Mobile Network Testing

Challenges and Measurements in terrestrial and non-terrestrial networks

Arnd Sibila
Technology Marketing Manager
Mobile Network Testing

ROHDE & SCHWARZ
Make ideas real
White spots of Mobile Communication (status Jan. 2024)

We immediately think about oceans, deserts and outlands. Example: Bavaria in Germany

- Are there white spots in Bavaria?
  - Only 2G / GSM: 3.56% of area
  - Coverage hole: 0.57% of area
  - Grey spots (only 1 operator): 17.57% of area

- You cannot “measure” the coverage of a 100% area
  - Typical benchmarking campaigns cover 25% of the population area (QoE comparison)
  - Using drive and walk tests or even “fly” tests
  - Even Crowdsourcing data is only available where people are.

Source: BNetzA (Gigabit-Grundbuch)
What about 5G / LTE license obligations (status Nov. 2022)

Example: Bavaria in Germany

- 100 Mbps on federal streets and regional train tracks? LTE+5G measurements in Nov. 2022

<table>
<thead>
<tr>
<th>Bavaria</th>
<th>Federal streets &gt; 100 Mbps</th>
<th>Federal streets &lt; 100 Mbps</th>
<th>Train tracks &gt; 100 Mbps</th>
<th>Train tracks &lt; 100 Mbps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator 1</td>
<td>81.9 %</td>
<td>18.1 %</td>
<td>78.5 %</td>
<td>21.5 %</td>
</tr>
<tr>
<td>Operator 2</td>
<td>90.0 %</td>
<td>10.0 %</td>
<td>89.6 %</td>
<td>10.4 %</td>
</tr>
<tr>
<td>Operator 3</td>
<td>89.4 %</td>
<td>10.6 %</td>
<td>81.9 %</td>
<td>18.1 %</td>
</tr>
</tbody>
</table>

You can “measure” the coverage and performance of a defined area!

- Typical benchmarking campaign using a standardized test method (ETSI TR 103 559)
  - Passive tests using network scanners
  - Active tests using smartphone-based test solution → Network Performance Score acc. to ETSI

https://www.stmwi.bayern.de/fileadmin/user_upload/stmwi/Foerderungen/Mobilfunkinitiative/Abschlussbericht_Mobilfunk-Messungen_Bayern_2022_StMWi.pdf
To close coverage holes - Non-Terrestrial Networks (NTN)

- Mobile communication via satellites to close white spots of terrestrial networks

<table>
<thead>
<tr>
<th>Type of satellite</th>
<th>Altitude range</th>
<th>Typical beam footprint</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEO (Low-Earth Orbit)</td>
<td>300 – 1500 km</td>
<td>100 – 1000 km</td>
</tr>
<tr>
<td>MEO (Medium-Earth Orbit)</td>
<td>7000 – 25000 km</td>
<td>100 – 1000 km</td>
</tr>
<tr>
<td>GEO (Geostationary Earth Orbit)</td>
<td>35 786 km</td>
<td>200 – 3500 km</td>
</tr>
</tbody>
</table>

Constellation of multiple LEO satellites (some 100 to several 1000) to create a ‘net’ around Earth.

- LEO#1 in 1000 km altitude takes ~ 90 minutes to circle Earth
  - Beam footprint: LEO#1 visible for 1-2 min every 90 minutes (fixed beams, longer for steerable beams) → LEO network
- Direct-to-Cell (DTC) uses terrestrial spectrum that is allocated per country! What about borders?

Mobile communication via satellites to close white spots of terrestrial networks

LEO#1 in 1000 km altitude takes ~ 90 minutes to circle Earth

- Beam footprint: LEO#1 visible for 1-2 min every 90 minutes (fixed beams, longer for steerable beams) → LEO network
- Direct-to-Cell (DTC) uses terrestrial spectrum that is allocated per country! What about borders?
Example - FCC SCS - Supplemental Coverage from Space

► SCS operator must have a spectrum lease arrangement (from terrestrial licensee(s))
► SCS Bands - Implemented as bi-directional, secondary MSS (Mobile Satellite Service)
  - 600 MHz: 614 - 652 MHz and 663 - 698 MHz
  - 700 MHz: 698 - 769 MHz, 775 - 799 MHz, and 805 - 806 MHz
  - 800 MHz: 824 - 849 MHz and 869 - 894 MHz
  - Broadband PCS: 1850 - 1915 MHz and 1930 - 1995 MHz
  - AWS-H Block: 1915 - 1920 MHz and 1995 - 2000 MHz
► Power flux-density and in-band field strength
  - 40 dBµV/m for the 600 MHz, 700 MHz, and 800 MHz bands
  - 47 dBµV/m for the AWS and PCS bands
  - aggregate field strength (earth’s surface) by all visible beams and satellites providing service
► Certification of terrestrial devices: license by rule!
► the terrestrial licensee’s license parameters apply
► Interim 911 text and call routing requirements
  - Dedicated/appropriate SCS PSAP
Example: Coverage measurement of NTN LTE signal

- Scanner measurements of a LEO satellite network transmitting a standard LTE signal
- -120 dBm RSRP limit for smartphones
- ~ 90 minutes

May 2024
NTN – Technical challenges and what to measure passively?

- **Coverage / Propagation loss** – it’s a long way!
  - Cell Reference Signal Measurements in Downlink (RSRP, RS-SINR, RSRQ)

- **Doppler shift** – LEOs are fast!
  - In terrestrial networks: smartphone is moving in a car or train
  - Here, the “base station” (satellite) is moving with 8km per second!

- **Spectrum Utilization** – Case: Unmodified NTN with leased spectrum
  - Monitoring of NTN Band blocks
  - Expected NTN Channels vs Interfering NTN Channels from neighbor countries/regions

- Passive testing with network scanner
NTN – Technical challenges and what to measure actively?

- Coverage / Propagation loss
  - Cell Reference Signal Measurements in Downlink (RSRP, RS-SINR, RSRQ)
  - How to reach the satellite in Uplink direction?
    - Random Access (RACH): Success Rate and Response time
    - NB-NTN: Coverage enhancement repetitions (CE level)

- Cell Movement
  - Tracking Area Update: Success Rate and Interval

- Large Delays
  - Interactivity Testing: Round-trip Latency, Packet Loss, Packet Delay Variation, (also One-Way)

- Application testing: Messaging and Data Transfer (acc. to ETSI TR 103 559 test method)
  - SMS Testing: Success Rate, Send Duration, E2E Delivery Time
  - Small Data Transfer Testing (NB-NTN)

- Passive testing with a smartphone (QualiPoc Android SW)
Regulatory challenges / questions

► Many technical topics (KPIs) can be measured with passive and active testing solutions already now.
► But what about regulatory questions?

Examples:
► Spectrum Utilization in Direct-to-cell mode:
  – What will the regulators require to measure?
► Monitoring of NTN Band blocks:
  – What happens at country borders?
► Roaming issues:
  – various satellite constellations, various operator cooperations, various SIM/eSIM in unmodified devices, what interworks?

Thank you!  www.rohde-schwarz.com/mnt