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VIAVI Solutions

TIMING and SYNCHRONIZATION

Vital for 5G-NR TDD Network Success

NEW USE CASES

5G Enables the Flexibility to Support:

- **High Throughput** – Enhanced Mobile Broadband (eMBB)
- **Low Latency** – Ultra Reliable Low Latency Communications (URLLC)
- **High Connection Density** – Massive Device Capacity
- **Stringent, Demanding Synchronization**

THE CHALLENGES

5G is a Brave New World of Complexity with Much Stricter Requirements

Per ITU-T standards recommendation, both 5G-NR TDD and LTE-TDD networks need to be phase synchronized to limit the end-to-end time error to under 1.5µs.

5G End-to-End Synchronization Use Cases

Industrial Automation: Predictive Maintenance, Strong Data Security, Public Network

Event Solutions: Drone Security, 3D Tracking, Multi-Camera Live Stream

Automotive Solutions: 3D Location, Cloud Services, Telemetrics

Healthcare Solutions: Online Consultations, Medical Data Management, VR/AR Training

Timing and Synchronization Plays a Critical Role in Varied Network Configurations and Features

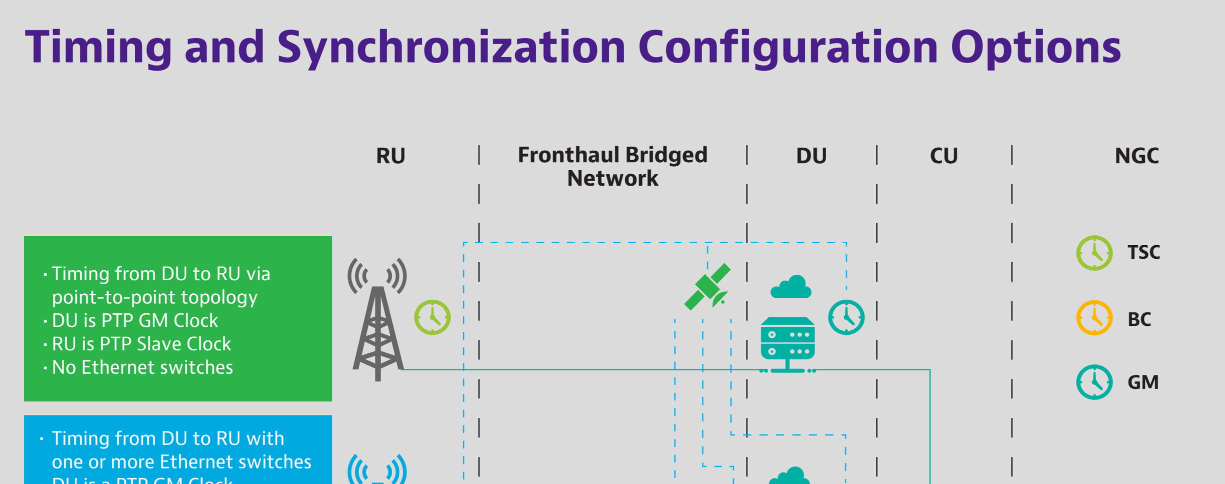
Frame Sync	LTE/ 5G-NR TDD	Slot Frame Coordination with Adjacent LTE or 5G	Signal Drift between Adjacent Cells	Poor Cell Performance (Capacity, Throughput, etc.).
Time Sync	LTE/ 5G-NR /CoMP/OTDOA	<1µs Relative OTA	RF Signal Coordination	Location Accuracy, Spectral Efficiency
Time Sync	LTE/ 5G-NR TDD/ eCIC	~1.5µs Absolute	Interference Management/ Coordination	Poor Performance, (Interference, Capacity, etc.)
Time Sync	LTE/ 5G-NR/eMBMS/CA	~3-5µs Absolute	Video Decoding Carrier Aggregation	Poor Video Quality and CA Failure, Low Throughput
Time Sync	LTE/ 5G-NR FDD	~10µs Absolute	Time Slot Alignment	Accessibility and Retainability

Frequency Synchronization = 500ppb Absolute

Stringent Synchronization: More ↔ Less

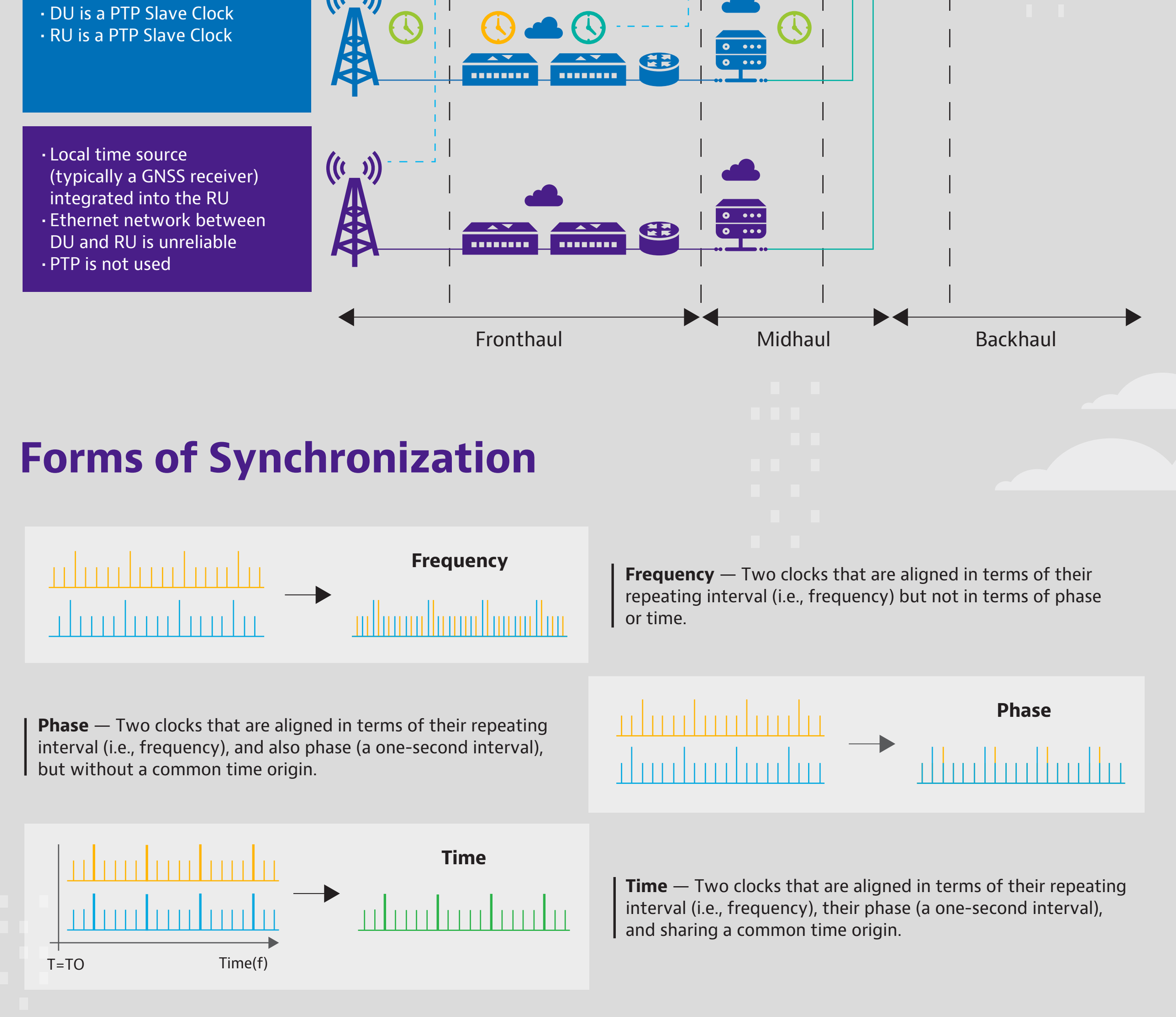
5G Raises the Bar on Synchronization, Speed and Accuracy

Regardless of RU, DU and CU location, Total Time Error between RU and the Grand Master cannot exceed 1.5µs.

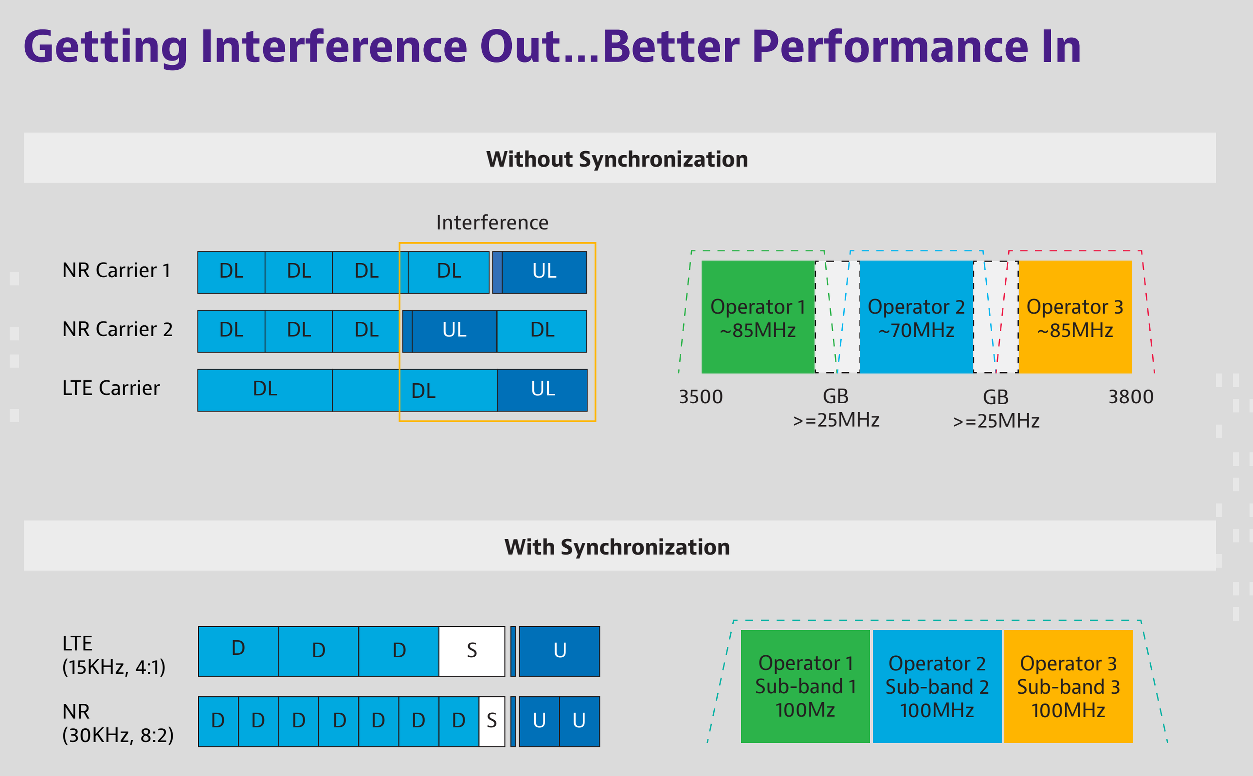


THE TECHNOLOGY

Timing and Synchronization Configuration Options



Forms of Synchronization



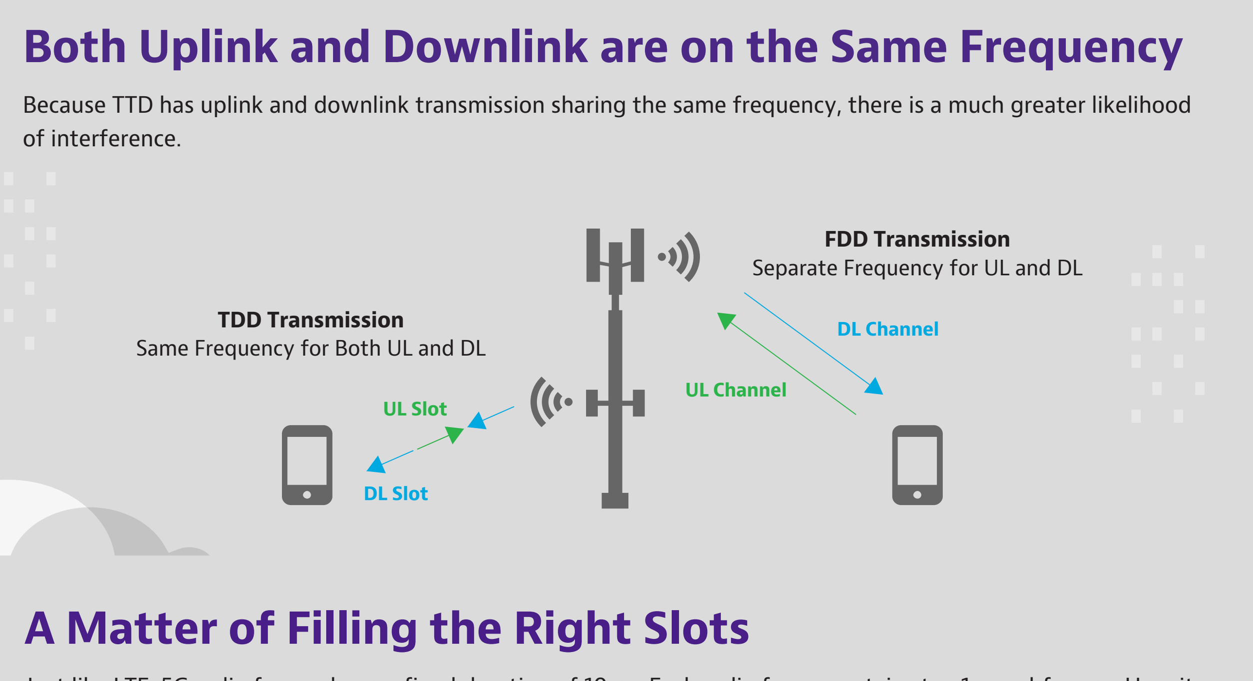
Frequency — Two clocks that are aligned in terms of their repeating interval (i.e., frequency) but not in terms of phase or time.

Phase — Two clocks that are aligned in terms of their repeating interval (i.e., frequency), and also phase (a one-second interval), but without a common time origin.

Time — Two clocks that are aligned in terms of their repeating interval (i.e., frequency), their phase (a one-second interval), and sharing a common time origin.

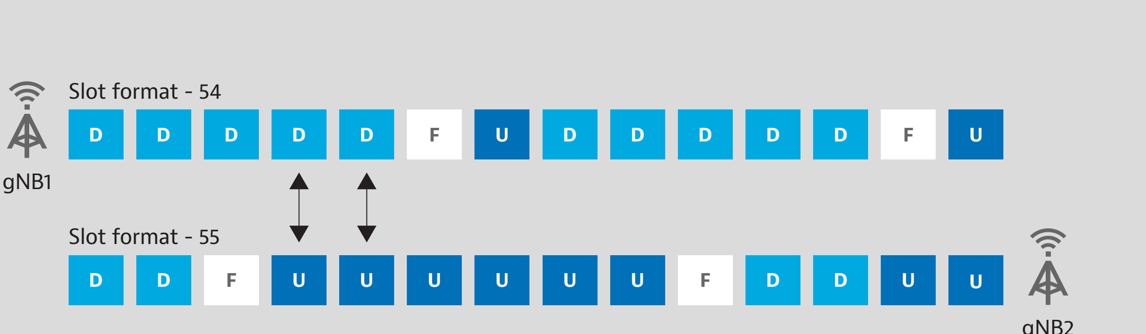
Frame — A compatible frame structure to avoid simultaneous UL/DL transmission, which determines a specific DL/UL transmission ratio and frame length.

Getting Interference Out…Better Performance In



Both Uplink and Downlink are on the Same Frequency

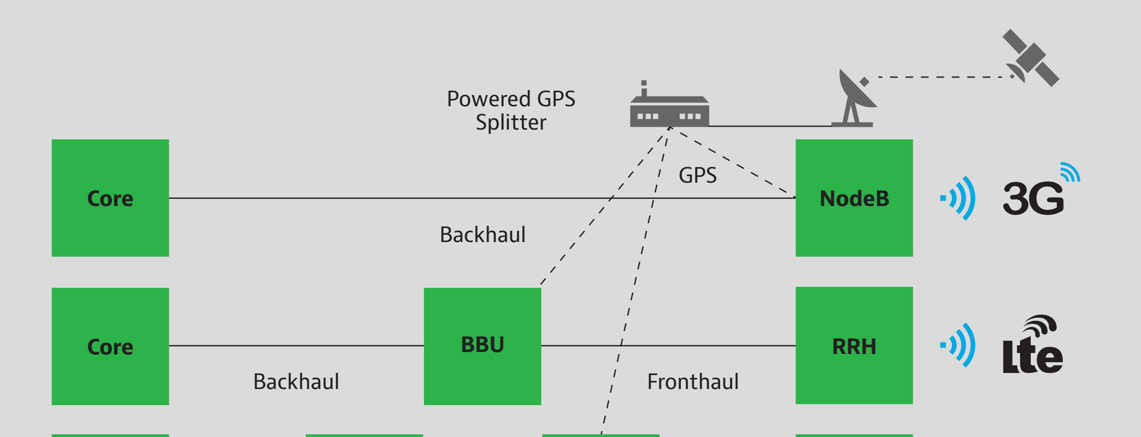
Because TTD has uplink and downlink transmission sharing the same frequency, there is a much greater likelihood of interference.



A Matter of Filling the Right Slots

Just like LTE, 5G radio frames have a fixed duration of 10ms. Each radio frame contains ten 1ms subframes. How it differs from LTE is that in 5G-NR, subcarrier spacing changes the number of slots and symbols per subframes.

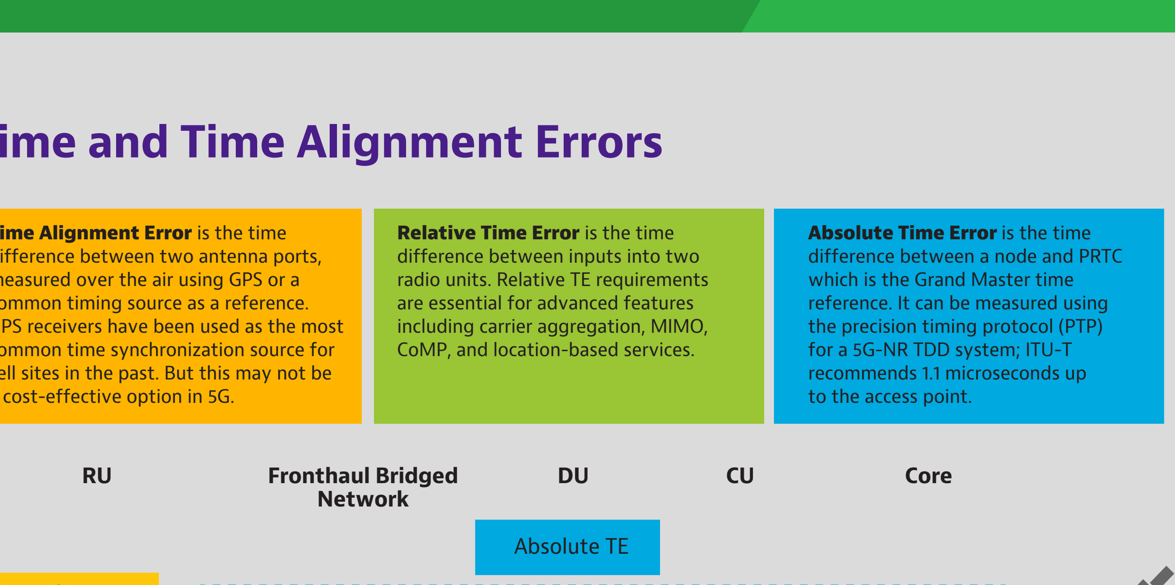
Release 15 version of 3GPP 38.213 has defined 56 slot formats, each of which is a predefined pattern of downlink/flexible/uplink symbols during one slot. Service providers can use these different formats to flexibly accommodate different types of service. QoS issues may arise when two networks offering different types of service are located next to each other. Though they may be synchronized in time, interference can result if their slot formats are not synchronized.



5G Network Topology Changes

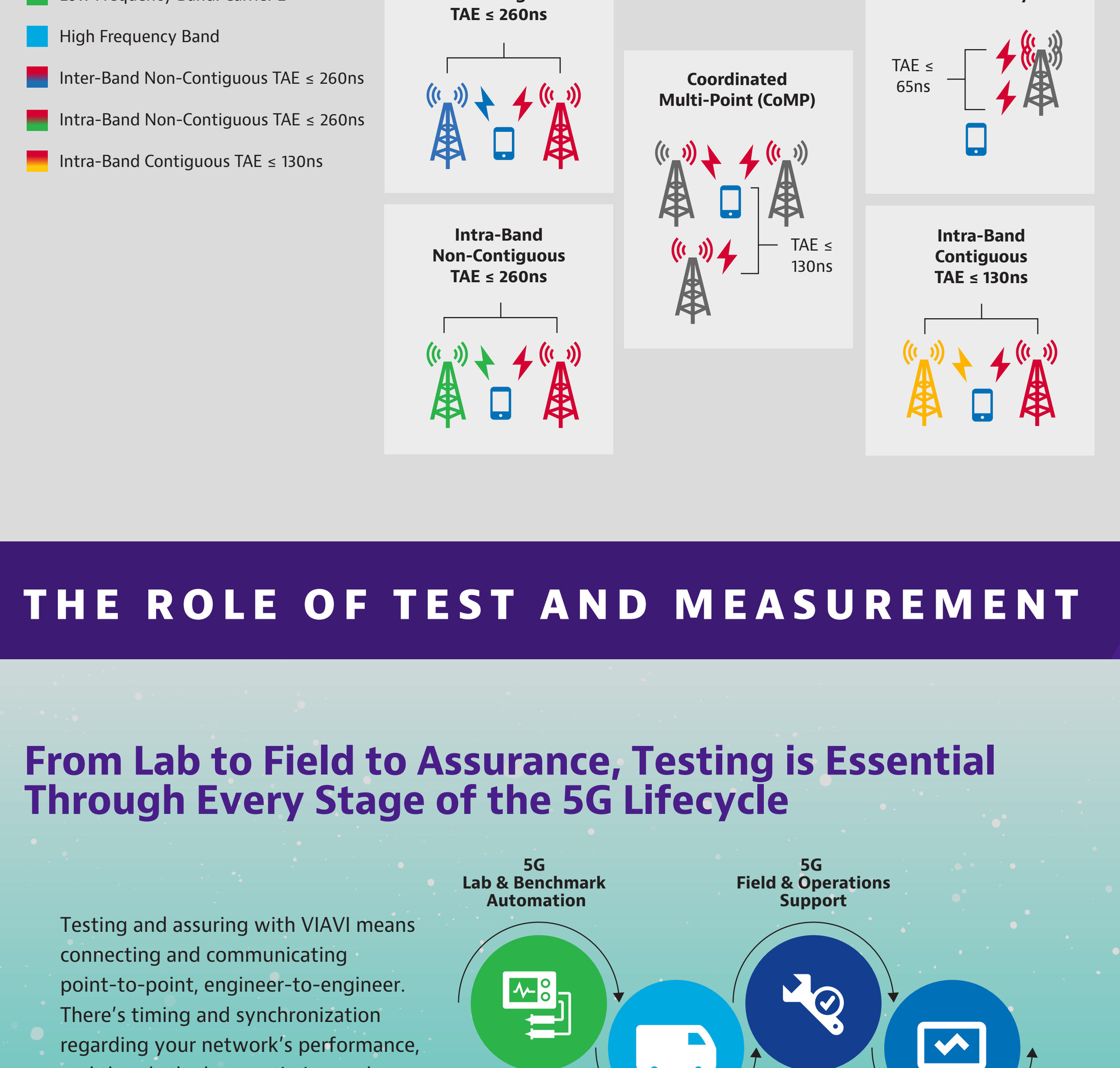
CPRI, (a synchronous fronthaul interface) which is the technology used today for LTE, may not be practical for all 5G use cases. CPRI enforces stringent delay requirements which are well-suited for centralization, but can cause difficulties with bandwidth and node flexibility.

CPRI is not very efficient in terms of statistical multiplexing and cannot scale to the demands of 5G, especially for massive MIMO and larger bandwidth increments. The required bandwidth and antennas in a 5G scenario would push the CPRI bandwidth above 100Gbps. That is why using Ethernet for fronthaul and midhaul is very practical.



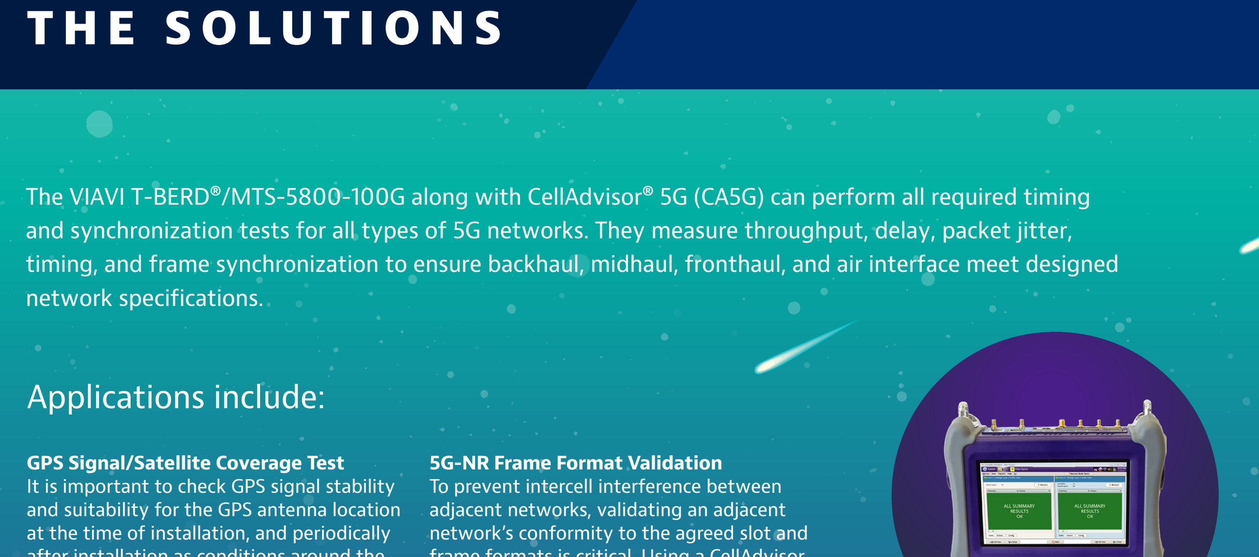
THE POTENTIAL ERRORS

Time and Time Alignment Errors



THE ROLE OF TEST AND MEASUREMENT

From Lab to Field to Assurance, Testing is Essential Through Every Stage of the 5G Lifecycle



THE SOLUTIONS

Applications include: