

Inteli-DAS, LLC



Fiber Optic Quantitative Distributed Acoustic Sensing with Artificial Intelligence



Turnkey Fiber Optic and Security Solutions for:

Pipeline Leak / ROW & Perimeter Intrusion Detection, Pig Tracking, Landslide, Detection, Power Distribution Protection, High net worth properties.

Telecommunication Solutions:

Fiber Cable installation, Fiber communications, SCADA interface, Edge technology security cameras, Microwave and last mile connectivity.

We also can incorporate off-grid remote power solutions and 24/7 Monitoring through PHMSA compliant and redundant control rooms.



Fiber Optic Distributed Acoustic Sensing

Acknowledgement

With kind permission of Blackstar Fiber LLC and EPIC Midstream

Thank You



Rayleigh Scattering

The phenomena today known as Rayleigh scattering, named after the 19th-century British physicist Lord Rayleigh (John William Strutt) 3rd Baron Raleigh, is the predominantly elastic scattering of light or other electromagnetic radiation by particles much smaller than the wavelength of the radiation. Conservation of kinetic energy.



The blue color of the sky is caused by the scattering of sunlight off the molecules of the atmosphere. It is more effective at short wavelengths (the blue end of the visible spectrum).

Therefore, the light scattered down to the earth at a large angle with respect to the direction of the sun's light is predominantly in the blue end of the spectrum.





What is Fiber optic Distributed Acoustic Sensing “DAS” and how it works?

- Mostly just referred to as (DAS) is fiber optic technology that uses Optoelectronics to detect vibrations and capture acoustic energy along the length optical fiber.
- It is when you fire a laser pulse down a standard fiber optic strand, monitor and interpreted any reflections or Rayleigh backscatter from fiber.
- Rayleigh Scattering – There are microscopic impurities left in the glass fiber after manufacturing

Fiber Optic Distributed Acoustic Sensing

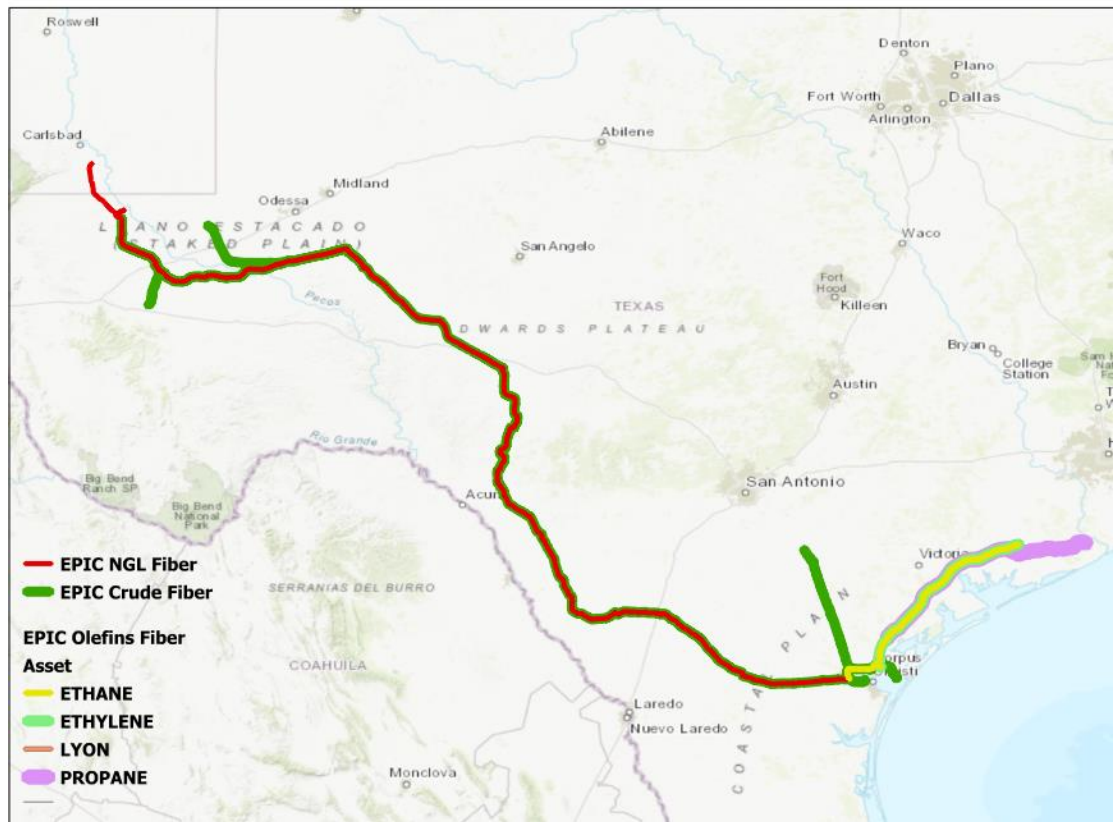


Asset Overview

- 100% new-build fiber network by Inteli-DAS
- Geographically redundant lines throughout network
- Huts spaced every 50mi with Handholes on average every 1500 ft.
- Protected by next-gen Distributed Acoustic Sensing (DAS) technology

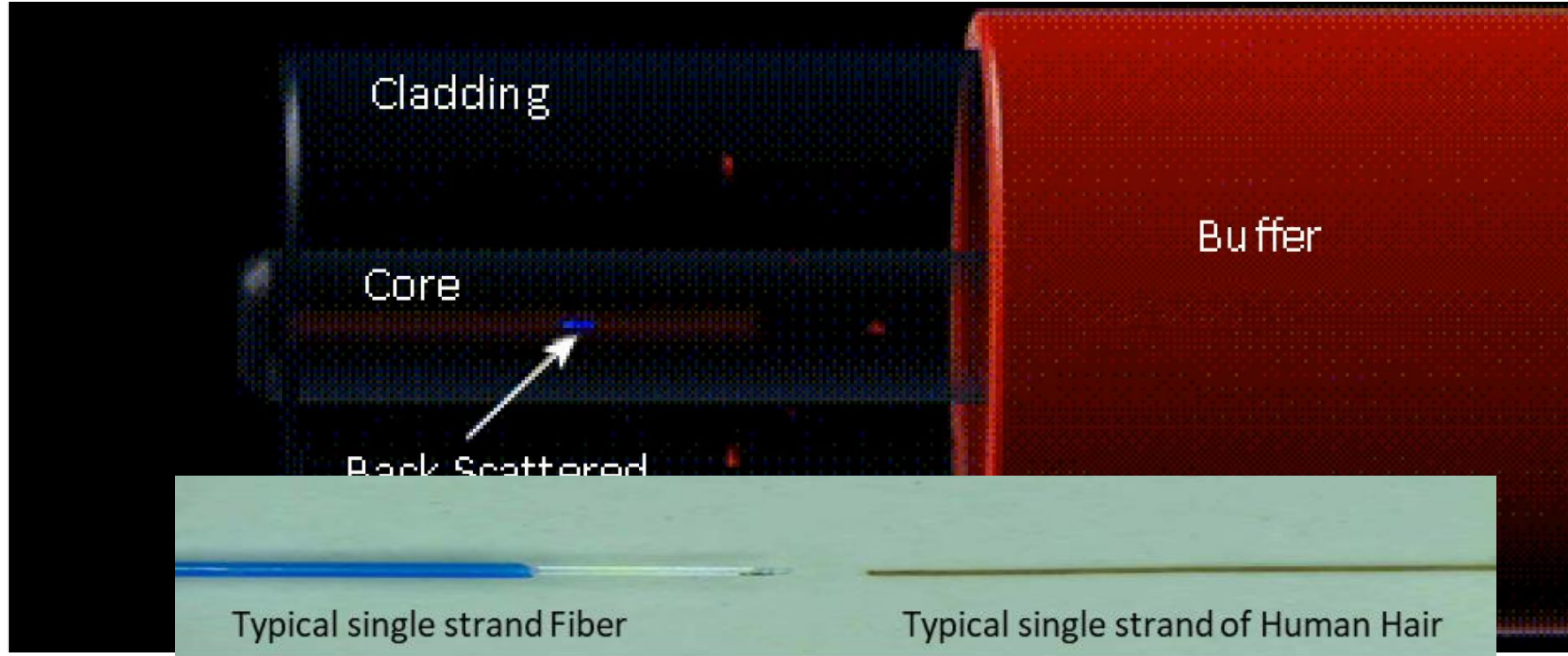


We have the longest Fiber Optic Pipeline Distributed Acoustic Sensing (DAS) in the for Leak and intrusion detection in the North America
Total of 1800 miles



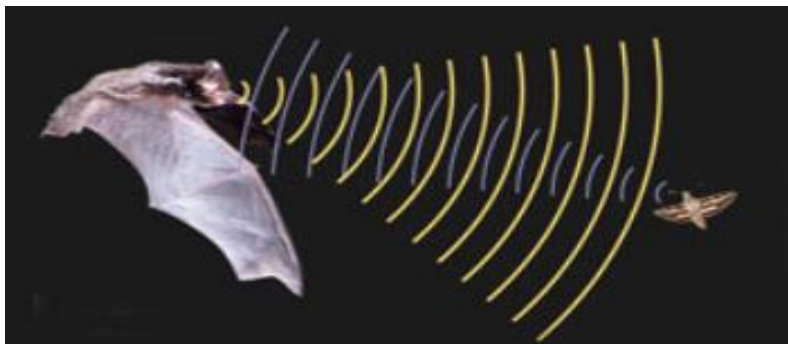


How Fiber Optic Distributed Acoustic Sensing works



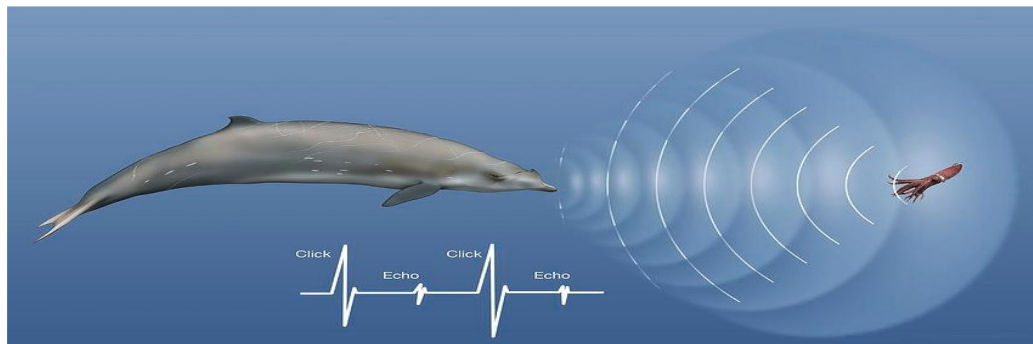


Fiber Optic Distributed Acoustic Sensing



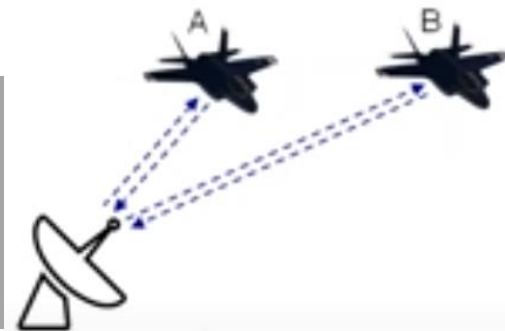
Bats use a similar technology with sound pulses traveling at 343 m/s, or 1,125 ft/s in Air

Distance to and back again from an object is the speed of the pulse \times the time of flight



Whales Dolphins use a similar technology with Sonar pulses traveling 4 to 5 times faster than Sound in Air

Radar uses the same principles using Pulses traveling at the speed of light approximately 300,000 km/s, or 186,000 mi/s





The backscattered light sent back along the fiber is uniquely influenced by external physical events:

1. Bending and stretching the Fiber cable. Straining the cable
2. Vibration imparted by the surrounding environment
3. And Temperature

The returning backscattered pulse can tell us lots on what is appending along the length of the fiber

Distance to the even, C the speed of light = $2 \times \text{distance} / \text{time}$, OTDR

Along with time of flight. Intensity, Phase, frequency change and other properties characterize the activity along the fiber path

Further electronics and algorithms (not too dissimilar to Alexa or Google speech recognition) are used to accurately report and characterize on a particular event

Rayleigh Backscatter to acoustic energy

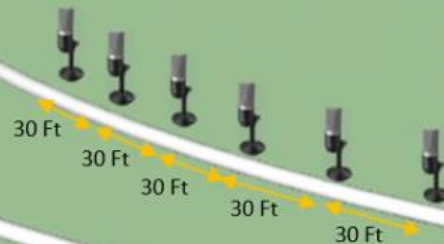


Short burst of Laser Light
Transmitted down a single fiber

Backscatter / Reflections
from impurities

HOW FIBER OPTIC DISTRIBUTED ACOUSTIC SENSING WORKS

Using the reflective properties of
standard single mode Fiber optic
telecommunication cable to turn one
of the fibers into a listening device





How can we put this to use on Pipelines and ROW security

- The vibrations generated by leaking pipes, hot-tapping, moving vehicles, ROW intrusion, construction equipment, mechanical and manual digging and Pigging operations all impact on the fiber cable.
- This aids in detecting, classifying and accurately locating the site of vibrations or defects.
- In comparison to the traditionally used methods, DAS systems do not require discrete sensors and additional transducers.

The fiber cable is not only for DAS it can be used for what it is traditionally used for, communications, Network Backbone, Instrumentation and Control Etc.



Fiber Installation Overview

Type of Cable:

Standard Single Mode Telecommunications cable:

Can be armored or Un-armored

In conduit or direct buried

Or

It can be multi-mode but the cable type will have to be tested and assessed.

For DTS, both types of cable can be used, but it depends on the measurement mode. Raman (MM) or Brillouin (SM)





Fiber Optic Distributed Acoustic Sensing

Other areas it is primarily used for monitoring:

Oil and Gas pipelines and Facilities - Road and Rail Infrastructure - Power Transmission Lines – Dams & Retention Ponds - Seismic Activity & Landslides – Seismic Downhole Well Characterization - Perimeter - Border Security – Correctional Centers - High Net Worth Protection such as Airports, Power Plants and Data Centers

Our Troops Currently use it:
Protect Supply Routes - Temporary Camps and our Southern Border

Other Areas supported by DAS

Border Surveillance

In support of the US Customs and Border Protection (CBP) Quantitative systems were selected after a thorough evaluation process to provide gapless, persistent surveillance along the 1,900 miles extent of the southern border between the United States and Mexico.

Operationally is configured to detect the movement of people and vehicles crossing the border as well as identifying other prohibited activity.



Infrastructure interference detection, using OPGW



Control Room & SCADA services



Dams & Retention Ponds
Seismic Activity & Landslides



High net worth Assets (Data Center)
perimeter intrusion detection



Correctional Centers



Pharmaceutical Farms

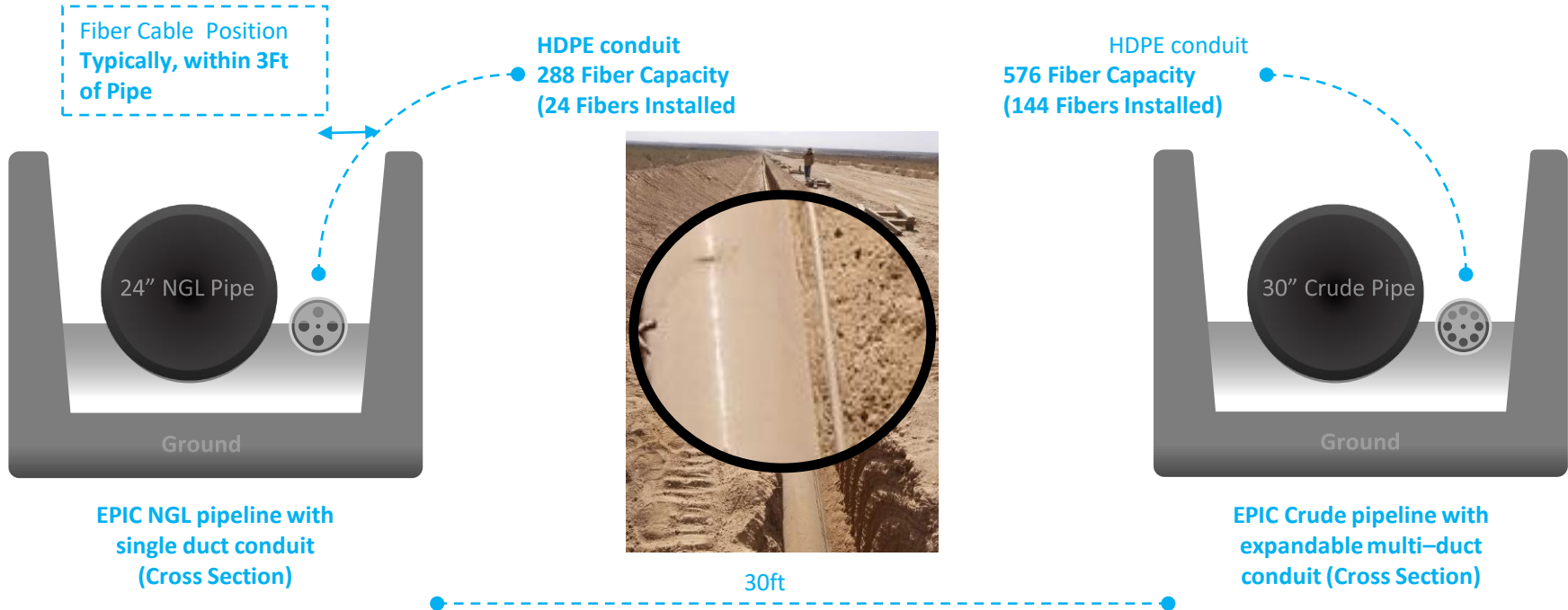


Airport Security



Fiber Installation Overview

“Built alongside two major pipeline systems, the Fiber protects a key energy corridor running through Texas”





The next Generation of Fiber Optic distributed acoustic sensing

Learned from an Operators perspective

Cost is high and
its very labour
intensive

Too many alerts,
operators struggle
to cope

Most of the alarms
are outside of my
right-of-way

We need a
complete security
solution, not just
DAS

And more....?

User interface
is too complex

We need a
Control Room
for Monitoring



The next Generation of Fiber Optic distributed acoustic sensing

There have been three key areas to focus in on:

- **Design out cost** – Address both equipment and implementation costs
- **Improve performance** – Measure what needs to be measured and reduce NARFAR
NAR is the rate of invalid alarms caused by nonthreat sources. FAR is the rate of invalid alarms caused by unknown sources
- **Simplify use** – Streamline commissioning, operation and support – Automate processes



The next Generation of Fiber Optic distributed acoustic sensing - Design out cost



OLD



A Major leap forward in design

Smaller, lighter and lower cost



Reduced SWaP:
 Size: 3U (5.25in x 19in)
 Weight: 17 kg
 Power: <100W
 Fully integrated processing capability

Quantitative measurements
 100km range
 Two 50km fiber sensing ports
 (Per 100km equivalent system)

HOW IT WORKS

Like going from 3G to 5G in one leap

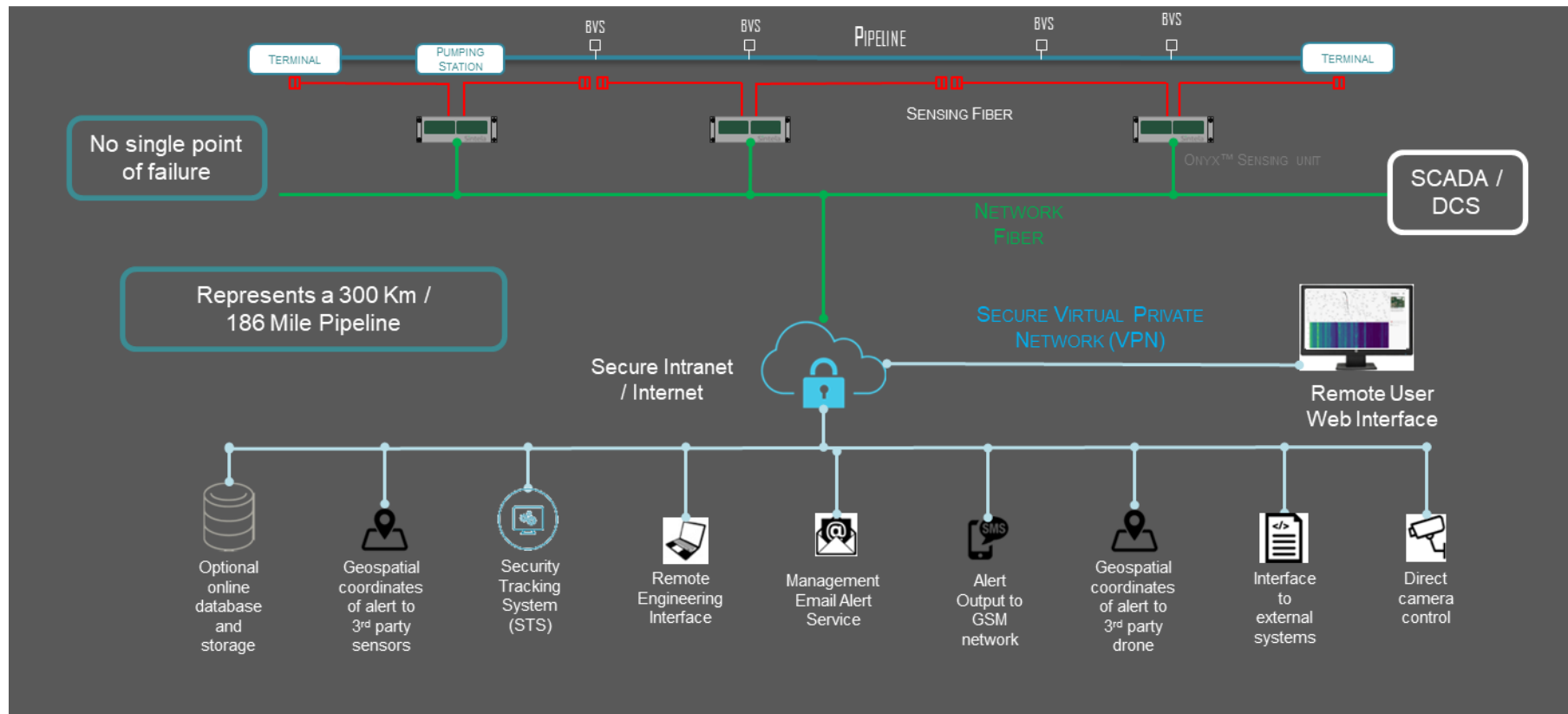
NEXT
GENERATION



This is what EPIC have done – reduced a multi unit system into a single unit directly compatible with any of the older generations



The next Generation of Fiber Optic distributed acoustic sensing - Design out cost





The next Generation of Fiber Optic distributed acoustic sensing - Design out cost

The EPIC pipeline Represents a 2900 Km /
1800 Mile Pipeline

Approximately 870 different pieces of equipment reduced to 29

= less cost

3000 Drawings and documents reduced to 300

= less cost

Power consumption at each location 600W reduced to <100W

= less cost

Reducing the cost of large-scale deployment throughout project lifetime



The next Generation of Fiber Optic distributed acoustic sensing – AI / Machine Learning

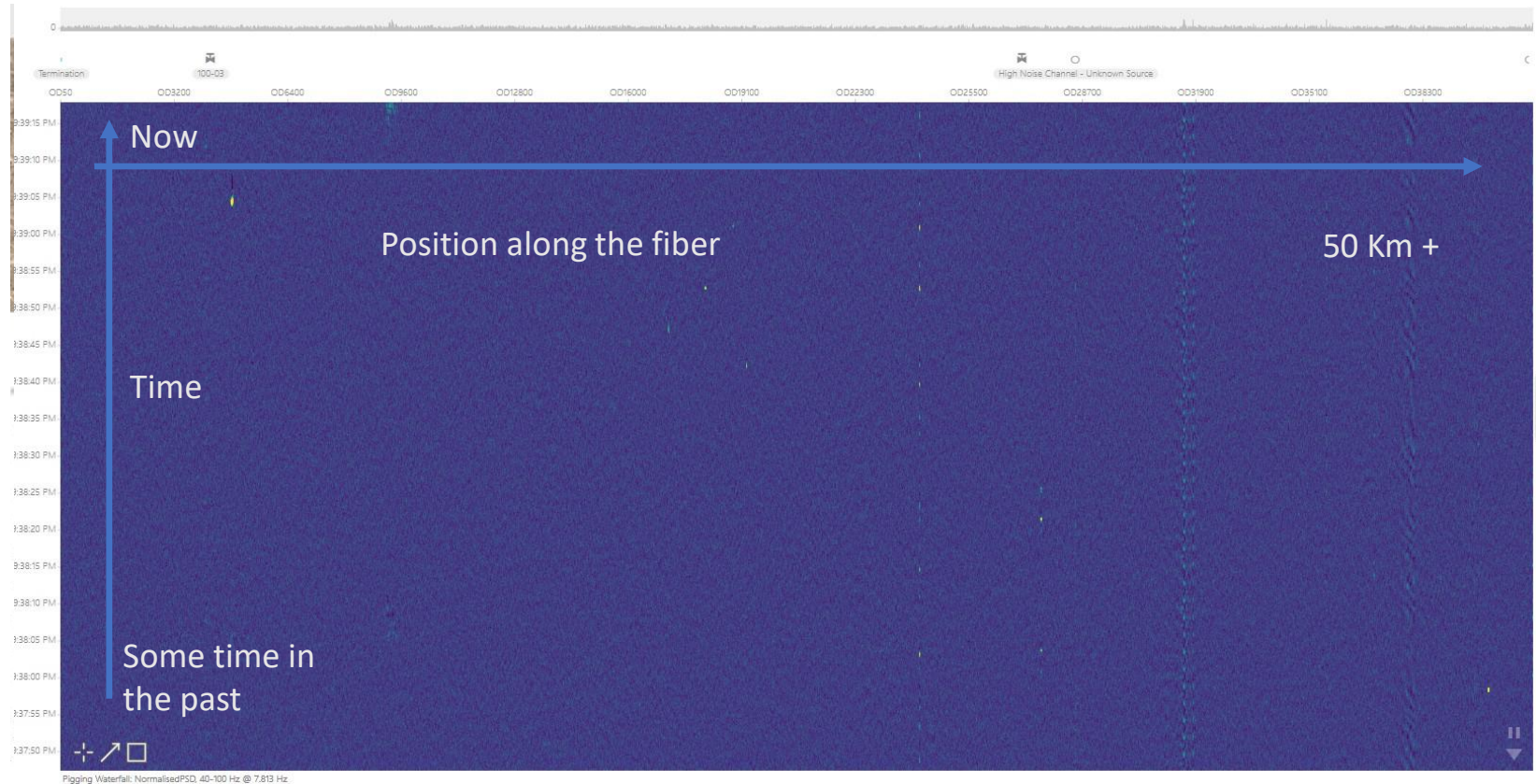
Algorithm Validation

The quantitative nature of the next generation DAS units and the utilization of AI/machine learning models means.

1. Detailed signal analysis is not required, and the installation is now a validation process of the AI models supplied. This results in a reduction of installation and commissioning time of around 50% compared to other DAS installations.
2. Where an quantitative unit is being installed to replace an existing DAS unit the existing test recording can be used to create site specific data tiles for the AI models to reduce the amount of on-site works required.
3. To verify the AI models, it is recommended two test points are identified on each fiber section one should be in the 90-100% distance of the fiber and the second should identify an area within the first 50% of distance of the fiber.
4. Where there is no algorithm test data (e.g., digging, mechanical digging, etc) tests should be performed every 10 km's along the fiber route and at this time the 50% SAT test point and 90% SAT test point will be identified.

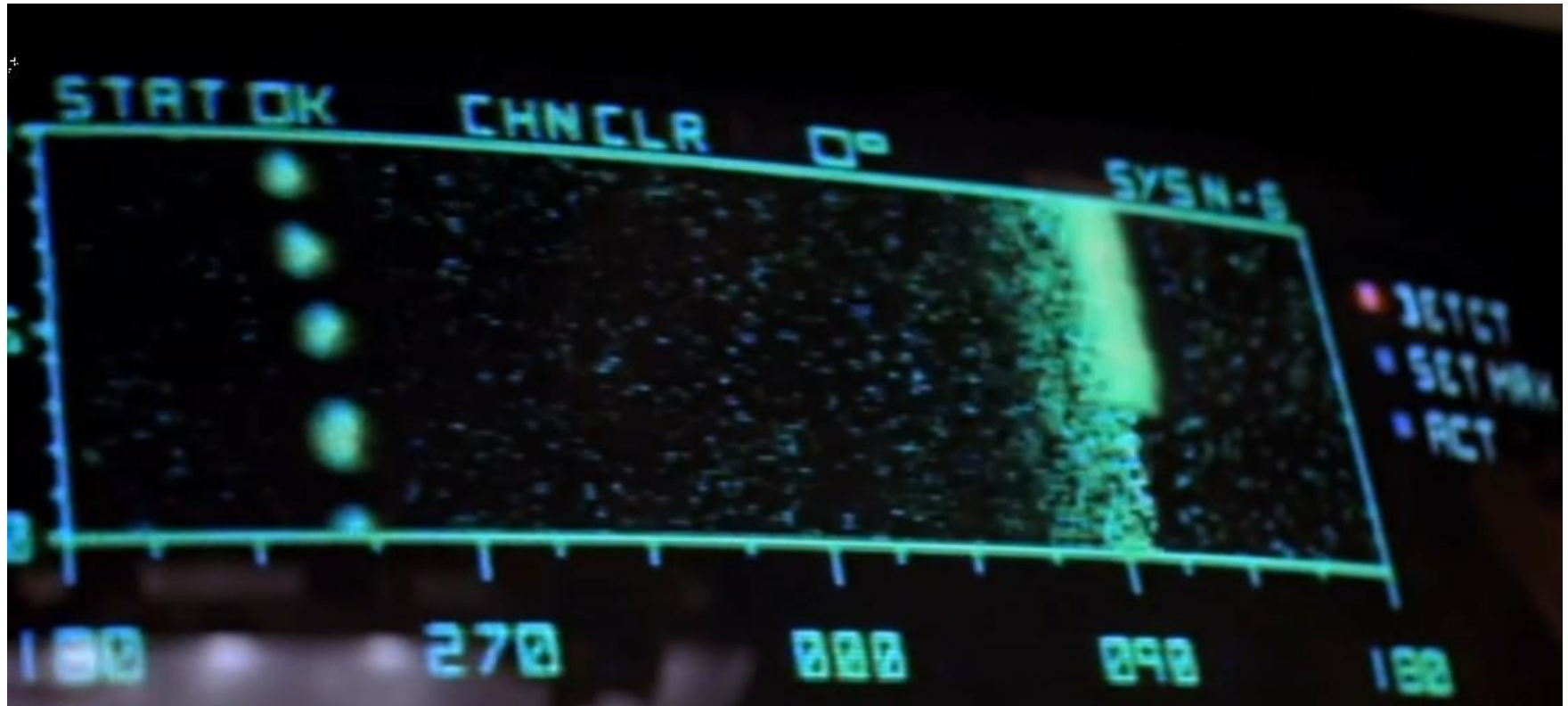


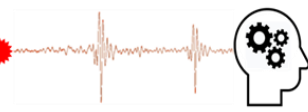
The next Generation of Fiber Optic distributed acoustic sensing - Streamline commissioning, operation and support – Automate processes





The next Generation of Fiber Optic distributed acoustic sensing - Streamline commissioning, operation and support – Automate processes



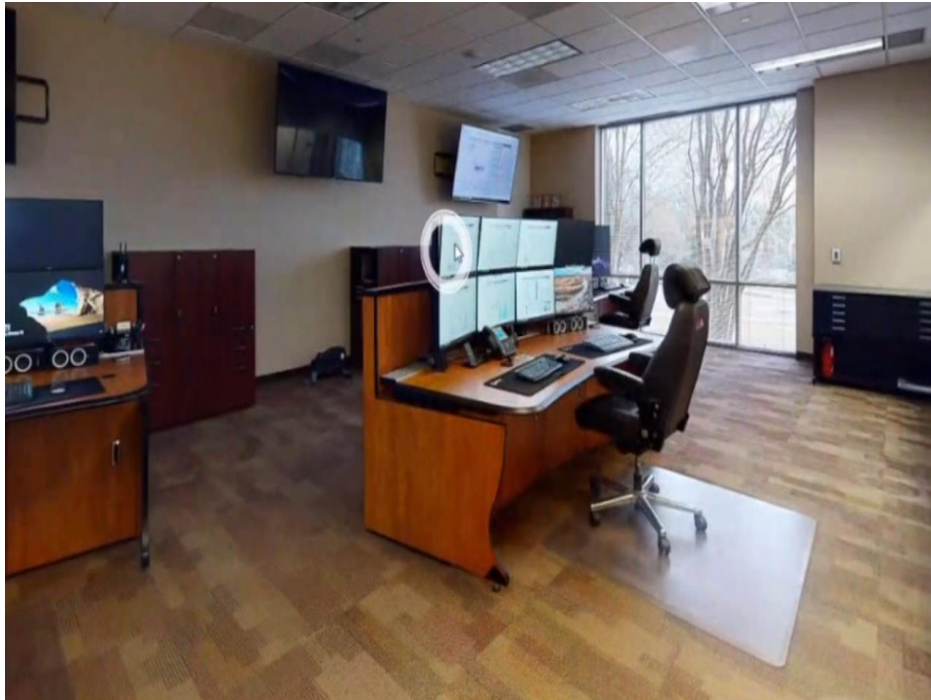


The next Generation of Fiber Optic distributed acoustic sensing - Streamline commissioning, operation and support – Automate processes





Control Room



The next Generation of Fiber Optic distributed acoustic sensing - Streamline commissioning, operation and support – Automate processes

Remote Equipment Hut





Improving performance with a Quantitative rather than the commonly used Qualitative approach.

Aspect	Qualitative	Quantitative	Example
Data	Data that consists of descriptive statements. Text based	Data that is measured and expressed numerically.	Very high, low, near, far v pE, uE, fs/s, ft/s/s etc.
Distance	Distant	Within 20 to 25 ft	
Analysis	Statistical analysis is harder	Statistical analysis is easier	What is the average of loud and not so loud, versus 68dB and 30dB
Outcome	Develop an initial understanding	Recommend a final course of action	There is something there but not quite sure what and how much. V there is a backhoe, and it is outside the right of way



Hear the ONYX™ difference

20dB (x10) improved acoustic noise performance for superior detection and classification

DIGGING WITH CURRENT DAS

LISTEN >

DIGGING WITH ONYX™

LISTEN >

WALKING WITH CURRENT DAS

LISTEN >

WALKING WITH ONYX™

LISTEN >

Improve performance

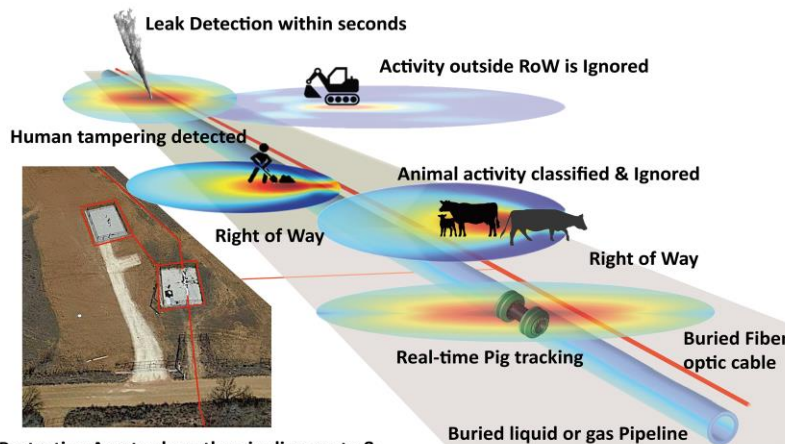
Use **Fully Quantitative Measurement** vs Energy measurement
20dB factor of 10 better noise floor

A quantitative response is critical

Categorizing events in terms of their type and offset range can substantially reduce the nuisance alarm rate
Decreases the operator burden and costs

Pipeline Leak and Intrusion Detection

ROW is continuously monitored & activities are accurately classified



Protecting Assets along the pipeline route &

Monitoring machine noise for integrity management

Typical Activity Threat Matrix

Activity Type

Scraper / Piging activity

Seismic activity

Movement of large animals

Movement of humans

Vehicle movement

Bush / Tree cutting

Manual excavation

Ploughing

Digging / Drilling

Mechanical excavation

Fiber break

Distance from Fiber

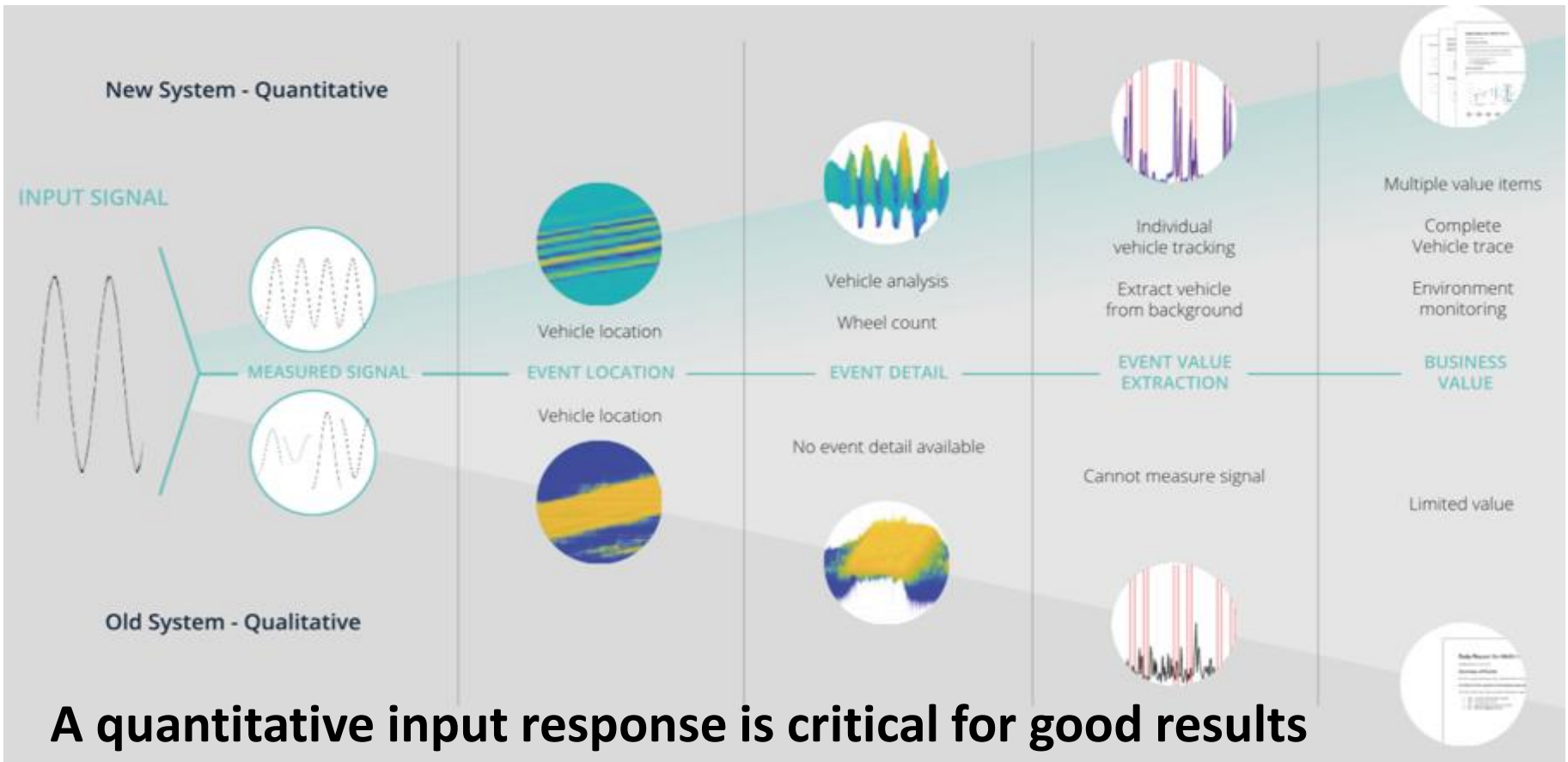
0 - 10 m 33 ft From Fiber	10 - 20 m 33 ft to 66 ft From Fiber	>20 m >66 ft From Fiber
Advisory event	No event	No event
Advisory event	No event	No event
Advisory event	No event	No event
Advisory event	Advisory event	No event
Critical event	Advisory event	No event
Critical event	Advisory event	No event
Critical event	Advisory event	No event
Critical event	Critical event	Advisory event
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0 - 10 m 33 ft From Fiber	10 - 20 m 33 ft to 66 ft From Fiber	>20 m >66 ft From Fiber

Most false and nuisance alarms are caused by not knowing how far away the event is occurring.

Using AI & Quantitative measurements, we have solved that issue.

With this new technology. Retro fitting pipelines has become significantly easier, allowing the fiber to be installed at a greater distance from the pipeline.

Improve performance A leap forward in Pipeline monitoring



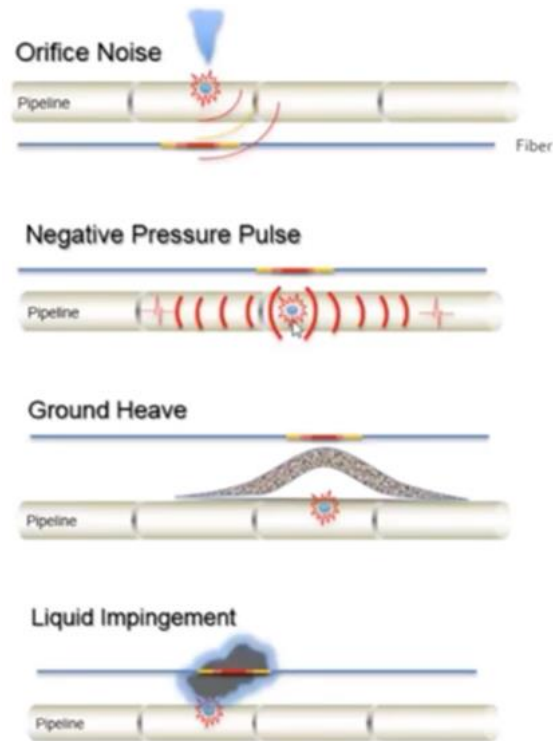
A quantitative input response is critical for good results

Improve performance A leap forward in Pipeline monitoring

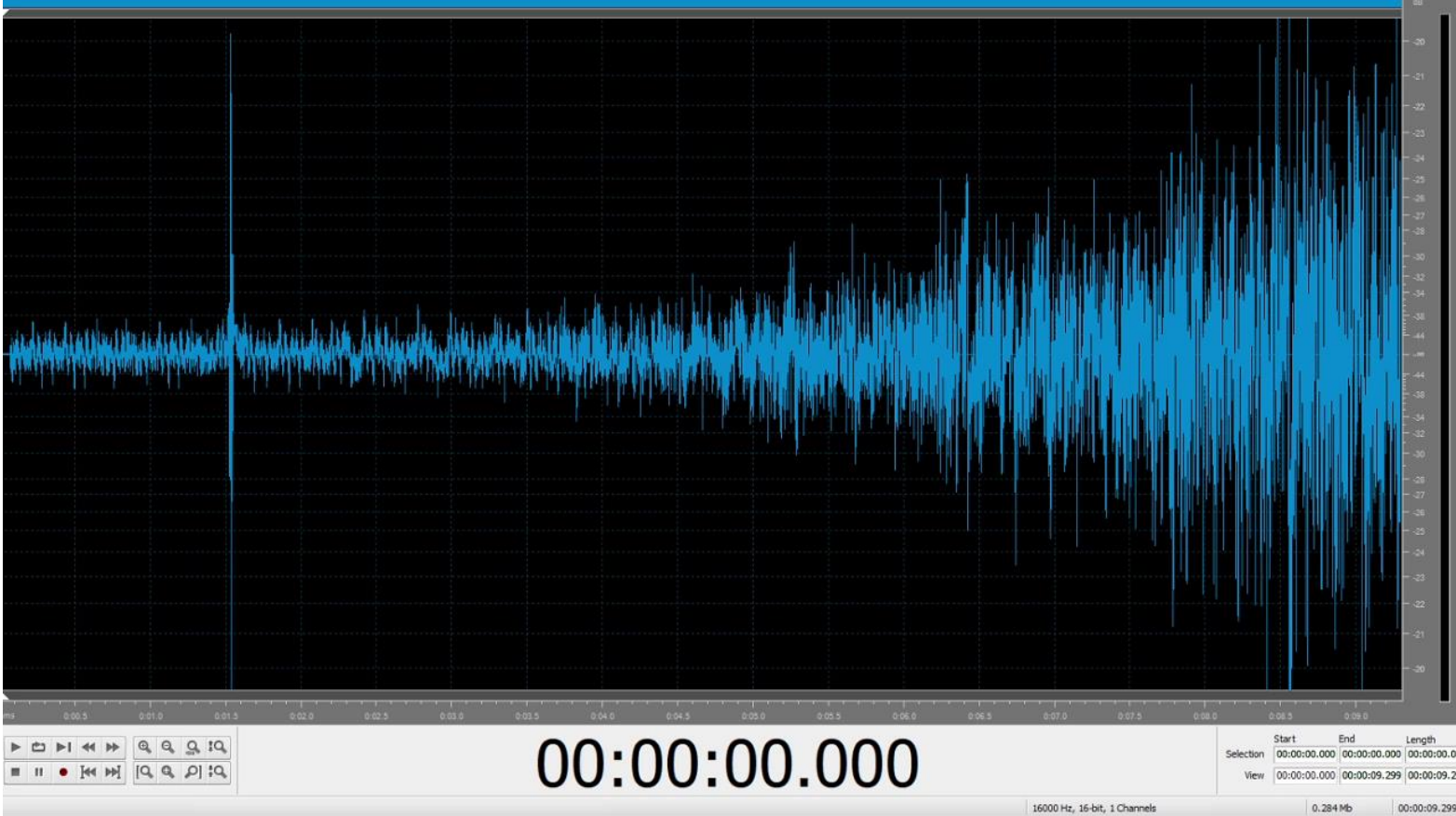


Leak Detection | Four Supporting Modes

- Detection of oil and gas leaks achieved by combining different measurements available from DAS
- Multiple Acoustic and Vibration leak signals are also available
 1. Orifice Noise from leak in pipe
 2. Negative Pressure Pulse propagation in pipe
 3. Ground Heave / Displacement from a gas leak
 4. Leaking liquid impingement on the cable

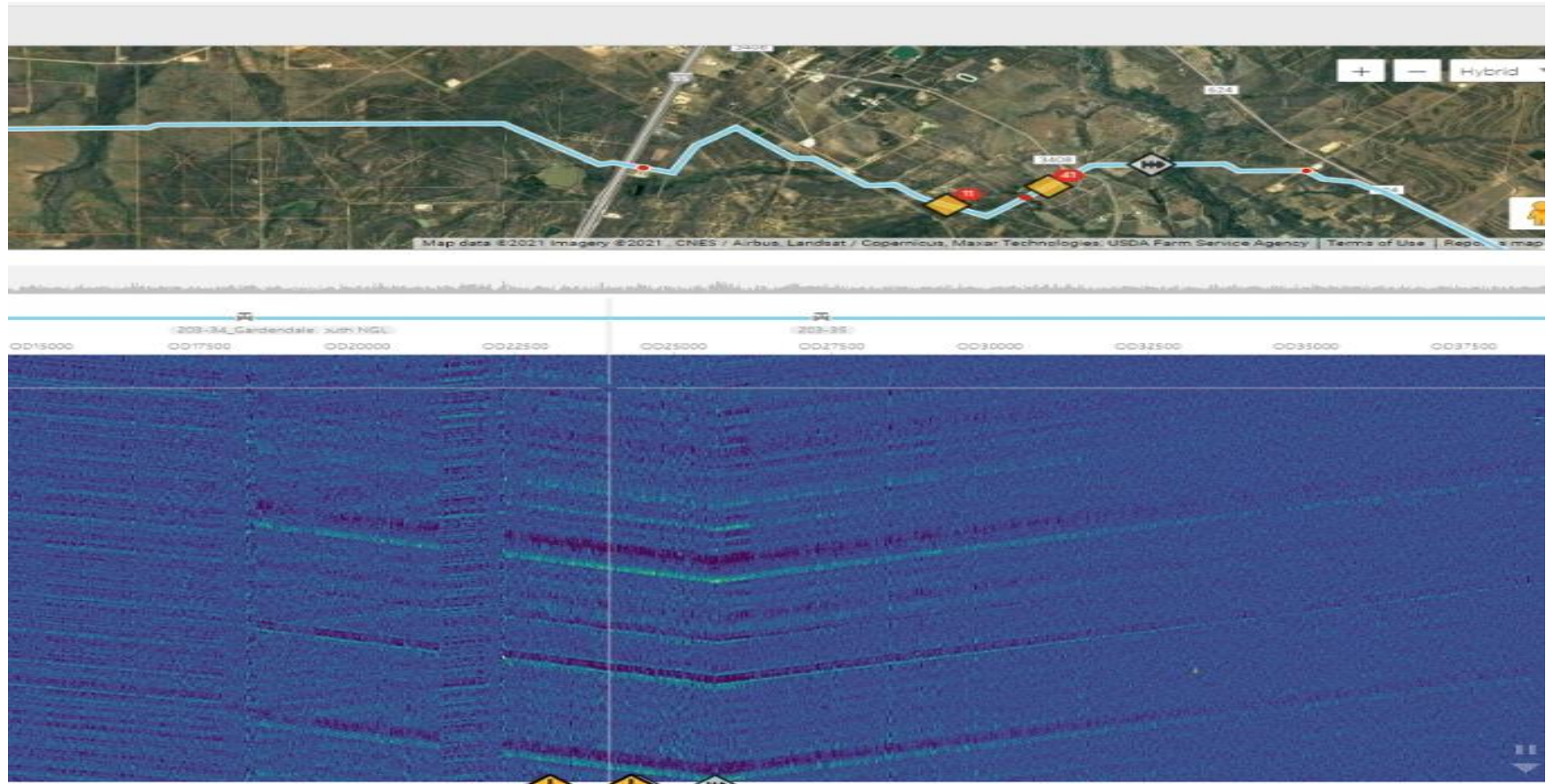


Quantitative DAS – Employs a 5th mode of Cross Correlation for a higher signal to noise ratio to detect the smallest of leaks.





Pig Tracking





Pig Tracking



Approx 25 Km / 15 ½ miles

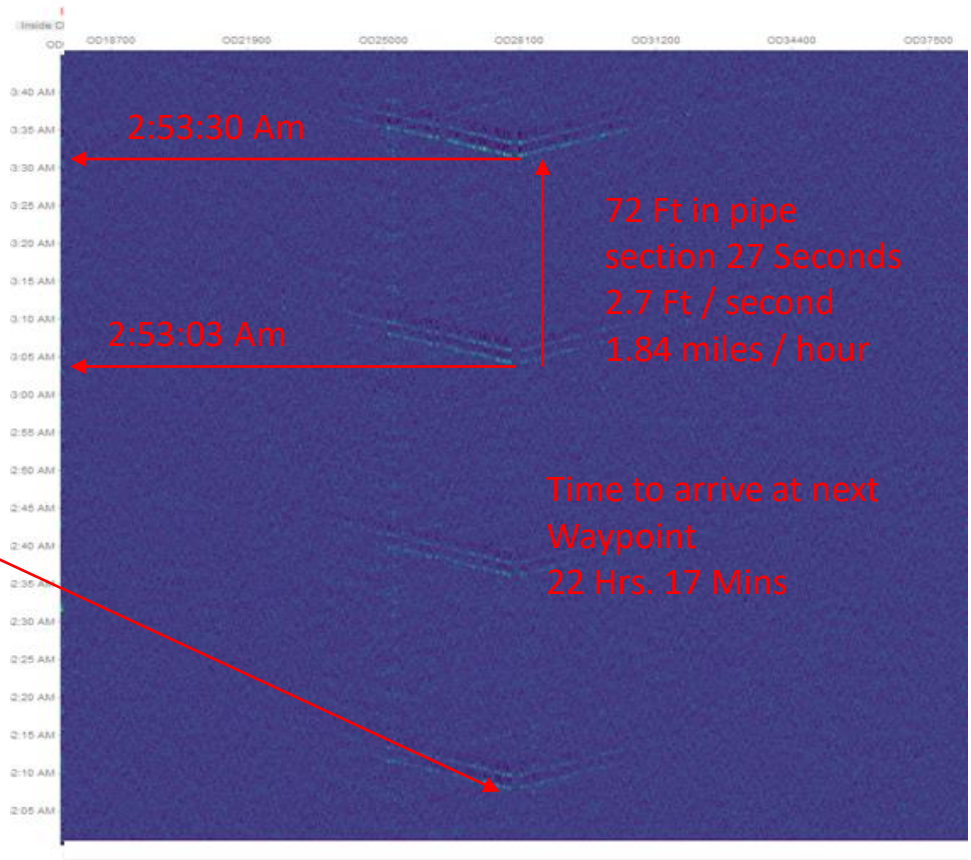
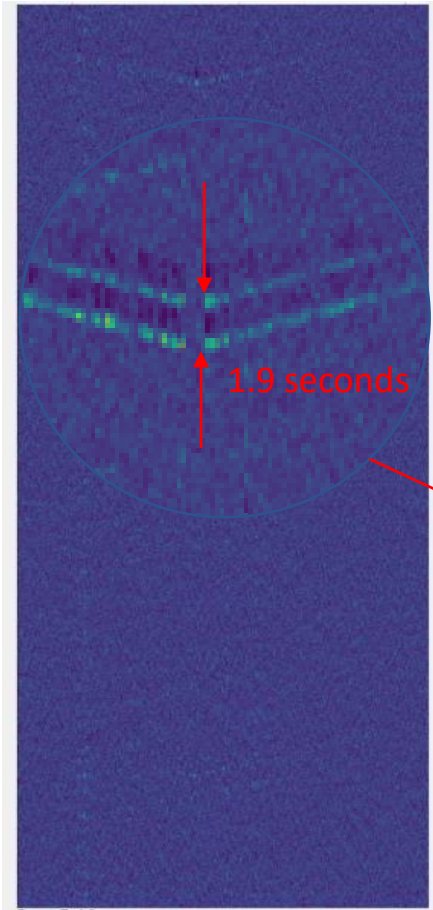


Pig Tracking

X 20



Realtime

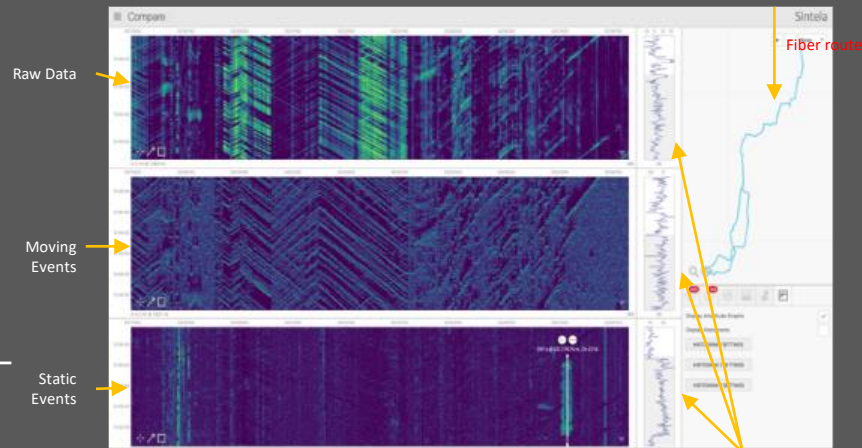
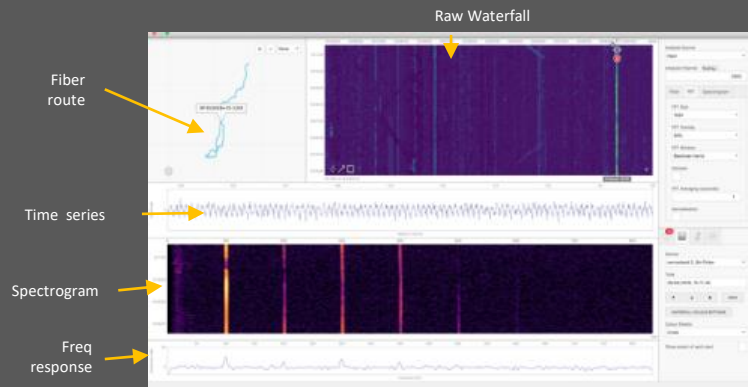




Cutting-Edge engineering and analysis tools

- Multiple waterfall displays can be compared to filter noise and perform **advanced threat analysis** on detected events and alerts
- **Sophisticated processing techniques** previously required specialist software – these are now integrated seamlessly to the user interface

Streamline commissioning, operation and support –
Automate processes

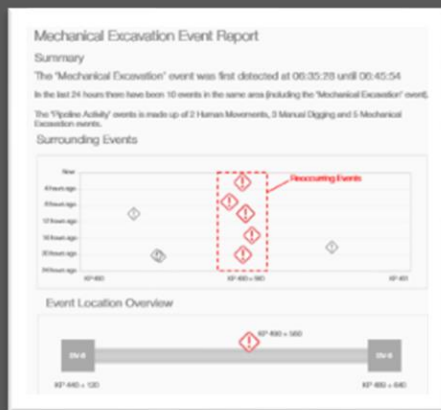


- New **automated analysis tool** assists system engineers to improve system tuning
- Simple and **modern interface**, fast and easy use, detailed and **clinical output**
- **Open-Source software**, enables new routines to be developed without the manufacture's involvement



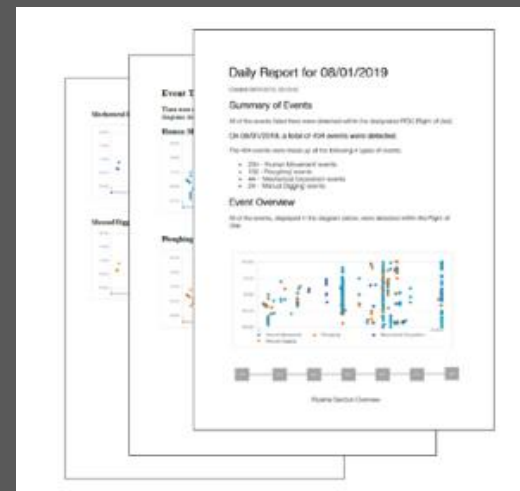
Streamline commissioning, operation and support – Automate processes

Advanced Alert Analysis and Reporting



- Real-time event reports and alert analysis
- Assists operators to react **correctly** and **quickly**
- **Intelligently** links and reacts to alarms to reduce alert rate overwhelming system operators

- Alert Report function allows extended reports to be produced and exported in seconds
 - ✓ No more manual analysis required
- Trending graphs inform system event analysis for intrusion / event detection and system performance improvements





- Leak detection
- ROW Intrusion detection
- Slug Detection
- PIG tracking
- Facility intrusion detection

- Facility and Asset connectivity and control
- Well Pad connectivity and control
- Robust and Secure private network with high bandwidth
- Revenue generator – Leased spare fiber capacity

- Subsidence and Earthquake Detection
- 24hr/7d autonomous monitoring with no human interaction
- No V-SAT / Microwave network costs

- Reduced insurance premium or consequence to event
- Litigation
- Permitting, and environmental mitigation
- Low Operating cost

Helps with ASME B318S: Managing System Integrity of Gas Pipelines



In summary

When selecting a Fiber optic leak distributed acoustic sensing system

- Does the system make “Quantitative or Qualitative” measurement.
- What footprint does the system take up.
- Does the system offer an open-source software solution
- Does the system use a form of artificial intelligence
- Are there sufficient software application included with the system.
- Automaton of Routine reporting.

The Next Generation of Quantitative Fiber Optic Distributed Acoustic Sensing with AI

New

- Incorporates Artificial Intelligence
- Interrogator 3U height
- 80-mile, 130km capability
- Low < 100W Power requirements
- 20dB x10 better noise floor
- Open Software architecture
- Onboard analysis software included
- Can determine distance of noise source
- Substantially cost effective
- Installation and commissioning reduced
- PHIMSA compliant remote-control room
- Directly replaces existing DAS system
- Can run with any web browser
- Turnkey Solutions Available
- Retro-Fitting Available

Old

- Obsolete DAS Technology
- 14 U multiple boxes in a Large Rack
- Very high 600W Power consumption
- Max distance 50km 31 Miles
- Qualitative Energy Measurement
- Closed Software architecture
- More Expensive
- Labor Intensive
- Months to install
- Do not supply Turnkey Solutions
- Needs Special display PC



Other Areas supported by DAS

Border Surveillance

In support of the US Customs and Border Protection (CBP) Quantitative systems were selected after a thorough evaluation process to provide gapless, persistent surveillance along the 1,900 miles extent of the southern border between the United States and Mexico.

Operationally is configured to detect the movement of people and vehicles crossing the border as well as identifying other prohibited activity.



Other Offerings Complementary to DAS

Fiber cable installation, Fiber communications, SCADA interface, Edge technology security cameras and drones. Microwave, and last mile connectivity. Off-grid remote power solutions and 24/7 Monitoring through PHMSA compliant and redundant control rooms.

The End Any Question

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<https://www.linkedin.com/company/Inteli-DAS-LLC/>

The Next Generation of Quantitative Fiber Optic Distributed Acoustic Sensing with AI

Fully quantitative: A measurement that a Value and Unit can be assigned to, e.g., 1.6 picostrain is the smallest detectable strain.

We have the only system to make coherent quantitative measurements on over 130 km/80 miles of fiber optic cable

With a minimum detectable signal at -80dB, 10 times more sensitive than others.

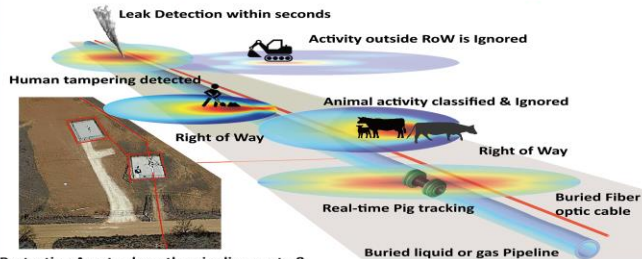
This enables the implementation of advanced **Artificial Intelligence** techniques to be used to train the system to distinguish between different types of activity. This ensures that the system has industry leading detection, performance and sensitivity whilst greatly reducing nuisance and false alarm rates that are experienced with other systems.

We can also claim to be the only provider that can instantly tell how far from the fiber the event takes place, which gives a far greater understanding of the threat.

Please ask Stand Attendant further information and audio demonstration of the improvements.

Pipeline Leak and Intrusion Detection

ROW is continuously monitored & activities are accurately classified



Protecting Assets along the pipeline route & Monitoring machine noise for integrity management

Typical Activity Threat Matrix

Activity Type	0 - 10 m 30 ft From Fiber	10 - 20 m 30 ft to 60 ft From Fiber	>20 m >60 ft From Fiber
Scraper / Piggings activity	Advisory event	No event	No event
Seismic activity	Advisory event	No event	No event
Movement of large animals	Advisory event	No event	No event
Movement of humans	Advisory event	Advisory event	No event
Vehicle movement	Critical event	Advisory event	No event
Brush / Tree cutting	Critical event	Advisory event	No event
Manual excavation	Critical event	Advisory event	No event
Plopping	Critical event	Advisory event	No event
Digging / Drilling	Critical event	Critical event	Advisory event
Mechanical excavation	Critical event	Critical event	Advisory event
Fiber break	Critical event	Critical event	Critical event
Distance from Fiber	0 - 10 m 30 ft From Fiber	10 - 20 m 30 ft to 60 ft From Fiber	>20 m >60 ft From Fiber

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