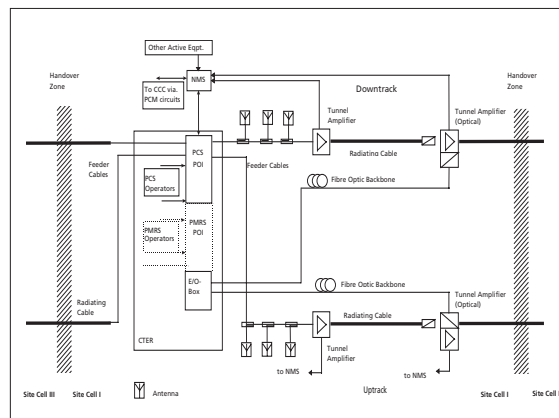


Wireless Indoor Solutions

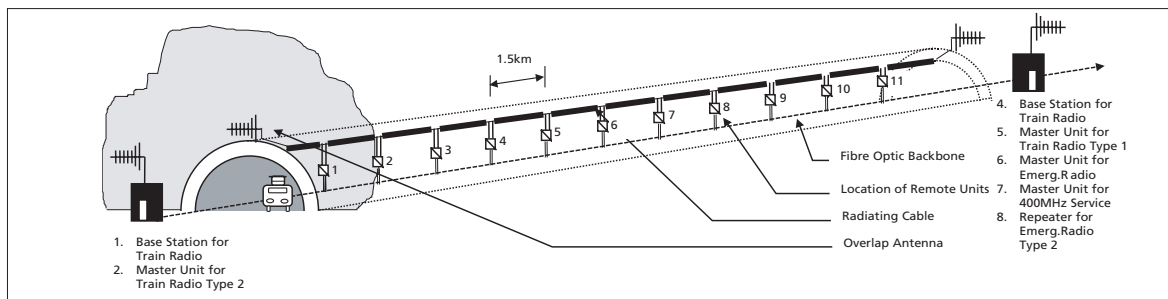
Tunnel Applications

RFS' comprehensive range of products for tunnel communication systems includes broadband passive components such as coaxial and radiating cables, antennas, power splitters, and accessories as well as bi-directional amplifiers, fiber-fed remote units, RF coupling systems (POI's) and network monitoring/management systems (NMS). This will allow deploying multi-band, multi-operator systems for voice and data in a shared infrastructure, minimizing CAPEX.

For complex multi-band applications with commercial and/or essential radio typically radiating cable solutions will be used for tunnel coverage while shorter tunnels (500 m 2G, 300 m 3G) or tunnels with a large cross section can be covered by point antennas, especially for single-band services.

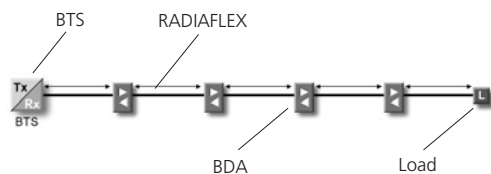


Case Study Metro Tunnel and Station



Case Study 17 km Railway Tunnel

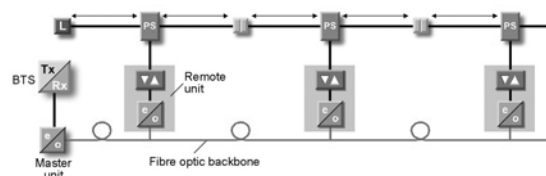
Active tunnel systems can be realized with cascaded bi-directional amplifiers (BDA), which re-amplify the RF signal after a certain distance. The spacing between those BDA's depends on the frequency and the diameter of the radiating cable. Due to noise and intermodulation performance BDA's can only be cascaded to a maximum of 6 in order to compensate for insertion loss of radiating cable runs and therefore are only suitable for medium to short tunnels. Systems of cascaded BDA's are cost effective but do not offer any system redundancy in those cases where the radiating cable is damaged/interrupted due to a fire or accident.



A more sophisticated approach is the use of fiber-fed remote units as shown in the case studies above. The fiber-fed remote units, as a matter of fact, are bi-directional amplifiers with integrated electric-optic converters. In this case the voice/data signal is being distributed via a low-loss fiber backbone throughout the tunnel.

Depending on the frequency and the radiating cable/antenna in use, remote units are placed in the tunnel and are feeding the signal in a T-shaped radiating cable/antenna configuration. In case the cable is damaged/interrupted due to a fire or accident, one still has RF power from both sides of the tunnel section.

The solution with fiber-optic backbone and remote units allows to cover tunnels up to a length of 20 km.



Wireless Indoor Solutions

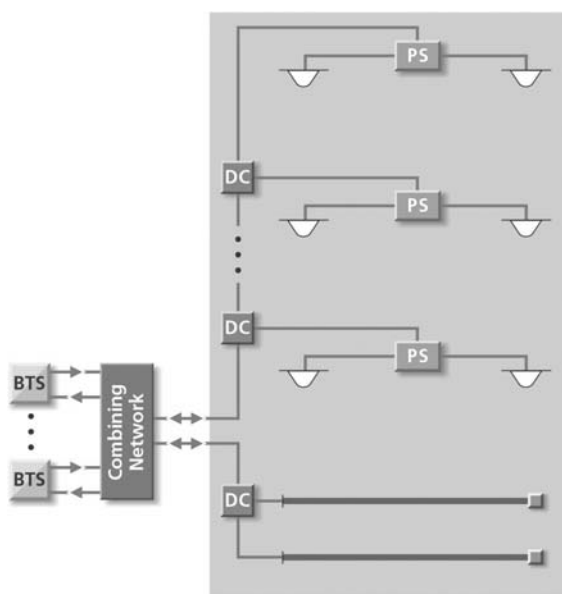
Passive and Hybrid Distributed Antenna Systems

A passive DAS provides coverage for up to 50,000 sqm and consists of only passive components, such as coaxial and radiating cables, power splitters, directional couplers and indoor antennas. All these components are RF broadband, ensuring that a single deployed DAS can simultaneously support multiple applications such as 2G, 3G and WLAN/WiFi as well. A passive DAS ensures some major commercial and technical benefits:

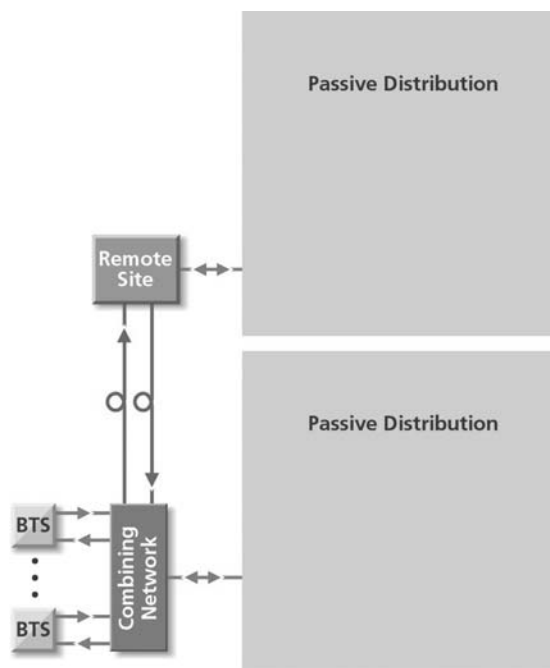
- Technology neutral with no capacity limit – future-proof
- Ideal for multiple operator and multiple system needs – RFS In-building DAS is truly RF broadband catering for frequencies ranging between 300 MHz and 2.5 GHz. Operators may easily add new services to an existing In-Building DAS solution by simply adding a new Radio Port at the equipment room. The inclusion of new pilot tones or additional (independent) signaling (RF) carriers is straightforward with the DAS solution. There is practically no limitation in channel capacity.
- Solution for the majority of buildings in terms of size (up to 50,000 sqm for single passive DAS).
- Passive products require no adjustment or preventive maintenance; therefore a passive DAS is maintenance free and doesn't implicate any operational expenditure.

- The use of point antennas and/or radiating cables is possible - this enables the designer to provide optimum coverage profile for any particular building shape and design.
- Passive DAS introduces no additional noise or intermodulation to the signal path. This enables multi-channel (and multi-operator) signals to be distributed without fear of service degradation due to the interference problems usually experienced for such applications. Such low interference and noise is crucial for reliable high data rates especially required by 3G applications.

For large in-buildings the single passive DAS is extended to several additional passive DAS by using fiber-fed remote units (RF amplifiers). This is the hybrid-DAS solution. The design principles and products needed to implement each DAS are the same, thereby minimizing design time and installation experience required. The RFS hybrid solution has a very low number of easily accessible active parts (Master Unit and fiber-fed Remote Units) resulting in a high MTBF and system availability.



Passive DAS <50,000 sqm



Hybrid DAS >50,000 sqm