Distributed Acoustic Sensing - fiber optic pipeline monitoring

JJ Williams
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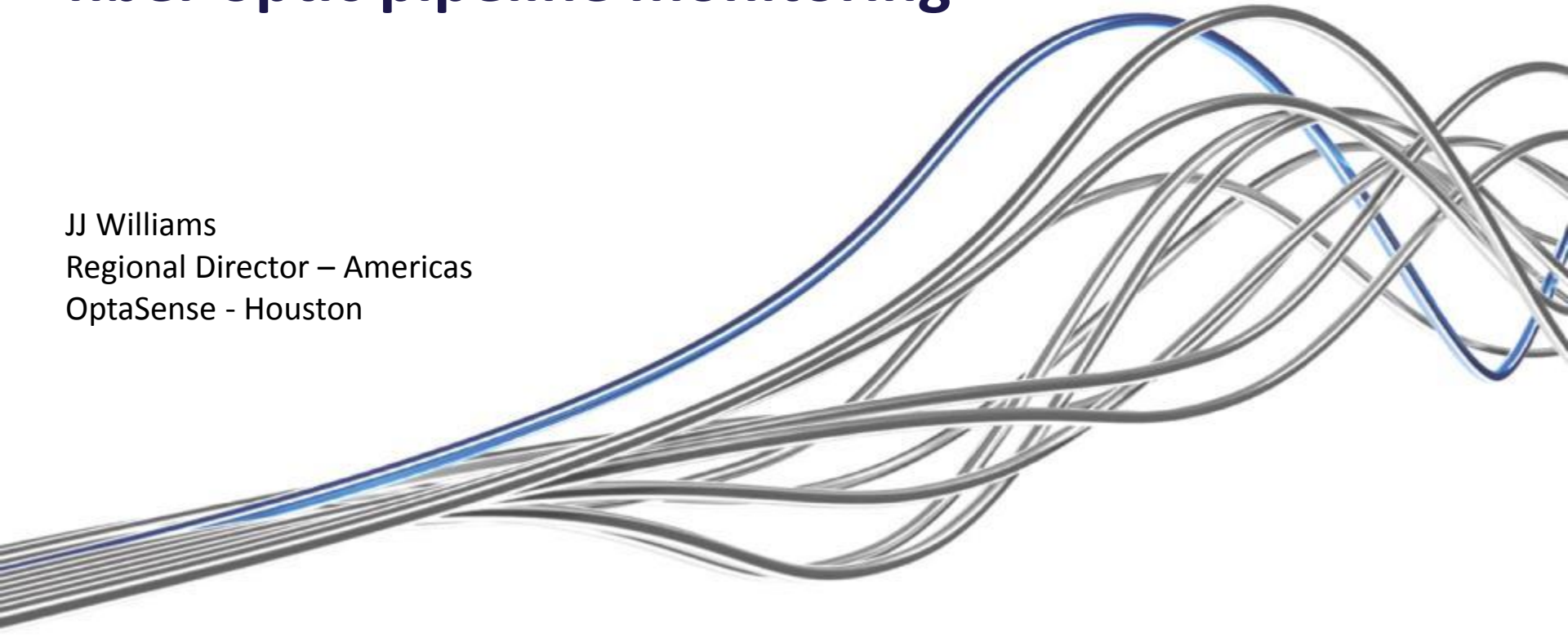
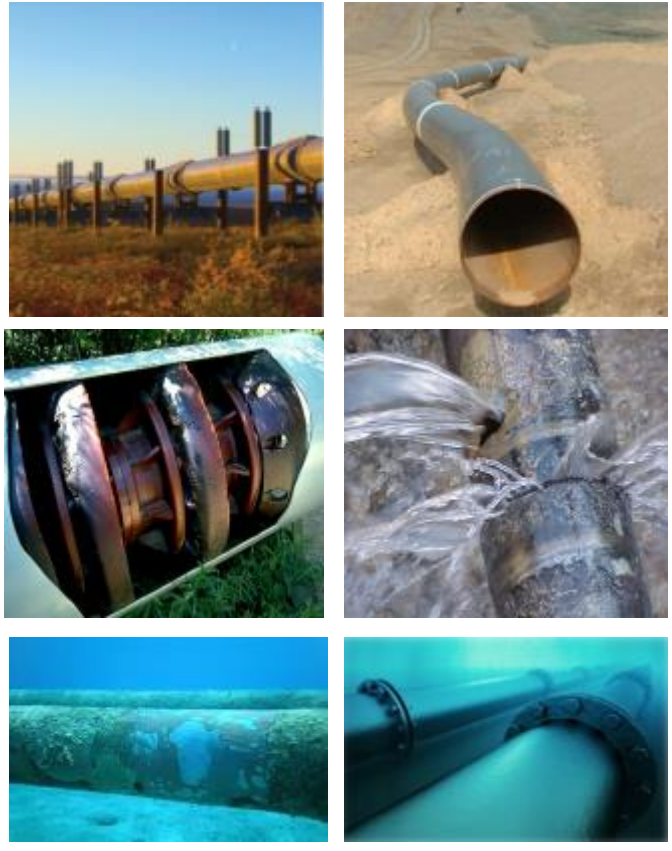
OptaSense - Houston



Agenda

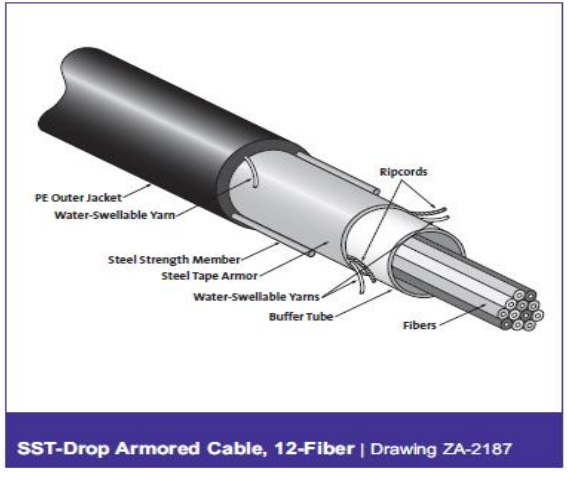
- What is Distributed Acoustic Sensing?
- Typical system architecture
- Installation
- Applications:
  - Leak detection
  - ROW intrusion monitoring
  - PIG tracking and others
- Notable projects
- Fiber Optic Sensing Association



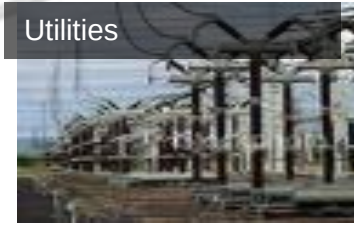
About DAS

Convert a fiber optic cable into a listening device every 30ft over long distance

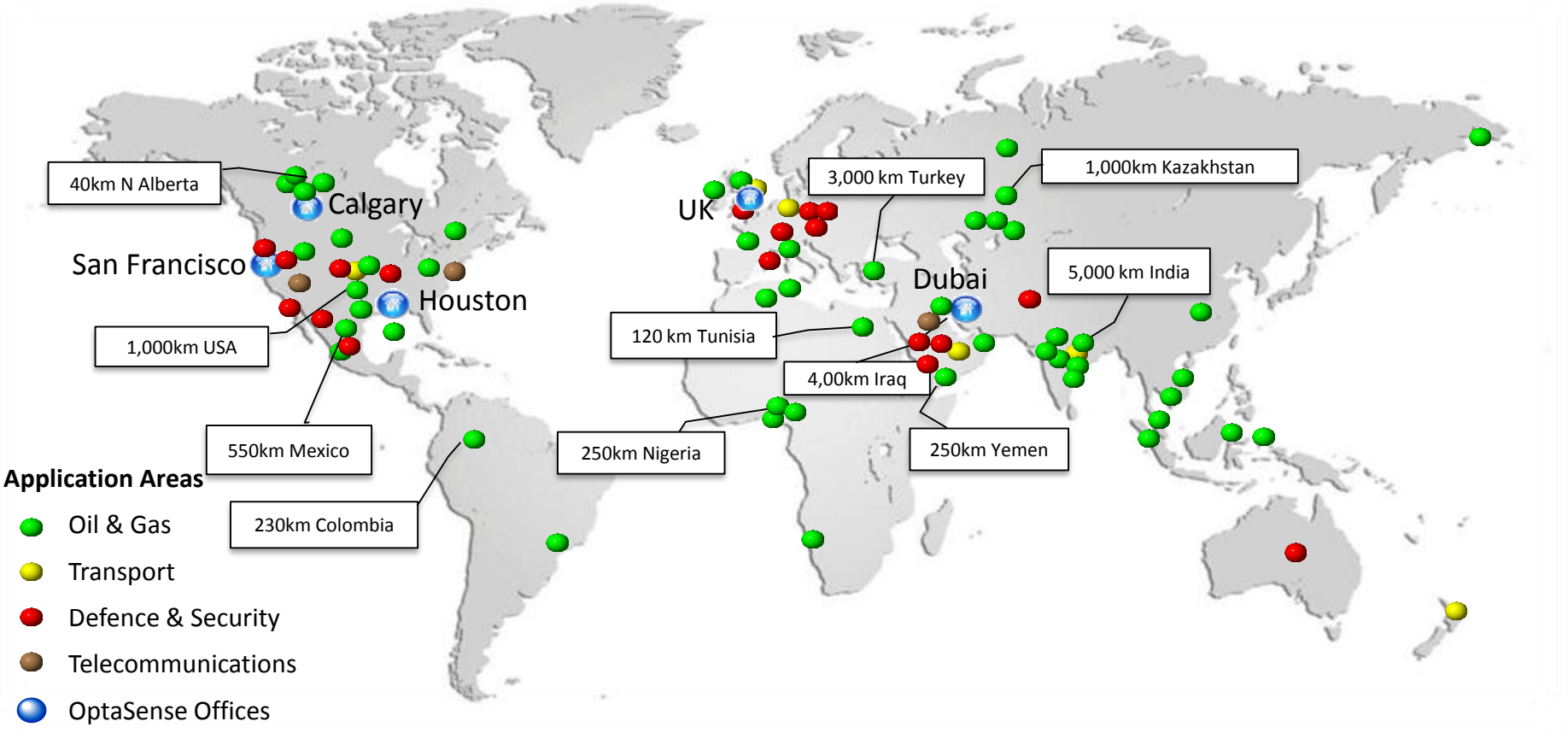
Standard commercial cable – up to 25 miles with 1 unit



OptaSense Interrogator Unit



>20,000 miles proven performance on pipelines



Principals of DAS

The fiber is the sensor

- OptaSense® employs a Coherent reflection technique which uses the Rayleigh backscatter phenomenon of telecoms cable to convert the fiber into a highly sensitive acoustic sensor.

Standard Single Mode optical fiber

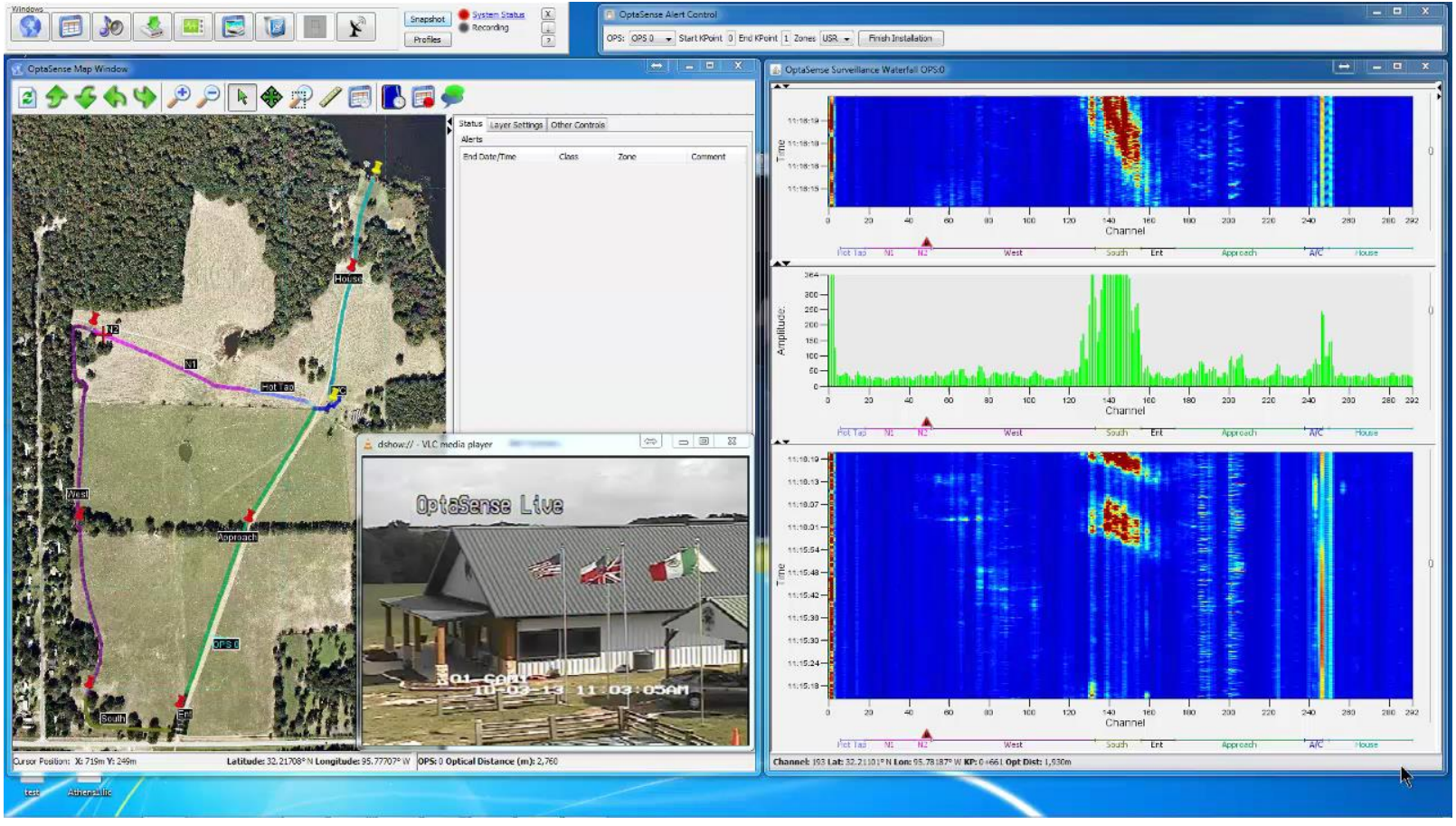
A_1 A_2 A_3 A_4 .....

- Changes in the reflected light are reactions to the acoustic activities present at each ~30ft increment along the pipeline, railway, border etc…

Pulse of light

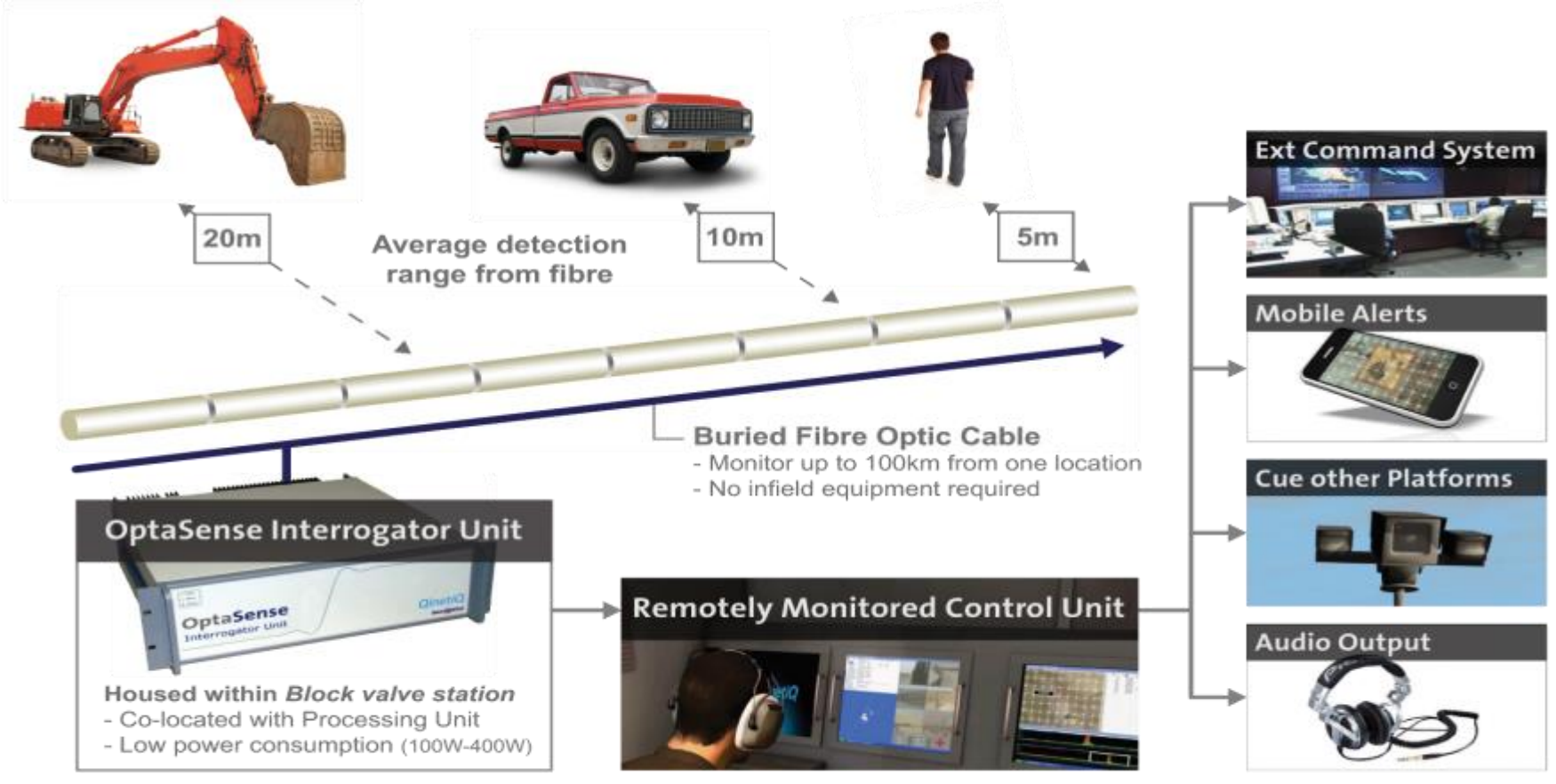
$A_{4,995}$ $A_{4,996}$ $A_{4,997}$ $A_{4,998}$ $A_{4,999}$

Quick Demo



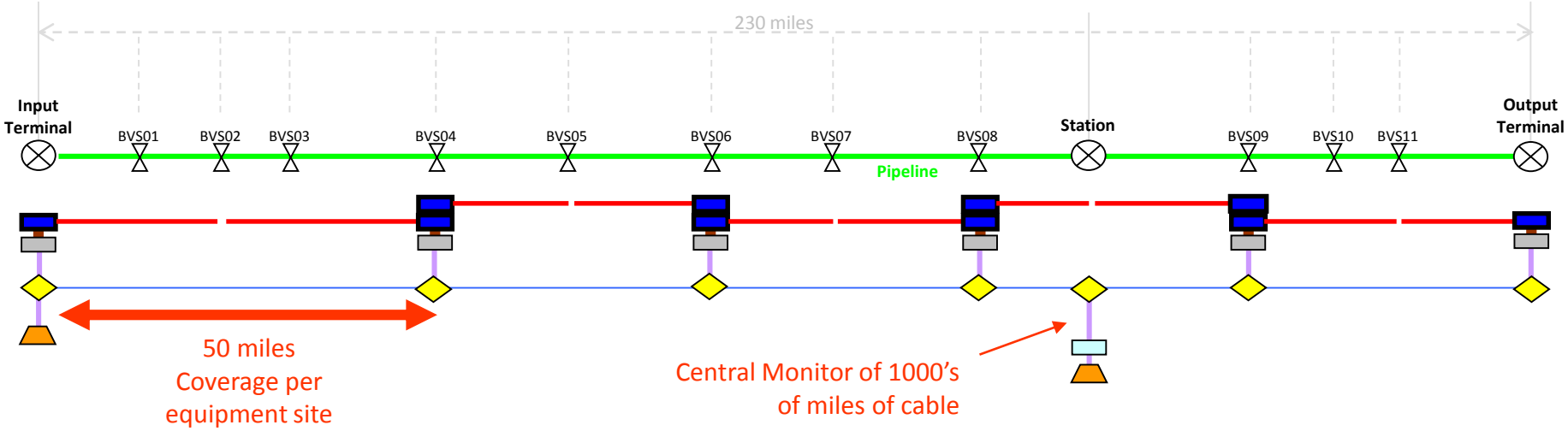
System overview

OptaSense can be deployed stand alone or integrated into existing systems



Typical pipeline architecture

Example: 230 mile pipeline



- Block Valve Station
- Interrogation Unit
- Processing Unit[1] (with local storage)
- Network Attached Storage[1]
- Ethernet network switch[1]
- Operator Workstation[1]

- 1Gbit CAT5 Ethernet
- 100Mbit CAT5 Ethernet
- Telecomm optical fiber[2] (used for sensing)
- Telecomm optical fiber[2] (used for comms)

Note:
1. Can be supplied as an option
2. Both telecom optical fibers can be from the same fiber-optic cable

This deployment requires:

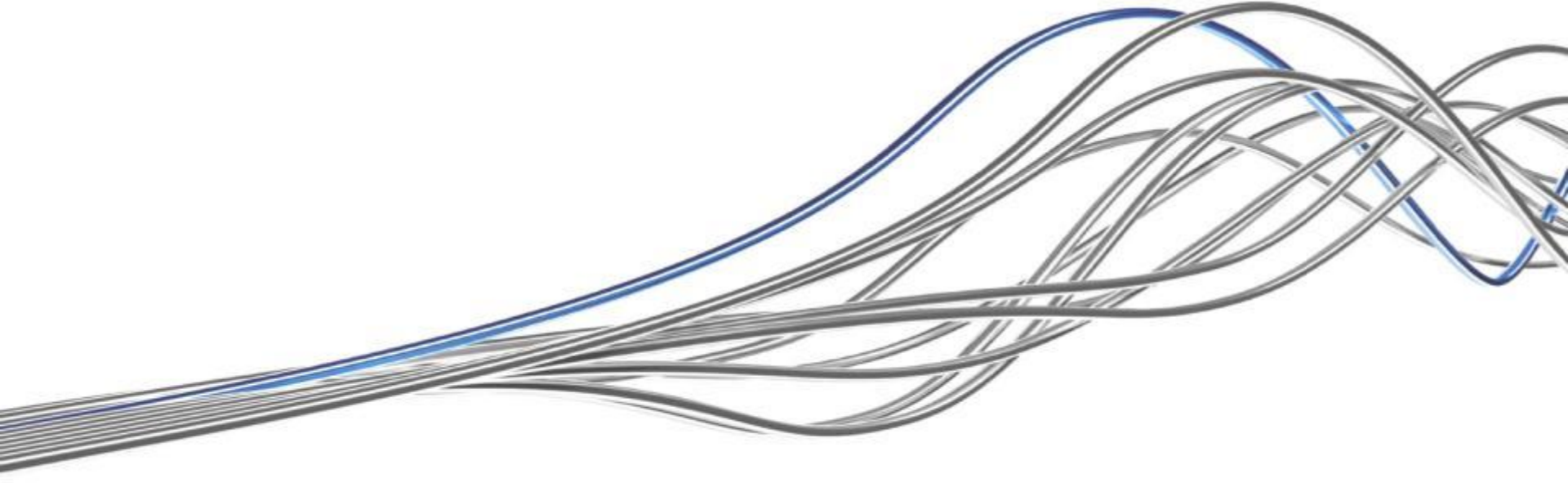
10 Interrogation Units

6 Processing Units

1 Network Attached Storage

2 Operator Workstations

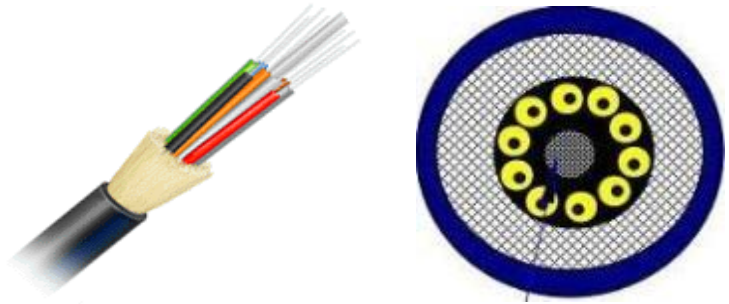
Fiber optic cable installation



Cable and installation overview

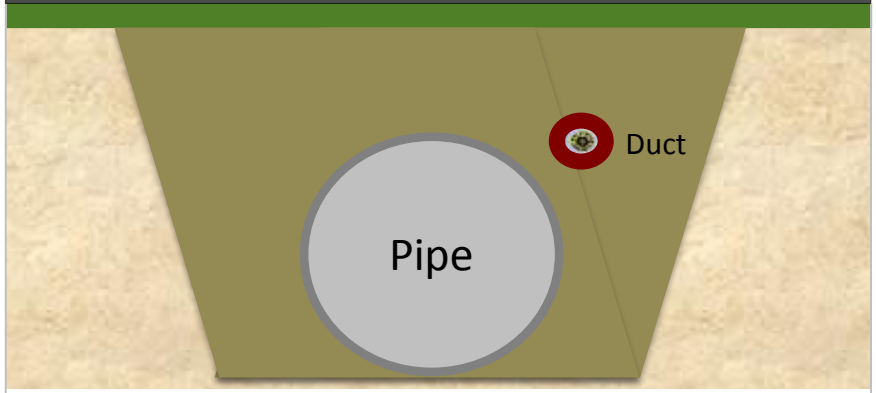
More suited to new pipeline construction – optimizing an open trench

Standard single mode fiber optic cable



- Single mode fiber optic cable
- Certain cables preferred but not specialized
- Off the shelf
- Cost effective
- Fiber optic infrastructure is highly reliable

Fiber located in close proximity for Leak Detection



- Direct buried or in a HDPE conduit
- Position is not as important as proximity
- 2 o'clock position within 1ft is common
- HDD – 2 x conduits often pulled through the same bore as the pipe, then fiber blown
- Installation considerations are available from the industry (FOSA)

Cable installation example

- Recent example from West Texas
- Cable both directly buried (armored) and installed in conduit (unarmored)
- Multiple crossings – HDDs and bores
- Aggressive construction schedule with no delays

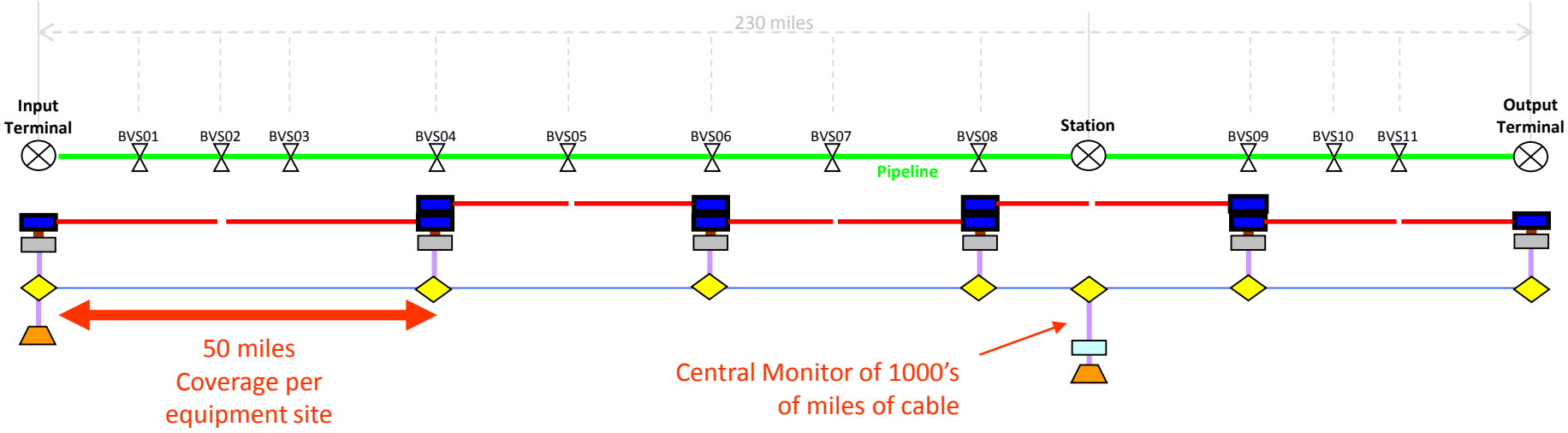
Cable Retrofit

Currently challenging but R&D in progress

- A focus of industry and government R&D
- Current project with Southwest Research and PRCI
- Fiber Optic Sensing Association ready to support
- Open trench less challenging than crossings
- Solution must be safe and cost effective

Typical pipeline architecture

Example: 230 mile pipeline



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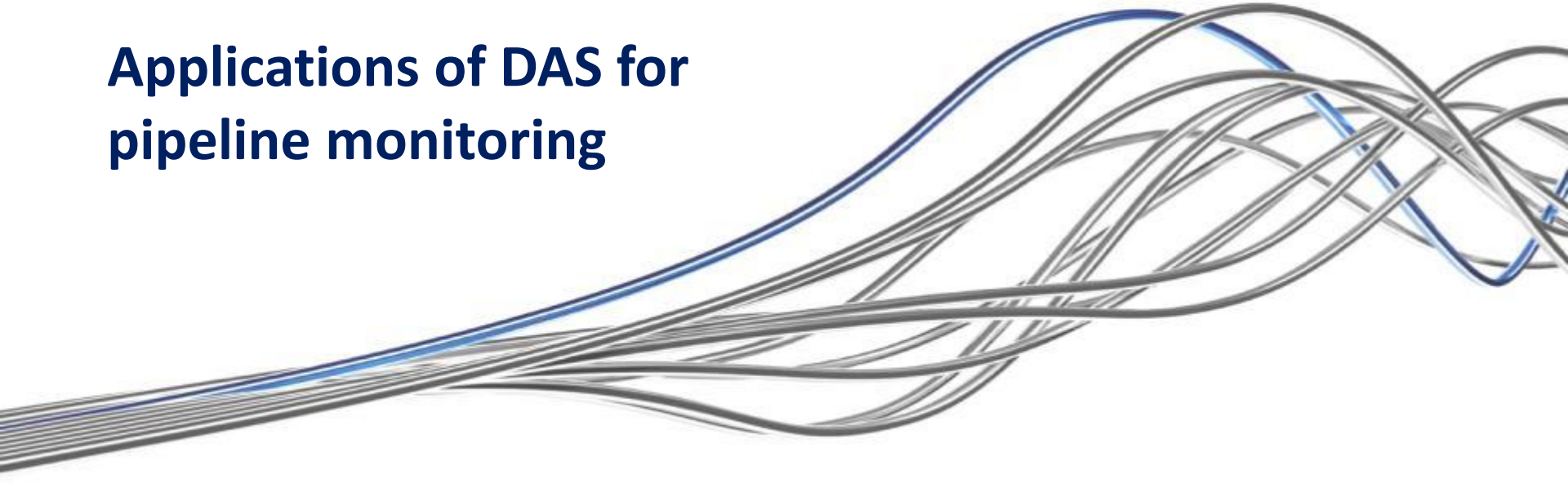
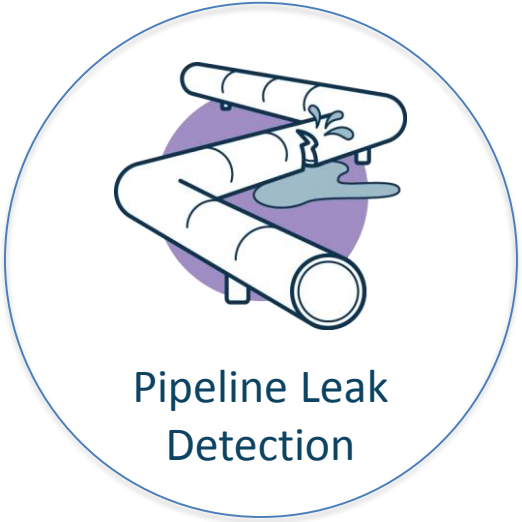
Applications of DAS for pipeline monitoring

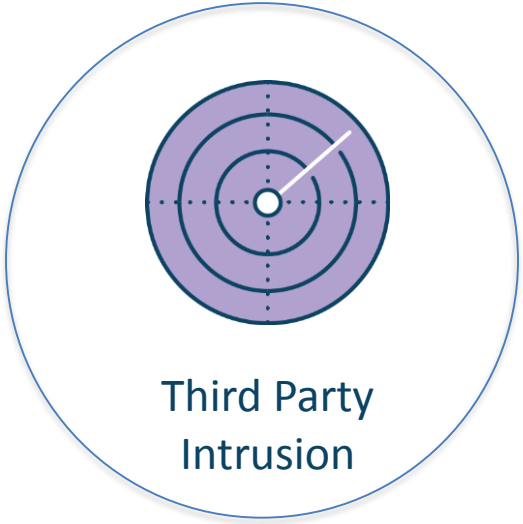


Applications of DAS

Focused on leak detection and third party intrusion detection

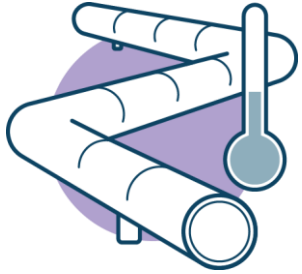


Pipeline Leak Detection



Third Party Intrusion

Geo-Technics



Pipeline Heat Trace Monitoring

DAS

Vibration

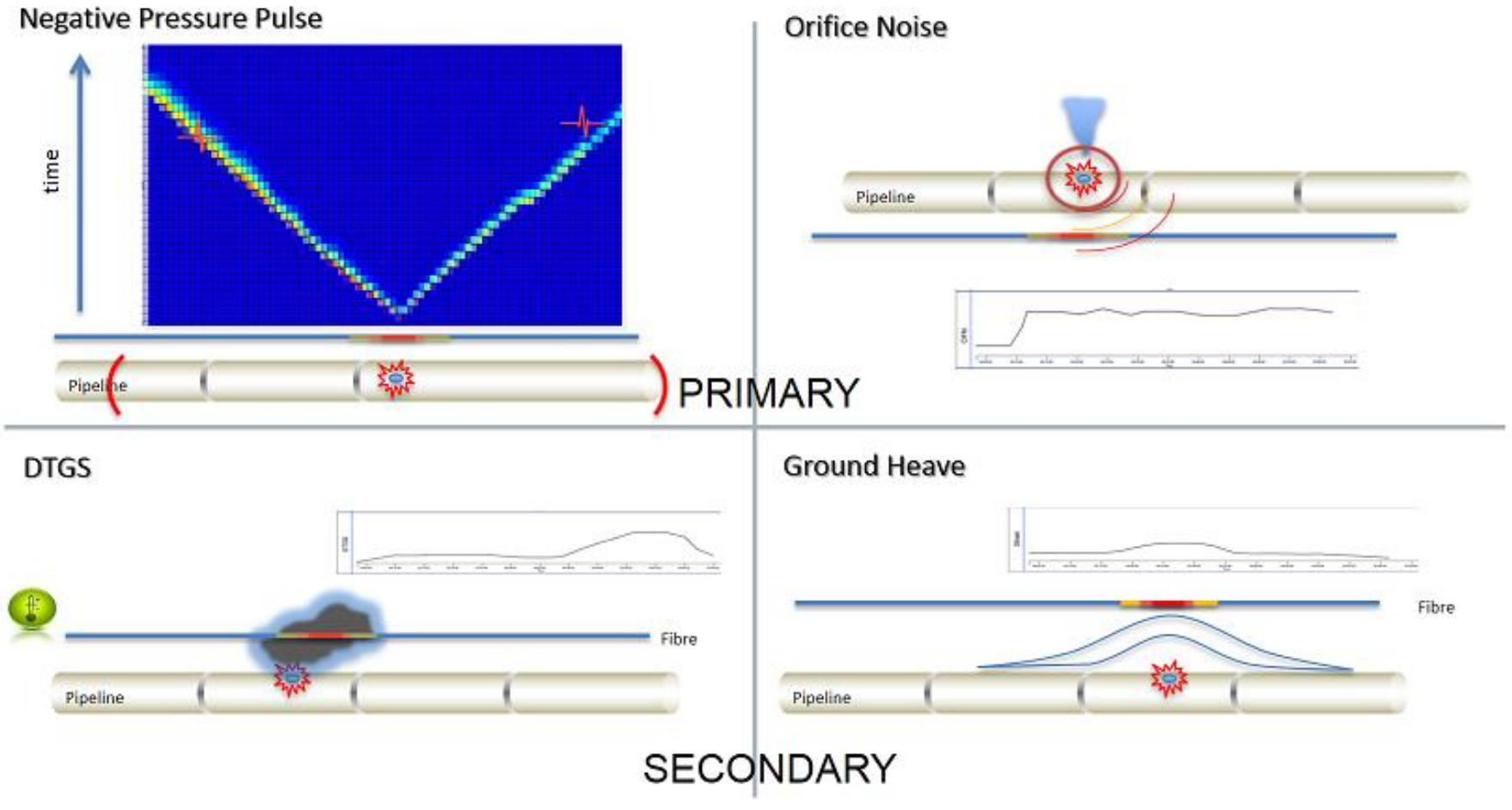
DSS

Strain

DTS

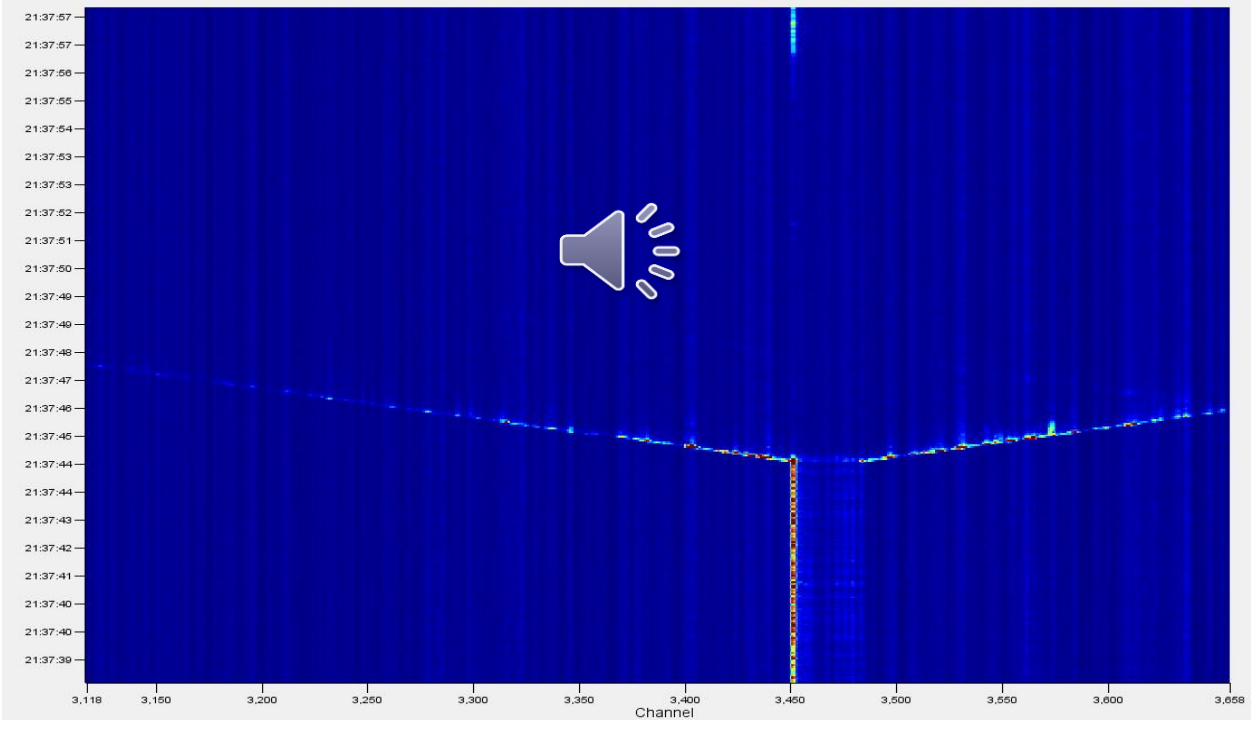
Temperature

DAS multi-signature Leak Detection



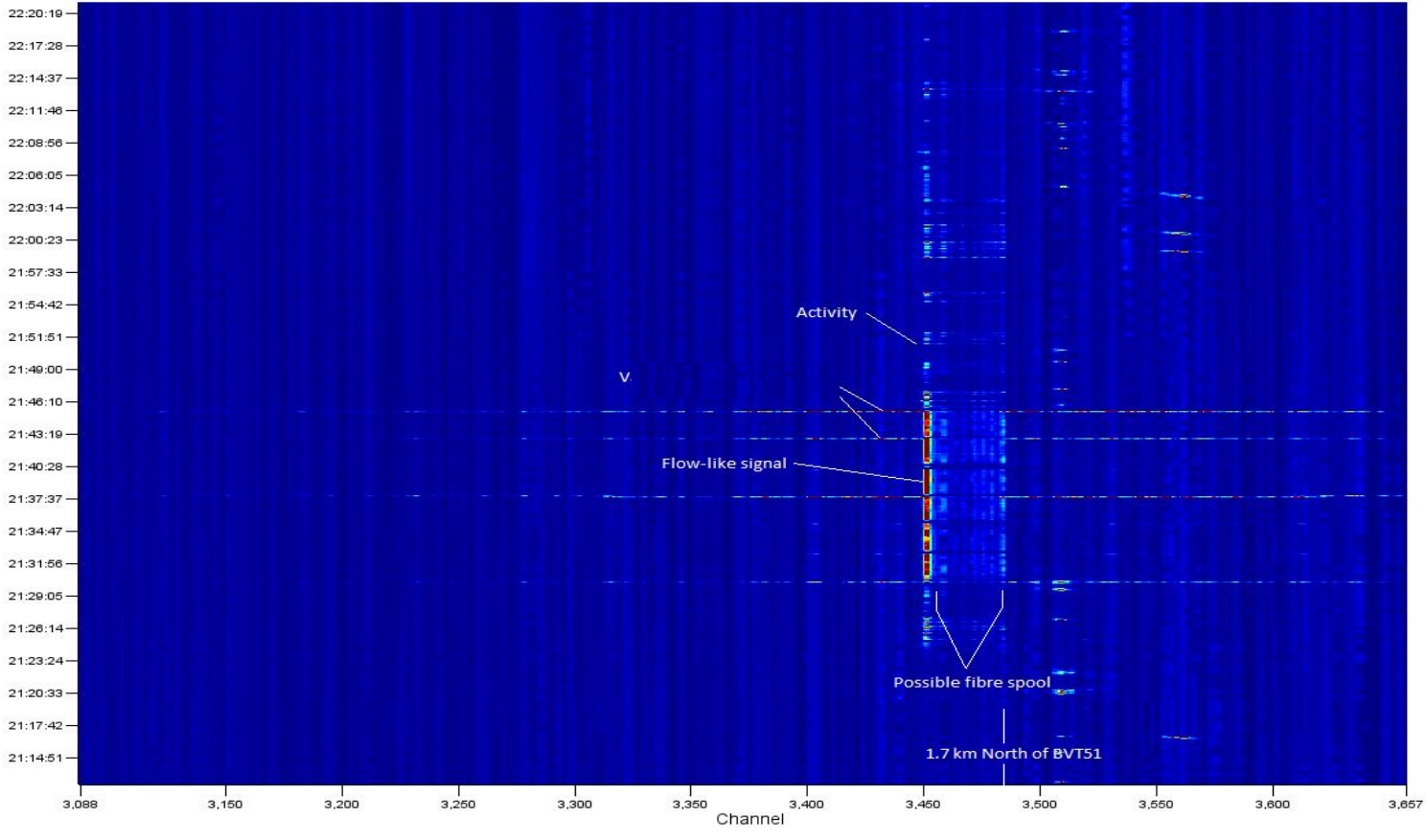
Leak Case Study

21/06/2011 21:36:57	Medium	Vehicle	3452	00:01:12	1025.943925	true
21/06/2011 21:37:49	High	Leak	3459	00:00:00	1026.009346	true
21/06/2011 21:45:16	High	Leak	3457	00:02:21	1025.990654	true
22/06/2011 09:35:03	Medium	Vehicle	3426	00:00:34	1025.700935	true



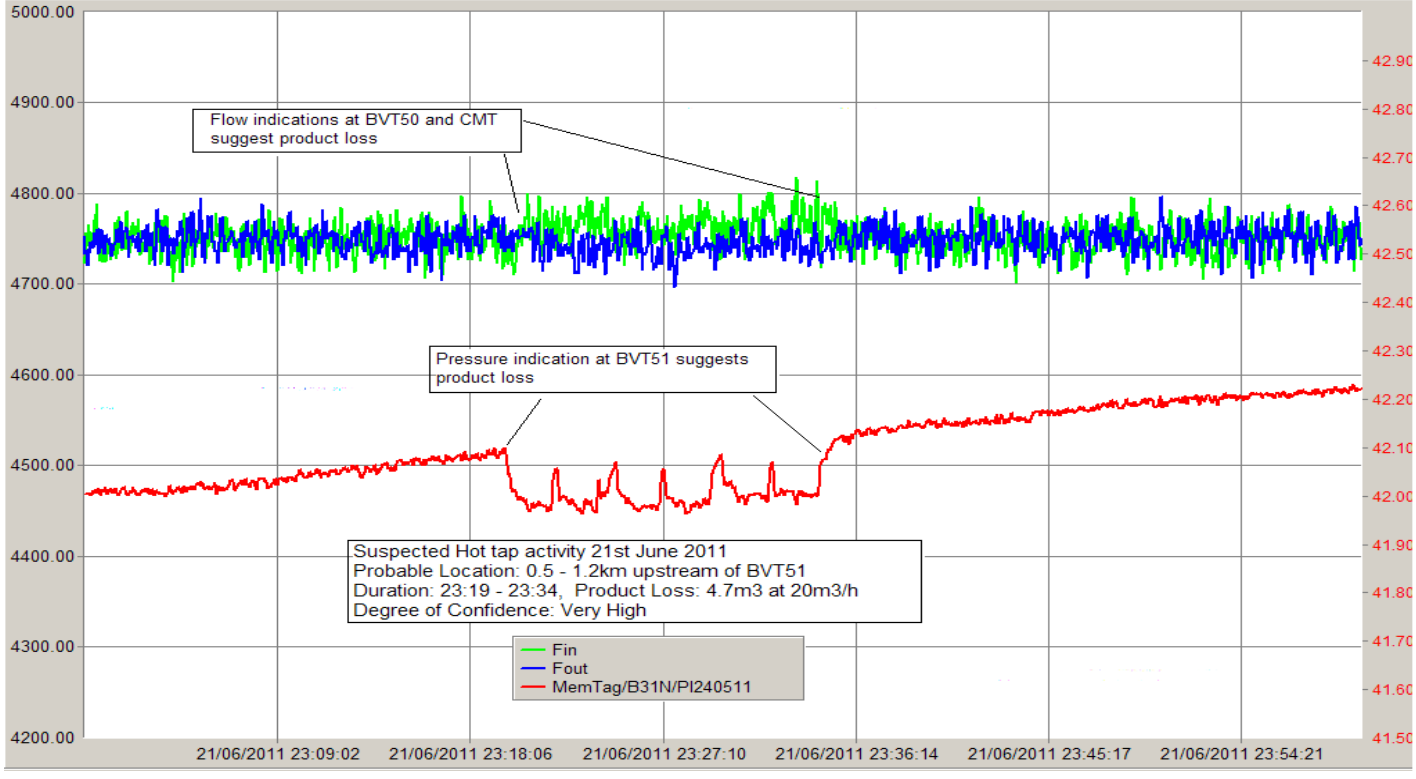
Recorded Data

Leak Detection via Acoustics



Leak detection Case Study

CPM system took 3 hours to detect



Leak detection performance

Consult experts for specific pipeline analysis

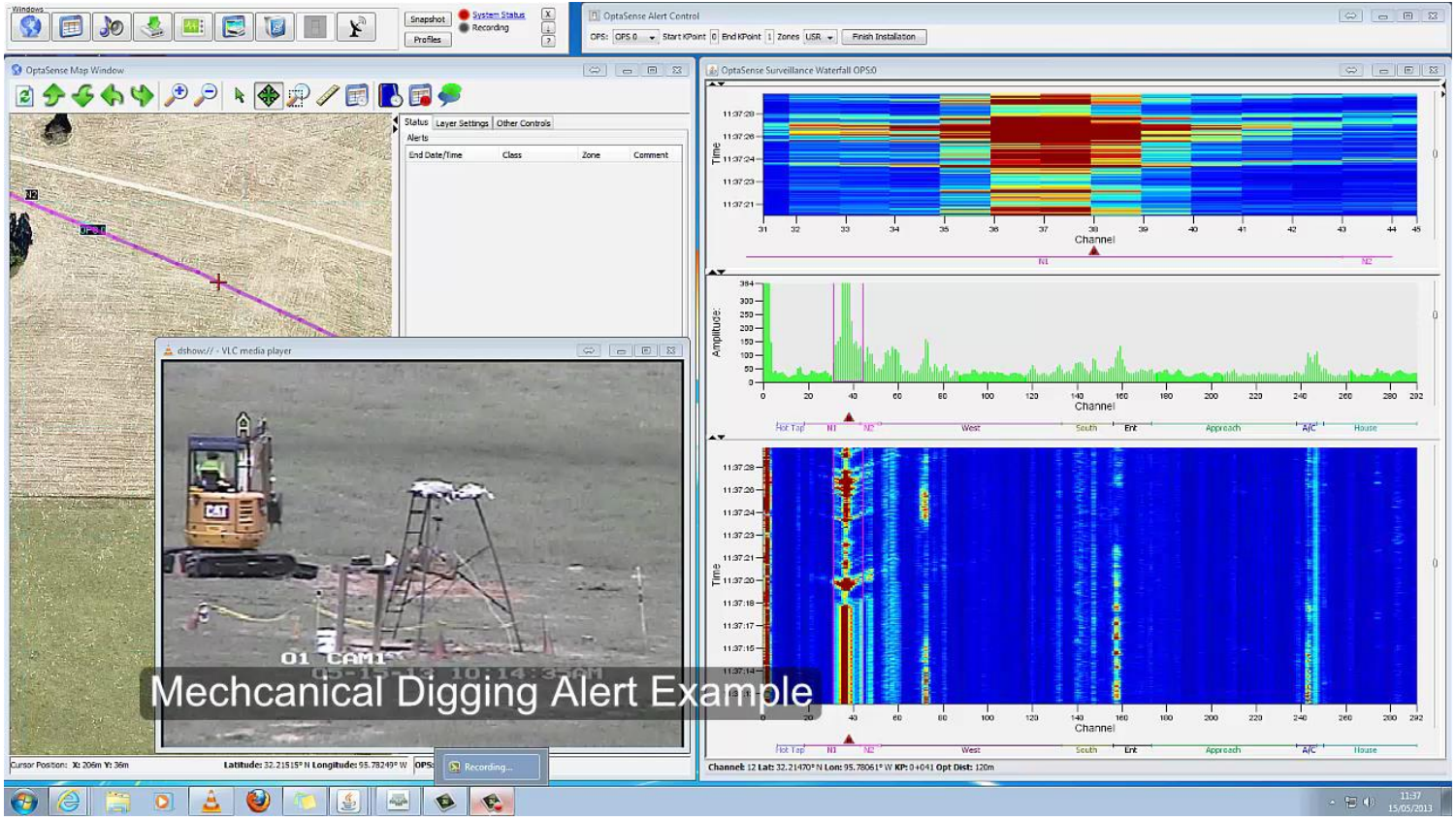
- Typical performance for DAS is around 0.1% leak size detectable (of pipeline flow)
- So for a 100,000 bpd pipeline, this is a leak size of 100 barrels
- This is detected 1-5 minutes, with a location accuracy of 10m or 30ft
- Traditional leak detection performance typically floors at around 1%
- For 100,000 bpd pipeline, this would be 1,000 barrels, detected in hours with less location accuracy

- 1% leak size
- 1-5 mins detection time
- 10m or 30ft location

Represents a ~10X improvement on traditional methods

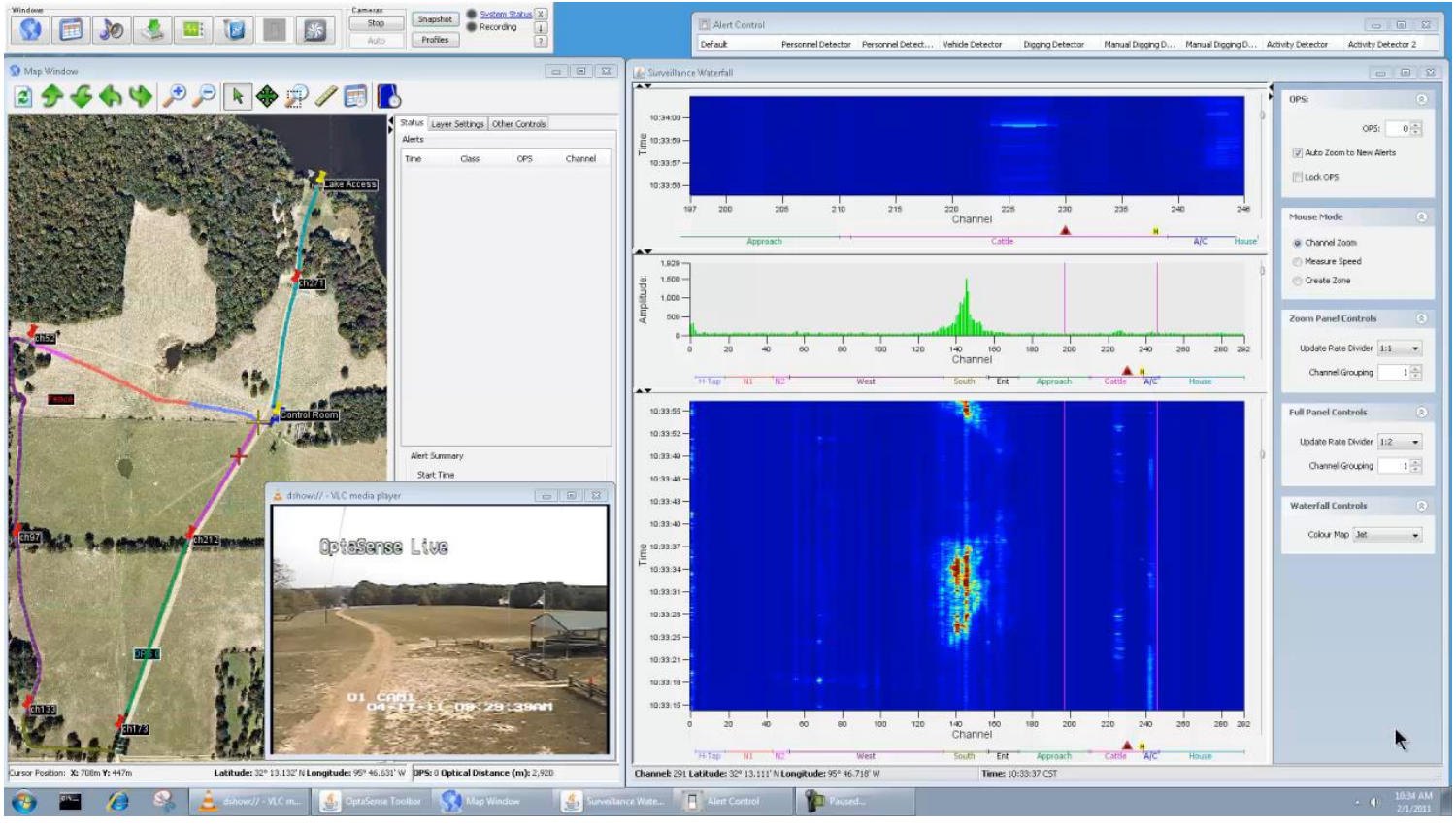
Third Party Intrusion

Real time detection with high locational accuracy



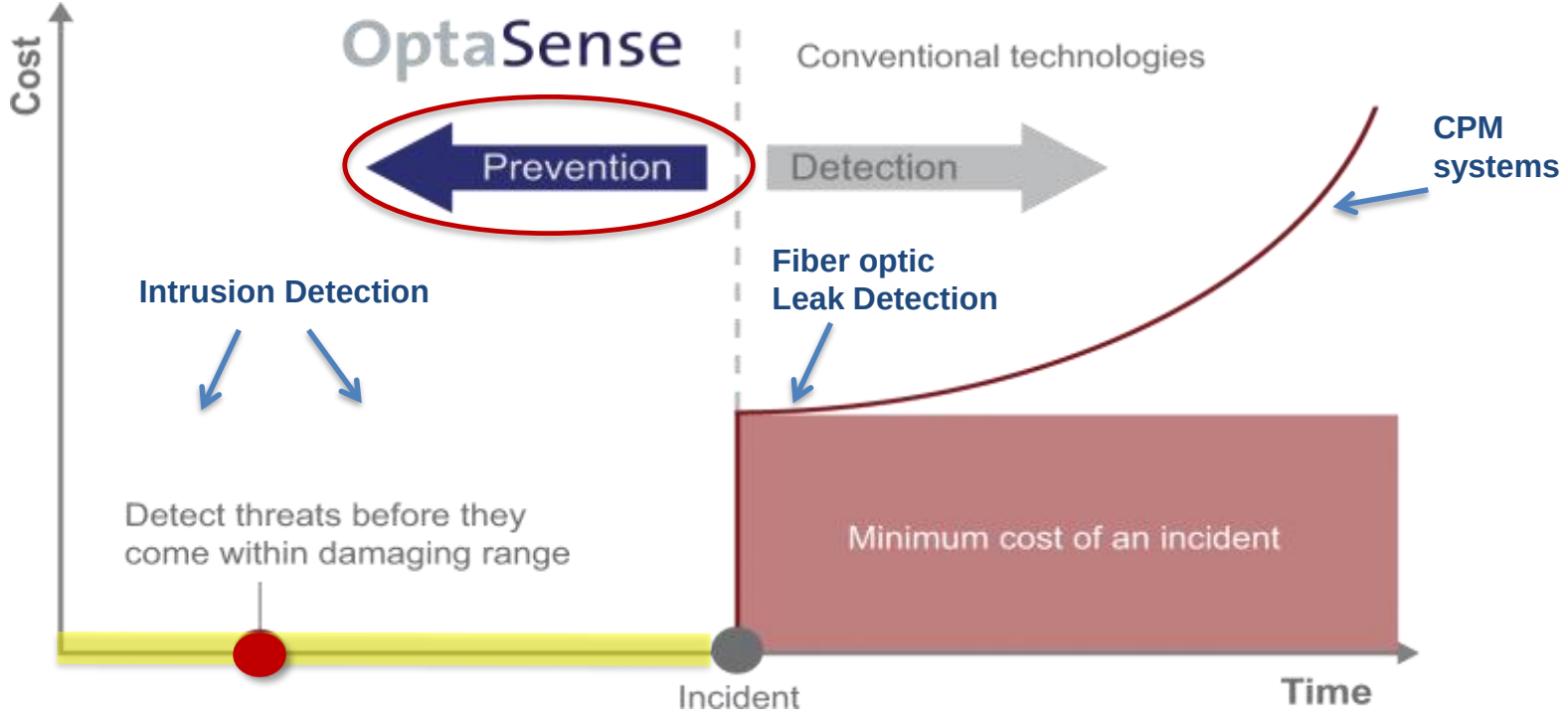
What about false alarms

The ability to classify activity using acoustic signal processing



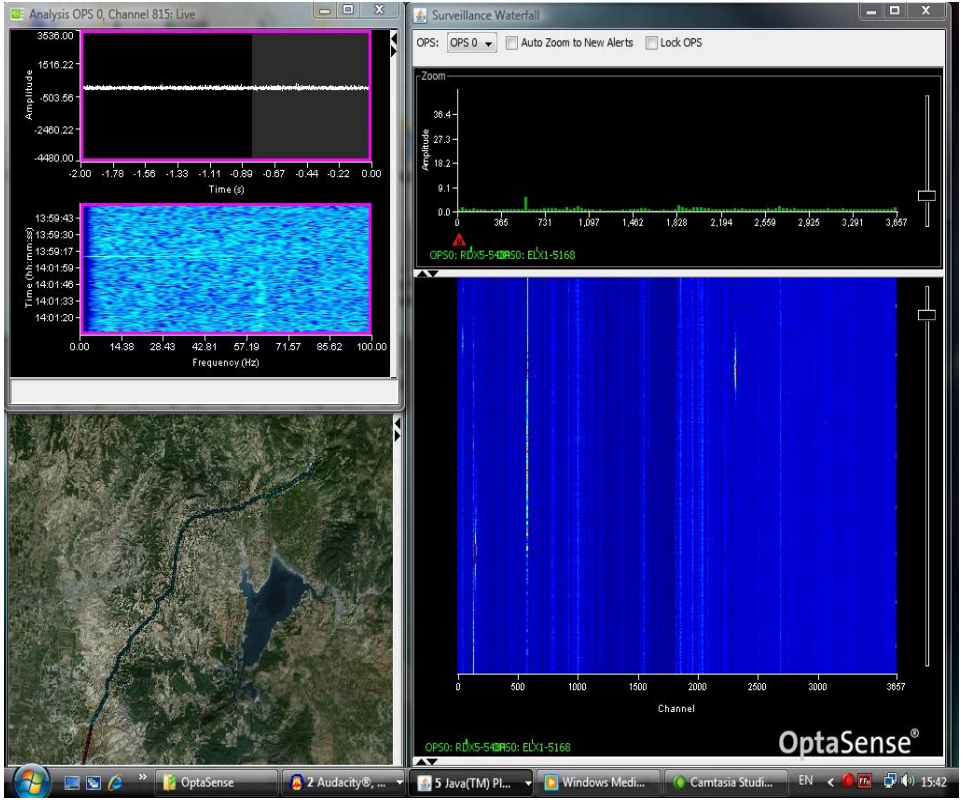
Damage prevention and early leak detection

Avoid costs altogether or minimize leak impacts



Earthquake Monitoring

Magnitude 3.8 earthquake in Turkey

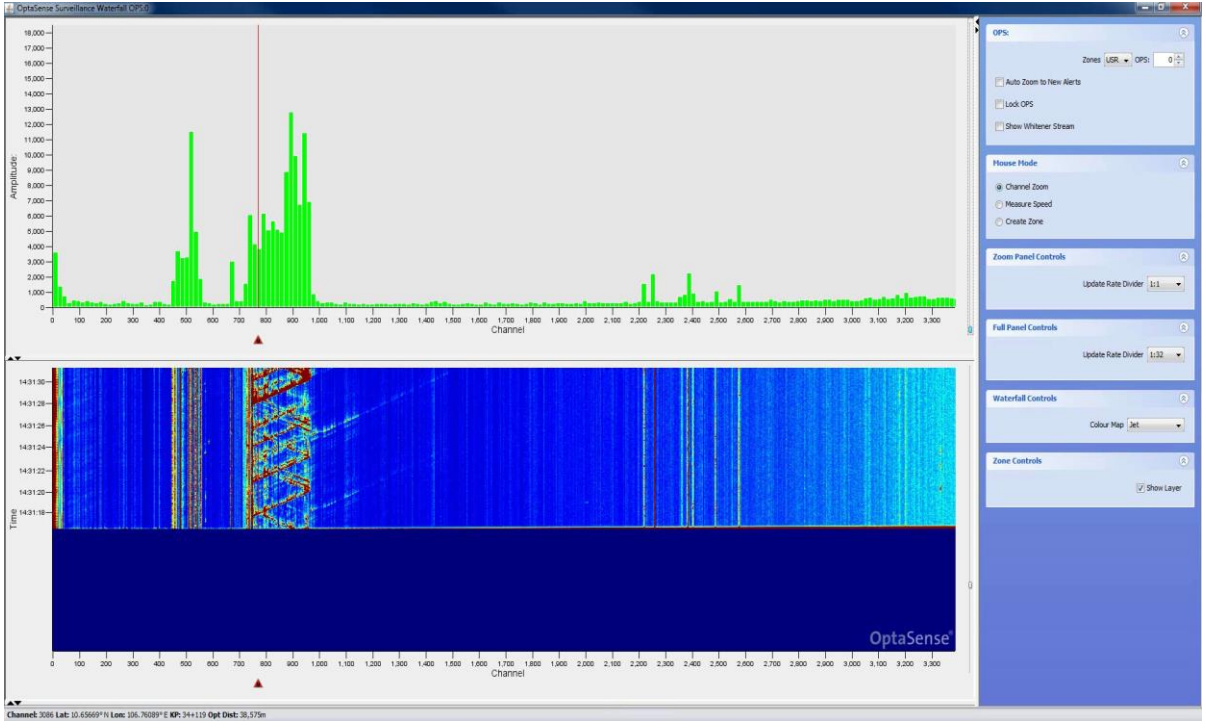


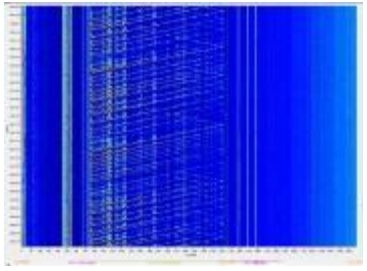
35 km

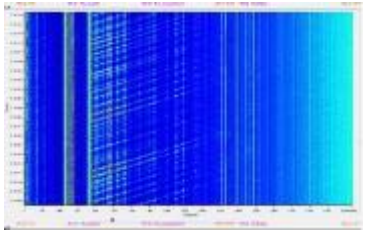
- During a routine deployment at a customer pipeline a magnitude 3.8 earthquake was observed and recorded
- OptaSense provided early warning of potential pipeline damage in a seismically sensitive location
- Before and after analysis was preformed in order to focus on inspections

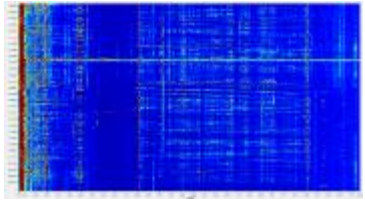
Flow monitoring

Slack Lines



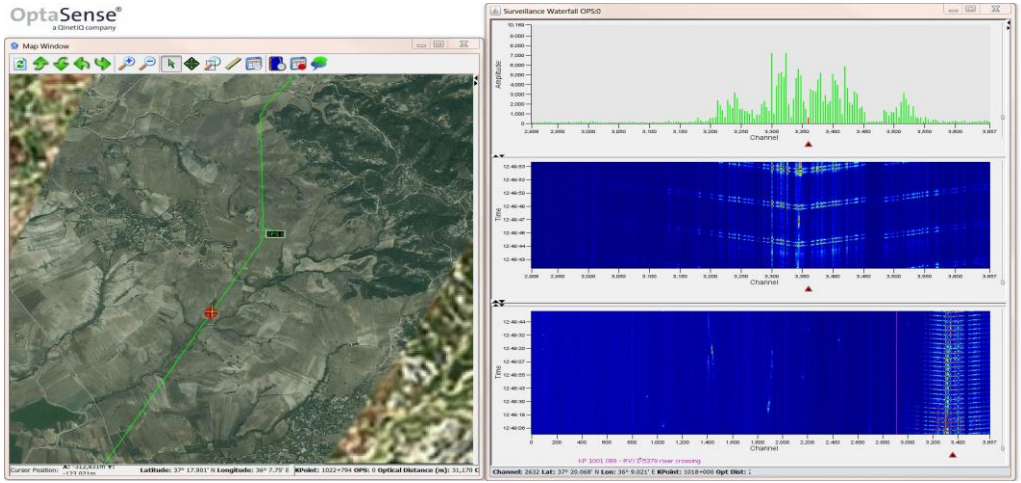


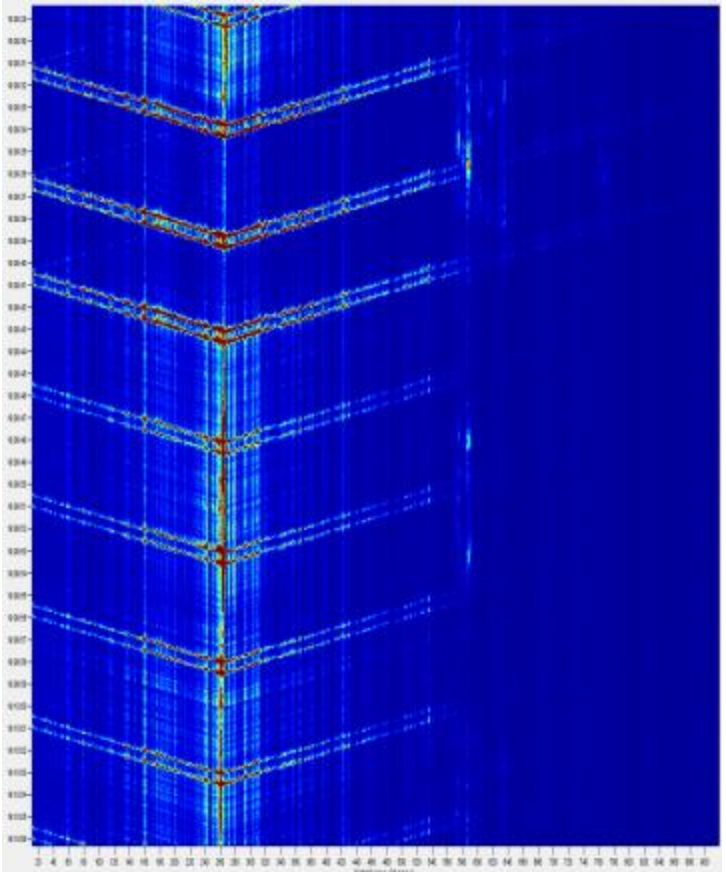




Pig Tracking

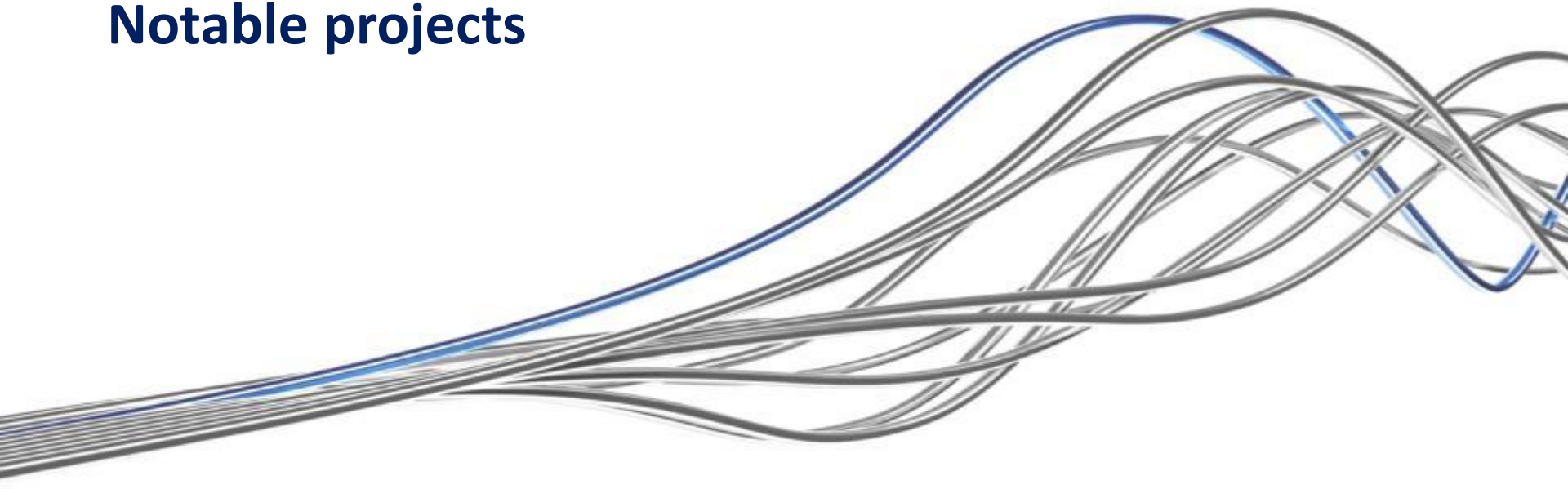
Automated detection and tracking of pig in oil pipeline





- The interaction of a cleaning pig / scraper with the side walls and butt welds creates a moving series of pressure pulses
  - Long used for very precise PIG location ID

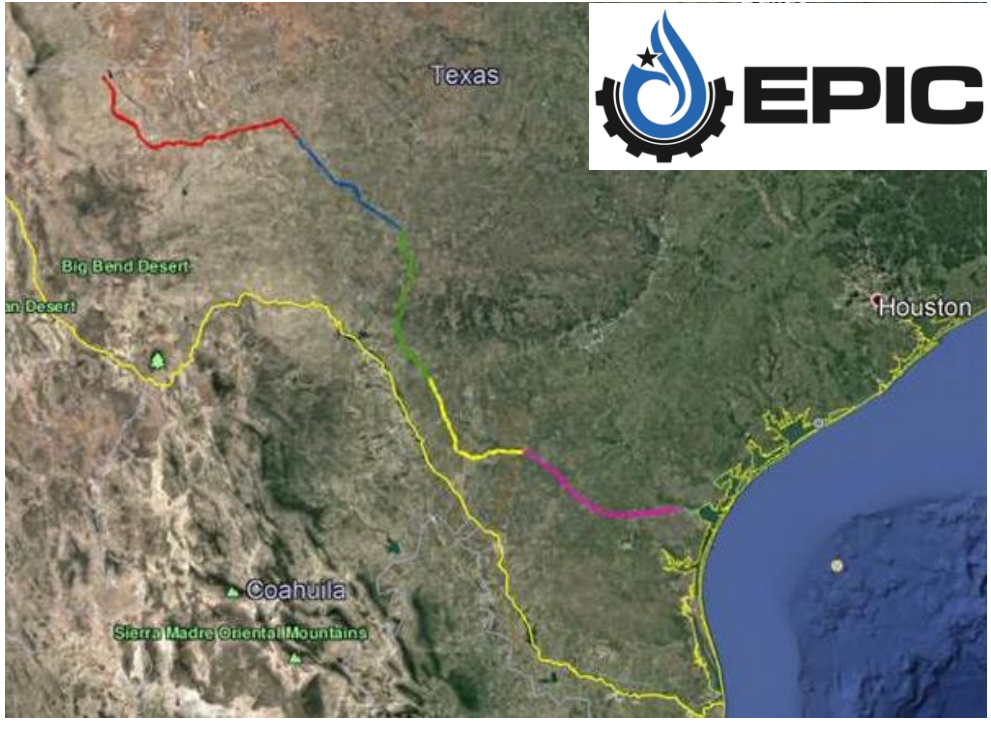
Notable projects



Largest fiber optic sensing system in North America

1,100 miles (initially)

- **Details:**
  - 730 miles NGL and Crude line from the Permian to the Coast
- **Applications:**
  - Leak detection and ROW intrusion detection
- **Benefits:**
  - Has detected a leak on separate pipeline that crosses the ROW
  - Has detected multiple excavators on the ROW
  - Kept up with aggressive construction schedule



TANAP – Caspian gas to Europe

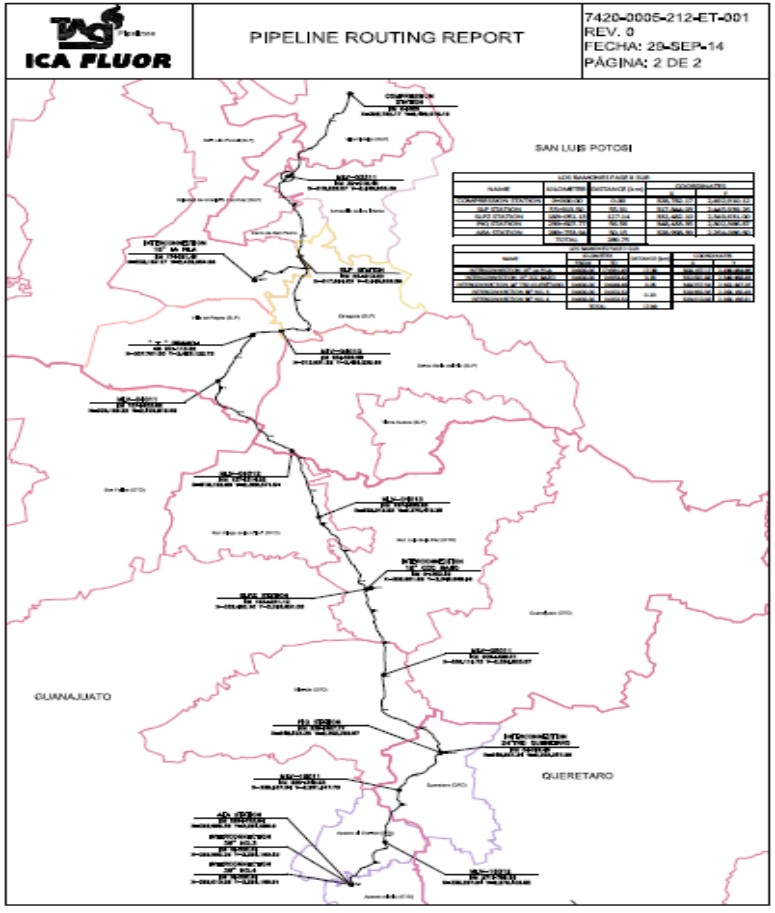
1,100 miles

- **Details:**
  - 1,800km gas pipeline
  - 164 units in a networked system
- **Applications:**
  - Leak detection and security monitoring
  - Scope includes in-line facility perimeter security
  - Scope includes a 30km water crossing
- **Benefits:**
  - Combines pipeline and facility monitoring in one system

Los Ramones SUR Mexico

200 miles

- **Details**
  - Gas pipeline
- **Applications**:
  - Leak Detection
  - Intrusion
  - Land slides
- **Benefits**:
  - Multiple functions
  - ONE cable
  - ONE system

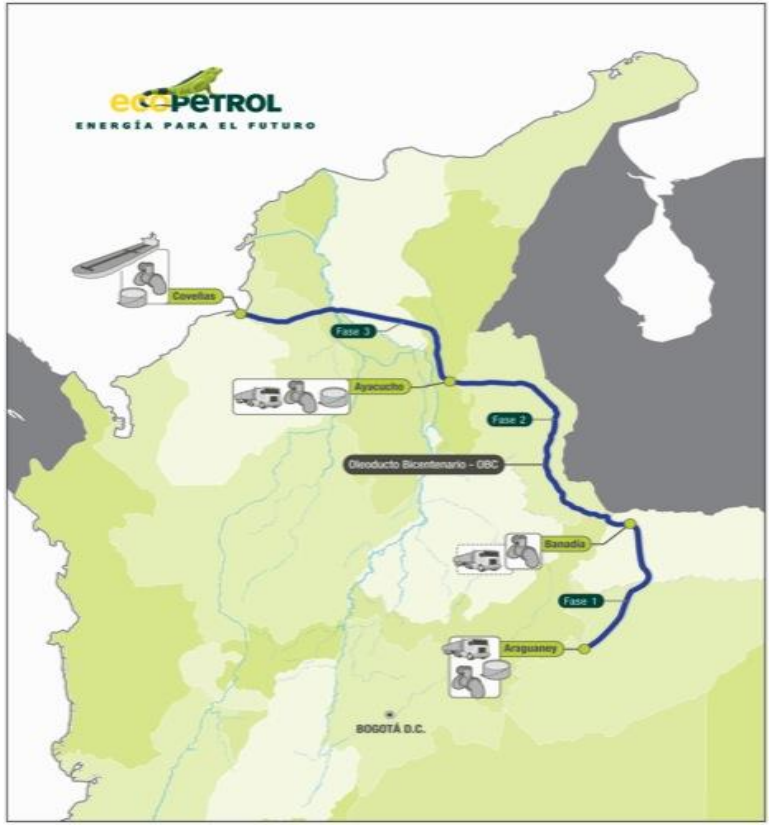


Bicentennial Colombia

150 miles

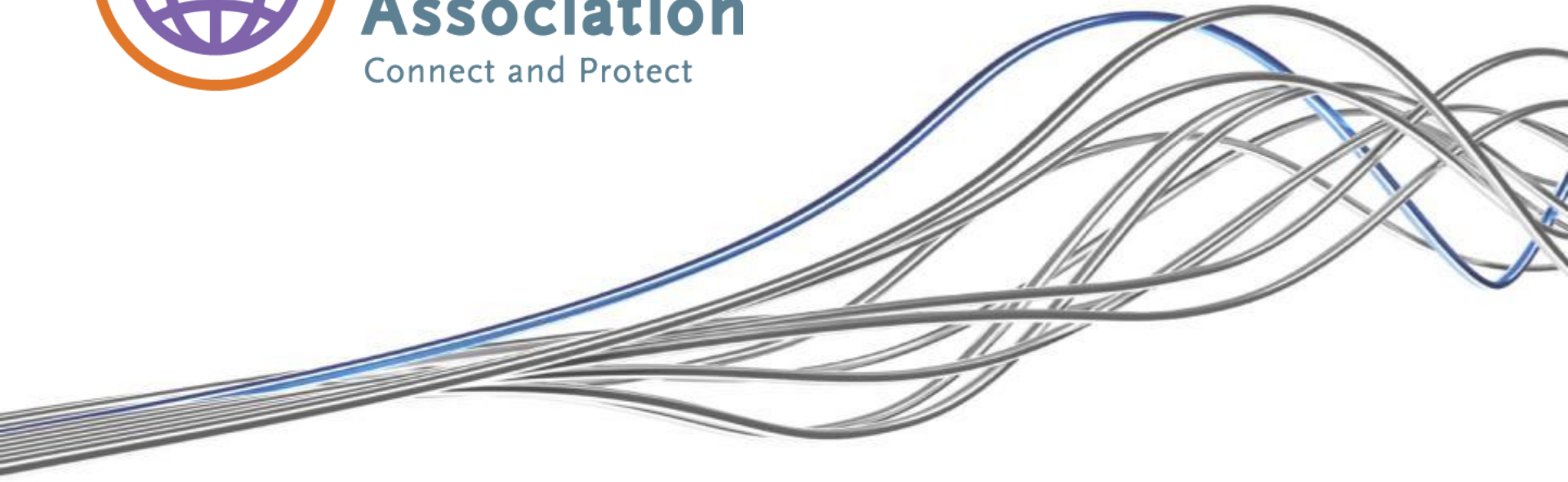
- **Details**:
  - Oil pipeline
  - Installed in 2014
- **Applications**:
  - Intrusion
- **Benefits**:
  - “Since installation, OptaSense DAS has detected multiple intrusions on the pipeline, reducing incident rates and overall pipeline risk.”

    Operations Director, OBC
- **Won an ASME global pipeline award 2015**



Fiber Optic Sensing Association

Connect and Protect



FOSA

A fantastic resource for all things related to distributed fiber optic sensing

- FOSA is a non-profit industry association formed in 2017 in Washington D.C.
- Promoting Distributed Fiber Optic Sensing (DFOS) across many markets
- Providing education on the benefits of DFOS technology, through:
  - Technology Awareness Campaigns
  - Promotion of DFOS Solutions
  - Technology best practice development
- Membership is open to companies globally who make, install, support and use distributed/quasi-distributed fiber optic sensors.
- Hands-on activities – members organize, manage, and collaborate regularly

- www.fiberopticsensing.org

Fiber Optic Sensing Association
Connect and Protect

FOSA members

www.fiberopticsensing.org

Summary

What can DAS technology provide?

- **Long reach** – spans greater than 50 miles (80 km) possible
- **Quick scan** – entire length scanned in seconds – real time reporting
- **High spatial resolution** – thousands of sensing points, detect every few feet
- **Precise event location detection** – know quickly and accurately when problems occur
- Very low maintenance
- Add additional fiber to the sensor cable – built-in communications capability along rights-of-way / broadband delivery

- THANK YOU!
- QUESTIONS?

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