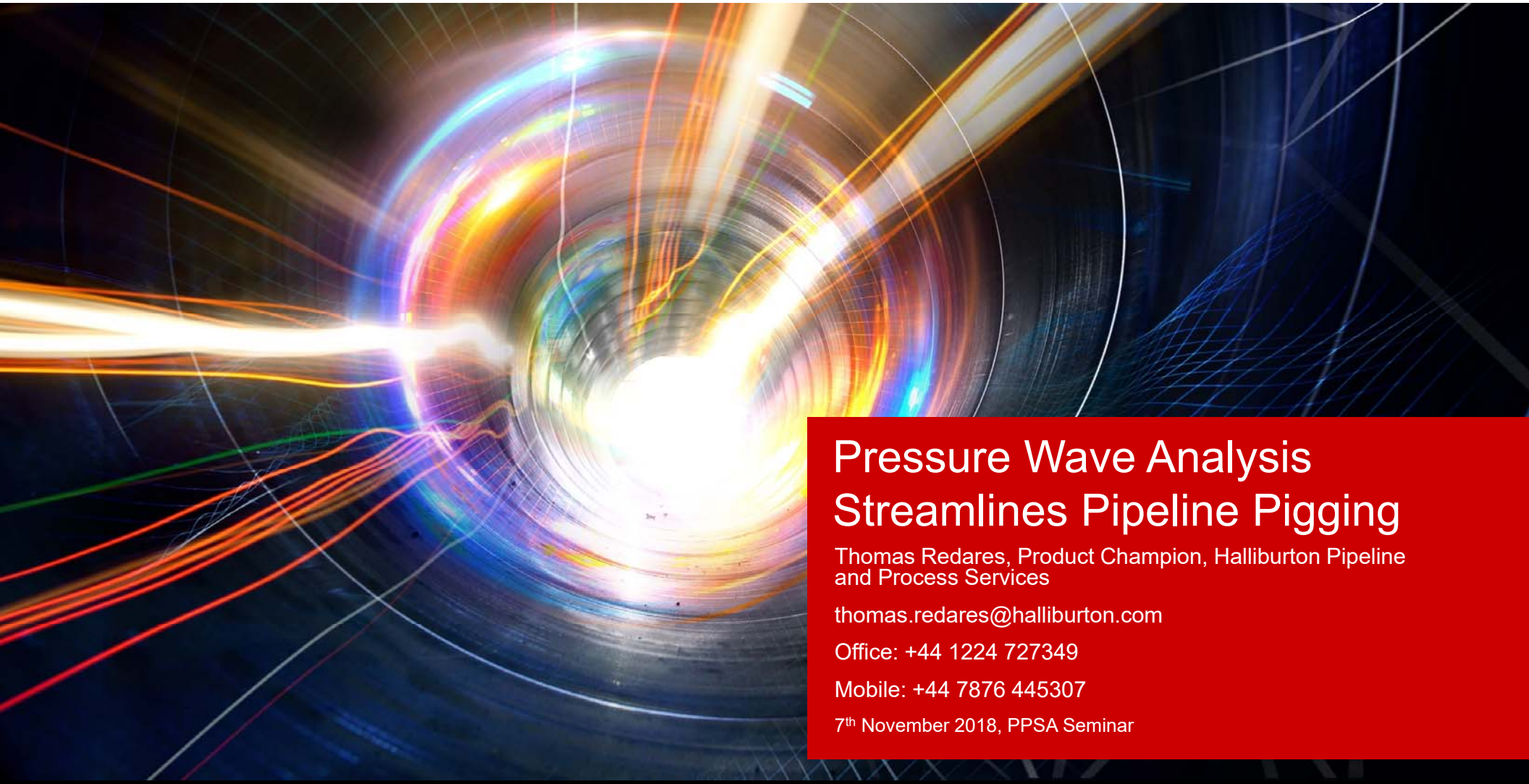

Pressure Wave Analysis Streamlines Pipeline Pigging

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Pipeline Operators Objectives and Challenges

- Achieving balance for peak returns
  - Maximise asset performance
  - Minimise maintenance cost
  - Minimise risk

- Debris can build-up overtime
  - Bore restriction impact business performance
  - Risk of full blockage if not managed properly

- Significant effort and resource by Operators into determining pipeline conditions and maintaining their assets

State of the Art Technologies Available for Deposit Assessment

- Accurate upfront diagnostics information required for:
  - Better planning
  - Reduce remediation time, cost and risk

Technologies	Advantages	Disadvantages
Pressure and flow monitoring	Minimal operational requirement	Only basic knowledge gained
Theoretical modelling	No operational requirement	Theoretical and relies on assumptions
Debris mapping pigs	Accurate	Access constrained Intrusive
Camera inspection	Visual and easily interpreted	Localised measurement Intrusive
External scanning	Accurate Non-intrusive	Localised measurement Time consuming for long system Access constrained

Halliburton solution: Pressure Wave

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Pressure Wave Analysis Overview

- A pressure wave (the pulse) is created at one end of the pipe.
- This wave travels in the pipe at the speed of sound while returning a reflected signature wave corresponding to features in the pipe:
  - Barriers to flow partial or complete
  - Changes in medium (phase, density)
  - Leaks
- Blockages position, deposit profile, and leaks are then estimated by analysis of the signal response

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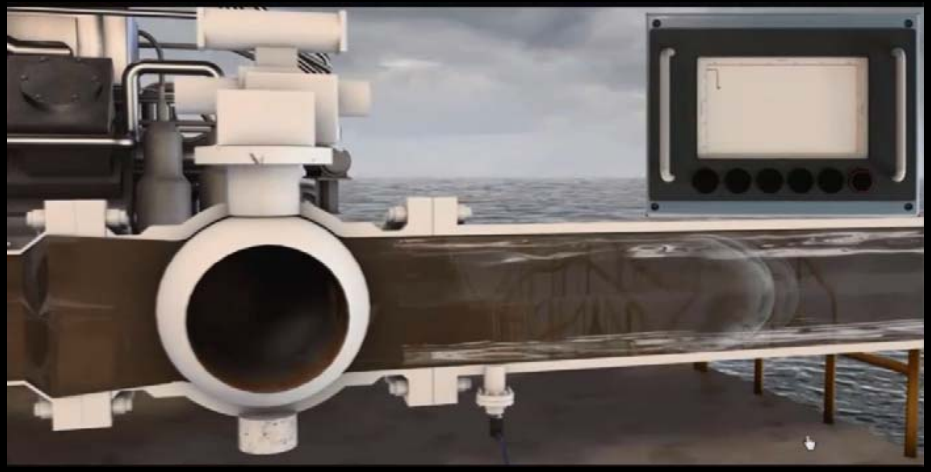
Data Collection

- Single person operation
- Minimal equipment
- Simple setup
- Non-intrusive
- Fast execution



- Engineer / model
- Induce pulse
- Record reflections
- Repeatable survey
- Transmit data
- Perform analysis
- Report findings

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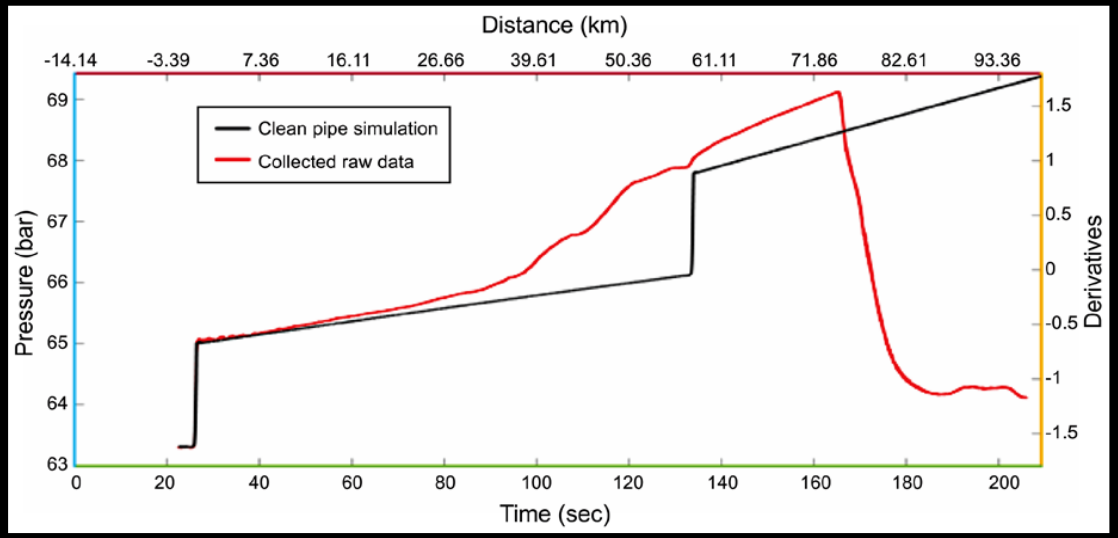
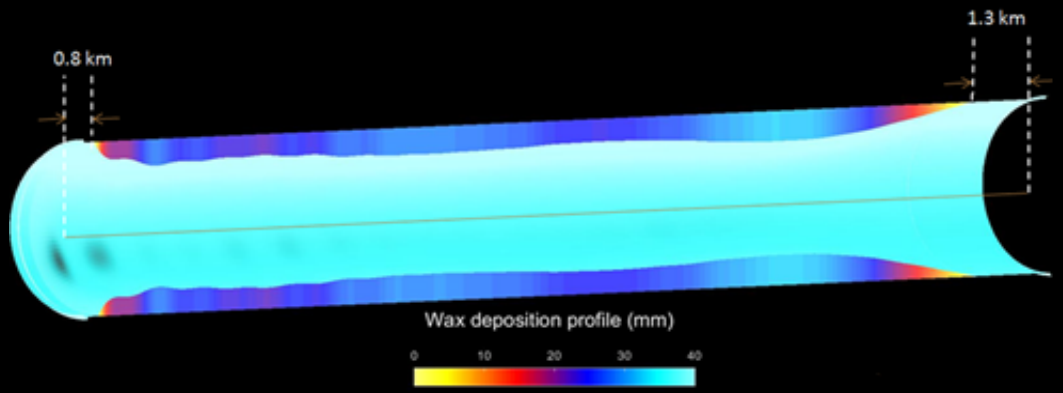
Analysis and Results

- Determine fluid properties and pulse velocity profiles
- Apply pressure and temperature gradients
- Normalise datasets
- Simulate clean pipeline
- Apply proprietary algorithms
- Extrapolate deposit profile
- Issue detailed results





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Application During Planning

- Significant effort necessary to plan cleaning
- Planning performed for worst-case scenario:
  - Theoretical understanding of pipeline condition
  - Risk / fear of blockage
  - Unnecessary resources
  - Large number of pig types and quantity
- Clear information about the pipeline condition allows:
  - Assessing piggability
  - Better planning pigging program
  - Determining chemical treatment requirements
  - Identifying debris handling needs

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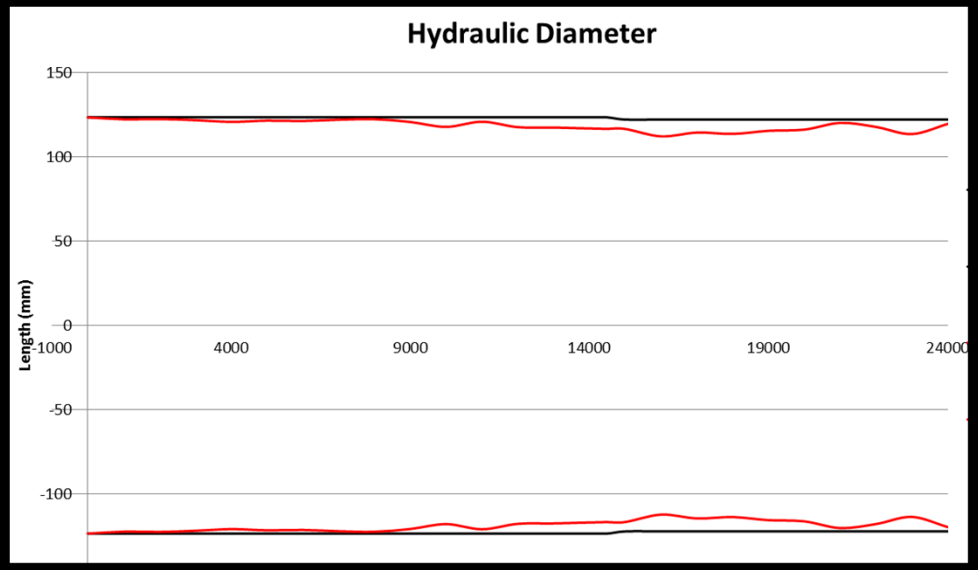
Case study 1

- 10” x 23.5 km condensate export pipeline
- Production started in 1997, no pigging maintenance since first oil
- ILI required by Authority to prepare end-of-life

➔How would you prepare the pipeline for running an ILI?

- Pressure Wave Analysis
- Minimum effort required to clean the line
- Successful ILI and conclusive data



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Application During Operations

- Conservative approach often considered
  - Reduce flowrate to adjust pig speed
  - Operation team fully focused on pigging
- Monitoring methods are flawed:
  - Rely on Subject Matter Expert
  - Pig condition assessment is subjective
  - Received volume of debris can be washed away by the pipeline flow or during pig trap flushing before opening
- Pressure Wave analysis allows:
  - Non-subjective decision criteria
  - Measurement of remaining debris in actual pipeline
  - Clear and fast decisions on effectiveness of the pigging program

Survey Allows Optimisation of Pigging Campaign

Pigging programs can be optimised

- Understanding of starting pipeline conditions may remove the need for undersized / non-aggressive pigs.
- No requirement for debris assessment caliper tool
- Potential significant reduction in the number of cleaning pigs necessary

Additionally:

- Ensures cleaning has progressed to the level necessary to help prevent a failed ILI run.

Pig Type	Pig Description
1	Gel pig
2	80% ID Medium Density Foam Pig
3	80% ID High Density Foam Pig
4	100% ID Medium Density Foam Pig
5	Foam Caliper Tool
6	95% ID Bi-Directional Cleaning Pig
7	100% ID Bi-Directional Cleaning Pig
8	100% ID Bi-Directional Cleaning Pig c/w Wire Brush
9	100% ID Bi-Directional Gauge Pig
10	Inline Inspection Tool

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Case Study 2

- 20” x 25 km multiphase export pipeline
- Stuck pig 40 days after 1st oil!
- Progressive pigging campaign post stuck pig recovery, short time window available

➔How would you optimise the pigging campaign without compromising safety?

- Initial Pressure Wave Analysis during the planning stage
- 51 pigs and 18 types procured for the project
- Various deposit assessments during pigging campaign
- Line returned to full production with “only” 14 pig runs of 10 different types

Conclusions

Pressure wave analysis provides the following benefits:

- Surveys pipeline debris quickly and safely with a repeatable and verified high level of accuracy
- Allows detailed knowledge of pipeline conditions for planning purposes
- Helps reduce the risk of stuck pigs
- Tracks and optimises the campaign as it progresses and confirms efficiency of the cleaning methodology
- Saves time, resources, and helps lower costs throughout cleaning programs

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THANK YOU
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