How Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS) Work

1. Introduction

Optical fiber sensing technologies are transforming how critical infrastructure is monitored by turning a standard fiber optic cable into a continuous sensor capable of measuring conditions over many kilometres.

Unlike conventional point sensors that measure at individual locations, fiber optic sensing provides **distributed monitoring** — delivering measurements continuously along the full length of the fiber.

Two of the most widely deployed distributed sensing technologies are:

- **Distributed Temperature Sensing (DTS)** — for continuous temperature measurement
- **Distributed Acoustic Sensing (DAS)** — for distributed vibration and acoustic event detection

Together, these technologies support applications ranging from fire detection and power cable monitoring to leak detection, pipeline security, perimeter protection, and infrastructure monitoring.

This guide provides an overview of how DTS and DAS work and where they are applied.

PART I — DISTRIBUTED TEMPERATURE SENSING (DTS)

2. What is DTS?

Distributed Temperature Sensing (DTS) uses an optical fiber as a continuous linear temperature sensor.

A single fiber can provide thousands of temperature measurement points over distances ranging from a few hundred metres to tens of kilometres.
Rather than installing point detection along an asset, the fiber itself becomes the sensor.

3. How DTS Works

DTS operates by sending short laser pulses into an optical fiber from a measurement control unit.

As light travels through the fiber, a very small portion is naturally scattered back toward the interrogator.

This phenomenon is called backscattering.

Raman Backscatter

For most DTS systems, temperature measurement is based on **Raman scattering**, which produces two key backscattered components:

- **Stokes signal**
- **Anti-Stokes signal**

The anti-Stokes signal changes strongly with temperature.
By analysing the ratio between these signals, the system calculates temperature at each point (typically 1 metre) along the fiber.

4. Locating Temperature Along the Fiber

DTS also determines where a temperature event occurs using time-of-flight measurement.

Because light travels at a known speed in fiber – approximately 200,000 Kms per second:

- Laser pulse launched
- Backscattered signal returns
- Return time indicates distance along the fiber

This works similarly to radar, but with light.

Result:

- Temperature measurement
- Event location with an accuracy of around 1 metre
- Continuous temperature profile over the full fiber route

5. DTS Measurement Output

DTS typically provides:

- Temperature versus distance profile
- Real-time thermal trends
- Hot spot detection
- Alarm zones and event localisation

Typical performance parameters include:

- Sensing range: hundreds of metres to tens of kilometres
- Spatial resolution: typically 1–4 m (application dependent)
- Temperature resolution: typically 0.1 degree
- Update rates: seconds to minutes depending on configuration

6. Common DTS Applications

DTS is widely used for:

Fire and Linear Heat Detection
- Tunnels – road, rail, metro and utility
- Conveyor belts
- Warehouses and storage facilities
- Car Parks
- PV solar farms
- Mining

Power and Energy
- Power cable monitoring
- Dynamic cable rating
- Transformers and substations
- Battery energy storage systems

Pipelines
- Leak detection

7. Why DTS is Different from Point Sensors

Traditional sensors:
- Measure at individual point locations
- Require many devices for long assets
- Can leave gaps between sensors

DTS:
- Measures continuously along the asset
- No blind spots
- Precise event localisation
- Single fiber can replace thousands of discrete sensors

PART II — DISTRIBUTED ACOUSTIC SENSING (DAS)

8. What is DAS?

Distributed Acoustic Sensing (DAS) uses optical fiber as a continuous vibration and acoustic sensor.

Instead of measuring temperature, DAS detects disturbances acting on the fiber such as:

- Vibration
- Strain changes
- Acoustic energy
- Mechanical impacts

The fiber acts as thousands of virtual microphones or vibration sensors.

9. How DAS Works

DAS typically uses coherent Rayleigh backscatter.
A control unit sends laser pulses into the fiber.
Microscopic variations naturally present in the fiber scatter light back.

When the fiber experiences vibration or strain:

- Backscattered phase changes
- Signal patterns change
- Disturbance can be detected and located

The control unit continuously analyses these changes.

10. Event Localisation in DAS

Like DTS, DAS uses time-of-flight principles to determine event location.

The system can identify:

- What happened
- Where it happened
- When it happened

Often with metre-scale localisation.

11. Event Detection and Classification

DAS can detect events such as:

- Digging
- Vehicle movement
- Footsteps
- Fence disturbance
- Pipeline interference

- Gross impact

Advanced analytics can classify events and distinguish:

- Benign activity
- Environmental noise
- Potential threats
- Critical alarms

This supports high probability intelligent detection with reduced nuisance alarms.

12. Common DAS Applications

Security and Intrusion Detection

- Perimeter security
- Border monitoring
- Pipeline third-party intrusion detection
- Right-of-way security

Infrastructure Monitoring

- Rail monitoring
- Cable route protection
- Tunnel monitoring
- Structural monitoring

Energy Applications

- Pipeline security
- Above and below ground HV power cable monitoring

PART III — COMBINING DTS AND DAS

13. One Fiber, Multiple Sensing Functions

In many applications, a single fiber can support multiple sensing technologies.
Examples:

Pipeline Monitoring

- DTS for leak detection
- DAS for intrusion detection

Critical Infrastructure

- DTS for fire detection
- DAS for perimeter security

Utilities

- DTS for asset monitoring
- DAS for excavation detection

This creates a powerful integrated monitoring platform.

14. Key Benefits of Distributed Fiber Optic Sensing

Continuous Coverage
Monitoring over long distances with no gaps.

Precise Event Localisation
Identify where an event occurs with precision accuracy of a few metres

Passive Sensing
No power or electrics required in the field.

Harsh Environment Suitability
Works in environments challenging for conventional sensors.

Multi-Function Capability
One sensing infrastructure can support multiple applications.

Low Maintenance
Passive fiber sensors typically have long service life and control equipment is virtually maintenance free.

15. Key Components of a Fiber Optic Sensing System

A typical system includes:

Sensing Fiber
Installed along the asset to be monitored. Either multi-mode, single-mode or mixed-mode dependant on the application. Using either existing fiber or newly installed.

Control Unit
Typically, rack mounted in a server or equipment room. Launches laser pulses and analyses returned signals.

Software Platform
Provides:

- Visualisation
- Alarm management
- Event analysis

- Integration with control systems

Integration Interfaces

Links to:
- SCADA
- Fire systems
- Security systems
- Asset monitoring platforms

16. DTS vs DAS — At a Glance

Technology	Measures	Typical Use Cases
DTS	Temperature	Fire detection, leak detection, power cables
DAS	Vibration / acoustics	Intrusion detection, security, disturbance monitoring

DTS answers:
"What is the temperature, and where?"

DAS answers:
"What is happening, where, and when?"

Combined, they provide broader operational awareness.

17. Future of Distributed Fiber Optic Sensing

Fiber optic sensing continues to evolve through:
- Advanced analytics and AI event classification
- Multi-parameter sensing approaches
- Greater integration with digital asset platforms
- Enhanced predictive monitoring
- Expanded applications across energy, utilities, transport, and security

Distributed sensing is increasingly moving from specialised monitoring technology to a core element of intelligent infrastructure management.

18. Conclusion

Distributed Temperature Sensing and Distributed Acoustic Sensing use standard optical fiber to provide continuous, real-time monitoring over long distances.

DTS delivers precise distributed temperature measurement, while DAS enables distributed vibration and acoustic detection. Together, they provide powerful tools for protecting assets, improving safety, and increasing operational visibility across critical infrastructure.

Understanding how these technologies work is the first step to applying them effectively.

19. Further Information

For application guidance or technical support on distributed fiber optic sensing technologies, please contact fotas@samm.com