THEFT, IMPACT AND LEAK DETECTION ON ONSHORE PIPELINES USING ACOUSTIC SENSING

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Theft, Leak and impact detection

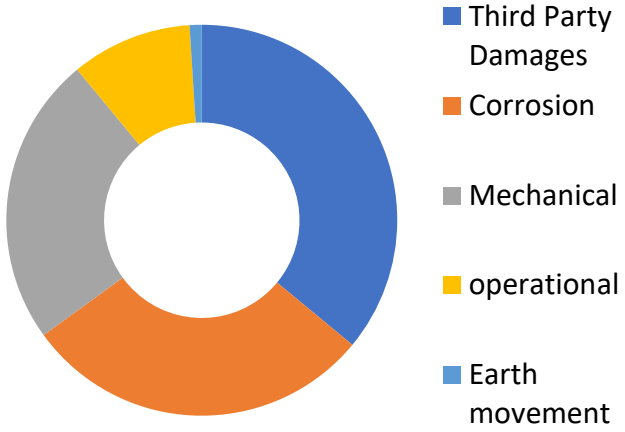
Main pipeline integrity matters:

Corrosion leaks

Product steal

Third party damage

Main accident causes



Main consequences resulting in dramatic issues:
→ Human life and environment
→ Economical loos and political images

Theft, Leak and impact detection

PipeLIDS system → Based on acoustic technology

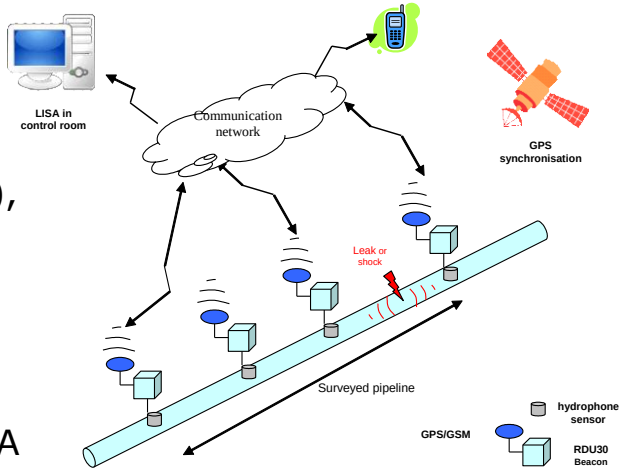
- This system uses acoustic detection of abnormal noise generated by impacts or leaks;
- This noise is propagated very quickly in both directions over long distances inside the pipe;
- Noise is seen by intrusive acoustic sensors installed regularly on the pipeline;
- PipeLIDS measures the sound wave's amplitude and time difference

→ Quick localization, evaluation and alarming

Theft, Leak and impact detection

PipeLIDS's Architecture

- Hydrophone probes, installed on fitting on the pipeline, measures the acoustic noise fluctuation
- They are connected to a local Remote Detection Unit (RDU), with GPS time synchronization
- The RDU continuously analyses the acoustic fluctuation to confirm, localize and transmit alarms
- Alarms are sent directly to the operator (by SMS) or to LISA display located in the control room, through the used network
- LISA is able to inform about the type of event, its time, magnitude and its location,



Typical PipeLIDS architecture

→ For long transport pipelines
→ For point to point short pipelines
→ For High Critical areas (HCA)

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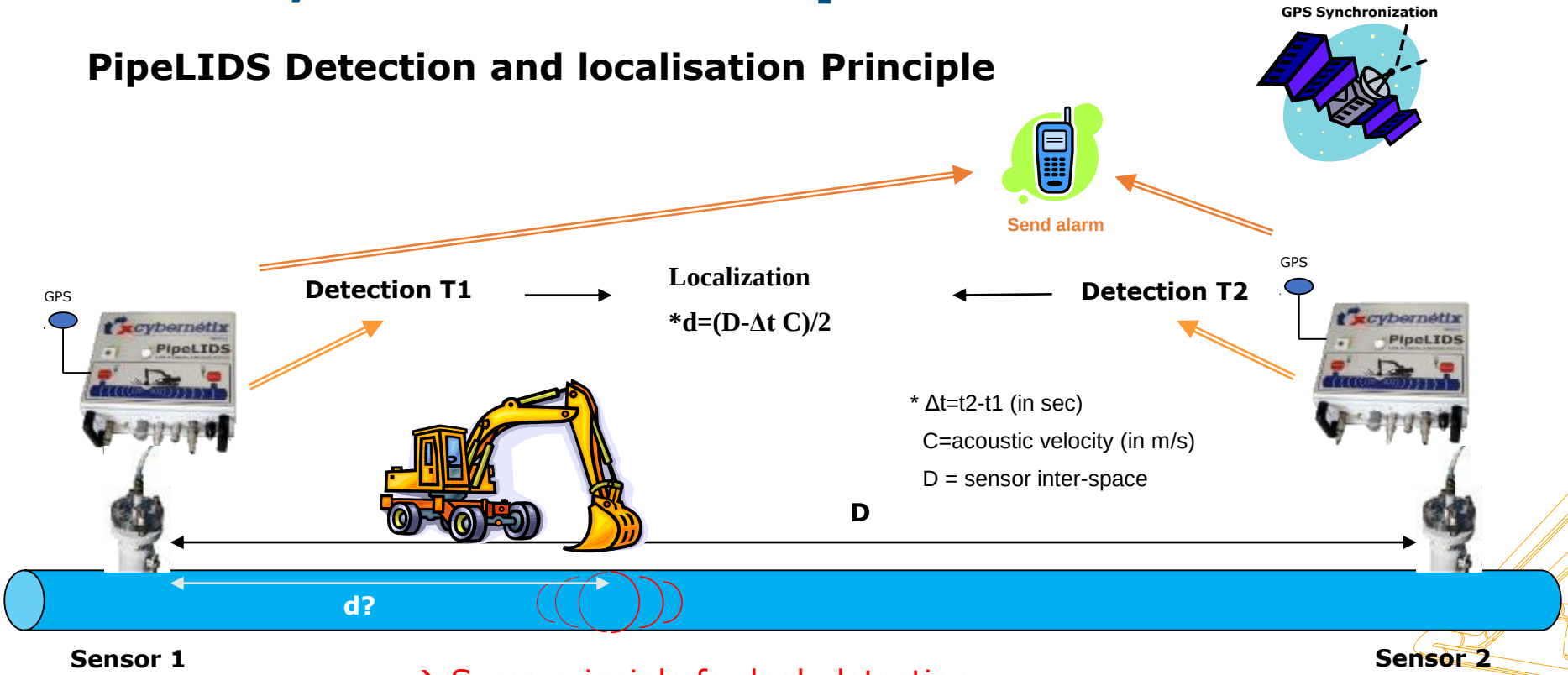
PipeLIDS Detection and localisation Principle

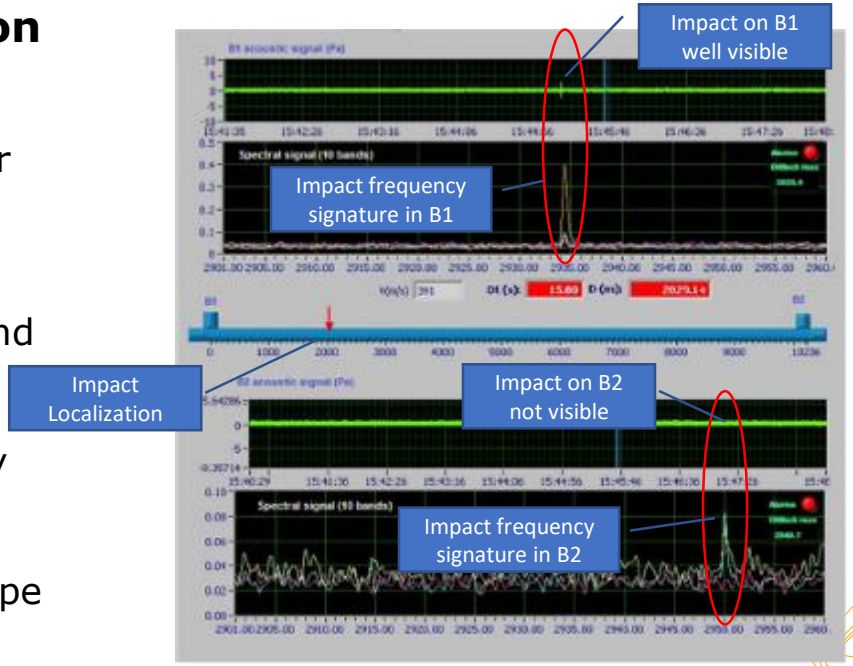


→ Same principle for leak detection

Theft, Leak and impact detection

PipeLIDS system → Impact detection

- An unexpected event such as hammer, excavator, drill, on the pipeline, explosion or ground movement creates an impact noise source.
- The noise propagates along the pipeline and is remotely detected and located.
- The shock is easily identified as it is a very energetic and short pulse.
- Its amplitude and length depend on the type of shock itself.



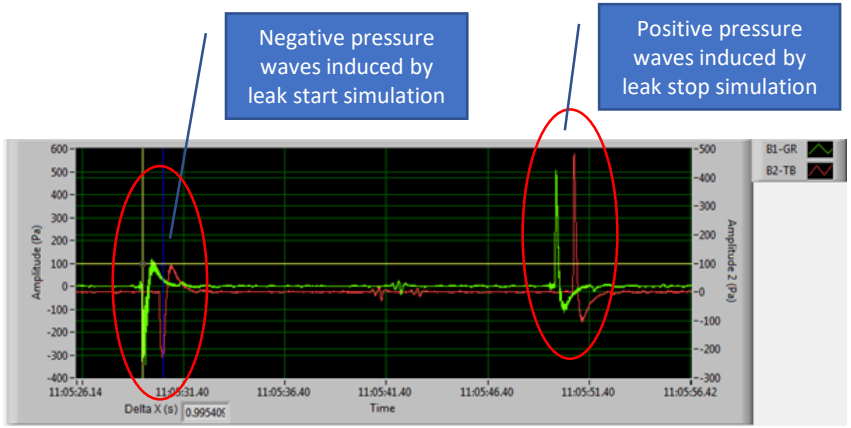
Spectral analysis of 700 joules impact on 10 km gazoduc

→ Patented powerfull spectral algorithms are used by PipeLIDS

Theft, Leak and impact detection

PipeLIDS system → Negative pressure wave detection (leak or theft)

- Negative pressure waves are generated in case of sudden leak or theft of product
- It is a sudden drop in pressure at the leak point followed by rapid line repressurization
- The resulting low-pressure wave travels at the speed of sound through the liquid away from the leak in both directions
- Sensors developed for CYBERNETIX' PIPELIDS system, have been designed to measure over the usual acoustic frequencies, these particular low frequency waves.



12 mm Leak simulation on a diesel pipeline

→ Theft of product (valve opening and closing) could be detected by this way

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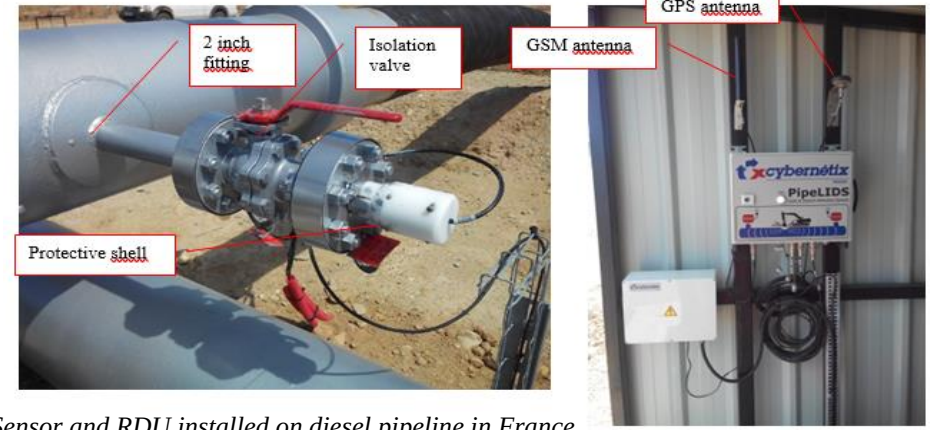
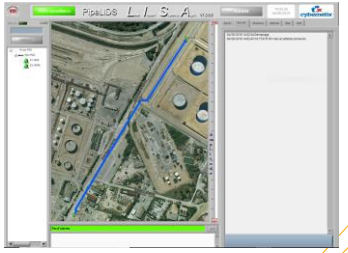
PipeLIDS system → Example on diesel pipeline

- PipeLIDS system installed on a 16 inch diesel pipeline in France
- Monitoring of 1 km of pipeline used to transfer diesel at low pressure (<10 bar)
- A couple of APS30 sensor and RDU are installed at each extremity and connected by wireless 3G communication to the LISA display in the control room



Sensor and RDU installed on diesel pipeline in France

LISA display



LISA HMI

RIO PIPELINE CONFERENCE & EXHIBITION

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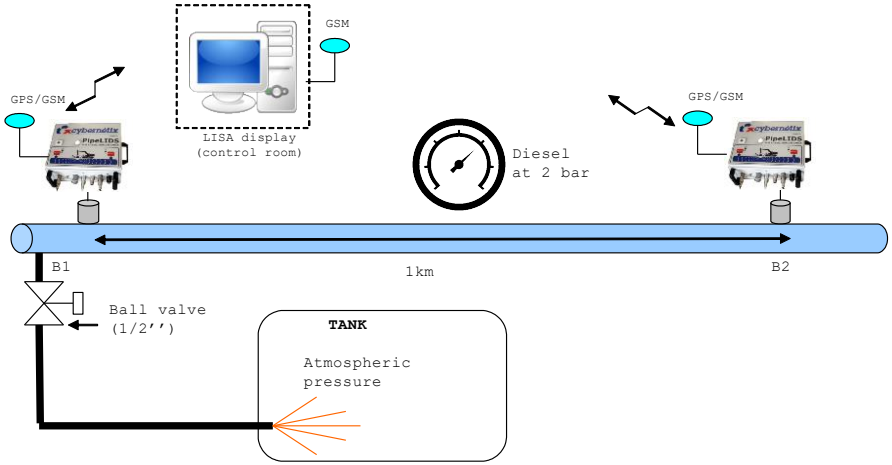
PipeLIDS system → Leak simulation testing

- Leak simulated by 12 mm ball valve opening
- And discharge of product towards a tank at atmospheric pressure



Leak simulation overlay

Leak simulation at pig launcher

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PipeLIDS system → Leak simulation results

- In green the acoustic signal of the valve opening measured in sensor B1 and in red the signal measured in sensor B2 (Fig 1),

- The subsidiary waves are caused by reverberation against the line extremity valves which were closed,

- We observed a low spectral signature on both B1 and B2 which is characteristic of a negative pressure wave caused by valve opening (Fig 2),

- The leak itself does not produce a sound all along its duration but the beginning and end of the leak are well visible,

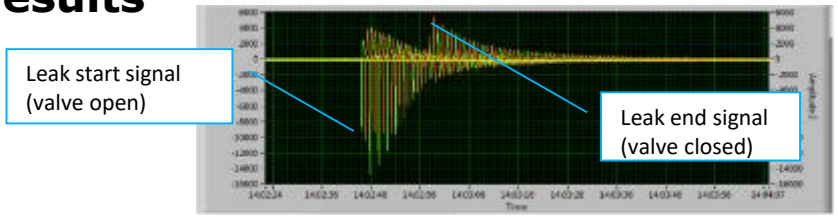

Fig 1: Leak acoustic signals on B1 (Green) and B2 (Red)

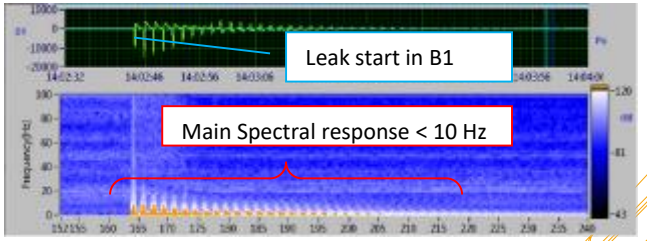

Fig 2: Leak acoustic spectral response

Theft, Leak and impact detection

Estimation of Negative pressure wave detectable distance

• For each echo the wave travelled two times (round trip), one echo has travelled 2*1km = 2km (Fig 1).

• 8 echoes are seen above the BN (Fig 2), meaning this negative pressure wave could be detected on longest pipeline at minimum of 8 echoes x 2 km = 16 km.

• Echo's amplitude decreases as energy is lost at each reflection (acoustic attenuation =1 dB/km in that case)
•With this attenuation, and considering the wave should be higher than the BN to be detected, the maximum detectable distance in a longest pipeline could be estimated using: Dist = 20 LOG (BN/Surge max)/Att

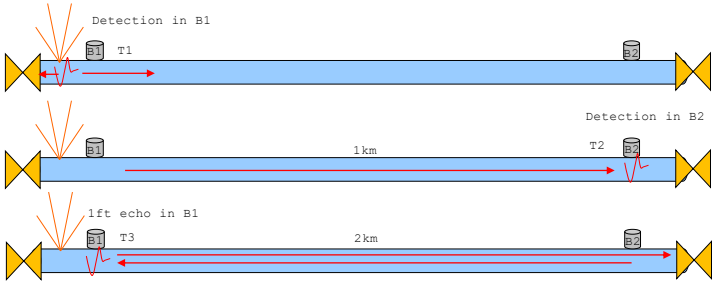

Fig 1: Pressure surge echoes principle

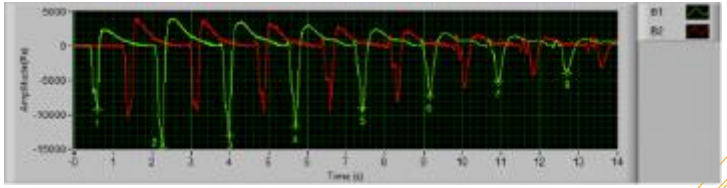

Fig 2: Pressure surge echoes details

- For **low background noise** (10 Pa = pipe stop): → **Max estimated Distance = 57 km**
- For **high background noise** (2000 Pa = pipe running): → **Max estimated Distance = 16 km**

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Conclusions

• PipeLIDS system is able to detect impact and leak on onshore pipeline using acoustic method;

• It was demonstrated that a leak simulation by valve opening is a good way to estimate the maximum detectable distance, for instance for a 16 inch diesel pipeline, it is around 57 km in low BN, and 16 km in high BN.

• And finaly Acoustic method is a good way to detect theft of product:
  - First by detecting the noise produces by illegal taping (drilling, shock)
  - Then by detecting the opening and closing of the illegal branching

Acknowledgements / Thank You / Questions

Thank to the attendees and to Rio Pipeline which gave us the opportunity to present our Acoustic Impact and Leak Detection system PipeLIDS