APPLICATION NOTE

Distributed Temperature Sensing (DTS) for Road, Rail, and Metro Tunnels

Road, rail, and metro tunnels are critical infrastructure assets that require continuous monitoring to ensure operational safety, asset protection, and regulatory compliance. Fire incidents, overheating equipment, and ventilation failures pose significant risks in enclosed tunnel environments where evacuation and emergency response are inherently challenging.

Distributed Temperature Sensing (DTS) using optical fiber technology provides continuous, real-time temperature monitoring along the entire length of a tunnel.

Unlike traditional point sensors, DTS delivers a fully distributed profile, enabling early detection of abnormal thermal events and precise localisation of incidents.

Key Challenges

- **Early fire detection:** Rapid identification of fires is critical to minimise risk to life and infrastructure.
- **Harsh environmental conditions:** Dust, humidity, vibration, and electromagnetic interference can impact conventional sensors.
- **Long distances:** Tunnels often extend for several kilometres, making full coverage difficult with point sensors.
- **Maintenance constraints:** Limited access and operational disruption make frequent maintenance challenging.
- **Regulatory compliance:** Stringent safety standards require reliable and redundant monitoring systems.

DTS Technology Overview

Distributed Temperature Sensing systems use optical fibers as linear temperature sensors. A DTS unit sends laser pulses through the fiber and analyses the backscattered light (typically Raman scattering) to determine temperature along the cable.

Key Benefits

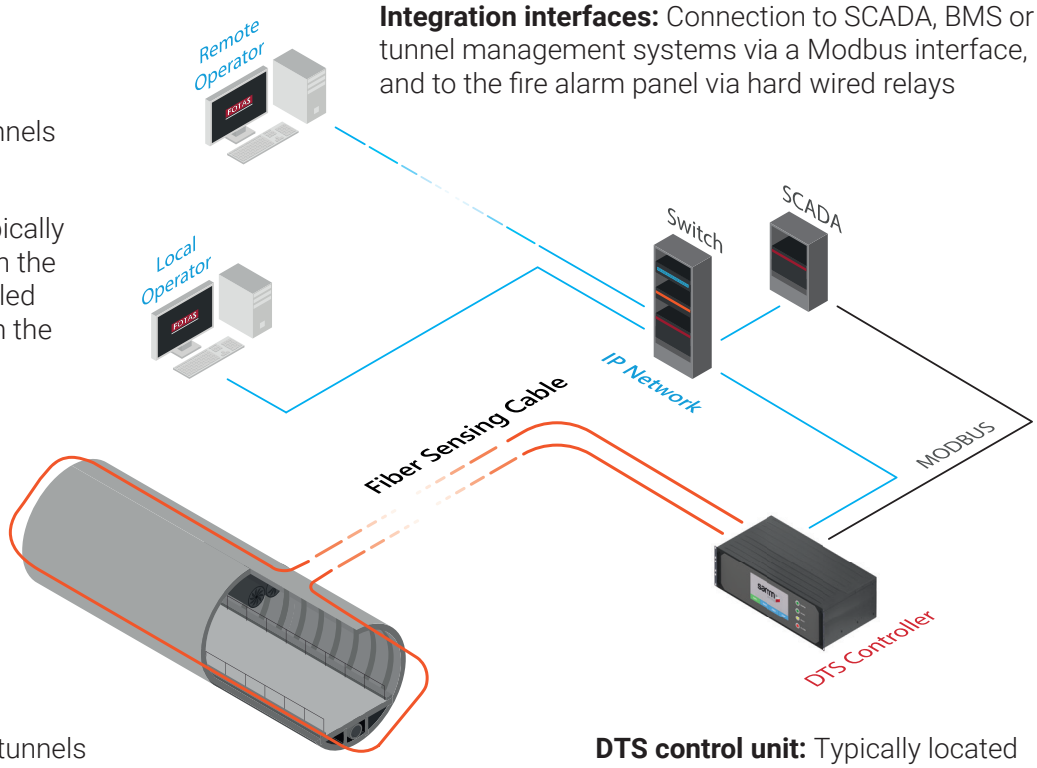
- Provides a continuous temperature reading every meter with an accuracy of ±1°C
- Real-time monitoring providing temperature data and early indications of a potential fire
- Immunity to electromagnetic interference (EMI/FRI)
- Passive sensing element (no power required in the tunnel)
- Sensing cable with a design life of 25+ years
- Minimal maintenance requirements

System Architecture

A typical DTS installation in tunnels includes:

Fiber optic sensing cable: Typically installed on the tunnel ceiling in the middle but also could be installed on the side walls dependant on the tunnel height, width and usage

Optional redundancy: Both controller and/or cable loop configurations for enhanced reliability



Integration interfaces: Connection to SCADA, BMS or tunnel management systems via a Modbus interface, and to the fire alarm panel via hard wired relays

DTS control unit: Typically located in a control room or equipment cabinet

Installation approaches:

- Linear layout for standard tunnels
- Redundant loop for critical infrastructure
- Zonal segmentation for detailed monitoring and alarm management, typically when integrated into a fire suppression or smoke extraction system

Key Factors for Successful Deployment

- **Mounting location:** Typically ceiling-mounted for optimal heat detection
- **Redundancy:** Loop configurations for critical applications
- **Integration:** Compatibility with existing control and safety systems
- **Zoning strategy:** Logical segmentation for alarm management to align with fire suppression systems, smoke extraction, ventilation, etc
- **Cable selection:** Fire-resistant, Low smoke Zero Halogen (LSZH) armoured, and suitable for harsh environments

Key Applications

DTS systems can trigger alarms based on:

- Fixed temperature thresholds
- Rate-of-rise detection
- Differential temperature profiles

Fire Detection and Alarm

DTS functions as a continuous linear heat detection system, identifying temperature rises anywhere along the tunnel.

- Early fire detection before ignition or flames spread
- Accurate localisation of alarm event (within meters) to aid a fast response to minimise risk of loss of life, operational disruption or asset damage
- Compliance with tunnel fire safety standards
- Rapid detection enables rapid activation of ventilation, suppression, and evacuation systems.

Asset Monitoring

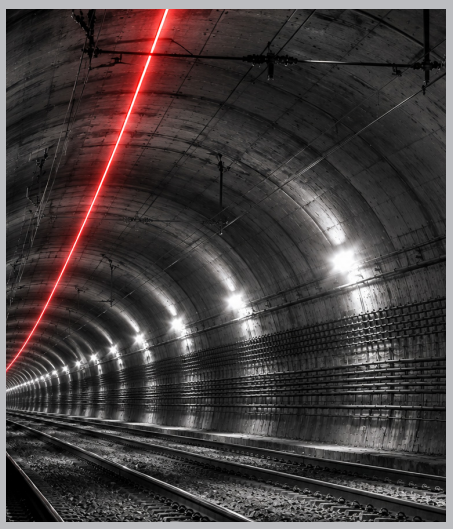
Early detection of overheating reduces downtime and prevents failures. Critical tunnel equipment can be monitored, including:

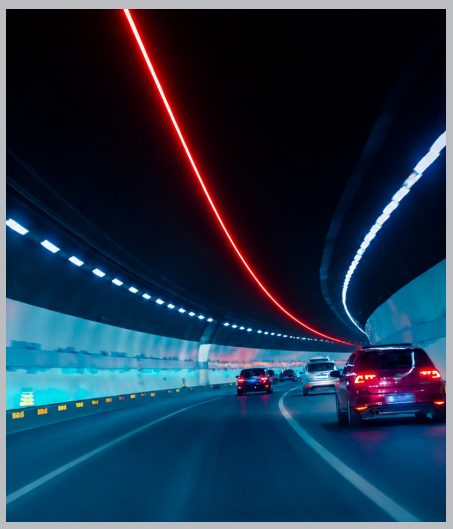
- Cable trays and power lines
- Signalling equipment
- Ventilation systems
- Transformers and substations

Ventilation System Optimisation

Temperature profiles along the tunnel help:

- Assess airflow efficiency
- Optimize jet fan operation
- Support smoke control strategies during incidents





Key Benefits

- **Full coverage:** Continuous monitoring over entire tunnel length
- **Fast response:** Early detection of thermal anomalies
- **High accuracy:** Precise location of events
- **Low maintenance:** Passive fiber with long operational life
- **Reliability:** Resistant to harsh tunnel conditions
- **Scalability:** Suitable for both short metro tunnels and long road tunnels
- **Integration-ready:** Seamless connection with existing safety systems