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

Stakeholder

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

Measures to ensure QoS

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

QoS – important requirements

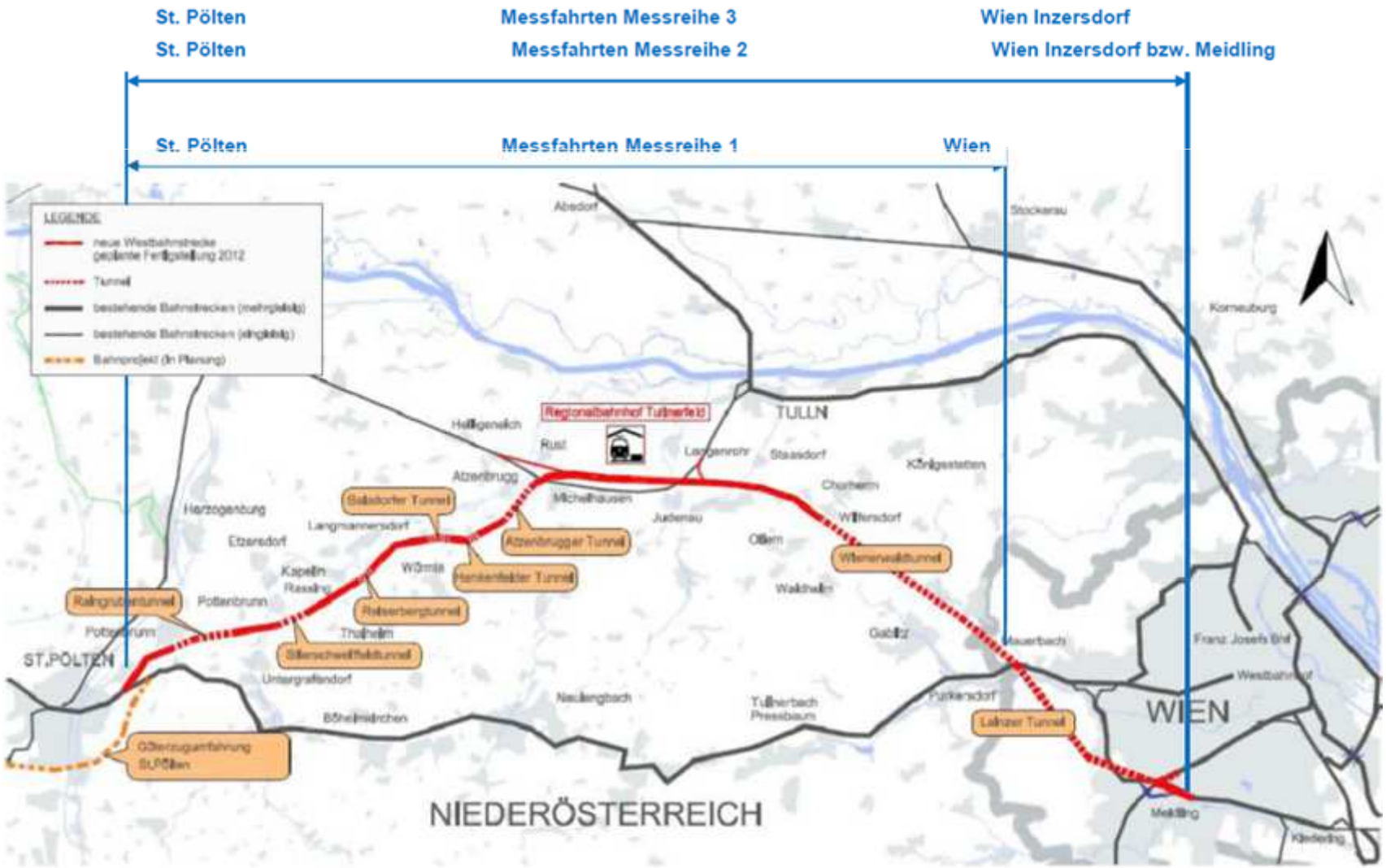
Important requirements regarding all activities to ensure QoS are:

- 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!

NBS Wien–St. Pölten



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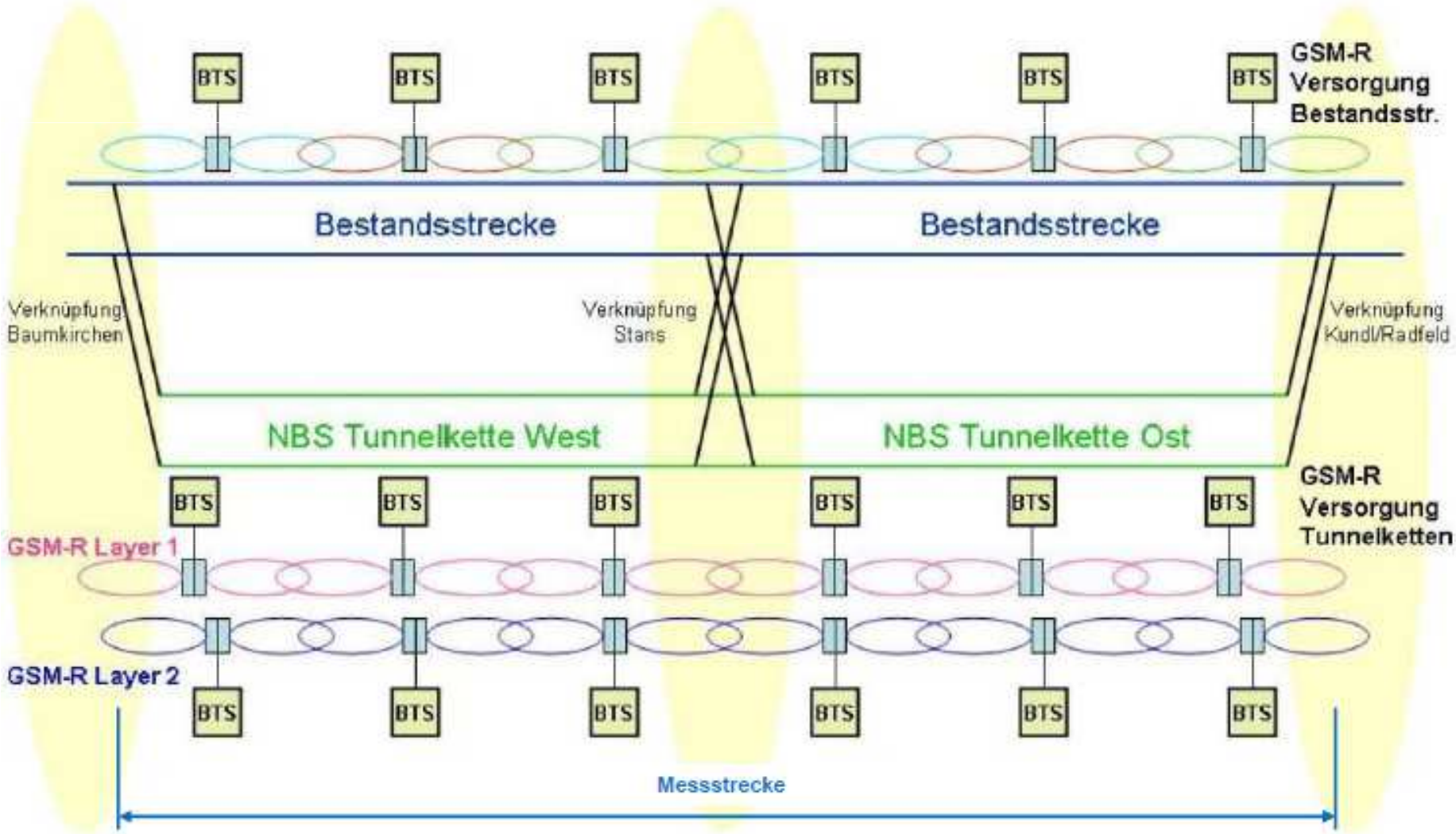


QoS measurements for ETCS L2

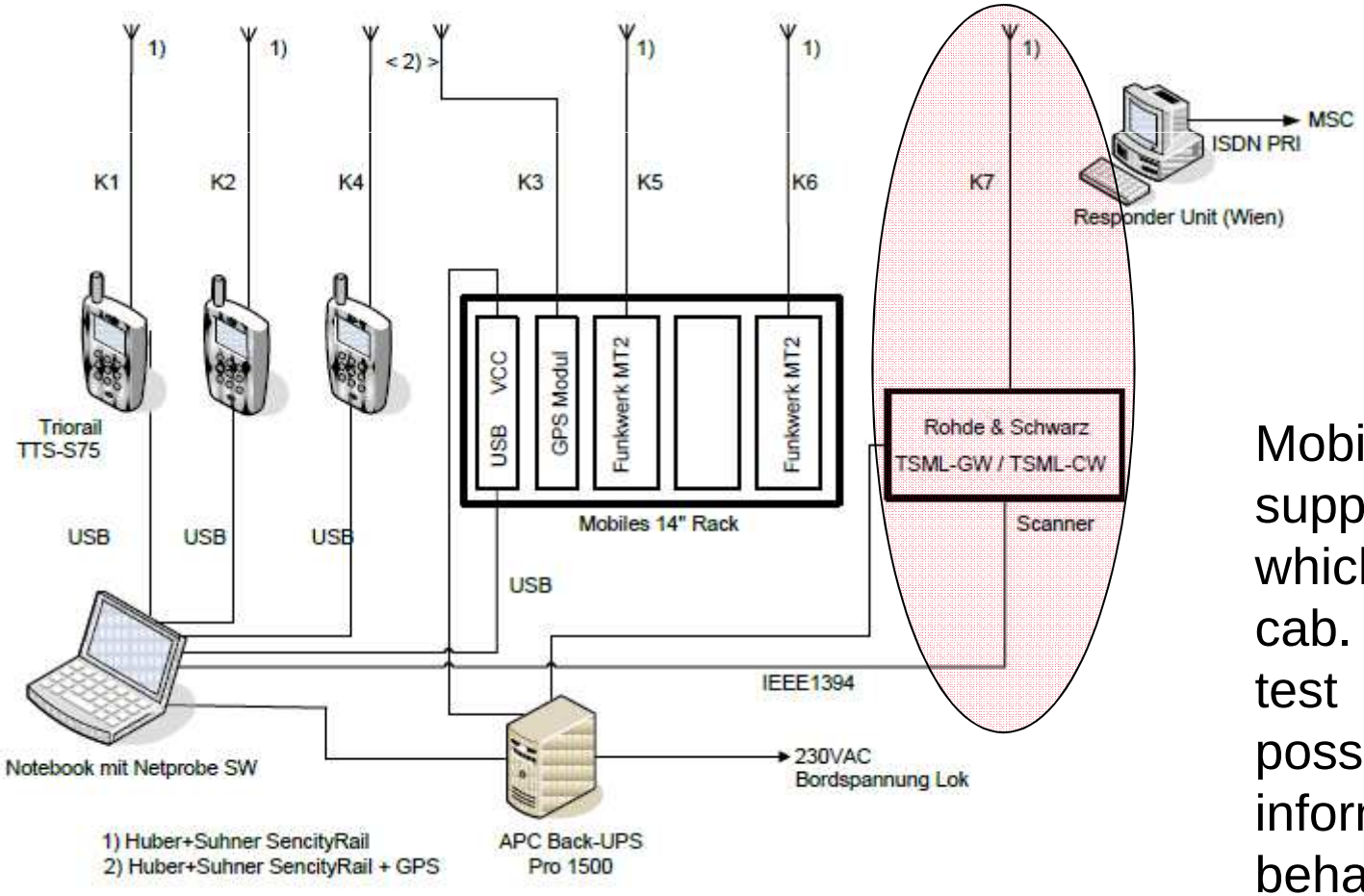
- For the new built lines QoS measurements were done for a speed up to 330km/h
- The measurements are done within different campaigns
  - After every measurement campaign the systems have to be optimized!

- 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

Parameter	QoS	QoS
Connection-Establishment-Delay	<8,5s (95%), ≤10,5s (100%)	min. 100 / recommended >> 100
Connection-Establishment-Error-Ratio	$<10^{-2}$	min. 1076
Connection-Loss-Rate	$\leq 10^{-2}$/h	300 h
Handover-Success-Rate	>99,95%	6000 Handover (for 99,95 % success rate) 600 Handover (for 99,5% success rate)
End-to-End-Transfer-Delay	≤0,5s (99%)	10.000 30-Byte-blocks
Transmission-Interference-Period	< 0.8s (95%), <1s (99%)	1.500 30-Byte-blocks / km
Error-Free-Period	>20s (95%), >7s(99%)	1.500 30-Byte-blocks / km
Network-Registration-Delay	≤30s (95%), ≤35s (99%), ≤40s (100%)	min. 100
Network-Registration-Error		min. 1200 (if 1/400 agreed)

QoS Measurement System 2



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

Messtage	27.7. - 7.8.2012	Daten von Messsystem 1+2	
Call type	KPI group	KPI	Value
Data call	Call	Count	1469/1461
		Total Time [h]	178
		Average Time [s]	446
	Connection Loss	Count	0
		Rate %	0,00%
		Probability [1/h]	0,00
General	Handover	Count	5732/5732
		Success rate inkl. Intra HO	100,00%
		Success rate exkl. Intra HO	100,00%
		Average break time [ms]	128
		Max break time [ms]	328
		99% <=300msec	99,91%

Key Performance Indicator (2)

Messung 27.07. - 07.08.2012		Daten von Messsystem 1 + 2		
Name	Value	Samples	Min	Max
Network registration delay [sec]	4,89	9159	0,125	79,5
<= 30 sec [%]	100			
<= 35 sec [%]	100			
<= 40 sec [%]	100			
<= 50% [sec]	4,80			
<= 90% [sec]	9,64			
<= 95% [sec]	10,23			
<= 99% [sec]	12,91			
Connection establishment delay [sec]	4,09	1455	3,50	6,73
< 8.5 sec [%]	100			
<= 10 sec [%]	100			
<= 50% [sec]	3,99			
<= 90% [sec]	4,69			
<= 95% [sec]	4,88			
<= 99% [sec]	5,23			
Connection establishment error ratio [%]	0,55	1463		
Connection loss rate [1/h]	0	73h3'0"		
Transfer delay of user data frame [sec]	0,364	4.964.226	0,023	39,3
<= 0.5 sec [%]	100,00			
<= 50% [sec]	0,353			
<= 90% [sec]	0,405			
<= 95% [sec]	0,413			
<= 99% [sec]	0,429			
Recovery time (download) [sec]	85,53	2887	0,258	1512,7
> 20 sec [%]	94,11			
> 7 sec [%]	96,95			
<= 50% [sec]	69,93			
<= 90% [sec]	138,96			
<= 95% [sec]	192,73			
<= 99% [sec]	409,56			

Transfer interference time (download) [sec]	0,259	3193	0,043	2964
< 0.8 sec [%]	99,53			
< 1 sec [%]	99,75			
<= 50% [sec]	0,198			
<= 90% [sec]	0,429			
<= 95% [sec]	0,450			
<= 99% [sec]	0,587			
Recovery time (upload) [sec]	81,12	3118	0,215	1504,2
> 20 sec [%]	92,14			
> 7 sec [%]	96,82			
<= 50% [sec]	66,61			
<= 90% [sec]	136,91			
<= 95% [sec]	181,88			
<= 99% [sec]	411,38			
Transfer interference time (upload) [sec]	0,211	3409	0,043	6,8
< 0.8 sec [%]	99,18			
< 1 sec [%]	99,27			
<= 50% [sec]	0,189			
<= 90% [sec]	0,286			
<= 95% [sec]	0,289			
<= 99% [sec]	0,682			

Summary of QoS measurement results

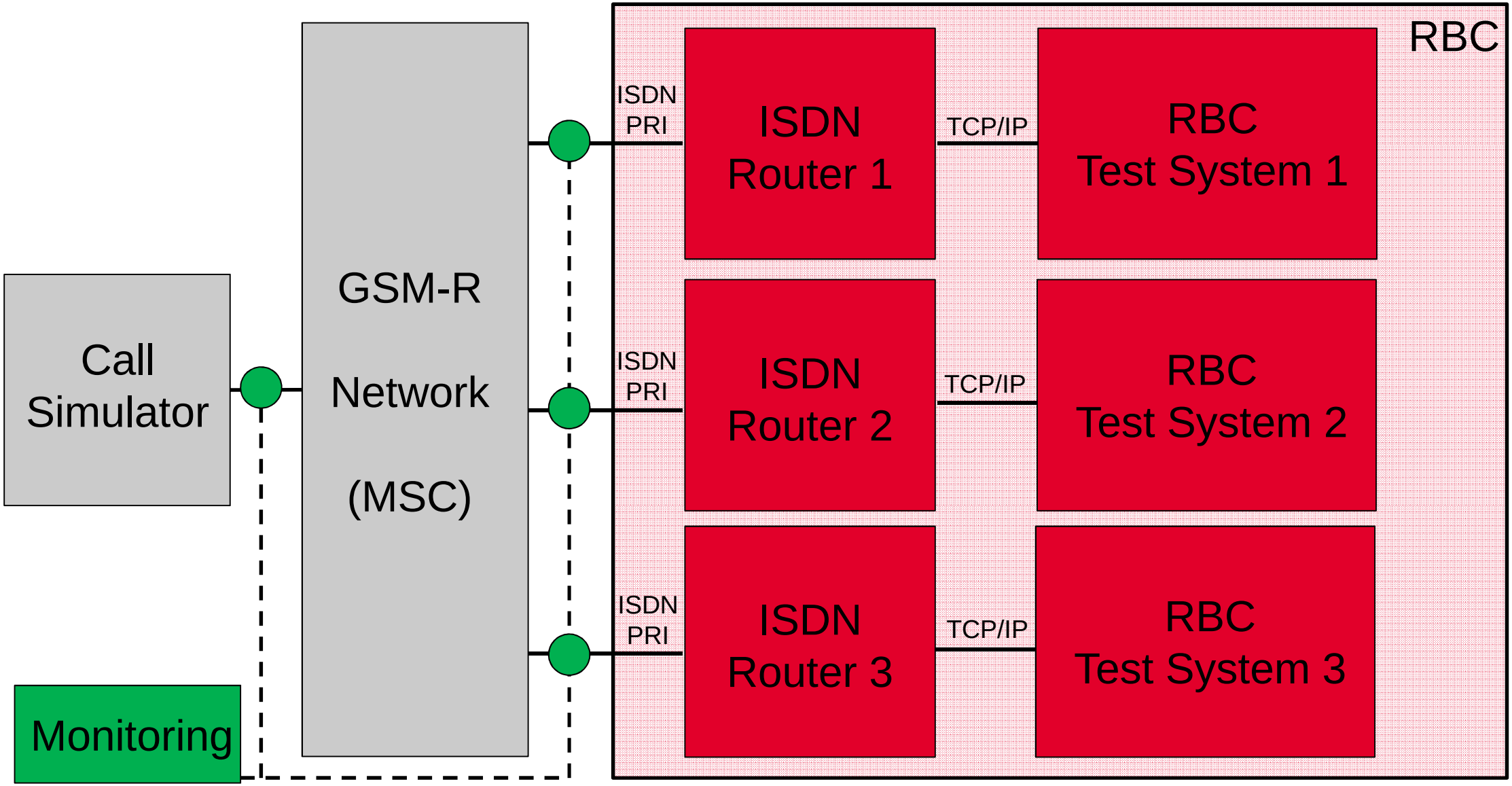
- all measuring days
- both measurement systems

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



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!