World Class Pipeline Monitoring
HIFI COMPANY BACKGROUND

• Founded 2007, Calgary, Alberta, Canada
• High end electrical and software engineers, with significant energy experience.
• We develop turn key distributed fiber optic sensing systems sensors, hardware & interpretation software
• System agnostic:
  – Use best in class components, test, compare, open and non-exclusive
  – Build, re-design, modify, develop own in house tech, 43 patents
• This structure allows us to focus on key goal - **high quality data**
• Strategic investors – focus is downhole and pipeline safety

• Downhole systems in over 1000 wellbores
  – Licence to service suppliers
• Technology and co-marketing relationship for control room software
The industry needs more advanced & intelligent sensors

- Point sensors (mass balance sensors, microphones) may not have sufficient resolution and precision
- Periodic surveys (manual inspections, drones, helicopters, smart-balls) may not be deployed at the right time
- There will always be doubt across “space and time” unless we can achieve 100% coverage

How can we achieve 100% coverage and get 100% assurance?
FIBER OPTICS AS INTELLIGENT SENSOR

CONTINUOUS - EVERY CENTIMETER is sensitive with high DYNAMIC RANGE

- 0.001°C DELTA TEMPERATURE
- SONIC & ULTRASONIC ACOUSTICS
- VIBRATION
- STRAIN

100% COVERAGE  24/7/365  COST EFFECTIVE
• DTS, DAS, DSS Around 15 years – not integrated

• Impurities in the glass cause light to reflect, carrying the data it sensed at that particular meter

• Environment Influences backscatter and severe signal instability

• 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

• Need significant continuous/repeated LOUD vibration to get strong signals

• Low fidelity systems prone to false positives, missed leaks, errors
ANALOG: 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)
- We do everything we can to optimize, maintain, restore

High Fidelity Sensing For Pipelines Assets Is The Same!
BEST IN CLASS SENSING

• Hifi ceased telecom fiber based system development due to lack of fidelity
• Fundamental redesign of sensors, interrogators, and software now optimized for high fidelity; integrated operation hassle free for customers
• Each element of the system specifically designed for sensing, not telecom
• ONE BOX, ONE FIBER: integrated acoustic + temperature + strain/vibration

• Costs similar to DTS, DAS, DSS but with significantly higher fidelity (multiple orders of magnitude increase in sensitivity) and effective over much longer distances representing a responsible investment with an attractive payback
• Higher sensitivity eliminates false positives, which supports 100% alarm accuracy and more intelligent decision making ultimately to support PREVENTATIVE PIPELINE LEAK DETECTION
BEST IN CLASS SENSING

Fiber Bragg Gratings as a Reflector

Multiple Measurements = High Confidence
EXTERNAL / ON PIPE DEPLOYMENT
• Strap fiber sensor in electrical conduit directly on the pipe
• Fiber jetted in after construction or preloaded in advance
• Applicable for new construction
• Best / cheapest for new construction (< 1% of new pipeline cost)

EXTERNAL / NEAR PIPE DEPLOYMENT
• Place fiber sensor in electrical conduit close to pipe (12”)
• Fiber jetted in after construction or preloaded in advance
• Applicable for new construction or existing pipelines
• Best / cheapest for new construction (< 1% of new pipeline cost)
• Can be used for horizontal boring / directional drilling and micro trenching

INTERNAL DEPLOYMENT
• Place protected fiber sensor (stainless steel cap tube) inside pipe
• Very similar to downhole wellbore applications
• Very cost effective for existing pipelines
• Can be retractable in high consequence areas (short KM’s)
• Testing ability to co-exist with pigging
SYSTEM DEPLOYMENT

Near Pipe Deployment

Hifi Sensing Fiber
(in electrical conduit near the pipe)

Junction Boxes (every 2KM)

In Situ Verification System
(for event simulations: thermal, acoustic, strain, leak)

Hifi HDS System Enclosure
(includes optical HW, computing resources, SW algorithms, HVAC controls, etc.)

Pipeline (Buried)
EXTERNAL DEPLOYMENT

On pipe and near pipe external deployment in multi-microduct electrical conduit
EXTERNAL DEPLOYMENT
HORIZONatal DRILL (HDD / HDB) DEPLOYMENT

Hifi sensing fiber in ¼” cap tube strapped to composite pipe & Hifi sensing fiber in electrical conduit attached to HDD pull head
HDS FIDELITY COMPARISON TO DTS
SIDE BY SIDE TESTING

- 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 #1 – Raman DTS vs HDS**
  - Eyedropper 3-10mL each (hot – hot – cold – cold)
  - Blast of compressed air (2 second blast)
  - 10 second update, 2 meter

- **Acoustic Test #2 – Rayleigh DAS vs. HDS**
  - Water bath – acoustic ping
  - 10m spatial on both
5 MINUTE REAL TIME – AMBIENT TEMPERATURE

DTS Fidelity: 6.5

HDS Fidelity: 6921.7
TEMP TEST – 2 DROPS COLD WATER / 2 DROPS HOT

DTS Fidelity: 6.5

HDS Fidelity: 91306.8
EXAMPLE – ABNORMAL STRAIN

Vehicle Traffic On Roadway Above Buried Pipeline
EXAMPLE – SECURITY INTRUSION DETECTION
EXAMPLE – DISTANT EARTHQUAKE MONITORING

Earthquake detected with an intensity rating of 3.0 at a distance from the epicenter of over 300KM where in the intensity rating was 5.2.

*information from https://earthquake.usgs.gov/earthquakes/eventpage/us10009757#shakemap
EXAMPLE – PIG TRACKING

• Interpretation of vibration spikes
  – A pig causes vibrations when it goes through a pipe weld
  – The vibrations travel along the pipe
  – For this pipeline, there are welds at every 60ft
  – Based on the line flow rate, the estimated velocity is 0.25m/s
  – Estimated time between groups of spikes is approximately 53 seconds

• Each peak in the lower plot to correspond to pig cups

• Pig tracked 15KM away!
EXAMPLE – FLOW MONITORING

Start of flow

- Correlation between fiber and production data
- Main correlation features:
  - Flow start/stop
  - Changes in flow rate due to pressure/set point changes
- Fiber distance from pipe is 12 inches
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
- Offshore / near shore pipelines

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

Other
- Offshore riser management
- Railway monitoring
- Slope monitoring (Mining)
- Infrastructure monitoring (bridge decks, other structures)
- Turbine monitoring
The HDS system has been deployed by Husky Midstream, and is currently on a number of shorter pipeline segments in high consequence areas as well as a new longer distance pipeline build in excess of 150KM. **Hifi HDS will be the design standard for new Husky Midstream large diameter pipeline projects**

- **Husky MidStream**

  “We believe that Hifi has the potential to help the energy industry’s future and our goal of 100% safety”

- **Enbridge**

  “We look forward to seeing how Hifi’s unique sensing technology performs in real time as we continue to evaluate how it can be deployed most effectively on our pipeline systems in the future.”

- **TransCanada**

  “In 2016, Plains collaborated with Hifi to deploy their fiber optic based, high fidelity distributed sensing (HDS™) monitoring system at multiple pipeline locations, allowing us to determine potential issues on the pipeline with improved accuracy. Plains has been very pleased with the performance of the Hifi HDS systems deployed”.

- **Plains MidStream Canada**
HIFI IN THE NEWS

- **Hifi Engineering Announces New HDS™ Technology Platform And Deployments With Husky Midstream** (Jan 2018)
- **Hifi, Plains MidStream, BHGE Announce Vigilant Control Room Software** (Nov 2017)
- **New Technology to Enhance Pipeline Safety** (Sept 2017)
  - ASBIRI initiative announced by Alberta Innovates, Enbridge, TransCanada, and Hifi
- **Hifi Hosts Catherine McKenna, Canada’s Environment Minister** (Aug 2017)
  - “This Canadian company has some amazing pipeline leak detection technology!”
- **Hifi named one of the Top 20 Most Promising Oil & Gas Technology Solution Providers** (Aug 2017)
- **Hifi profiled in Plains MidStream Canada annual stakeholder report** (Apr 2017)
- **Hifi announces 100% Accuracy In Pipeline Leak Detection Performance Testing** (Feb 2017)
  - “HiFi Engineering's technology is proof of the importance of investing in energy innovation”, said Navdeep Bains, Minister of Innovation, Science and Economic Development.
- **Hifi mentioned in Globe & Mail Article** (Nov 2016)
- **Alberta Energy Minister Visits Hifi** (July 2016)
  - “I am encouraged to see a “Made In Alberta” technology aimed at achieving 100% safety in the pipeline industry.”
- **Hifi mentioned in GE Reports Article** (July 2016)
  - “Could Pipeline Leaks Be A Thing Of The Past?”
- **Hifi named as SDTC Success Story** (June 2016)
- **Hifi mentioned in Alberta Oil Magazine** (Nov 2015)
  - “Building A Pipeline Monitoring System That Actually Works”
- **CEPA launches innovation video series** on Hifi and preventative pipeline leak detection technology (Sept 2015)
- **Hifi named as one of Alberta’s Most Innovation Organizations** by Alberta Venture (Aug 2015)
- **Hifi Launches HDS™ Pipeline Leak Detection Technology; Announces Project Investment With SDTC** (March 2015)
- **Hifi named one of Canada’s Top Energy Innovators** for 2015 by Alberta Oil (March 2015)
- **Hifi Engineering is Named in the 2014 Global Cleantech 100’s Ones to Watch** (Nov 2014)
- **Hifi Engineering closes $5.4 million in financing with Enbridge and Cenovus** (Feb 2014)
- **Hifi Engineering Named Winner In 2013 ASTECH Awards** (Oct 2013)
See video demo – [www.hifieng.com/technology](http://www.hifieng.com/technology)

Contact us at [info@hifieng.com](mailto:info@hifieng.com)

Thank You