ATMOS Wave

Leak Detection by Rarefaction Wave Analysis

Dr Jun Zhang

ATMOS International Ltd

165D Burton Road, Manchester

Web: www.atmosi.com

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Overview

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- Introduction to ATMOS International
- Background to ATMOS Wave
- Principle of ATMOS Wave
- Field Test Results
- Conclusions

ATMOS International History

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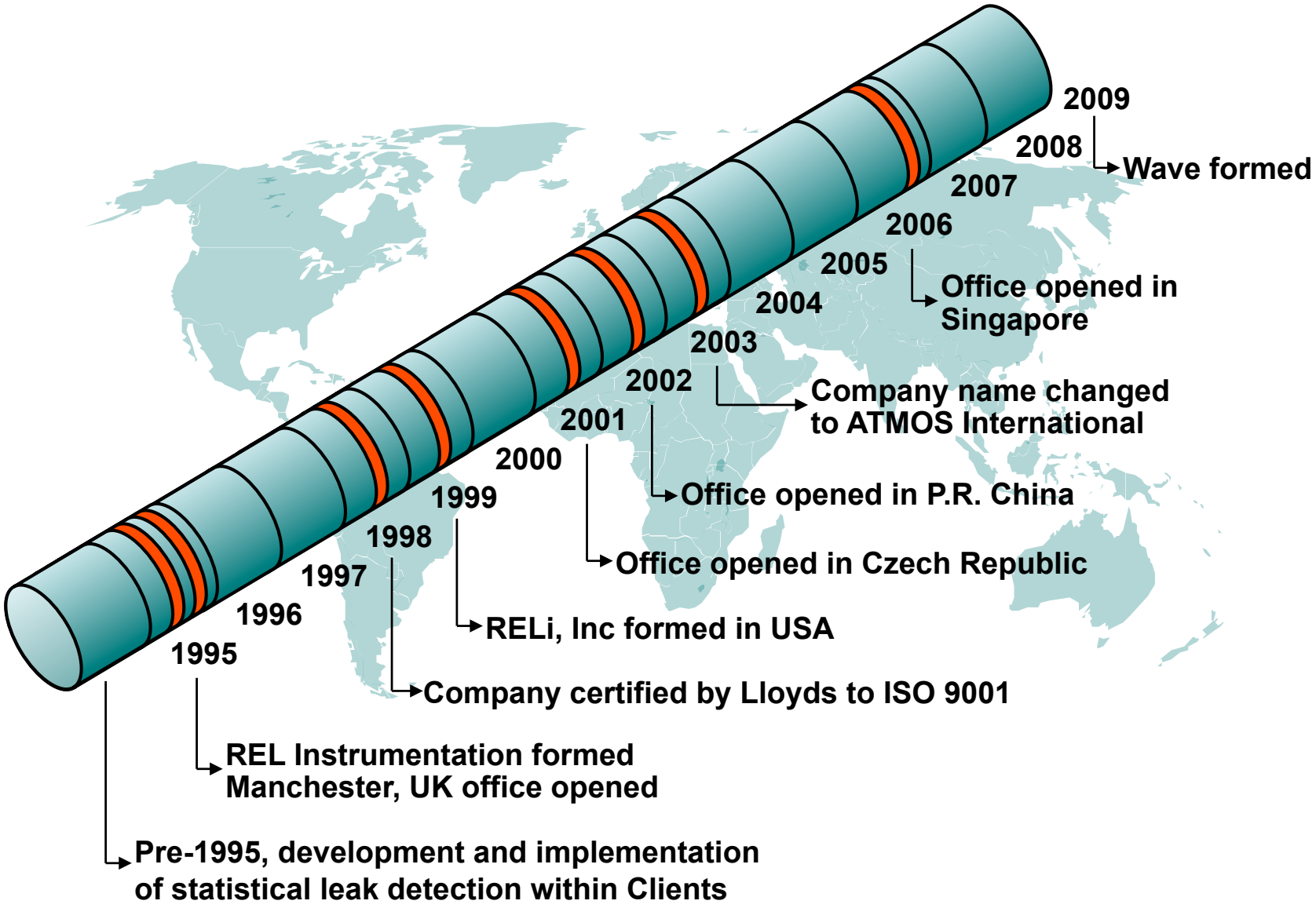

What does ATMOS do?

ATMOS PIPELINE SOFTWARE

We supply world class software for pipeline operations to:

- Detect and locate leaks reliably, quickly and accurately
- Simulate pipeline hydraulics accurately and realistically
- Track product batches and cleaning/inspection pigs accurately
- Optimize pipeline operations by minimizing costs in running pumps or using DRA
- Train pipeline operators by the use of a Trainer to simulate emergency and unusual operations realistically

What does ATMOS do?

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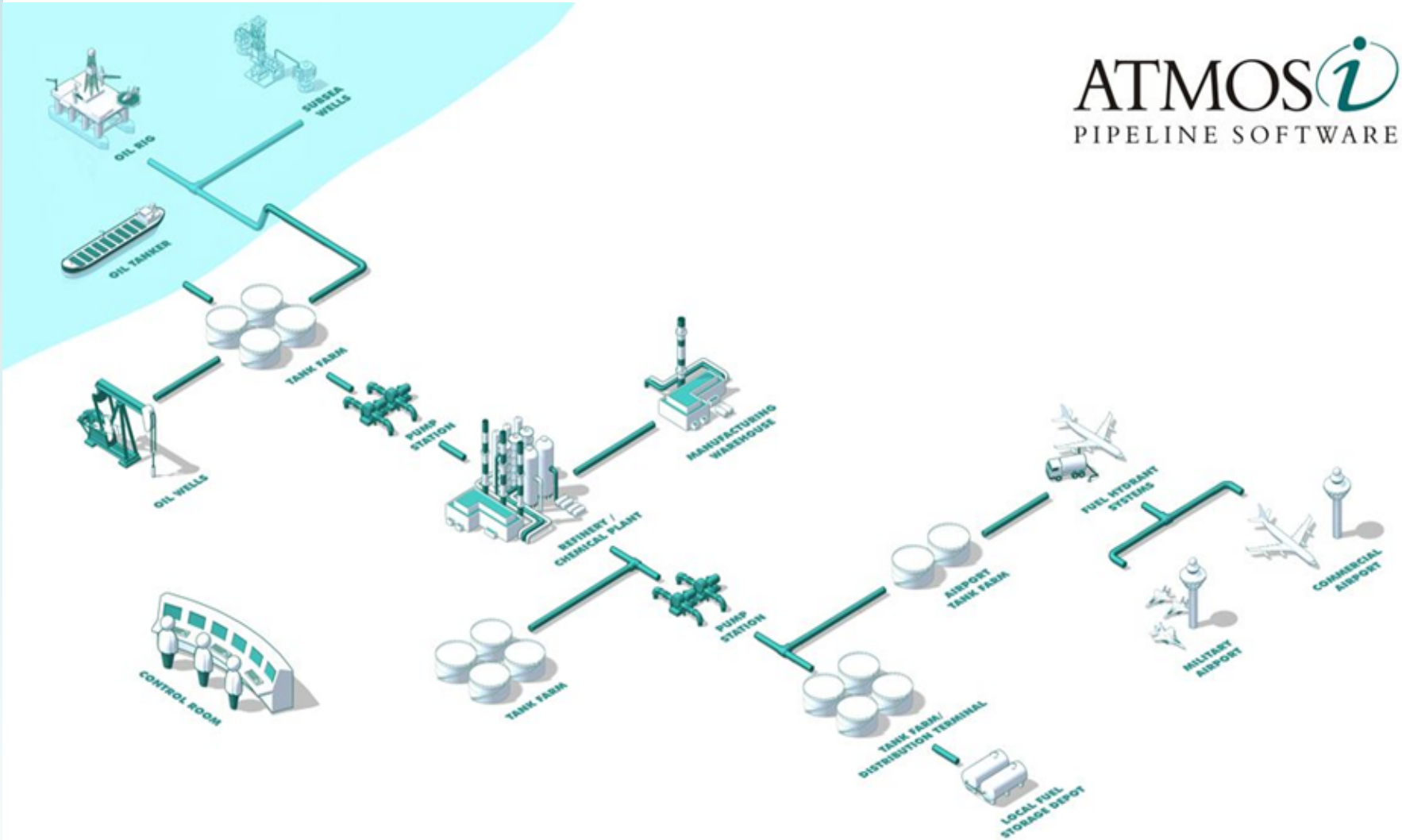
PIPELINE SOFTWARE



Clients, Markets, Geographies

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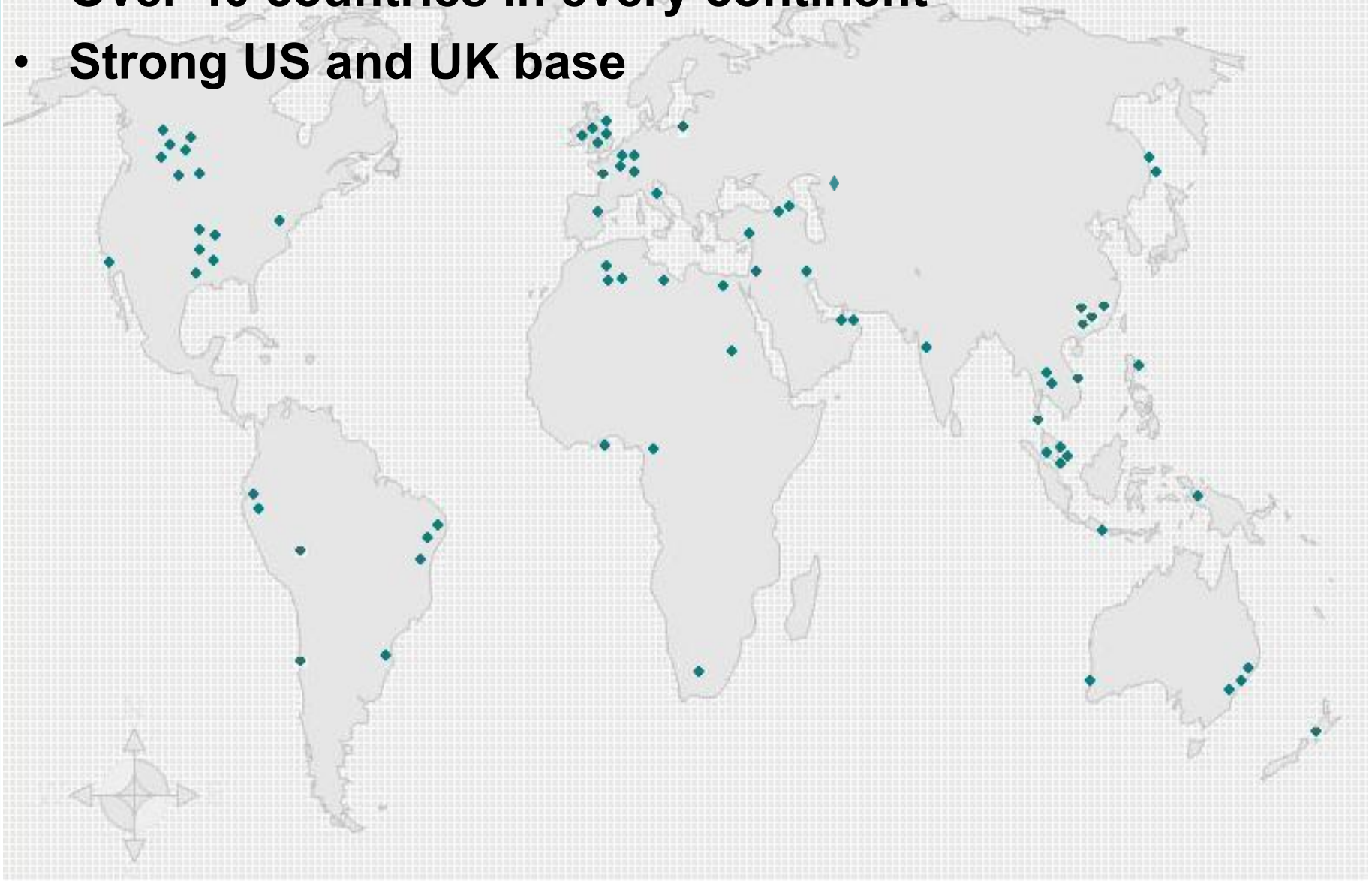
- More than 460 pipeline applications
- Over 40 countries in every continent
- Strong US and UK base



Pipeline Applications Per Country

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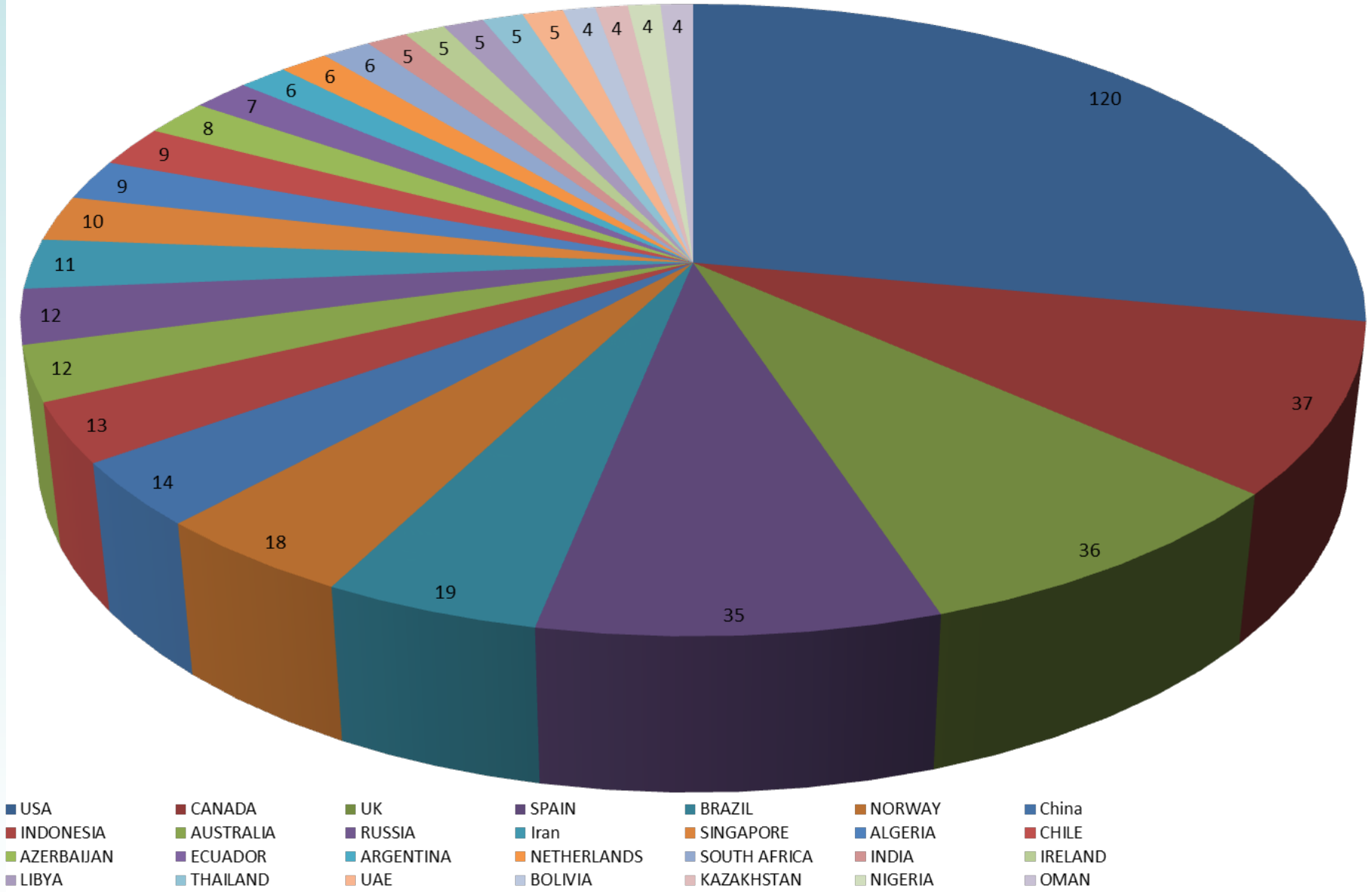

Pipeline Applications Per Fluid Type

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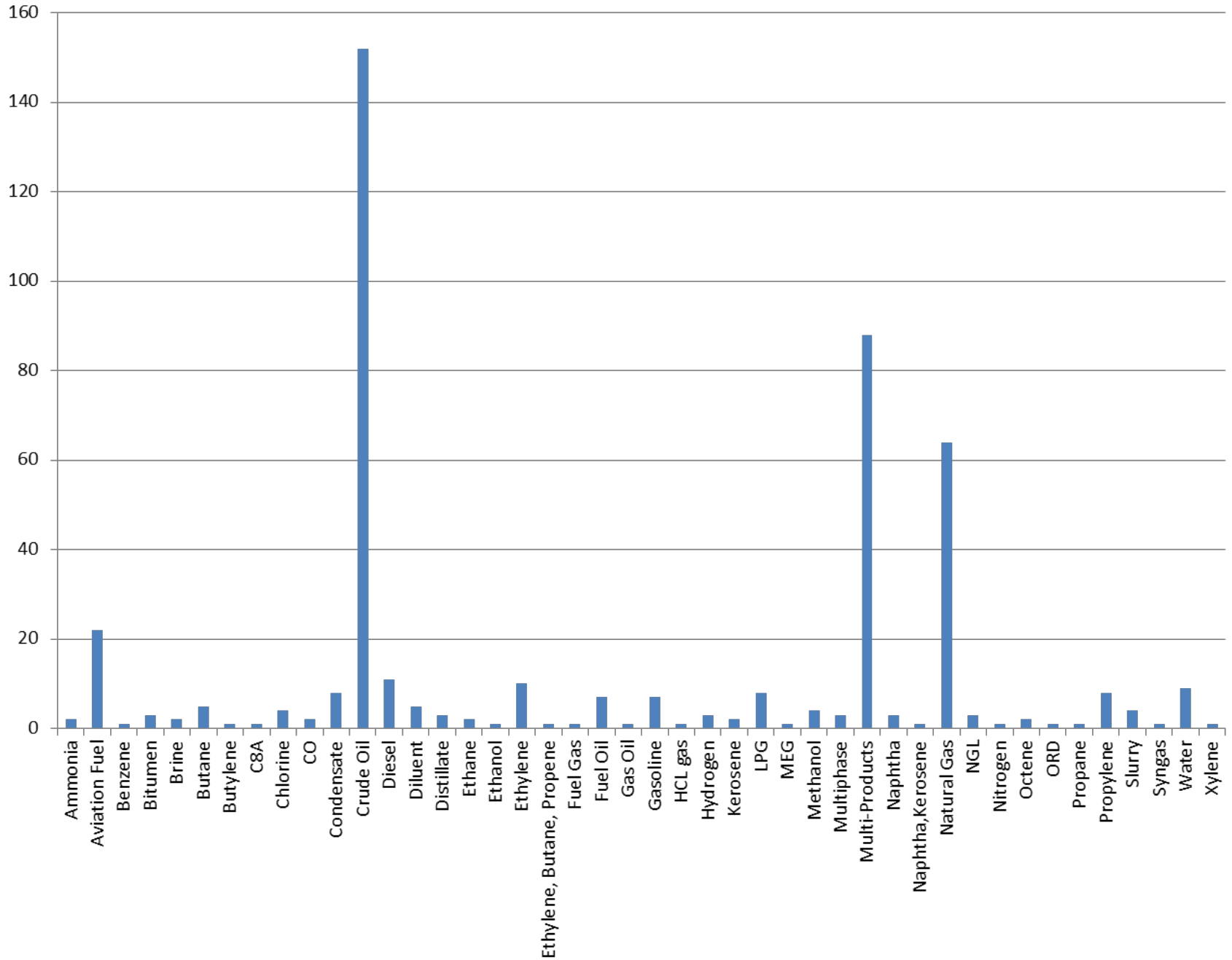

Why A New Leak Detection System?

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- High accuracy flow meters are expensive
- Most flow meters have an accuracy of 2% or worse
- Leak detection would be more affordable if it works with pressure sensors alone
- Modern communication technology provides high bandwidth
- Availability of fast response pressure sensors (e.g. Druk high accuracy resonant silicon sensors)
- Increased computing power makes data processing faster
- **Pipeline companies want faster and more accurate leak detection solutions**

The Short Journey Of ATMOS Wave

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2007-2008:

In house research and development

2009:

Research grant by North West RDA

Dec 2009:

Field test by BP on a jet fuel pipeline in the UK

2010 – 2011:

Field tests in Taiwan, USA, Mexico
More than 100 withdrawal tests have been conducted

2012 installed systems:

30 km crude line in the USA

30 km water line in South America

3 tanker unloading lines USA

2 inter-refinery product lines in the USA

130km crude oil line in South America

The Short Journey Of ATMOS Wave

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2012 on going installations:

- 190km crude oil line in Turkey
- 400km crude oil line in Abu Dhabi
- 134km multiproduct line in Indonesia
- 56km fuel line in Malaysia
- 16 multi-product lines in UAE

2012 on going tests:

- Multiphase well head gathering system
- Gas pipelines
- Water transmission & distribution pipelines

ATMOS Wave Overview

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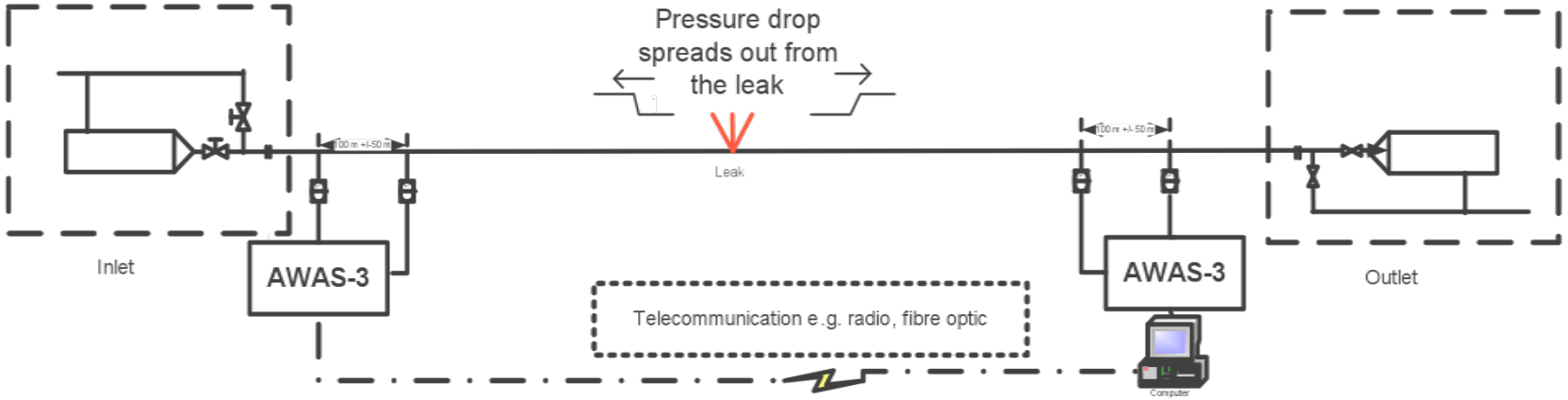
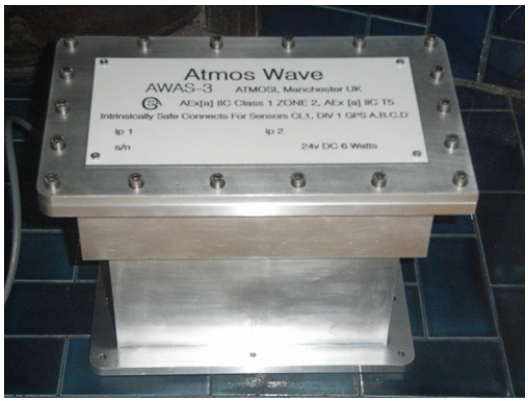
Leak detection using rarefaction waves





ATMOS Wave Overview

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- Leak sensitivity < 1%
- Leak location < 1% for leaks >1.6%
- Leak detection time <5 minutes
- 500m to 220km between sensors
- Basic system: two pressure sensors at each end of the pipe
- Achieves sensitivity without flow meters
- High data rates up to 480 Hz
- GPS time stamped data
- Atex Eex d [ia II C T4] or DIN rail mounted system

Potential Applications

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- Short gathering lines where no flow meter is available
- Critical applications running alongside traditional balance methods
- Pipelines where high location accuracy or short detection time is needed
- Pipelines where it is difficult to have reliable flow meters e.g. drilling rigs, platforms, process plants, multi-phase, water
- Theft detection
- Leak location confirmation for a mass balance system

System Principles

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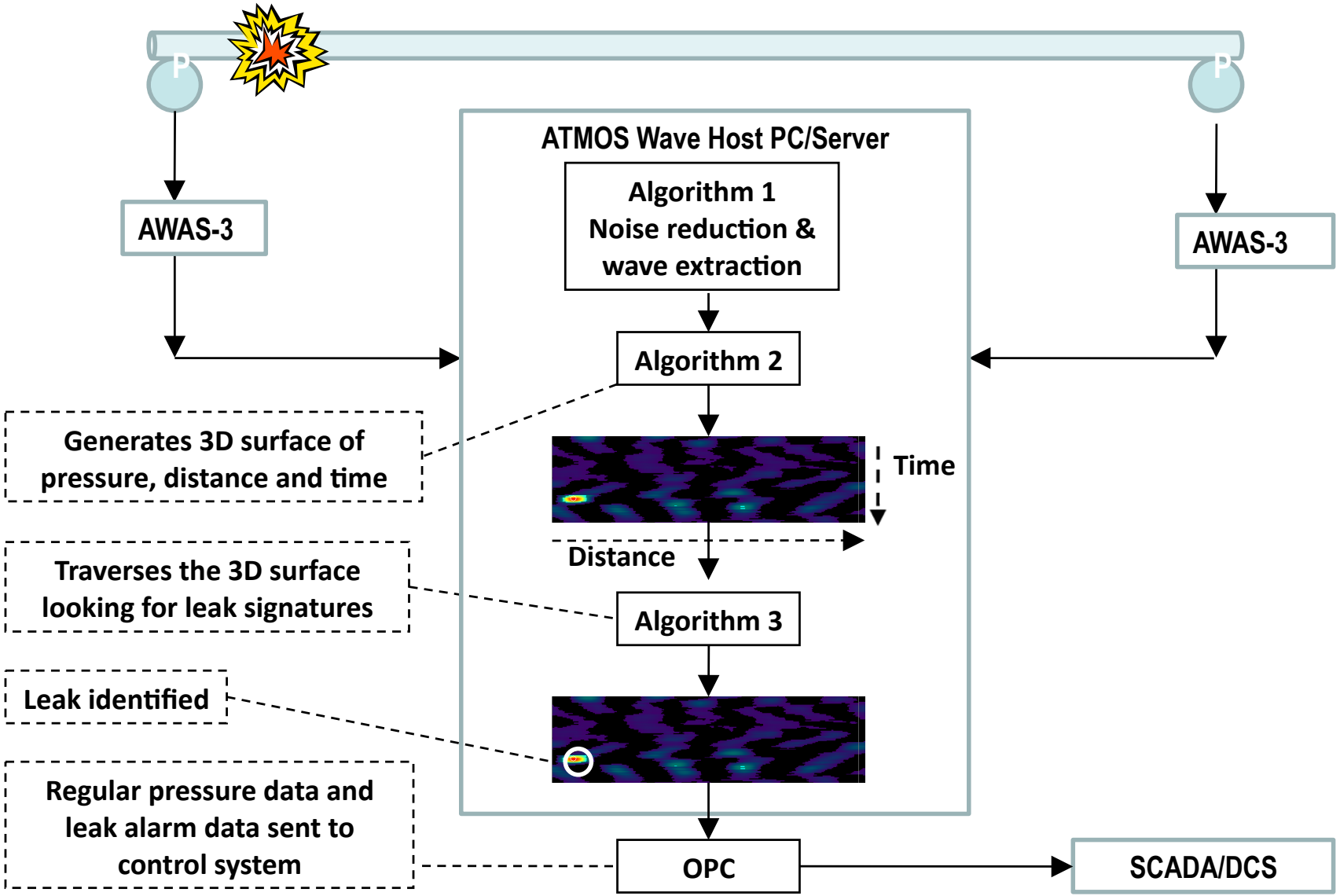

System Principles

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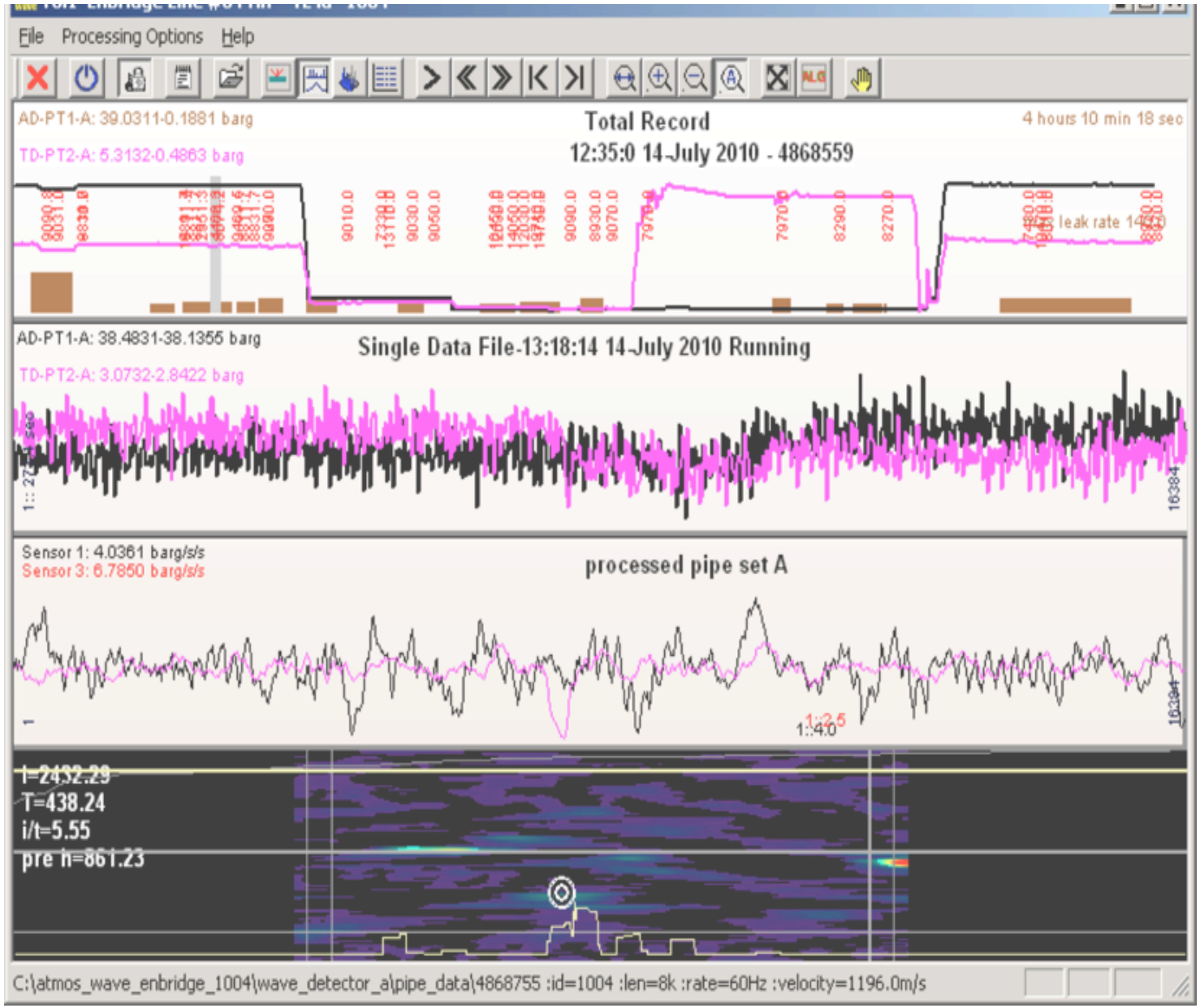

Pressure record over 4 hours 10 minutes

Pressure record of 136 seconds to be processed

Pressure output of 136 seconds processed by Algorithm 1

3-D pattern map by Algorithm 2 Leak identified by Algorithm 3 & circled in white

Field Test – Output Display

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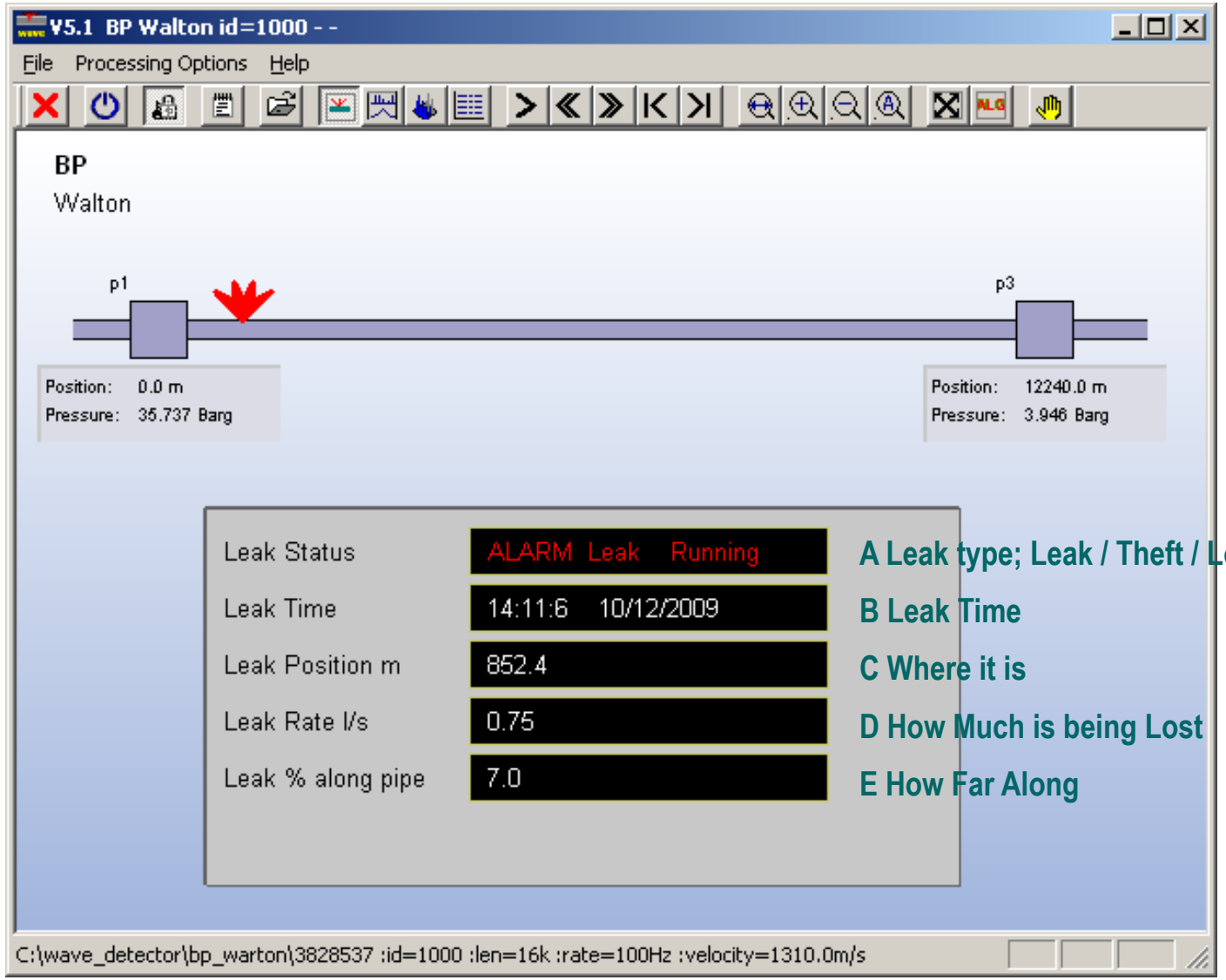

A Leak type; Leak / Theft / Lost / Slow

B Leak Time

C Where it is

D How Much is being Lost

E How Far Along

Field Test – Jet Fuel Pipe Results

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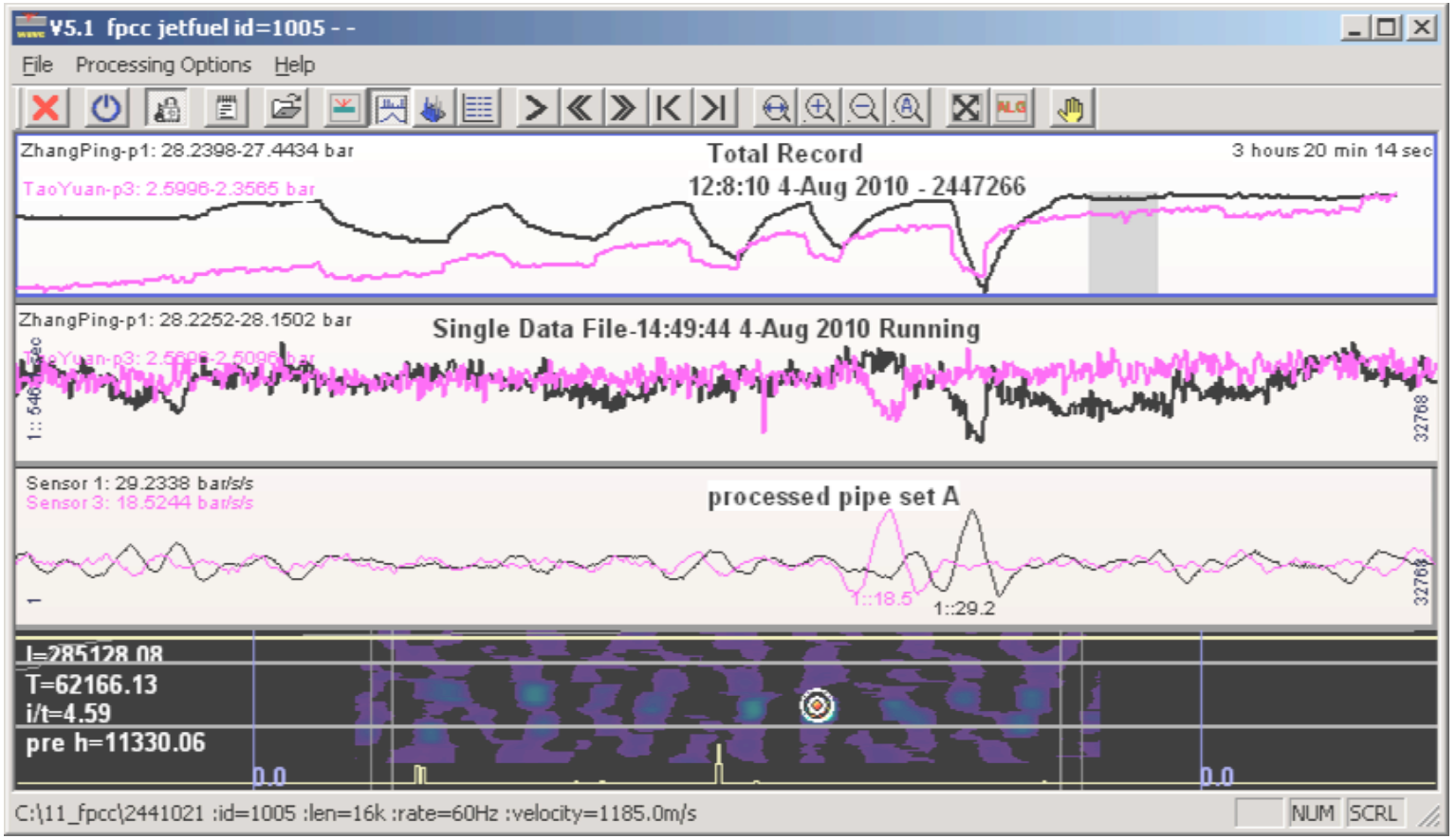
Detection of a 1 liters/s leak lasting for 15 seconds during running conditions on a 140km long pipe

- **Total fuel loss of 15 liters**
- **Located at 92.2 km with an 800 m error**



ATMOS Wave for Large Crude Lines

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- Installed on a 41 mile 42” diameter section
- Line was carrying crude with 5 batch separation pigs
- Seven test leaks were done on the line on 30th September
- Leak rates between 85 and 1129 barrels per hour generated
- The leak test point measured at 25.7 miles
- Time of detection for leaks was 5 minutes
- The maximum amount of oil that would be on the ground before Wave gave an alarm would be 19 barrels

Leak No	% Open	Start Time	End Time	GPM	Actual BPH	Location Miles	Atmos Wave Recorded BPH	% Flow Rate
1	25	9:17	9:19	159	274	29.1	750	1.6
2	40	9:32	9:34	594	1019	25.7	900	6
3	45	9:55	9:57	596	1023	25.7	1165	6
4	25	10:21	10:23	270	463	25.6	650	2.7
5	50	10:40	10:42	658	1129	25.7	1740	6.6
6	25	10:54	10:56	130	223	27.5	375	1.3
7	15	11:06	11:08	49	85	25.5	401	0.5

Field Test – Leaks Under Transient

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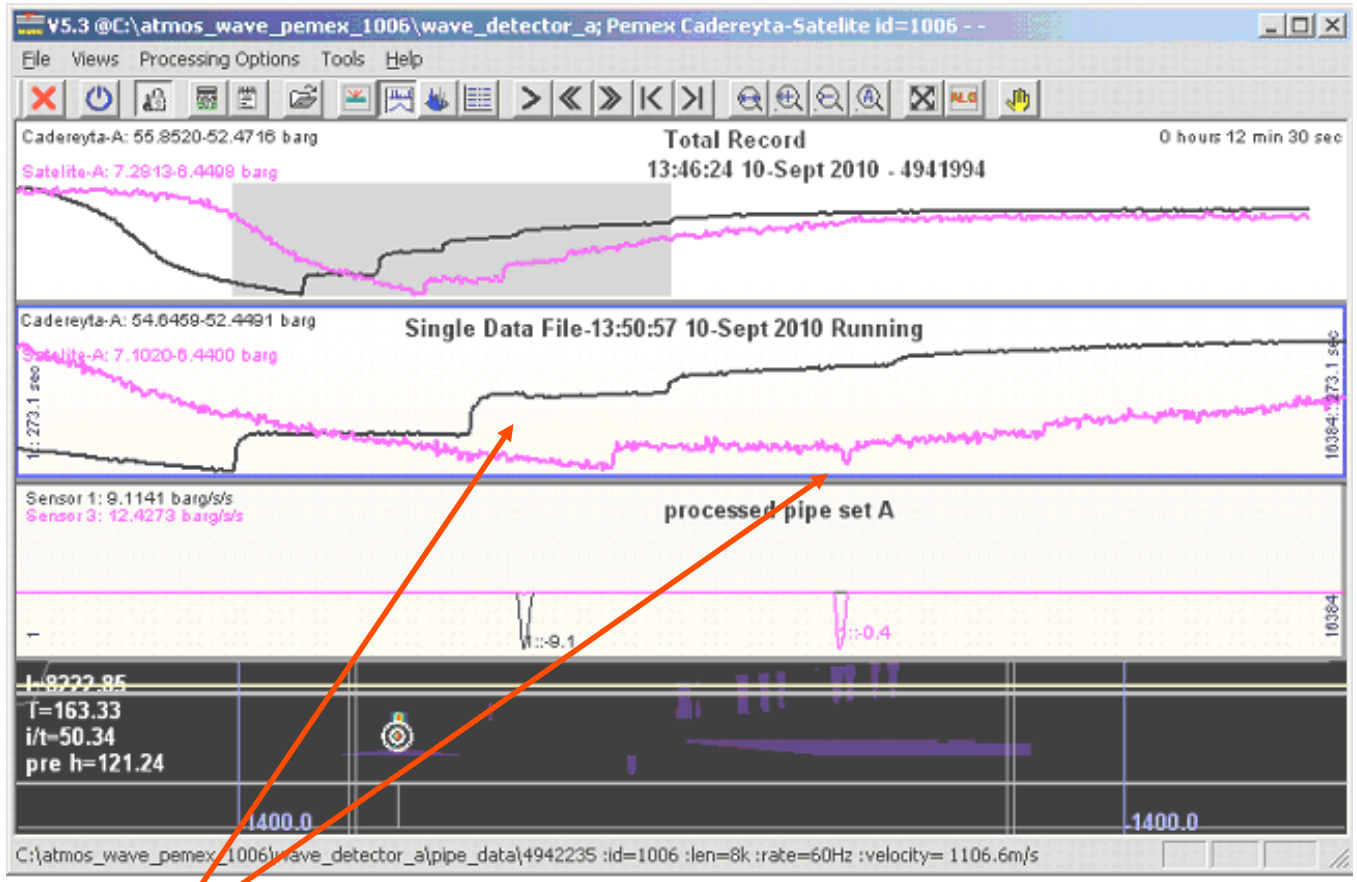
Batch change over with a variable speed pump



Leak is detected easily despite the stepped pressure response of the pump starting up

Field Test – Hydro Test

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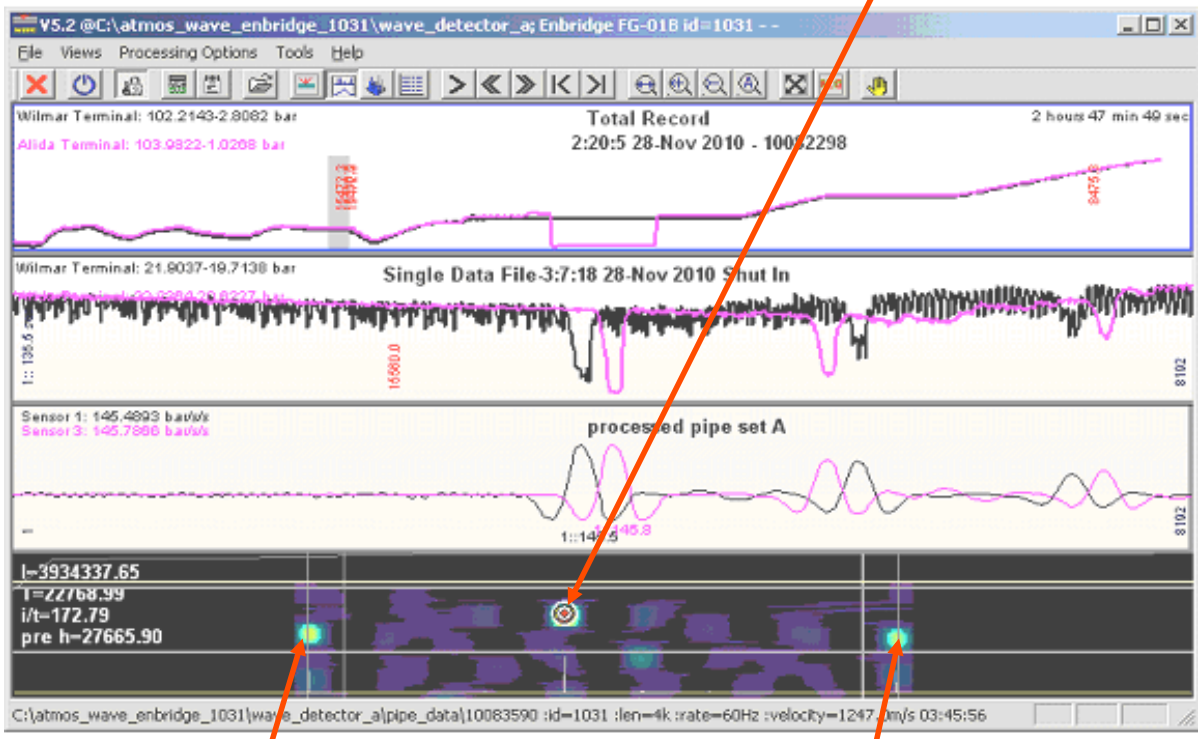
ATMOS Wave was connected up to a pipe undergoing a shut in pressure test. The pipeline length was 35.6km, diameter 6”. No leaks were detected during the test but shown here is a “leak” caused by a gate valve moving



Velocity indicators show that the line is 100% liquid filled

Field Test – Theft Location Accuracy

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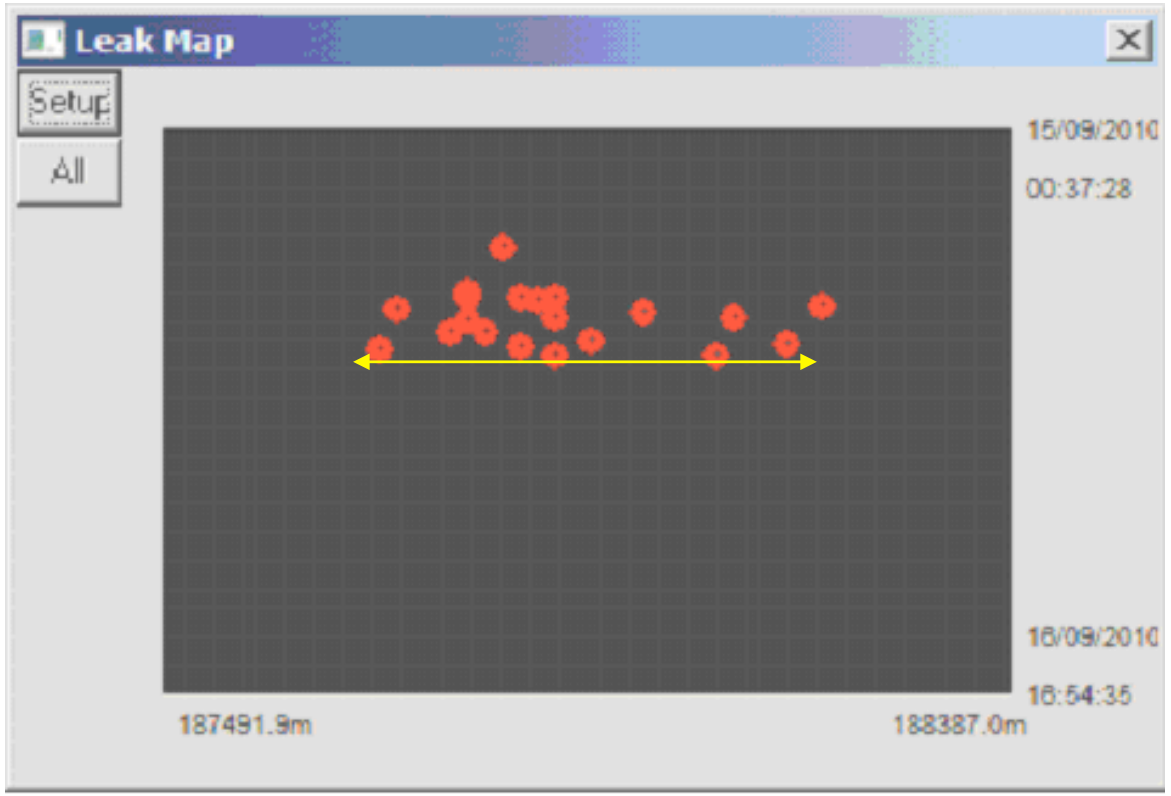
ATMOS Wave was connected up to a multiproduct pipeline suffering from real thefts. The line was 220km long and over a couple of days thefts were detected. Shown here is the Leak Map Report showing leak location over time.



500 meters spread in leak location

Signal To Noise Note

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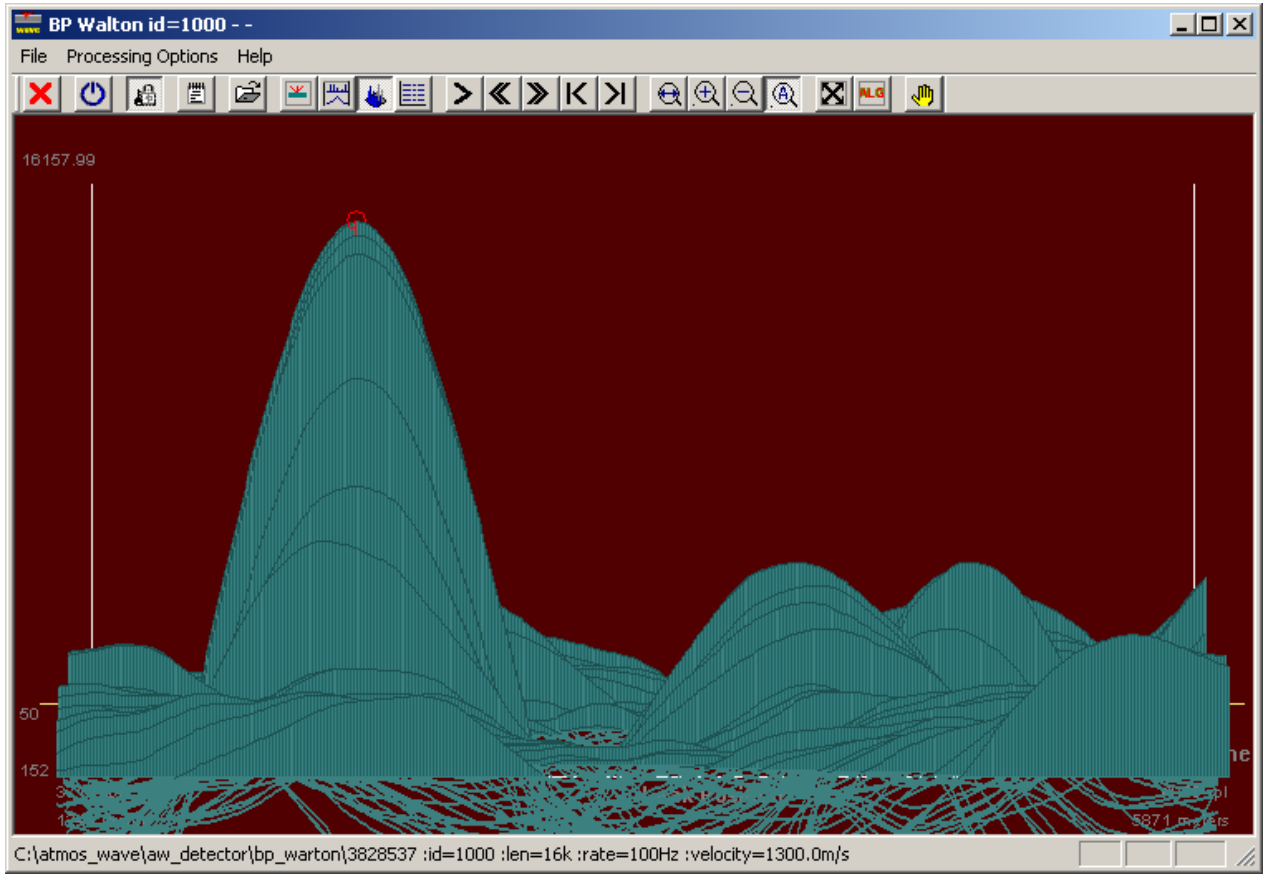
The algorithm determines real leaks by looking for hill tops in the 3-D map. Only hills that are 80 times taller than the background are considered to be leaks.



Because the sensor data is kept in “analog space”, signals below the signal to noise threshold in the matrix are accumulated to give the PLIB signature.

PLIB- Post Leak Indication Buildup

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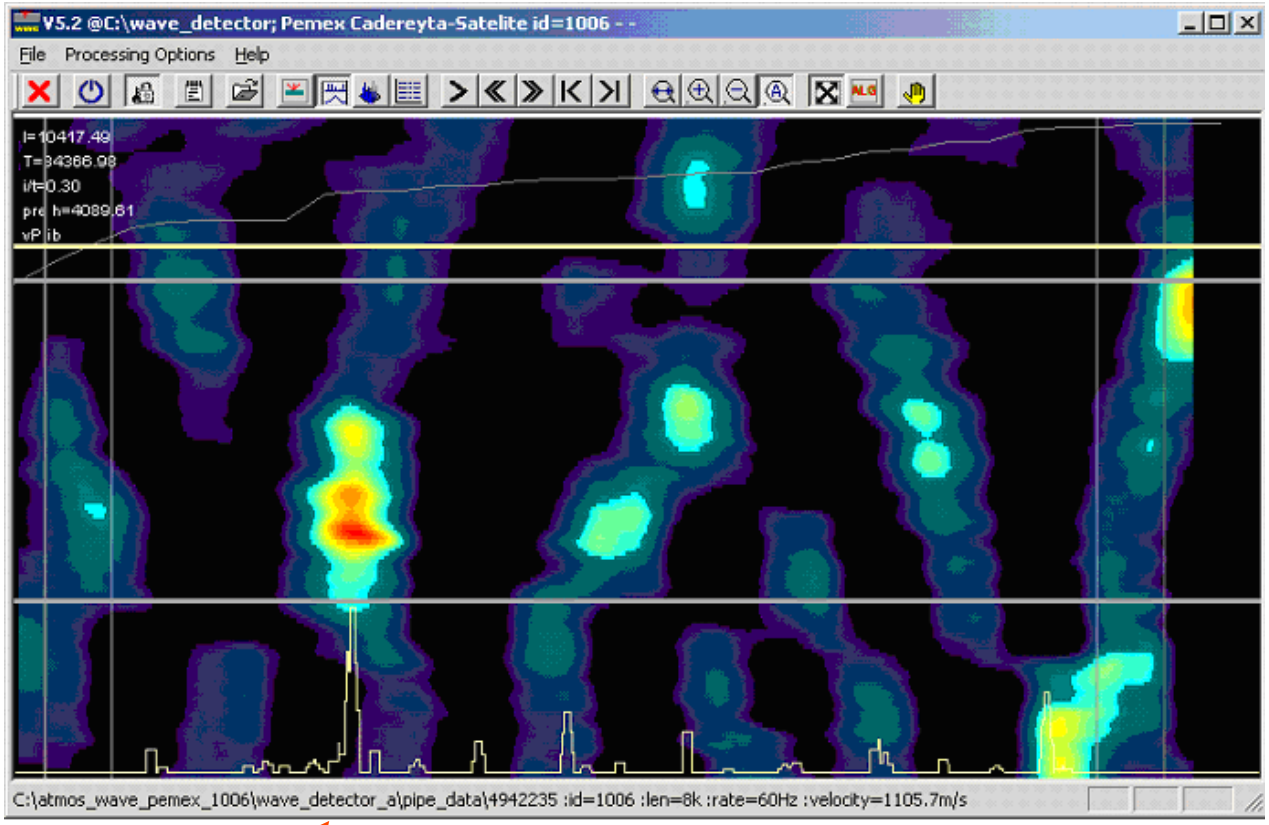
Atmos Wave can detect very low level leaks that may not alarm but are recorded for future analysis. The PLIB signature builds up. This PLIB signature is from customers “leak free” line.



PLIB signature at the bottom of the plot .

PLIB- Leak Free Line

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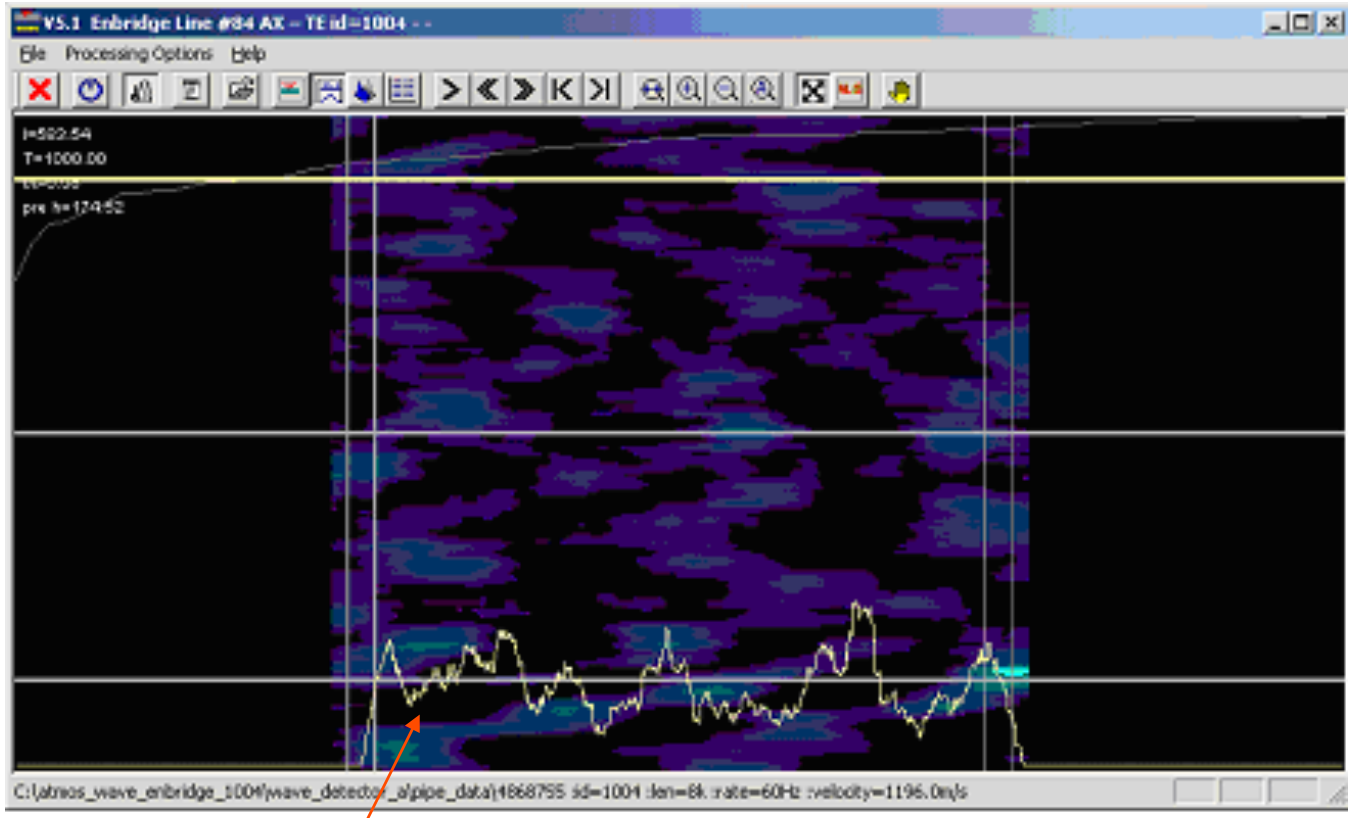
Lines that are leak free have a PLIB signature that is flat.



Neutral PLIB signature.

Water Leakage Problem “Plib at the Limit”

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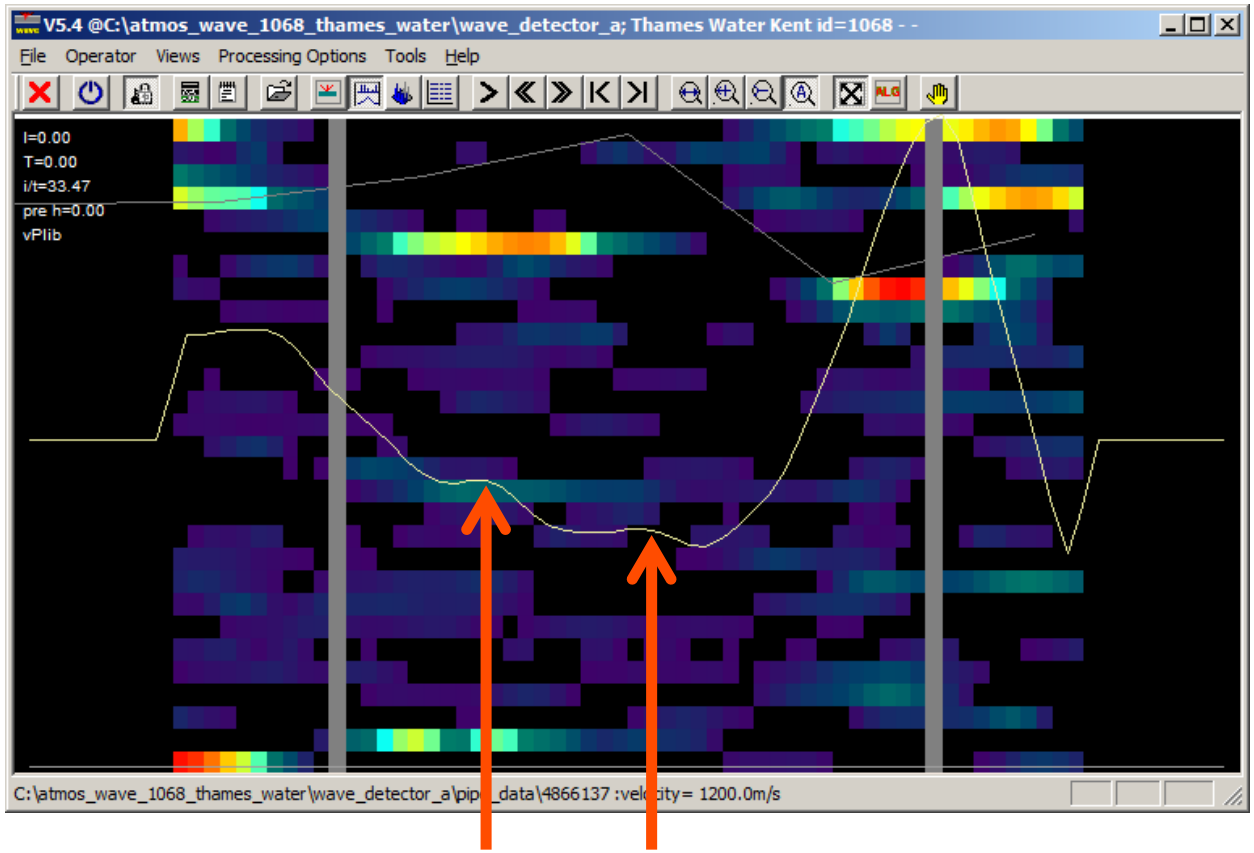
Shown here is a blind test on two existing pinhole leaks on a real water line. Plib correctly located both leaks at the limit of its current abilities.



The two leaks correctly located here in a blind test

Comparison with Competitive System

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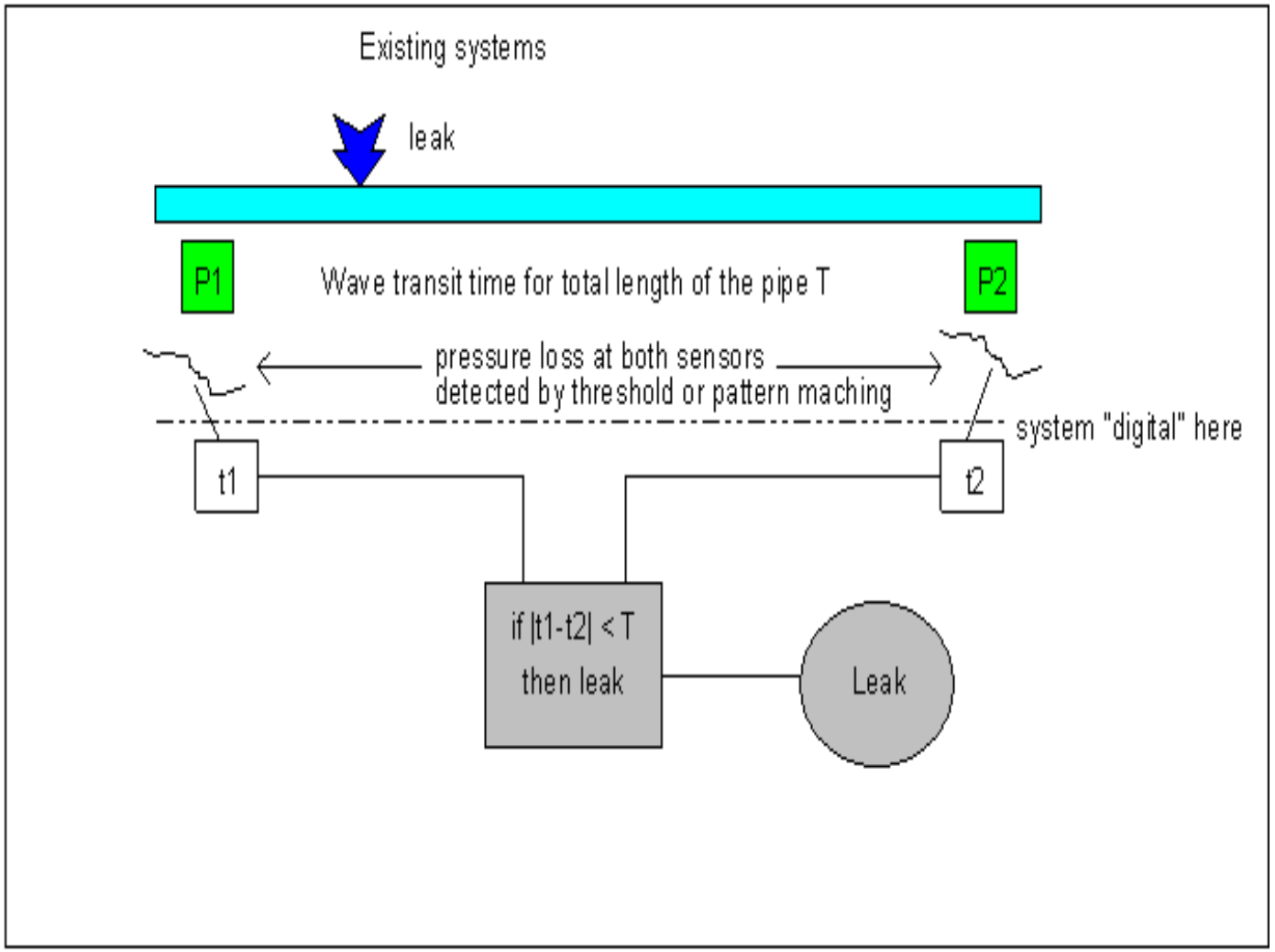

- **Digitized locally, thus analog data is lost**
- **Relies on historical leak profiles**

Conclusions

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A breakthrough in leak detection technology

- Use of standard pressure sensors
- Small leaks such as 1% can be detected within a few minutes
- Leaks down to 0.1% have been detected during shut-in
- Leaks can be detected under transient, steady-state and shut-in conditions
- Leaks above 1.6% are located within 1% of line length
- Low false alarm rate is achieved by tuning
- Works without flow meters

Huge potential for water industry as it works on all pipe materials: Lead, PVC, HDPE, MDPE, Cast Iron, Steel, Cement

Pipe - Wave

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	ATMOS Pipe	ATMOS Wave
Track Record	> 460 lines	Tens
Instruments	Flow, Pressure	Pressure, maybe others
Telemetry	Not dedicated	19,200 bit/s
Data Acquisition	Existing SCADA	AWAS Units
Distance Between Sensors	0 to 1000 KM	0 to 220 KM
Detection Time	1 min – 24 hrs	1 min – 11 min
Location Error	0 – 20%	0 – 1%
Application	Liquid, gas, chemical, hydrant pipelines	Liquid, gas, chemical pipelines

Which System Would You Buy?

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Thank you