Quality of Service
How do we manage it?
Why is Quality of Service important?

- GSM-R is essential for train operations
- QoS is important to support safe and on time train operations
- Restrictions have influence on delay minutes
- Frequent disruptions cause unintended actions by users which lead to unsafe conditions
QoS is not only relevant for GSM-R network operators to fulfil requirements and expectations of users and to avoid rail service disruptions.

Who else is interested in a high QoS?

- Train operating companies, to provide good service to passengers
- Rail infrastructure managers, to avoid unsafe conditions and penalties for delay minutes
- National authorities and Notified Bodies, to approve and certify the GSM-R network according to technical specifications for interoperability
What are the basic activities to ensure the needed QoS in Austria?

- Detailed QoS measurements before start of operation
- Repetitive measurements (at least once a year)
  - including public networks
- Usage of Performance Monitoring Tools
- Analysis of data provided by GSM-R management tools (e.g. fault history, error statistics)
- Monitoring of KPI development
- Consideration of additional information provided by:
  - Connected Systems (Onboard equipment, RBC)
  - Users
- External support to verify existing data
Important requirements regarding all activities to ensure QoS are:

- completeness
- traceability
- automatisation
- acceptance

...definition of standardized testcases is vital!
...and it must be clear what the impact on train operations is, if a KPI cannot be fulfilled!
QoS measurements for ETCS L2

• For the new built lines QoS measurements were done for a speed up to 330km/h

• The measurements are done within different campaigns
  – After every measurement campaign the systems have to be optimized!

• For statistical valid results measurements are performed several times for every track!
  – ~ 16 days per track
  – ~ 120 test runs in total per track
  – more than 200 hours of measurements per track
## QoS Measurement

<table>
<thead>
<tr>
<th>Parameter</th>
<th>QoS</th>
<th>QoS</th>
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</thead>
<tbody>
<tr>
<td>Connection-Establishment-Delay</td>
<td>&lt;8.5s (95%), ≤10.5s (100%)</td>
<td>min. 100 / recommended &gt;&gt; 100</td>
</tr>
<tr>
<td>Connection-Establishment-Error-Ratio</td>
<td>&lt;10^{-2}</td>
<td>min. 1076</td>
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<tr>
<td>Connection-Loss-Rate</td>
<td>≤10^{-2}/h</td>
<td>300 h</td>
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<tr>
<td>Handover-Success-Rate</td>
<td>&gt;99.95%</td>
<td>6000 Handover (for 99.95% success rate)</td>
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<td>600 Handover (for 99.5% success rate)</td>
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<tr>
<td>End-to-End-Transfer-Delay</td>
<td>≤0.5s (99%)</td>
<td>10,000 30-Byte-blocks</td>
</tr>
<tr>
<td>Transmission-Interference-Period</td>
<td>&lt;0.8s (95%), &lt;1s (99%)</td>
<td>1,500 30-Byte-blocks / km</td>
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<tr>
<td>Error-Free-Period</td>
<td>&gt;20s (95%), &gt;7s (99%)</td>
<td>1,500 30-Byte-blocks / km</td>
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<tr>
<td>Network-Registration-Delay</td>
<td>≤30s (95%), ≤35s (99%), ≤40s (100%)</td>
<td>min. 100</td>
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<tr>
<td>Network-Registration-Error</td>
<td></td>
<td>min. 1200 (if 1/400 agreed)</td>
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</table>
Mobiles from different suppliers were used which are installed in the cab. Based on the shown test equipment, it is possible to get information about the behaviour of different onboard equipment.
Key Performance Indicator (1)

Summary of measurement results of both measuring days and both measurement systems:

- Connection Loss Rate
- Handover Success Rate

<table>
<thead>
<tr>
<th>Message</th>
<th>Daten von Messsystem 1+2</th>
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<tbody>
<tr>
<td>Call</td>
<td>KPI group</td>
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<tr>
<td>Data call</td>
<td>Call</td>
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<td>Connection Loss</td>
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<tr>
<td>General</td>
<td>Handover</td>
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</tbody>
</table>
### Summary of QoS measurement results
- all measuring days
- both measurement systems
Call Performance Monitoring

• Needed functionality:
  – GSM-R interface monitoring
  – Reconstruction of processes from beginning till end
  – CDR generation for every transaction (e.g. PtP call)
  – Calculating high level KPI based on the CDR`s
  – Creation of reports

• Reports:
  – Radio Module: RxLev, RxQual, Timing Advance,…
  – ISDN Module: terminated and originated PtP Calls, VGCS,…
  – Euroradio Module: ETCS and GSM-R features
  – Roaming Module: inbound / outbound roaming,…
  – GPRS Module: data application QoS analyses
Interface Tests connected systems

Call Simulator

GSM-R Network (MSC)

Monitoring

RBC

ISDN
Router 1

TCP/IP

RBC
Test System 1

ISDN
Router 2

TCP/IP

RBC
Test System 2

ISDN
Router 3

TCP/IP

RBC
Test System 3

ISDN PRI

ISDN PRI

GSM-R

TCP/IP
Conclusions

• The effort to ensure QoS in the Austrian network is about 3 FTEs
• The Austrian experience is that continuous QoS activities should be done with internal resources in order to take into account railway specific conditions
  – Nevertheless it is necessary to define for which activities external support is necessary (SLA contracts, detailed evaluations, etc.)
• Try to combine QoS measurements with other activities such as track inspection
  – This allows to reduce efforts and to combine different information (e.g. GPS coordinates and track position)
• Results have to be taken into account in further planning processes
  – Information exchange between network operations and planning department
• It is important to identify critical areas and to focus on that
Actual situation

- Since QoS has been continuously monitored no problems regarding train operations were caused by GSM-R
- No impairment of the operation of ETCS level 2, which has been caused by inappropriate performance of the GSM-R network, has been observed so far
- The availability of the GSM-R (99,998%) system is continuously monitored and reported to the management board

→ QoS ensuring is an ongoing process, therefore we are still working to improve the applied methods!
Questions?

Thank you for your attention!