



WSTS

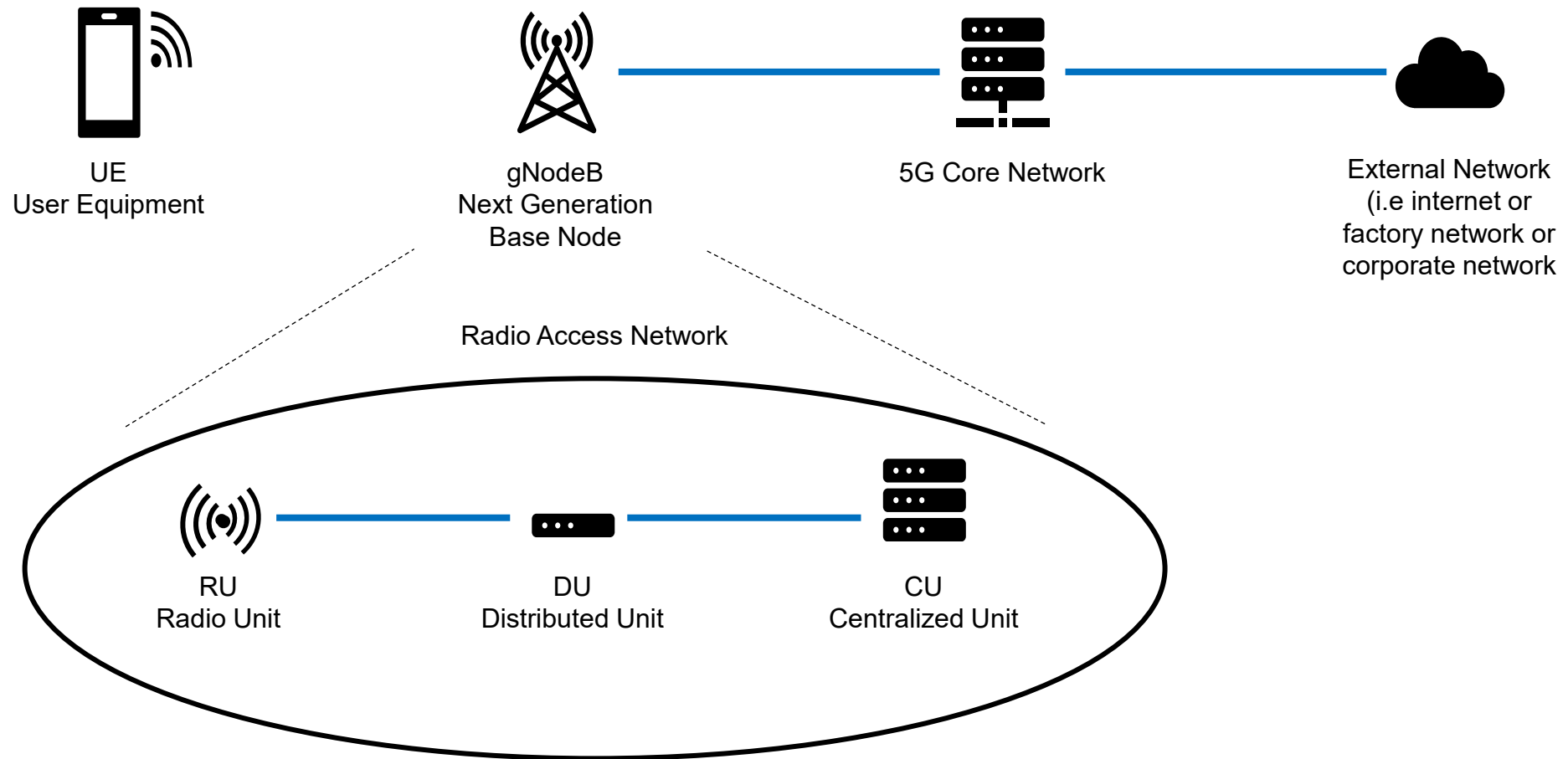
5G Radio Unit synchronization testing: from baseband to bits

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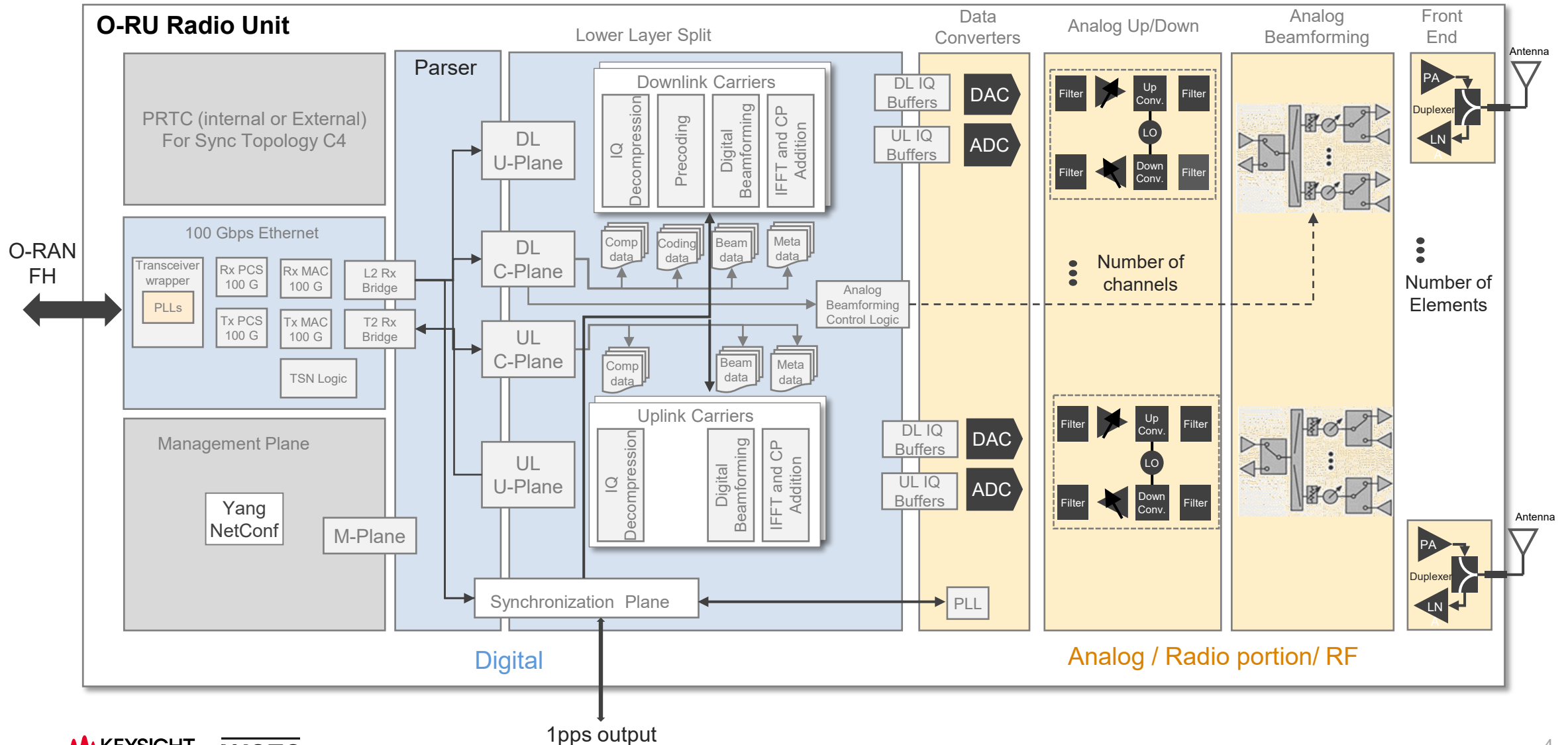
Agenda

- Brief 5G architecture
- Anatomy of an RU
- O-RAN defined tests
- Test Setup
- Exemplary test results
- Conclusion

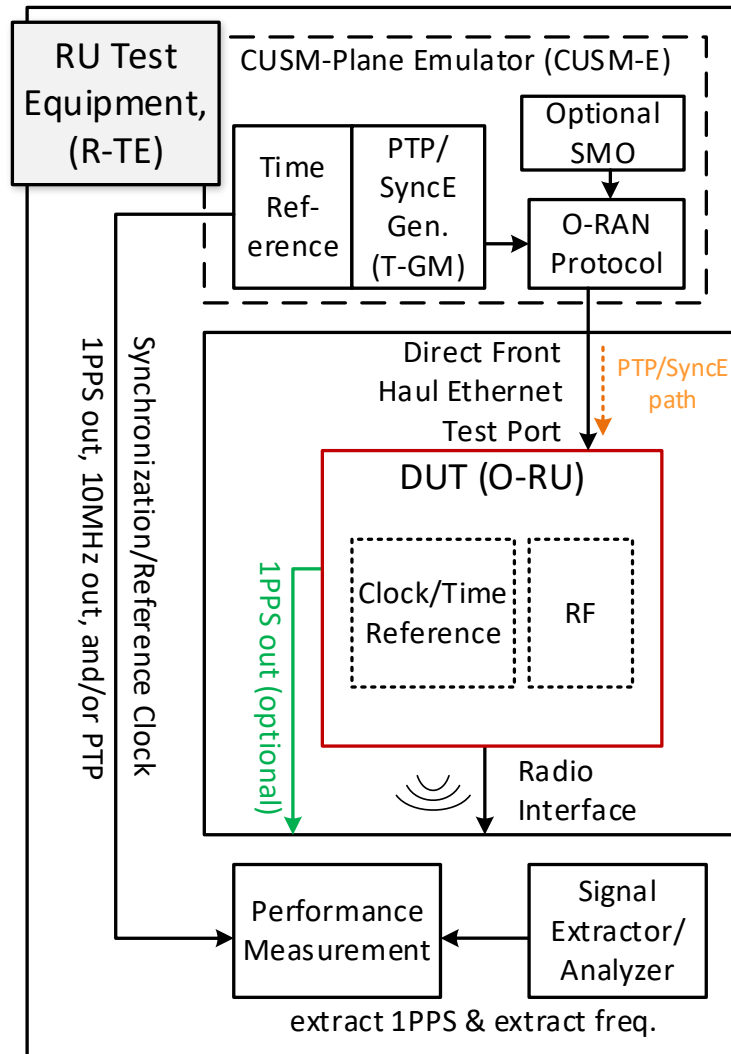
5G Architecture



Anatomy of a 5G Radio Unit (O-RU)



O-RAN WG4 S-plane Device Tests: Section 3.3



3.3 Synchronization test use cases, parameters and methodologies

3.3.2 Functional test of **O-RU** using ITU-T G.8275.1 PTP profile

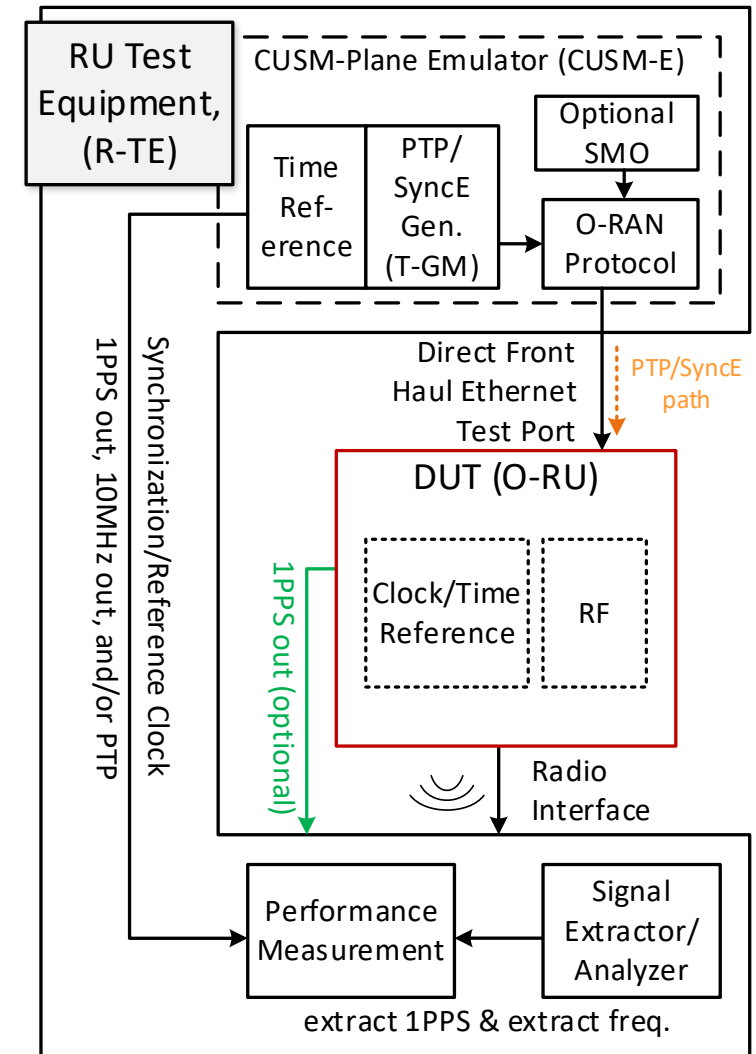
3.3.3 Performance test of **O-RU** using ITU-T G.8275.1 PTP profile

3.3.4 Performance test of **O-RU** using LLS-C4 [not yet defined]

O-RAN WG9 S-plane System Test Use Cases: Section 9.1

9.1 Synchronization test use cases, parameters and methodologies

- 9.1.1 Network Time Synchronization-LLS-C1 (Option-A)
- 9.1.2 Network Time Synchronization-LLS-C1 (Option-B) config: Scenario-1
- 9.1.3 Network Time Synchronization-LLS-C1 (Option-B) config: Scenario-2.
- 9.1.4 Network Time Synchronization-LLS-C1 (Option-C)
- 9.1.5 Network Time Synchronization-LLS-C2 (Option-A)
- 9.1.6 Network Time Synchronization-LLS-C2 (Option-B) config: Scenario-1
- 9.1.7 Network Time Synchronization-LLS-C2 (Option-B) config: Scenario-2
- 9.1.8 Network Time Synchronization-LLS-C2 (Option-B) config: (Fail-over: Scenario-1)
- 9.1.9 Network Time Synchronization-LLS-C2 (Option-B) config: (Fail-over: Scenario-2)
- 9.1.10 Network Time Synchronization-LLS-C2 (Option-B) config (Fail-over: Scenario-3)
- 9.1.11 Network Time Synchronization-LLS-C2 (Option-B) config (Time Error with Traffic)
- 9.1.12 Network Time Synchronization-LLS-C2 (Option-B) config (SyncE network wander limit for chain of EEC and eEEEC clock)
- 9.1.13 Network Time Synchronization-LLS-C2 (Option-B) config: (1PPS TE on O-RU)
- 9.1.14 Network Time Synchronization-LLS-C3 (Option-A)
- 9.1.15 Network Time Synchronization-LLS-C3 (Option-B)
- 9.1.16 Network Time Synchronization-LLS-C3 (Option-B) config: (Time Error with Traffic)
- 9.1.17 Network Time Synchronization-LLS-C3 (Option-B) config: (PTP Holdover test)
- 9.1.18 Network Time Synchronization-LLS-C3 (Option-B) config: (PTP Fail-over/redundancy)
- 9.1.19 Network Time Synchronization-LLS-C3 (Option-C)



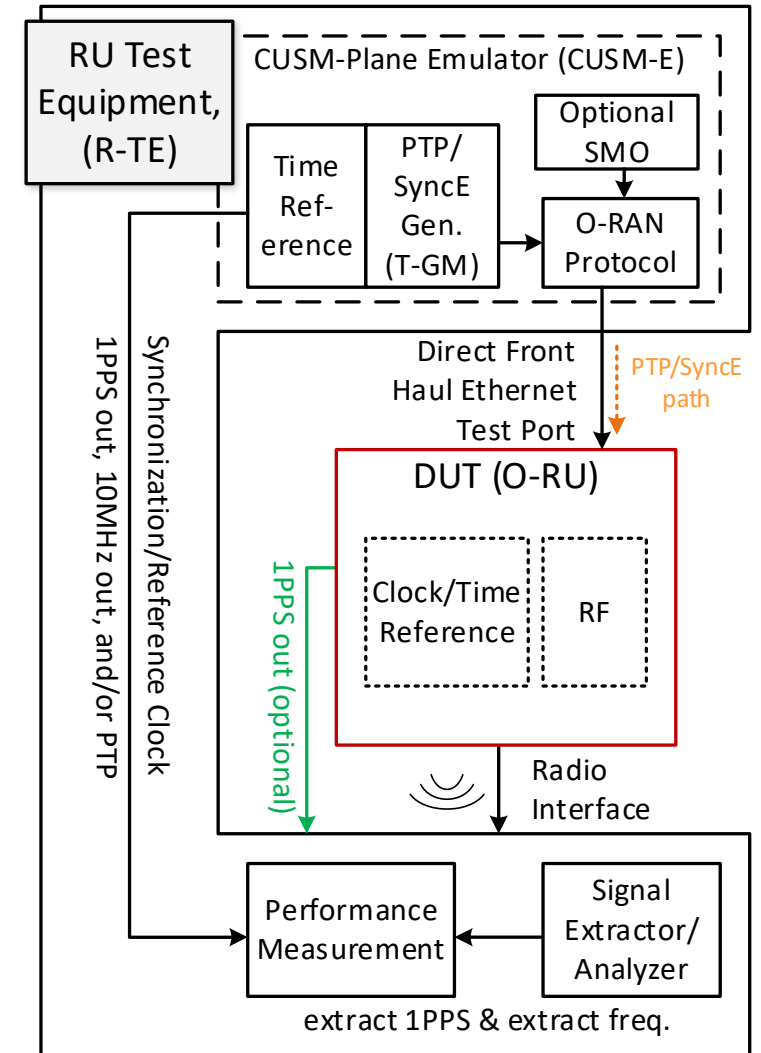
O-RAN WG9 S-plane Test Use Cases: Sections 9.2 & 9.3

9.2 SyncE performance per G.8262.1 clock specifications

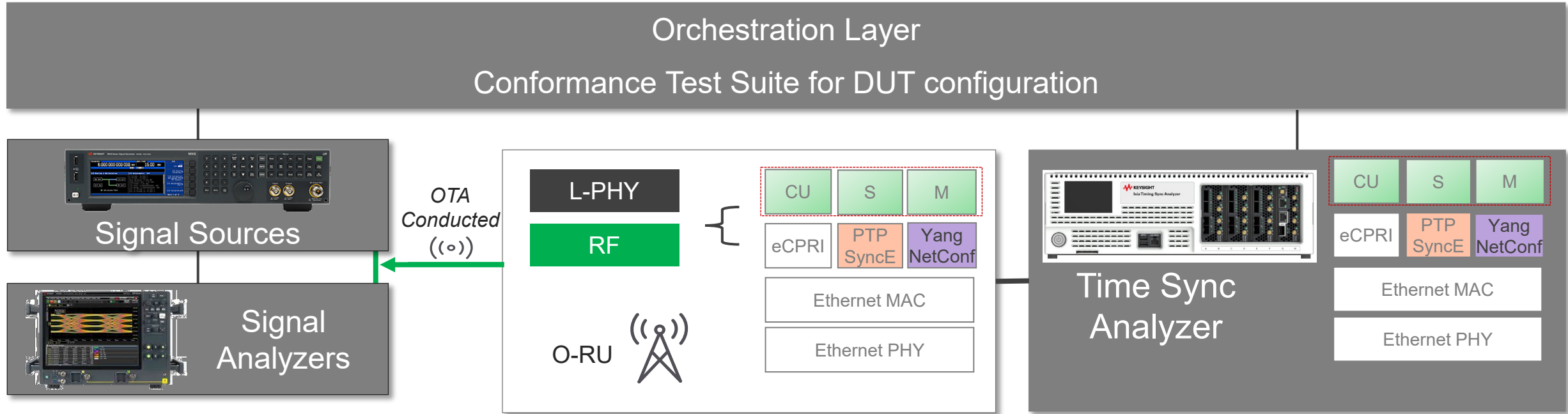
- 9.2.1 Pull-in/Hold-in/Pull-out Limits
- 9.2.2 Wander Generation Limit for eEEEC Clock
- 9.2.3 Wander Tolerance Test for eEEEC Clock
- 9.2.4 Frequency Holdover Limits as per G.8262 eEEEC Clock
- 9.2.5 Short-term phase-transients

9.3 PTP performance as per G.8273.2 clock specifications

- 9.3.1 Time Noise Generation Performance
- 9.3.2 Time Noise Tolerance Performance Test
- 9.3.3 Time Holdover Performance Test



Exemplary O-RU S-plane Performance Test Topology



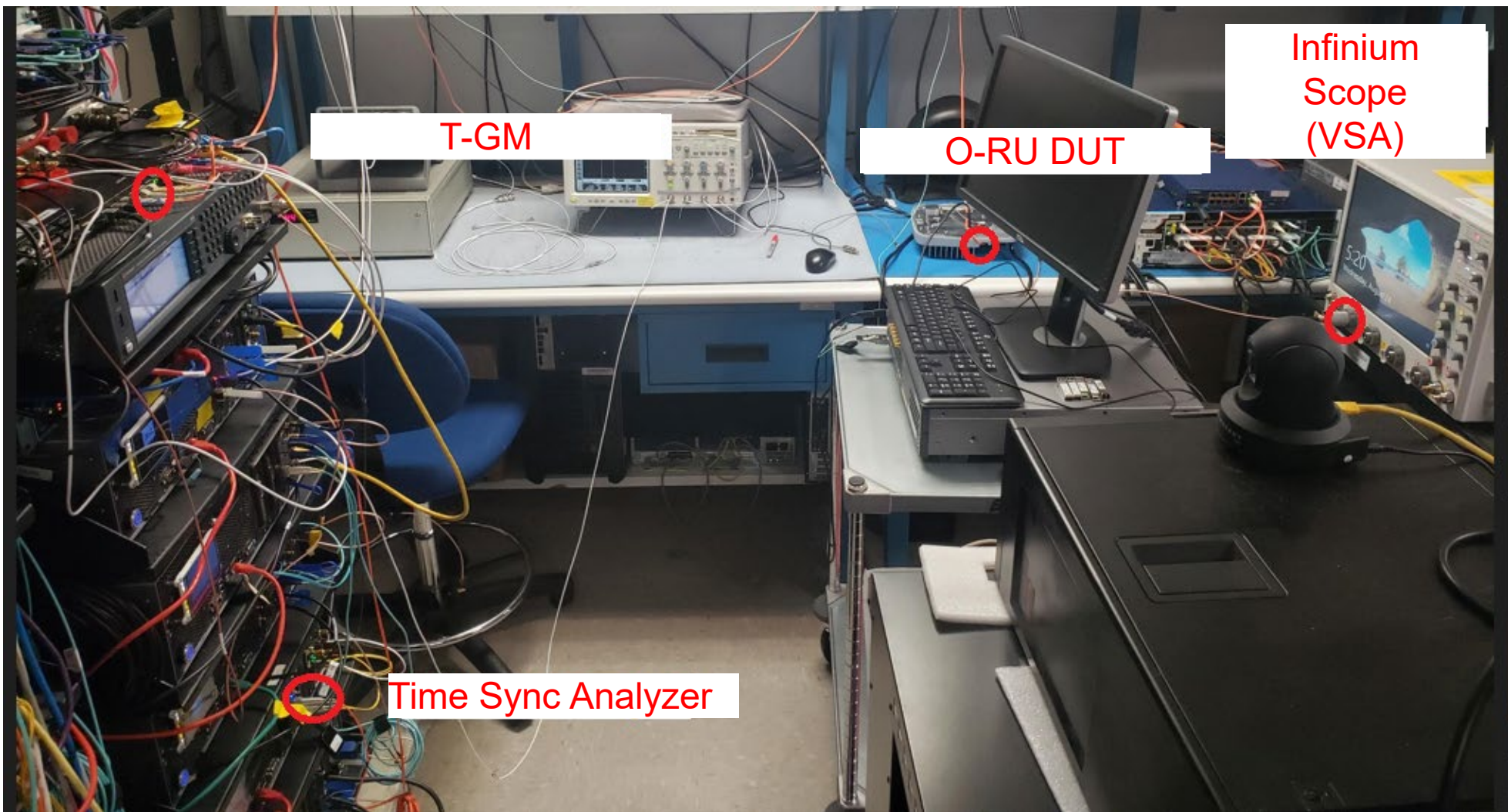
Performance Test for 3.3.3

- DU emulator with built in T-GM providing CU, S, and M plane traffic
- Impairments adds PDV, time wander, or packet drops as required
- Signal Analyzers & Sources enable evaluation of RF timing

T-GM providing reference clock

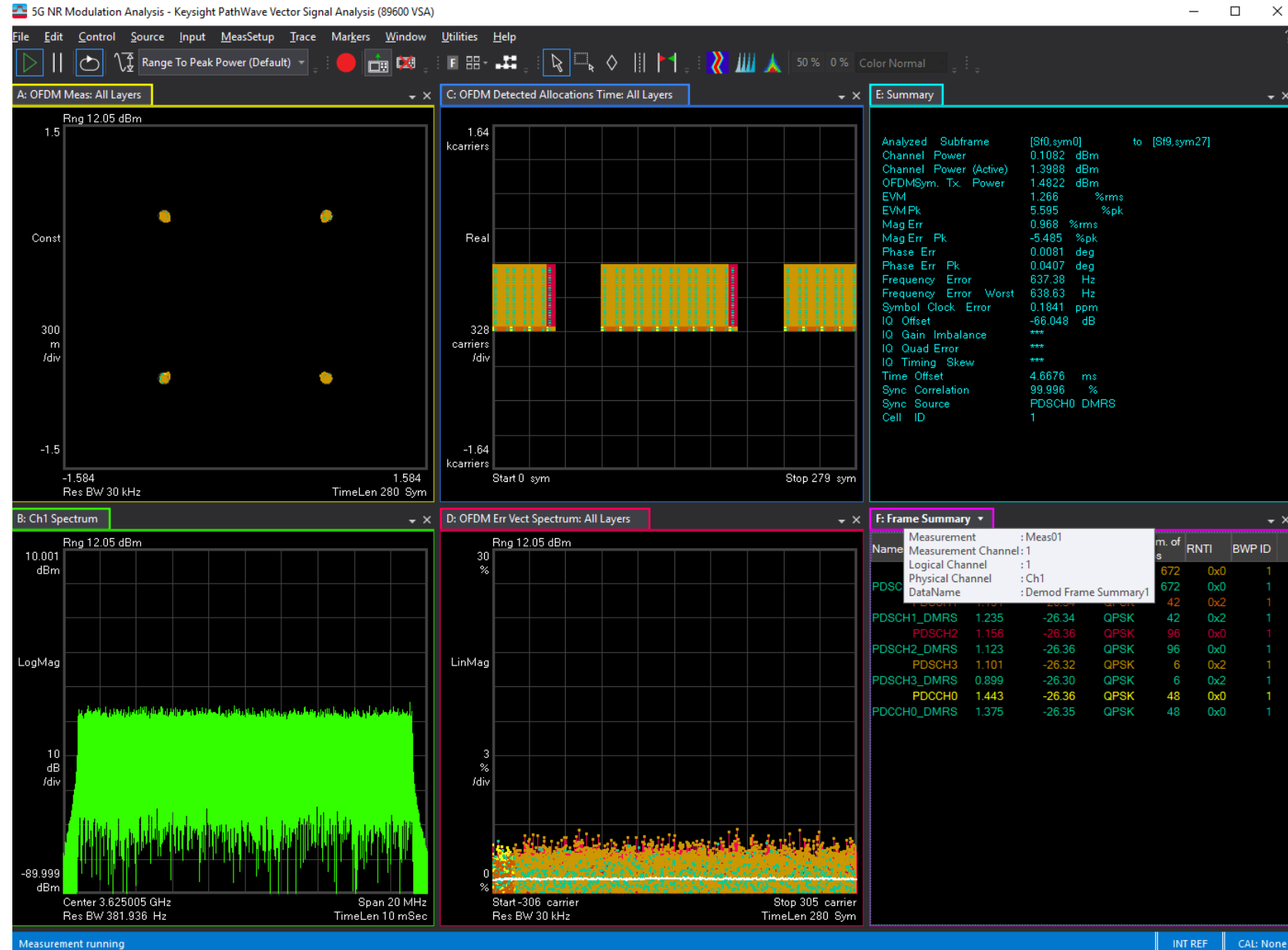
Clock: PTP or 1PPS / ToD

Lab setup



VSA output showing 5G frame timing offset

- VSA is syntonized to GM
- Trigger input from TSA provides expected frame start time
- VSA demodulates and decodes 5G frame
- Start of frame is detected and offset compared to trigger
- Frequency is compared against reference frequency



Sample WG4 3.3.3 test stimulus and results for a real RU

- Wander gen config (top left)
- Wander stimulus (bottom left)
- Time Error results for RU (top right)
- Frequency Error results for RU (bottom right)

Constant Time Error (cTE)

-710 ns

G.8275.1 Noise Pattern

Stop Noise Pattern

Dynamic Time Error Frequency

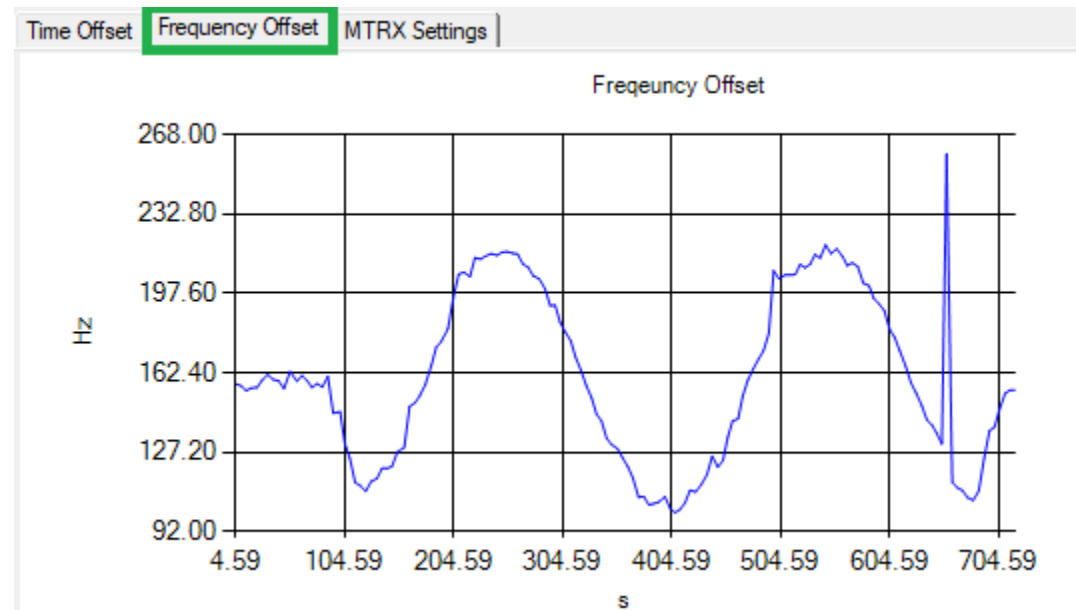
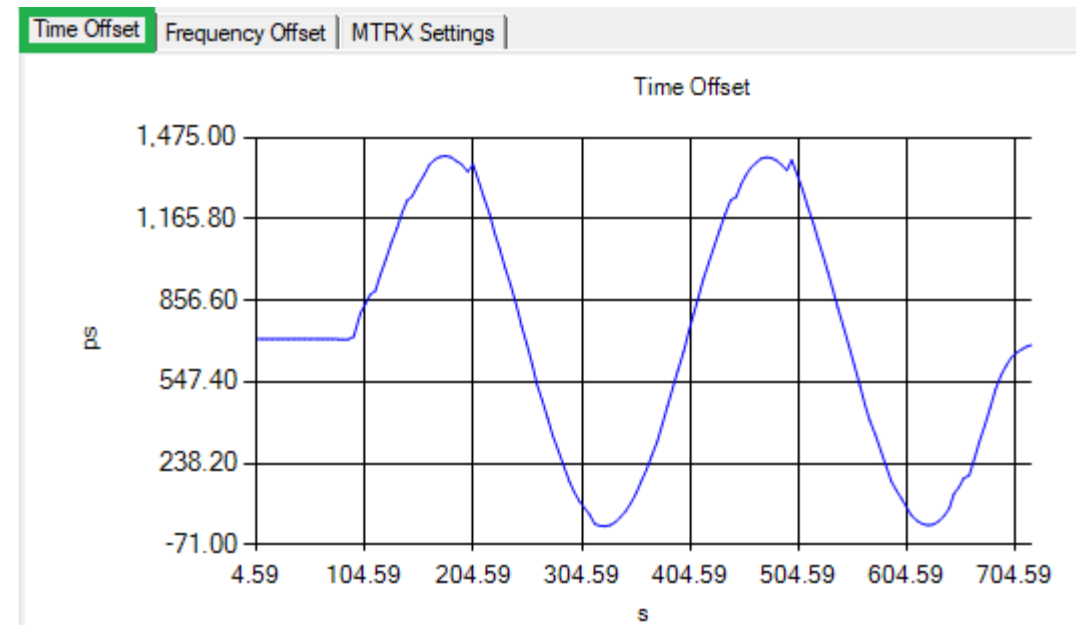
0.003362 Hz

Dynamic Time Error Amplitude

-710 ns

Dynamic Time Error Duration

600 s



Conclusion

- An O-RU requires accurate time synchronization due to interactions with RF signals from other radio units
- To validate that the O-RU meets the stringent requirements, ORAN WG4 & WG9 defined standardized tests
- Testing an O-RU requires a test system supporting both Ethernet & RF testing including both S-plane as well as CU-plane data
- Orchestration layer coordinating the test steps across the different equipment enables automation
- Results enable analysis to determine if the O-RU is conformant



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DU Emulators



S-Plane Testers



Oscilloscopes



5G Protocol Analyzers



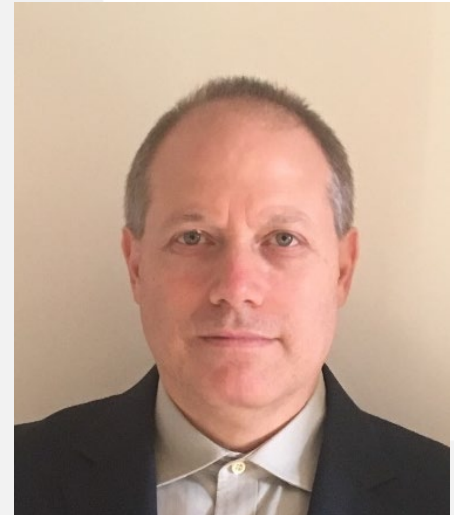
GNSS Emulators



Network Impairment Emulators

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Questions?



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Thank you