NAVIGATING THE 5G FRONTIER:

OVERCOMING CHALLENGES TO SUCCESSFULLY DEPLOY

NEXT-GENERATION WIRELESS NETWORKS

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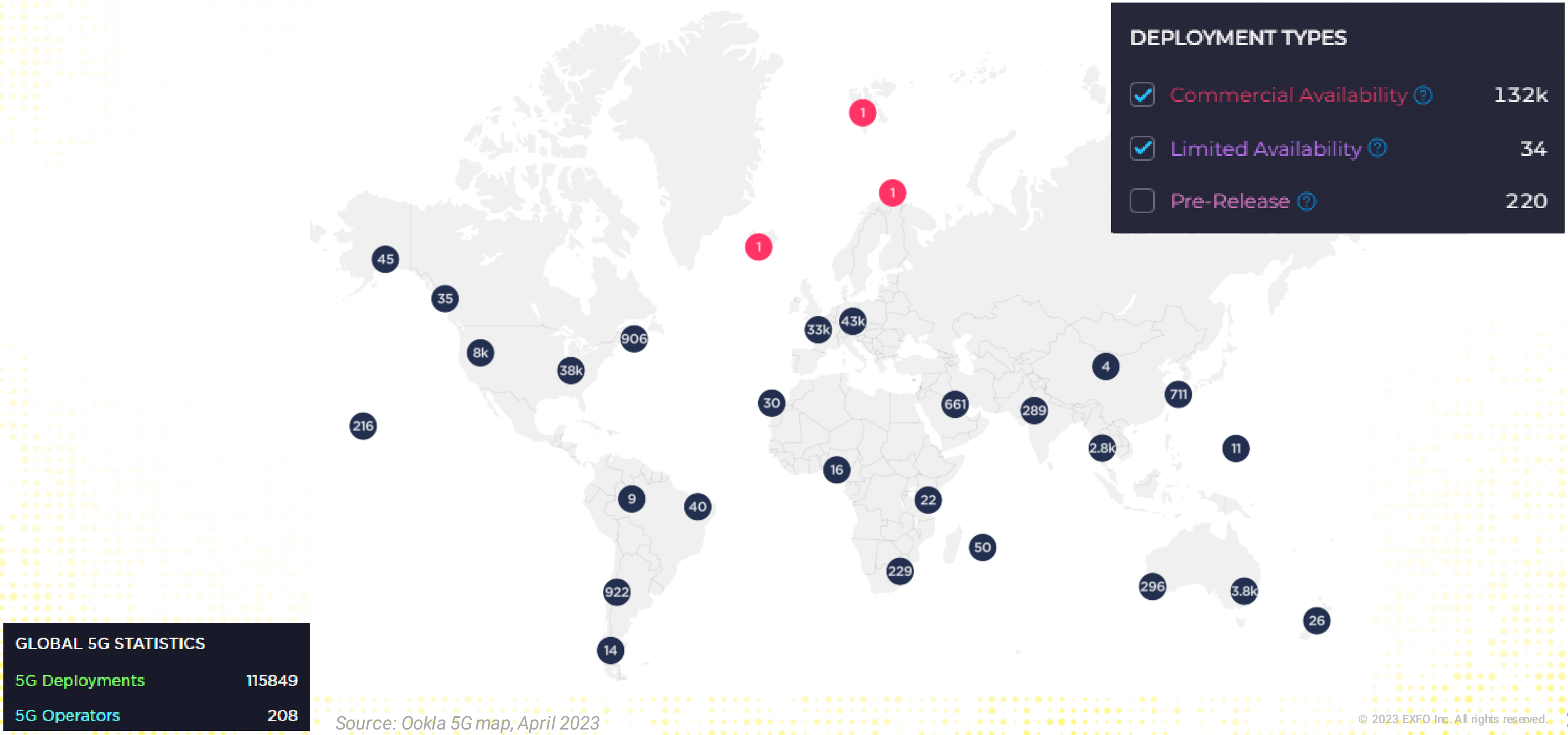
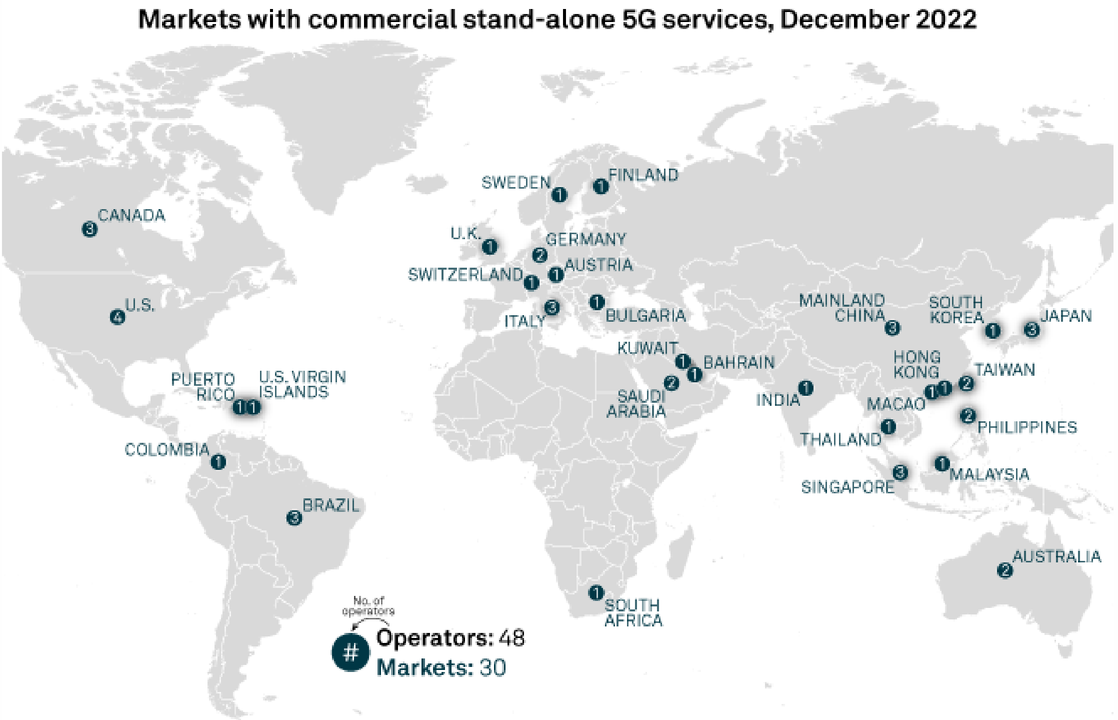
EXFO

2023: 5G Deployments



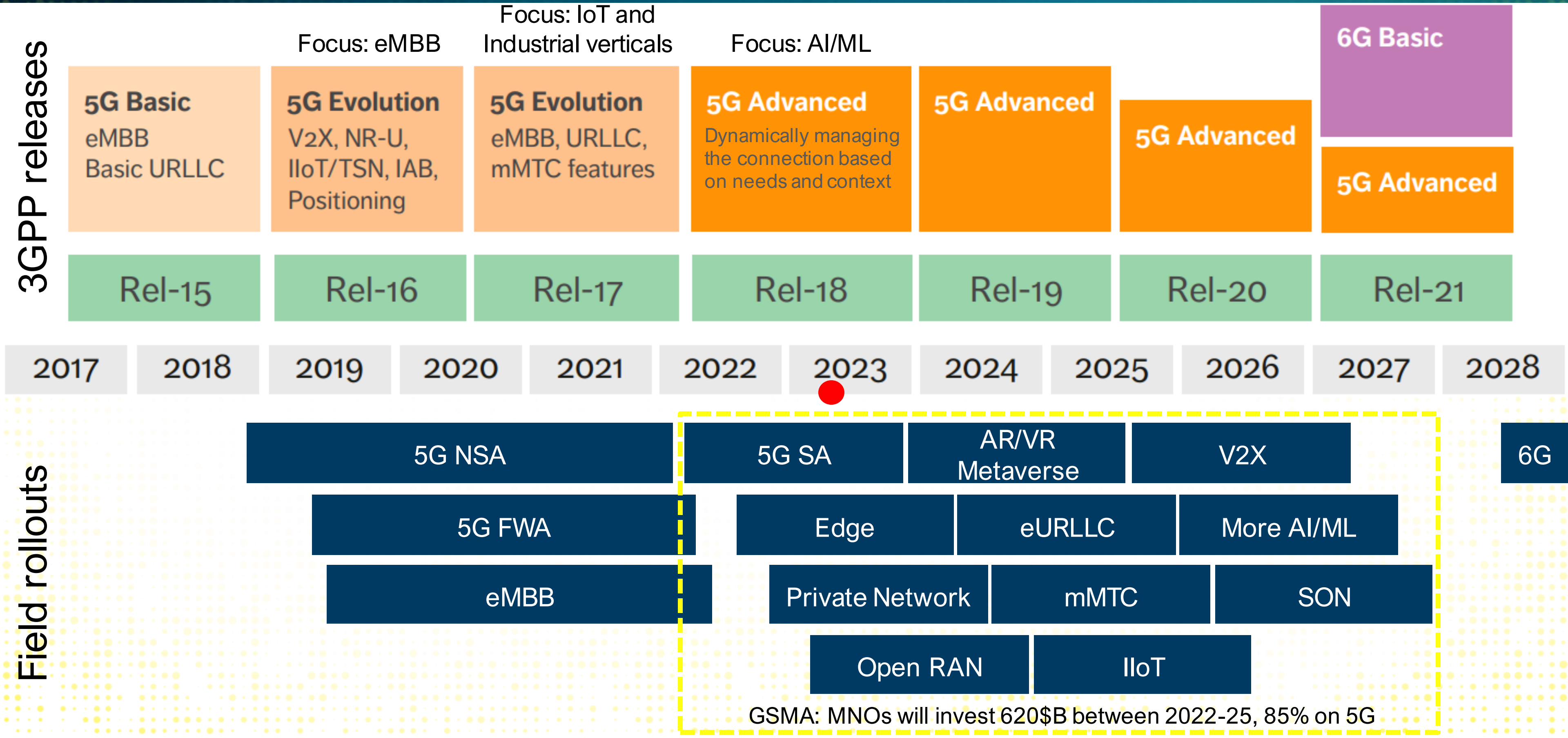
Source: Ookla 5G map, April 2023

5G Standalone Deployments



Data compiled January 2023.
Sources: Industry data; Kagan estimates
Kagan, a media research group within the TMT offering of S&P Global Market Intelligence.

3GPP and industry evolution



RAN/Mobile Market Trends

1 Network densification

- More cell sites and small cells
- Huge 5G C-Band buildouts
- Historic fiber buildout effort
- Pressure to hit the dates!

2 Next phase of 5G

- Shift to 5G SA and 5G core
- Low latency and network slicing
- Edge and Azure, Google, AWS
- Timing is critical

3 IoT and industrial verticals

- Private network and URLLC
- Automotive, smart factory, etc
- Mission critical applications are key opportunity for operators

4 Adoption of Open RAN

- Open, intelligent, virtualized RAN
- EXFO contributor since Feb 2019
- 1&1, BT, DT, Orange, Vodafone, Virgin Media O2, TEF

Private 5G: CAGR of 49% from 2022 to 2030

Manufacturing/Industry 4.0

Mining

Power/Utilities

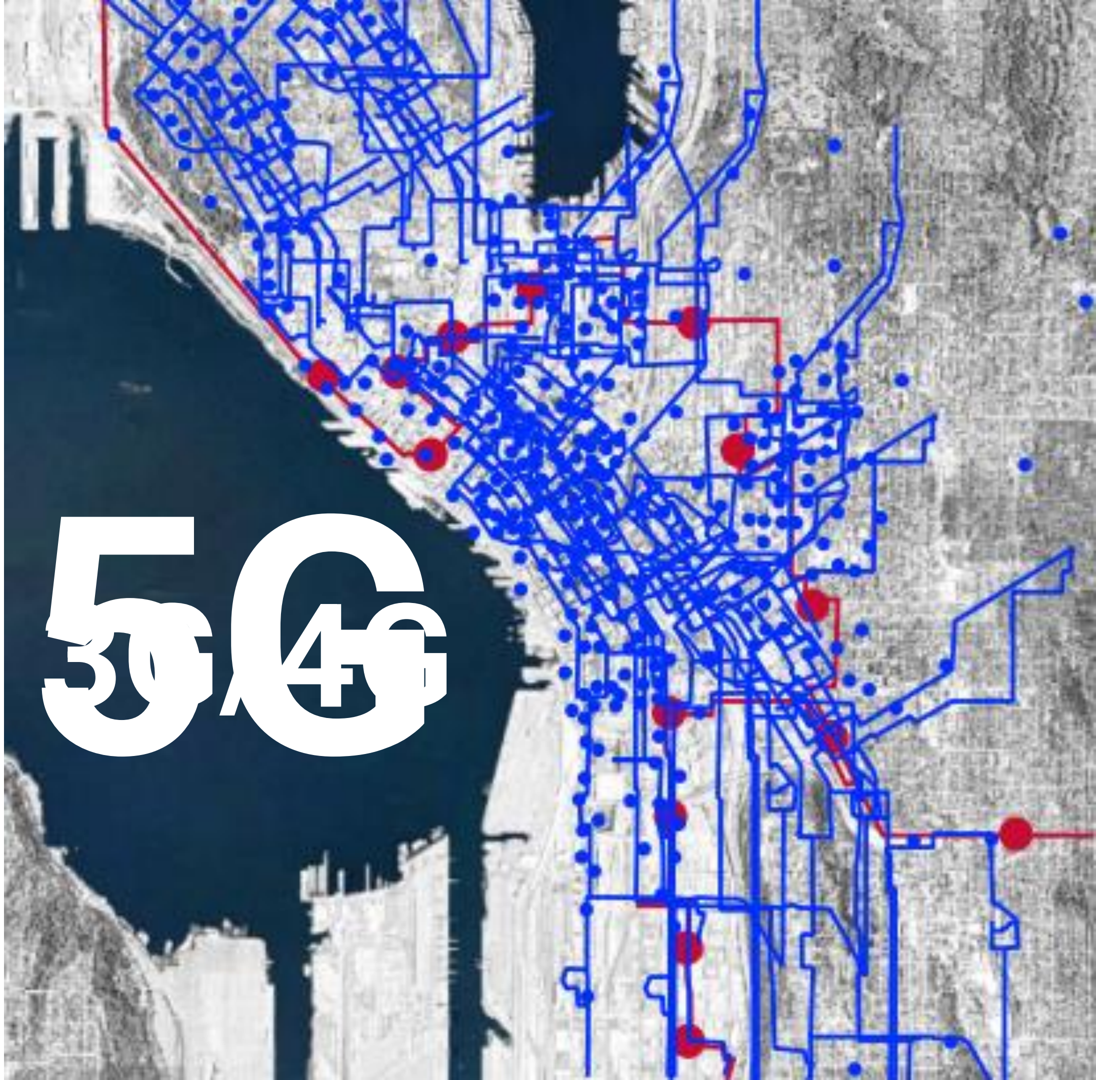
Smart Seaports/Airports

Warehouse/Supply chain

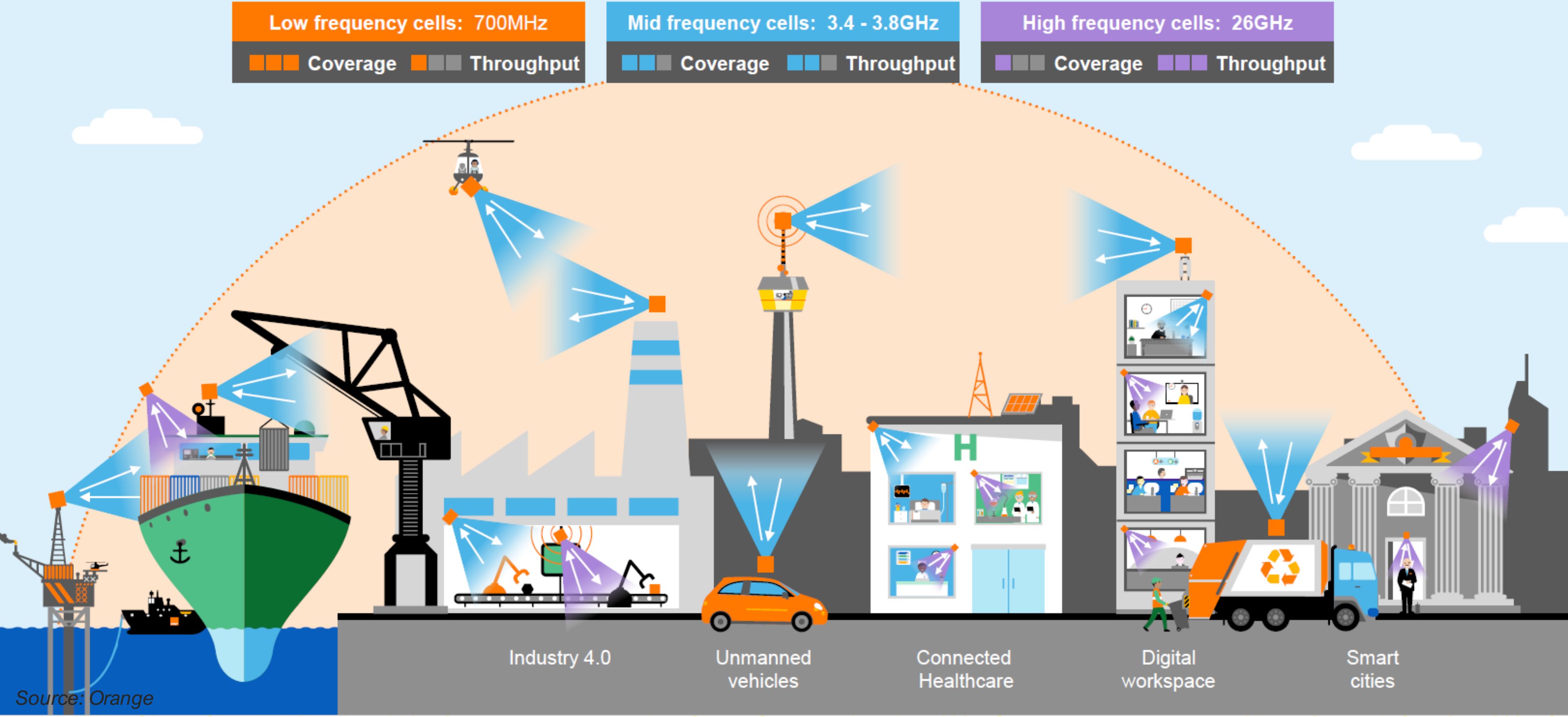
Connected healthcare

Fiber density

~100x more fibers



5G is a mix of multiple frequencies bands



Source: Orange

5G RAN is Diverse


Source: Samsung

64T64R Mid-band
4x4 Low-Bands
Urban Rooftop

Rural Coverage
700MHz, DSS


Source: Vodafone Germany

mmWave on a
Macro site

Source: @olkitu


Source: Nokia

mmWave
Stadium

Outdoor mmWave
DU/RU, vCU

Source: Airspan, Rakuten

mmWave Relay


Source: Pivotal Commware

8T8R Mid-band
Urban Macro

Source: @pedroclarke1,
Commscope, Nokia

Indoor 5G

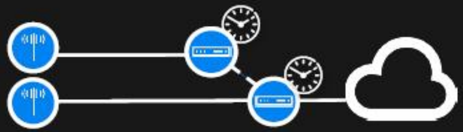

Source: Ericsson

Impacts on transport from 5G RAN

New bands & multiple carrier layers (M-MIMO)

Increased fronthaul and backhaul capacity.
10GE, 25GE and 100GE port requirements.

New RAN architecture, TDD and coordination features



Low to ultra low latency and accurate time/phase sync.

RAN densification

Operational simplicity and high degree of automation.

Source: Ericsson

5G key summary requirements

Latency
> 10x decrease
URLLC : < 1ms E2E

Reliability
> 10x increase
URLLC : > 99.999%

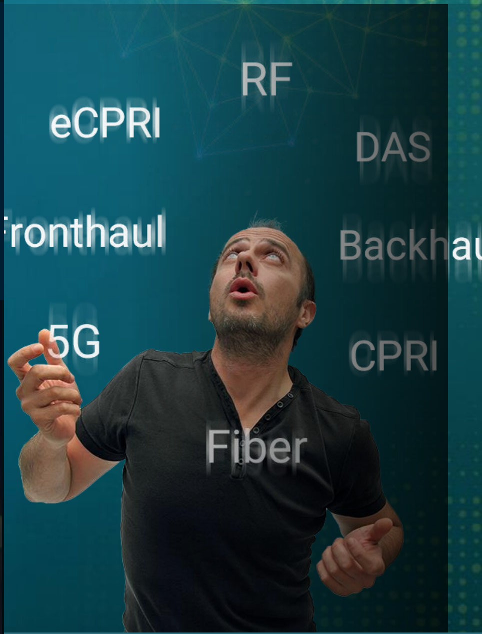
Throughput
> 10x increase
eMBB : 1 Gbit/s
(20 Gbit/s peak)

5G deployments challenges

Meet deadlines

Do more with less

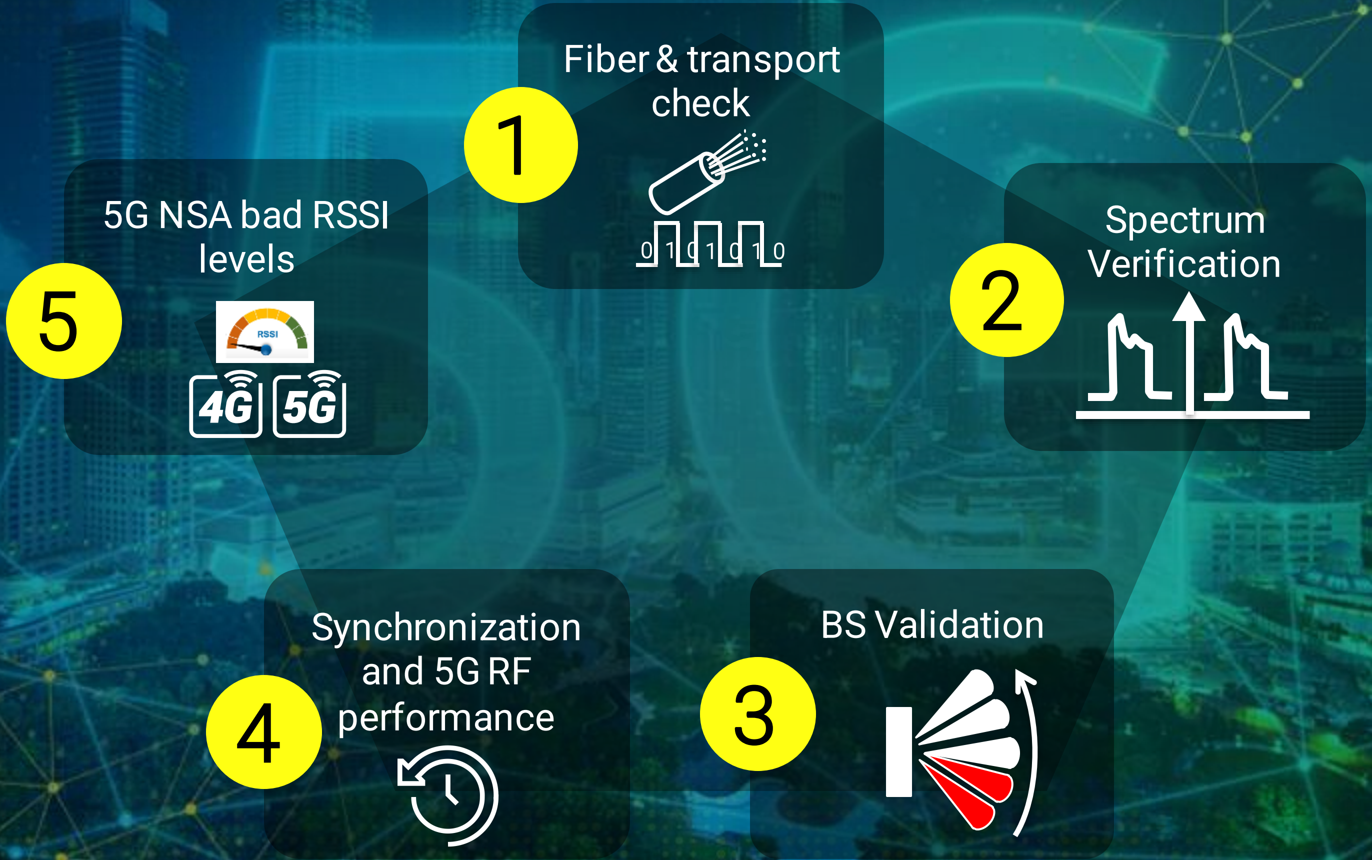
Scarce workforce and limited telecom expertise



Complex mix of architectures and technologies

5G field measurements

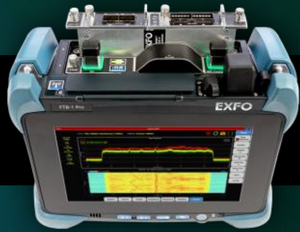
5G and RF main challenges in field testing



5G and RF main challenges in field testing

1. Fiber & transport check
2. Spectrum Verification
3. BS Validation
4. Synchronization and 5G RF performance
5. 5G NSA bad RSSI levels

1 5G deployment challenges



CHALLENGES

Slow cell sites and small cell rollouts
Radio and link issues
Back-and-forth between cell sites
Finger pointing.

SOLUTIONS

FIP automatically detects dirty or damaged fiber connectors
iOLM automatically identify location of fiber issues
CPRI/eCPRI/Ethernet link validation to confirm proper operation of the radio

1

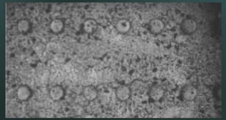
2 iOLM | intelligent Optical Link Mapper

3 CPRI/OBSAI Fronthaul eCPRI Fronthaul Ethernet F1 Midhaul

Use case **NETWORK DEPLOYMENT**

1

Fiber is the foundation of 5G
Check, clean, check, connect, test, repeat...



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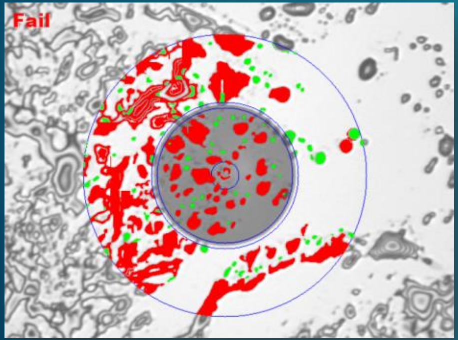
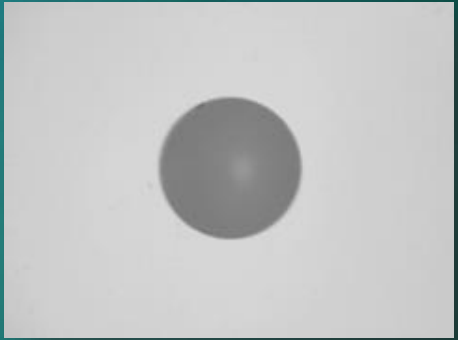
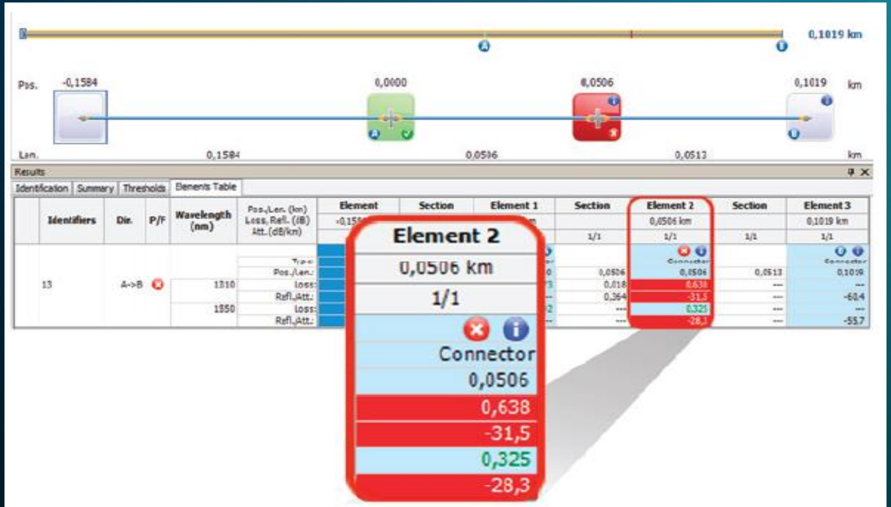
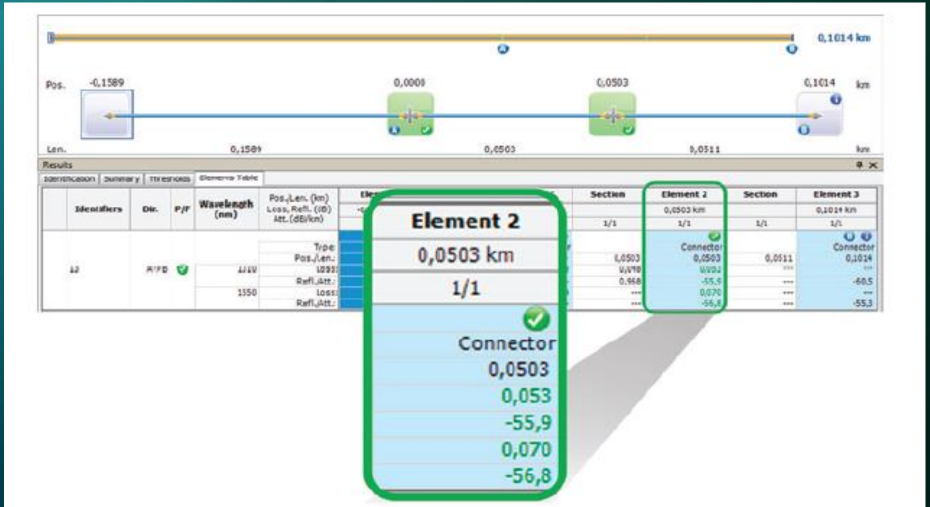
Before

After









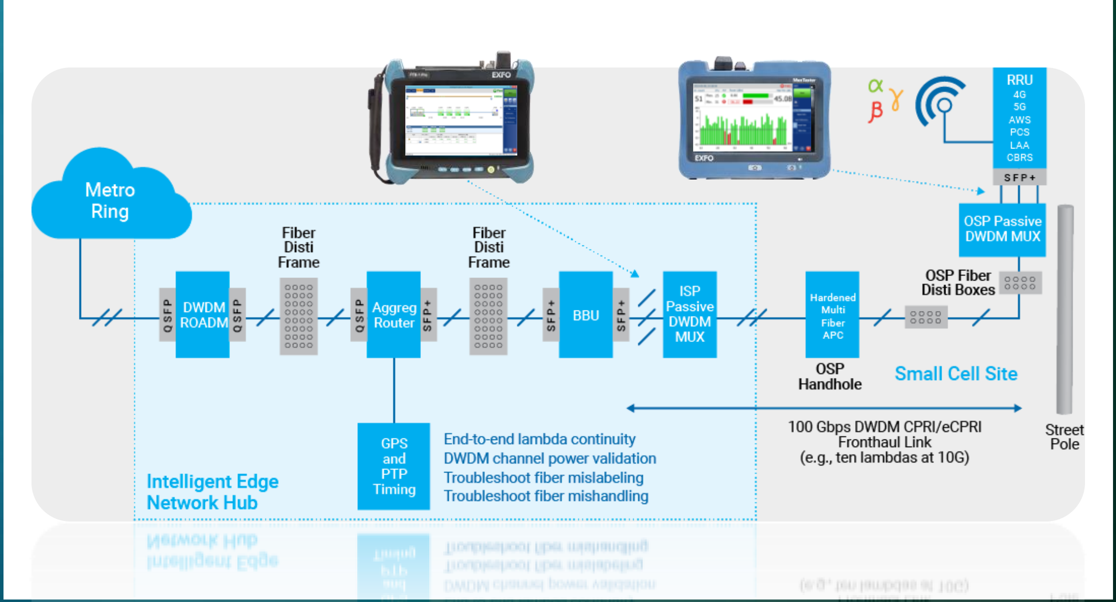
1 5G fiber exhaustion – DWDM

CHALLENGE | SOLUTION RESULTS

Fast solution to fiber exhaustion

Uses existing fiber, saving time and money

Validate power per channel/sector



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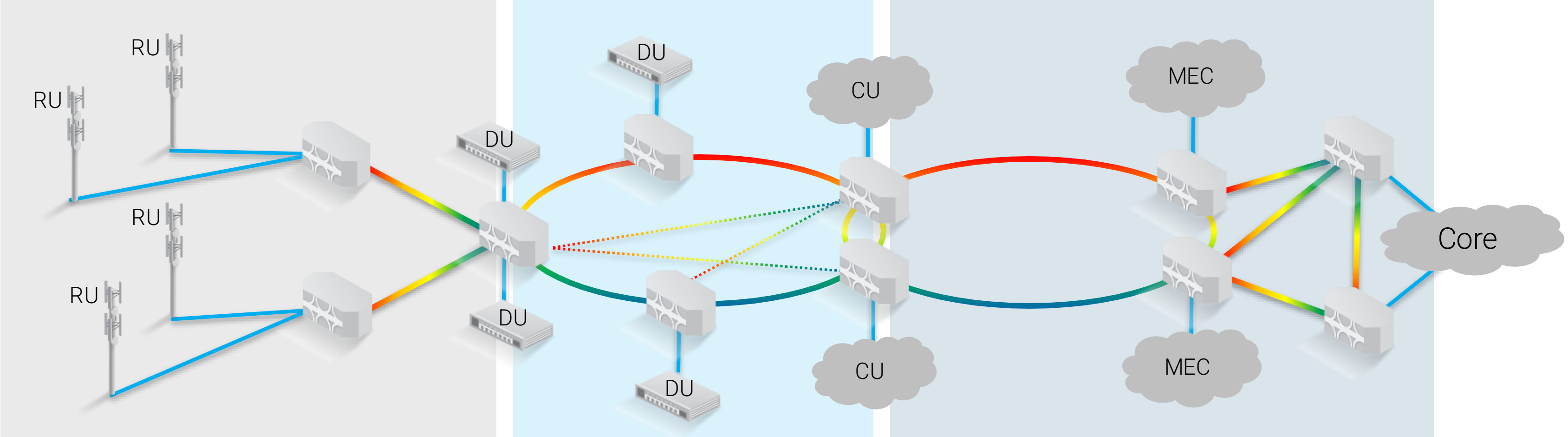
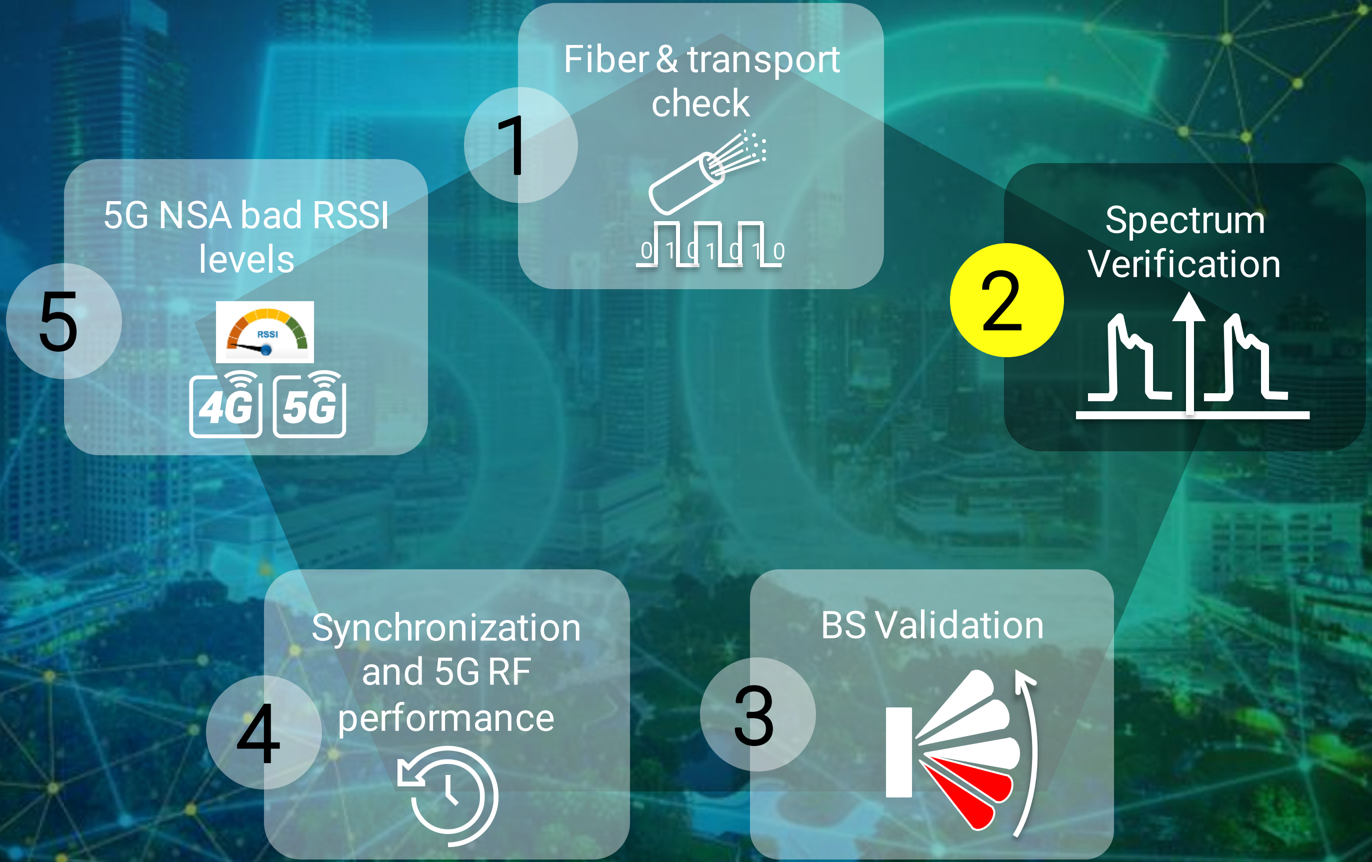
XHaul testing in 5G technologies



	Access/Fronthaul	Aggregation/Midhaul	Core/backhaul
Legacy	CPRI; OBSAI		OTN; ETHERNET 1GE / 10GE / 100GE
WITH 5G	eCPRI/O-RAN 10G/25G; 10G xPON; ETHERNET 10GE/ 25GE/ 50GE; RoE; 802.1CM TSN; OTN	F1 ETHERNET; SyncE + IEEE1588/PTP; FlexE; OTN	Ethernet 400GE; Network Slicing; FlexE; SPN/G.mtn; OTUCn/FlexO

5G and RF main challenges in field testing



2 Spectrum Verification: spectrum clearing

CHALLENGES

5G will use some new bands, like C-Band, 700 MHz band and mmWave bands.

Some of them had a prior use and MNO's need to verify the spectrum is clean and BS can be deployed.

SOLUTIONS

Full spectrum analysis needs to be performed to check the bands are clean and within limits.

Use case **NETWORK DEPLOYMENT**

Check RSSI levels to verify spectrum is clean

2 Spectrum Verification: interference finding

CHALLENGES

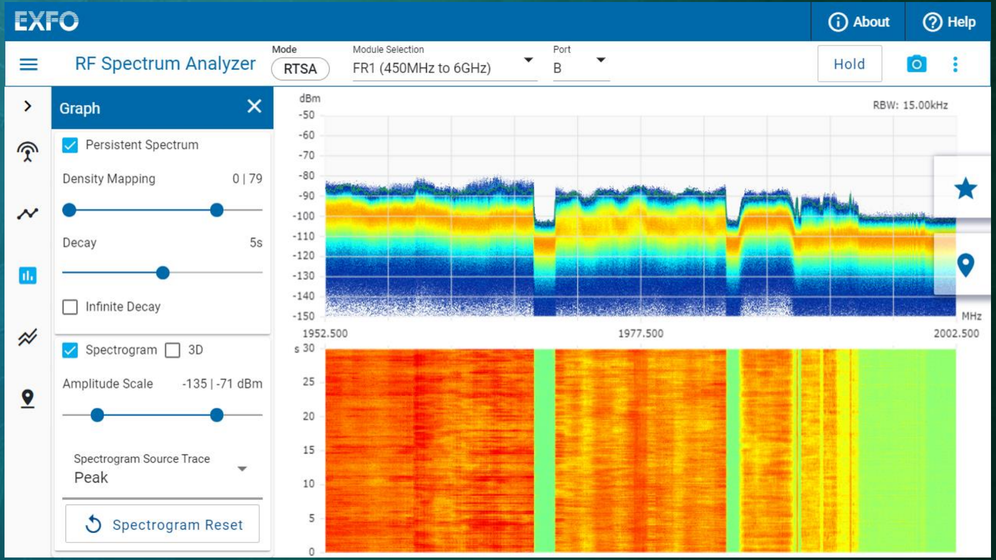
Interferences falling in our channel with a bursty signal like 5G troubleshooting can turn difficult.

With a regular spectrum analyzer, config can be tedious and we can even miss some signals.

SOLUTIONS

RTSA can show those signals masked inside our channel with a different color density, and also show transient signals that change very fast in time..

Time gating can also help in troubleshooting



Using RTSA without any settings we can see quickly the interferers.

Use case **TROUBLESHOOTING**

2 Spectrum verification: Interference finding

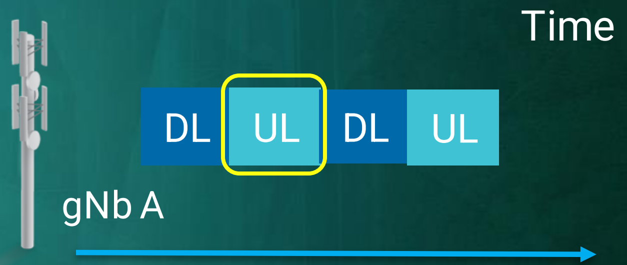
CHALLENGES

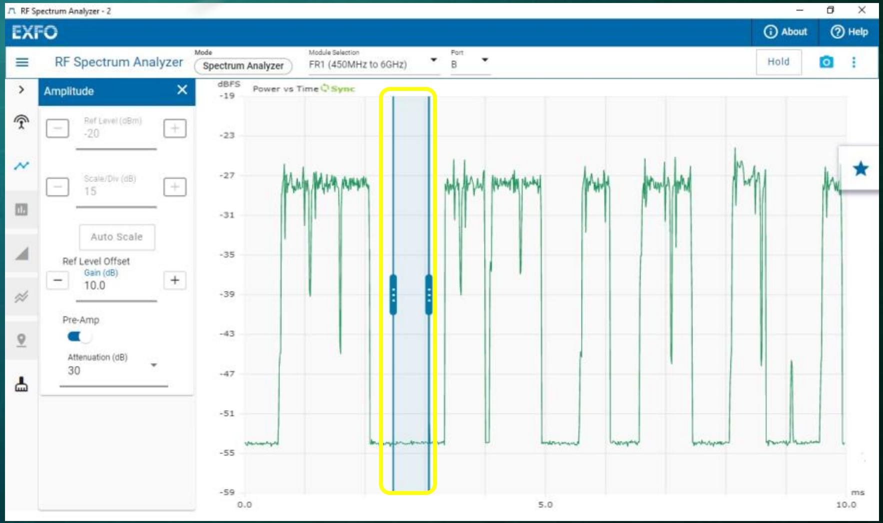
A TDD base station uses some slots to transmit and some slots to receive signals from UE. The challenge of this approach is to validate the UL channel is free of interferences, considering we have the BS transmitted signal in the same frequency as the UL.

SOLUTIONS

TDD gated sweep to switch the spectrum to power vs. time and lock onto a specific uplink to look for any RF interference

Use case TROUBLESHOOTING





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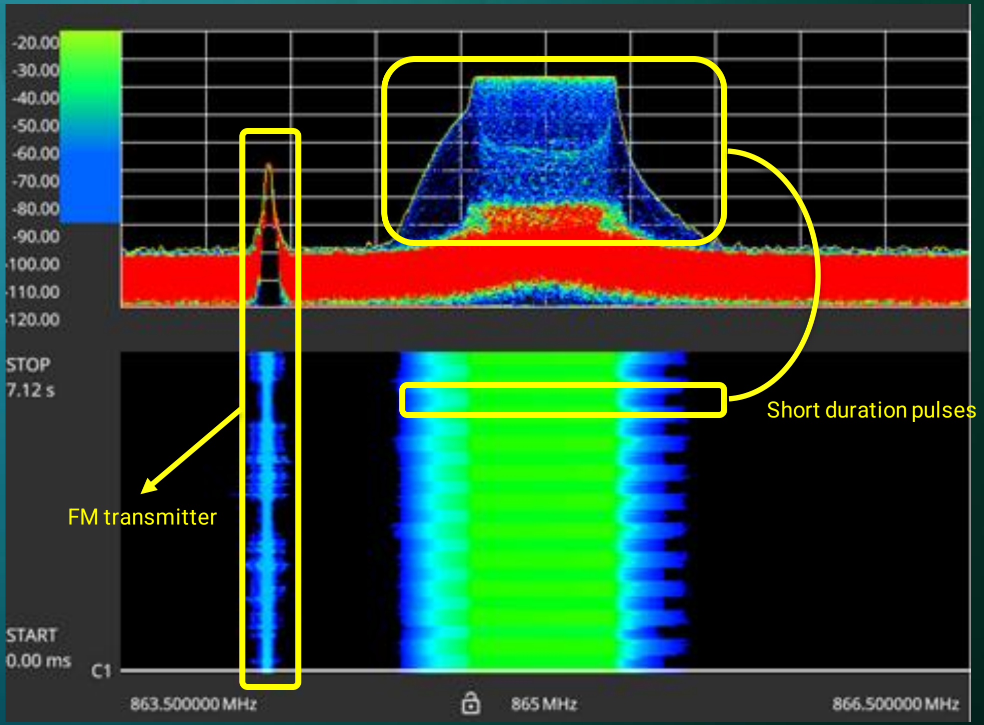
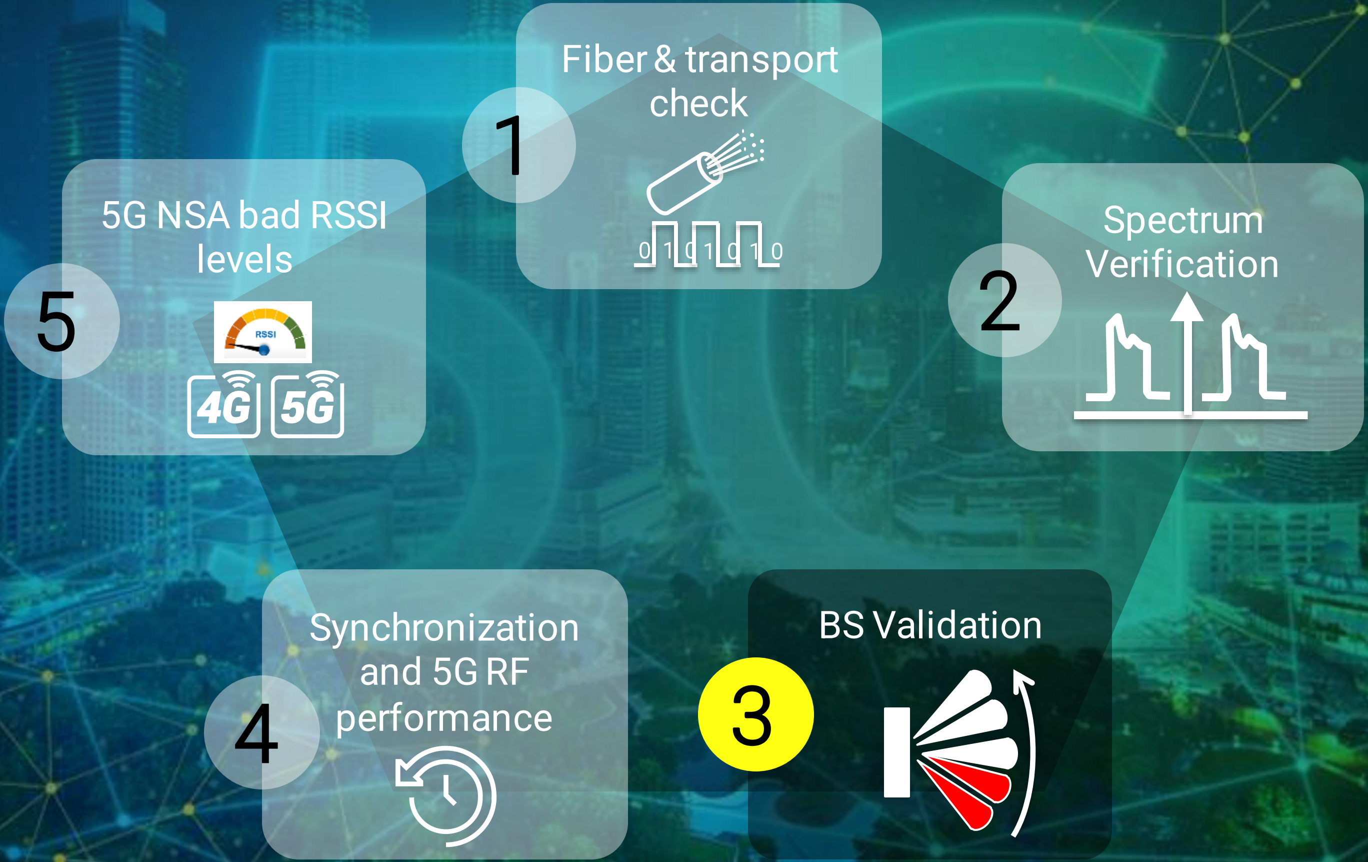


5G and RF main challenges in field testing

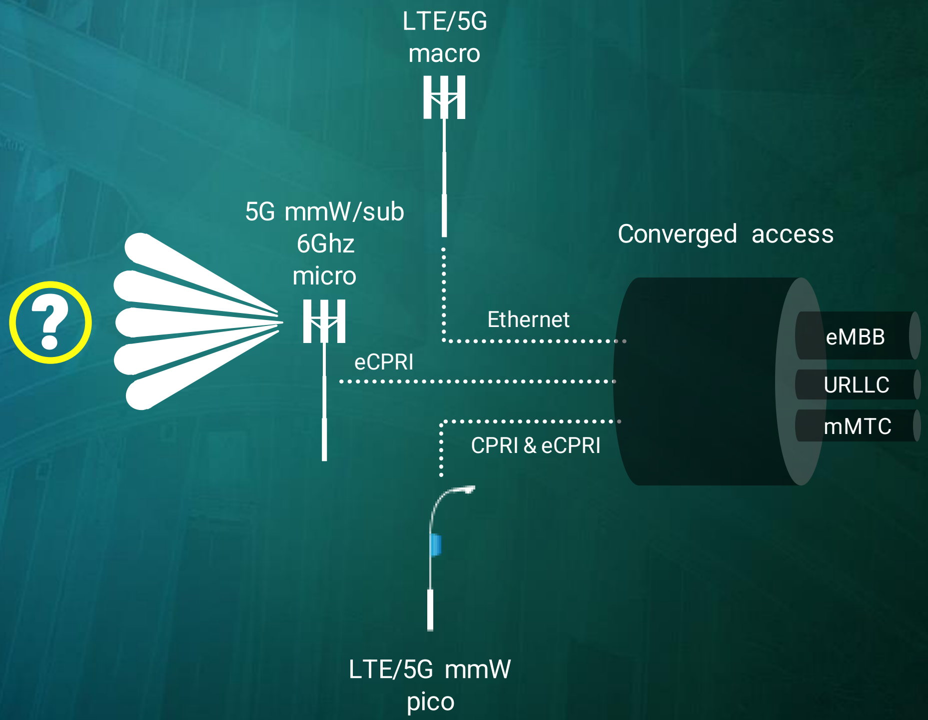


3 Verification of the grid of beams (SSB burst)

CHALLENGES

As antennas getting more complex with multiple technology : mMIMO, Beamforming, active antennas.

The challenge for MNOs is how to make sure radio unit is working properly and that all beams are transmitted correctly, as well as verifying the power profile makes sense



Use case

DEPLOYMENT

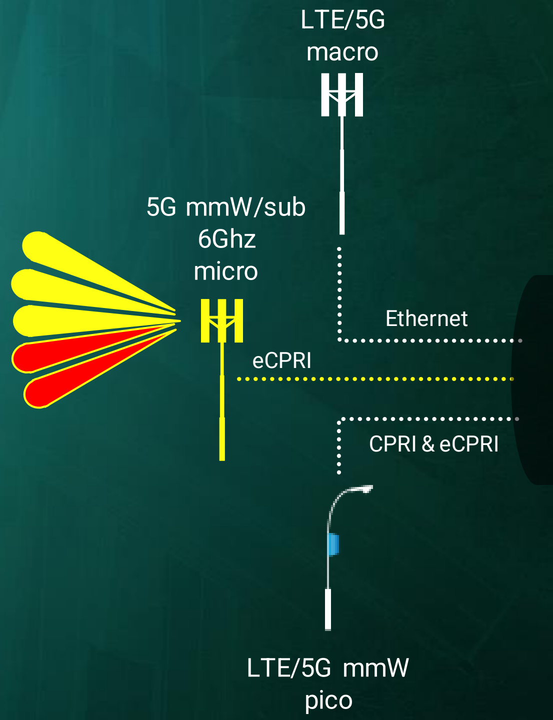
SSB : synchronisation signal Bloc

3 Verification of the grid of beams (SSB burst)

SOLUTIONS

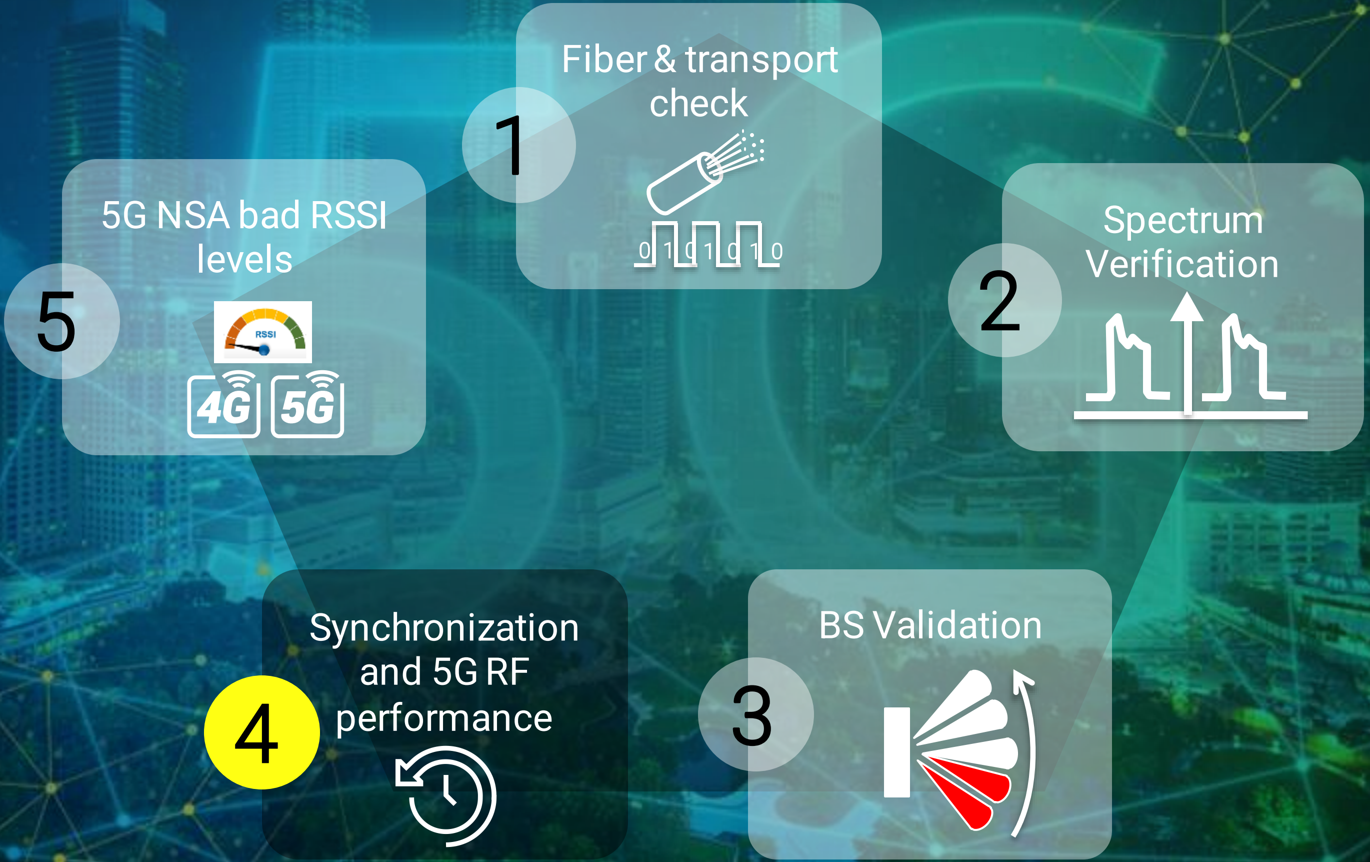
A quick check of power parameters in SSB we can realize whether all beams are being transmitted or not

For example, at 3.5 GHz, if a base station is transmitting all 8 beams, we should receive RSRP, RSRQ and SINR for all SSB's (from 0 to 7)



Use case	Application
DEPLOYMENT	**5GNR SIGNAL ANALYZER**

5G and RF main challenges in field testing

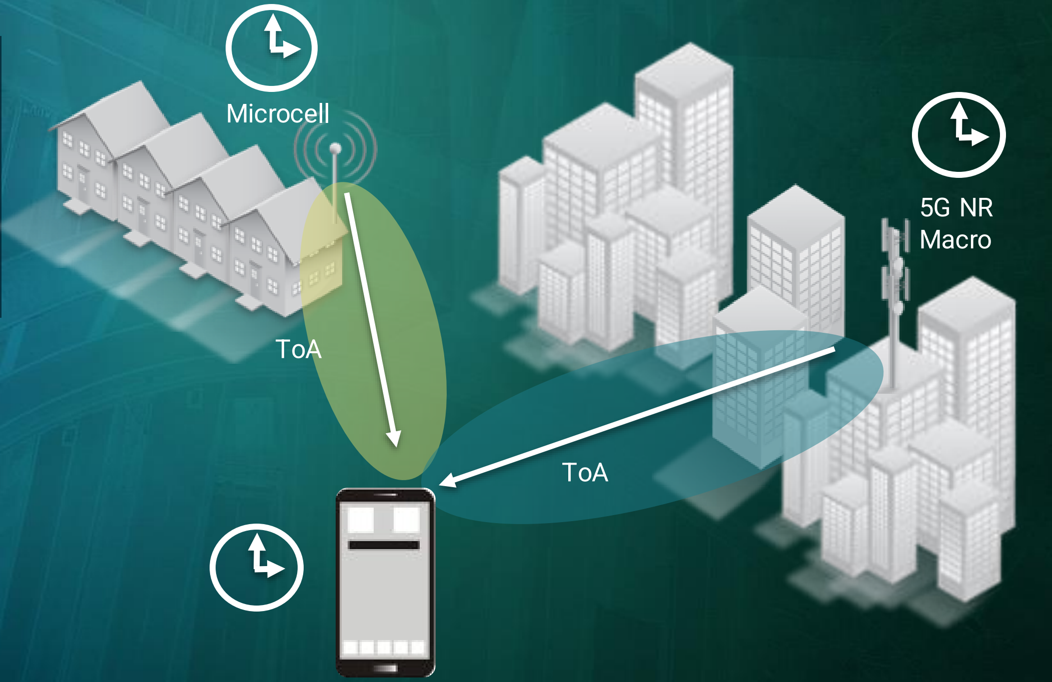


4 Un-synchronized network and 5G RF performance

CHALLENGES

Timing issues dramatically impact performance of 5G networks:

- TDD Issues between UE and BS
- Cell sites interfering with each other
- Handover issues



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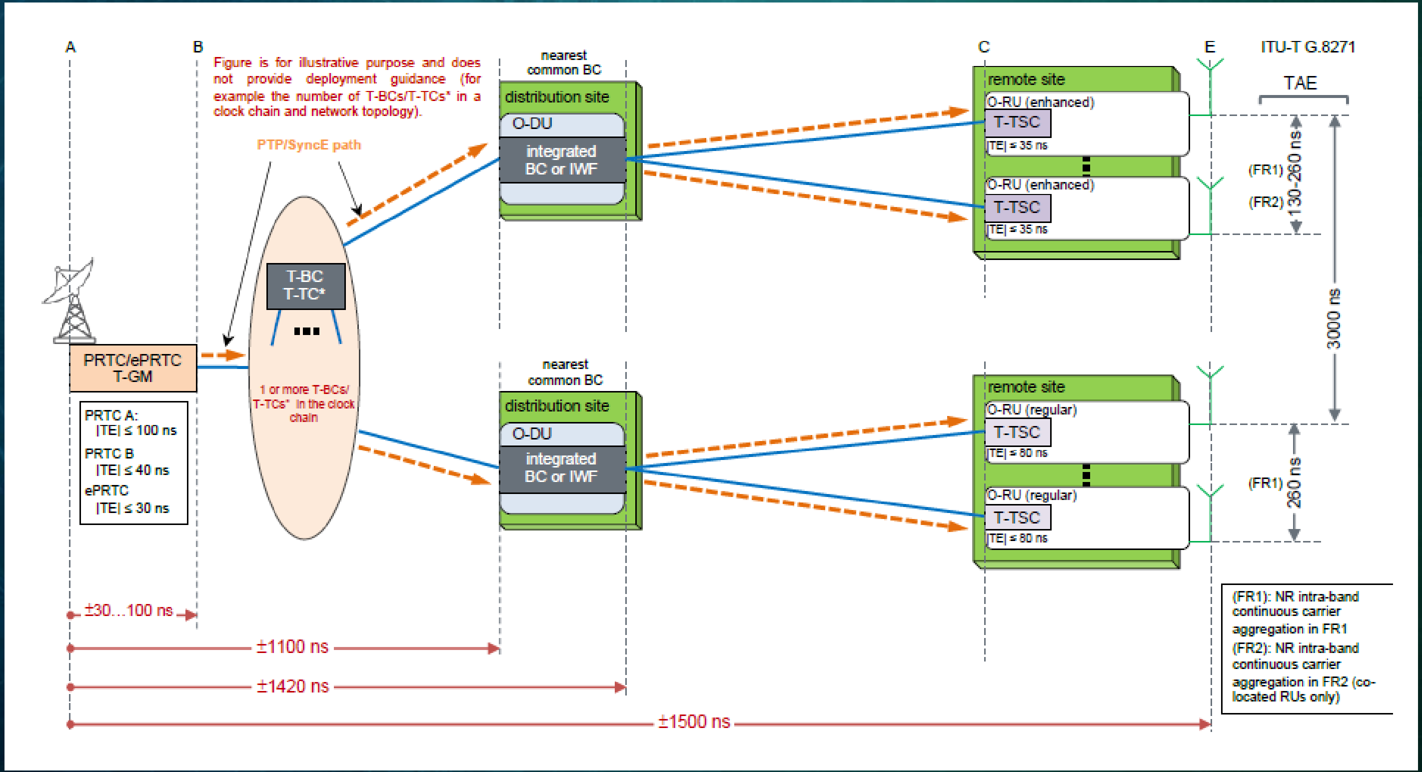

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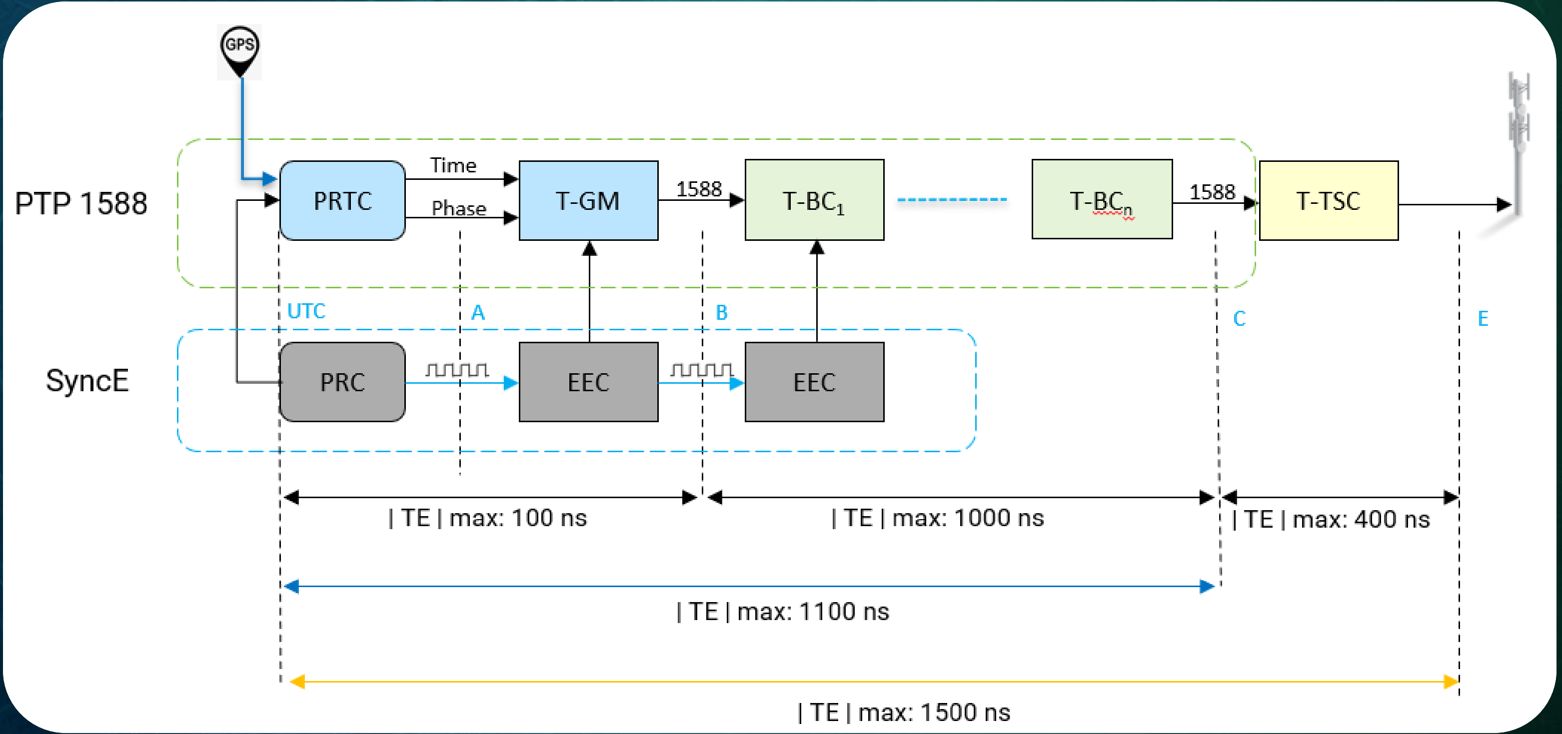


Primary reference time clock (PRTC)
Telecom grandmaster (T-GM)
Telecom boundary clocks (T-BC)
Telecom time slave clocks (T-TSC)

Primary reference clock (PRC)
EEC: Ethernet Equipment Clock

4 Un-synchronized network and 5G RF performance

CHALLENGES

Timing issues dramatically impact performance of 5G networks:

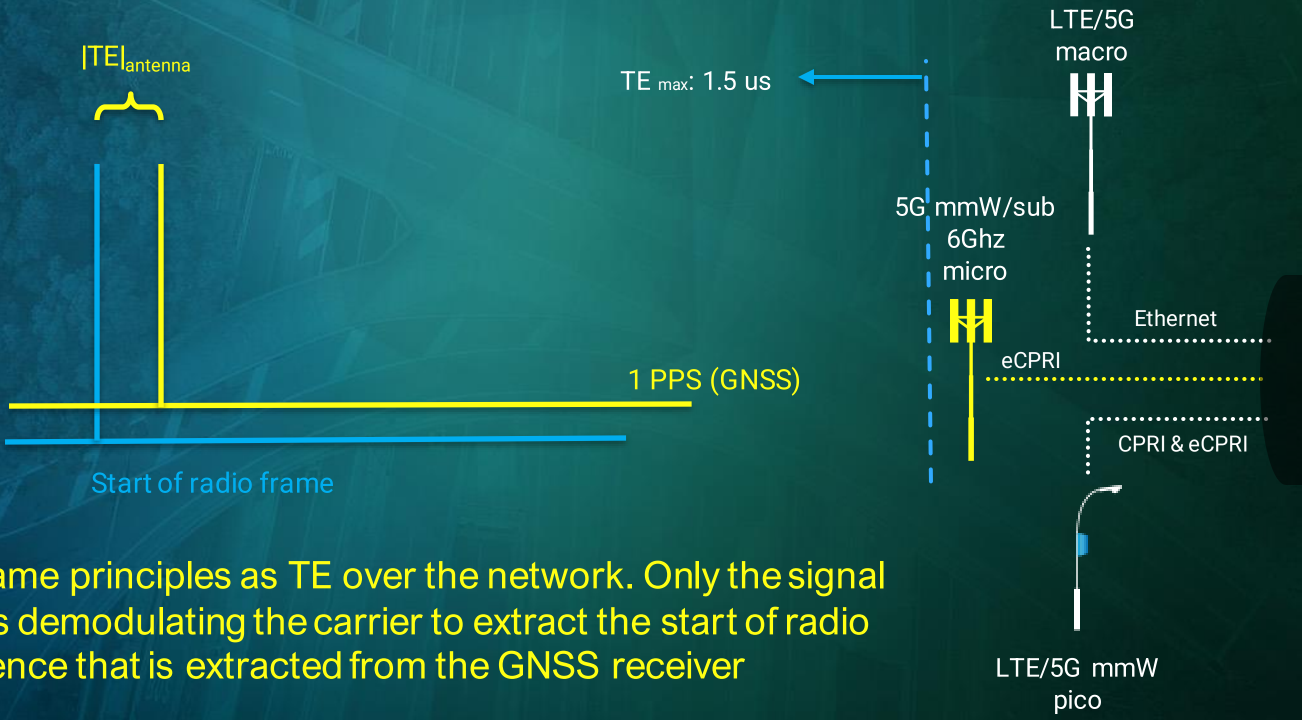
- TDD Issues between UE and BS
- Cell sites interfering with each other
- Handover issues
- Carrier aggregation

SOLUTIONS

1588, SyncEthernet and Wander applications will be key to understand synchronization performance

Time Error (TE) measurement OtA will help understand status of network synchronization status in the air interface.

4 Un-synchronized network and 5G RF performance



Measuring $|TE|_{antenna}$ uses the same principles as TE over the network. Only the signal under test is different. It requires demodulating the carrier to extract the start of radio frame and compare it to a reference that is extracted from the GNSS receiver

The GNSS receiver must be stationary for the 1PPS to be valid

4 Un-synchronized network and 5G RF performance

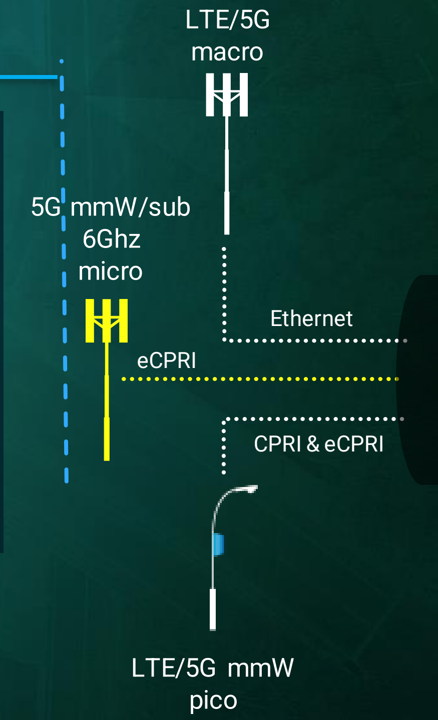
Accurate and fast GNSS synchronization

Distance compensation

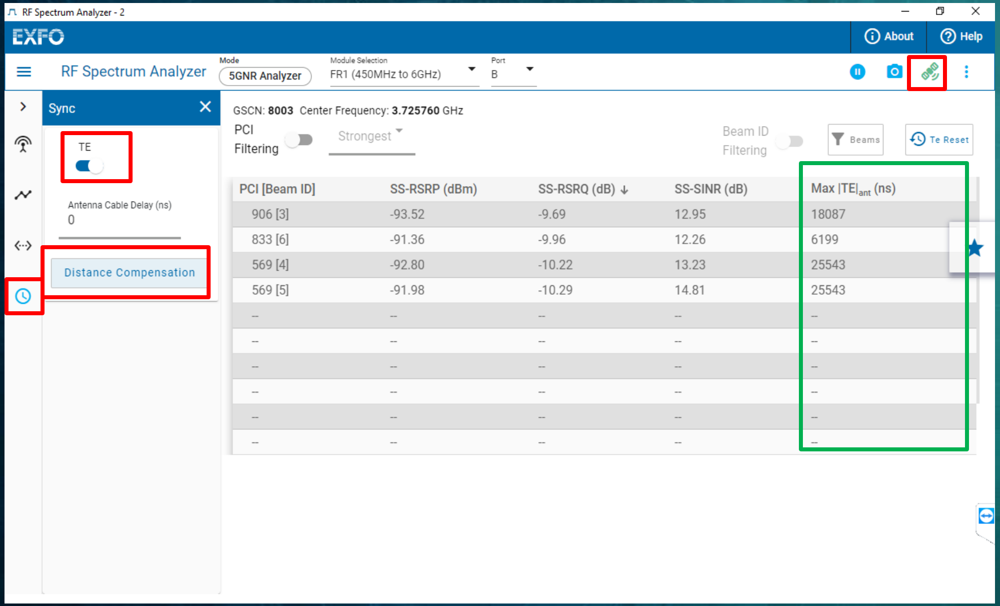
- ✓ Distance
- ✓ Coordinates

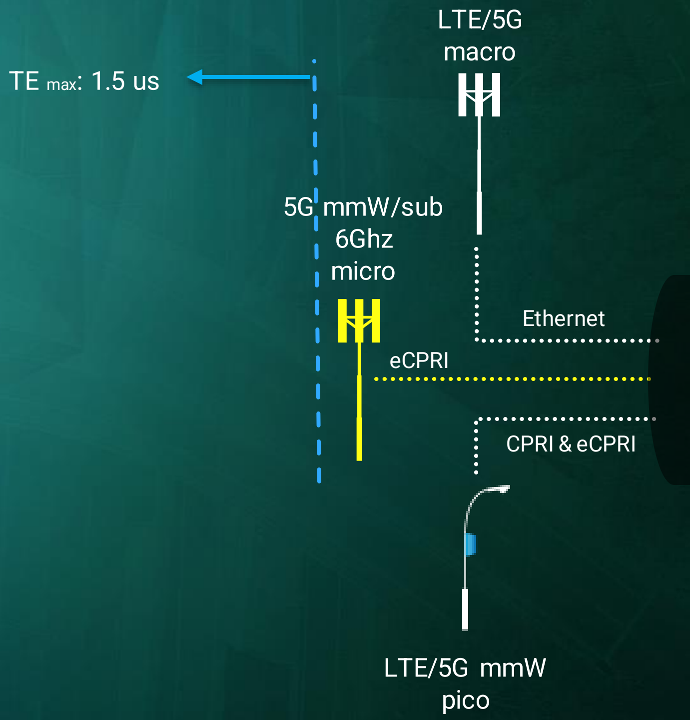
MultiPCI TE measurements

TE $_{max}$: 1.5 us



4 Implementation





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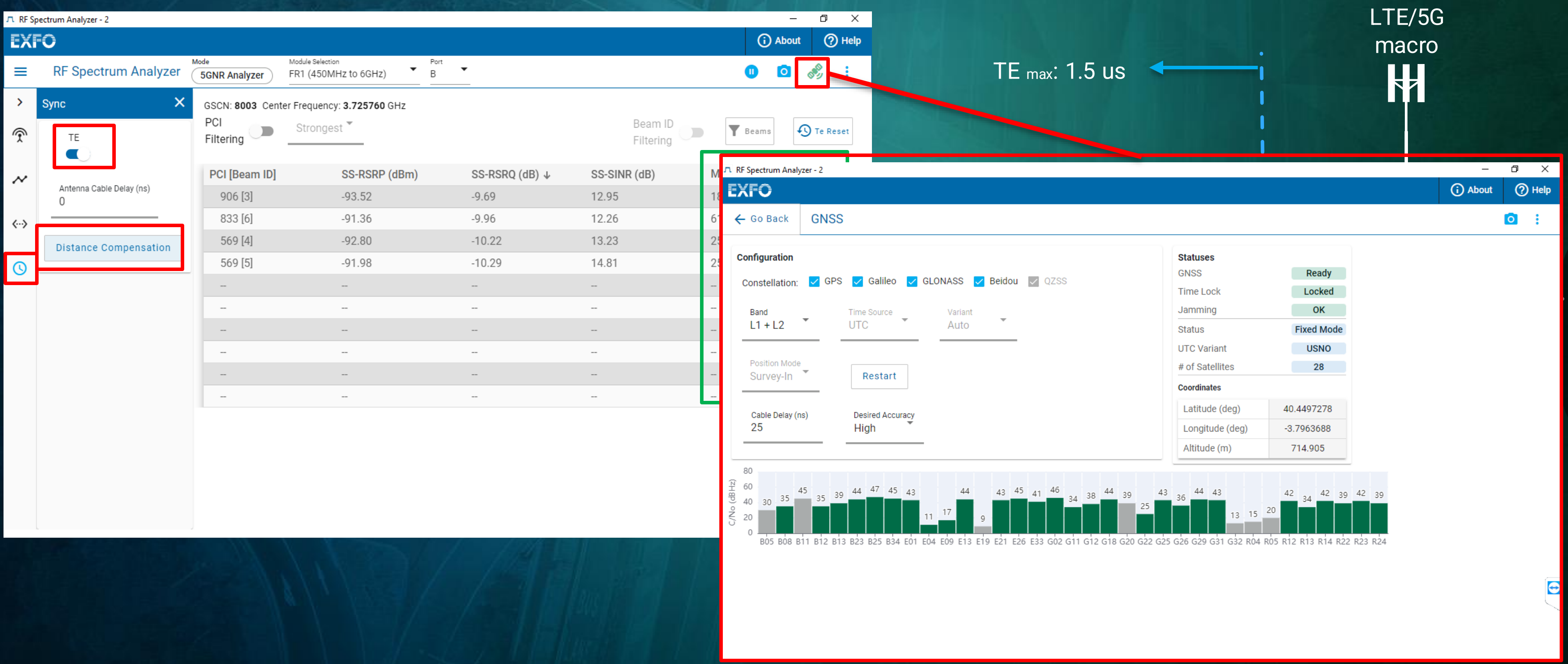

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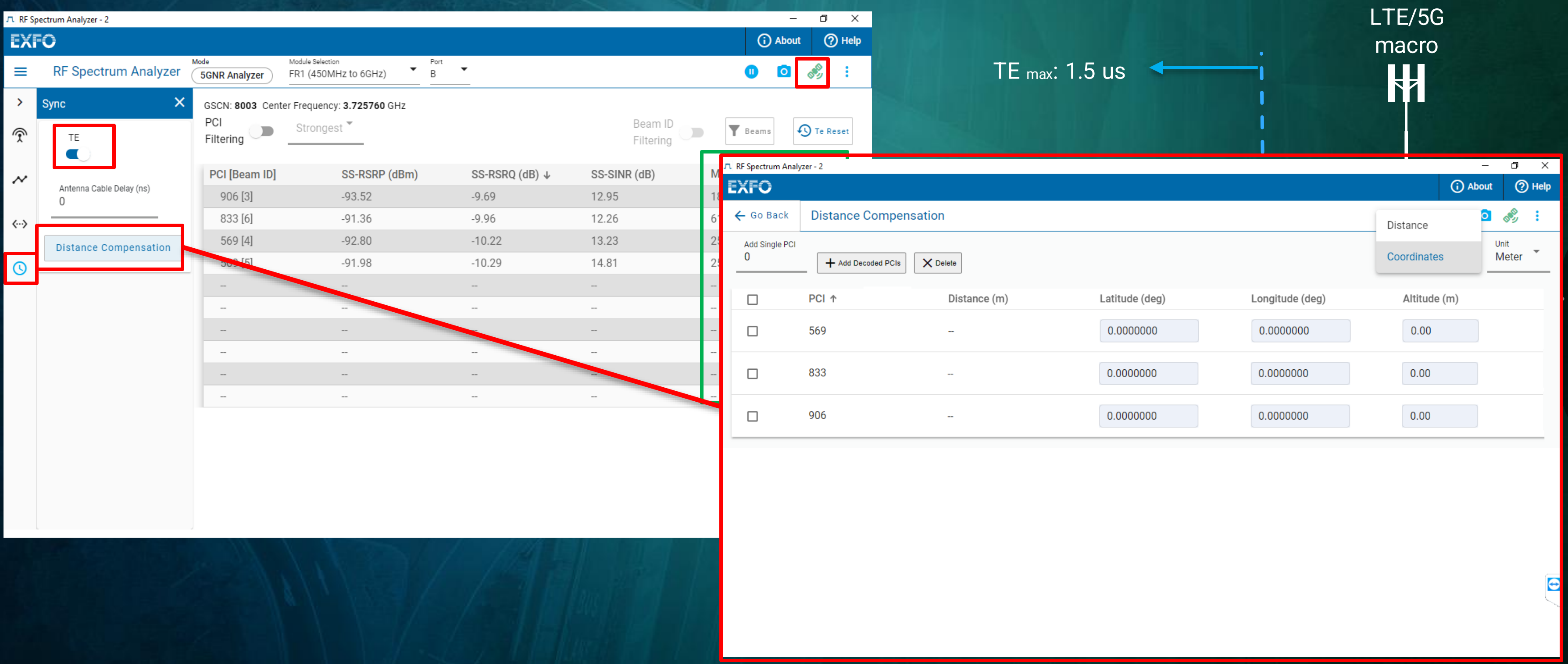

Distance compensation: The 1.5us is referenced at the tower antenna directly. As it is not practical to perform the measurement directly up the tower but rather some distance away under the coverage, the propagation delay (distance to antenna) must be compensated. @3.33ns per m

5G and RF main challenges in field testing

1. Fiber & transport check
2. Spectrum Verification
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4. Synchronization and 5G RF performance
5. 5G NSA bad RSSI levels

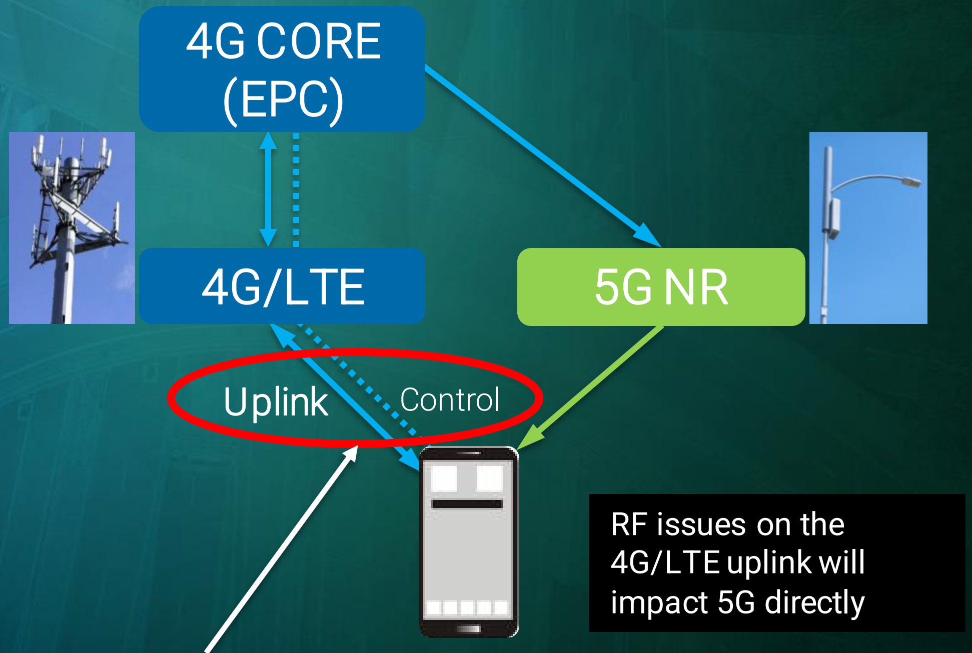
5 5G NSA wrong RSSI levels

CHALLENGES

Looking across the BW of a site, multiple interferers can be identified, and the challenge is determining which one is affecting the site under test.

For most installations, access to the RF segment of the RAN is challenging, so a different method of testing Is needed

5G Non-StandAlone (NSA)

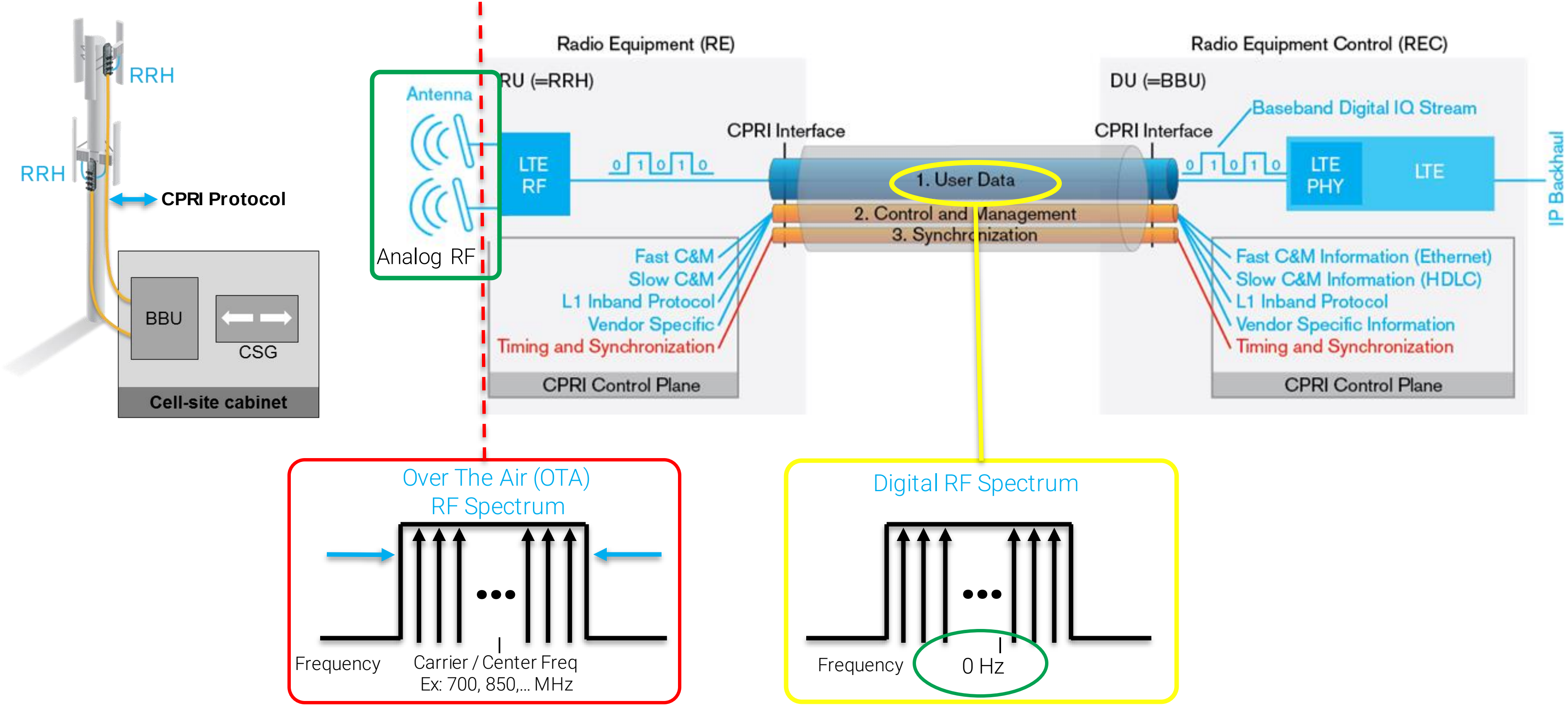


RF over CPRI on 4G/LTE Uplink

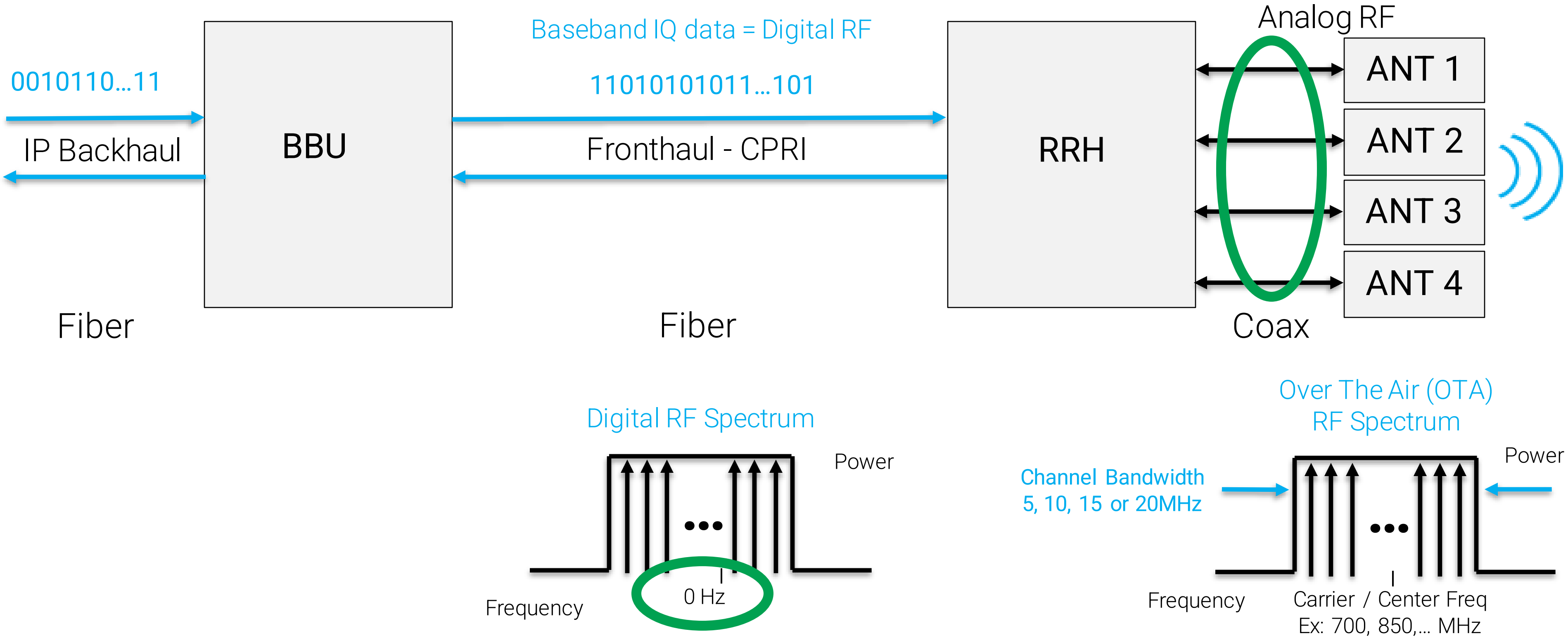
Use case **TROUBLESHOOTING**

Application **iORF/ SPECTRUM ANALYZER**

CPRI Communication Flows



Mobile Communication
IP ←→ Digital RF ←→ Analog RF



5 5G NSA bad RSSI levels

CHALLENGES

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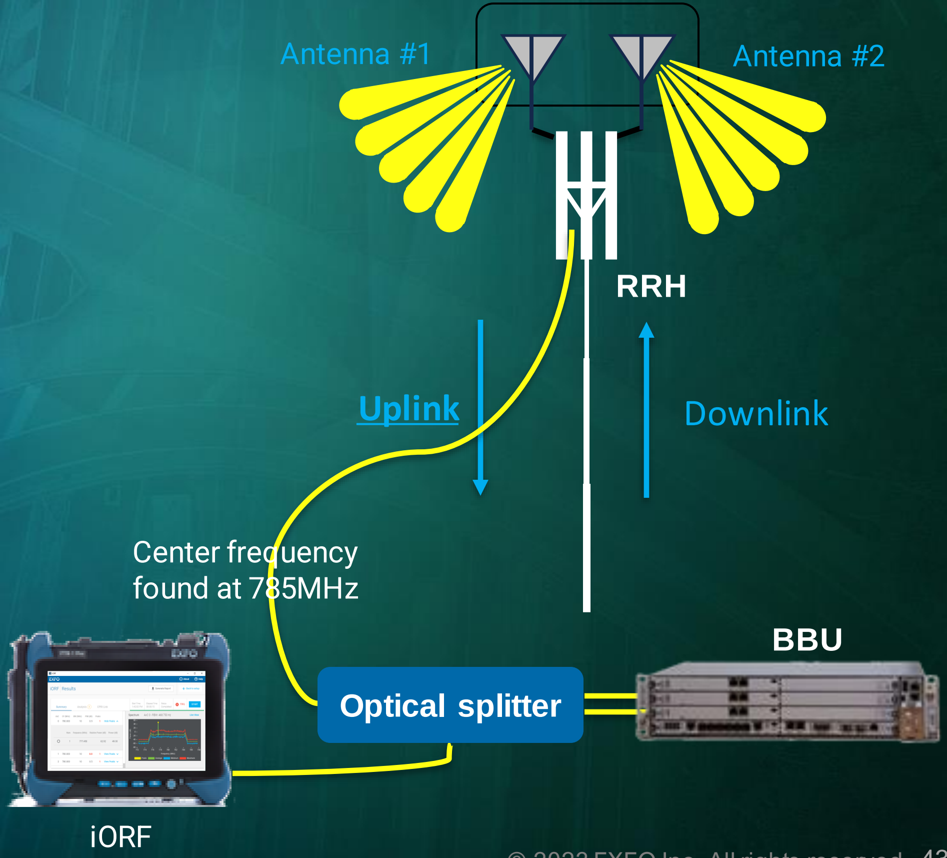
SOLUTIONS

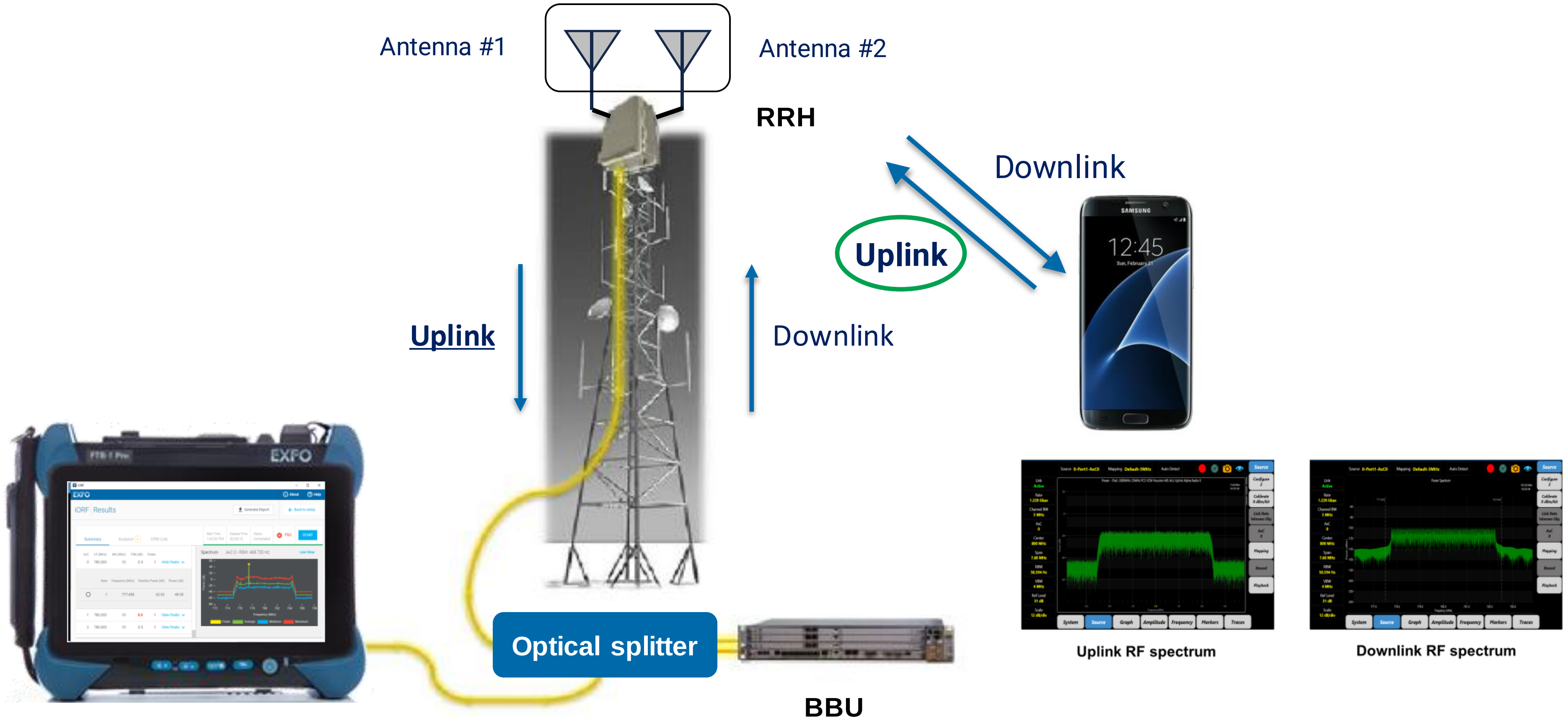
Analyze spectrum over CPRI with iORF to look for issues and determine whether internal or external.

If external, user regular Spectrum Analyzer to hunt.



Use case	TROUBLESHOOTING
Application	iORF/ SPECTRUM ANALYZER

Uplink or Downlink?



Glossary

RTSA: Real time spectrum analyzer

RSSI : Received signal strength indicator.

TDD: Time domain division

eMBB (enhanced Mobile Broadband)

URLLC (Ultra Reliable Low Latency Communications)

mMTC (massive Machine Type Communications)

SSB : synchronisation signal Bloc

CSI-RS SINR: Channel State Information Reference Signal-to-noise and interference ratio

PDSCH SINR: Physical Downlink Shared Channel Signal-to-noise and interference ratio

SS-SINR: SS signal-to-noise and interference ratio (in the SSB)

SS-RSRP: Synchronization Signal reference signal received power

SS-RSRQ: Secondary synchronization Signal Reference Signal Received Quality

SSS : secondary sync signal

PSS : Primary sync signal

PBCH: Physical Broadcast channel

AoA: angle of arrival

ToA: time of arrival

TDD: Time Division Duplex

FDD Frequency Division Duplex

PTP: Precision Time Protocol

PCI: Physical cell ID

Ref:

https://www.youtube.com/watch?v=lixbaIEPglQ

Questions?

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