DFOST®

Distributed Fiber Optic Sensing

The Sustainable Solution for Infrastructure
& Environmental Challenges

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Our Vision

Fiber Optic Sensing Technologies that protect our environment

DFOST® provides its customers innovative distributed fiber optic sensing solutions to enhance the security and the safety of people and capital assets (infrastructures, buildings, and industries) by monitoring the assets in real-time, in a non-intrusive manner and a cost-effective way, using state-of-the-art technology including artificial intelligence to mitigate any impact in a sustainable way.

The DFOST® Difference

DFOST® is capitalizing on 70 years of expertise and experience in sensors design and development and in monitoring of structural assets.

In developing its first solution, LUMINIS for Distributed Acoustic Sensing (DAS), DFOST® has used the following criteria: innovation, performance, and affordability to meet the challenges of its customers.

Innovation

Innovation means developing a solution that responds to the entire customer requirements. Innovation also means offering applications that can sustain the ESG Program of its customers based on their need to monitor critical assets and mitigate any impact.

Performance

Performance means that our system has two optimal components, the hardware (primarily the interrogator and processing units) and the software for data visualization, analysis, storage, and interpretation that monitor in real-time the asset and detect events.

Affordability

Affordability means developing a solution that considers a design-to-manufacturing approach with optimal (quality & reliability) state-of-the-art optoelectronic components including a careful attention to quality to cost ratio in order to achieve an affordable solution for applications.

Our DAS Flagship Product

After five years of research and development, the hardware and software prototypes of our Distributed Acoustic Sensing Solution (DAS Luminis) have been developed & tested, and the industrial phase has been launched.

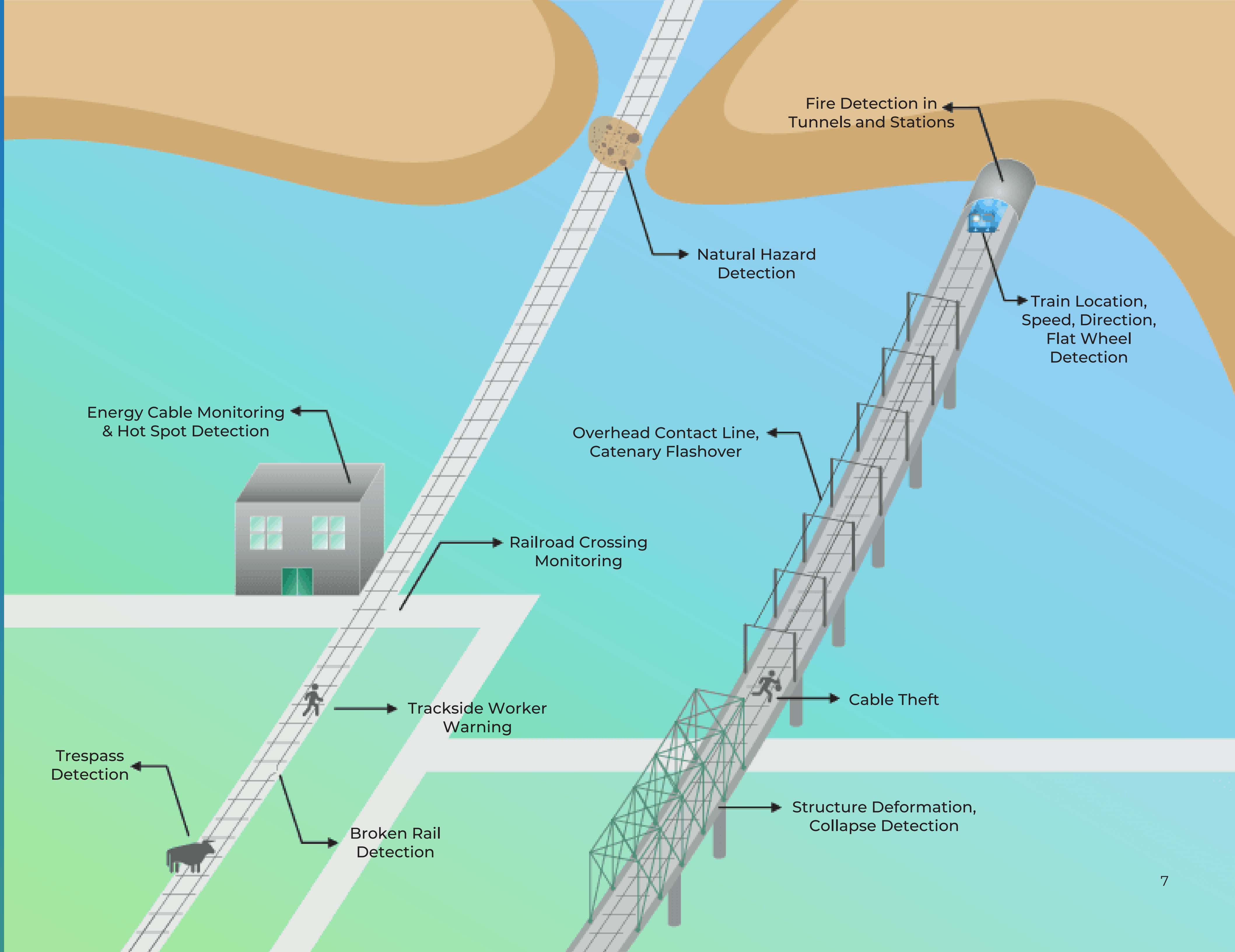
The hardware solution includes a state-of-the-art optoelectronic interrogator and a powerful data acquisition and processing unit, each housed separately in a standard 4U rack-mount enclosure.

The system is capable of reflectometry of vibration with a spatial resolution down to 5 meters for a range of approximately 50 kilometers.

The software solution has been designed for great user experience and to provide full control to its operator and customer in monitoring their strategic assets with a few modules, including for system settings & health, monitoring & detection, event recognition, alert management information system and threat analysis.

DFOST® End-to-End Solution

Sensing Relentlessly Detecting Accurately



How DFOST® work?

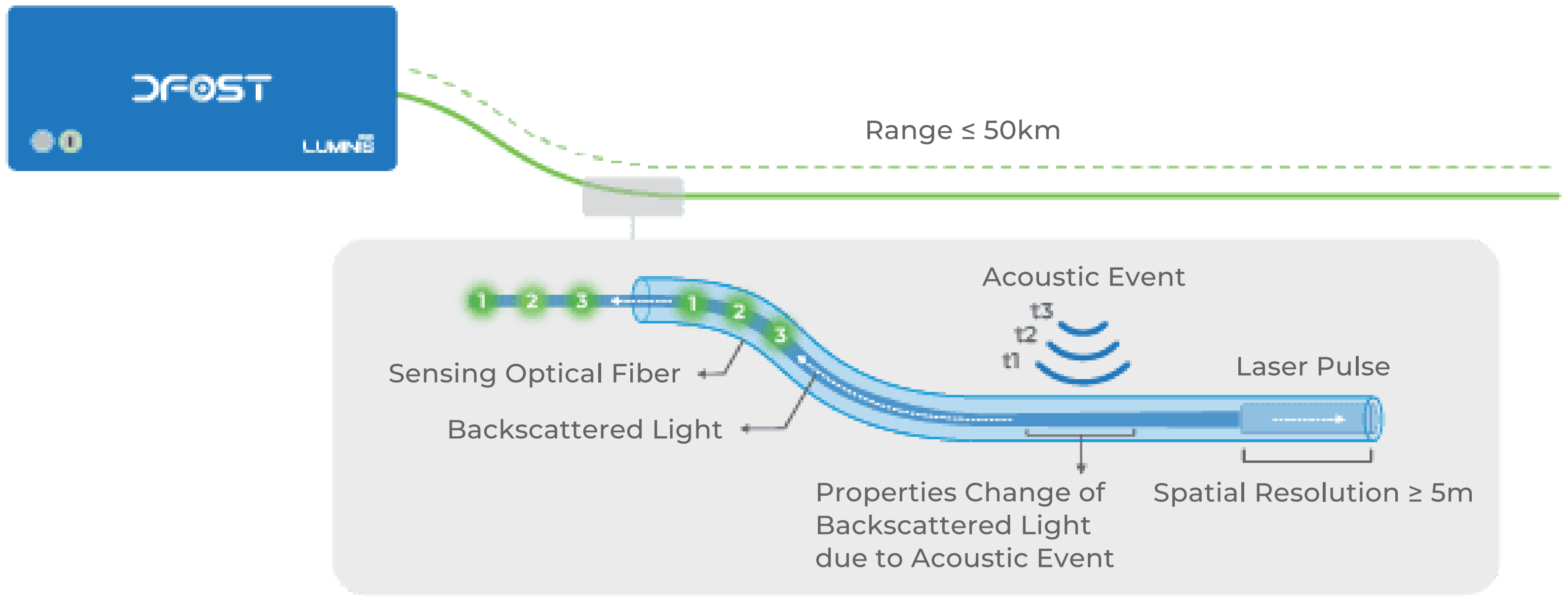
The measurement of vibration, strain, and temperature in a fiber optic cable relies on the interaction between laser light and the glass in an optical fiber.

When light travels through a transparent media, the main pulse travels forward, however, a small fraction is backscattered through interaction with the glass particles.

This changes at every point along the cable in accordance with the local environment.

Different backscatter processes can be used to extract relevant information.
That backscatter signal can be exploited by different technologies to understand the external environment–vibration, strain, temperature, etc.

The end data can be used to understand the environment at every point along the fiber and act on the information.



Monitoring several parameters with fiber optic cables from a single location via pulsed light

24/7 Continuous Monitoring over long (km's) continuous distances

1,000's of sensing points with high resolution & meter size localization potential

Passive sensor: No power required along the asset being monitored

Multiple applications are possible in a single system

Upgradable technology – without replacing sensor

Our Advantages

Overall, DFOST® offers a flexible and versatile solution for monitoring physical parameters along large structures and in harsh environments and provides a high-resolution, long-range, and cost-effective alternative to traditional point sensors.

01 Long-range & Real-time Sensing

DFOST® systems can measure physical parameters in real-time over long distances, useful for monitoring pipelines, bridges, and other large structures.

02 High Resolution

DFOST® systems can provide high-resolution measurements of physical parameters, useful for detecting precisely in subtle changes.

03 Low Power Consumption

DFOST® systems consume very little power, which makes them useful for monitoring remote or hard-to-reach structures.

04 Immunity to Electromagnetic Interference

DFOST® systems are immune to electromagnetic interference, which are useful for monitoring structures in harsh environments.

Multiplexing 05

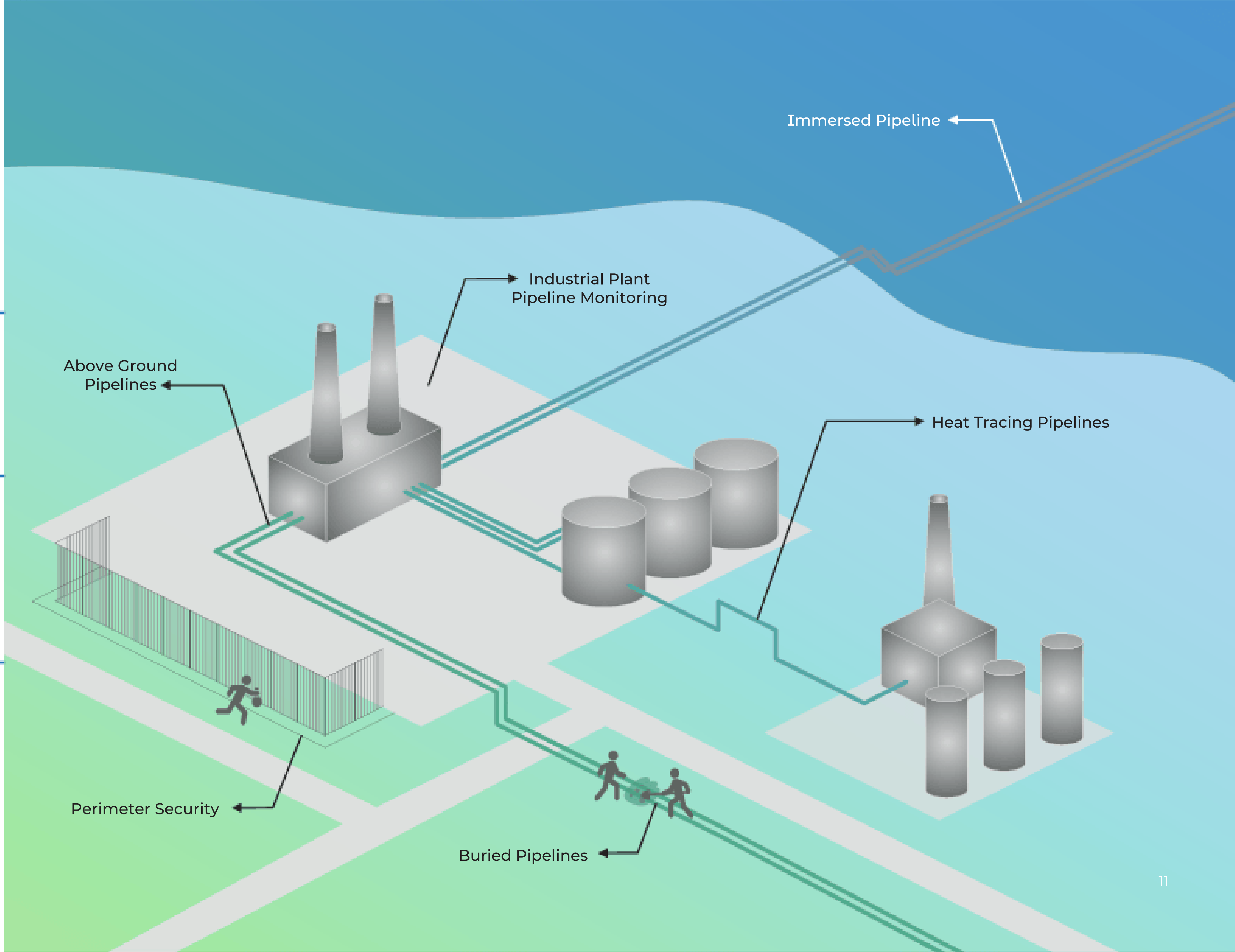
DFOST® systems can multiplex multiple sensing points into a single optical fiber, allowing a large number of sensors to be deployed.

Low Maintenance 06

Fiber optic cables are low maintenance, flexible, durable, and non-conductive, also well-suited for installation in harsh and inaccessible environments.

Cost-effective 07

DFOST® systems can be cost-effective compared to traditional point sensors, as a single fiber optic cable can carry multiple sensing points.



Machine Learning :
An Integral Part in Our Solution

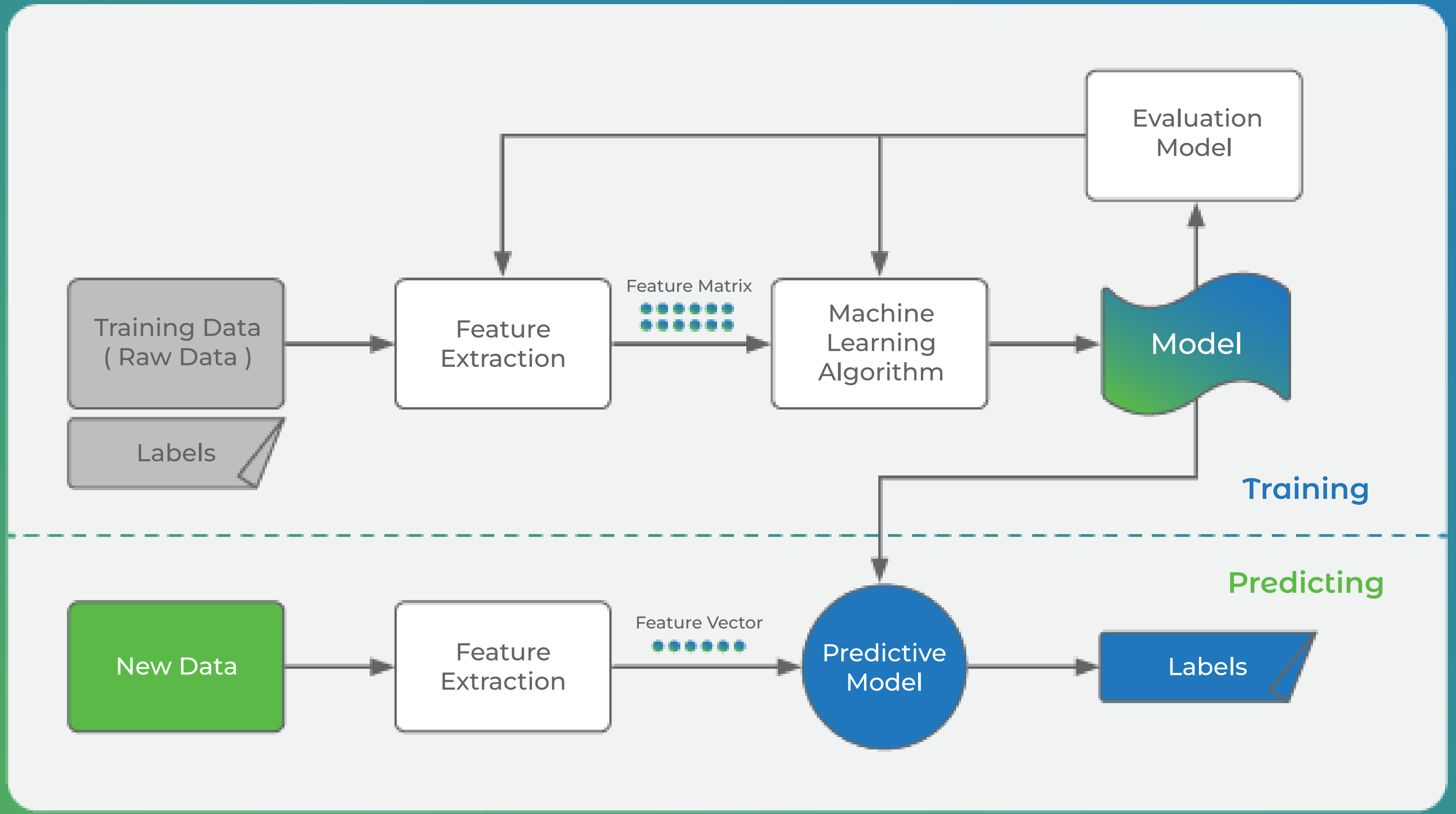
Distributed Acoustic Sensing (DAS) is a technology that enables the transformation of fiber optic cables into thousands of individual sensors for detecting sound waves. Machine learning techniques can be applied to DAS data to extract valuable information and insights from the collected signals.

The primary objective of using machine learning in DAS is to improve the accuracy, efficiency, and effectiveness of acoustic signal processing. Machine learning algorithms can learn to recognize and classify specific acoustic patterns or anomalies that could indicate a potential problem or threat, such as the presence of a leak in an oil pipeline, a fracture in a wind turbine blade, or an intrusion in a border security system.

By processing and analyzing large volumes of DAS data using machine learning techniques, it is possible to identify subtle changes or deviations from normal patterns that could indicate potential issues, providing early warning alerts that can help to prevent more serious problems from occurring.

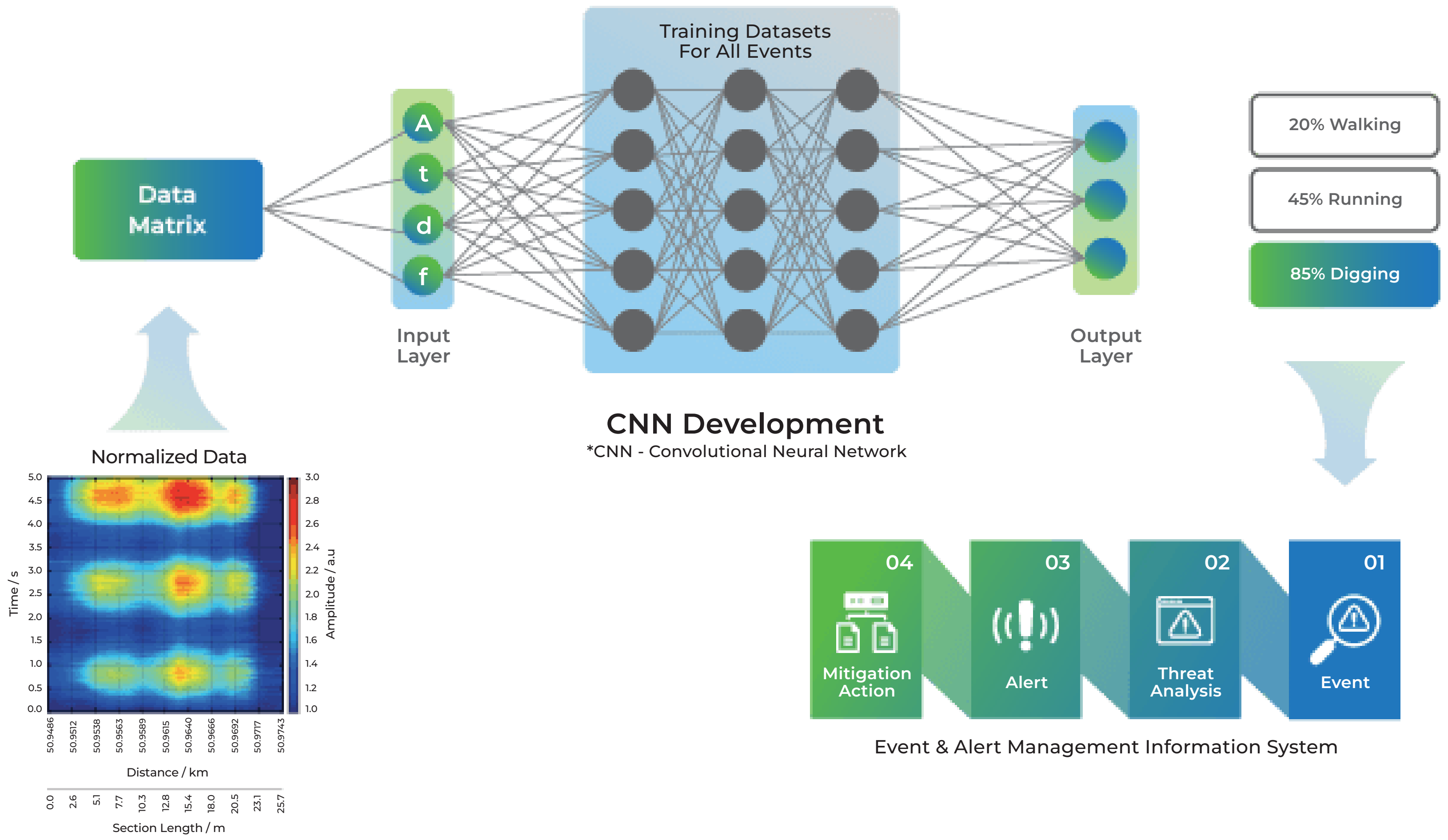
In summary, the objective of using machine learning in DAS is to leverage the power of artificial intelligence to enhance the capabilities of this technology in a variety of industries and applications, ranging from oil and gas exploration to infrastructure monitoring and security.

The processing of DAS data with machine learning typically involves the following main steps, which are depicted below assuming a supervised learning model is applied: Data Pre-processing, Feature Engineering, Model Training, Model Evaluation, Prediction, or Analysis.



DFOST® - Event & Alert Management Information System

An effective event and alert management information system is a critical component of any organization's operations. Such a system enables organizations to monitor, detect, and respond to critical events, incidents, and alerts promptly and efficiently, thereby minimizing their impact and ensuring business continuity.



Event & Alert Management Information System

Main Applications & Objectives

Distributed Acoustic Sensing (DAS) is used for monitoring various types of infrastructures because it provides a real-time, cost-effective and non-intrusive method of monitoring. DAS works by sending light down a fiber optic cable and measuring the backscattered light to detect vibrations caused by changes in various factors.

Pipeline Monitoring
Leak / Intrusion / Security / Pig Tracking / Hot Tap / Valve Detection

Borehole & Well Monitoring
Seismic / Fracking / Flow Profiling

Power Cable Monitoring
Fault Finding/ TPI (Anchoring)/ Cable Conditions

Industrial Equipment & Facilities Monitoring
Conveyor Belt / Tank & Vessel / Electrical Substation

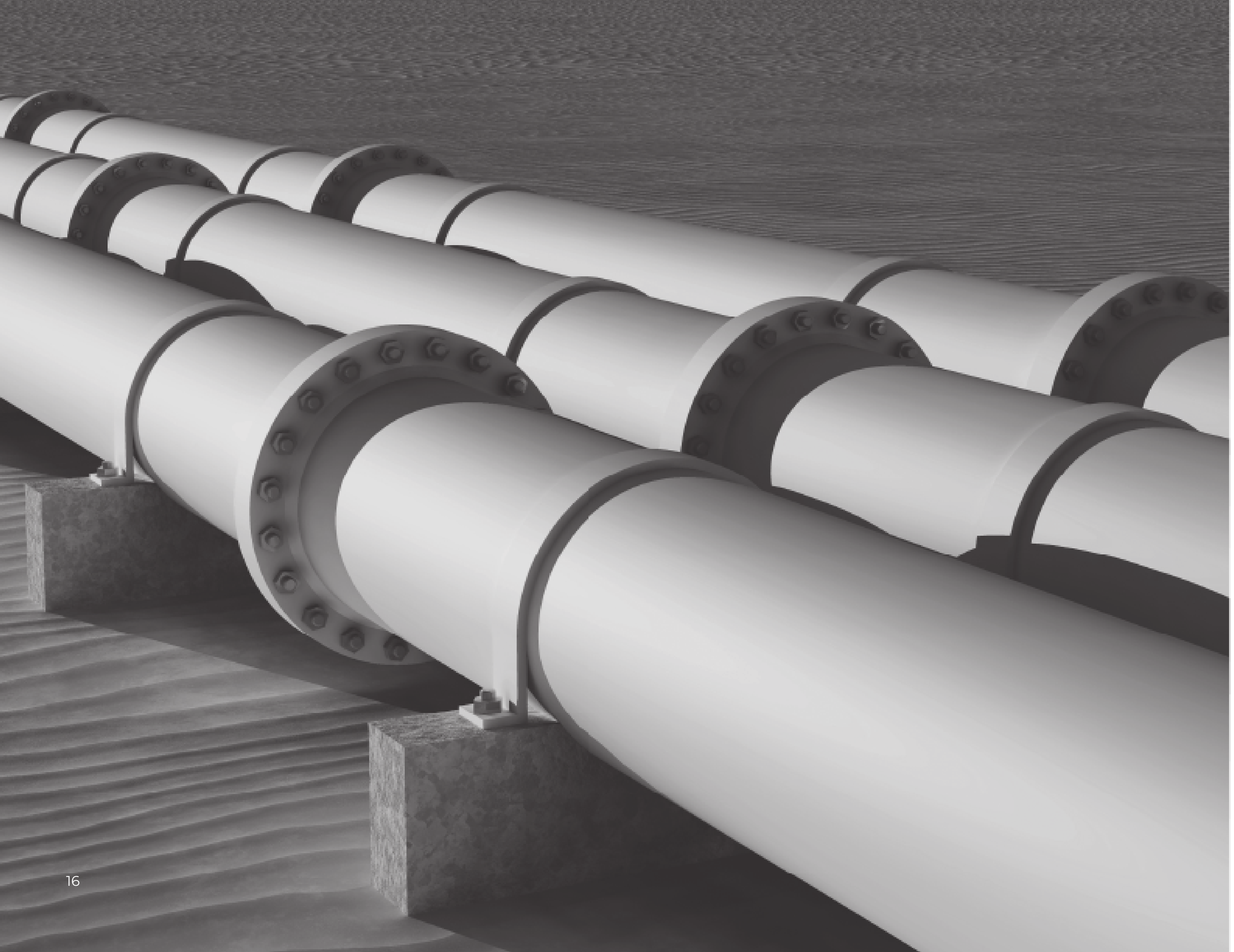
Transport Monitoring
Train Tracking / Traffic Flow / Track & Rolling Stock Condition / Rock Fall

Perimeter Intrusion & Border Protection Monitoring
Perimeter Security / Activity Detection / Tunneling Detection

Geotechnics Monitoring
Seismic / Rock Fall / Landslide

Structural Health Monitoring
Crack / Deformation / Strain

Source: Adapted from Fiber Optic Sensing Association (FOSA)



Pipeline Monitoring

Distributed Acoustic Sensing (DAS) is an effective method for pipeline monitoring due to its ability to detect acoustic vibrations along the entire length of the fiber optic cable. This enables DAS to detect and locate changes or anomalies in the pipeline, such as leaks, blockages, or third-party interference, and provide valuable data for pipeline operators to make informed decisions. Here are some specific reasons why DAS is an effective method for pipeline monitoring:

- High sensitivity: DAS can detect even small acoustic signals with high sensitivity, enabling it to detect changes or anomalies in the pipeline.
- Continuous monitoring: DAS provides continuous, real-time monitoring of the pipeline, which allows pipeline operators to quickly detect and respond to any issues.
- Long sensing range: DAS can cover long distances, making it suitable for monitoring pipelines that are several kilometers long.
- Non-invasive: DAS is a non-invasive method of monitoring, as it does not require any additional equipment to be installed in the pipeline, reducing the cost and complexity of the monitoring process.
- Multiple measurements: DAS can measure multiple parameters, including pressure, and strain, providing a more comprehensive understanding of pipeline conditions.
- Cost-effective: DAS is a cost-effective method of pipeline monitoring, as it can monitor multiple pipelines simultaneously, reducing the need for additional monitoring equipment.

Overall, DAS is an effective method for pipeline monitoring due to its high sensitivity, continuous monitoring capabilities, long sensing range, non-invasive nature, multiple measurement capabilities, and cost-effectiveness. By providing real-time data on pipeline conditions, DAS can help pipeline operators detect and respond to issues quickly, reducing the risk of pipeline failures and ensuring safe and efficient pipeline operation.

Borehole & Well Monitoring

Distributed Acoustic Sensing (DAS) is an effective method for borehole & well monitoring because it can provide high-resolution data over the entire length of the well or borehole, enabling operators to better understand the behavior and performance of the borehole. Here are some specific reasons why DAS is an effective method for borehole & well monitoring:

- Real-time monitoring: DAS can provide continuous, real-time monitoring of the borehole conditions, which allows operators to quickly detect changes and respond to any issues that may arise.

- High sensitivity: DAS can detect even small changes in the borehole conditions, such as changes in flow rate or pressure, which can provide early warning of potential problems.

  Non-invasive: DAS is a non-invasive method of monitoring, as it does not require any additional equipment to be installed in the borehole, reducing the cost and complexity of the monitoring process.

- Long-term monitoring: DAS can be used to monitor boreholes over long periods of time, providing data that can be used to optimize production and better understand the behavior of the borehole.

- Multiple measurements: DAS can measure multiple parameters simultaneously, including pressure, flow rate, and acoustic signals, providing a more comprehensive understanding of borehole conditions.

Overall, DAS is an effective method for borehole & well monitoring due to its ability to provide real-time data, high sensitivity, non-invasive nature, long-term monitoring capabilities, and the ability to measure multiple parameters. By providing detailed information about borehole or well conditions, DAS can help operators optimize well performance, improve production, and reduce the risk of borehole- or well-related issues.

Power Cable Monitoring

Distributed Acoustic Sensing (DAS) is an effective method for power cable monitoring for several reasons:

- Early fault detection: Preventing downtime and potential safety hazards.
- Long-distance monitoring: Providing a cost-effective option for large-scale monitoring of power transmission and distribution networks.
- Non-invasive sensing: It does not require physical contact with the power cable being monitored offering a safe and low-risk monitoring option, especially for high-voltage power cables that can be difficult to access.
- High sensitivity: Providing early warning of potential cable faults, allowing for preventative maintenance to be carried out before a fault occurs, reducing downtime and repair costs.
- Versatility: Providing a monitoring solution for a wide range of power cable types such as underground, aerial, and submarine.

This information can be used to detect issues such as line sag, ice accumulation, and line corrosion, all of which can impact the stability and safety of the transmission line. By monitoring these factors, power transmission line operators can detect and address problems before they become serious, reducing downtime, and improving safety.

Additionally, DAS can cover long distances with a single fiber optic cable, making it well-suited for monitoring transmission lines over large areas.

Industrial Equipment & Facilities Monitoring

Distributed Acoustic Sensing (DAS) is an effective method for industrial equipment and facilities monitoring for several reasons:

- Continuous Monitoring: DAS allows for continuous monitoring of large areas, providing real-time data on the condition of equipment and infrastructure. This is particularly useful in industrial settings where downtime can be costly and potentially dangerous.

- Non-Invasive: DAS is a non-invasive monitoring method, which means it does not require physical contact with the equipment or infrastructure being monitored. This makes it a cost-effective and low-risk monitoring option, especially for equipment and facilities that are difficult to access or located in hazardous environments.

- High Sensitivity: DAS can detect very small changes in vibrations and acoustic waves, which can provide early warning of equipment or infrastructure failure. This can allow for preventative maintenance to be carried out before a failure occurs, reducing downtime and repair costs.

- Versatility: DAS can be used to monitor a wide range of industrial equipment and facilities including conveyors, pipelines, bridges, railways, and power transmission lines.

Overall, distributed acoustic sensing is an effective monitoring method for industrial equipment and facilities because it provides continuous, non-invasive, sensitive, and versatile monitoring that helps the operator to prevent accidents, reduce downtime, and improve safety and efficiency.

Transport Monitoring

Distributed Acoustic Sensing (DAS) is an effective method for transport monitoring, including railways and highways, considering its multiple advantages:

- Continuous monitoring & real-time alerts: Providing information to security & maintenance crews in real-time when there is an anomaly or problem detected allowing for prompt repairs and maintenance.
- High-resolution: Providing information that can be used to identify, locate problems or anomalies in the infrastructure, such as cracks, deformations, or loose bolts.
- Long-range detection: Allowing it to monitor large sections of transport infrastructure with a single system & the ability to detect multiple types of issues.
- Multi-purpose: From traffic flow to broken rail; from security to environmental monitoring.

It can help ensure the safety and reliability of transport infrastructure while reducing the cost of monitoring (as it can be installed on existing fiber optic cables, which greatly reduces the cost of deployment). This information can be used to monitor track conditions, detect track defects, and track the location and speed of trains, all of which are critical for ensuring the safety and efficiency of railway operations.

By monitoring these factors, railway operators can detect and address problems before they become serious, reducing downtime, and improving safety. Additionally, DAS is immune to harsh weather conditions, making it a robust and reliable method of monitoring railways.

Perimeter Intrusion & Border Protection Monitoring

Distributed Acoustic Sensing (DAS) is a technology that utilizes fiber optic cables to detect vibrations caused by sound waves or physical movements. When used for perimeter intrusion detection and border protection monitoring, DAS combined with artificial intelligence can be a highly effective method for several reasons:

- Coverage: DAS can provide coverage over long distances, making it an ideal technology for monitoring large perimeters such as those around military bases, airports, or other high-security facilities and international borders.

- Sensitivity: DAS can detect even the slightest vibrations caused by an intruder, including footsteps, climbing, digging, or cutting through fences. This high sensitivity makes it possible to detect intruders before they have a chance to breach the perimeter.

- Flexibility: DAS can be installed in a variety of configurations, including buried underground, attached to fences, or along walls. This flexibility allows for customized deployment based on the specific needs of a particular site.

- Accuracy: DAS can provide accurate information about the location of an intruder, allowing security personnel to quickly respond to a potential threat.

- Reliability: Fiber optic cables used for DAS are highly reliable and can withstand harsh environmental conditions, making them a suitable option for outdoor perimeter monitoring.

Overall, DAS combined with artificial intelligence can be a highly effective method for perimeter intrusion detection monitoring due to its ability to provide reliable and accurate coverage over long distances, detect even the slightest vibrations, and provide flexibility in deployment.

Geotechnics Monitoring

Distributed Acoustic Sensing (DAS) is an effective method for earthquake and geotechnical monitoring because it can detect and locate seismic waves with high accuracy and resolution, as well as provide real-time and high-resolution data on the behavior and condition of geotechnical structures. Here are some reasons why DAS is an effective method for earthquake and geotechnical monitoring:

- High resolution: DAS provides high-resolution data, allowing for detailed analysis of the seismic waveforms and the behavior of geotechnical structures.
- Real-time monitoring: DAS provides real-time data, allowing for prompt and effective response to earthquake events or changes in the behavior of geotechnical structures.
- Continuous monitoring: DAS provides continuous monitoring of seismic activity and the behavior of geotechnical structures, allowing for early detection of changes and potential problems.
- Large coverage area: DAS can cover large areas, allowing for monitoring of earthquake activity and geotechnical structures over a wide region.
- Cost-effective: DAS is a cost-effective method for earthquake and geotechnical monitoring, for example it can utilize existing fiber optic cables and does not require additional equipment or sensors.
- Multi-purpose: DAS can be used for a variety of purposes beyond earthquake and geotechnical monitoring, such as pipeline and power cable monitoring, providing additional benefits for infrastructure management.

Overall, DAS provides a valuable tool for earthquake and geotechnical monitoring, allowing for accurate and timely detection of seismic activity and the behavior of geotechnical structures, providing critical information for emergency response and infrastructure management.

Structural Health Monitoring

Distributed Acoustic Sensing (DAS) is an effective method for structural health monitoring because it can detect subtle changes in the structure caused by different factors such as stress, strain, cracks, and deformations. Here are some reasons why DAS is an effective method for structural health monitoring:

- Real-time monitoring: DAS provides continuous real-time monitoring of a structure, detecting changes and anomalies as soon as they occur. This helps to identify problems before they become serious and allows for timely maintenance and repairs.
- High sensitivity: DAS can detect very small changes in the structure, allowing for early identification of potential issues before they become significant. This can help prevent catastrophic failures that could result in safety hazards and costly repairs.
- Large coverage area: DAS can cover long distances, up to several kilometers, using a single optical fiber cable. This allows for monitoring of large structures or critical infrastructure, such as long bridges and tunnels, dams, and water pipelines.
- Non-destructive: DAS is a non-destructive method of monitoring structural health, which means it does not require drilling, cutting, or other invasive procedures that can damage the structure or disrupt operations. It uses existing optical fiber cables, which minimizes the need for additional installation costs.
- Cost-effective: DAS provides a cost-effective way to monitor structural health over long distances, reducing the need for frequent manual inspections or expensive sensor installations.

Overall, DAS is an effective method for structural health monitoring because it provides continuous, real-time monitoring, is highly sensitive, covers large areas, is non-destructive, and is cost-effective. Its ability to detect small changes in structures and provide early warnings can help prevent catastrophic failures and ensure the safety and longevity of critical infrastructure.

Applying Machine Learning to Structural Health Monitoring

In structural health monitoring (SHM), DAS technology can be used to detect acoustic signals generated by structural vibrations or other mechanical stresses in a variety of infrastructure assets, such as bridges, tunnels, buildings, and wind turbines. This generates large amounts of acoustic data that can be difficult to interpret and analyze manually.

By applying machine learning techniques to DAS data, it is possible to automatically detect and classify patterns in the acoustic signals that may be associated with specific events, such as the presence of a crack, deformation, or other structural damage. The machine learning algorithm can be trained on a set of labeled data, which includes examples of normal structural behavior as well as examples of structural damage, to identify features that distinguish between the two.

For example, a deep learning-based algorithm, such as a convolutional neural network (CNN), could be trained to classify acoustic data as either "normal" or "damaged" based on the patterns in the data.

The algorithm could be designed to identify subtle changes in the acoustic signals that may be associated with the presence of a crack, deformation, or other structural damage, and to generate alerts when such events are detected.

Machine learning can also be used to improve the efficiency of DAS data processing. For example, clustering algorithms can be used to group similar acoustic signals together, reducing the amount of data that needs to be analyzed manually. This can help to prioritize the data and focus attention on the most relevant events.

Overall, machine learning can greatly enhance the capabilities of DAS technology for structural health monitoring, providing more accurate and efficient detection of structural damage and reducing the risk of failure or collapse of critical infrastructure assets.

Striving for Sustainability with Advanced Technology

Technology plays a crucial role in achieving sustainability by enabling us to create innovative solutions that reduce our impact on the environment and promote more efficient use of resources.

Monitoring strategic capital assets using modern & innovative fiber optic sensing technologies may prevent an environmental catastrophe to occur by detecting an initial anomaly in the system.

With this approach, not only it will save the resources that would otherwise be lost forever and preserve the environment to a great extent, but it will also prevent major health risks to the surrounding population, providing an effective means to our customers to mitigate environmental risks.

It is also responsible for corporate governance to employ such advanced technologies to mitigate risks by monitoring capital assets in a precise, continuous, and real-time manner.

DFOST® provide sustainable opportunities and solutions for infrastructure operators and owners to gain valuable and critical insights into their capital assets by monitoring them proactively to mitigate the impact and improve operational efficiency. These assets can range from railways to highways, from gas to water pipelines, from long bridges to tunnels, from offshore to onshore wind farms, and from aerial to subsea power cables.

DFOST® provide total integrated solutions to enable its customers to positively impact their corporation and the environment in a sustainable way.

Distributed fiber optic sensing combined with artificial intelligence empowers us to tackle infrastructure and environmental challenges with sustainable solutions, revolutionizing the way we meet the demands of a changing world.