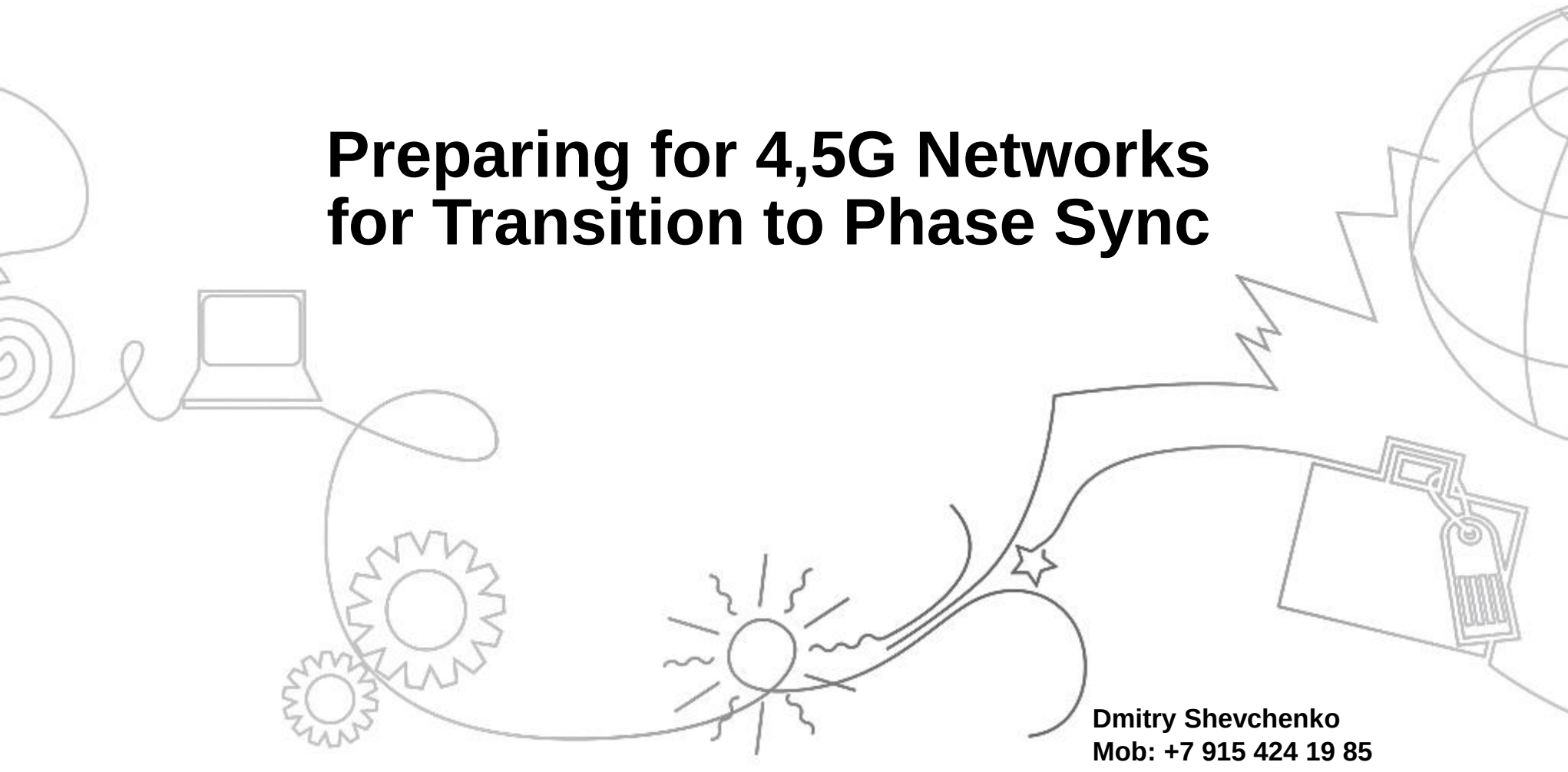
Preparing for 4,5G Networks for Transition to Phase Sync



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Measurement and testing procedure: what we test and how

- Packet utilization on real network – typ. 80%
- Packet selection percentage – 0.25%
- **Tests are done by means:**
  - *Calnex Sentinel with external reference GNSS*
  - *Vendor Base station Performance Monitoring*
  - *OTA module Calnex Sentinel, near future ….*
- **3G/4G Frequency**
  Time Interval Error
  Wander (MTIE)
- **4G Phase**
  2way Time Error
- **4,5G Phase**
  2way Time Error, Dynamic Time Error planning to use

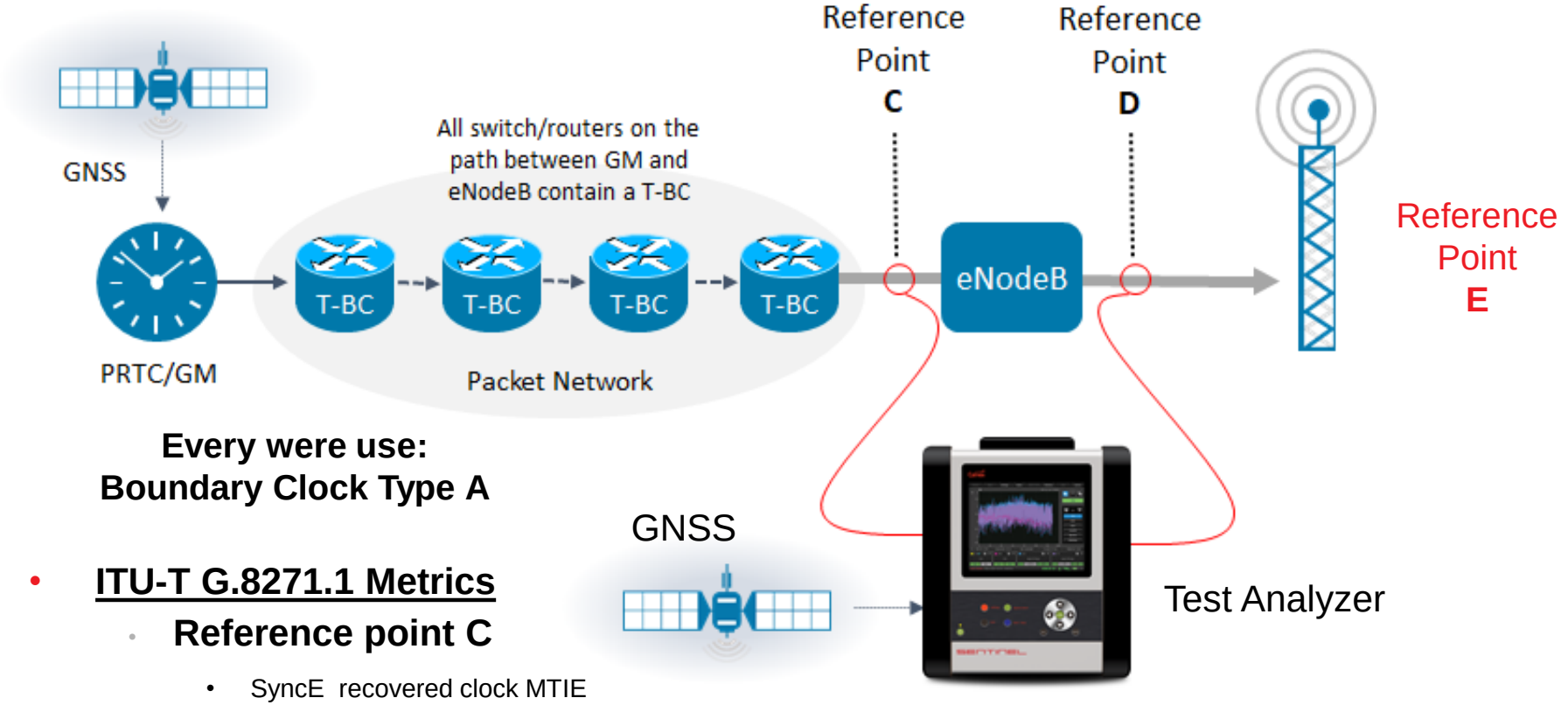
Currently, the stable operation of cellular communications equipment is directly dependent on GNSS signals (GLONASS / GPS).

The accuracy of synchronization of base station radio interfaces, charging and billing of voice, Internet traffic depends on the **exact location data**. it is also acutely felt in the conduct of financial and banking operations conducted through the mobile Internet.

Multiple tests are currently being conducted on carriers' transportation networks to combat Spooffing & Jamming issues. They are preparing to launch and there are already positive results from testing **local mini GMs in the SFP form factor.**

Measurement of time delays Time Error (TE) using SFP mini GM modules is still being studied. However, it already shows that **using SFP mini GM, ease of deployment and low power consumption is a significant technological solution** for existing communication networks.

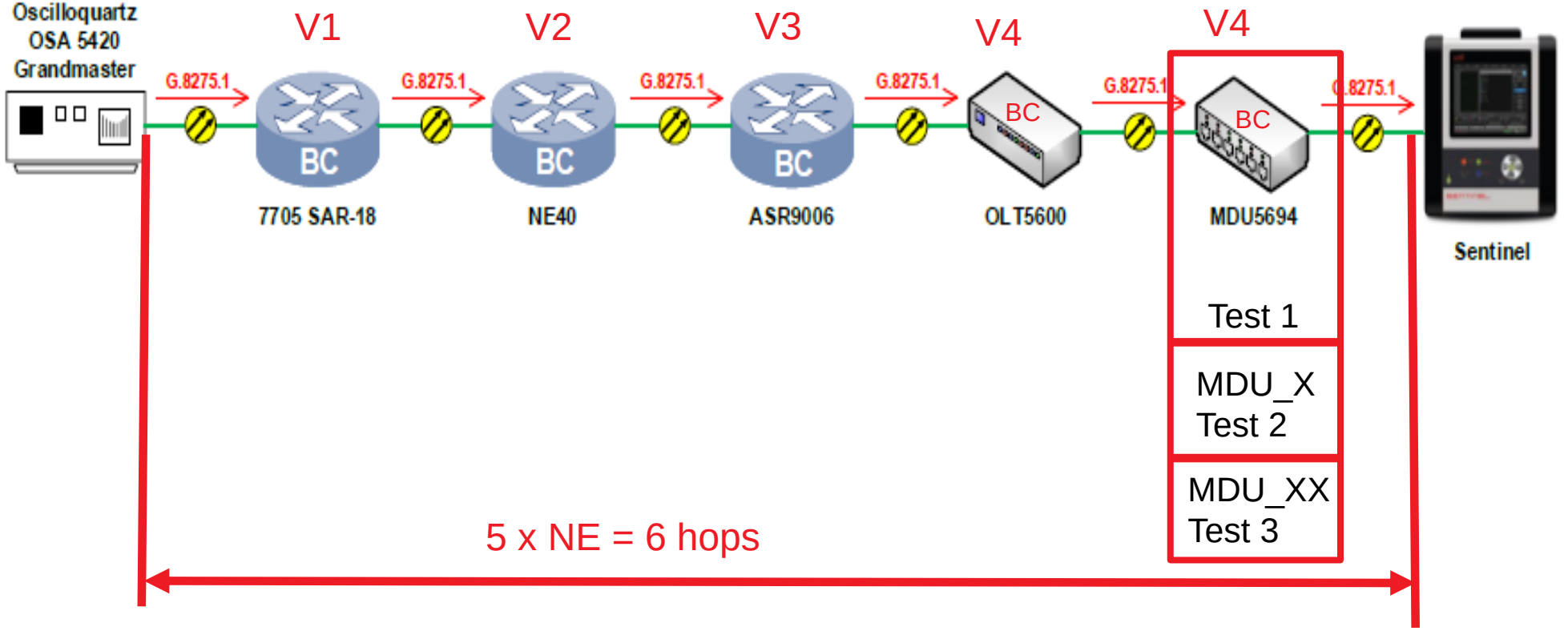
Time and Phase Full Time Support - FTS (ITU-T G.8275.1)



Every were use:
Boundary Clock Type A

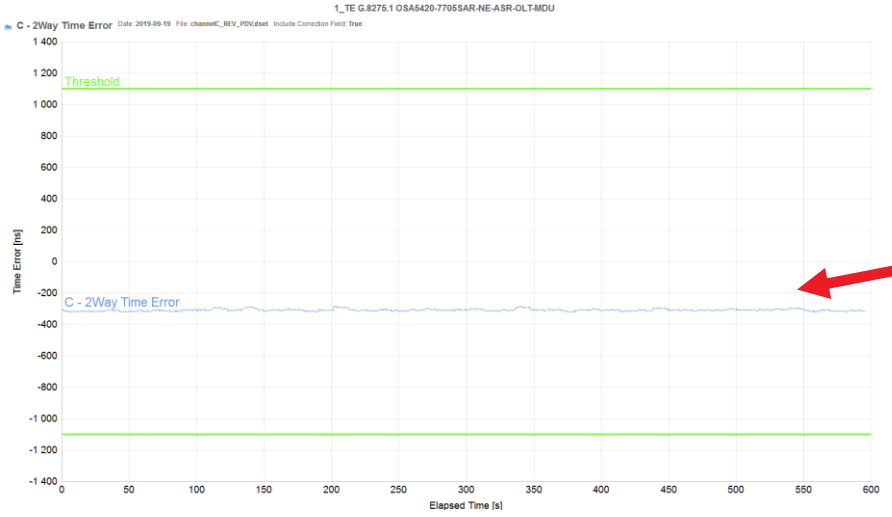
- **ITU-T G.8271.1 Metrics**
  - **Reference point C**
    - SyncE recovered clock MTIE
    - E1 / T1 / 10MHz recovered clock MTIE
    - PTP 2 Way Time Error
  - **Reference point D**
    - 1PPS Time Error
  - **Reference point E**
    - OTA frame phase alignment

Testing Field **PON Network** profile G.8275.1 with support Boundary Clock. Typical Scheme 1

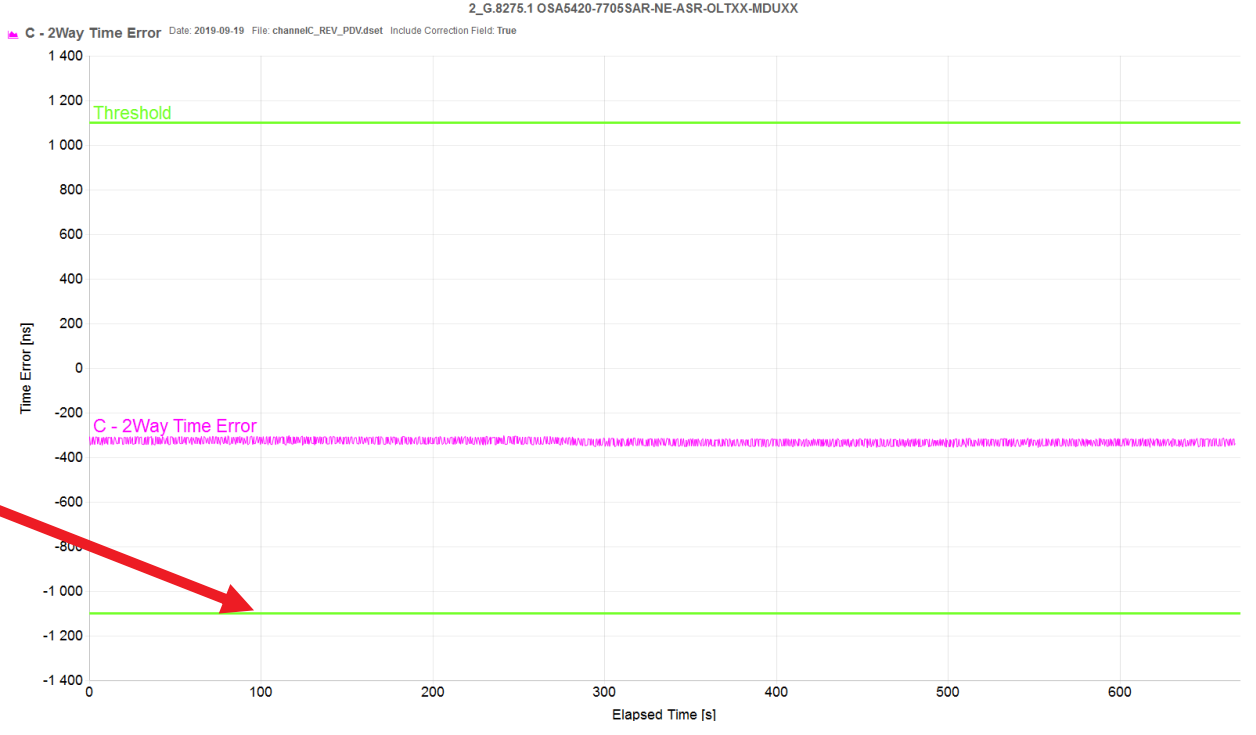


Task: Connect eNodeB via existing P O N

TE Results. Point C. ± 1,1 µsec Network equipment budget.

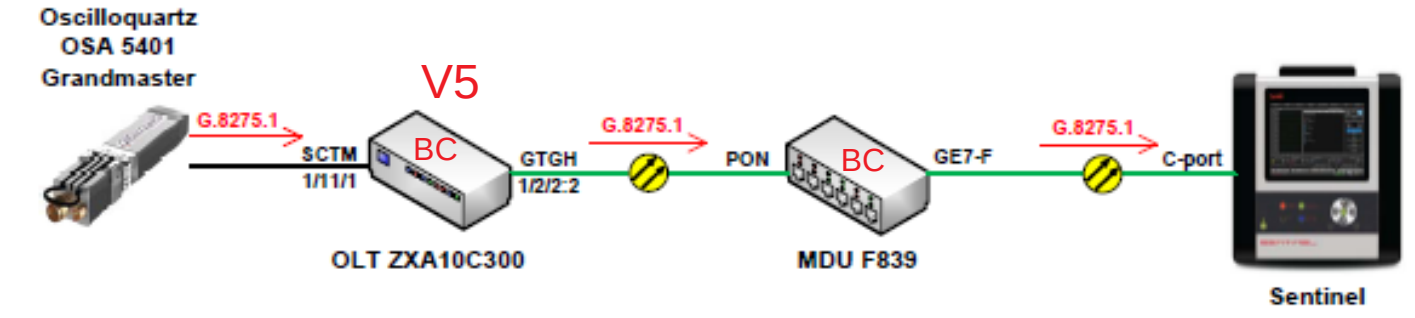


TE
Max – Min ~ 39 ns

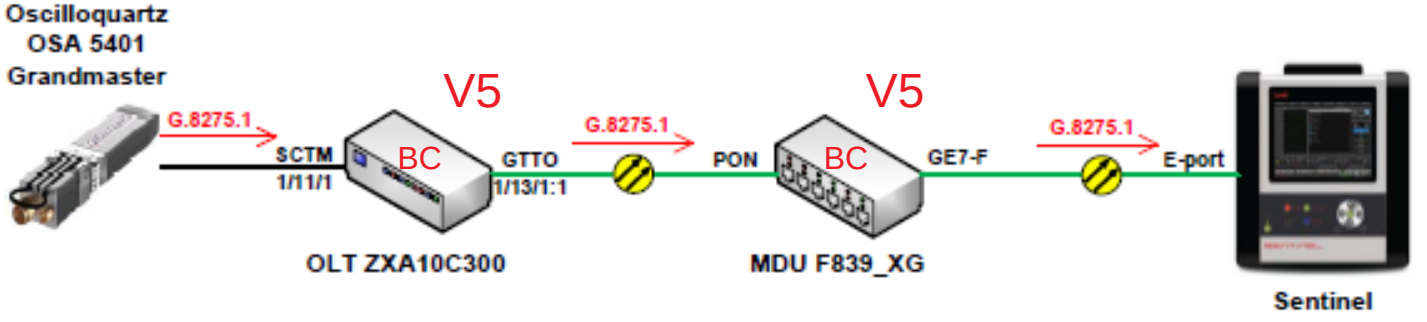


TE
Max – Min ~ 55 ns

Testing Field PON Network profile G.8275.1. Typical Scheme 2



TEST 1



TEST 2

2 x NE = 3 hops

Task: Edge mini GM deployment on P O N last mile

TE Results. Point C. ± 1,1 µsec Network equipment budget

TEST 1

No Traffic

TE

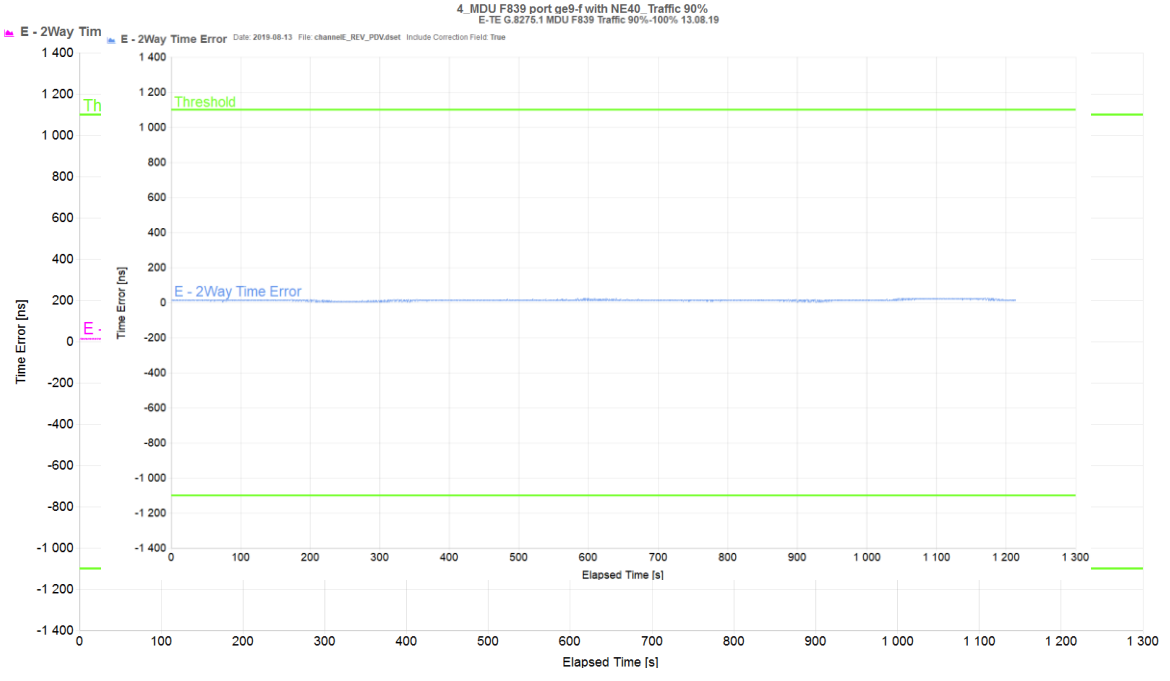
Max – Min ~ 80 ns

TEST 2

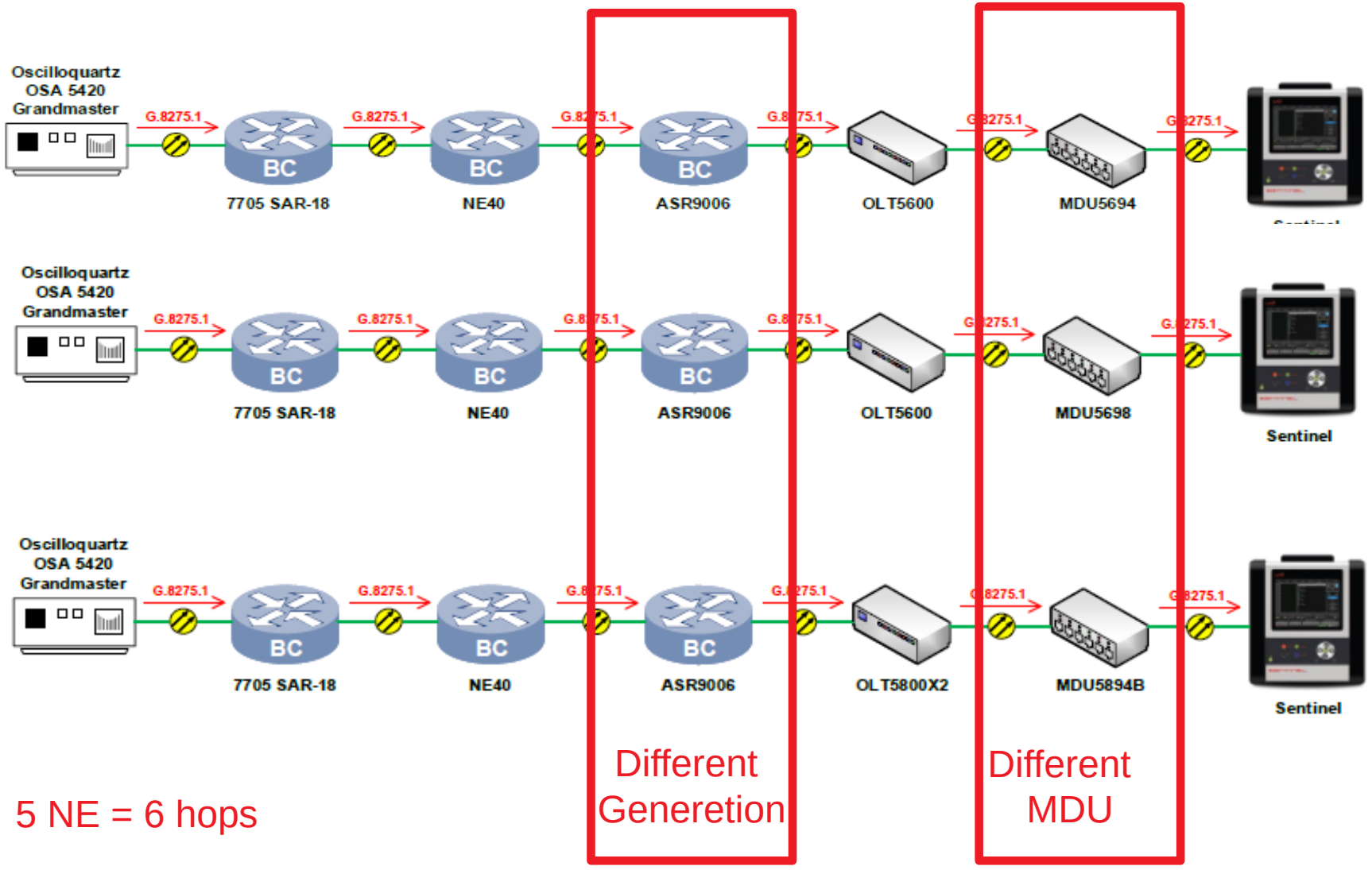
TE

Max – Min ~ 24 ns

Full Traffic – 90%



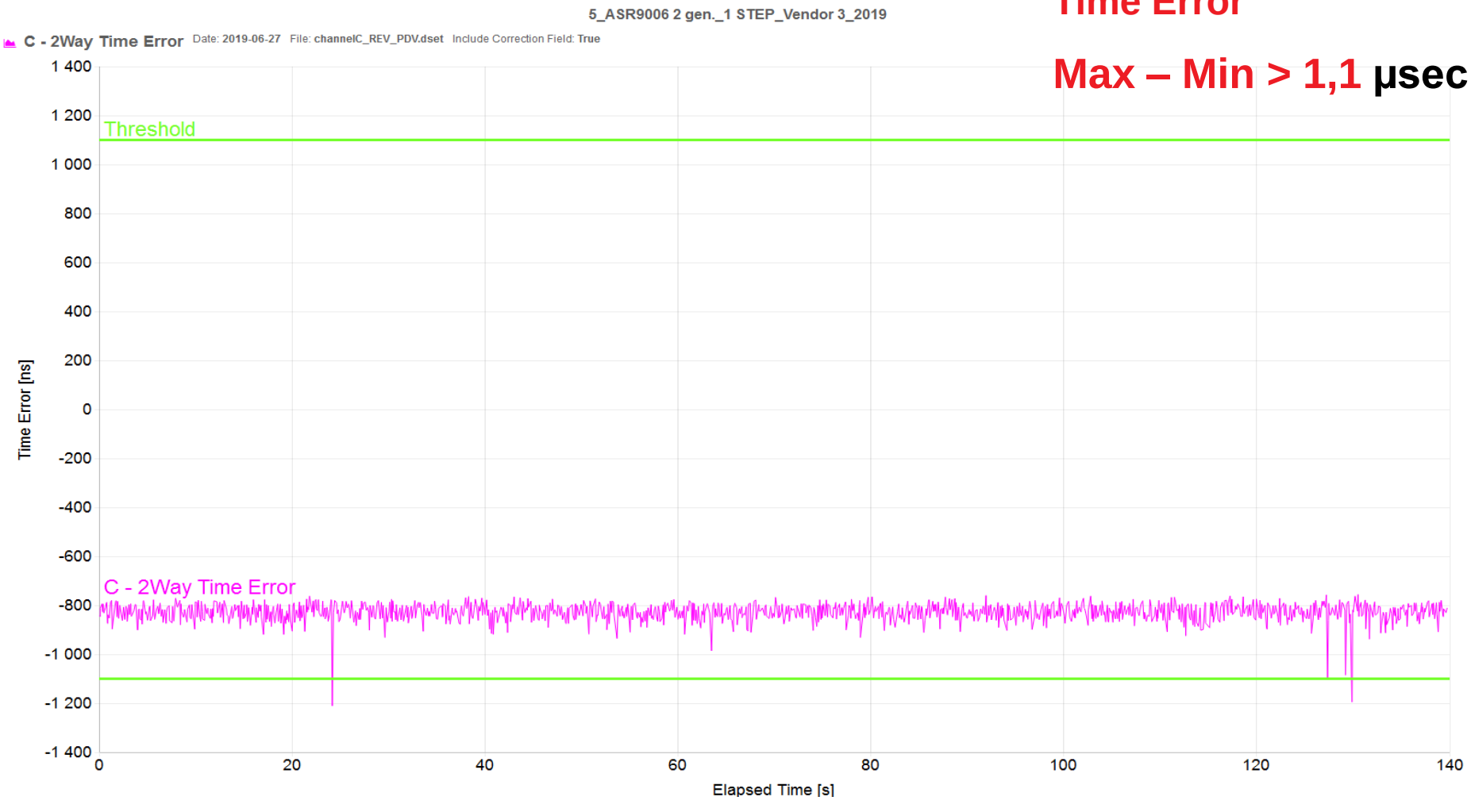
Testing Field PON Network profile G.8275.1. Typical Scheme 3 (Variation of Typical Scheme 1) One-Step & Two-Step Sync Mode. Difference



TE Results. Point C. ± 1,1 µsec Network equipment budget. Vendor 3
One-Step Sync Mode

Time Error

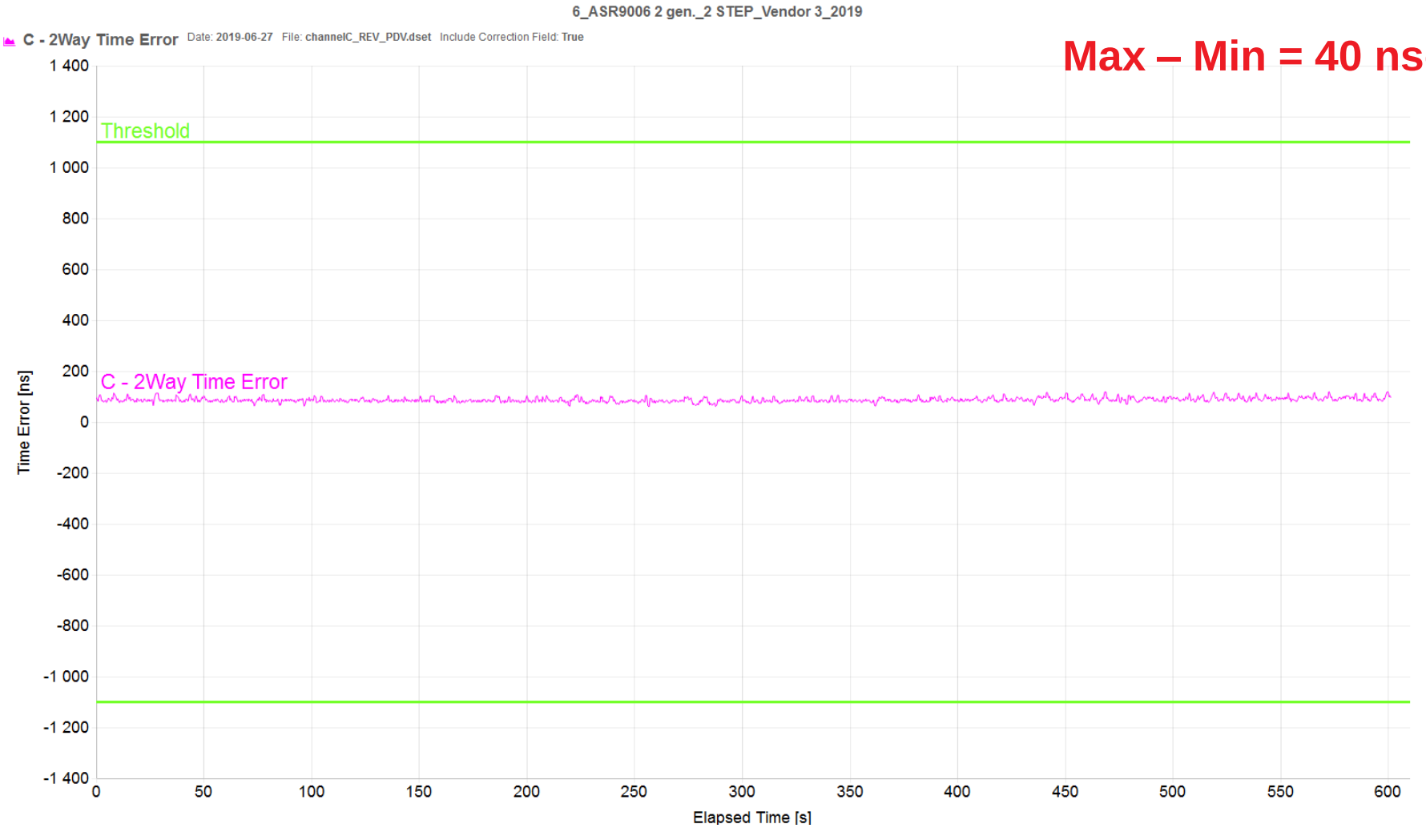
Max – Min > 1,1 µsec



TE Results. Point C. ± 1,1 µsec Network equipment budget. Vendor 3
Two-Step Sync Mode

Time Error

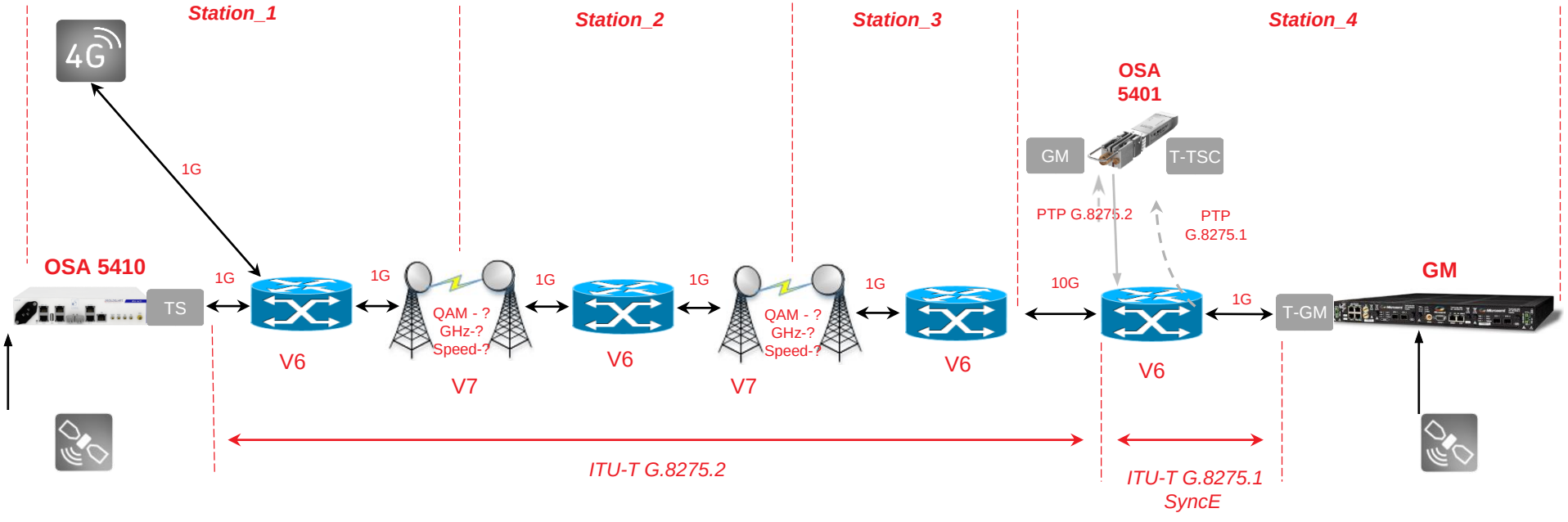
Max – Min = 40 nsec



Scheme 4. MBH Phase continuity

- L2 PTP Multicast ITU-T G.8275.1 to L3 Unicast ITU-T G.8275.2 profile conversion

Whole PTP chain, 8 transport nodes



All NE (MBH+RRL) = 13 hops

Measurement results Scheme 4

- **OSA 5410** has been configured to measure TE and MTIE functions of the embedded TS vs GNSS ref. signal.

- max │TE│≈ **695 ns is within** phase norms specified in G.8271.1 recommendation (***p.7.3 Network limits in reference point C***) ≤1.1µsec.

- MTIE result – **is within** norms specified in G.8271.1 recommendation (***p.7.3 Network limits in reference point C***, ***figure 7-2 – Dynamic time error network limit (MTIE)***).

- Two Way TE result should be additionally filtered as specified in ITU-T recommendation G.8271 (***p.7.3 Network limits in reference point C/7.3.2 Packet network limits for PTS/p.7.3.2.1***). Such packet selection cannot be applied by current SW of OSA 5410. Therefore is recommended to provide additional tests by equipment which support such feature (Calnex).

➔ **TE test PASSED**

➔ **MTIE test PASSED**

Scheme 4, OSA 5410, TE result

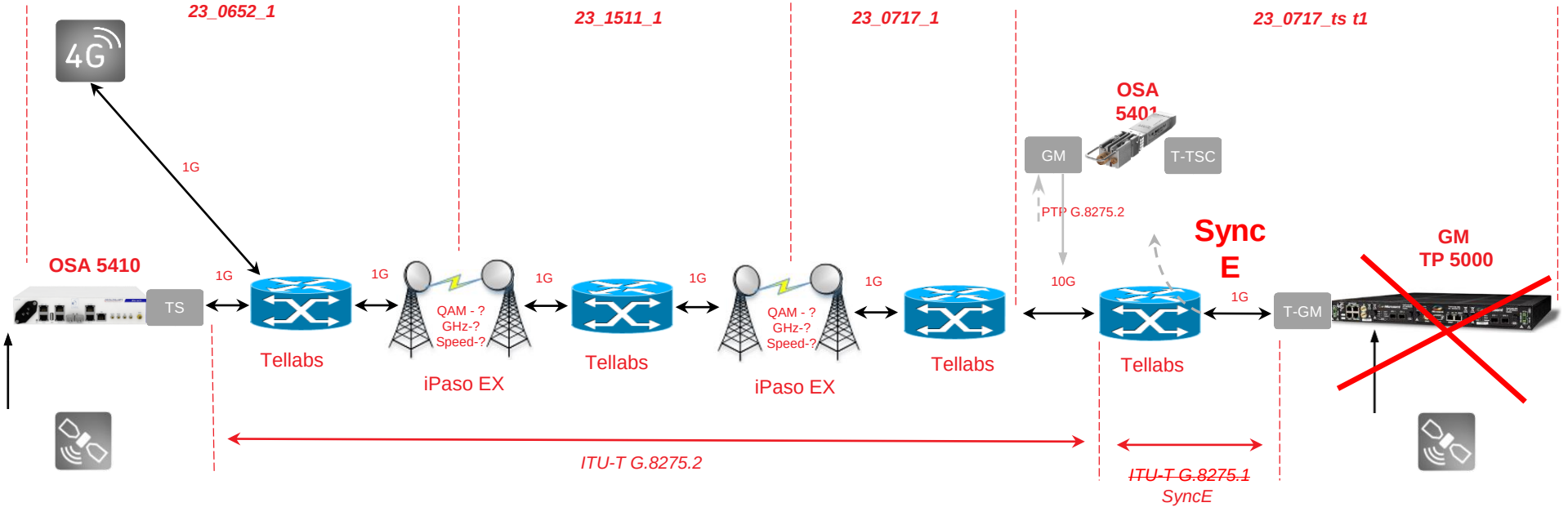
Clock Probe, Slave vs GNSS

Max absolute \|TE\| ≈ 695 ns

Scheme 5. Sync Fail Over Scenario (Holdover with Frequency Back Up)

- L2 PTP Multicast ITU-T G.8275.1 to L3 Unicast ITU-T G.8275.2 profile conversion

Whole PTP chain, 8 transport nodes

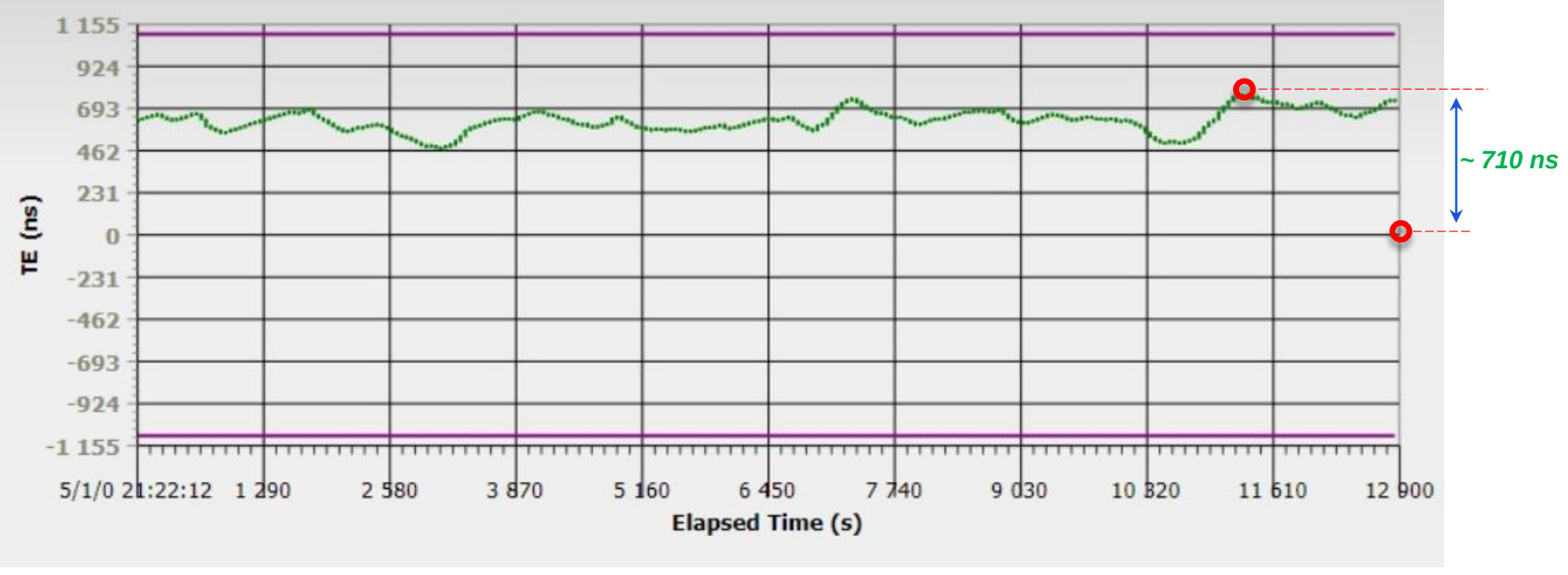


All NE (MBH+RRL) = 13 hops

Scheme 5. OSA 5410, TE result

Clock Probe, Slave vs GNSS

Max absolute |TE| ≈ 710 ns



Scheme 5. Results

- **OSA 5410** has been configured to measure TE and MTIE functions of the embedded TS vs GNSS ref. signal.

- max |TE| ≈ **710 ns is within** phase norms specified in G.8271.1 recommendation (***p.7.3 Network limits in reference point C***) ≤1.1µsec.

- MTIE result – **is within** norms specified in G.8271.1 recommendation (***p.7.3 Network limits in reference point C***, ***figure 7-2 – Dynamic time error network limit (MTIE)***).

- Two Way TE result should be additionally filtered as specified in ITU-T recommendation G.8271 (***p.7.3 Network limits in reference point C/7.3.2 Packet network limits for PTS/p.7.3.2.1***). Such packet selection cannot be applied by current SW of OSA 5410. Therefore is recommended to provide additional tests by equipment which support such feature (Calnex Sentinel).

➔ **TE test PASSED**

➔ **MTIE test PASSED**

System Verification Test aspects – SVT as we see for Sync

1. All new equipment GrandMasters must be tested in the fields before sync traffic in operation:

- Interoperability testing
- Traffic load
- Sync fail over

2. Indoor equipment (MGW, BSC, MBH and others) must check phase and frequency compatibility & Phase synchronization required:

- Example Test On: 1-Step, 2-Step Modes

3. After checking and testing for compliance with the requirements of the G.82XX recommendations, a so called Passport is created;

Conclusions, proved by test done:

There are fundamentally two strategies:

1. Place PTP Grandmasters sufficiently close to the base station without upgrading the network (e.g. keeping the G.8275.2 PTP profile for Partial Timing Support PTS).

2. Upgrade the whole network with G.8273.2 Boundary Clocks or G.8273.3 Transparent Clocks function in order to render it compatible with the G.8275.1 PTP profile for Full Timing Support (FTS), and place PTP Grandmasters at a hop distance in accordance with G.8271.1 (10 hops if T-BC and T-TC are of class A, 20 hops if they are of class B, confirm with tests)

Several protection schemes are possible, depending on the chosen strategy.

Thank you!

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