Omnisens' Lynx

Pipeline Monitoring by Fiber Optic Sensing
State of the Art & Basic Concepts

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Prysmian Group

Pipeline

Company overview

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Prysmian Group

Fibre Optic based Distributed Temperature, Strain and Acoustic/Vibration monitoring with unique capabilities for long distance with highest performance

- Established 1999 as Spin-off from Swiss Technology University Lausanne (EPFL)
- Now part of Prysmian Group (13B EUR – 30k Employees)
- Optical team of Prysmian EOSS Division (100 FTE's)
- Headquarters & Production in Morges, Switzerland
- 2 R&D Centers in Morges (CH) and Palermo (IT)
- Highly qualified and dedicated team
- Worldwide customer base
- ISO9001:2015, ISO140001:2015, ISO45001:2018

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Company overview

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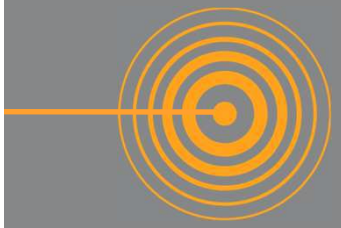

Fibre Optic based Distributed Temperature, Strain and Acoustic/Vibration monitoring with unique capabilities for long distance with highest performance

Prysmian EOSS Division

- More than 100 collaborators worldwide
- More than 30 engineers to support Project Management and Operations
- 2 R&D centers in Europe
- Complete portfolio with all available technologies for cable and pipeline monitoring
- All products are fully developed and maintained in house
- All products are fully interfacing with a unique platform
- Installation managed by a unique entity without any third party involved
- If any support needed: direct contact with Software and Hardware R&D team
- Flexibility in major projects execution
- Fiber Optic Cable design capabilities
- Power cable design, manufacturing, installation and monitoring experts

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Extensive Experience

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Leak Detection		
> 2300 km	35 Projects	23 years

Geohazard Monitoring		
> 1500 km	20 Projects	20 years

Intrusion Detection		
> 700 km	11 Projects	13 years

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Energy Focus

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Turnkey Monitoring Solutions

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In-house Distributed Technologies

Temperature and/or strain profiles with meter resolution (DTS/DSS)

High sensitivity Distributed Acoustic Sensing (DAS)

Long distance capabilities >180km (between stations)

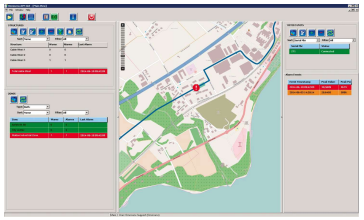
Partial Discharge Monitoring

Asset Integrity Monitoring Software

Lynx - Pipeline integrity (detection of leak, TPI and landslide)

Cobra - Power cable integrity (detection of cable damage and over-heat)

Subsea Umbilical Riser and Flowline Asset Integrity Monitoring



Integrated Solutions

Design Engineering and Project Management

Automatic unattended permanent monitoring

- GUI with interactive map system
- SCADA Integration with alarm communication

Wide range of temperature and strain sensing cables

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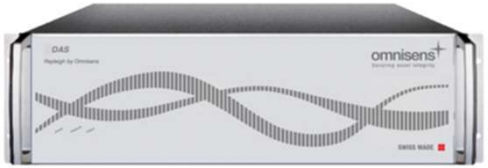
Omnisens Technology

Working Principles



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Backscattering Mechanisms

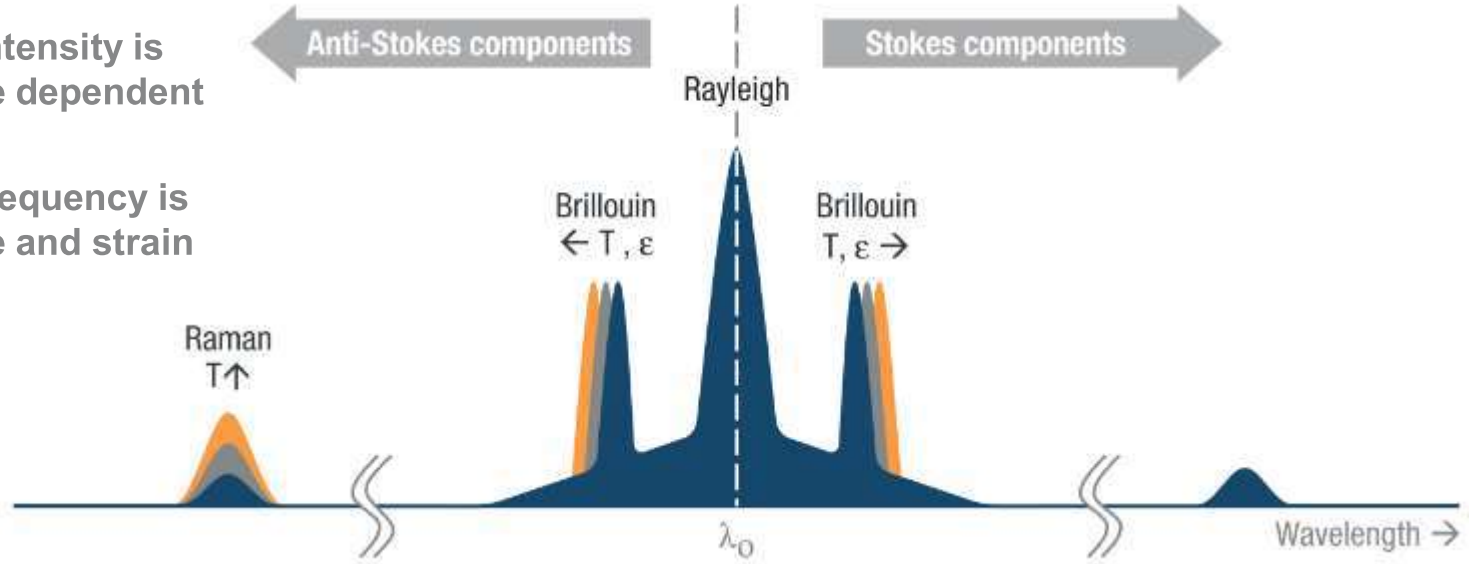
Scattering medium

Laser, λo

Rayleigh
Detection and analysis of scattered intensity

Raman
Scattered intensity is temperature dependent

Brillouin
Scattered frequency is temperature and strain sensitive



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Brillouin based DTS/DSS

Time Domain

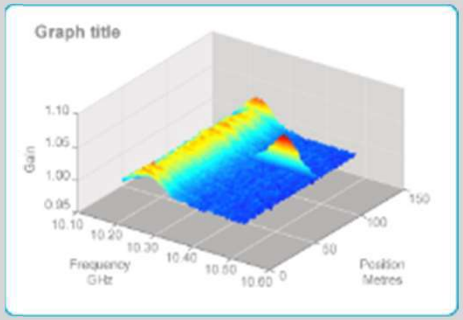
The activating signal is a propagating pulse and the position is given by the time of flight.

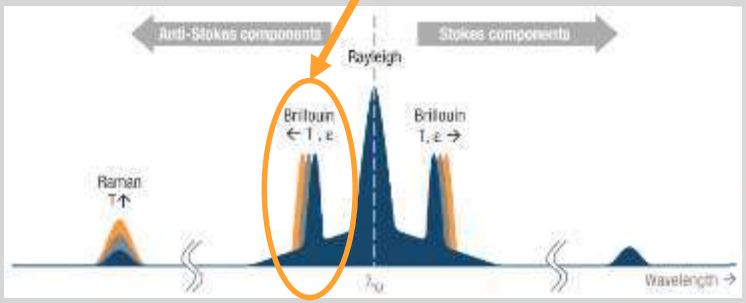
Spatial resolution is given by the pulse width.

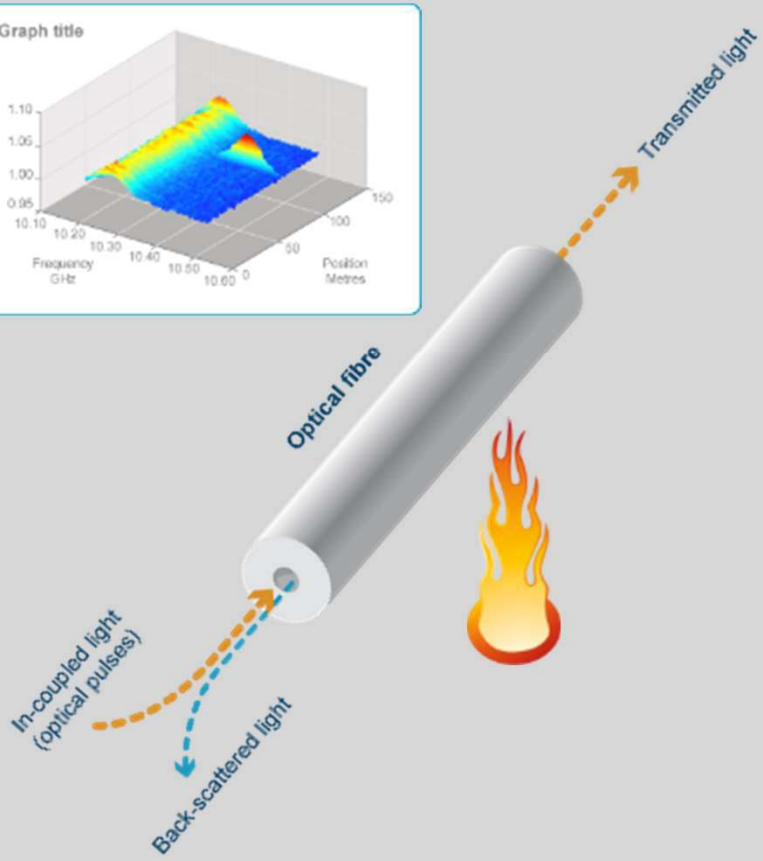
+

Frequency Domain

The frequency shift is computed by recording the Brillouin spectrum at different frequencies and extracting the maximum peak location.







BOTDR: spontaneous scattering, single end access

BOTDA: stimulated scattering, loop configuration

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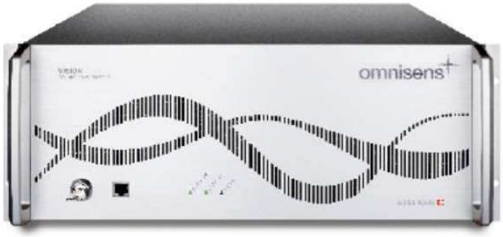
DITEST DTS/DSS Interrogator

- Brillouin frequency-based technology capable of DTS and DSS measurements
- High performance and stability
- 4 optical channels
- Sensing distance range: up to 70 km/channel (140 km total sensing range)
- Requires 2x SM fibers per channel
  - 2x loose tube if temperature
  - 2x tight buffer if strain
- Integrated self-diagnostics



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Raman DTS Interrogator

Performance Table*				
Distance (km)	Temperature Repeatability, 2σ (°C)			
	Measurement Time: 1 minute		Measurement Time: 5 minutes	
	SM	MM	SM	MM
5	1.3	0.4	0.6	0.2
10	1.8	0.5	0.8	0.2
15	2.3	0.8	1.1	0.3
20	3.5	0.9	1.6	0.4
25	4.7	1.3	2.1	0.6
30	6.1	1.8	2.7	0.8

***Measurement Parameters**
Spatial Resolution (setting): 1 m
Spatial Sampling: 0.5 m

- Single-mode or Multi-mode
- Passive cooling
- Single channel instrument
- Modular approach
- Very low power consumption

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Rayleigh based DAS

Time Domain

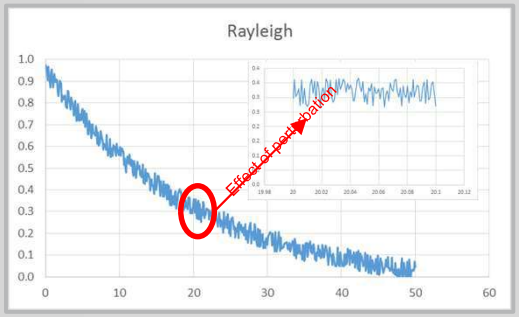
The activating signal is a propagating pulse and the position is given by the time of flight.

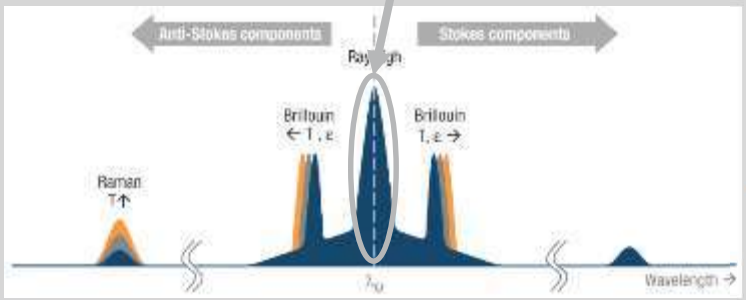
Spatial resolution is given by the pulse width.

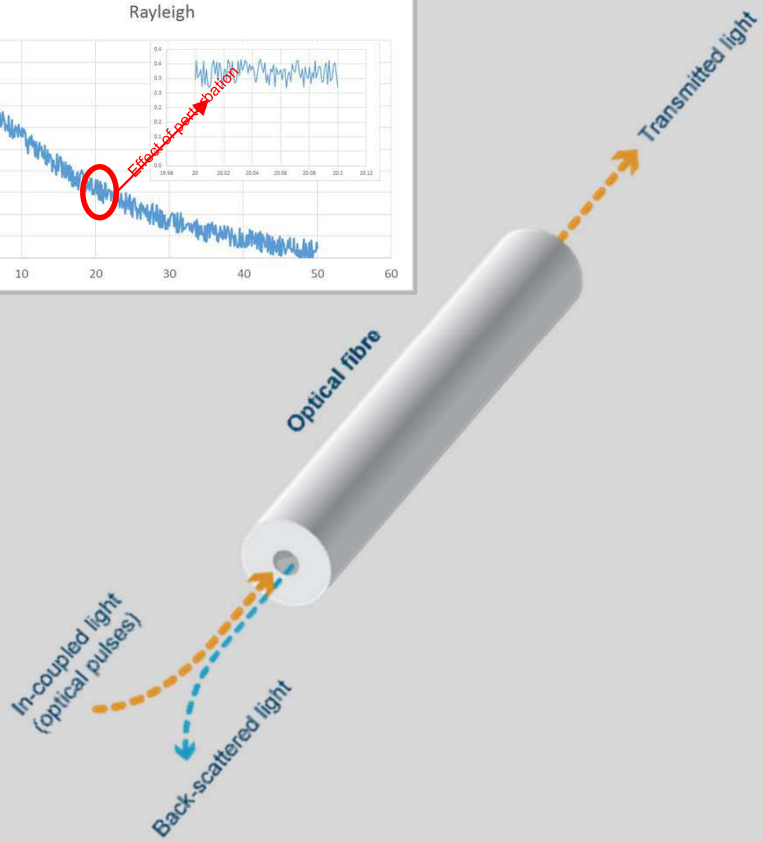
+

Intensity/phase Domain

The intensity/phase variations of the Rayleigh signal as a function of time provides acoustic signature.







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DAS Capability

Parameter	DAS-M	DAS-L
Range	50 km	70 km
Type of fiber	SM	SM
Spatial Resolution	5-20 m	5-20 m
Optical budget	10 dB	14 dB
Channels	1 or 2	1 or 2
Data Storage	Internal HDD 4 TB (possible up to 16 TB) External add-on RAID up to 256 TB	
Data format	HDF5 - Opensource	

- Patented chirped pulse Rayleigh frequency to time analysis
  - No fading/blind Rayleigh areas along fiber
  - Linear response to vibration and strain
- Requires only 1x SM fiber per channel (no need for looping back fibers)
- Integrated self-diagnostics

Refer to datasheet DT-240

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Long Range Distributed Sensing

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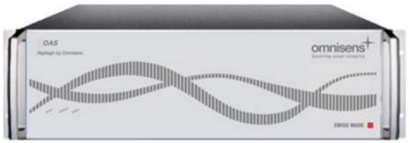
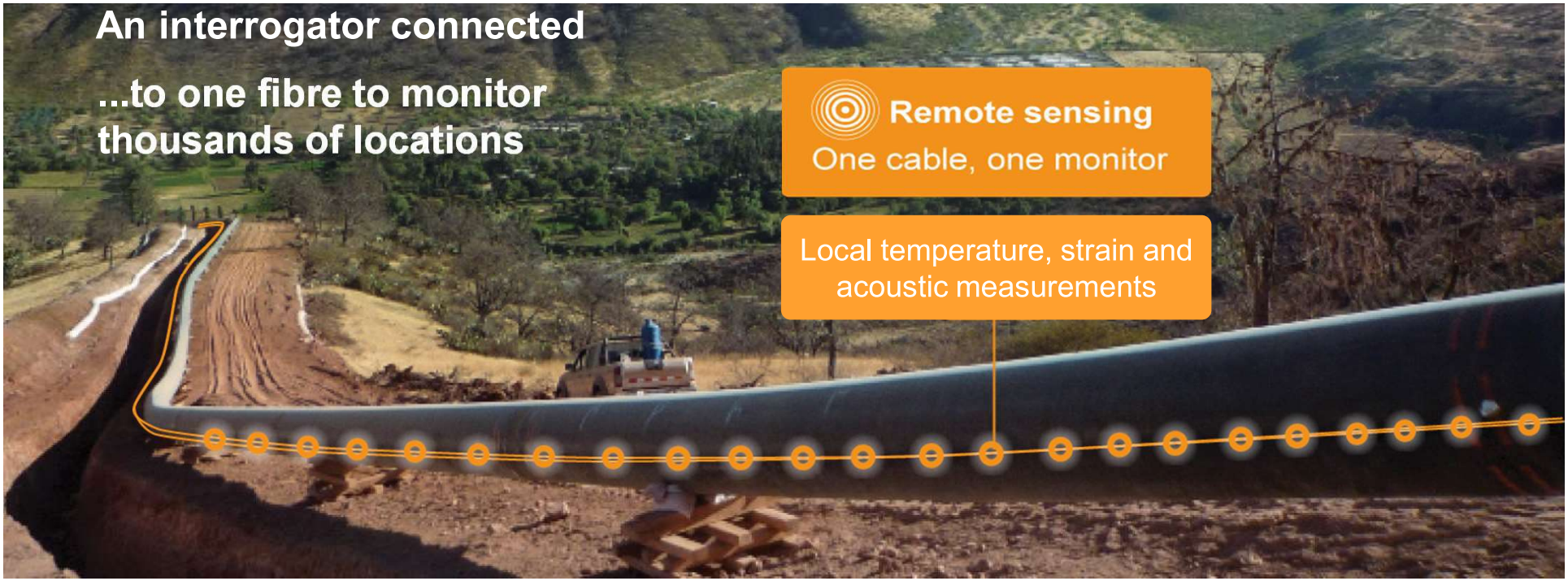


Turning optical fibers into a fully distributed sensor



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Lynx Pipeline Monitoring System

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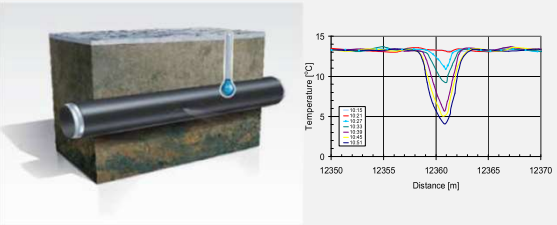
Early detection of leaks, geo-hazards and intrusion threats

Pinpoint location within meters

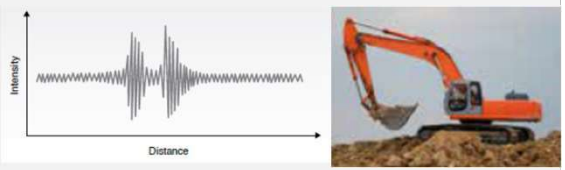
Minimum false alarm rate

Leak Detection



- DTS/DAS or DTS+DAS
- >100 km range
- Few meters accuracy
- Measurement from seconds to few minutes
- Suitable oil products, crude oil, gas, chemicals or water

Intrusion Threats & PIG Monitoring



- DAS based
- 100 km range
- ±10 m location accuracy
- 5 m human digging
- 10 m machine digging
- PIG monitoring
- Very fast detection

Geo-Hazards

- DSS & DTS based
- Focus high risk areas
- Micro-strain sensitivity
- Few meters accuracy
- Soil erosion
- Terrain subsidence
- Ground movement

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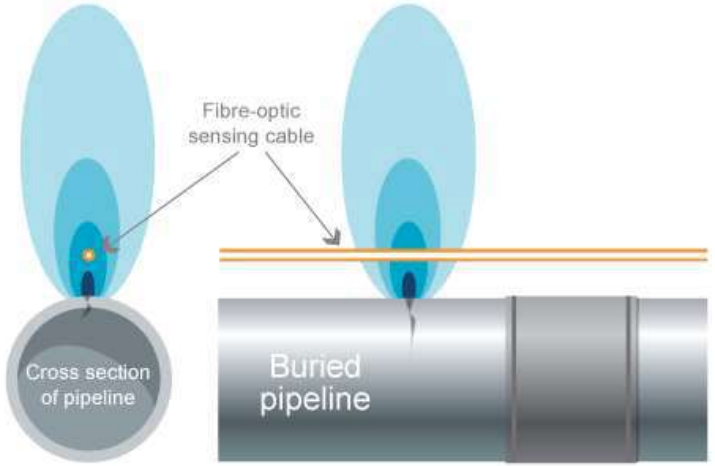
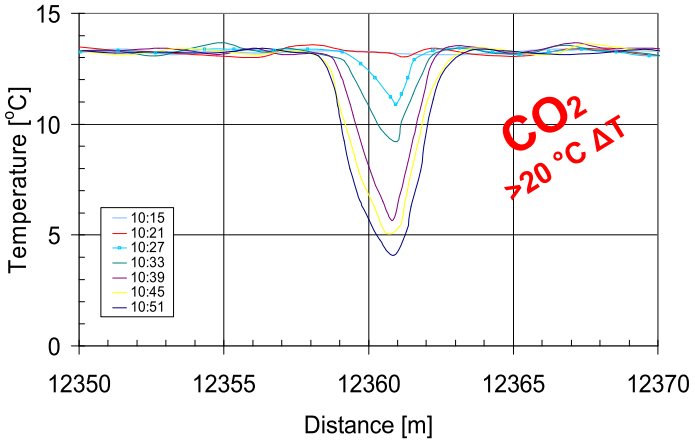
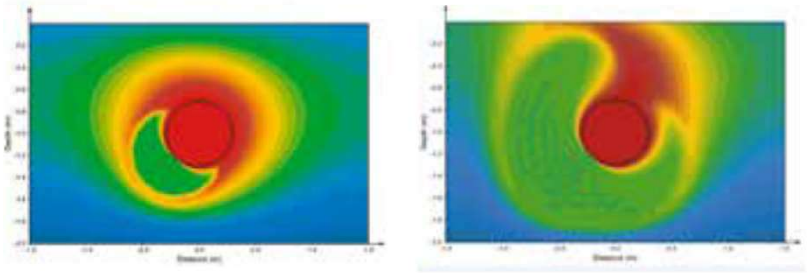
How does it work? Leak Detection

- DTS based – Local temperature difference caused by released fluid
- DAS based – Acoustic signature caused by released fluid
- Crude oil, oil products, gas, chemicals, water pipelines







Simulations showing the rapid temperature changes occurring after a leak at 7 o'clock/0700 hour position in a gas pipe.

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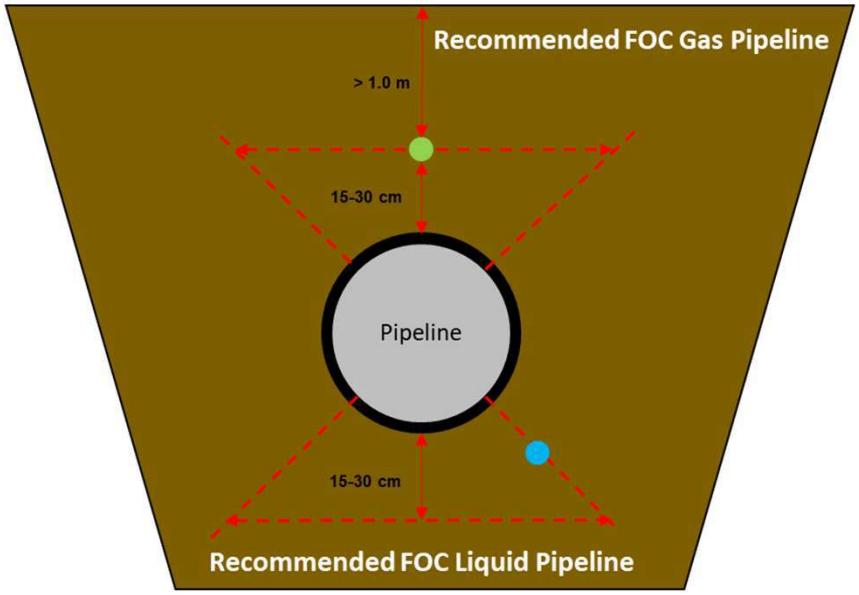
How does it work? Leak Detection



Recommended FOC position for Gas Pipelines:
Between 10h and 2h, 15-30 cm from pipeline surface and >1 m below ground surface

Recommended FOC position for Liquid Pipelines:
Between 4h and 8h, 15-30 cm from pipeline surface and >1 m below ground surface

Other FOC positions are possible or advisable depending on:

- Operational conditions
- Water table
- Thermal insulation
- Combination of applications
- etc

FOC characteristics:

- DTS based – Standard telecoms FOC with loose tube.
- DAS based – Standard telecoms FOC with either loose tube or tight buffer
- Optical fibers must be Single Mode (ITU-T G652C/D or G657)
- HDPE deployment possible but direct ground burial recommended

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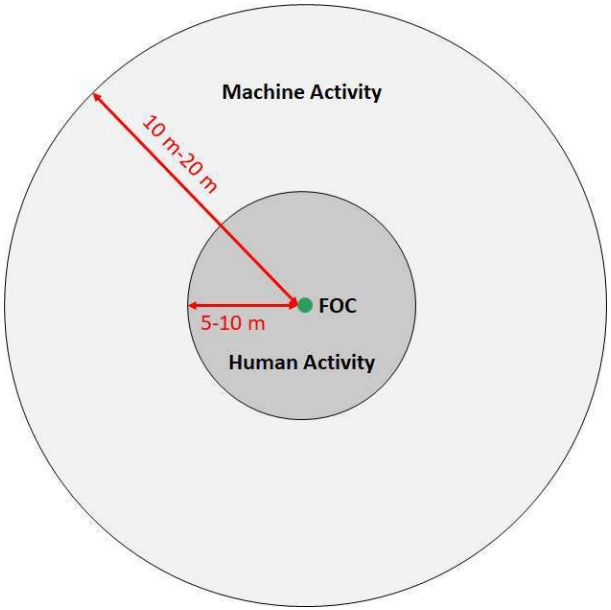
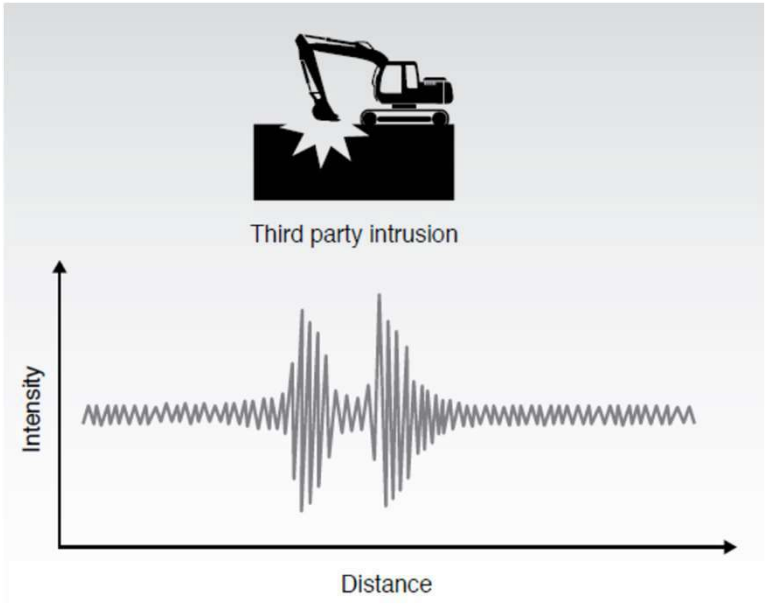
How does it work? Intrusion Threats

Analysis acoustic signature of potential pipeline threats

- Human activity 5m around FOC
- Machine activity 10m around FOC
- PIG tracking
- Others (i.e. seismic events)





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Field Trials Video

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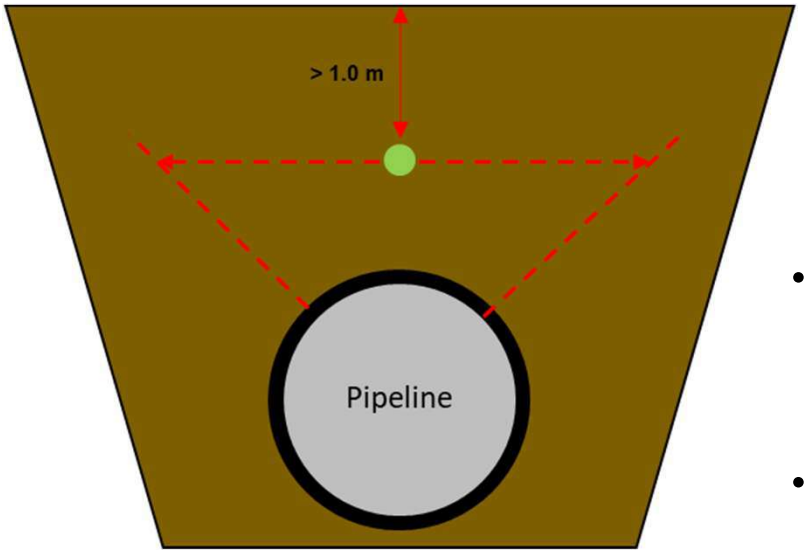
How does it work? Intrusion Threats



- DAS based – Standard telecoms FOC with either loose tube or tight buffer.
- Optical fibers must be Single Mode (ITU-T G652C/D or G657)
- HDPE deployment possible but direct ground burial recommended

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Strategy

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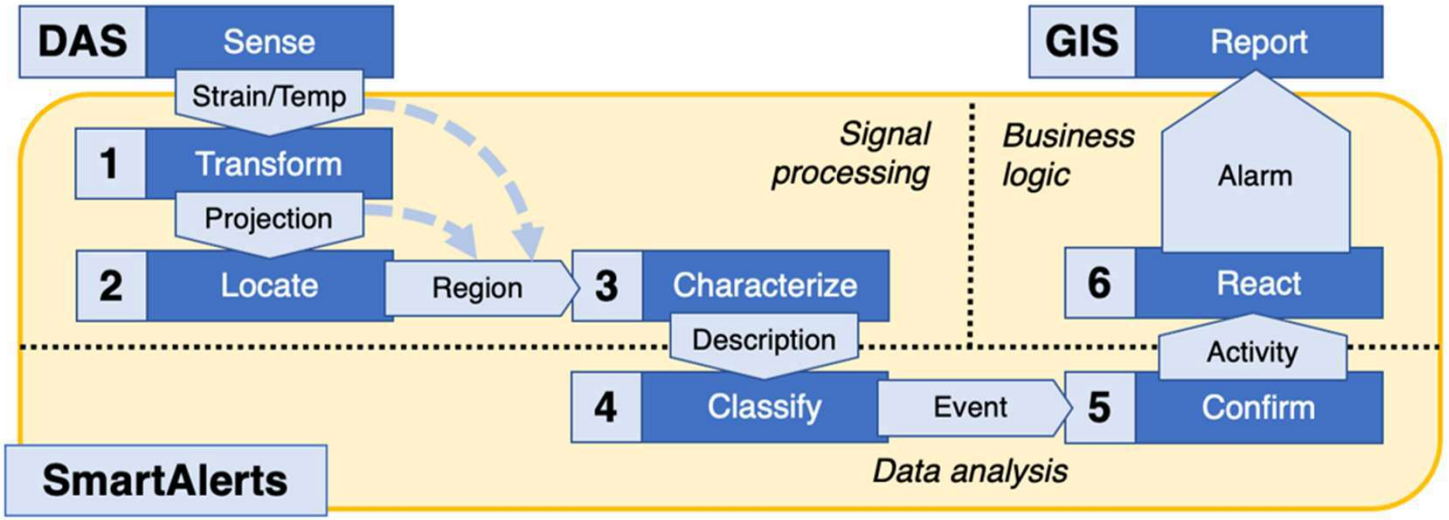
Decompose the problem in layers with different optimization goals that do not require to fully solve the problem on their own



Next slides: a practical example illustrating the different steps

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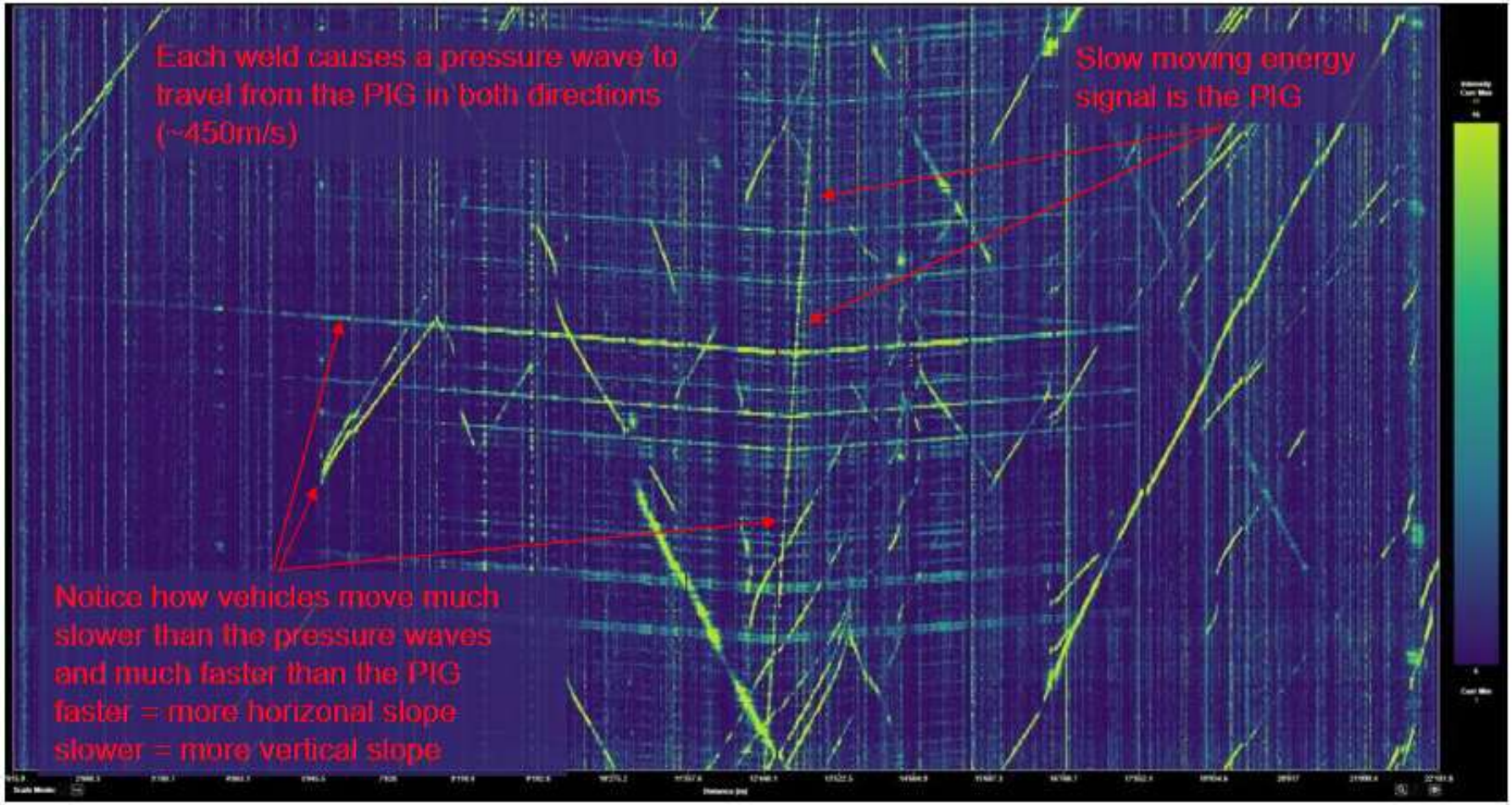
Pig-Tracking – Obstruction Finding



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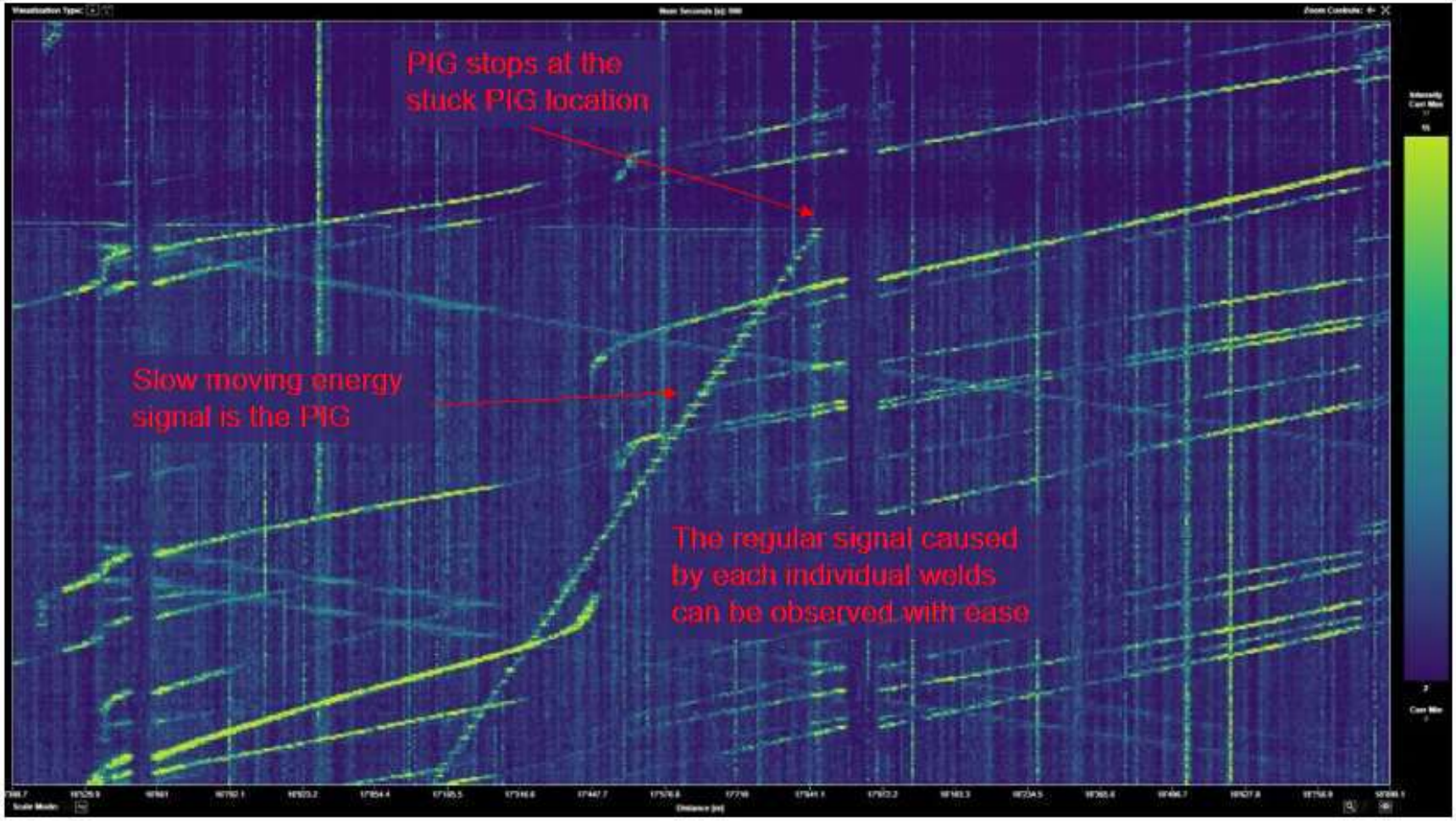
Pig-Tracking – Obstruction Finding



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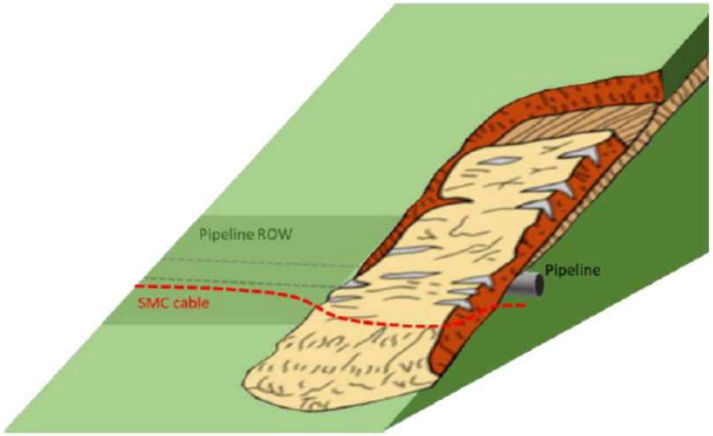
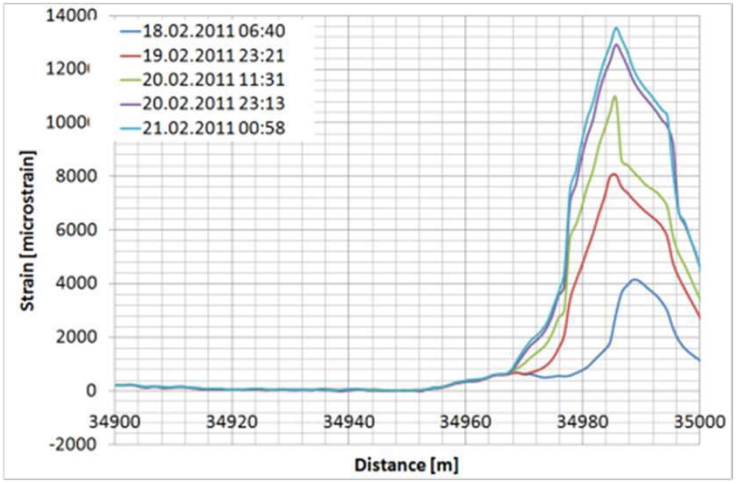
How does it work? Geo-Hazards

- DSS – Landslides, terrain subsidence, pipeline deformation, etc.
- DTS – Soil erosion
  - Water infiltration
  - Wind erosion





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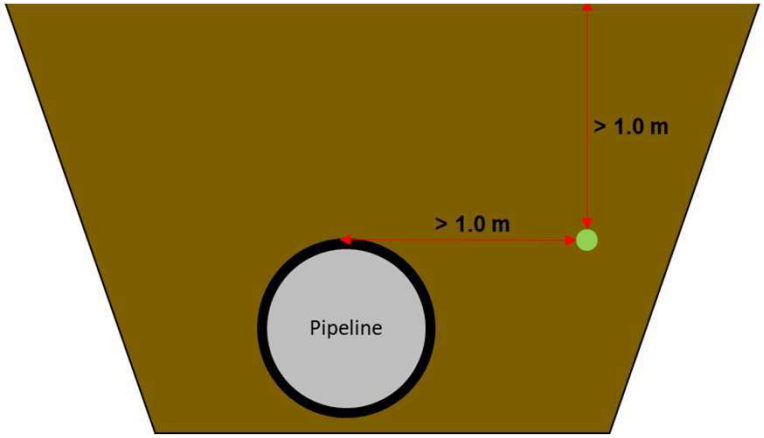
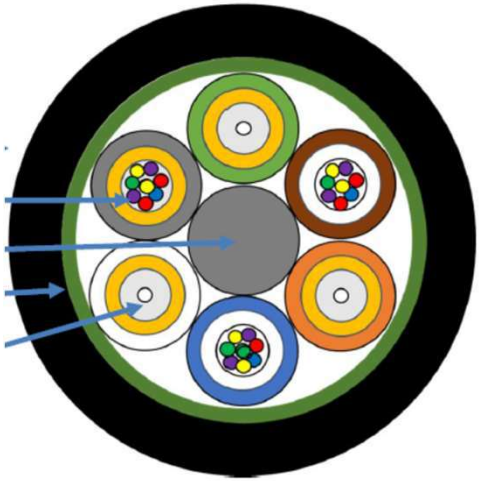
How does it work? Geo-Hazards



- Special tight buffer strain sensing FOC required for close monitoring, but standard telecom cable can provide early detection too.
- Optical fibers must be Single Mode (ITU-T G652C/D or G657)
- HDPE deployment not possible. Must be direct ground burial

AIMCOM Monitoring Cable



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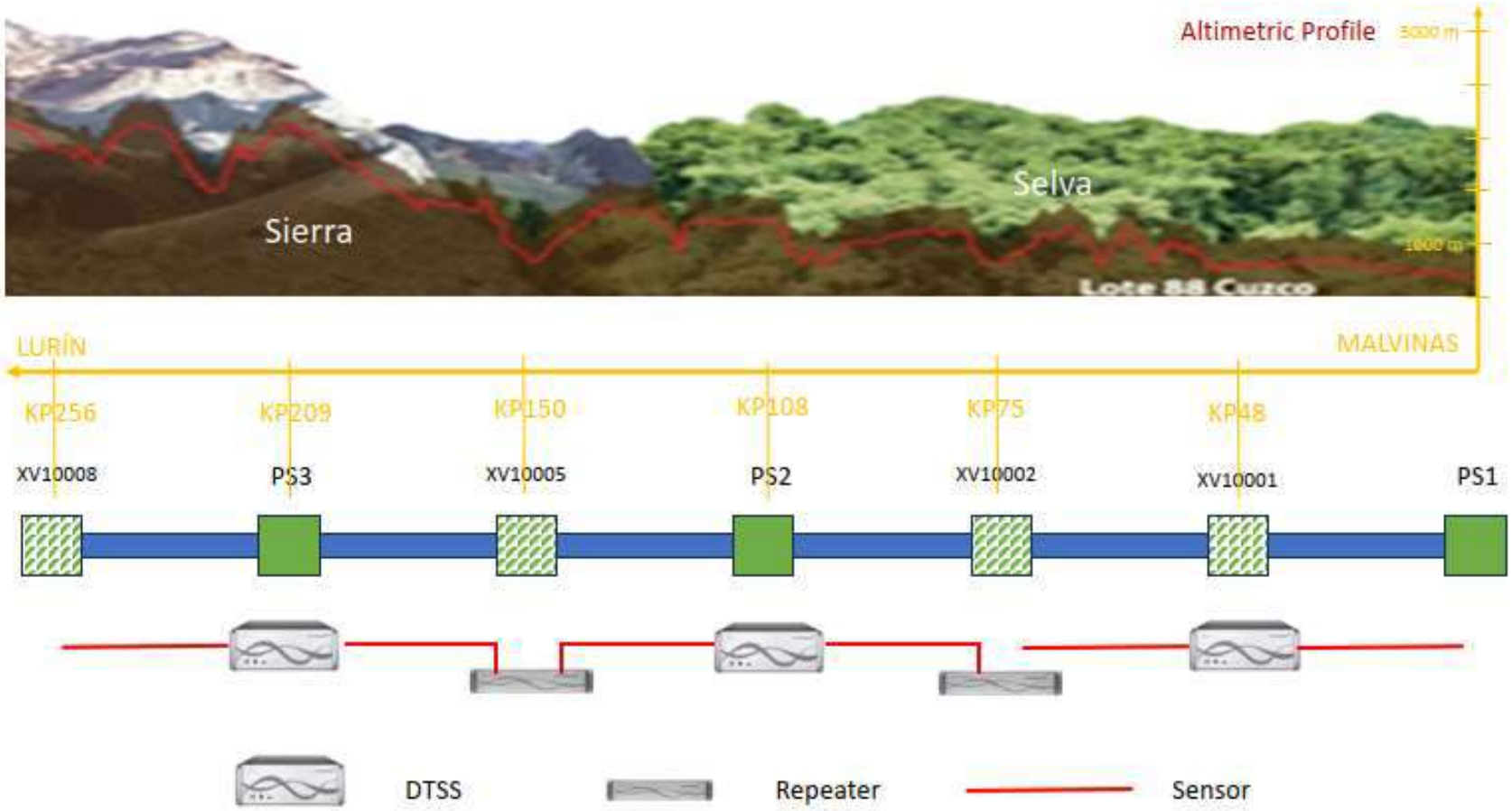
Geo-Hazards Recent Detection



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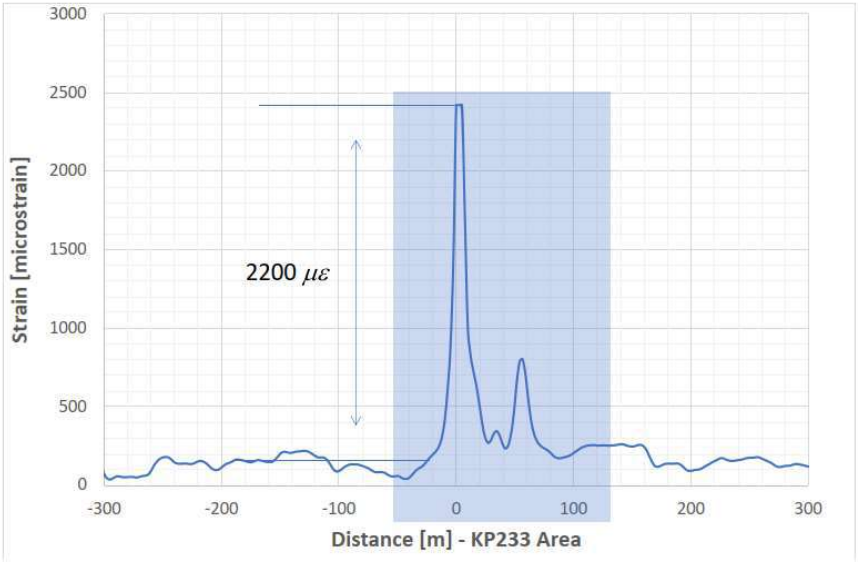
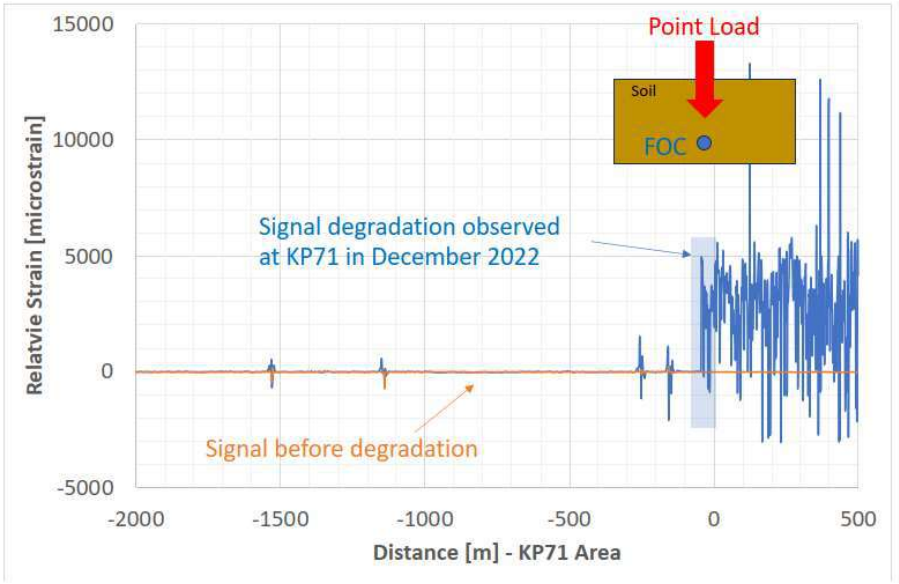
Geo-Hazards Recent Detection





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