

Overview of CMIS-LT the Flexible OB Link Training

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Overview

- Problem statement
- LT background
- Challenges of using CL72/136 LT for C2M
- Overview of CMIS-LT
- Status of CMIS-LT
- Detail of CMIS-LT
- Comparisons of CMIS-LT with CL136/162 and a hybrid in-band/out-band
- Summary.

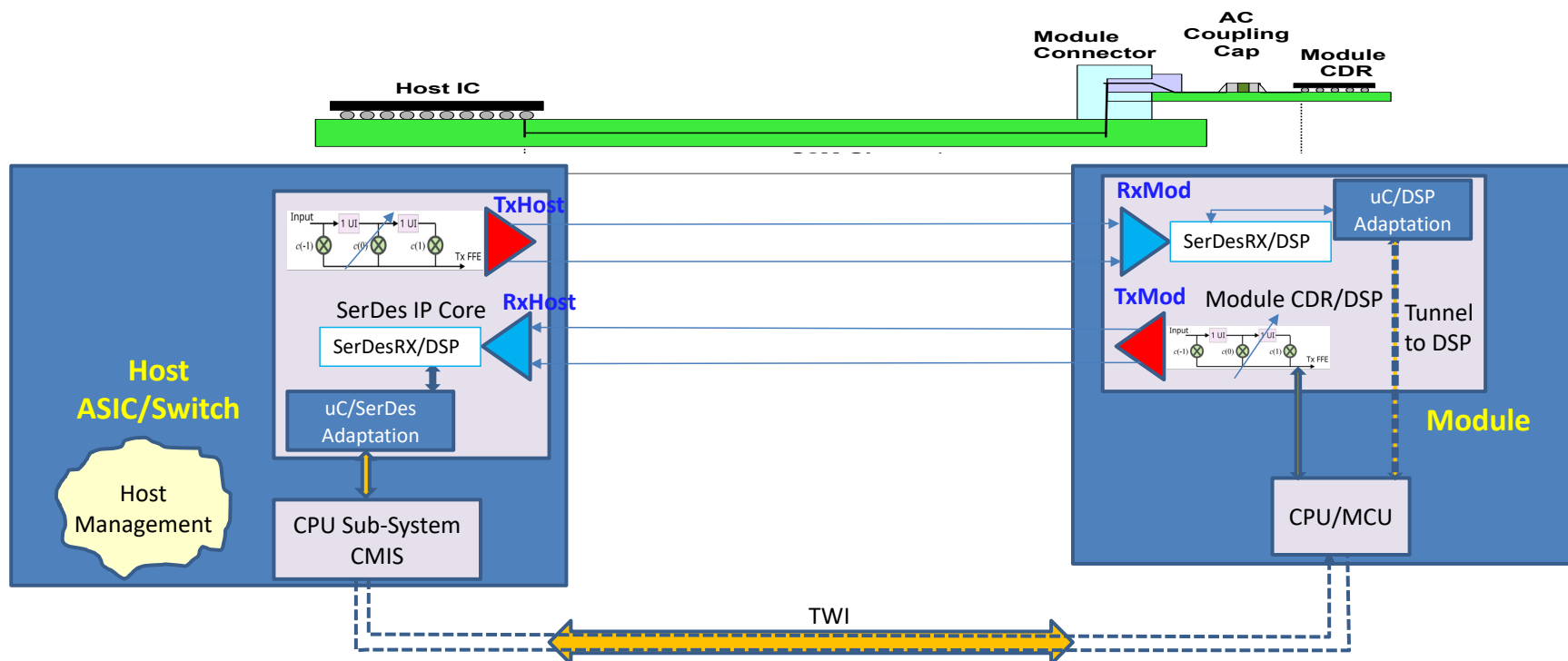
C2M Problem Statement

❑ Host SerDes TX FIR is tuned at manufacturing per given port

- Host management select AUI-S or AUI-L for TxMod setting

❑ What is the problem with above approach?

- As long as the receiver need help from the transmitter the scope optimized host measurement with HCB and module measurements with MCB not identical plugging a real module into a host
- Setting with HCB and MCB may not be the optimum setting for link in service!



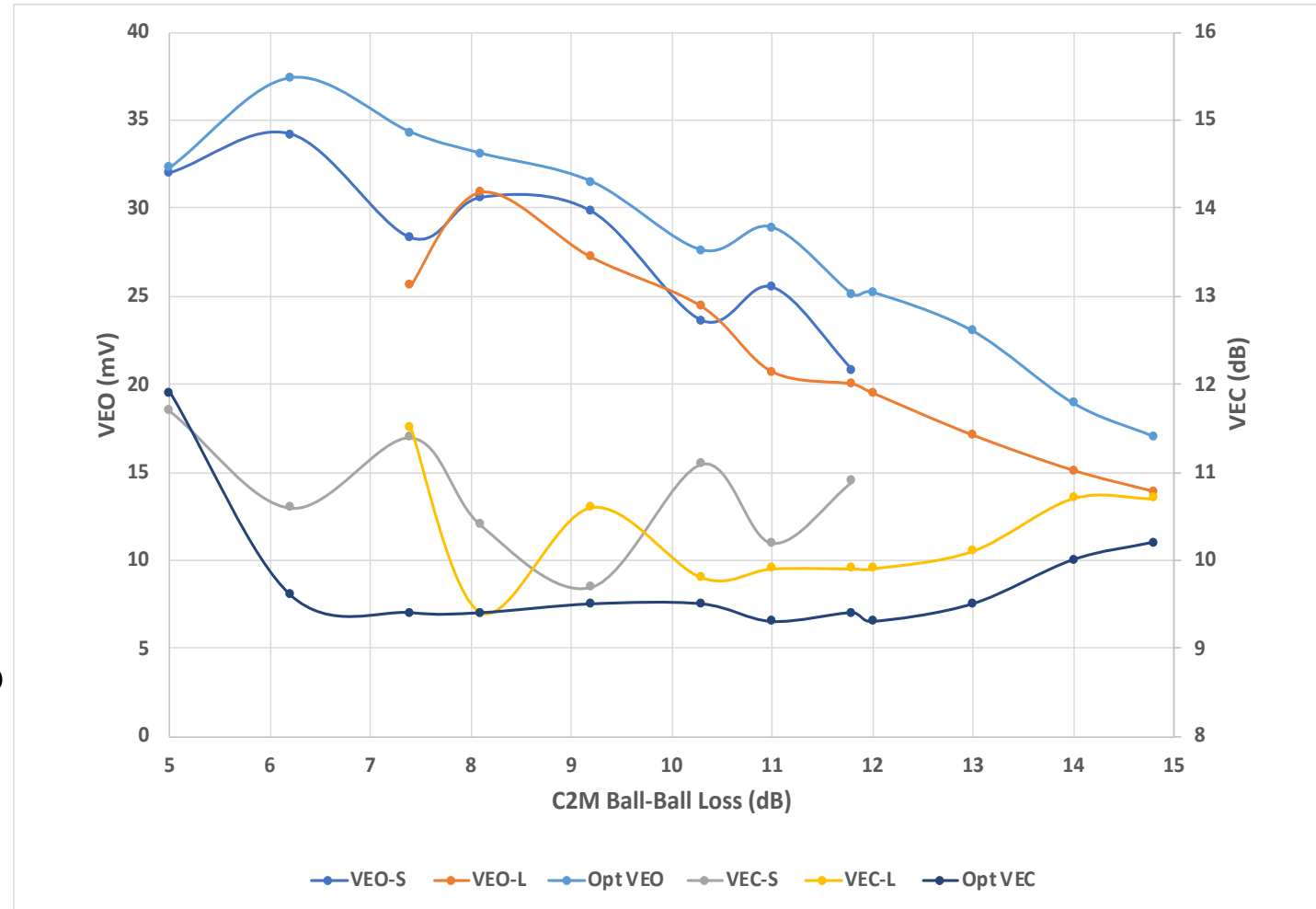
Is There Enough Benefit to Introduce LT for 100G-CK AUIs

□ **IS there a need to adjust pre/post cursors given that CK defines AUI-S and AUI-L addressing lower loss and higher loss channels for 4T DFE receiver**

- Penalty from optimum over AUI-S range
 - Up to 6 mV (34%) in VEO penalty
 - Up to 1.6 dB in VEC penalty
- Penalty from optimum over AUI-L range
 - Up to 8.2 (40%) mV in VEO penalty
 - Up to 1.1 dB in VEC penalty

□ **Realistic modules/system likely will have more than 1.6 dB VEC penalty observed at least for 4T DFE receiver**

- Given that most of the benefit were due to Tx FFE pre-cursor compensation a DSP receiver with pre-cursor compensation may not rely on TX pre-cursor compensation and the reported benefit will decrease.



See https://www.ieee802.org/3/ck/public/21_07/ghiasi_3ck_01_0721.pdf

Background on Ethernet AN/LT

- ❑ Ethernet LT 1st developed for 10GBASE-KR require point-point link operation implementing LT based on CL72 (NRZ), CL136/162(PAM4), and and Autoneg based on CL73
 - LT require the link to operate in loopback (point-point) and works well for two end-stations
 - Host A and host B both operate as initiators with independent management entities.

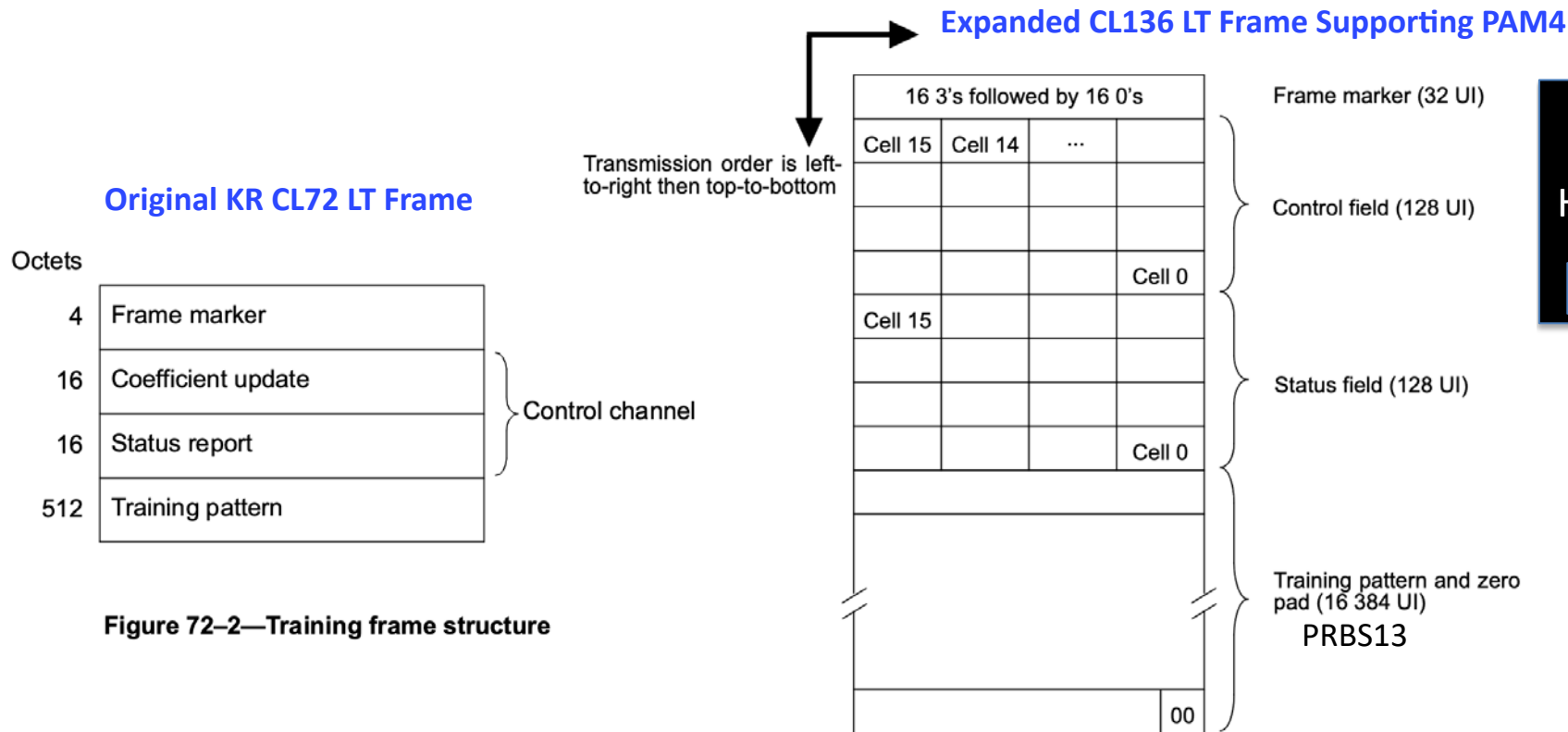
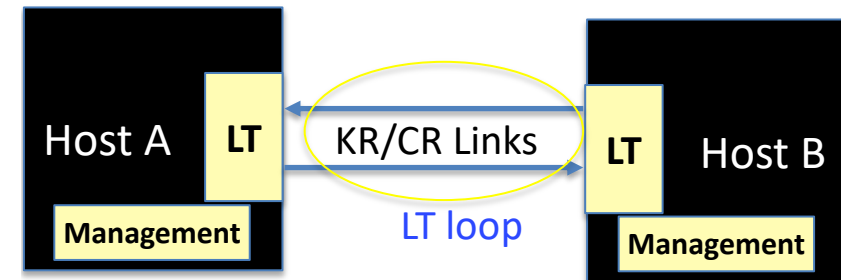


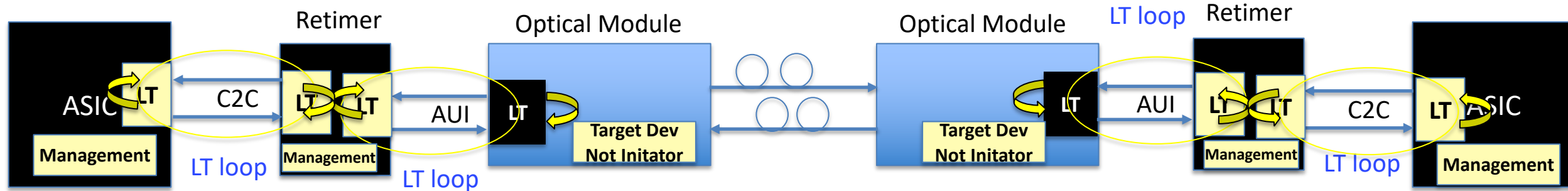
Figure 72-2—Training frame structure

Figure 136-3—Training frame structure
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Why not Just Use the Proven Ethernet AN/LT?

- ❑ An optical link may consist of 2-4 segments where each segment must be trained
 - LT on the backplane or CR links operate as point-point links
 - 4 segmented link with 8 LT engine need to work seamlessly as shown in diagram below just to bring up an optical link
 - LT frames from one link segment can't be allowed to propagate to another segment as it will confuse the downstream state machine
 - A module CDR implementing Ethernet LT would require full Mux/De-mux with AN-PCS increasing complexity and latency
 - Any C2M LT must interact and coordinate with CMIS!



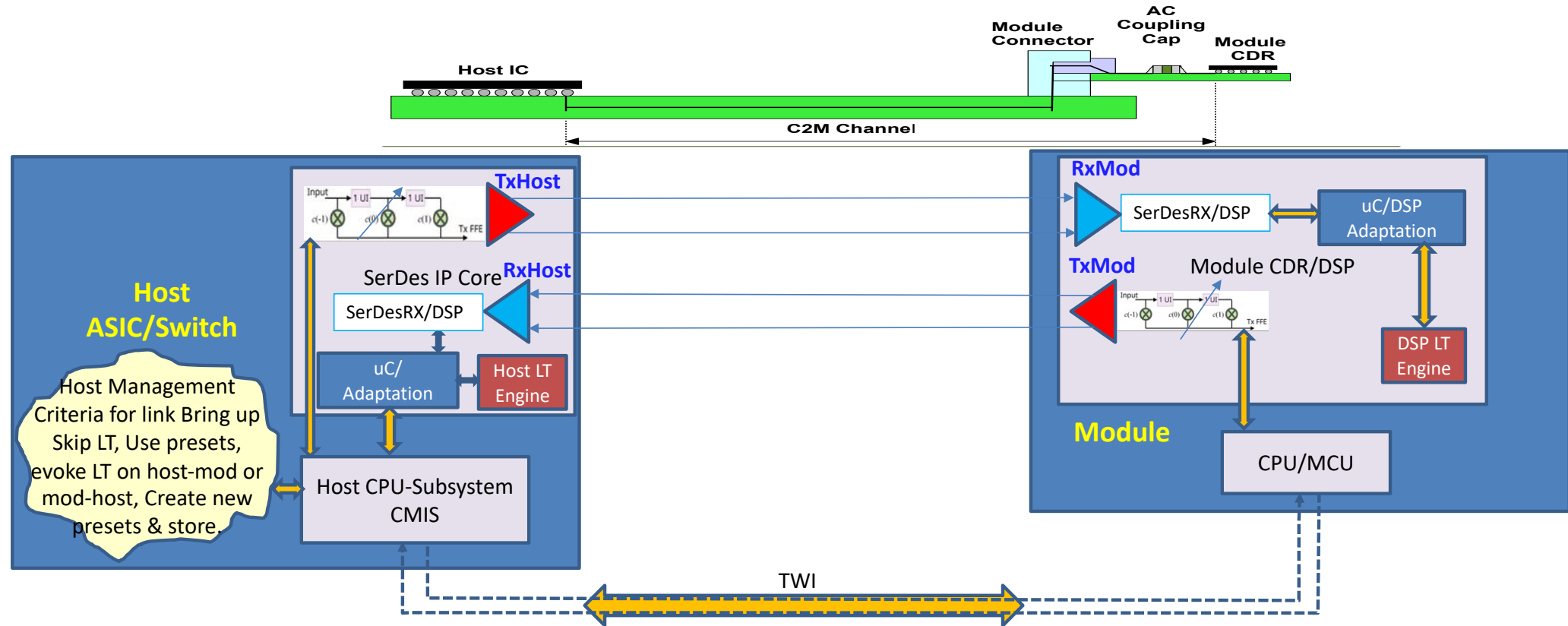
See https://www.ieee802.org/3/ck/public/18_09/ghiasi_3ck_02_0918.pdf

What are the LT Options for C2M?

- I. Use/reference OIF protocol agnostic CMIS-LT based on out-of-band (OB) TWI as currently under definition by the OIF management**
 - CMIS-LT SerDes adaption/MMSE is identical to current Ethernet LT but the messages are sent OB
 - CMIS-LT offer Tx FFE tuning, Amplitude tuning, pre-coder, create user optimized presets, direct read/write/restore, direct request to jump to certain TX FFE taps, real BER/SNR reporting, dynamic degrade
 - CMIS-LT is an optimized solution for C2M LT when there is a communication channel available
- II. Modify CL136/162 Ethernet LT to coordinate with CMIS then switch to in-band/out-band**
 - Use TWI OB to setup and configure App Select
 - After module DPSM configuration and prior to module ready one would need to enable Ethernet in-band LT hardware/state machine to send the LT request in-band
 - Through coordination with CMIS shut the in-band LT hardware/state machine off
 - Use CMIS to configure module into ready state
 - Initial link tuning Inc/Dec/Hold can be faster but require dedicated HW in the CDR.

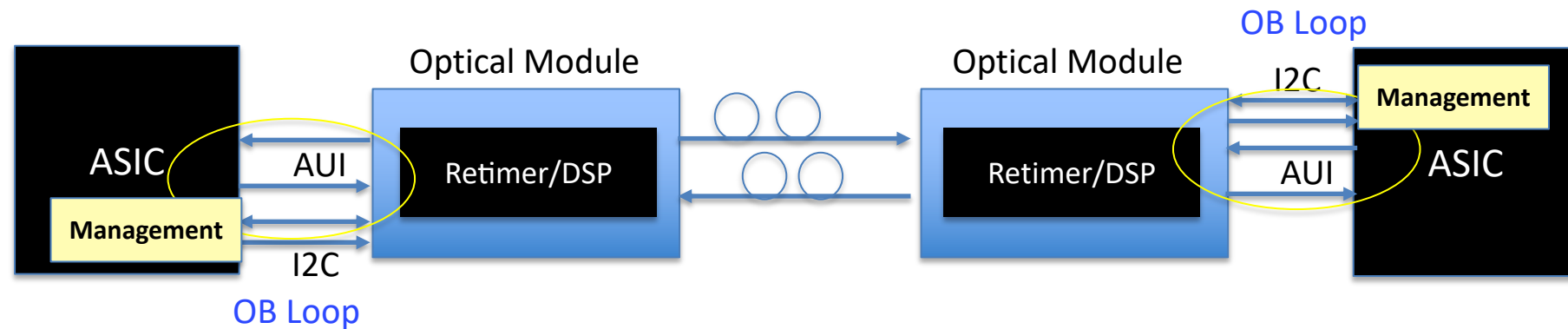
Elements of CMIS-LT OB Controls

- Two independent LT engines optimize TxHost-RxMod and TxMod-RxHost links using single management entity in the host that engages the LT engines
 - RxMod and RxHost requests are relayed to the partner transmitter through TWI
 - Adaptation/LMS algorithms are self-contained in the host SerDes and module DSP SerDes.



CMIS-LT Overview

- CMIS-LT uses Out of Band (OB) management based on CMIS to optimize host and module TX FFEs, Amplitude, and provide diagnostics
 - Approach does not require any dedicated HW and is built on top of CMIS
 - Single host-based management entity engages LT and has visibility to both host and module LT operations
 - CMIS-LT leverages Ethernet LT but instead of sending training frames the LT requests are sent on TWI
 - CMIS-LT take advantage of availability of OB link and enhances Ethernet LT given the availability of OB link.



Status of CMIS-LT

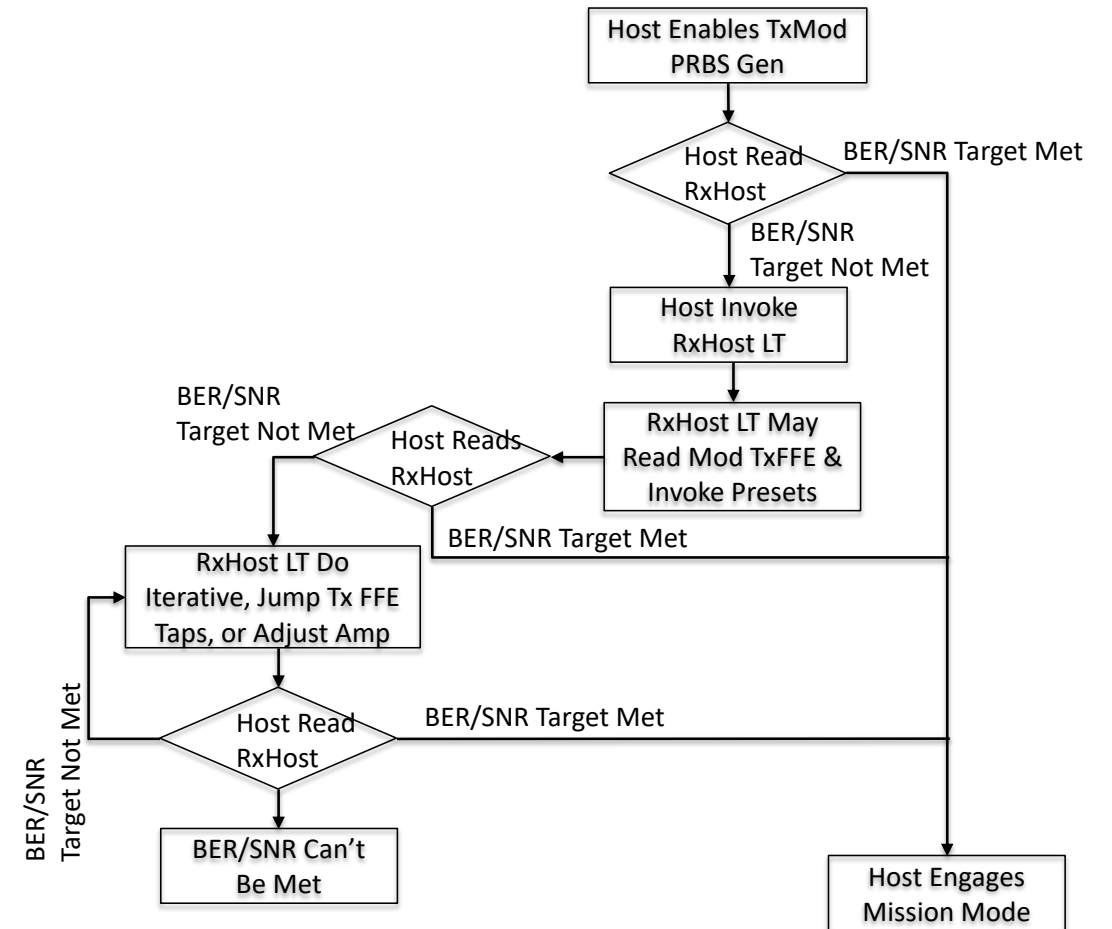
- ❑ **CMIS-LT project was authorized during OIF Q1-2022 meeting**
 - Project is owned by the OIF management to include the CMIS register in support of CMIS-LT
 - Based on number of joint PLL/Management meeting the group converged on an adaptation method identical to Ethernet CL72/136 where the receive DSP drives the adaptation decision
- ❑ **Author has created CMIS-LT WP (Q4-22) and detail CMIS register (Q1-23) as bases to incorporating CMIS-LT into future draft of CMIS**
 - CMIS-LT provide protocol agnostic mechanism to tune TX FFEs, TX amplitudes, and store optimized Presets
 - Dynamic degrade will signal link partner to either bring down link for service or make small tweaks
- ❑ **Recommend IEEE 802.3dj to establish liaison with the OIF management regarding CMIS-LT to receive document and provide input to the OIF.**

CMIS-LT Key Features

- **CMIS-LT simplified solution to the complex DSP adaptation is to let the host RxDSP and module RxDSP adjust their partners TX FFE/AMPs through a set of CMIS control registers**
 - Make it simple, predictive, and deterministic regardless who builds the module
 - Optimized stored in-service presets can be applied without the need to start from zero with tedious Inc/Dec/hold
 - When host invokes link tuning the module RxDSP passes its' request to the module where host reads
 - CMIS-LT can be engaged on Egress, Engress, or both
 - Provide flexibility how RxDSP may choose to adjust its' partner TX FFE and TX Amplitude
 - Increments/decrements/hold, and support variable step sizes or RxDSP may request a jump
 - Ability to store prior optimized setting on the host that can be used after reset/power down
 - Read/write and store optimized in-service presets
 - Dynamic degrade can provide advance warning/adjustment for link due to aging/temperature etc.

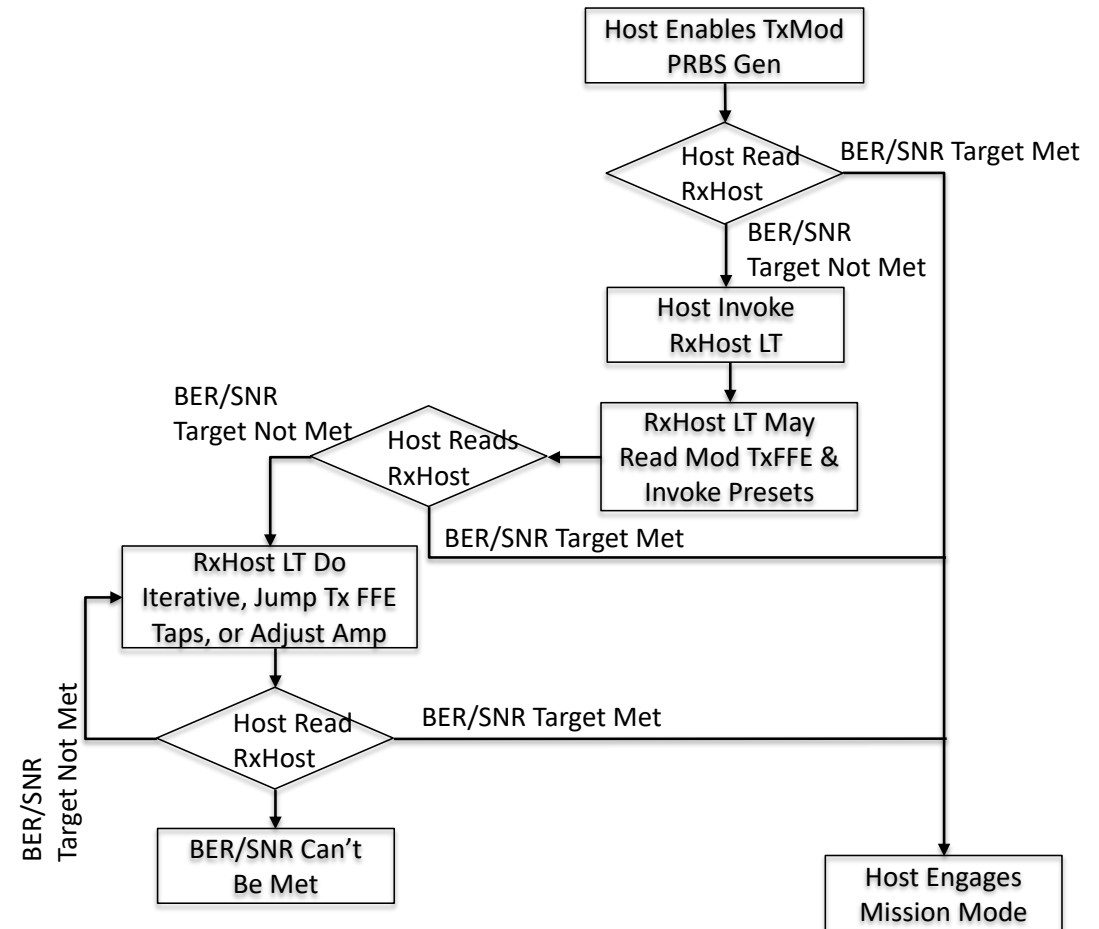
CMIS-LT Host to Module LT Operation

- I. Based on SI parameters SNR/BER host determines if TxMod-RxHost need training with default setting.
 - If BER/SNR target is met, then go to mission mode
- II. Host set target
 - Host enables TxMod PRBS generator
 - Meet best BER/SNR, meet certain BER/SNR
- III. Host invokes RxHost link training LT
 - RxHost SerDes passes its request to the host CMIS
 - Host may try using presets including enabling pre-coder before iterative tuning or RxHost LT directly goes to iterative tuning and adjustment
 - RxHost SerDes may request from the module its normalized TxMod FFE coefficients
 - RxHost SerDes goes through the preset settings
 - Module informs host TxMod FFE updated
 - if for any preset setting the target BER/SNR is met then RxHost DSP informs the host
 - Host may store optimized TxMod FFE
 - Host may engage the mission mode
 - If the target BER/SNR are not met RxHost SerDes may try iterative tuning (increment/decrement), request brand new set of taps (jump), enable pre-coder, including increment/decrement amplitude
 - Module informs Host TxMod FFE and/or Amplitude updated
 - RxHost SerDes determines to repeat or stop and inform the host
 - Target BER/SNR is met then host engages mission mode and stores optimized TxMod FFE
 - Host may retry optimizing, n=number of retry
 - Target BER/SNR is failed – may have faulty host or module, or the target BER/SNR set too high.



CMIS-LT Module to Host LT Operation

- I. RxMod module CDR/DSP request for adjustment to TxHost are initiated with module Interrupt and then host will poll the module
- II. Based on SI parameters SNR/BER host determines if TxHost-RxMod need training with default settings
 - Host enables TxHost PRBS generator
 - If BER/SNR target met go to mission mode
- III. Host set target
 - Meet best BER/SNR, meet certain BER/SNR
- IV. Host invokes RxMod link training
 - RxMod CDR/DSP passes its request to the module CMIS
 - Module requests to the host starts with an interrupt then host read and implements module requests
 - Module may request from host to read normalized TxHost FFE coefficients or RxMod LT directly goes to iterative tuning and adjustment
 - Host provide normalized TxHost FFE to the module if requested
 - RxMod CDR/DSP goes through preset settings including enabling pre-coder
 - Host informs module TxHost FFE updated
 - if for any preset setting the target BER/SNR is met module informs the host
 - Host may store optimized host TXHost FFE setting
 - Host engages the mission mode
 - If the target BER/SNR not met RxMod CDR/DSP may try iterative tuning (increment/decrement), request brand new set of taps (jump), enable pre-coder, or increment/decrement amplitude
 - Module informs Host TxMod FFE and/or Amplitude updated
 - RxMod CDR/DSP determines to repeat or inform host
 - Target BER/SNR met – then host engages mission mode and stores optimized host TxHost FFE
 - Module may retry optimizing, n=number of retry
 - Target BER/SNR is not failed – may have faulty host or module, or the target SNR/BER set too high.



Comparisons of CMIS-LT vs CL72/136 LT for C2M

Parameters	CMIS-LT	CL CL136/162 for CR/KR	CL 136/162 with CMIS Assist
Operation	Out of band	In-band	Hybrid OB/In-band/OB
Supports C2M/Modules	Yes	NA	Yes
CDR Complexity	Low	High	High
Uni-directional LT	Yes	No	No
Amplitude Tuning	Yes	No	At present no
Dynamic/mission mode Alarm/Tune	Yes	No	No
Qualify Link BER/SNR	Yes	No	At present no
LT View/status/Diagnostics	Yes	Need a Sniffer	Need a Sniffer
Time to Tune Due to TWI Speed	Impacted (I3C and E-SGMII overcomes link speed)	Not impacted	Not impacted
Store/Restore Optimum Preset	Yes (overcomes initial time to tune)	No	At present no
Host Management Complexity	Complex	Moderate	Complex

Summary

- ❑ **CMIS-LT uses OB communication by leveraging existing MMSE in the host/module DSPs to train/tune the host and the module transmitters**
 - CMIS-LT supports up to 7 pre-cursors and 8 post cursor to support future 200G and XSR+ applications
- ❑ **CMIS-LT follows Ethernet LT adaption model but with numerous enhancement given the availability of OB COM link**
 - Optimum host-module TX FFE presets are stored on the host to avoid tedious link training after reset/shutdown
 - DSP receiver may compute optimum TX FFE and request wholesome change to all taps
 - Amplitude tuning allow reduce receiver VGA gain and save power and improve linearity
 - As part of CMIS-LT link bring each link is test with prior optimized presets and standard defined presets against the target BER/SNR to see if link tuning is required and then engaged the link
 - CMIS-LT can be used as a diagnostic/compliance tool during product manufacturing, bring up, and deployment
- ❑ **CMIS-LT offer flexible host-module OB LT and diagnostics for IEEE802.3dj C2M applications without requiring dedicated CDR HW**
 - To make traditional CL72/136 LT work with CMIS require OB CMIS assist to engage in-band LT then use CMIS to disengage the LT HW and bring up the module to ready/mission mode
 - Both in-band and OB LT must interact with CMIS so might as well leverage rich CMIS capabilities!