Calnex **Sentinel**

4G and 5G OTA / 1pps / 10G / 1G / 100M

Calnex
Insight and Innovation

The dedicated synchronization tester

Now with 5G Over-the-Air measurements

- Verify Phase, Time and Frequency synchronization
- Monitor performance and diagnose synchronization issues on 3G/4G/5G Mobile, Datacenter, Financial, Power and other Telecoms networks

PERFORMANCE AT-A-GLANCE

Sentinel provides a comprehensive measurement suite including:

- Time Error (TE)
- Time Interval Error (TIE)
- MTIE
- TDEV
- ESMC Quality Levels
- 2wayTE
- Dynamic Time error
- High and low pass filtered 2wayTE
- Packet Selected 2WayTE
- SyncE wander
- Packet Delay Variation (PDV)
- Floor Packet Percentage (FPP)
- Frequency Error

Flexible network connection options:

- As a pseudo T-TSC to measure upstream network synchronization
- As a network monitor measuring live network PDV and TE

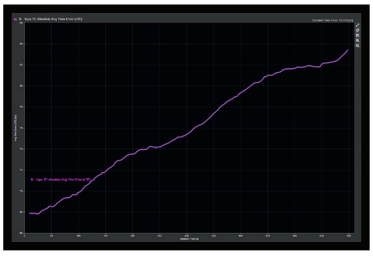
Clear Pass/Fail Metrics for easy analysis:

- ITU-T specified masks
- ITU-T, standards-based, vendor-specific limits
- Detailed measurement report in pdf format

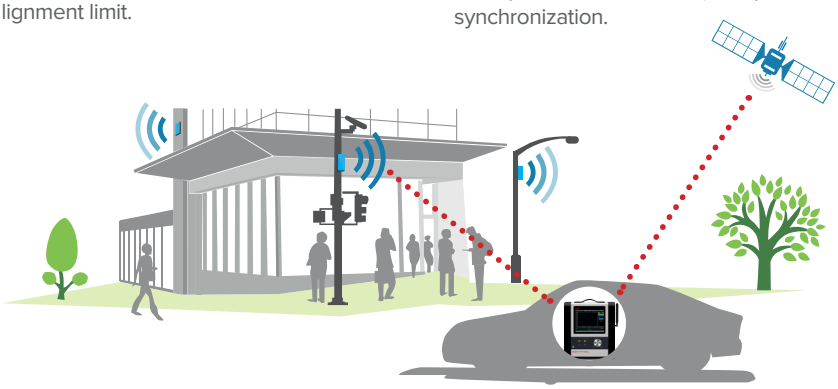
Test Over-the-Air synchronization in 4G and 5G mobile networks

How do you know if your Small Cells conform to 3GPP standards? With TDD and FDD systems implementing newer LTE features such as eICIC and CoMP, measuring the sync accuracy of a Small Cell/eNodeB is crucial. It's also quite a challenge, particularly when these network devices often lack a physical 1 pps output.

However, with Sentinel's non-invasive OTA test capability you can now measure, with precision, the Time Error between eNodeBs or gNodeBs and UTS to ensure they meet the 3GPP's ≤3 µs phase alignment limit.

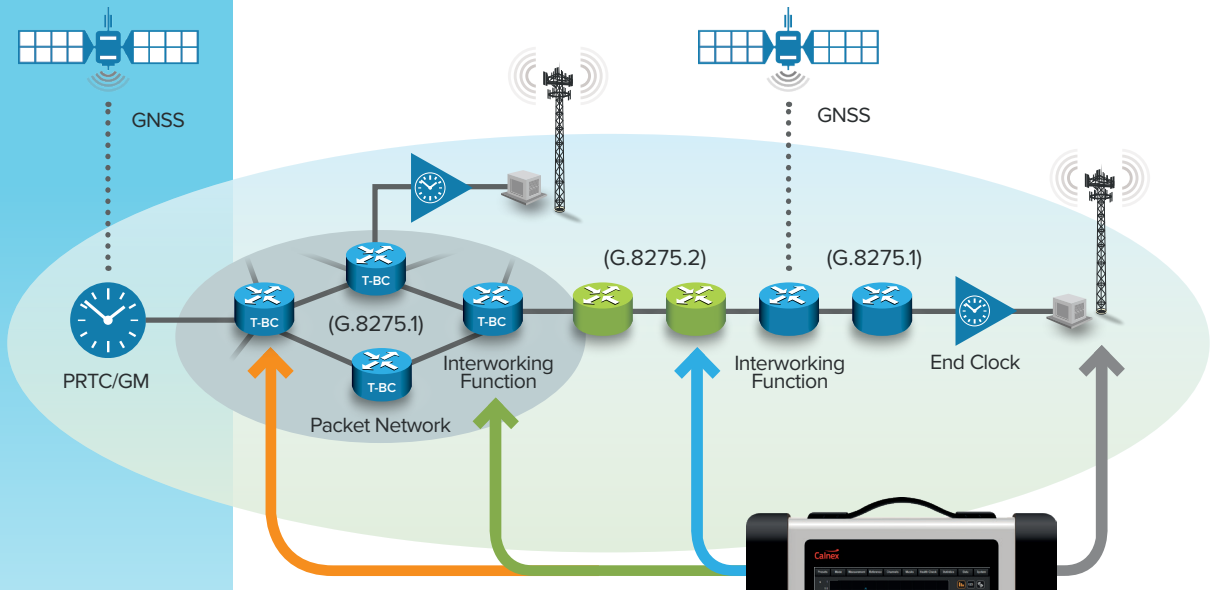


Evaluate OTA measurements using the CAT for detailed insight into static and dynamic time and frequency synchronization.



Test 3G/4G/5G and Small Cell deployments at various points in the network, including near to the GrandMaster (GM), and validate network performance to ITU-T limits.

Deliver the fast, stable services your customers can rely on



Easily test the performance of your network's synchronization. Sentinel captures all data simultaneously enabling you to correlate timing performance at different points in the network, even between different timing architectures.

- PTP 2WayTE, SyncE, 1 pps TE
- 1 pps TE
- PTP pktSelected2wayTE, 1 pps TE
- Over-the-Air, TE

Use Sentinel to make long-duration, unattended measurements to identify slow variations in timing or sporadic transient behaviors.

Measurements are graphed in real time allowing you to easily check the status of an ongoing measurement, and gives you confidence of the measurement integrity before you commit to a long term test.

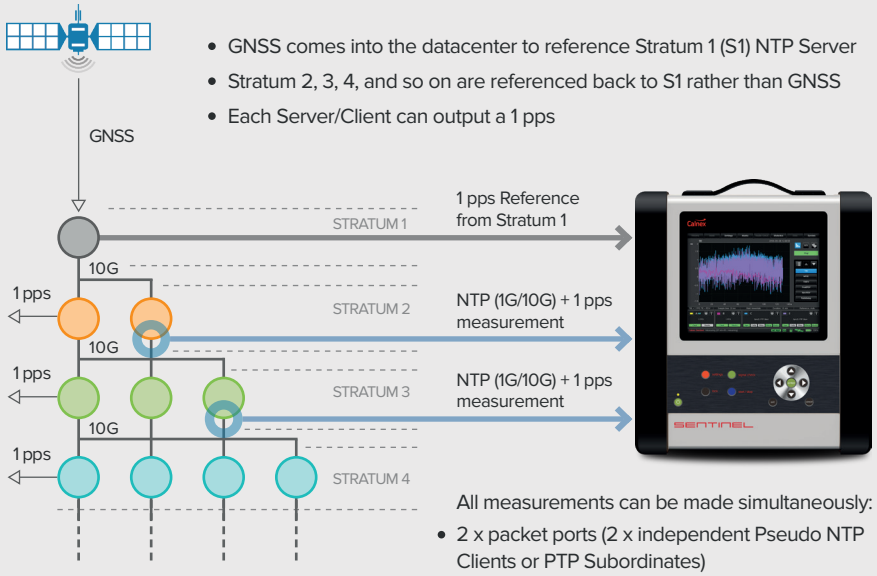
Test PTP and NTP synchronization in datacenters

Time synchronization is not new in datacenters but the required accuracy is increasing. This is being driven by higher throughput, the need for lower latency, the movement of storage and computation to the network edge, and regulatory and standards body requirements.

While NTP was traditionally sufficient to maintain millisecond level synchronization, the need for synchronization to 100s or 10s of microseconds, and sometimes even tighter, is now required.

Sentinel allows you to easily and thoroughly verify and monitor the synchronization within your datacenter, and prove time/phase accuracy with microsecond precision.

What's more, Sentinel's holdover performance and transport mode allows you to move around your facility and test synchronization without having to maintain a reference GNSS or 1 pps signal. This makes Sentinel an indispensable tester for deployment, troubleshooting and network maintenance.

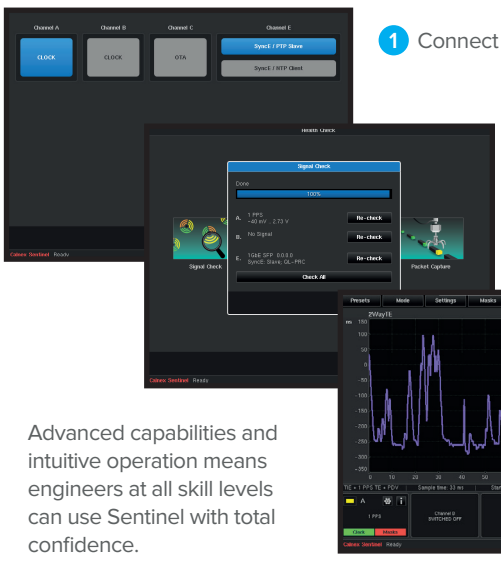


- GNSS comes into the datacenter to reference Stratum 1 (S1) NTP Server
- Stratum 2, 3, 4, and so on are referenced back to S1 rather than GNSS
- Each Server/Client can output a 1 pps

All measurements can be made simultaneously:

- 2 x packet ports (2 x independent Pseudo NTP Clients or PTP Subordinates)
- 4 x clock ports

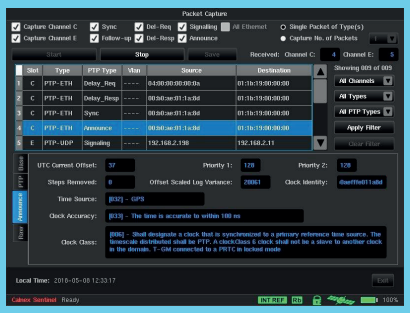
Whatever your application, start testing in 3 easy steps



1. Connect to the network
2. Run 'Health Check' to auto-discover connections and check PTP protocol compliance
3. Start all measurements at the same time

Advanced capabilities and intuitive operation means engineers at all skill levels can use Sentinel with total confidence.

For detailed PTP Protocol Analysis, download data to Sentinel's on-board Packet Capture feature or by downloading data to the PTP Field Verifier (PFV) software.



Packet Capture and Decode

Capture and decode Signaling, Sync, Del-Req, Del-Resp and Announce messages to help identify:

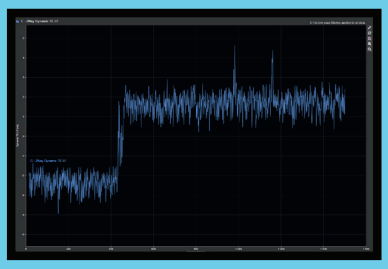
- **Configuration issues – such as mismatch domain number configured for Master Clock and Subordinate Clock**
- **Protocol Implementation issues – such as the log interval of Del-Resp does not reflect the real packet rate as expected in multicast mode**
- **Protocol Signaling issues – such as signaling messages do not repeat after the negotiated contract period**
- **Capture and decode Announce messages – provides detailed information about the PTP GM which is fundamental to build up the Master-Subordinate clock hierarchy**

PTP Field Verifier

Analyze PTP protocol for conformance to standards or user-defined profiles.

- **Automatic Pass/Fail indication – check captured PTP messages against a pre-defined set of rules, with clear Pass/Fail alerts**
- **Check transmitted PTP messages for compliance with ITU-T, IEEE and user-defined standards and rules – areas of non-conformance immediately visible**
- **Flexible XML rules allow full customization of pass criteria**
- **Full report generation capability**

Use the CAT for a clearer picture ...

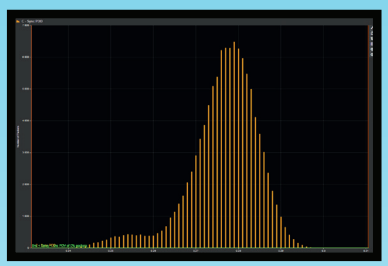


LTE-A/TDD LTE

- PTP/1 pps MaxTEI
- PTP/1 pps dTE
- pktSelected2wayTE (APTS/PTS)

LTE-FDD/3G

- PDV FPP
- 16 ppb frequency wander
- MTIE/TDEV

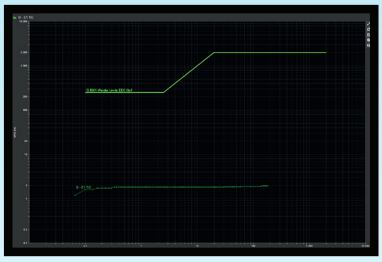


Financial/Power Networks

- NTP PDV distribution
- NTP 2wayTE

SyncE

- E1/T1 wander
- MTIE/TDEV
- ESMC



TDM/Legacy

- E1/T1 wander
- MTIE/TDEV
- SSM

Get greater measurement insight with the Calnex Analysis Tool (CAT)

The CAT provides powerful insight into network and device performance. All your measurement results are now in one place, and you can view multiple graphs simultaneously for easier correlation of your results.

Enhanced graphics makes it easy to evaluate ITU-T metrics such as Time Error (cTE, dTE), MTIE and TDEV against ITU-T masks. While the customizable multi-graph window lets you rapidly select measurements and channels for detailed analysis.

CAT also provides one button generation of reports in PDF format including Pass/Fail statistics and details of failures. This allows you to share captures and results with vendors for fast, efficient and accurate troubleshooting.

Lab quality performance in an easy-to-use, portable package

No test port?
Use OTA measurements

Perform synchronization tests without physical connection to the network.

- 4G LTE-A
- 5G NR

No GNSS signal?
Use internal high-stability Rubidium (Rb) clock

Sentinel's built-in Rb clock is both highly stable and precise. Once disciplined, it has exceptional holdover performance allowing you to get to where you need to be and to make accurate measurements even when no reference 1 pps or satellite signal is available.

Problem in the network?
Use Capture and Replay

Measure the network and send measurements back to the lab/vendor to replay and fix issues. Data can be transferred from Sentinel via a memory stick or via ftp to a remote PC. Plus, you can ftp results from ongoing measurements.

Actual network performance can also be downloaded to the Calnex Paragon to test individual network components.

Ordering Information

Calnex Sentinel Sync Analyzer with built-in GNSS receiver. Needs minimum of one measurement option (module/port).

Included with shipment: Calnex Analysis Tool (CAT), GNSS antenna, antenna cable (20 m), hard transport case, user manual on USB, line power cord, 1-year warranty and support.

Configurable Options

- Option 610: Clock module 1 pps/E1/T1, any clock from 0.5 Hz up to 200 MHz with 0.5 Hz step. (maximum two per instrument)
- Option 615: 100M/1G packet port (PTP/NTP/SyncE). Can order maximum of 2 x Opt. 615. Includes SyncE/ESMC analysis for 100M/1G optical and electrical rates. (maximum two – Opt. 615 and/or 616 per instrument)
- Option 616: 100M/1G/10G packet port (PTP/NTP/SyncE). Can order maximum of 2 x Opt. 616. Includes SyncE/ESMC analysis or 100M/1G/10G optical and electrical rates. (maximum two – Opt. 615 and/or 616 per instrument)
- Option 705: Over-the-Air (OTA) Time Error measurement module (maximum one per instrument)

Additional Options

- Option 620: PTP and NTP PDV measurement software (one license per instrument).
- Option 630: Internal battery backup for Rubidium.
- Option 812: One year extension of product warranty.
- Option 813: Two years extension of product warranty.

Optional Accessories

- Option 75: 120 Ω balanced RJ45 to 75 Ω unbalanced BNC impedance converter (balun).
- Option 133: External 1 pps/ToD/frequency converter accessory.
- Option 511: Carry-on bag.

Related Products

Tempo

- **Provides canned tests for quick testing**
- **Test PTP, SyncE and legacy networks**
- **Verify Ethernet performance in either loop-back or peer-to-peer mode**
- **Simulate realistic traffic conditions**
- **Rugged and lightweight (< 2 kg)**

Calnex Paragon-X

- **Test PTP (1588), SyncE, NTP, CES and OAM up to 10GbE**
- **Stress-test equipment with real network profiles from field tests to debug network issues**
- **Complete standards compliance testing to ITU-T G.826x/827x**
- **Test PTP Ordinary Clocks, Boundary Clocks and Transparent Clocks**

Calnex Paragon-neo

- **Industry-leading Time Error solution delivering sub-nanosecond accuracy – essential for validating new, high accuracy 5G network devices.**
- **Addresses all 5G and ORAN Enhanced Time requirements at rates up to 400GbE.**
- **Capture and decode PTP packets for analysis and Time Error testing**
- **Prove SyncE jitter and wander performance to ITU-T G.8262.1/G.8262**
- **Evaluate MTIE/TDEV pass/fail results to ITU-T G.8262.1/G.8262 masks**
- **Control ESMC (SSM) message generation for testing to ITU-T G.8264**

Specifications

Metrics and Masks

Test Modes

Masks or test limits can be applied to TE, 2wayTE, pktSelected 2wayTE, 2wayTEL, 2wayTEH, TIE, MTIE, and TDEV graphs
PRC/SSU/SEC: Masks for G.811/G.812/G.813-clocks (ETSI 300 462-3).
Networks: According to G.823/G.824/G.8261/G.8261.1/G.8271.1/G.8271.2
SyncE: According to G.8261, G.8262
ANSI-standard: DS1 and OC-N masks.

Graph Display

Display modes: TE, 2wayTE, pktSelected 2wayTE, TIE, MTIE, TDEV, Path Delay, PDV, 2wayTEL, 2wayTEH, Distribution of PDV
Selected PDV, Floor Packet Percentage, Maximum Average Frequency Error
Number of Graphs: Up to 6 graphs of the same type can be over-laid on screen. Color coded.
Masks on Screen: Up to 6 MTIE and TDEV masks according to selected test mode. Pass/Fail result available for each mask.

Clock Module Specifications

Pre-defined Signal/Clock Types

- 1 pps (PTP Subordinate recovered clock).
- 8 kHz (frame clock).
- 64 kHz/64 kb/s (E0/DS0).
- 1.544 MHz/1.544 Mb/s (T1/DS1 clock/data).
- 2.048 MHz/2.048 Mb/s (E1 clock/data).
- 5 MHz/10 MHz (frequency reference).
- 25 MHz/125 MHz/156.25 MHz (SyncE clock rate).
- 34 Mb/s (E3), 45 Mb/s (DS3).
- 155.52 MHz/155 Mb/s (STM-1/STS-3 clock/data).

User-defined Clock Types

From 0.5 Hz to 200 MHz in 0.5 Hz steps. Note: symmetrical, unipolar clock signals.

Measurement Ports

Number of Ports: 2 per module.
Connector: BNC.
Impedance: 75 Ω, VSWR <2:1 or 1 MΩ.
Voltage Range: ±5.00 V.
Sensitivity: min input voltage 60 mVpp, Signal Check voltages are for indication only.
Signal Type: Symmetrical pulse (clock signal); Unsymmetrical repetitive pulse (clock signal);
HDB3-coded data (data signal); AMI B8ZS, B3ZS (data signal).
1 pps: Constant TE measurement accuracy with reference to GNSS ±75 ns.

Ethernet Specifications

Synchronous Ethernet

SyncE clock measurement.
Conformance to G.8261 masks (MTIE/TDEV).
Extract and graph ESMC message (SSM).
Generate and change ESMC.

PTP (1588) and NTP

Network 2-way TE, Forward (Sync) PDV, Reverse (DelReq) PDV and Network Delay.
Raw PDV (*vs* time and distribution graphs).
Selected Packet PDV (*vs* time and distribution graphs).
Cluster/band packet selection.
Pseudo-Subordinate Clock Mode or Monitor Mode.
1 ns resolution timestamp.
Captured PDVs can be replayed on Calnex Paragon-X for troubleshooting.

PTP (1588): Layer 2 Multicast and Layer 3 (UDP/IPv4, UDP/IPv6) Multicast/Unicast.
NTP: Layer 3 (UDP/IPv4/IPv6) Multicast/Unicast.

Measurement Ports

Number of Ports: Maximum of 2.
Connector: RJ45 for 10/100/1000 Base-T, SFP/SFP+ for 100M/1G/10G Optical (SFP/SFP+ not supplied).

Accuracy

PTP/NTP constant TE measurement accuracy with reference to GNSS ±75 ns.

OTA Module Specifications

Measurement Accuracy ±100 ns.
Maximum input power -20 dBm.
Operating Frequencies Up to 6 GHz.
NR and LTE Bands TDD and FDD.

Platform Specifications

Reference Clock Built-in Rubidium reference or external reference input 1 MHz, 5 MHz or 10 MHz.
Internal Data Storage Up to 32G.
External Data Storage USB memory stick.
Start/Stop Via START/STOP key.
Signal Check Parameters Signal type (Clock, Data or Unknown); Frequency (for clock signals); Pulse width (for data signals).
Display Color TFT, 8.4”, 800 x 600 pixels, resistive touchscreen.

Specifications

Platform Specifications (continued)

	Internal Rb Clock
Stability	Output frequency accuracy (7 mins to warmup): 1×10^{-9} Ageing (1 day): $<1 \times 10^{-12}$ Ageing (1 year): $<5 \times 10^{-10}$
	GNSS-disciplining
Built-in GNSS Module	12 channels, TRAIM GNSS receiver, high sensitivity. GPS, GLONAS, Beidou, Galileo.
Time Accuracy	±15 ns at 1σ after 24 hours lock.
Frequency Accuracy	2×10^{-12} averaged over 24 hours.
GNSS Disciplining Modes	Always disciplining, always in holdover, disciplining only between measurements. Requires 6 hours discipling if disconnected from GNSS for <1 week; 12 hours if >1 week. Requires 1 hour disciplining if using Cs quality 1 pps (from any state).
	External References
Frequency Reference Input (std)	Input Frequency: 10 MHz, 5 MHz. Voltage Range: 0.1 Vrms to 5 Vrms. Impedance: Approx. 50 Ω.
External 1 pps Timing Input	Voltage Range: 0 V to 0.8 V (Low), 2 V to 3.3 V (High) into 50 Ω. Required Accuracy: ±100 ns to UTC.
GNSS Timing Reference	Antenna Input: N-type connector. DC-feed: +5 V on center pin to active GNSS antenna.
	Output References
Reference Frequency Output	Reference Frequency: 10 MHz sine-wave. Output Levels: 1 Vrms in 50 Ω. Impedance: Approx. 50 Ω.
1 pps Output	Source: Internal Rubidium oscillator. Output Logic Levels: TTL levels in 50 Ω.
E1/T1 Output	Connector: Clock: BNC. Data: Isolated BNC. Frequency: 2.048/1.544 MHz, 2.048/1.544 Mb/s. Output Level: Accurate to G.703 ±1.2 V ±10% in 75 Ω.
	Interfaces
USB Device Port	Connector: Std USB type B. USB Version: 2.0
USB Host Port	Connector: Std USB type A. Maximum Supply Current: 400 mA. USB Version: 2.0
Ethernet	Communication Port: RJ45, 10/100 Base-T. Protocol: DHCP, FTP, VNC.
Remote Operation	Remote operation via VNC. Event Log: On screen log of measurement start/stop, duration, alarms, loss of data, loss of communication link, etc. Log can be saved as text file. Report Generation: Printable, custom-designed measurement report in pdf format. Security: Password secured access.
	Environmental Data
Operating Temperature	0°C to 40°C. (30°C when charging Rb backup-battery.)
Storage	Temperature from 0 to 50°C and Humidity up to 90% non-condensing.
Safety	EN 61010-1: 2010.
EMC	EN 61326: 2013.
Power Supply	Line Voltage: 100 to 240 Vrms ±10%, 50 Hz to 60 Hz, <100 W.
Optional Battery Backup	3 hours autonomy for Rubidium only to maintain internal timebase accuracy during transport mode.
	Mechanical Data
	Fold-out stand. Ruggedized casing.
Dimensions (w x h x d)	320 x 388 x 126 mm (12.6” x 15.3” x 5”).
Weight	Net <7 kg (15 lb); Shipping with transport case <16 kg (35 lb). Weights are approximations based on varying configurations.

Specification is subject to change without notice.

Calnex Solutions is a global leader in Test and Measurement solutions for next-generation telecom networks. For more information on the Calnex test equipment, and to take advantage of Calnex's extensive experience in Packet Sync and OAM testing technologies, contact Calnex Solutions today:

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