# Common LAN WDM Grid Proposal for all 100GE SMF Reaches

**IEEE 802.3 Higher Speed Study Group**

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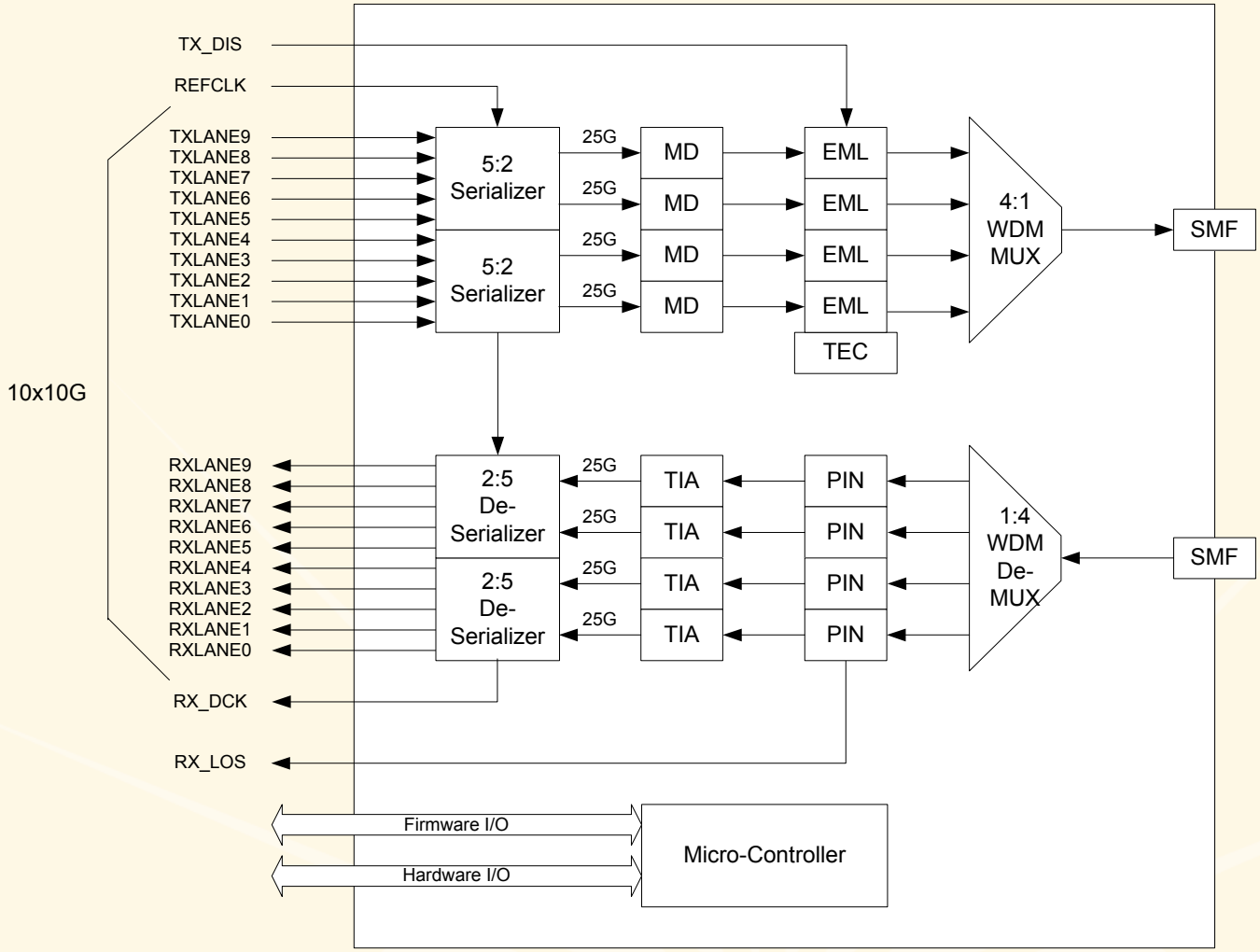
# Outline

- HSSG 100GE SMF Status
- 4x25G Transceiver Architecture
- WDM Grid Alternatives
- Cooled TX Optics Cost
- Un-cooled TX Optics Cost
- Mux/DeMux Cost
- Scenario Alternatives
- Discussion

# HSSG 100GE SMF status

- Consensus to date on 40km SMF reach objective
  - Metro applications
  - 4x25G WDM architecture
  - 1312nm center
  - Widely spaced DWDM grid, 400 to 800GHz (2 to 4nm)
  - Cooled EML (or possibly cooled DML) transmitter
  - SOA + PIN photo-receiver
- Consensus to date on 10km SMF reach objective
  - Enterprise applications
  - 4km reach objective maybe lower cost (10km link budget is challenging)
  - 4x25G WDM architecture
  - 1312nm center
  - EML or DML transmitter
  - PIN photo-receive
- Disagreement on 10km (or 4km if modified) SMF reach objective
  - Alt. 1: LAN WDM grid (widely spaced DWDM grid, 400 to 800GHz)
  - Alt. 2: CWDM grid
- It is critical that the industry arrive at a consensus on the WDM grid for 10km (or 4km) reach objective so that development efforts can start.

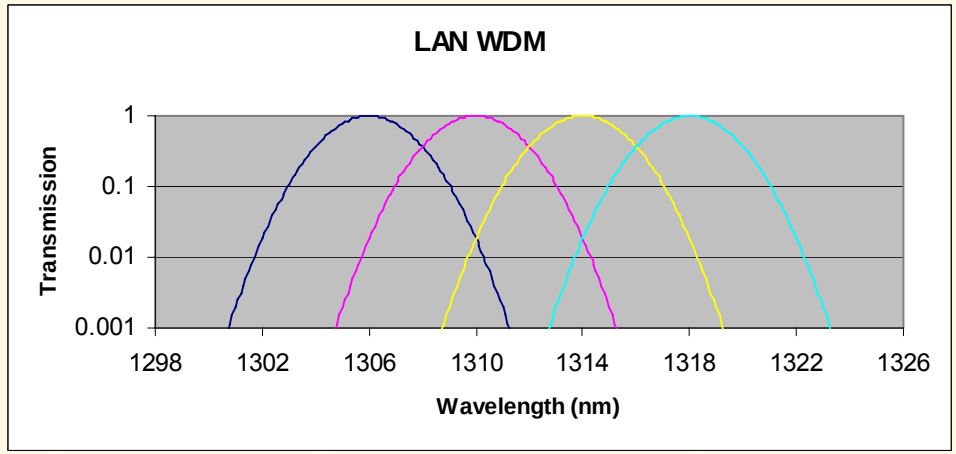
# 4x25G Transceiver Architecture

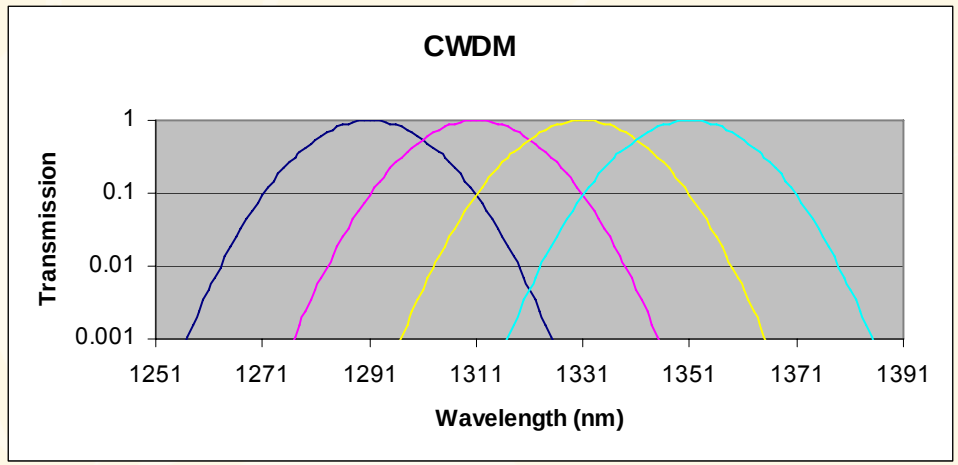



(Transceiver Architecture for Metro Applications includes SOA(s).)

# WDM Grid Alternatives

- Alt.1: ITU G.694.1 widely spaced DWDM grid for LAN applications (LAN WDM)
  - 1306 – 1318nm (O band)
  - 193.1THz base
  - 400, 600, or 800GHz spacing (2, 3, or 4nm)
  - 1, 2, or 2.5nm width (requires cooling of TX optics)
- Alt. 2: ITU G.694.2 CWDM grid for LAN applications (CWDM)
  - 1291 – 1351nm (O band)
  - 20nm spacing
  - 13nm width (in principle does not require cooling of TX optics, although today feasible 25G TX optics require cooling)



# Cooled TX Optics Cost

- Extensive commercial experience with 10G and 40G EMLs provides solid data to predict 25G EML cost and performance, and to support standards development.
- LAN WDM spacing (>400GHz) does not impose stringent frequency stability requirements on lasers (unlike WAN DWDM spacing <200GHz.)
- LAN WDM spacing (>400GHz) has minimal non-linear effects (unlike <200GHz.)
- For 25G operation, cooled TX optics (EML or DML) have significantly higher yield then un-cooled TX optics, determined by output power issues at hot temperature. This yield difference is far more significant then extra costs due to cooling (TEC and packaging.)
- LAN WDM 6nm to 12nm band results in:
  - uniform laser processing steps,
  - reduced manufacturing costs for discrete lasers,
  - significant low cost potential through manufacturing monolithic laser arrays,
  - ultimate low cost potential through monolithic integration of Mux/DeMux.
- Amortization cost is reduced by sharing development expenses with 40km reach.
- Unit cost is reduced through economies of scale by sharing volume between all reaches (4km, 10km, 40km.)
- What is known:
  - Near term 25G LAN WDM TX optics are feasible and have significant low cost potential for the future.

# Un-cooled TX Optics Cost

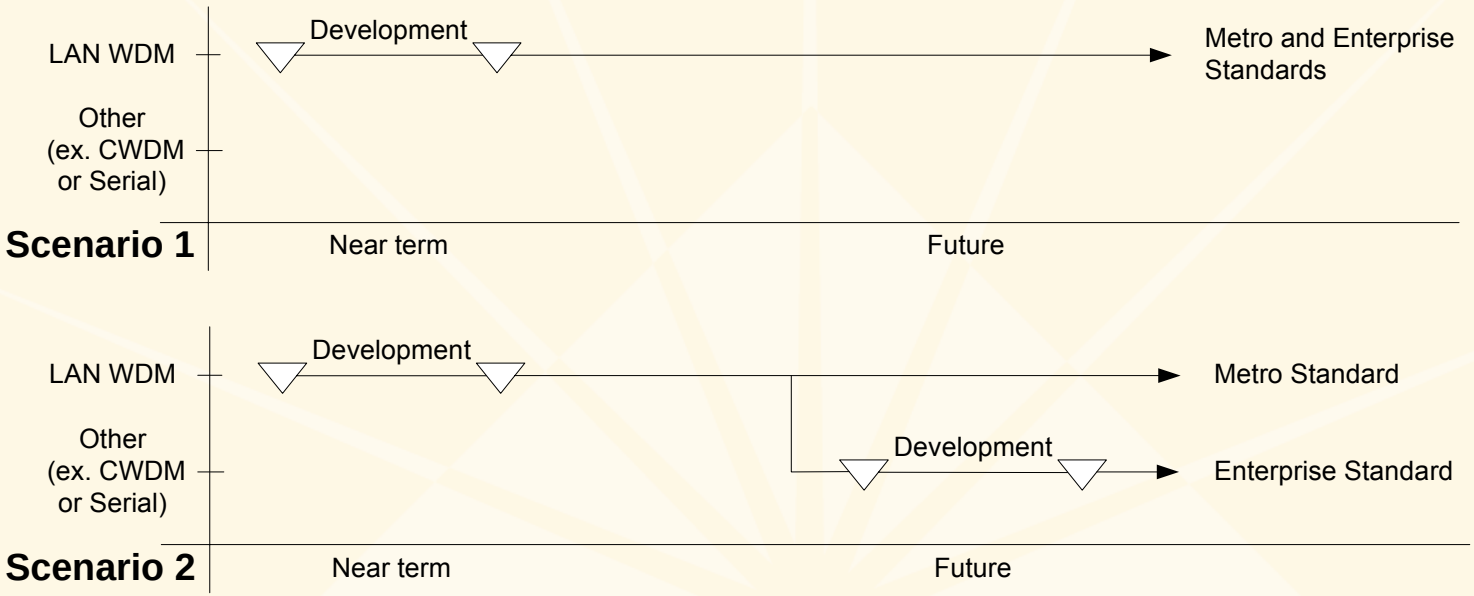
- No commercial un-cooled 25G DFBs exist today.
- New process technology has to be developed for 100GE applications.
- No yield data exists to accurately predict performance or cost, or to support standards development.
- 2.5G un-cooled TX optics costs can not be extrapolated to 25G optics cost
  - Perception of low cost is based on 2.5G data, for example as in the ITU CWDM study that estimated ~40% cost savings
  - For 25G applications, cooling costs (TEC and package) are a small fraction of the total cost, and small compared to laser yield related cost.
- CWDM 60nm band results in:
  - complex laser fabrication processing steps,
  - difficult monolithic laser array processing, limiting long term cost reduction.
- What is known:
  - Near-term 25G un-cooled CWDM DFB technology does not exist and is not a feasible approach
  - Long-term 25G un-cooled CWDM DFB technology is not the lowest cost.
- What is predicted:
  - Mid-term 25G un-cooled CWDM DFB technology will be lower cost then cooled alternatives.

# LAN WDM & CWDM Mux/DeMux Cost

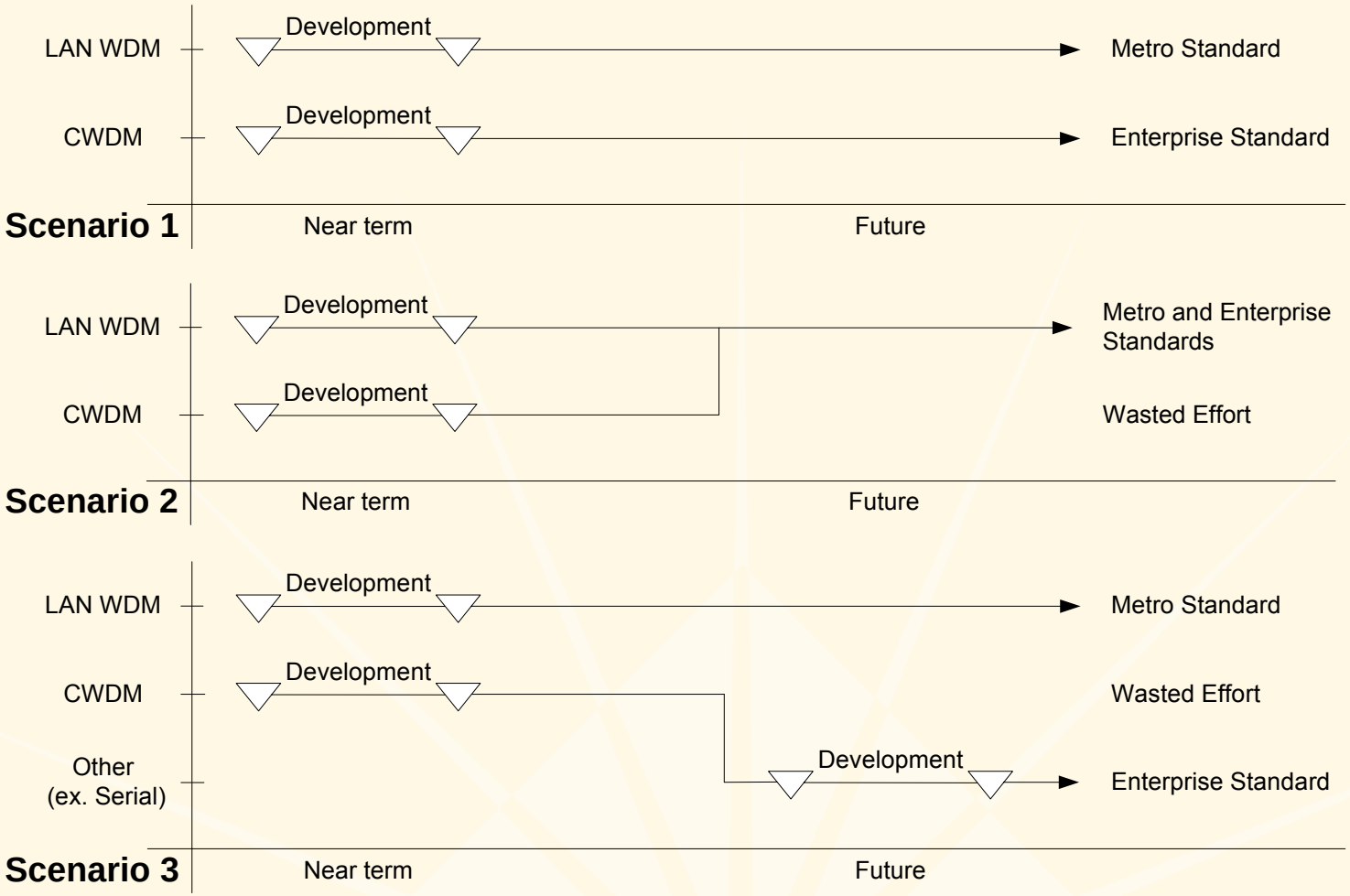
- LAN WDM does not have the same tight matching requirements as WAN DWDM.
  - WAN DWDM example: 100 GHz spacing requires less then +/- 0.1 nm wavelength drift of laser relative to filter, which drives yield and is expensive.
  - LAN WDM example: 800 GHz spacing allows +/- 0.8 nm wavelength drift of laser relative to filter, which is not a yield driver and is inexpensive.
- Dielectric filter based Mux/DeMux
  - Cost driven by physical size and yield
  - Similar size for LAN WDM and CWDM implementations
  - Yield insensitive to filter bandwidth above 200GHz
  - Same cost for commercially available LAN WDM or CWDM filters
- PLC based Mux/DeMux
  - Cost driven by physical size and yield
  - Similar size for LAN WDM and CWDM implementations
  - Yield insensitive to filter bandwidth above 400GHz
  - Same estimated cost for LAN DWDM or CWDM PLCs
- LAN WDM and CWDM Mux/DeMux cost is the same

# Common LAN WDM Near Term Standard Scenarios

- In the near term, the only accurate and data based cost projections for 100GE Enterprise Transceivers are based on cooled TX optics technology.
- In the future, accurate and data based cost projections will become available based on other TX optics technologies, like CWDM (un-cooled) and Serial.
- In the future, regardless of which technology was chosen in the near term, the lowest cost TX optics technology will be used for high volume 100GE Enterprise Transceivers. Cost is the driver!



# LAN WDM & CWDM Near Term Standards Scenarios




- CWDM (unlike LAN WDM) near term Enterprise Standard scenarios require twice the simultaneous effort, with potential for wasting half of that effort.

# Discussion

- It is critical that the industry arrive at a consensus on the WDM grid for 100GE Enterprise applications.
- Until agreement is reached, substantial investment will not be made into Enterprise optics because of risk of not being IEEE standard compliant.
- In the near term, 100GE LAN WDM grid approach:
  - is technically feasible and demonstrated,
  - is lowest risk for EML or DML optics development,
  - is lowest cost,
  - minimizes standards and optics development efforts.
- In the future, 100GE LAN WDM grid approach:
  - has significant low cost potential,
  - if other 100GE approaches prove to be lower cost, then a second standard can be developed when actual data justifies the effort, with no wasted effort in the near term.