Interference mechanisms
The interferences caused to GSM-R terminals are more and more often caused by public mobile networks. There are two principal interference mechanisms – the unwanted emission from a public base station and GSM-R terminal blocking. Interference is often experienced when the UMTS900 base station is closer to the railway than the GSM-R base station.

The unwanted emission from the public mobile networks can, in the GSM-R terminal reception, shadow the network’s own base station signal and thus cause interference to the connection. The effect of the unwanted emission can be compensated by raising the minimum signal strength of the GSM-R network. A strong 900 MHz base station signal can overload or block the receiver of the GSM-R terminal. In this case the intermodulation products which are generated in the GSM-R terminal receiver will shadow the base station signals of the GSM-R network. What is found to be common to these interferences is that they are often local – up to a couple of hundreds of meters in reach – but can totally block communication between the driver of the train and the dispatcher, or block the GSM-R emergency calls to the users who are locating at the interference place.

Study Case: Finland
In Finland in 2007, the public operators were given a license to use UMTS base stations on the 900 MHz frequency band. In Finland, the UMTS900 networks were first rolled-out in rural areas. In urban areas the public operators were primarily using 3G networks on 2100 MHz band. In rural areas in Finland, the base station masts are typically 70-90m high. Due to this, the main beams of the base station antennas swipe above the trains and thus problems with very high signal strengths close to public base station can be avoided. At the moment the penetration of terminals supporting UMTS900 networks has risen in the public operator’s customer base and the operators have started to roll-out the UMTS900 base stations in urban areas. In urban areas the public base station antennas are lower than in rural areas and thus the very high signal strengths have become more common and therefore the interferences have increased.

Performance in practice
The blocking mechanism of cab radio receivers is more complex and the specifications do not give any limitations as to how strong UMTS900 signals the cab radios should tolerate, or how
Strong UMTS900 and GSM900 signals combined effect the radios should tolerate.

The reason behind this is probably the fact that when the first GSM specifications were written in the 80s and 90s, there was no knowledge about the fact that the GSM systems shall in the future work on the same frequency bands with broadband UMTS or LTE systems.

In December 2011, the UIC carried out a series of measurements on the interference tolerance of the GSM-R cab radios in the European Commission laboratory in Ispra, Italy. The measurements revealed that a cab radio, according to the specifications, tolerated the UMTS900 signal on -35 dBm level. It was also found that the GSM900 signals effecting significantly to interferences and that the summed total power of the 900 MHz base station signals matters for appearance of interferences.

**Combined effect**

Based on our experience in Finland, the interferences are worst when there is a combined effect of a UMTS900 base station and GSM900 signals. This is something that was not taken into account by the Finnish frequency authority when issuing UMTS900 licenses. Also, the ECC Report 96 assumed that only one UMTS900 base station signal would be interfering with the train radio. In addition, the used threshold of interference in the Report 96 was too high and the report did not take into account the combined effect of GSM900 and UMTS900.

**Changes in the usage of the 900 MHz band**

To begin with, the 900 MHz band was only allocated to GSM usage. With the European Commission decision (2009/766/EC), broadband UMTS and later also broadband LTE, were allowed on this frequency band. The decision refers to the ECC Report 96 that was later found to be inaccurate. However, the decision obligates the frequency authorities to ensure appropriate protection towards the systems on adjacent bands and now frequency regulators interpret what is appropriate and what is not.

**Decisions by the frequency authority**

Currently, the Finnish frequency authority, Ficora, is making the decision regarding the permanent license conditions for UMTS900. We assume that it is not very likely that the authority is willing to come back on their previous decisions regarding the threshold values and to set them on a level that would protect the cab radios from interference. They are primarily aiming to solve interference issues once they arise. From the point-of-view of a GSM-R operator, this can be quite a lengthy process. The main justification for this is that the threshold values do not need to be set on a level that would guarantee inexistence of interferences, since GSM-R is classified as a mobile service. Mobile service cannot be expected to be free of interferences.

Applying limitations that would guarantee interference-free operation of GSM-R would cause difficulties in building the public operator's base stations close to railway areas. It is possible that the frequency authority is not willing to impose such limitations. In practice this would lead to a situation where the interference tolerance of the GSM-R train radios and handheld terminals has to be improved. In addition, this increases the need of radio network measurements on the railways to follow base station building process of public operators. Omnitele strongly recommends lobbying the authorities regarding the needs of GSM-R operators. Omnitele has participated in this work in Finland in addition to technical advisory and services to the Finnish GSM-R operator. We find that the best solutions to tackle the interferences can be found by covering all the fronts simultaneously.

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