Antenna and Basestation Testing Challenges

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Target Account Management
Agenda in brief ….

- BTS Installation and Antenna Measurements
- Passive Intermodulation Measurement - PIM
- Over-the-Air Measurements
- Interference Hunting & Spectrum Clearance
Increasing Number of BTS Rollout & Installation

- Market Estimation 2015 to 2020
  - 30-40 Frequencies → today
  - 70-80 Frequencies → 2020 (incl. Small Cell)

BTS integrated test cases causes changes for
- VSWR
- Intermodulation
- RF-Spectrum Uplink

Small Cell BTS causes new complex network behavior
- Interferences
- Network Planning
- Optical

Active Antenna & 4X4 MIMO causes optical installations

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Site Installation is fundamental for Radio Networks

Three Step Site Measurement Concept

Performance of the Site

Radio Quality = Service Quality

Measurements are key for the service quality!
Agenda

- **BTS Installation and Antenna Measurements**
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Why do we need Cable and Antenna Measurements today?

- To ensure cable and antenna are properly installed before connecting to base station
- To prevent push of responsibility due to many contractors/vendors involve
  - Cable & antenna provider/installer
  - Base station vendors
- Minimize later trouble shooting

- 3 Sector Site to 6 Sector BTS incl. RET, 4X4 MIMO, integrated TMA
What can go wrong ..... 

Antennas
- Poor antenna isolation/matching
- Loose connectors
- Transport or weather damages

TMA and Ext. Components
- Gain problems
- Internal Filter problems
- A&E handling problems

Cables
- Poor or corroded cable connection
- Poor isolation or ground
- Damaged or broken cables
- Unpaired or interchanged cables

Connectors
- Improperly installed connectors
- Weather (entrapped moisture) problems
Cable and Antenna Measurements, still needed ...

Legacy / Macro

1 Port measurements
- Feeder / Jumper Return Loss / VSWR
- Distance to Fault (DTF)
- Antenna VSWR
- Cable insertion loss

2 Port measurements
- Antenna decoupling
- TMA gain test

Can be very long and complex in an In-Building-Solution

BS with RRH

RF jumper cable

RRH (RF/Modulation)

Fiber Optic (I/Q data)

Base band processing

TMA

RF jumper cable

Base band processing & RF / Modulation
Antenna analysis example

- Response is most commonly displayed as VSWR (voltage standing wave ratio) or magnitude.

- For magnitude, we want the maximum return loss dB (most negative value).

- For VSWR, we want a value as close to 1 (perfect match) as possible.

<table>
<thead>
<tr>
<th>No reflection</th>
<th>Total reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\infty$ dB</td>
<td>Return loss</td>
</tr>
<tr>
<td>1</td>
<td>Voltage standing wave ratio (VSWR)</td>
</tr>
<tr>
<td>0</td>
<td>Reflection coefficient $</td>
</tr>
</tbody>
</table>
Cables can be damaged during manufacturing, delivery, or installation. Damaged cables may cause loss of signal, high levels of reflected power, interference, and other issues.

By injecting a pulse into one end of the cable and measuring the reflected power vs. time, we can determine where the fault (or "normal" end of the cable) is.

Distance to fault measurement results can be provided graphically or in a table.

The parameters of interest are both the location of the fault (meters) and the magnitude of the returned signal (in dB).

A "fault" is usually defined by the magnitude of the reflection (e.g. connectors create lower level reflections than true faults).
Aligned Test Setup and Test Result Reporting becomes time extensive factor $\rightarrow$ Wizard and Report Generator

1. Centralized configuration

2. WIZARD guided measurements execution

3. Standardized reporting
Aligned Test Setup and Test Results
R&S Mobile View 1.0 for Android is live, via google play store.

https://play.google.com/store/apps/developer?id=Rohde+%26+Schwarz+GmbH+%26+Co.+KG&hl=en
R&S Mobile View currently supports instrument series FSH, ZVH and FPH.
Agenda

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- **Passive Intermodulation Measurement - PIM**
- Over-the-Air Measurements
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What is a PIM Analyzer?

PIM analyzers are specialized, self-contained instruments designed to test the linearity of an RF path.

These analyzers transmit two specific test tones into the system under test and measure the magnitude of the noise generated at a specific intermodulation frequency in order to “characterize the linearity” of that system.
What is a PIM Analyzer?
Agenda in brief ....

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Over-The-Air (OTA) Measurements for Outdoor & Indoor
Conducted vs. OTA measurements

Conducted measurements:
- Cable loss power
- Distance to fault
- Reflected power (VSWR, return loss)
- Transmitted power
- Insertion loss
- Gain
- Decoupling
- Passive intermodulation

Over the Air measurements:
- Spectrum monitoring
- Interference hunting
- Demodulation of pilot channels
- DL resource block allocation
- MIMO measurements
- Carrier aggregation measurements
- Functional testing

R&S®ZVH
R&S®ZPH
PiMPro Tower
R&S®FPH
R&S®FSH
R&S®PR100
QualiPoc Android
R&S®TSMA

Antenna and base station testing challenges
Over-The-Air (OTA) Measurement

Standard Spectrum Measurements

- Channel Power
- Occupied Bandwidth
- Power on pulsed signals (TDMA-Power)
- ACLR
- Spectrum emission mask
- Spurious emissions
- Harmonic distortion
- AM modulation depth
Over-The-Air (OTA) Measurement

RF Measurements - LTE

- Measurement of:
  - Constellation diagram
  - BTS Scanner
  - Resources allocation
Over-The-Air (OTA) Measurement

RF Measurements - LTE (Carrier Aggregation/MIMO)

- For LTE FDD / LTE TDD
- Measures 2 or 3 carriers over the air (OTA)
- User is setting Frequency and Bandwidth
- Main RF parameters displayed
- Pass indication is displayed if Cell ID is same
- Antenna values are greyed out if results are out of range (one of the antennas is not received)

- Application: quick check whether the CA feature is working OK during base station installation and maintenance
Carrier aggregation measurements on LTE-Advanced

R&S®FSH
✔ Measures 2 or 3 carriers over the air
✔ Friendly interface: user needs to set frequency and BW, the rest is automatic
✔ Available for FDD and TDD
The final test

Functional testing

- BTS components correctly installed
- BTS components tested
- Spectrum is clean
- BTS pilot channels are available
- User experience

[Image of a cellular tower labeled Base Band Unit (BBU)]
Network Scanning Tools

- Non-intrusive passive Scanners
- Subscribed UEs / Mobiles
  → Combination is best

What about…

- Detection of crossed feeders, broken feeders…
- System internal interference optimization (pilot pollution)
- Uplink / Downlink interference detection (Spectrum measurement)
- Decoding of BCH information (missing neighbors, configuration issues)
- Coverage
- ……
QualiPoc Android
Site Acceptance Report

Site Acceptance consists out of 3 parts:

1. **Project**: Contains project related information: site, tester, company, etc.

2. **Sectors**: Contains the sector technology and if cell locking shall be used, also channel and cell information

3. **Job**: Select the job containing all the tests that shall run in order to check this site
QualiPoc Android
Site Acceptance Report

Job – supported test types
The following basic tests are available for site acceptance tests:

- **Call to answering station**
  - Measuring call setup time

- **Call to any number**

- **FTP DL and UL**
  - Measuring data throughput

- **HTTP DL and UL**
  - Measuring round trip time (RTT)

- **PING**
After test is finished, Site Acceptance Report is created and immediately available on the device:

- Project information
- Measurement summary
- Results per sector
- Chart of recorded RF parameters
  - LTE: SINR, RSRP, RSRQ
  - WCDMA: Aggr. Ec/Io, Aggr. RSCP
  - GSM: RxLev, C/I
- KPI classification with all specified thresholds
Scanner example: Automatic Channel Detection

Multi-Band and Multi-Technology Networks

Network overview

GSM, UMTS, LTE, CDMA/EV-DO, TETRA, WIMAX
Scanner example: LTE Downlink / Uplink Allocation Analysis with scanner

Non-intrusive analysis of resource allocations

ULAA

DLAA

Optimization, Benchmarking, Network Probe
The final test
Functional testing - user experience

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- *Interference Hunting & Spectrum Clearance*
Type of Interference of a Mobile Network

Interference signal from the Mobile Network Internally
- Pilot Pollution
- Uplink Interference e.g. PIM issue

Interference signal from outside of the Mobile Network
- Spurious emissions from electronic devices
- Wrong-region devices
- Intentional or malicious interference
Interference hunting is the process of identifying and locating sources of interference. Analysis of the signal can provide important clues as to its origin / location. In almost all cases, radiolocation (direction finding) will be necessary to establish the physical location of the source.
Tools for Interference Hunting

- Handheld instruments fall into two categories
  - Monitoring receivers: FFT-based
  - Spectrum analyzers: swept / heterodyne-based
- Dedicated direction-finding systems can be useful in a number of cases
- Antennas (vehicle and handheld)
- Accessories (filters, LNAs, etc.)
Spectrum monitoring and interference hunting

R&S®PR100
It is a receiver: based on real-time FFT calculation.

Designed for signal detection:
- Fast scanning
- Noise reduction due to integrated preselector
- High selectivity

Detects any hopping, pulsed or sporadic signal.

R&S®FSH
It is a spectrum analyzer: based on a down conversion and sweeping principle.

The FSH is a multi-feature platform:
- Interference analyzer mode with geotagging, indoor mapping and long recording of up to 999 hrs
- MIMO, mobile standards analyzer
- Cable and antenna tester

It might miss a sporadic signal because of the sweeping, BUT, as a whole, the most complete tool for MNT field services
Automatic direction finding systems can determine the likely location of a signal source using one or more DF methodologies.

Systems normally consist of a DF receiver, specially-designed antenna, and control / processing SW.

Very helpful in locating short-duration interferers or distant interferers. Good multipath resistance also allows use in urban environments.
Location fix

When Mobile Locator obtains enough accurate bearing information, it generates a location fix (red circle)
Note that the location fix may move somewhat as you approach the target.
Thank you