

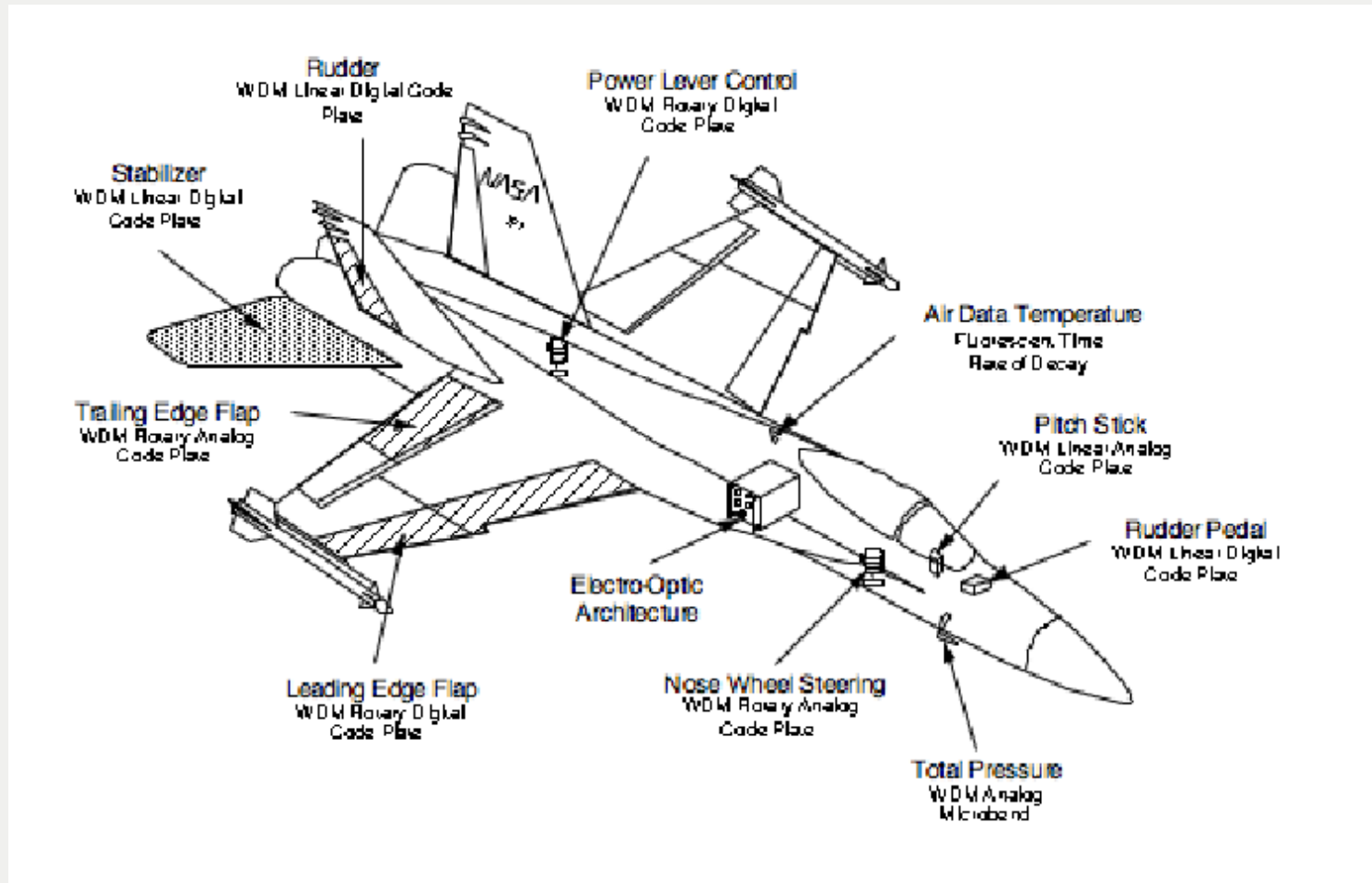
# Avionics Optical Networking

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# Network Goals & Features

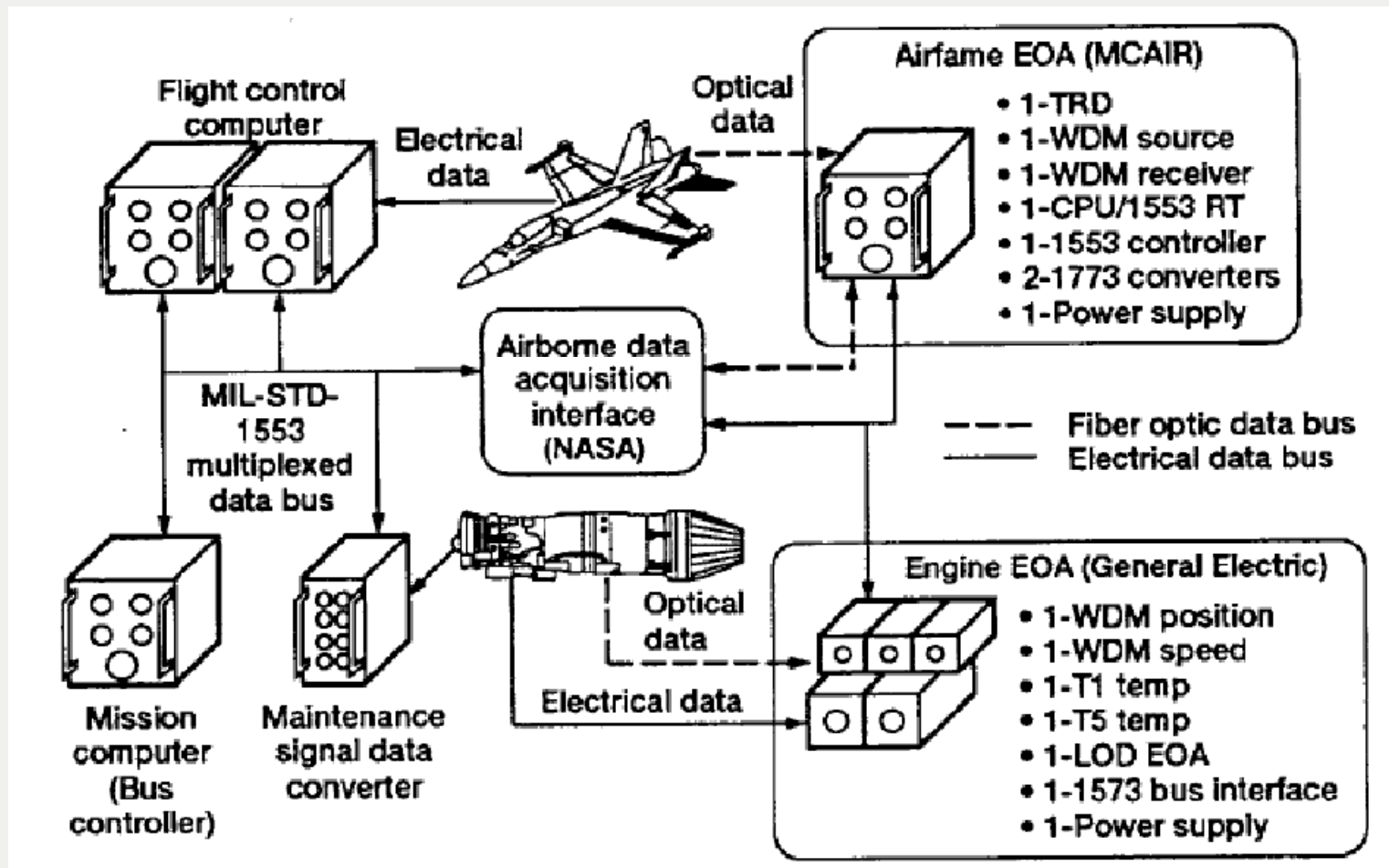
- Unified Network
  - Sensors, Command/Control, Video, Communications
- Minimized Electrical Connections
- Generic Processing Modules
- Transparent to higher level protocols
- Automatic Fault Isolation & Identification

# Fly-by-Light

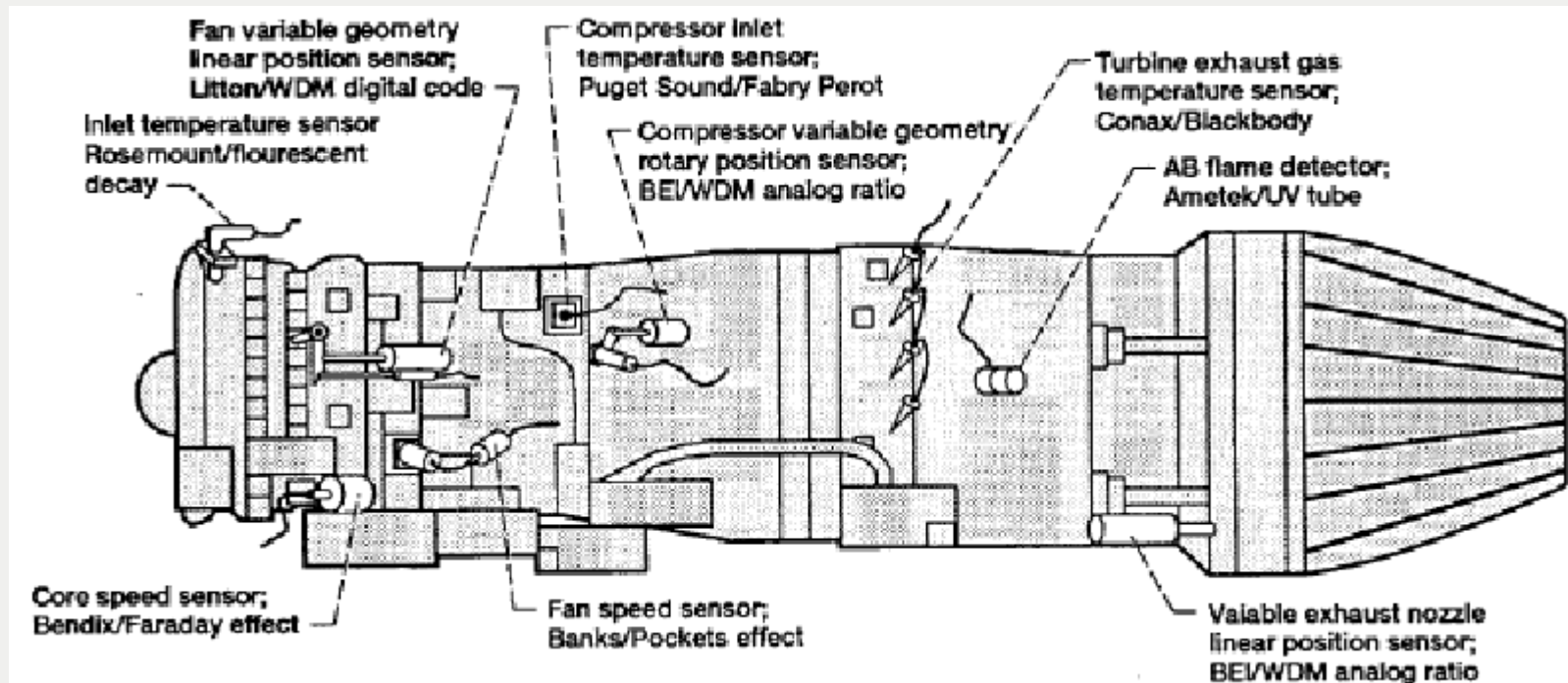


Optically controlled actuators and optical sensors

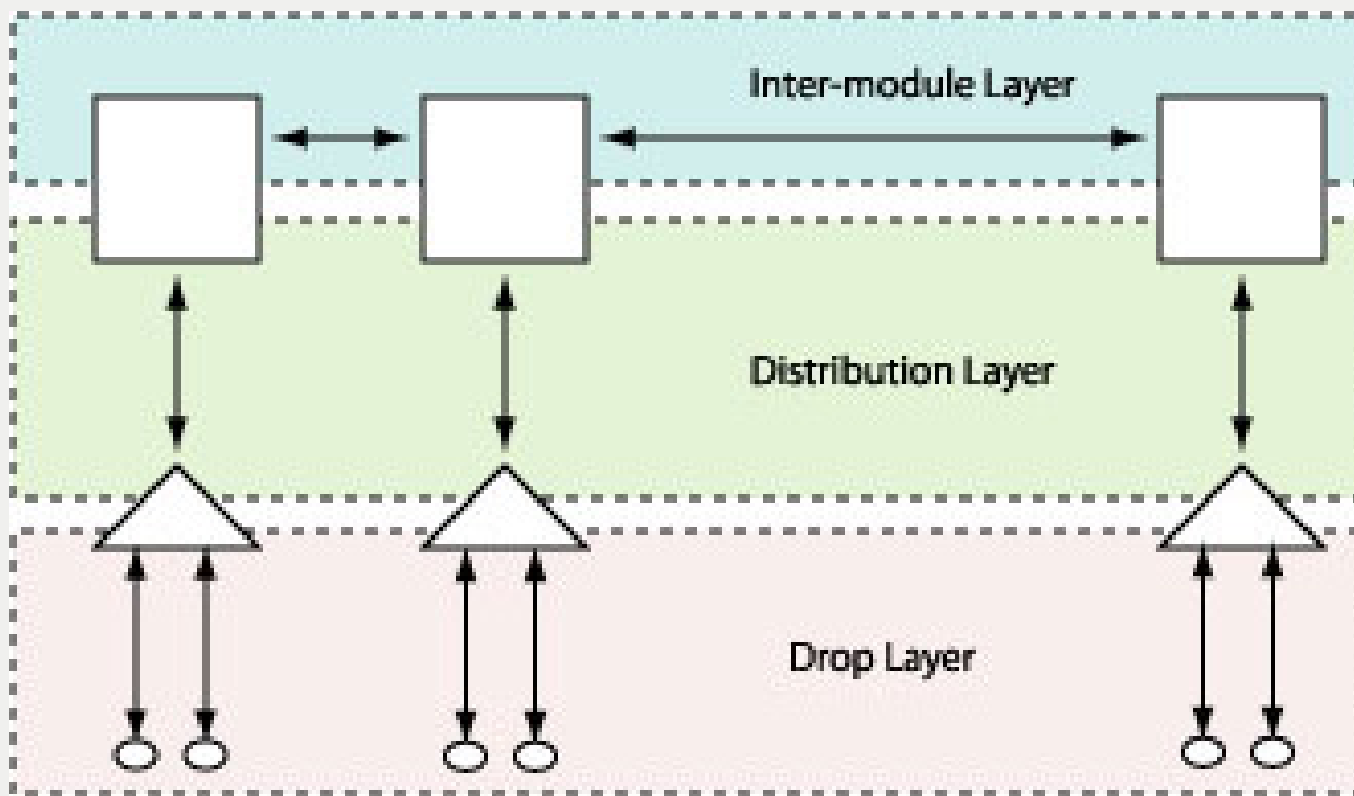
# FOCSI Architecture



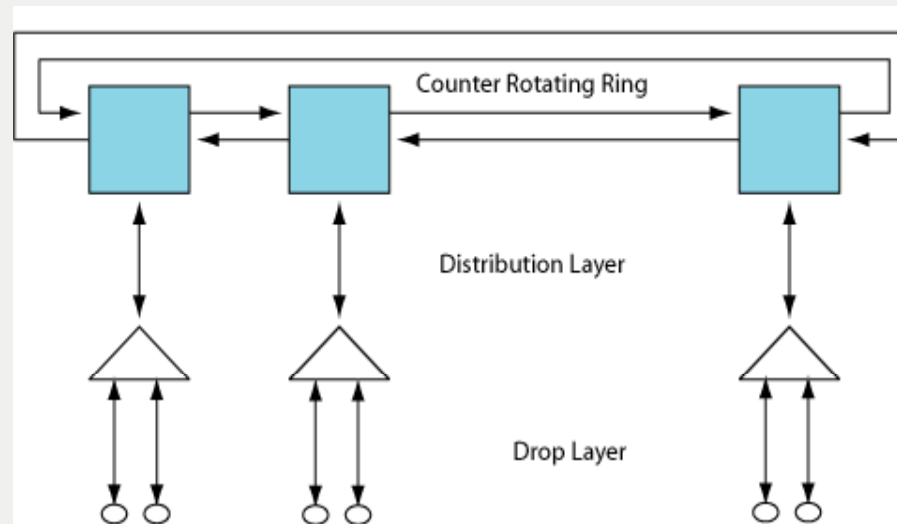
# FOCSI Propulsion Sensors



# Physical Connection Layers

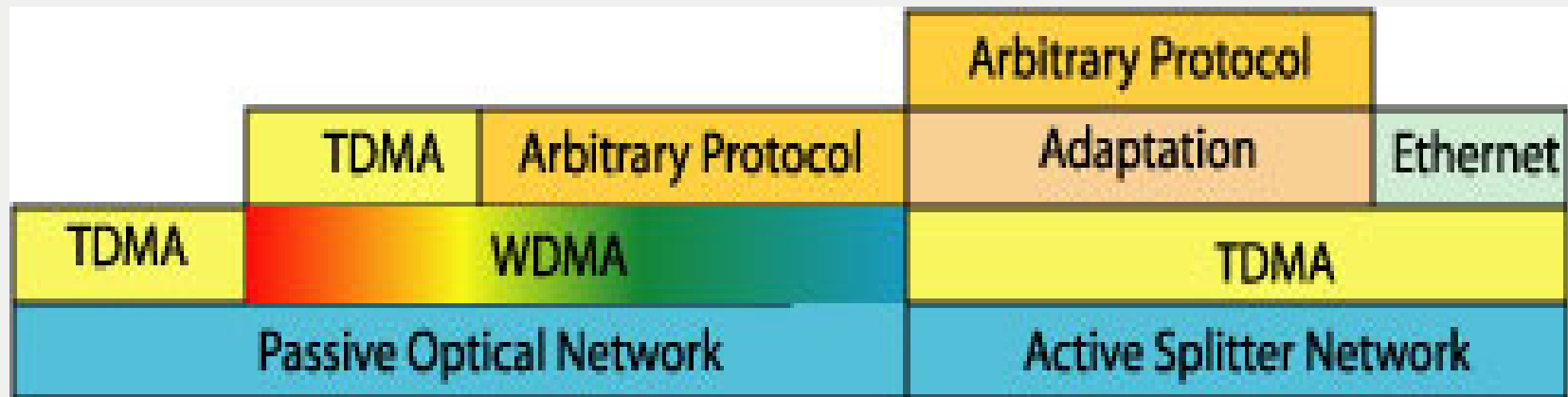


# Ring Topology for Inter-Module Layer



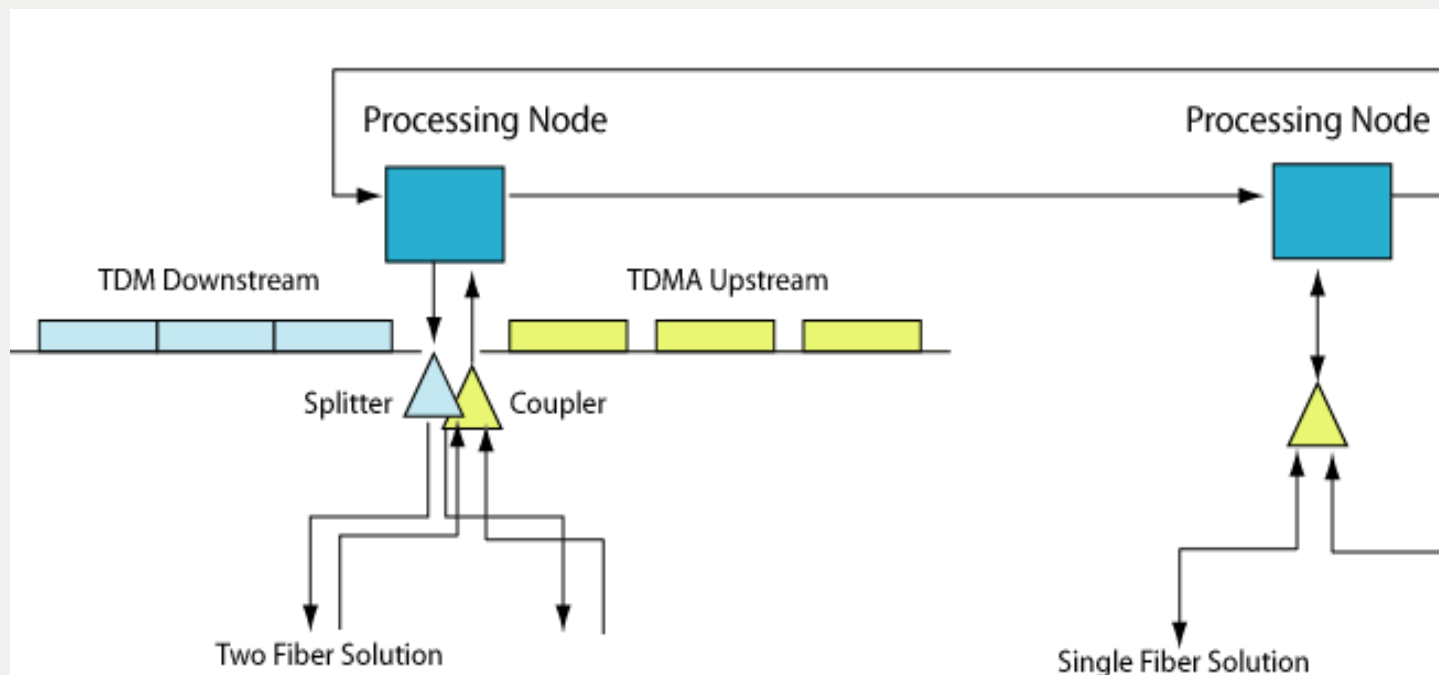
- Inter-Module Layer can be re-arranged or augmented over time
- Distribution and Drop Layers are fixed at installation time

# Protocol Hierarchy





# TDM/TDMA Distribution/Drop



# TDMA Ethernet

- Downstream is a stream of Ethernet frames possibly augmented with synchronization codes or short addresses/commands
- Upstream traffic consists of noncontentious (a la AFDX) Ethernet frames
- Upstream frames are allocated on frame-by-frame basis or allocated as specified repetitive time slots

# Passive Networking Split Ratio Determination

- $G_s(\text{at } R_r) + 10 \cdot \log_{10}(R_r/R_d) > N_c \cdot L_c + 3 \cdot \log_2(S_{\max}) + L_e + M_s$
- Where  $G_s = P_t - P_r$
- $P_t$  = Optical transmitter launch power (in dBm)
- $P_r$  = Optical receiver threshold power (in dBm)
- $R_r$  = Data Rate at which the threshold is determined
- $L_c$  = Connector loss (in dB)
- $N_c$  = Number of series connectors in the path
- $L_e$  = Excess Loss in a splitter ( in dB)
- $M_s$  = System margin (in dB)
- $R_d$  = Total downstream data rate
- $S_{\max}$  = Maximum Split Ratio

# Split Limits v. Gain & Bandwidth

Downstream Rate (MHz)	10 dB System Gain (1 GHz)	15 dB System Gain (1 GHz)	20 dB System Gain (1 GHz)
10	256	512	2048
20	128	256	1024
50	32	128	512
100	16	64	256
200	8	32	128
500	4	16	32
1000	2	8	16
2000	1	4	8

4 Connectors with 0.5 dB loss each, splitter excess loss = 0.5dB, margin = 3 dB

# Single v. Dual Fiber

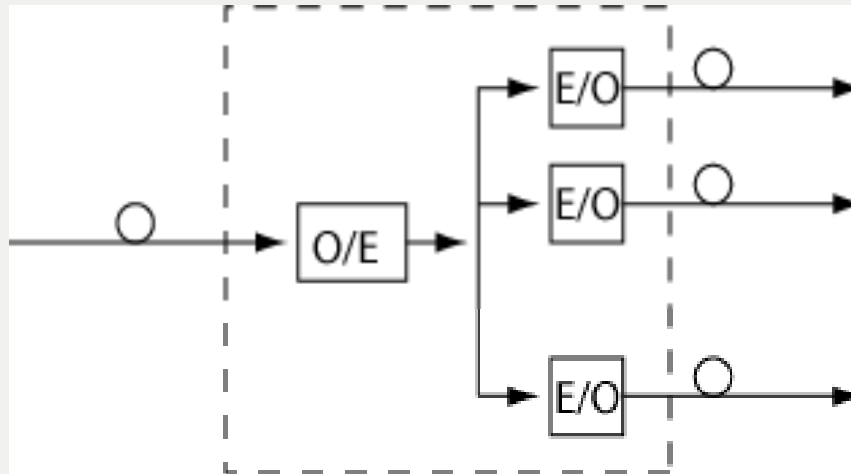
## Single Fiber Considerations

- Reduced Volume and Weight
- Receive Signal Quality is an Indicator of Transmit Signal Quality
- Absence of Receive Signal can Initiate Transmit Power Back Off
- Transmit/Receive Signal Isolation Increases Insertion Loss

## Dual Fiber Considerations

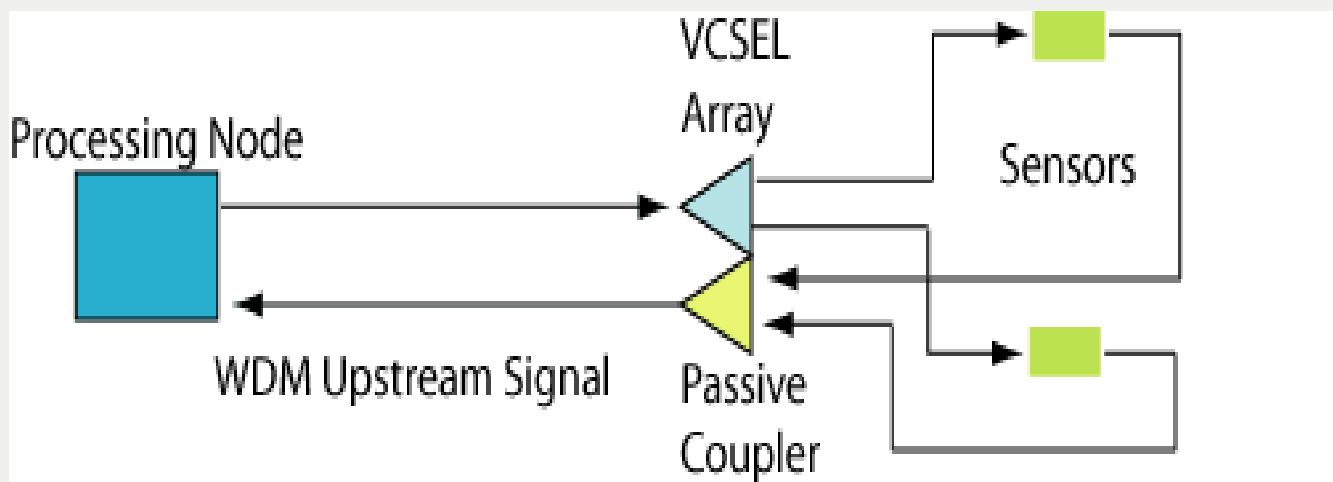
- Use of Active Elements is Simplified
- Transmit/Receive Isolation is Unnecessary

# Active Splitter for Higher Data Rate



Vertical Cavity Surface Emitting Laser Array

# VCSEL Sensor Support



VCSEL array produces a different wavelength for each sensor  
Sensors modulate the optical signal which is returned upstream  
Passive coupler multiplexes the upstream signals using WDM

# In Conclusion

- A network architecture that is flexible in the use of WDM, TDM, and Packet Protocols
- Identify the myriad of potential applications to determine the specific needs of those applications
- Develop means to interface existing equipment to the network
- Develop highly integrated, low volume, low power modules to support the architecture