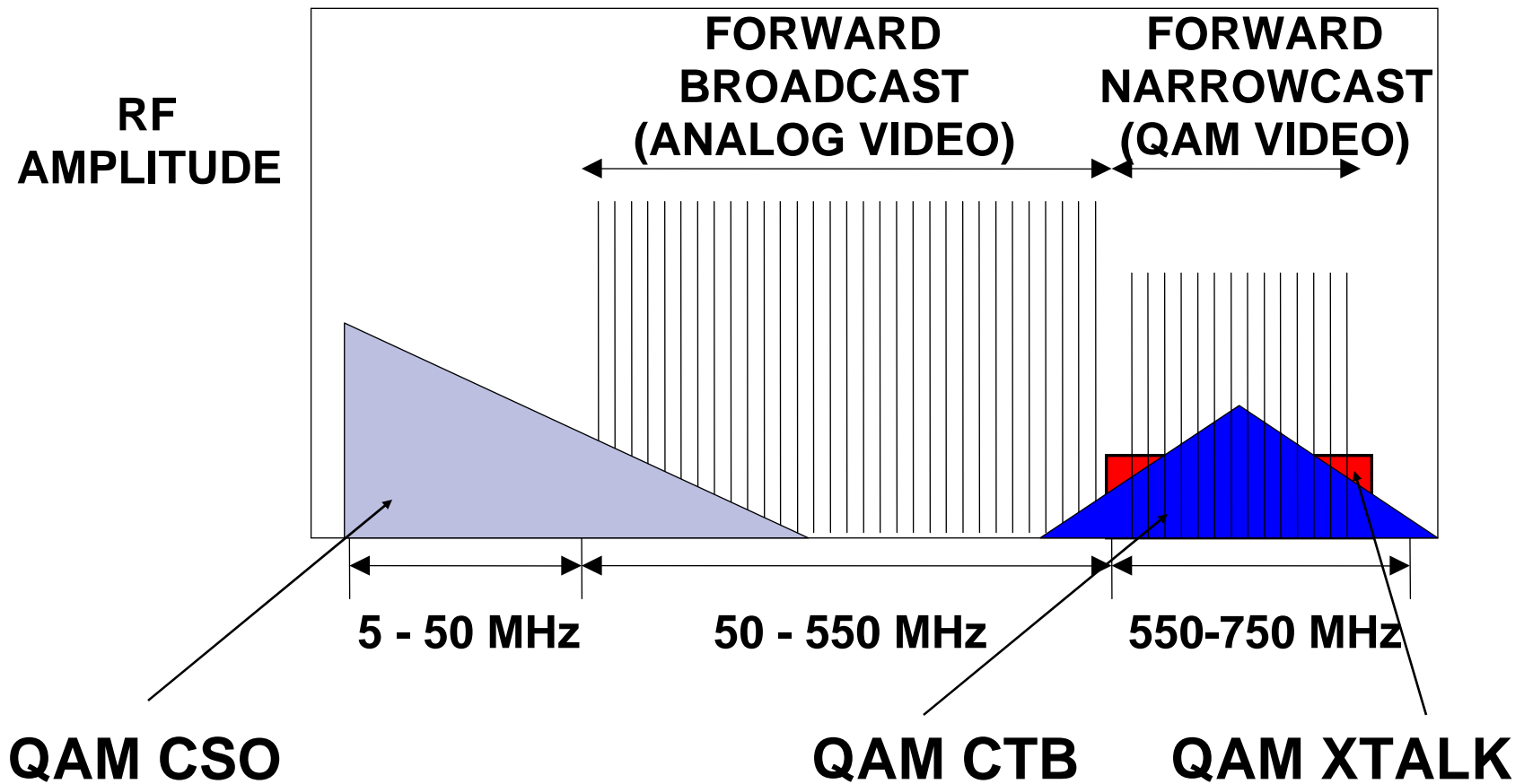
# Sixteen wavelength DWDM (Downstream)



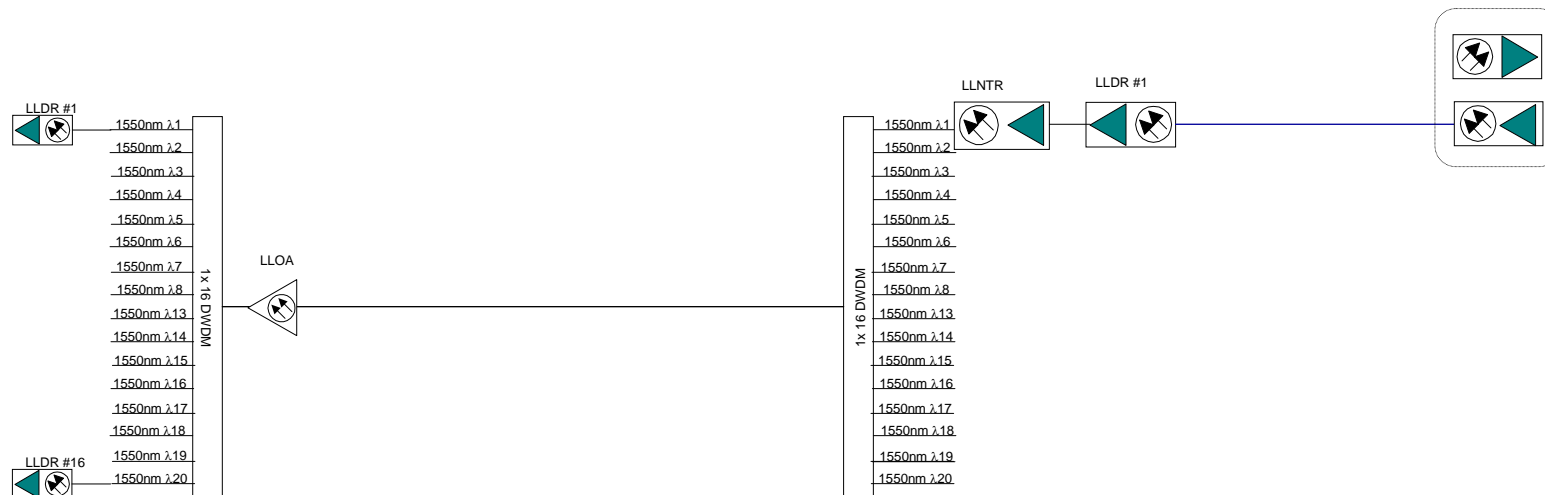
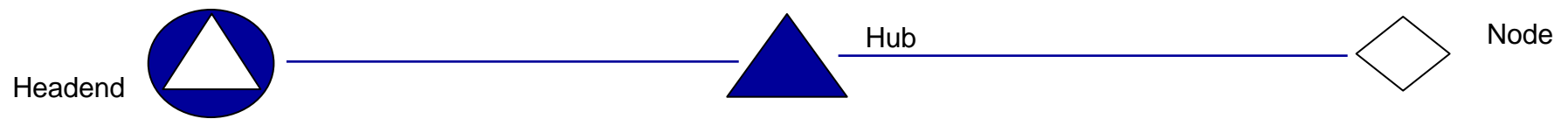
Gain Flattened EDFA for DWDM Systems



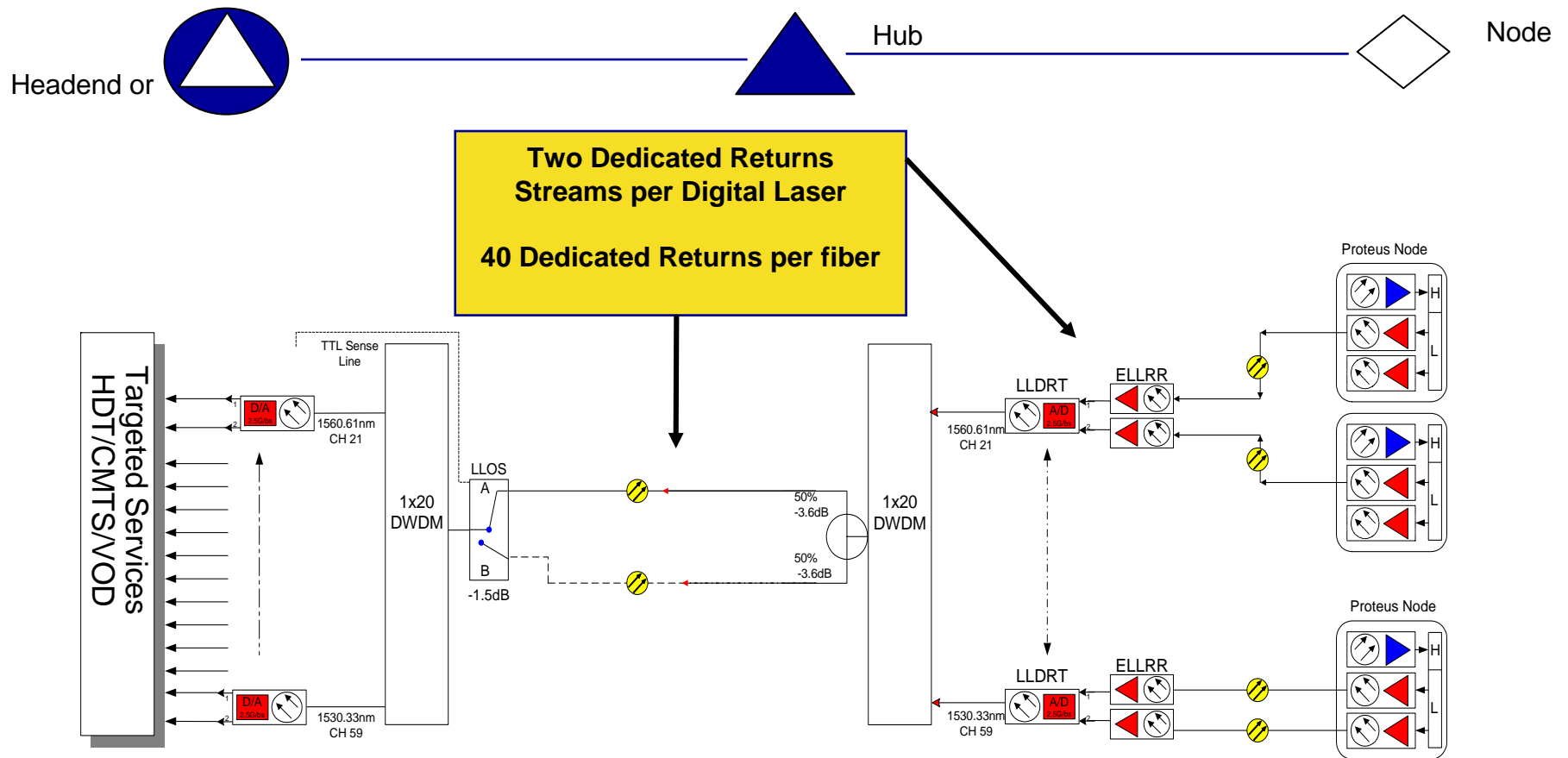
# Linear and Nonlinear Effects- Distortion



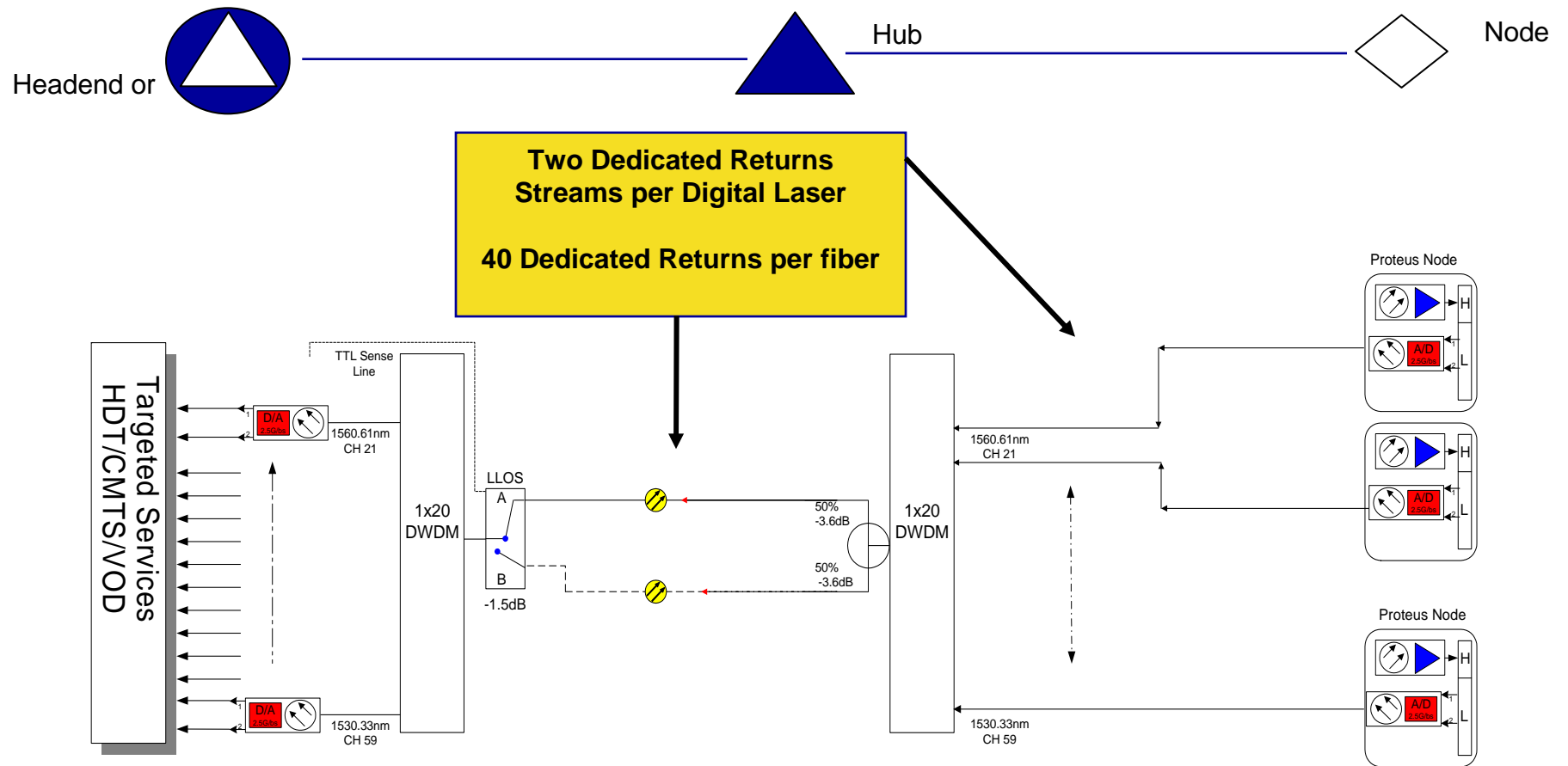
# DWDM System Upstream



# Hub-Based Digital DWDM Return



# Node-Based Digital DWDM Return



# Why Analog DWDM Transport

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- Save Fibers
- Transparent all optical network.
  - Passive optics: WDMs, DWDMs and Couplers
  - Opto-electronic regeneration equipment (EDFAs) at hubs, elimination of Optical to RF back to Optical conversion thus reducing the size of the facilities; i.e. Hub becomes OTN location
- Targeted Delivery
  - Allows up to eight 6MHz carriers modulated in different formats delivered to individual or multiple customer service areas
- Scalable
  - Add more wavelengths with demand, up to 16 wavelengths on the forward and 20 on the return

# Any Questions??

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*Thank you for  
Your Attendance*

