Going underground

Leaky cables bring mobile communications to subway systems.

*By **Graham Pitcher**.*

In its relatively short lifetime, the mobile phone has developed from a novelty to an essential tool. We're on the phone everywhere and any interruption in our ability to communicate is regarded as a major inconvenience.

Witness the desperate attempts of passengers to maintain conversations as they descend into the London Underground and the quizzical stares at mobiles as their trains enter the tunnels.

The London Underground network is one of the world's largest urban transportation systems. It has 249 miles of track, of which 45% are underground. Providing mobile phone coverage to the tunnels has been on the table for years. So far, that solution has yet to be determined.

But other cities around the world have managed to do just that. In places such as Hong Kong, Singapore, Beijing and Glasgow, passengers can enjoy the benefit of mobile phone communications wherever they are in the city; and that includes when they're on underground trains.

Markus Kalt is vice president of business development, EMEA, for Andrew's wireless innovation group. He described the importance of this in Hong Kong. "The ability to use a mobile phone has a very special place in Hong Kong. Because apartments there are often very small, people tend to 'live in the streets'. Mobility is very high and the mobile phone has very high penetration."

The result is that mobile phone operators needed to provide service on Hong Kong's underground transit system. "Hong Kong residents have to use the metro," Kalt continued, "because driving in the city is very difficult."

Finding space

Underground tunnels are not the ideal place in which to provide mobile phone communications. However, it's not the communications themselves which are the problem; it's finding enough space in stations to accommodate the various operators' basestations. Kalt said this was a particular problem in Hong Kong. "In the Hong Kong metro, five operators provide mobile phone service. In order to house their equipment, we had to build a 'basestation hotel'."

But he noted the next challenge was to implement the system. "When you are looking to provide mobile phone coverage in underground systems, the first problem you encounter is the lack of space. There's not much room between the train and the tunnel." That rules out straight away the use of wireless communications. The solution is a little more traditional: the 'leaky cable'.

"We typically use radiating cables," Kalt explained. "But that brings another set of problems. You need access to the train tunnel and that generally only has a window of three hours a day. So you need good project management, combining the installation work with other maintenance operations."And he pointed out the longer the network, the bigger the challenge.

The outputs from each basestation are combined and fed into the cable. Similarly, the conversations coming from the trains are picked up by the cable and routed back to the equipment room, where they are split into streams for each operator.

But why can't wireless communications work in underground systems? "You could take a single point antenna and put it at the tunnel's mouth," Kalt admitted, "but it all comes down to how big the tunnel is compared to the train. If it's a double track tunnel then it's likely a mobile phone signal could be picked up in the train.

"The antenna is shooting down the tunnel," he continued. "but the user is on

the train, so you need reflections from the tunnel wall in order to get signals into the train. If the train effectively fills the tunnel, then it's very difficult to get the signals through." Radiating cables provide a relatively simple solution. "It means the user is never more than around 3m away from the cable and transmission is at 90° to the cable," he explained.

Tunnel length is another variable. "If the tunnel is longer than about 1km," Kalt pointed out, "then you have to think about putting repeaters into the tunnel. That could be difficult in the London Underground," he added, "because tunnels are even narrower than in Hong Kong."

Typically, the repeaters consume about 1W per carrier, but this depends on cable length. "If you're providing gsm service," Kalt said, "you will need to use a 1 5/8 in cable. The problems start when you want to provide UMTS/GSM1800 service because the losses increase and you need more repeaters."

It all comes back to the maintenance issues. "We don't like putting repeaters in tunnels because you can only do maintenance during the night," he stated.

The gsm signal 'leaks' from the cable through slots in the outer conductor. So can the electrical environment interfere with the service? "No," said Kalt, "but one thing you must watch out for is induced voltages in the cable's outer layer."

Repeaters are connected to the ground of stations on either side. Meanwhile, each repeater's rf ground and power ground are connected.

Additional protection

Without extra protection, the radiating cable's outer conductor would connect the two station's grounds. A voltage potential difference between station grounds would drive a current flow in the radiating cable's outer conductor between the stations. This current could cause the repeater to fail, depending on the potential difference and the magnitude of the resulting current.

In order to protect the system, dc blocks are included at each repeater location. These blocks isolate the outer and inner conductor from the repeater and prevent a current flow. The dc block incurs an additional rf loss of around 0.1dB.

Another issue is the size of the cable drum. "You need a big drum for 1km of 1 5/8in cable," Kalt said, "and you can't always get that into a tunnel. So the typical cable drum diameter is 2m, containing about 500m of cable. Even though we could lay a full length of cable between stations, we can't because of the drum size."

Andrew's recent installations include the Beijing Metro, where additional capacity was needed during the Olympic Games. According to Andrew, the system ensured company personnel, and passengers had gsm, cdma or gprs signals available in tunnels and on platforms.

Andrew has also won a contract from French operator SCNF to supply and install repeaters for its private GSM-R (European standard for railway communications) system. He will extend radio coverage in tunnels over the railway's 14,500km network.

Meanwhile, London Underground's tunnels remain mobile free zones. According to Transport for London, it has yet to receive a proposal that makes 'commercial sense'. Whether that's a blessing or a curse depends on your level of mobile phone dependency. ■