ITU-T Sync Standards Update

October 2019

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ITU Sync Standards Categories

- Transfer of frequency to meet 50ppb *(2G/3G/4G FDD)*
  - Using SyncE, or using PTP over existing networks

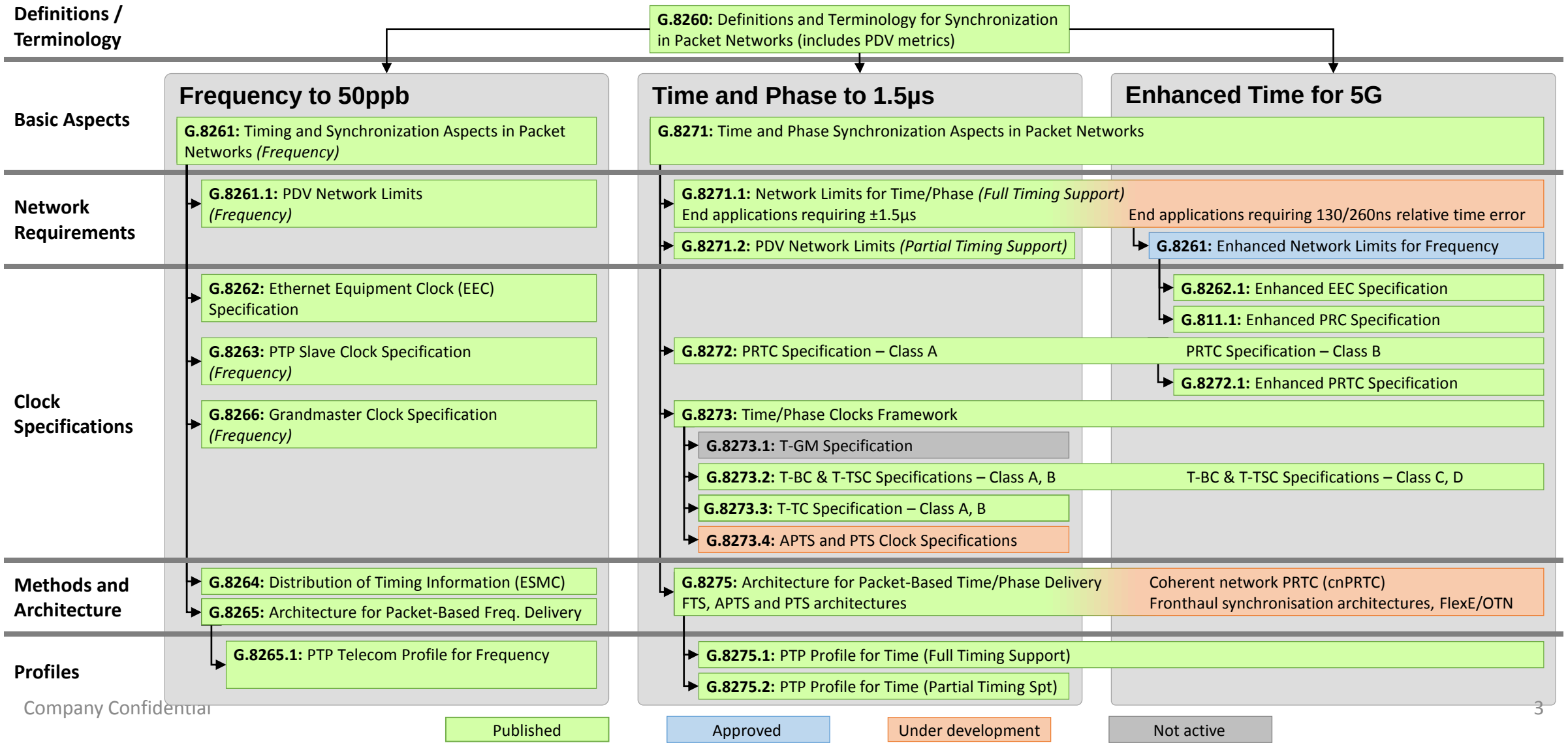
- Transfer of time to meet 1.5µs *(3G/4G TDD, LTE-A)*
  - Using PTP over new networks with T-BC and SyncE at every node

- Transfer of time to meet 1.5µs *(3G/4G TDD, LTE-A)*
  - Using PTP over existing networks

- Transfer of time to meet 130ns *(5G potential)*
  - "Enhanced" clock specifications

- Sync OAM *(general)*

ITU-T Packet Sync Recommendations



What's new?

Recommendations approved in July 2019

(to be published by end of 2019)

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Main new performance spec at July meeting

- Network limit specifications:
  - **G.8261 Revision** – Adds the network limit for a chain of enhanced clocks (e.g. eEECs)
  - **G.8271.1 Amd. 2** – Adds new appendix about fronthaul architectures
    - *No new performance specifications*
- High-accuracy "enhanced" clock specifications for 5G:
  - **G.8262.1 Amd. 1** – Adds wander tolerance spec, adds parameters S and T to transient response
    - Adds Appendix on back-to-back testing for media converters *(e.g. µW, OTN)*
  - **G.8272.1 Amd. 2** – Adds an integrated ePRTC/T-GM function *(same performance)*
  - **G.8273.2 Rev.** – Re-organizes the document to bring all clock classes into the main body
    - Includes guidelines on back-to-back testing of Class C clocks *(as well as A & B)*
- PTP Profile updates:
  - **G.8265.1 Amd. 1** – Adds a brief note about processing of Quality Levels. No technical change.
  - **G.8275.1 Amd. 3** – Adds support for transmission of PTP over OTN OSMC channel
  - **G.8275.2 Amd. 3** – Adds an Appendix describing operation of the profile over a LAG
- General Information:
  - **G.8275 Amd. 2** – Adds information about inter-working between G.8275.1 and G.8275.2
    - Adds information about timescale combination for the cnPRTC

Topics discussed at the October meeting

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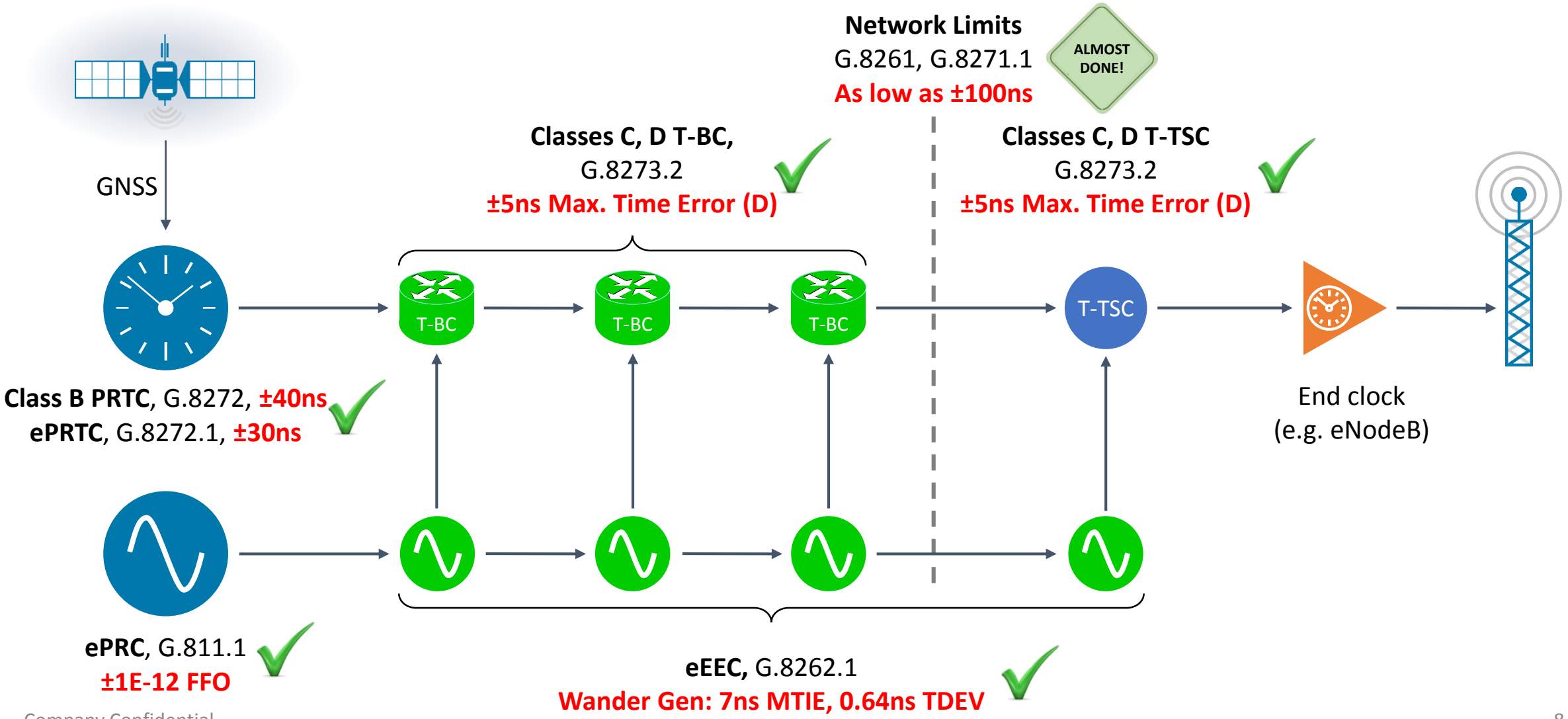
- Network limit specifications:
  - Network limits for short chains of clocks, typical of a fronthaul network
  - Relative time error network limits and measurement techniques
  - Budgeting for use of Class C clocks to meet 1.5µs, covering longer reference outages
- High-accuracy “enhanced” clock specifications for 5G:
  - Relative time error between ports of a boundary clock
  - Very high accuracy PRTC spec proposed by Chinese companies – probably too high to be achievable
- PTP Profile updates:
  - CMCC proposed a new TLV containing information about the clocks in the sync path, and a revision to the BMCA to make use of this information. Not yet agreed, but already supported by Paragon Neo
- APTS and PTS
  - Clarifications of draft specification to make it clearer and more testable
  - Discussed mixed network scenarios (e.g. PTS followed by an FTS segment) – topic coming from O-RAN
- SyncOAM
  - Clarifications on draft specification to make it ready for agreement in February

Enhanced Clocks and Network Limits

Enhanced Clock Specifications for 5G



Enhanced Specifications for 5G

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- Enhanced specifications agreed:
  - G.811.1 ePRC – published August 2017 ✓
  - G.8272.1 ePRTC – published August 2017 ✓
  - G.8272: PRTC Class B – published January 2019 ✓
  - G.8262.1: eEEC – published January 2019 ✓
  - G.8273.2: Class C and Class D T-BC and T-TSC – published January 2019 ✓
- G.8261: Network Limit for chain of eEECs
  - Network limit much lower, to permit better SyncE-assisted holdover of T-BCs and T-TSCs
  - Status: agreed, to be published by end 2019 ✓
- G.8271.1: Network Limit for chain of T-BCs
  - New budget to meet 1.5µs using Class C clocks, even under long outages (2-3 days)
  - New network limit based on Class C, D T-BC specification, targeting around ±130ns end-to-end
  - New network limit for relative time error, targeting fronthaul clusters
  - Status: update expected completion in early 2020

G.8272: Comparing PRTC Classes

Parameter	Conditions	Class A	Class B	ePRTC (G.8272.1)
Max|TE_L|	1pps: unfiltered PTP: 100-sample moving average low-pass filter	100ns	40ns	30ns
dTE_L MTIE	1pps: unfiltered PTP: 100-sample moving average low-pass filter	100ns (max)	40ns (max)	30ns (max)
dTE_L TDEV	1pps: unfiltered PTP: 100-sample moving average low-pass filter	3ns up to 100s, rising to 30ns @ 1000s	1ns up to 100s, rising to 5ns @ 500s	1ns up to 30Ks, rising to 10ns @ 300Ks

- ePRTC has very long-term holdover, requiring high-performance Caesium oscillator
- PRTC-B intended for distributed applications where an ePRTC would not be practical
  - Expected to be based on multi-band GNSS receivers to compensate for the ionosphere
  - Holdover provided by SyncE rather than a Cs oscillator

SyncE: Comparing G.8262 to G.8262.1

Parameter	EEC (G.8262)	eEEC (G.8262.1)
Frequency Accuracy	4.6ppm	Same value
Pull-in/Hold-in	4.6ppm	Same value
Wander generation	MTIE: 40ns @ 0.1s, rising to 113ns @1000s TDEV: 3.2ns @ 0.1s, rising to 6.4ns @1000s	MTIE: 7ns @ 0.1s, rising to 25ns @1000s TDEV: 0.64ns @ 0.1s, rising to 1.28 ns @1000s
Wander tolerance	250ns @ 0.1s, rising to 5000ns @ 1000s	Same value *(allows mixed chains)*
Jitter generation	0.5UI *(1G, 10G)* 1.2UI *(25G lanes)*	Same value (1G) 10G, 25G: for further study
Jitter tolerance	250ns @ 10Hz, reducing to 1.5UI (3.6UI for 25G lanes)	Same value (1G) 10G, 25G: for further study
Clock Bandwidth	1 – 10Hz	1 – 3Hz
Transient response	120ns initial step, then 50ns/s *(const. temp)*	10ns initial step, then 10 ns/s *(const. temp)*
Holdover	120ns initial step, then 50ns/s frequency offset, plus 1.16 x 10^{-4} ns/s^2 drift *(const. temp)*	10ns initial step, then 10 ns/s frequency offset, plus 1.16 x 10^{-4} ns/s^2 drift *(const. temp)*

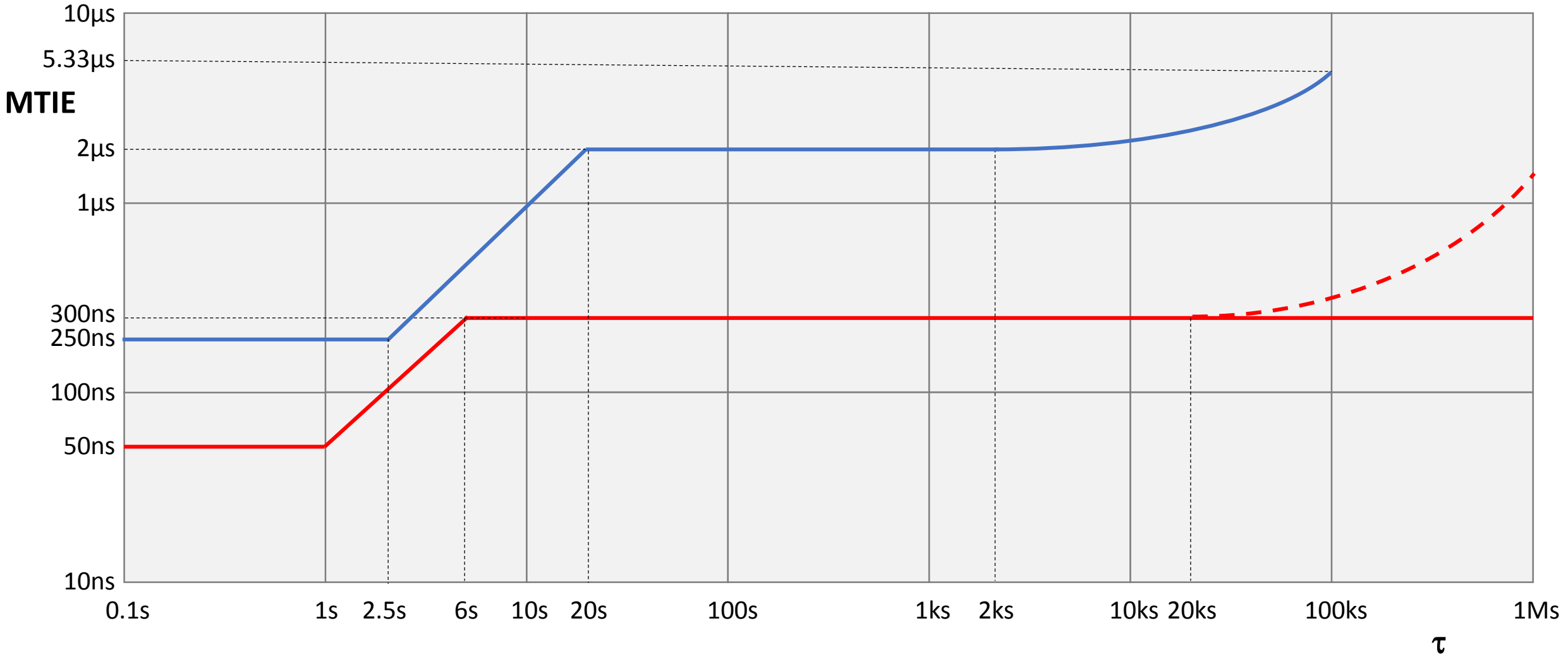
Key: Green – same as G.8262 EEC spec
Red – changes to G.8262 EEC spec

G.8273.2: Comparing T-BC Classes

Parameter	Conditions	Class A	Class B	Class C	Class D
Max|TE|	Unfiltered, 1000s	100ns	70ns	30ns	*FFS*
Max|TE_L|	0.1Hz low-pass filter, 1000s measurement	-	-	-	5ns
cTE	Averaged over 1000s	50ns	20ns	10ns	*FFS*
dTE_L MTIE	0.1Hz low-pass filter Const. temp, 1000s	40ns	40ns	10ns	*FFS*
	0.1Hz low-pass filter Var. temp, 10000s	40ns	40ns	*FFS*	*FFS*
dTE_L TDEV	0.1Hz low-pass filter Const. temp, 1000s	4ns	4ns	2ns	*FFS*
dTE_H	0.1Hz high-pass filter Const. temp, 1000s	70ns	70ns	*FFS*	*FFS*

- Class C aimed at shorter chains (up to 10 nodes)
- Class D aimed at longer chains (up to 20 nodes), and fronthaul networks in particular
- All classes now defined over 1, 10, 25, 40 and 100GE interfaces

SyncE vs. Enhanced SyncE Network Limits



Work in Progress

Future revisions planned for Feb. 2020

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- **G.8260 Revision** – *Definitions*
  - Add definition of relative time error, and clarifications on how to measure it
- **G.8261 Amd. 1** – *Network Limits for Frequency*
  - TDEV network limit for long chains of enhanced clocks
  - New MTIE limit for shorter chains in fronthaul
- **G.8271 Revision** – *Time Synchronisation Aspects*
  - General update
- **G.8271.1 Revision** – *Network Limits for FTS*
  - Timing budget for 1.5us with Class C clocks
  - Network limits for ±130ns
  - Network limits for relative time error
- **G.8273 Amd. 1** – *Framework for Phase/Time Clocks*
  - Appendix on Least Squares testing of noise transfer
- **G.8273.4** – *Partial Timing Support clocks* (1st ver.)
- **G.8275 Amd. 2** – *Time Sync Architectures*
  - Further details on Coherent Network PRTC (cnPRTC)
  - Possibly also material on FlexE and OTN-based fronthaul architectures
- **G.8275.1/.2** – *PTP Profiles*
  - Minor changes for consistency
  - No material changes to profiles
- **GNSS Technical Report**
  - New technical report on use of GNSS for timing
- **G.SupSyncOAM**
  - Supplement on recommended alarms and reported statistics for sync management systems

PTP over existing networks: APTS and PTS

- G.8273.4 (Slave Clock Specification) – *work almost complete*
  - Contains two clock specifications, for APTS clock and PTS clock
  - APTS Clock:
    - GNSS primary time source, PTP backup
    - Uses GNSS to measure PTP asymmetry during normal operation
    - Operates over switches/routers without PTP support (e.g. BCs, TCs)
  - PTS Clock:
    - Uses PTP as sole means of transferring time
    - Operates over switches/routers without PTP support (e.g. BCs, TCs)
  - Status: first agreement expected Feb. 2020
- G.8271.2 (Network Limits) published August 2017
  - Updated October 2018
  - No new updates planned at present

Coherent Network PRTC

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- Network of PRTCs for improved resiliency and accuracy
  - PRTCs exchange time information directly, enabling both ensembling and redundancy
  - “Rogue” PRTCs can be detected and eliminated from timing network
  - Interconnect might be PTP, high accuracy PTP (e.g. White Rabbit), or dedicated optical interconnect
- Possible connection to national lab for both highly accurate UTC(k) and legal time
- Information on cnPRTC to go into G.8275 (Architecture) document
- Status:
  - Initial information in G.8275 Amd. 1 (January 2019)
  - Update on timescale combination agreed (G.8275 Amd. 2), to be published by Sept. 2019
  - Expected completion by early 2020

GNSS Technical Report

- Technical Report looking at using GNSS receivers to obtain an accurate source of time
- Contents:
  - High level description of GNSS systems
  - Factors influencing the performance of a GNSS-based PRTC
  - Sources of time error in GNSS time distribution
  - Mitigation of time error in a GNSS-based PRTC
  - Operational schemes for mitigation of time error in GNSS time distribution
  - Appendices:
    - Cable delay effects and correction in a GNSS receiver
    - Ionospheric Delay and its effect on GNSS receivers
    - TRAIM (Time Receiver Autonomous Integrity Monitoring)
    - Solving GNSS equations to establish position and time
    - The effect of multiple reflections within the antenna cable
- Status: expected completion by early 2020

Sync OAM and Management

- Model proposed using an alternative PTP flow as a reference
  - Not a perfect reference, but a sanity check and indication of network-related issues
  - Described in G.SuppSyncOAM, a working document collecting Sync OAM material
  - Status: probable completion early 2020
- Frequency sync defects and parameters to be documented in a revised version of G.781
  - Status: Published August 2017
  - Update to be agreed February 2020
- Time sync defects and parameters to be documented in new recommendation G.781.1
  - Status: probable completion late 2020

Insight and Innovation

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