ITU-T Sync Standards Update

March 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

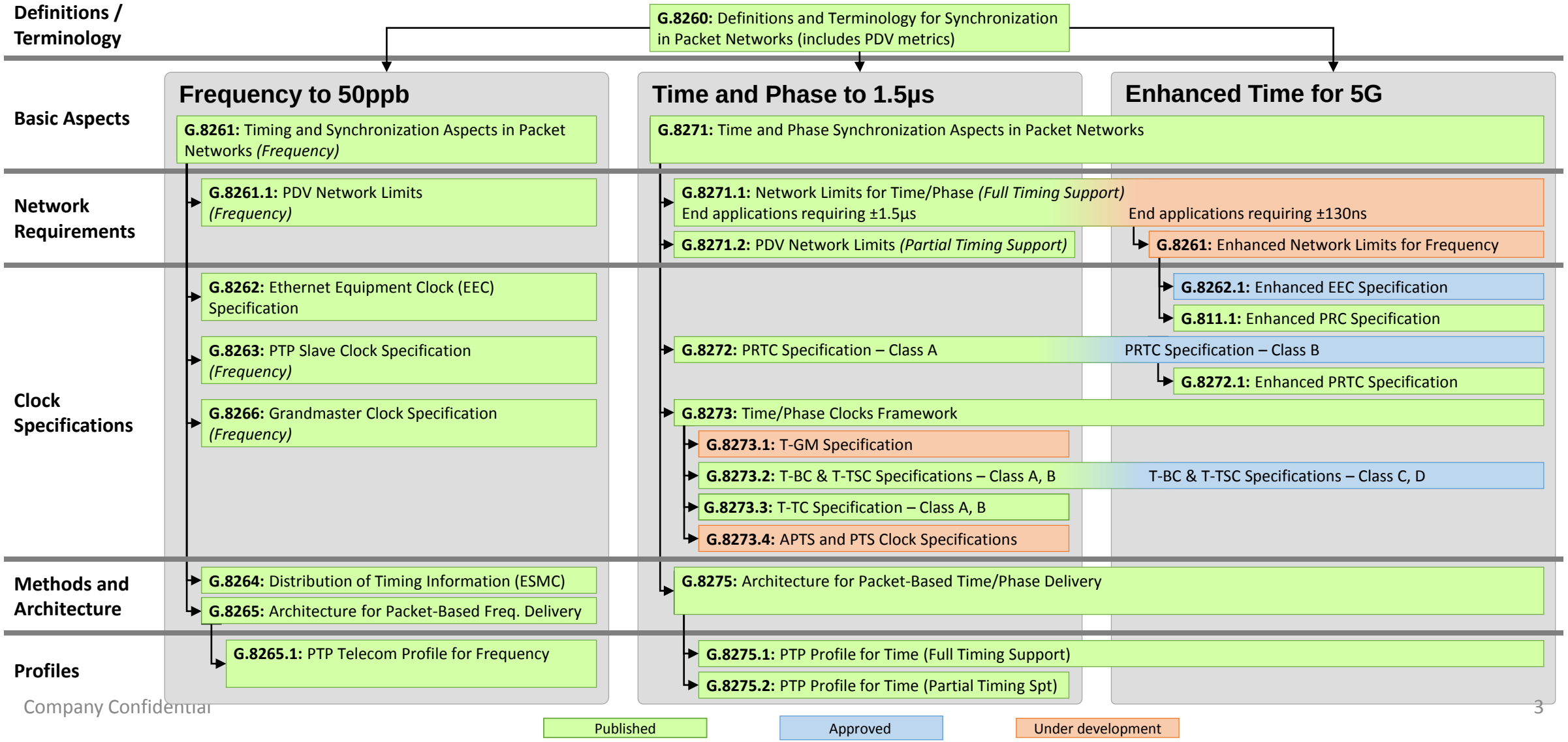
- Transfer of time to meet 1.5µs *(3G/4G TDD, LTE-A)*
  - Using PTP over new networks with T-BC and SyncE at every node

- 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 Jan. 2019

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- High-accuracy “enhanced” clock specifications for 5G:
  - **G.8262.1** (new) – Enhanced SyncE clock specification
  - **G.8272** Edition 3 – Adds the new Class B PRTC specification (40ns accuracy)
  - **G.8273.2** Amd. 2 – Adds new “Enhanced T-BC” specs, Class C and Class D
    - Also adds 25/40/100G interfaces for all clock classes
- “Regular” clock specifications updates:
  - **G.8262 Edition 4** – Adds the OEC (OTN Equipment Clock), with same wander spec as EEC
  - **G.8273.3 Amd. 1** – Adds 25/40/100G interfaces for all clock classes
- APTS/PTS updates:
  - **G.8260 Amd. 2** – Clarifies the step size for the pktSelected2WayTE metric, should be 20s or less
  - **G.8271.2 Amd. 2** – Adds network limit for point D (between slave clock and end application)
- General Information:
  - **G.8271 Amd. 2** – Adds latest information from 3GPP on sync requirements for LTE and NR (5G)
    - Clarifies the FCS calculation procedure for the serial ToD interface
  - **G.8275 Amd. 1** – Adds architecture information about cnPRTC (Coherent Networked PRTC)
  - **G.Suppl.Sim** – A supplement detailing the assumptions used behind all the simulations

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Approved Recommendations, Jan. 2019

SyncE: Comparing G.8262 to G.8262.1

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Parameter	EEC (G.8262)	eEEC (G.8262.1) – approved values
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

G.8272: Comparing PRTC-A to PRTC-B

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

Further agreements confirmed, Jan. 2019

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- Definitions
  - Added definition for “relative time error” in G.8260
  - Defined “step size” for pktSelected2WayTE
- Interfaces
  - All clocks (T-GM, T-BC, T-TC, T-TSC) will now be specified at 1, 10, 25, 40 and 100Gbit/s interfaces
  - SyncE can now be operated over 200GE and 400GE interfaces (using 50G PAM4 lanes)
- Serial Time-of-Day interface
  - Calculation method for FCS (Frame Check Sequence) was ambiguous, now is better specified
  - No change to the implementation, just clarifying the definition
  - Uses same method as CCSA serial time-of-day interface
- APTS network limits
  - Added a new limit for the interface between the T-TSC and the end clock (point D, 1350ns)
  - Clarified the step size to use for the pktSelected2WayTE metric
    (20s step size for a 200s window, i.e. 1/10 the window size)

Work in Progress

Future revisions planned for Sept. 2019

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- **G.8261 Rev. 4** – *Network Limits* – adds network limits for chains of enhanced SyncE clocks
- **G.8262.1 Amd. 1** – *Enhanced SyncE clock specification* – update to transient and holdover req'ts
- **G.8265.1 Amd. 1** – *PTP Telecom Profile for Frequency* – adds clarifications on quality levels
- **G.8271.1 Amd. 2** – *Network Limits for Full Timing Support* – information on relative time error
- **G.8272.1 Amd. 2** – *Enhanced PRTC* – addition of PTP GM function
- **G.8273.2 Rev. 3** – *T-BC clock specification* – document re-organisation
- **G.8273.4** – Partial Timing Support clocks – first version
- **G.8275 Amd. 2** – *Time Sync Architectures* – addition of Coherent Network PRTC (cnPRTC)
- **G.8275.1** and **G.8275.2 Amd. 3** – *PTP Telecom Profiles for Time* – minor editorial improvements
- **G.781 Amd. 1** – *Sync Layer Functions for Frequency* – extended QL for enhanced clocks

PTP over existing networks: APTS and PTS

- G.8271.2 (Network Limits) published August 2017
  - Updated October 2018
- G.8273.4 (Slave Clock Specification) work in progress
  - 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 publication expected Sept. 2019

Enhanced Specifications for 5G

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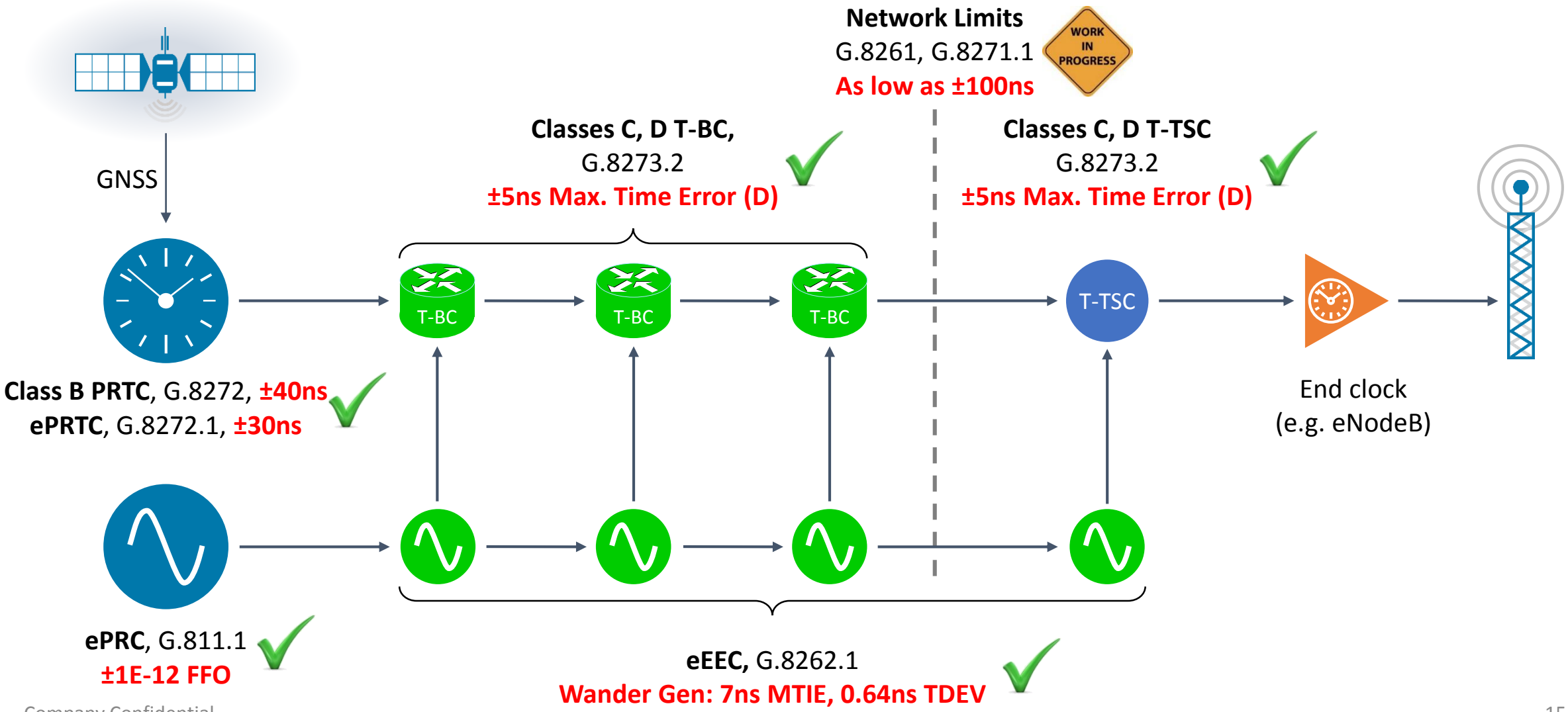
- Enhanced specifications agreed:
  - G.811.1 ePRC – published August 2017
  - G.8272.1 ePRTC – published August 2017
  - G.8272: PRTC Class B – published January 2019
  - G.8262.1: “eEEC” – published January 2019
  - G.8273.2: “Class C” and “Class D” T-BC and T-TSC – published January 2019
- G.8261: Network Limit for chain of eEECs
  - Network limit much lower, to permit better SyncE-assisted holdover of T-BCs and T-TSCs
  - Status: expected completion by Sept. 2019
- G.8271.1: Network Limit for chain of T-BCs
  - To be based on Class C, D T-BC specification, targeting around ±130ns end-to-end
  - Includes relative time error specification for network clusters
  - Status: expected completion by early 2020

Enhanced Clock Specifications for 5G



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 scheduled for 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
- Frequency sync defects and parameters to be documented in a revised version of G.781
  - Status: Published August 2017
  - Update expected Sept. 2019
- Time sync defects and parameters to be documented in new recommendation G.781.1
  - Status: possible completion by early 2020

Insight and Innovation

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