

HOW TO TEST 5G NR NETWORKS

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Technology Marketing Mobile Network Testing

ROHDE&SCHWARZ
Make ideals real



TELECOM INFRA EVENT 2019

26 SEPT 2019

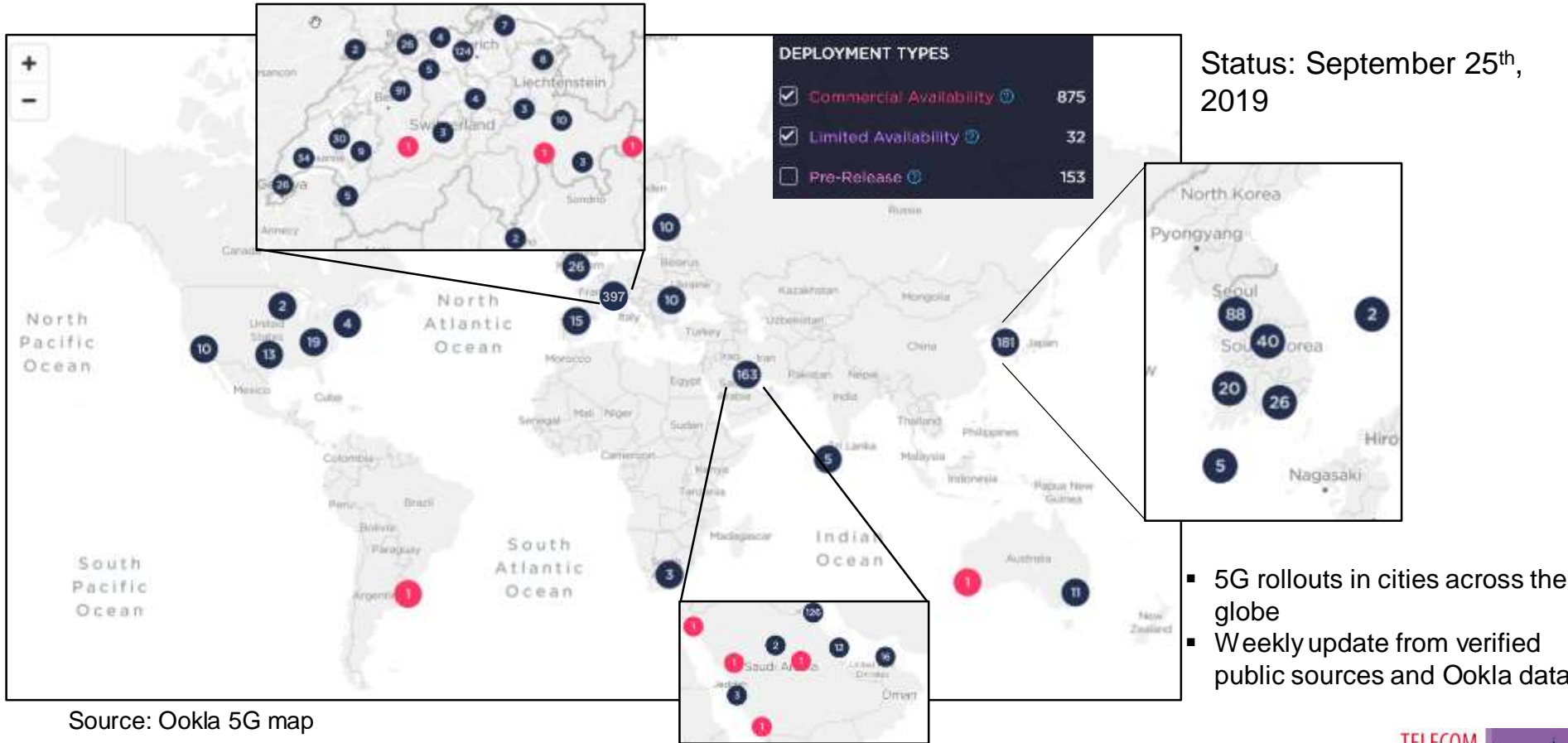
BREEPARK BREDA

CONTENTS



- **5G rollout status and key challenges**
- 5G NR network testing technology and challenges
- 5G network measurement results (3.7 GHz, 28 GHz)
- Conclusion

THE STATUS OF COMMERCIAL AND LIMITED 5G NR AVAILABILITY

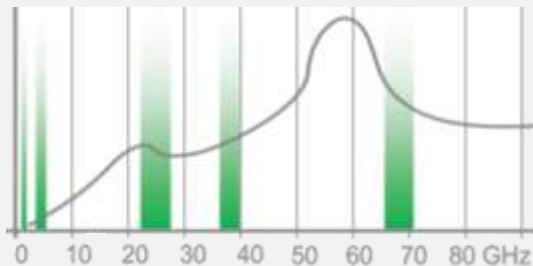


Source: Ookla 5G map

KEY CHALLENGES RELATED TO 5G NR RAN

New spectrum

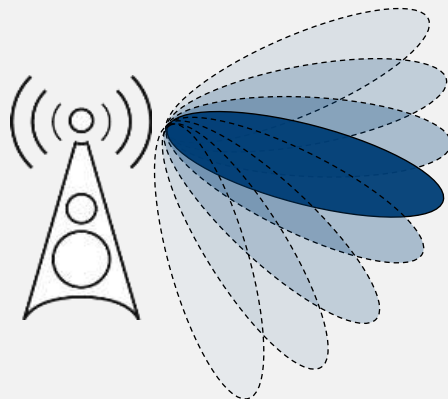
- Even 3.5 GHz is different from today's frequencies



- What about coverage?
- Spectrum clearance?

Beamforming for Synchron. and Broadcast Signals

- How does beamforming work?



Flexibility of air interface and gNB configuration

- Bandwidth:
5, 10, 15, 20, 25, 30, 40, 50, 60, 80, 90, 100 MHz (FR1)
50, 100, 200, 400 MHz (FR2)
- Subcarrier Spacing:
15, 30, 60 kHz (FR1)
60, 120, (240) kHz (FR2)
- Mapping onto antenna ports:
single beam / multi beam
sweeping

➤ **New technology elements drive the need for (and complexity of) 5G NR network measurements**

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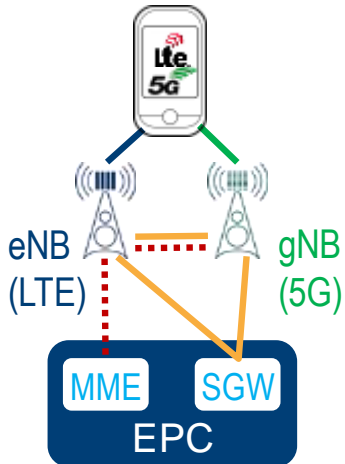
ARCHITECTURE OPTIONS

OPTION 3 IS PRIORITY 1 IN 3GPP, FOLLOWED BY OPTION 2

Non-standalone

Option 3:
EN DC: E-UTRA-NR

eNB is the
Master Node



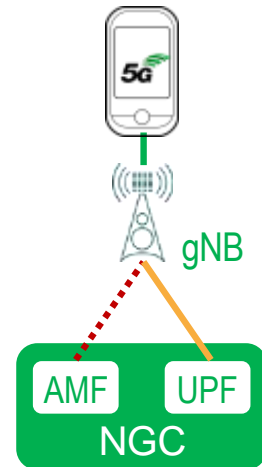
gNB is the
Secondary Node

— Data
..... Control

Network testing
needs to include
5G + LTE !

MME = Mobility Management Entity
S-GW = Serving Gateway

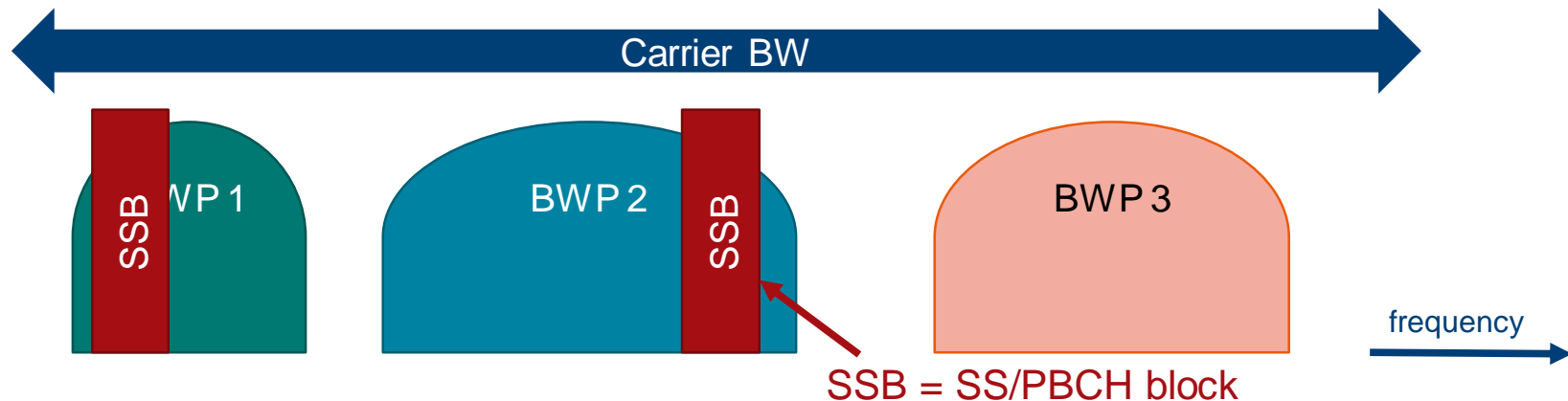
Option 2:
Standalone



AMF = Access and Mobility Management Function
UPF = User Plane Function

HOW CAN A UE IDENTIFY A 5G CARRIER?

First action of UE looking for 5G cell: search for Synchronization Signals



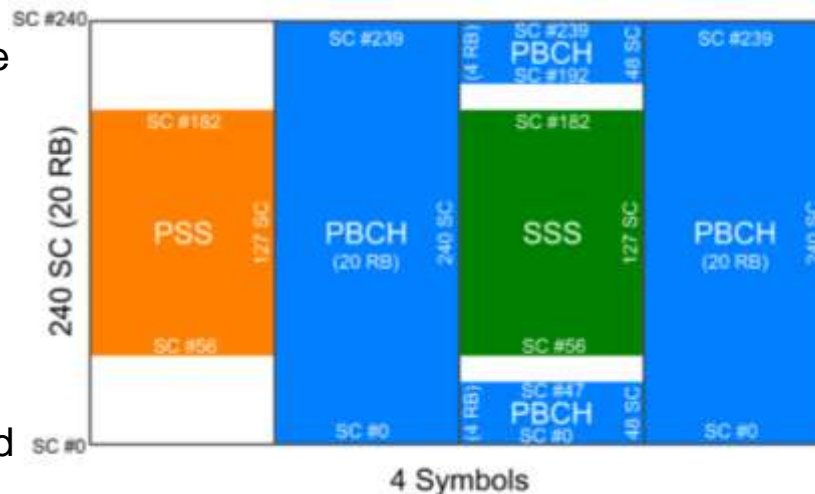
- One SSB is always transmitted → **the only Always-On signal in 5G NR!**
BUT: it is not easy to find!
- The 5G NR UE uses the SSB for
 - Synchronization
 - System information (MIB/SIB)
 - Cell and Beam quality measurements

BWP (BandWidth Part): contiguous subset of physical resource blocks within the overall carrier bandwidth

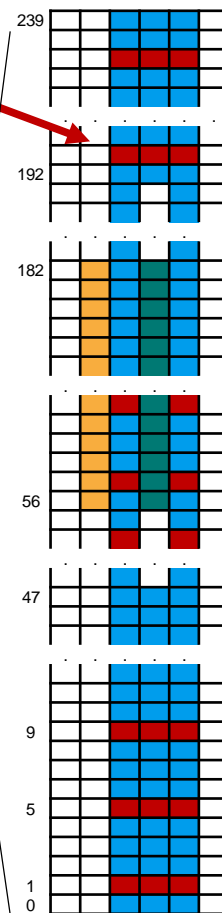
SS/PBCH BLOCKS = SSB

- ▶ Time domain:
SSB consists of 4 OFDM symbols, where PSS, SSS and PBCH with associated DM-RS occupy different symbols
- ▶ Frequency domain:
SSB consists of 240 contiguous subcarriers
- ▶ Like in LTE the Cell ID can be determined from the used PSS/SSS sequences

Synchronization Signal Block = SSB



DM-RS



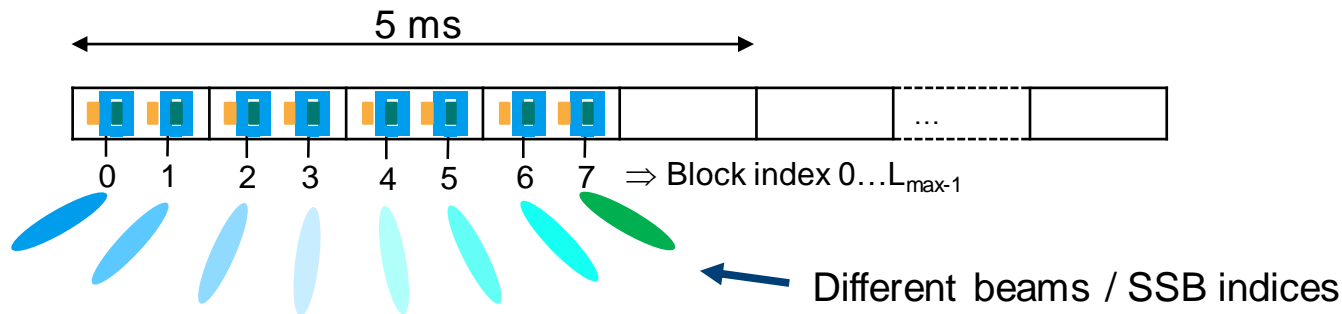
PSS: Primary Synchronization Signal SSS: Secondary Synchronization Signal
PBCH: Physical Broadcast Channel DM-RS: DeModulation Reference Signal

SSB AND DIFFERENT BEAMS – „BEAMFORMING“

- ▶ Demodulation of the PBCH → determines the SSB **index** and
→ distinguishes between the periodically broadcasted SSBs
- ▶ Each SSB uses different DM-RS embedded in the PBCH (FR1: PBCH in 3 OFDM symbols, in each symbol PBCH DM-RS sequence is initialized differently → $2^3 = 8$ options)
- ▶ Example: Case A with subcarrier spacing of 15 kHz and 8 SSB indices

Case A (15 kHz)

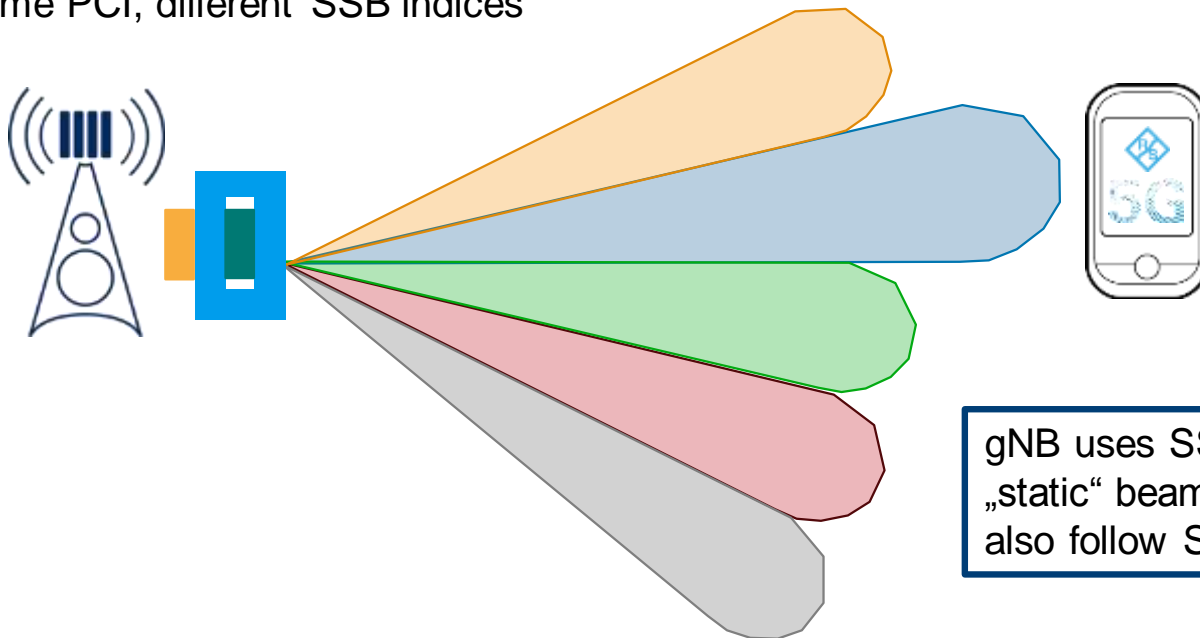
$3 < f \leq 6$ GHz ($L=8$)



➤ **Beamforming of synchronization signals and broadcast information via 5G NR SSBs**

5G NR: SIMPLE BEAMFORMING

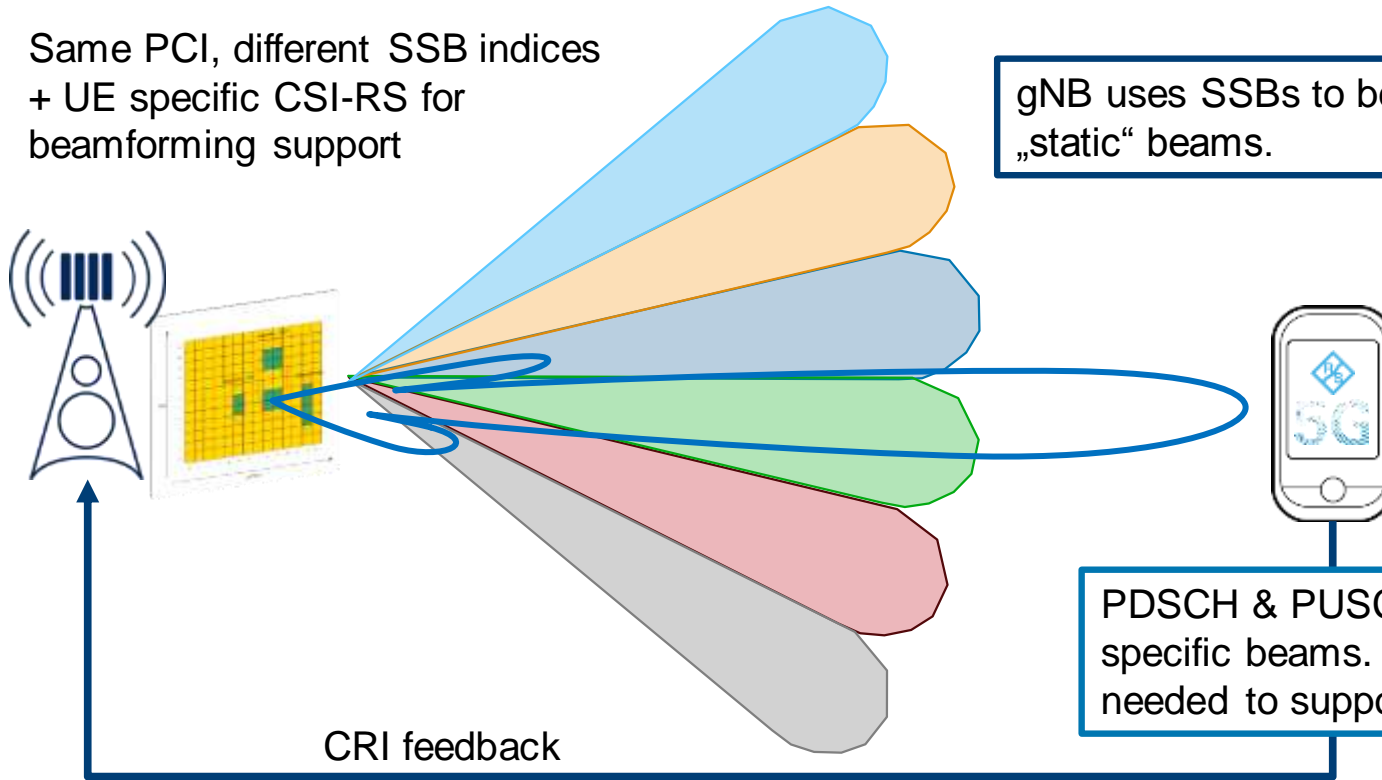
Same PCI, different SSB indices



5G NR: ENHANCED (UE SPECIFIC) BEAMFORMING

Same PCI, different SSB indices
+ UE specific CSI-RS for
beamforming support

gNB uses SSBs to be mapped on
„static“ beams.



PDSCH & PUSCH will be on UE
specific beams. CSI-RS and reporting
needed to support beam adjustment

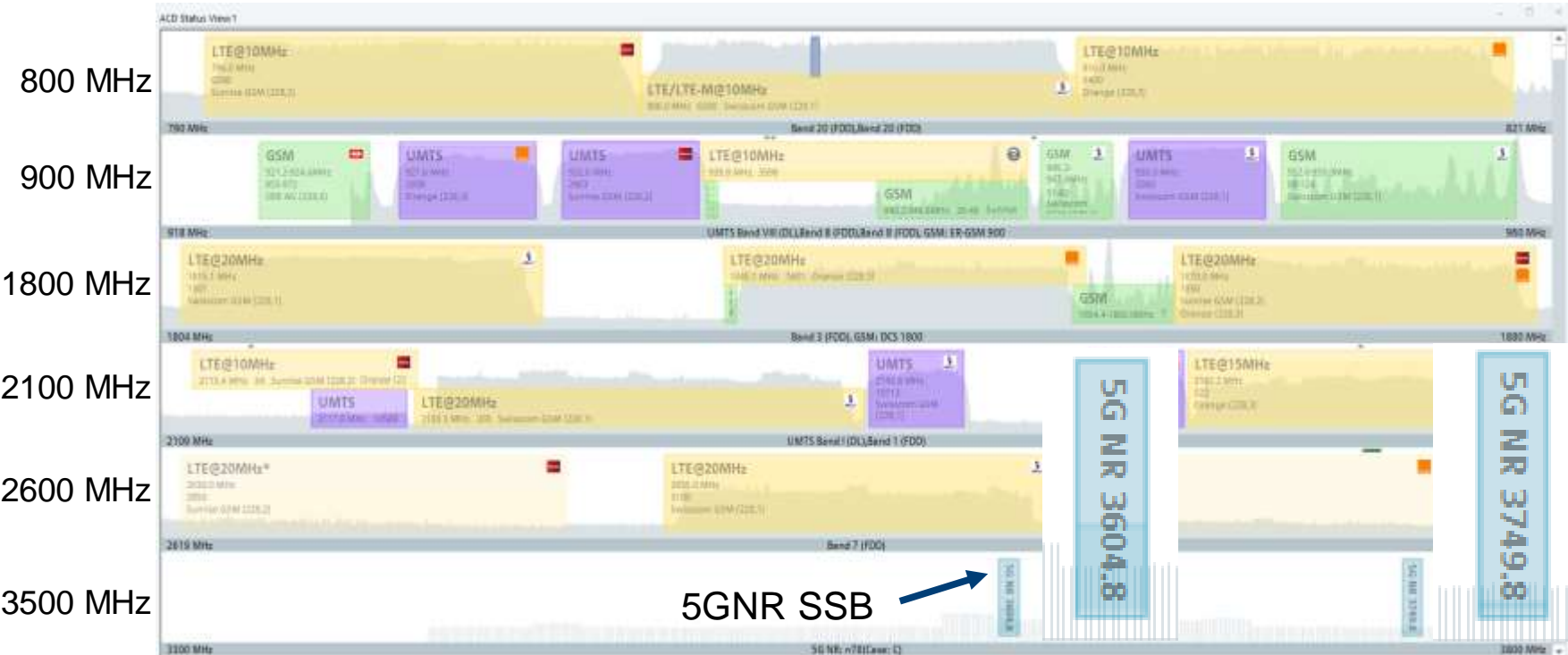
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HOW TO FIND THE SSB EASILY? OFTEN SSB FREQUENCY IS NOT KNOWN IN 5G TRIALS

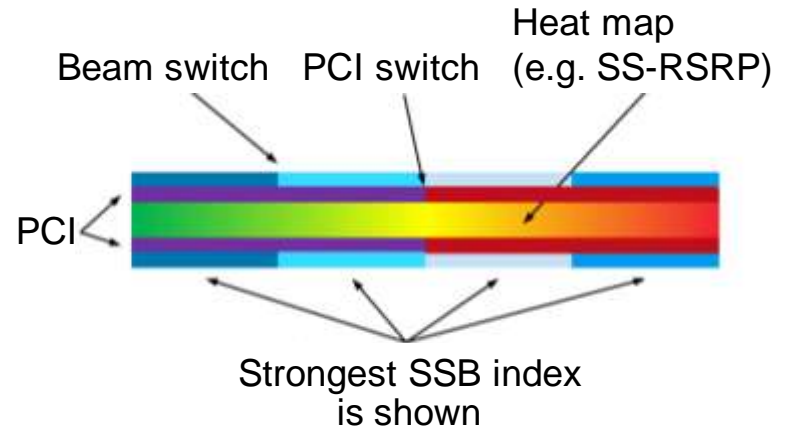
Wouldn't it be good to find it automatically?



It's available: Automatic Channel Detection (ACD)

HOW TO VISUALIZE THAT BEAMFORMING WORKS?

- ▶ Each SSB index can be mapped to a certain physical beam

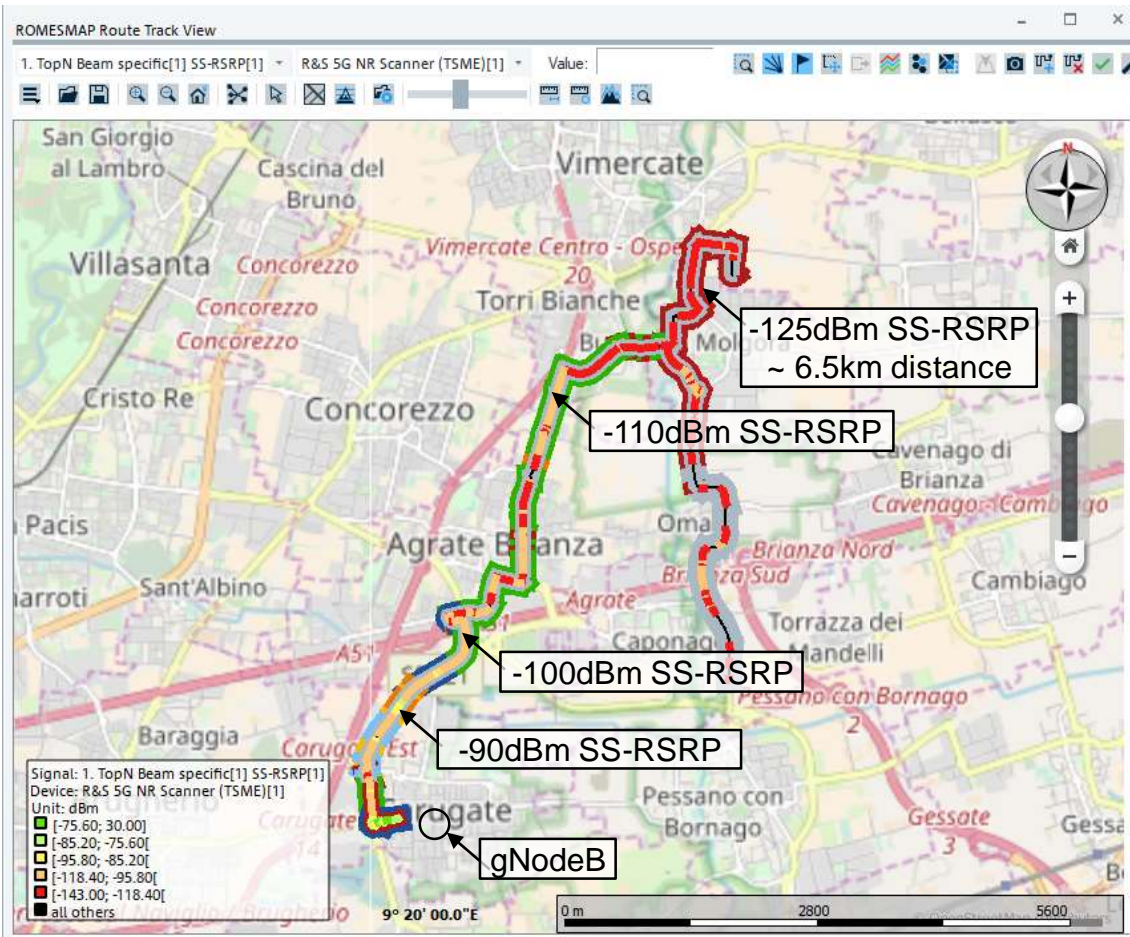


- ▶ Visualization: strongest SSB index on a map
→ Focus on the outer colour layer



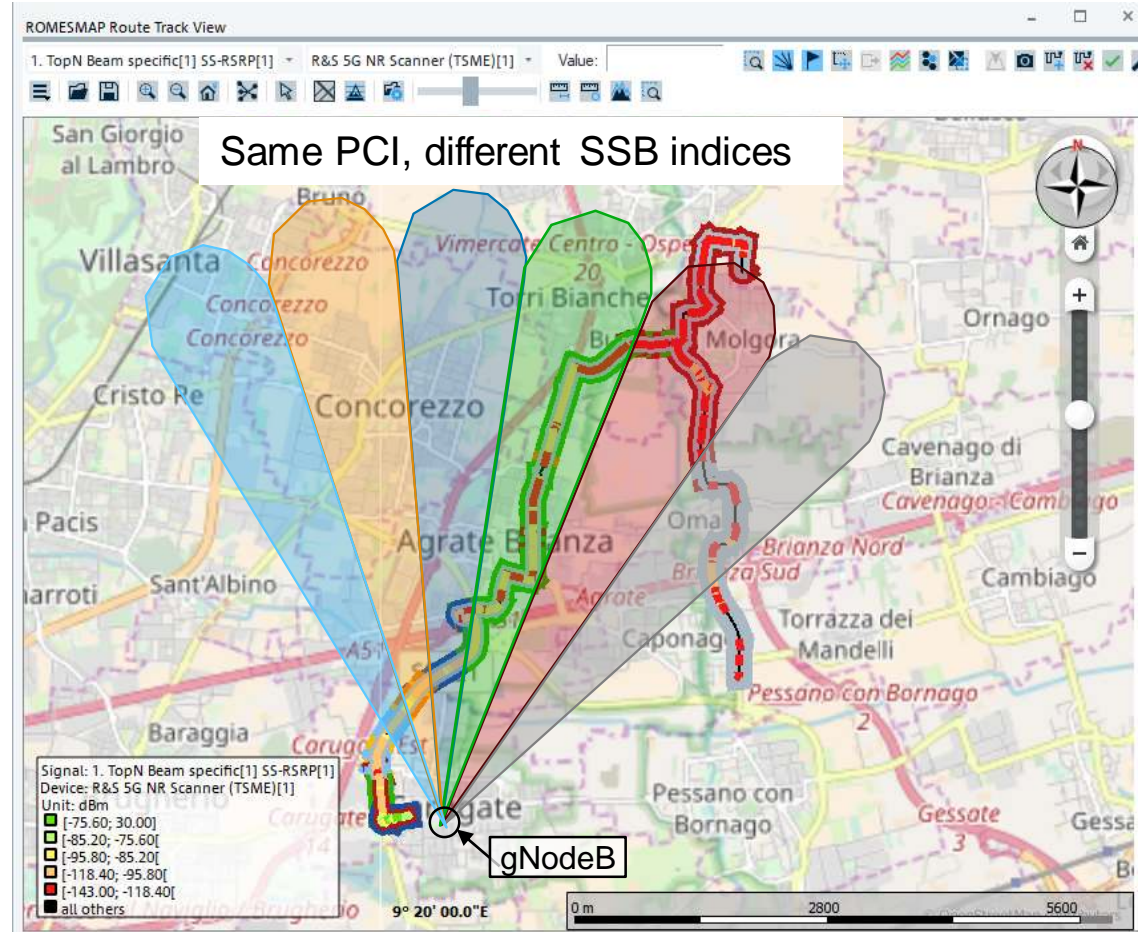
MAIN TAKE-AWAY – COVERAGE

- ▶ Expected UE sensitivity: ~ -120 dBm (SS-RSRP)
- ▶ Surprisingly good SSB coverage in suburban area (3.7 GHz)
- ▶ Analog SSB beamforming allows for long radio range



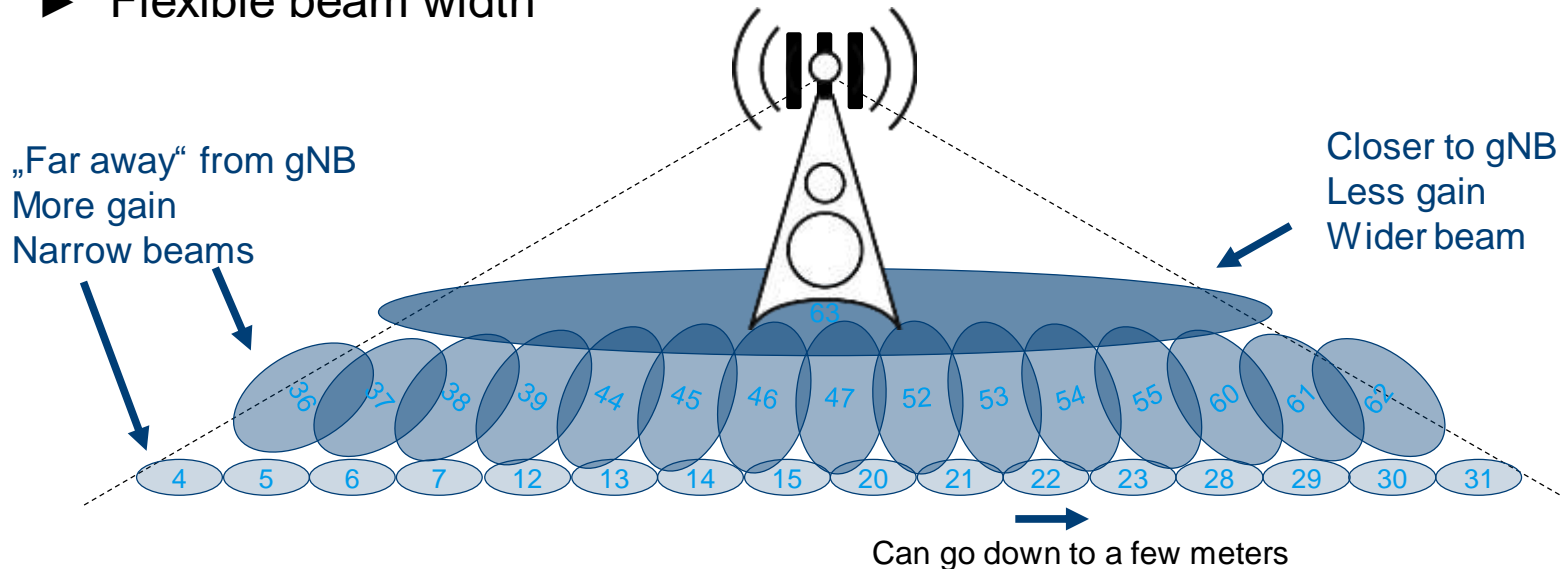
MAIN TAKE-AWAY – SSB / BEAM RANKING

- SSB / beam index visualized over time (history) and on the map
- Surprisingly good match with horizontal “micro sectors” (SSB beam indices)

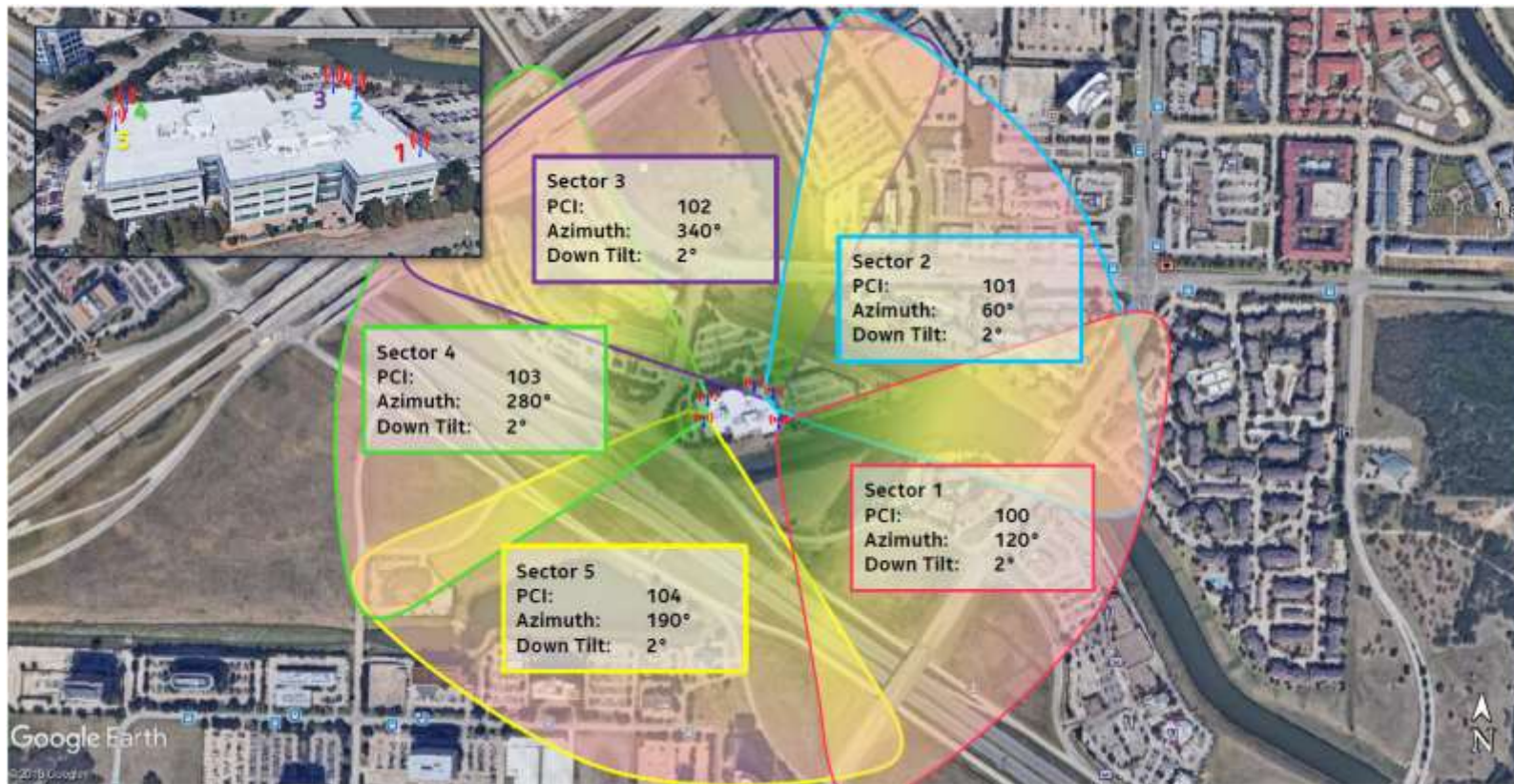


MILLIMETER WAVE NETWORKS - BEAMFORMING AT ITS BEST

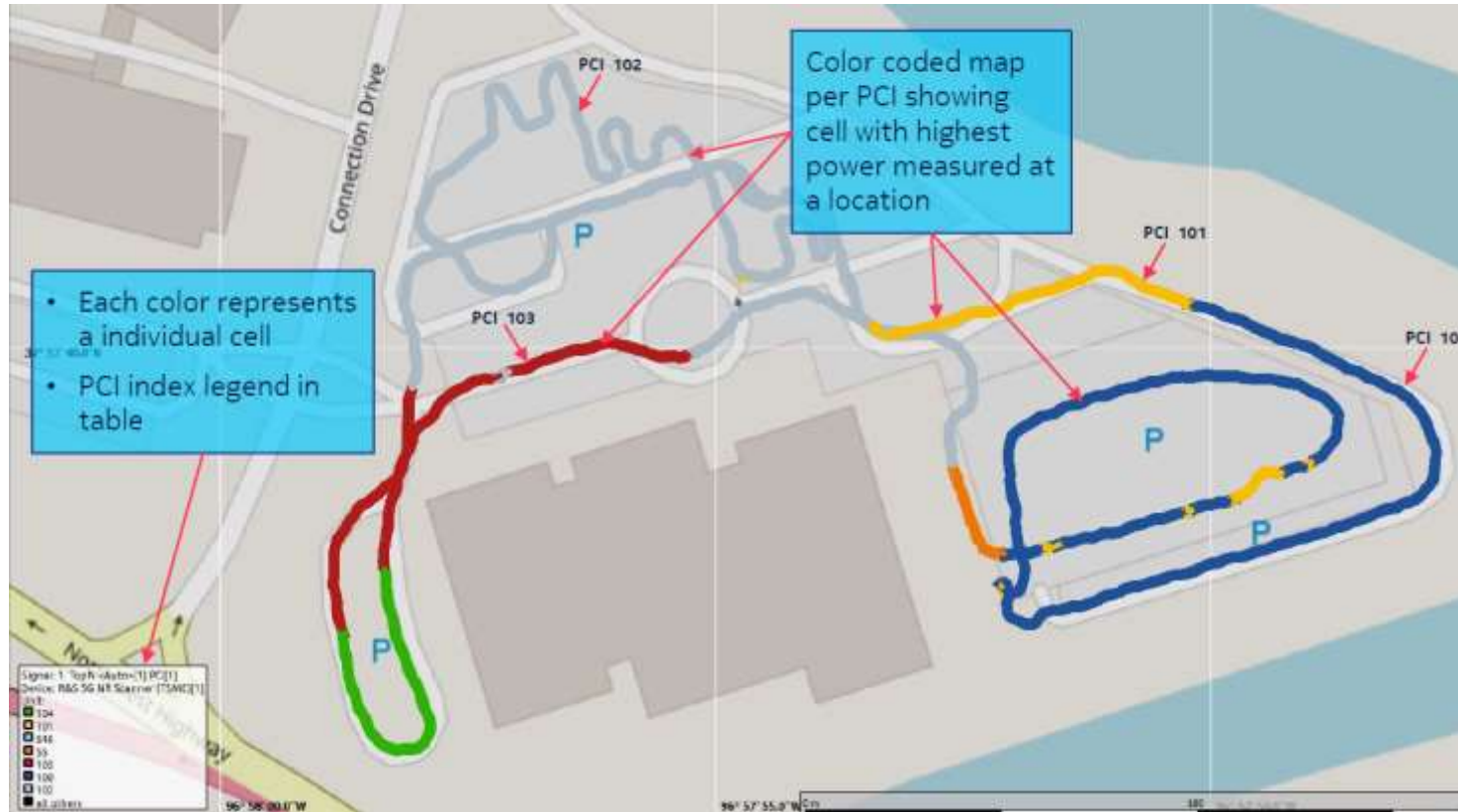
- ▶ Massive number of antenna elements („massive MIMO“) → max. 64 SSB beams
- ▶ SW controlled phased array antenna
- ▶ Ultra precise beamforming
- ▶ Flexible beam width



TRIAL NETWORK 28GHz



PCI / CELL COVERAGE EVALUATION IN THE FIELD



► Focus on PCI

BEAMFORMING EVALUATION IN THE FIELD



- ▶ PCI 102
- ▶ Focus on best beam (SSB index)

„Massive beamforming“ can be evaluated in the field

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5G NR NETWORK MEASUREMENT SOLUTION



Ultra-compact network scanner



Autonomous network scanner



5G NR Software for network engineering, analysis and optimization (in-field, real-time) running on laptop or NUC PC in Autonomous scanner

For comfortable walk tests



plus downconverter for 28 / 39 GHz frequency bands

➤ **Industry's first commercially available 5G NR network measurement solution launched by Rohde & Schwarz Mobile Network Testing in Sept 2018**

R&S TEST SOLUTIONS TO DEPLOY 5G NR NETWORKS

Spectr. Clearance / Interfer. Hunting



Network scanner



Spectrum Analyzers
TDD gated trigger



Monitoring receiver



MobileLocator

Site Acceptance



Site Testing Solution



Smartphone-based SW

5G NR network measurement solution

Passive measurements



Network scanner



Shoulder bag



Backpack for mmwave

Active measurements



5G Router

Mobile Test Platform

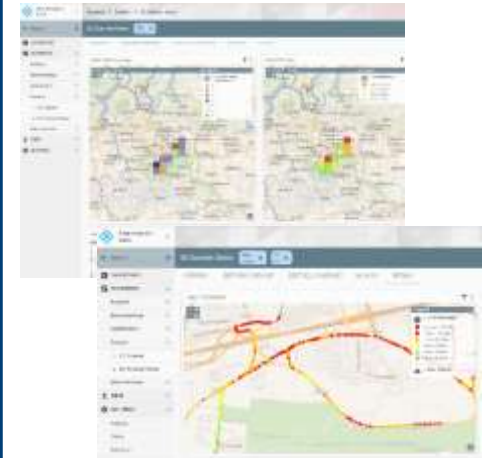


Smartphone-based SW



Data Analytics

Postprocessing SW



Postprocessing SW - NPS



CONCLUSION

5G NR commercial rollout running now – many pre-commercial trials!
Commercial 5G NR smartphones available on the market

5G NR network measurements need to cope with high flexibility, configurability and complexity of new technology elements

Commercial 5G NR network measurement solution available by Rohde & Schwarz

Verification of coverage and SSB beamforming in many networks with R&S

➤ **Rohde & Schwarz MNT is committed to support the industry with network test solutions from early trial phase to network optimization and benchmarking**

<https://www.rohde-schwarz.com/MNT-5G>

<https://blog.mobile-network-testing.com/>