Pipeline Innovation

HIGH-FIDELITY DISTRIBUTED SENSING

Intelligent Monitoring for Improved Pipeline Safety

Steven Koles – CEO

ACAMP Advanced Monitoring Seminar

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Company Overview

- Founded 2007, Calgary – to date invested > $15M in R&D
- World-class preventative leak detection and monitoring technology for wellbores and pipelines with Hifi's patented high fidelity / definition fiber optic sensing system (HDS™) and interpretation software
- SDTC grant (June 2014): part of $6M preventative pipeline leak detection development program
- 32 patents (6 issued), various trade secrets
- Strategic equity partners: Cenovus & Enbridge ~ 30%

- Downhole systems in over 1000 wellbores – Licence to service suppliers

- Technology and co-marketing relationship for control room software

Problem: The Need For Improved Safety

Monitoring linear assets such as pipelines is challenging

How can we ensure we don't miss critical events?

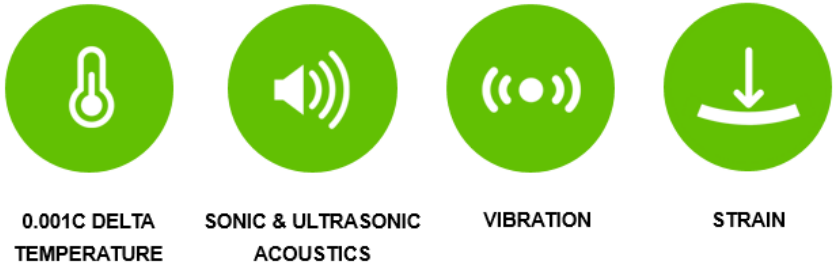
- Point sensors (mass balance sensors, microphones) may not have sufficient resolution and precision; they can also generate significant false alarms or not be able to determine where an incident has occurred
- Periodic surveys (manual inspections, drones, helicopters, pigs) may not be deployed at the right time
- The only way to be 100% sure is to have 100% coverage: **EVERY METER, 24/7/365**

How can the industry achieve this?

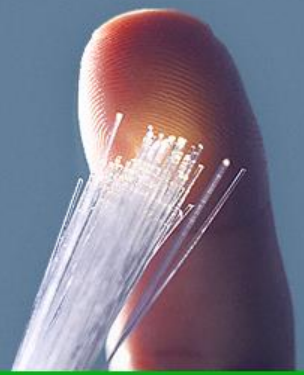
Solution: Fiber Optics For Distributed Sensing

FIBER OPTICS & HIGH FIDELITY DISTRIBUTED SENSING

- Originally designed for transporting telecom data, next generation fiber optics can also be used as a sensor
- The entire system can be specifically designed and optimized for sensing in extremely **high fidelity**
- Every centimeter of the fiber is sensitive, can span over kilometers of long distance, and is sensing real time / all the time, at the speed of light



100% COVERAGE **7/24/365** **BOTH SPACE & TIME**

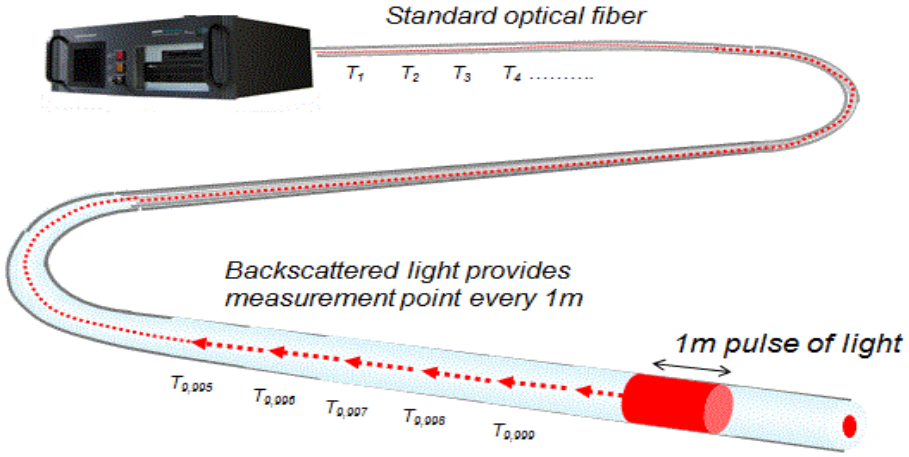


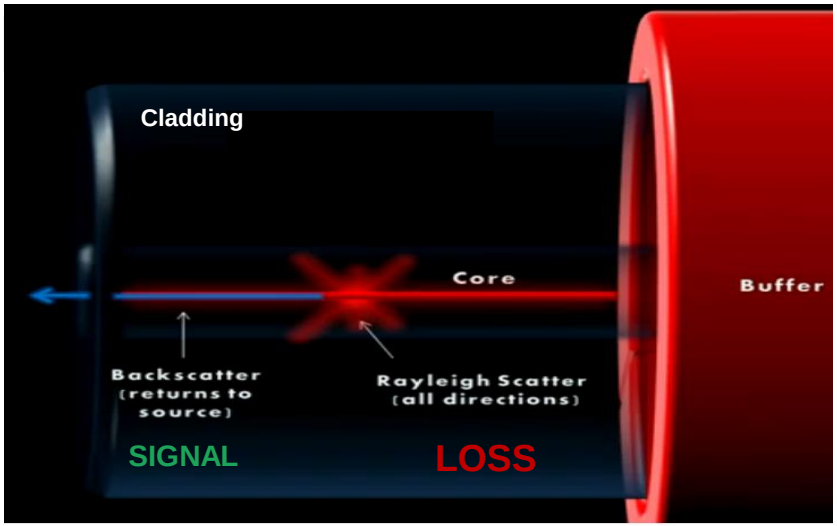
Analogy: High Fidelity Sensing For Humans

- Fidelity: Ability to accurately sense and understand surroundings, with little or no distortion
- Humans understand sensor system fidelity very well: senses + nervous system + brain
- How well we handle this = understand past, present, future = intelligence
- Fidelity is very important to us; as is data integration
- When we lose ability to understand our surroundings we come to a grinding halt (fog glasses, hearing impairment, etc.)
- We do everything we can to optimize, maintain, restore

High Fidelity Sensing For Pipelines Assets Is The Same!

Previous Generation Fiber Optic Sensing





- DTS, DAS, DSS Around 15 years – not integrated
- 'Packets' of light launched down fiber. Impurities in the glass cause some of that packet of light to reflect back to the box, carrying the data it sensed at that particular meter.
- Environment Influences backscatter
- Built on telecom diagnostic technology – simple – but not designed to be a sensor
- Simplicity comes with a consequence -– **LOW DATA FIDELITY**
- Impurities provide sensitivity, AND loss, therefore is inherently flawed as acoustic sensor
- Severe signal instability
- Need significant continuous/repeated LOUD vibration to get strong signals
- Low fidelity systems prone to false positives, missed leaks, errors

Next Gen Fiber Optics – A Solution to Improve Fidelity

- Hifi put backscatter telecom systems on hold due to lack of fidelity
- Complete redesigned (tip to tail) of the fiber optic sensing architecture
- Each element of the system specifically designed for SENSING
- ONE BOX, ONE FIBER: integrated acoustic + temperature + strain + vibration:

HDS™ HIGH-FIDELITY DYNAMIC SENSING

- Costs similar to DTS, DAS, DSS but with significantly higher fidelity (multiple orders of magnitude increase in SNR) and much longer distances

Can we prove this?

Side by Side Test – Temperature Fidelity

- Telecom fibers interleaved with HDS sensing fiber
- 25 wraps of both, evenly spaced, spooled around 10” mandrel
- Both systems experience exact same input, exact same time
- Real time raw data - No signal conditioning
- Relative fidelity comparison test – not accurately calibrated

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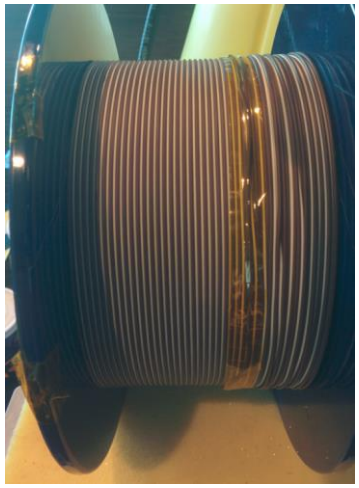
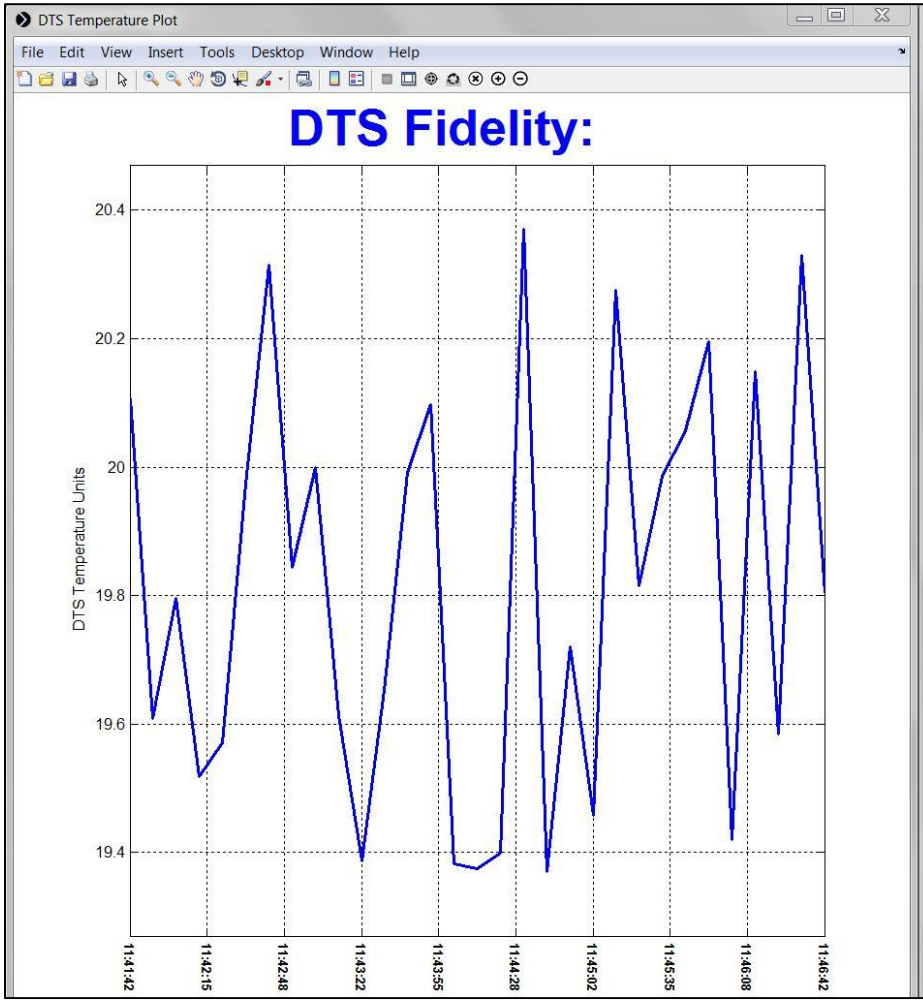
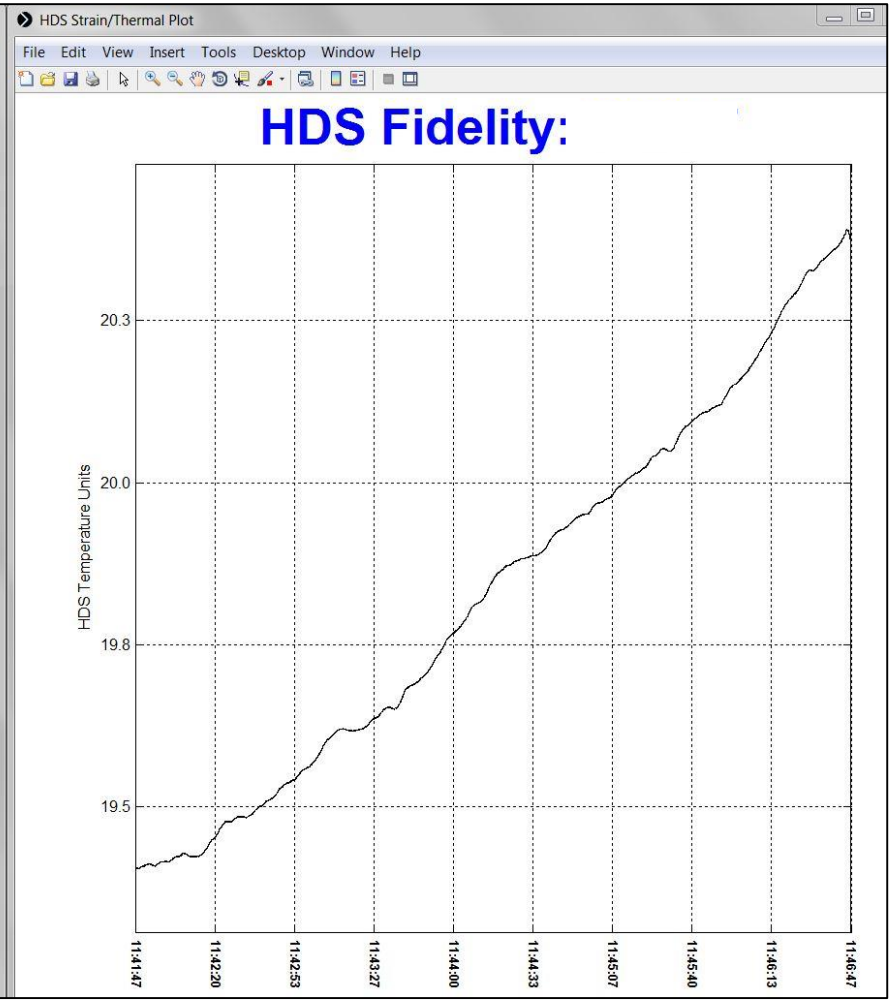
- **Temperature Test Example – Raman DTS vs HDS**
  - Eyedropper 3-10mL each (hot – hot – cold – cold)
  - Blast of compressed air (2 second blast)

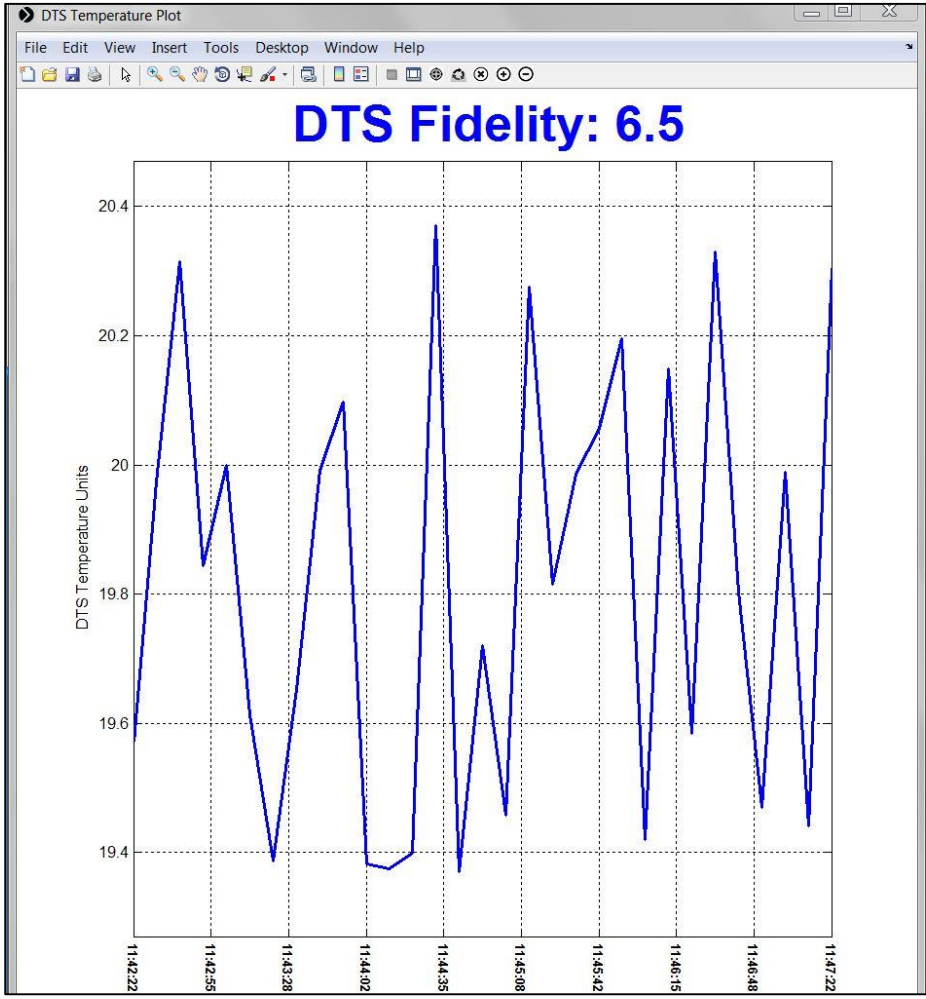


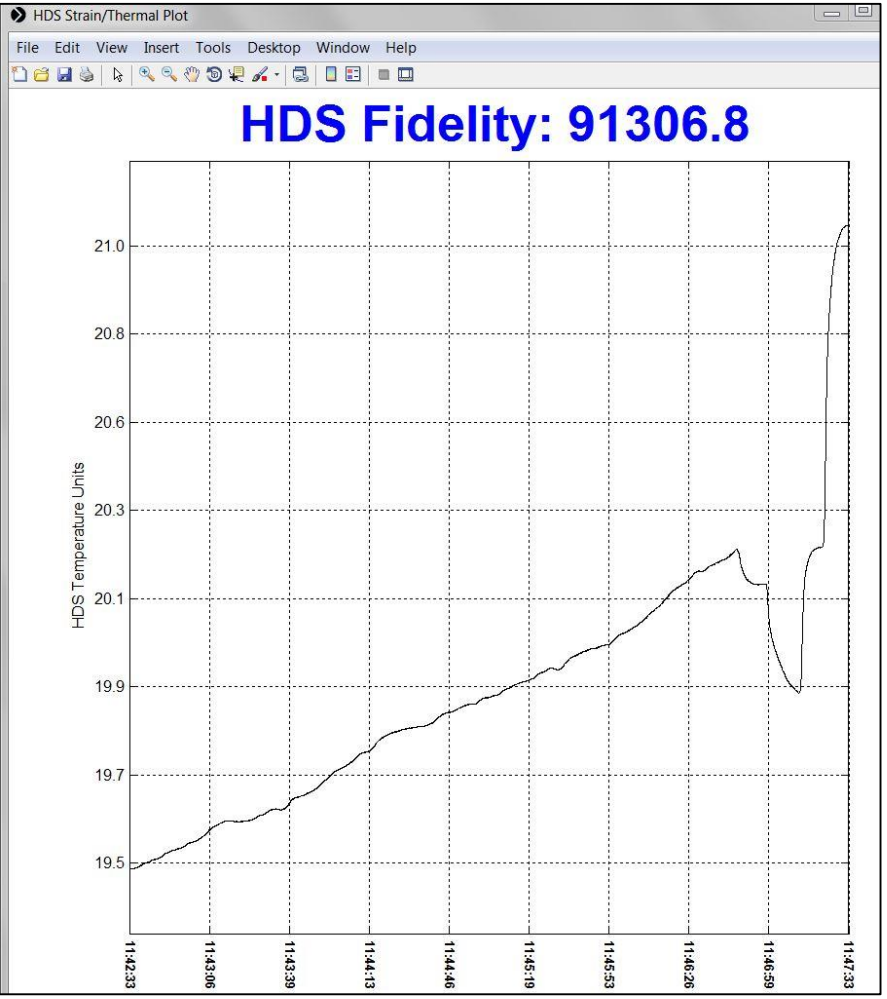
5 Minute Real Time – Ambient Temperature



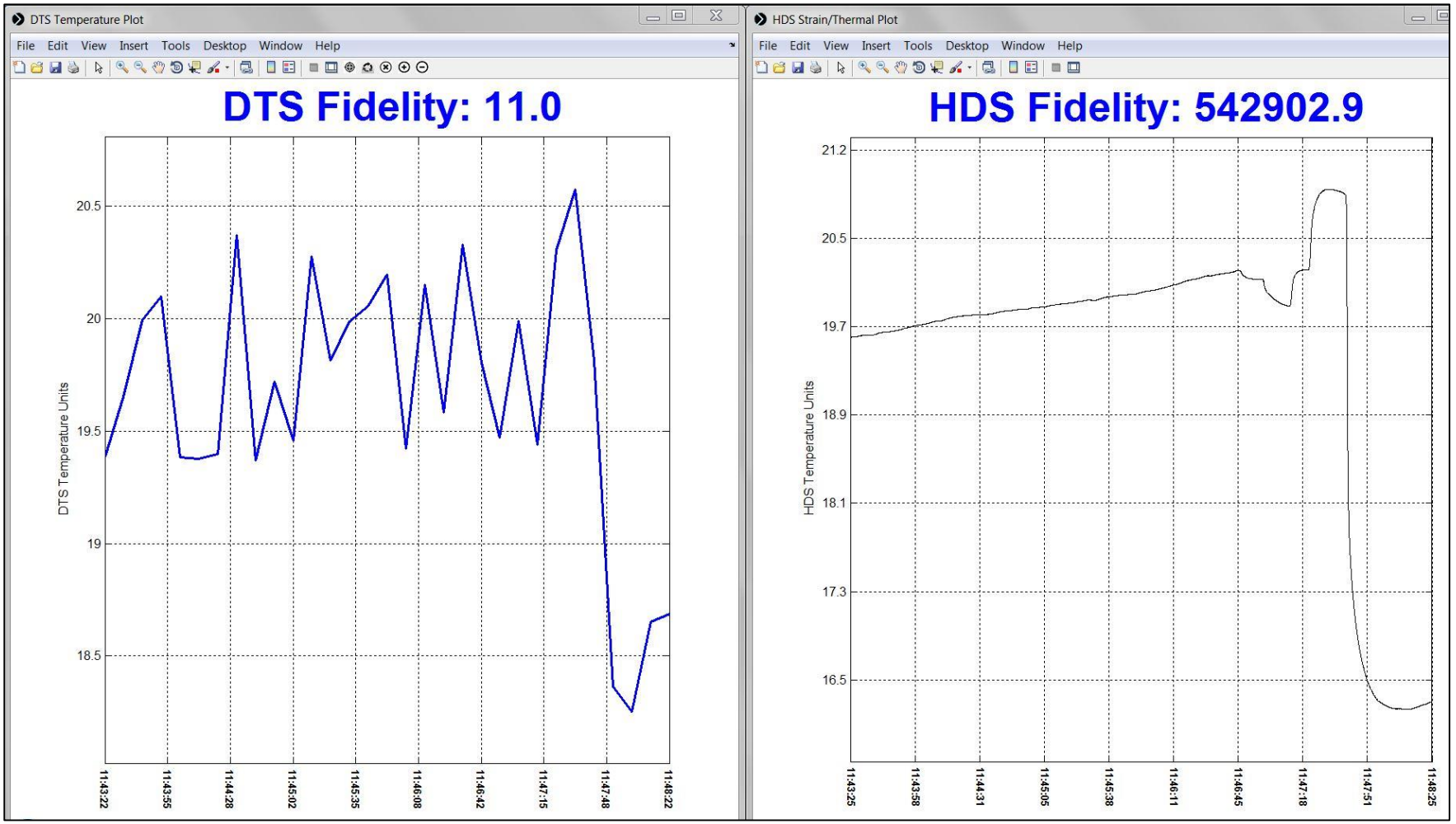


Temperature Test – 2 Drops Cold Water / 2 Drops Hot



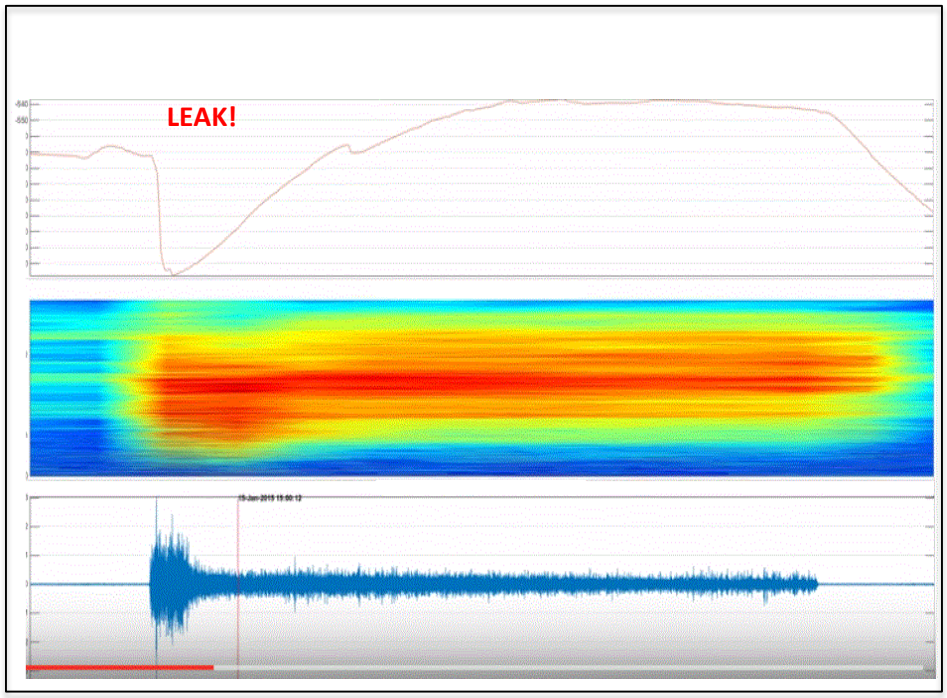


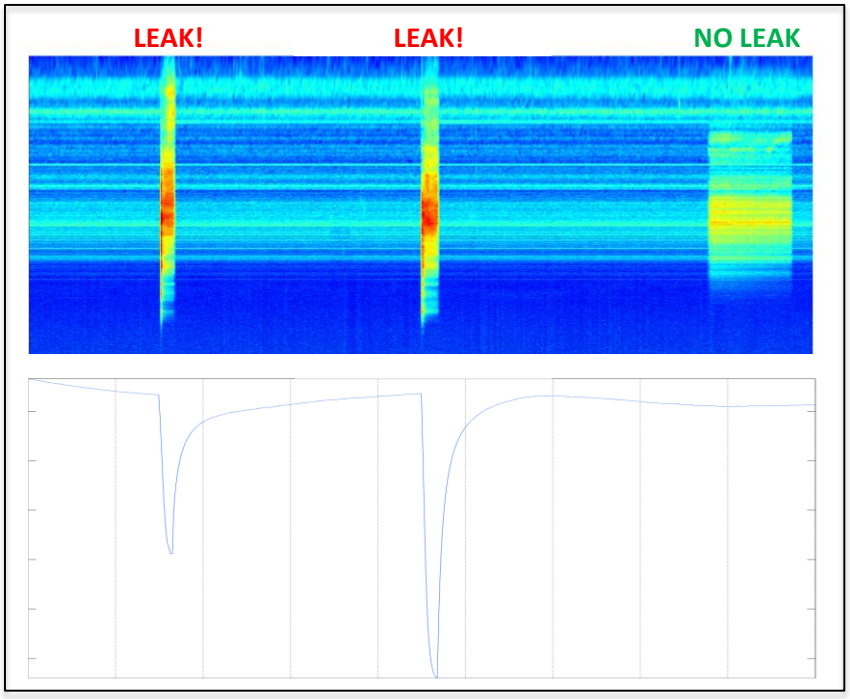
Compressed Air Test – JT Cooling Effect



So What, And What About False Positives?

Using high fidelity strain, temperature, acoustics to locate pinhole leaks





Relying on one variable alone (i.e. acoustics) might cause a mistake

Information Management Challenges

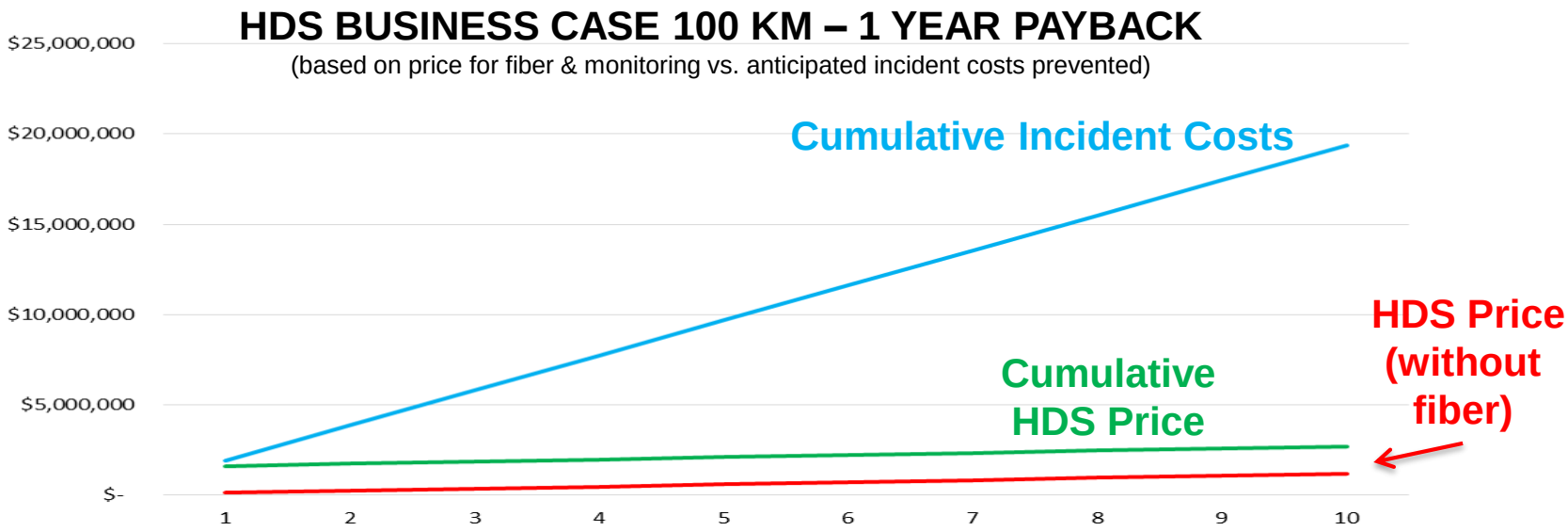
- Integrity management data is intensive - over 10 TB per day
- Small % of potentially useful data is tagged, less analyzed
- Data sets are continually changing
- Learning and experience is always advancing
- Intelligence builds from experience - need to understand past, monitor the present, in order to predict the future
- FEAR OF WHAT TO DO WITH THIS? HOW TO MANAGE?

FUTURE PROOF SOFTWARE ANALYTICS – GE PREDIX

- Simple and intuitive platform
- Industrial based with global scale (industrial Internet)
- Capable for extensive data fusion and big data management (supports the GE Intelligent Pipeline Solution – IPS)
- Predictive, adaptable and real time
- Open ecosystem
- Improved response time
- Reduced false positives

Business Case

- **Value proposition: Operator payback due to incident prevention - less than one year for a 100KM pipeline**
  - Regulatory statistics well documented on average number of annual pipeline incidents per thousand KM as well as direct $'s (including average leak sizes, remediation costs, regulatory penalties, profit forgone from operational downtime)
  - No soft costs included such as PR or social license
  - Additional value to be applied in "flow dynamics" in providing operators more data to increase efficiencies



New Measurements, New Opportunities

Pipeline

- Pin hole leak detection
- Leak Prevention – strain hot spots
- Pipe motion due to soil erosion or compaction
- Pig monitoring
- Detection and remediation of flow restrictions (wax)
- Internal Pipeline Surveys
- Intrusion 3rd party
- Pipeline strikes
- Pump monitoring
- Machinery analysis
- Flow estimations
- Seismic surges
- Heavy equipment roll over
- Hydrate blockage formation

Wellbore

- Leak detection / location using transient analysis
- Ultrasonic Measurements
- Gas lift optimization
- High Temp SAGD Injection / Production profile estimates
- Seismic VSP
- Well integrity management programs
- ESP monitoring

Summary: High Fidelity Sensing For 100% Pipeline Safety

- **Best In Class Sensing**
  - Optimized / next generation fiber optic sensing technology
  - Provides full coverage in space (fully distributed) and time (24/7 real time)
  - Immediate detection of acoustics, vibration, strain, isolated thermal events, and leaks in high fidelity

- **100% Alarm Accuracy**
  - Alarm / event ID with integrated variable analysis
  - Solution is both Preventative & Reactive
  - No false alarms with automated reporting and system verification

- **Hassle Free Service**
  - Turnkey deployment and operation
  - Multiple deployment methods
  - 7x24 system monitoring and support

- **Responsible Investment & Attractive Payback**
  - Less than 1 year payback for a 100KM pipeline
  - Future proofed with GE Predix to support future applications
  - Improved environmental & regulatory compliance
  - Improved insurability & stakeholder relations

SEE VIDEO DEMO – www.hifieng.com/technology

Thank You