Ensuring communications in tunnels

Communications within a road tunnel must operate without fail in an emergency situation. Radio channels can be monitored and their spectrums analyzed using special measuring devices.

Discussions about safety in road tunnels still cause many to grimly recall two dramatic events, the devastating fire in the Mont Blanc tunnel in 1999 and the catastrophic conflagration in the Swiss Gotthard tunnel less than two years later. These events marked the turning point in safety technology for these two tunnels. One of the key factors apart from the advances in fire protection since then has been the special communications channels, on which the emergency services are totally reliant when such disasters occur. Nowadays, with the aid of measurement system applications it is possible to effectively monitor the performance and functionality of all safety-relevant communications systems and thus reliably ensure their operation without much effort.

Communications within a tunnel must always be maintained. Human safety is the primary goal here. According to the EC Tunnel Directive, which the EU Commission ratified in 2004 as a consequence of major fires in certain alpine countries, the intention is not just to avoid such events, but to put increased emphasis on human safety. For example, if an accident has occurred somewhere, all passengers in vehicles must be informed about this through a suitable medium.

The category of communications equipment in tunnels includes radio-frequency equipment, video monitoring, emergency call points, and loudspeaker systems. By law, at least one VHF radio broadcaster that provides a traffic information service must also be receivable within the tunnel. This includes RDS (Radio Data System) or RDS-TMC (Traffic Message Channel). The frequency of this service must be displayed to drivers on a clearly legible sign when entering any tunnel that is more than 400 m long. The EC Tunnel Directive makes provision for some eight different radio channels to ensure communications between the tunnel monitoring and control center and the emergency services such as police, ambulance and fire brigade. These include the frequency ranges for internal highway maintenance (AM/SM) in the 2-meter band from 144 to 146 MHz as well as one channel for the police in both the 2-meter band and the 4-meter band from 68 to 87.5 MHz, with the same again for the fire brigade and rescue services. The 4-meter band is used for private mobile radio and for the emergency services (public authorities and organizations responsible for safety and security).

Safety in road tunnels: A special measuring system can effectively test and ensure the functioning of in-tunnel radio systems for first responders in emergencies.

Radio channels monitored by a measuring system

Willtron Technologies has developed its DTS-3000 software for the demanding safety measurements that are required for in-tunnel communications and other special path radio systems. DTS stands for Drive Test System.

Fig 1.

With it, the Austrian specialist for networks and communications systems has made easy to effectively monitor VHF, private radio, TETRA and mobile radio, WLAN and WiMAX channels reliably and safely. As an example, TETRA is an indispensable communications medium for first responders inside tunnels. The Willtron software handles the necessary coverage measurements. The only additional equipment needed to make this application into a complete, intelligent measurement system solution, apart from localization support from a microwave position transmitter, is a fast test receiver and a Windows™ laptop, notebook or tablet computer.

Finding the matching test receiver

On the question of a suitable fast test receiver, which is needed for drive tests in tunnels, the Austrian company decided on a collaboration with Narda Safety Test Solutions. The IDA2, Interference and Direction Analyzer, is connected via Ethernet and RJ45 connectors (figure 1). Reference applications have already shown that this portable signal analyzer has the necessary speed. The device detects, analyzes and localizes RF signals and interference between 9 kHz and 6 GHz, and is extremely fast, both in recording the measured values and in transmitting them. Until now, operators running a DTS project in a road tunnel would have to drive through the tunnel eight times, once for each channel being measured. Only one traverse is needed with the IDA2, during which the device records all eight channels simultaneously. The eight channels that can be recorded simultaneously by the IDA2 can be traced back to a specific DTS project in Vienna in which eight VHF channels were monitored at the same time. In theory, the IDA2 can measure up to 500 different channels simultaneously.

Fig. 2

The analyzer has a degree of built-in intelligence in that it carries out some special pre-processing. It is not necessary to individually query the results for each of the eight channels in the tunnel. The IDA2 can be pre-programmed with a channel table. It then measures all eight pre-programmed channels simultaneously and quickly outputs the eight results from the table. It is not necessary to query the levels of each channel separately. A further special feature of this measuring device is that if the measured values show inconsistencies, it is possible to look for the fault by its frequency and then to localize and eliminate the problem. The transmission method is irrelevant here; the signal level is captured in the frequency domain, and VHF and TETRA can be measured just as easily as mobile phone signals. Several different transmission technologies can be measured at the same time.

It could be assumed that merely measuring the field strength along the path through the tunnel would be enough. Logically, if there is no signal present, then communication will be impossible. But the reverse is simply not true; the technical expert who measures a strong signal level with the IDA2 cannot assume that communications are intact. Even if a high level is detected, the signal may be distorted so much by reflections that it is unrecognizable. In such cases, communications will be impossible for the receiver. Consequently, the system must precisely check the received digital data. To do this, the recorded values are demodulated and evaluated. Thus, for example, not only the channel power is measured for FM radio, but also (optionally) the RDS BLER (block error ratio). In the same way, the TETRA MER (message erasure rate) is determined for TETRA signals. The system is thus not only able to measure the signal strength, but also parameters such as the quality of the signal that is received over the entire path.

In addition to applications in road or subway tunnels (Bild 2), where the system operates with a radar position transmitter at 24 GHz, it can also be used outdoors (with a GPS receiver) or in buildings by using a building plan stored on a tablet. The program records the electric field strength in

the frequency range up to 6 GHz, this frequency being dependent on the test receiver that is used.
Furthermore, the so-called Lee criterion is met or exceeded, i.e. more than 50 individual measurements are made within a distance of 40 wavelengths (distance = 40 wavelengths = 40c/f), depending on the selected frequency range. The Lee criterion stipulates that this defined minimum number of measured values must be captured in order for the channel in question to be classified as operational in the professional sense. Once the test technician has recorded all the results for each separate defined channel in the DTS project, they can be exported in either pdf or csv format for the final documentation.

If sensors are no longer able to transmit location data because there is no signal reception inside the building, test technicians can plot the current position where they are making measurements on a plan of the building on their tablet (figure 3). The signals are measured and the matching measurement locations tapped on the tablet screen and saved with the corresponding field strength values.
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Fig 3.

Measuring field strength inside buildings

BTS-3000 (Building Test System) is the second version of the software, which analyzes field strengths inside buildings. Multi-story car parks and underground garages are examples of the types of buildings this software version is aimed at. The fire brigade, ambulance service, and police must be able to communicate with each other and be contactable in such places, too.

Figure 1: The IDA2 (Interference and Direction Analyzer) from Narda is connected to the DTS-3000 via Ethernet and RJ45 plug connector.

Figure 2: In subway tunnels the DTS-3000 operates with a radar sensor fitted to the front of the train as a distance transmitter at 24 GHz.

Figure 3: With the BTS-3000 from Willtron, the signals are captured by the Narda IDA2 while the technician taps in the corresponding locations on a building plan on a tablet. This saves the position together with the associated field strength.

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