Agenda

- Company Intro
- Thinking behind smart utility
  - IoE digital technologies – big data
  - Technology Gap
- Discovery Project overview
- Smart Foam
- Test data & Failures
- Way forward
- Summary
We are a sensor technology company – pioneering the integration of advanced sensors into simple utility pigs - A sensors on everything approach.

Core skills are in electromagnetics and digital signal processing.

- **Academia**
  - University of Manchester
  - Heriot Watt University

- **Utility Pig Manufacturers**

- **Competitors**
  - UT
  - MFL

- **Digital IoE Technology**
  - Cisco
Why – Digital technologies & big data!

- Digital technologies have changed the way Oil & Gas industry operates
- There has been huge investment in the Digital Oilfield
  - Wireless communication – connecting people & processes
  - Big Data driving better analytics – breaking down silos - sharing intelligence - preventative maintenance
  - Improved safety & efficiency with significant cost savings in many sectors

- Data underpins everything
  - **Volume of Data**
    - More frequent inspections
  - **Variety of Data**
    - Not just pipe wall anymore
  - **Velocity of Data**
    - Quick reporting

- To date the pipeline sector has not been able to maximise the benefits of digital technologies and big data analytics
- Data collection & data sharing is a problem
Why - Technology Gap

**Utility pig**
- Simple & cheap
- Does not disrupt production
- Little risk in getting stuck
- Used frequently
- No specialist personnel
- No specialist launchers / receivers

**Inspection pig**
- Complex & Costly
- Disruptive to Ops
- Risk of getting stuck
- Pipeline needs cleaning
- Speeds need to be controlled
- Specialist personnel and launch / receive

2 main types

**Technology Gap**
- Intelligent Pigs are too complex, too disruptive and run infrequently – little data
- Labour intensive analysis
- A lot of pressure to achieve first run success due to disruption
- Ageing infrastructure needs increasing inspection frequency

Used frequently but NO DATA  2 extremes  Used 3-7yrs DATA is infrequent
Discovery Project Objective – Smart Utility

- Rather than develop a new tool but to embed sensors into existing design make existing utility tools smarter

- We want to turn ILI into a more frequent activity use conventional utility tools – that are accepted by industry - while significantly lowering costs
  - **Volume of data**

- Advanced sensors for internal corrosion & cracking as well as production environment (PVT profiles) and product composition (water content)
  - **Variety of data**

- Data to be analysed by software rather than personnel – data analysed within hours not weeks or months
  - **Velocity of data**

- Extra data can drive integrity management programs
  - **Better decision making – improved efficiency – significant cost saving**

- Electromagnetics is ideal for this application as the pipe does not need to be cleaned – no couplant needed for gas pipelines.
Discovery Smart Foam Pig

- Inpipe make 10,000 foam pigs per anum – imagine the data from all those
- Ensures the electronics pod always comes out the pipeline
- Perfect for multi diameter – complex geometry – dirty scaled pipeline
- Sensor head is a disposable unit
- Pressure vessel can be used different size sensor heads – big value
- Greatly reduces the operational concerns over pigs getting stuck
- Internal corrosion, cracking, PVT, debris mapping and water drop out
- Feature mapping means no odometer anymore
Simple is harder than complex

Steve Jobs

1st Generation

- Keeping the pressure vessel in situ
  - Internal pressure vessel blew out the front of the foam body
  - The surface area of the pressure vessel was larger than the foam area
  - Need for uniform drive of the pig
Simplicity is not so simple

2nd Generation

- Keeping the sensors in place
  - Water proofing
  - Integration into the foam during manufacture
Finally!

3rd Generation

- Pressure vessel stays in place
- Sensors are manufactured and integrated in a way that they are embedded into the foam
- Result is a more durable pig that collects reliable and uniform data
- It’s a new hybrid pig – PU disk in the nose!
- The internal Pressure vessel is bolted to pigging disks front and rear
- Acts as a mandrel pig but deforms like a foam pig
1km Test facility - Petrofac

Launcher / receiver

Permanently pressurised system
Overview - 1km of Data
Data – Feature mapping = no odometer

- Flange
- Weld
- Top bends at road crossing
- Bottom bends at road crossing
- Launcher
- B 1
- B 2
- W
- W
- W
- W
- W
- W
- W
- W
- Slight drift in the baseline caused by water ingress into the sensor belt

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Data – Uniform welds & flanges

Zoom into loop response. 10 inch Foam pig. Montrose.
The electromagnetic system used by i2i gives a better reflection on shallower but wider defects. No special conditions are needed for inspection.

- Max pressure is 250bar
- Max inspection speed is 5-8m/s
- Longitudinal separation is 45mm
Velocity of data – Cloud reporting

- PiPeception

Automated Data Analytics

Visualization & Reporting

Combine Inspection and routine maintenance

Pipeline Data

Preventative Maintenance

- Discovery pigs used with greater frequency
- No specialist personnel on site
- No disruption to Operations
- No cleaning required

- High inspection frequency means big data
- Internal corrosion & cracking and PVT
- Data on type and location of deposits
- Data on water extent & location

- Signal recognition software analyses the data
- Digital IoT technologies connect global infrastructure
- Risk based reporting - preventative maintenance
- Better integrity, safety and cost savings

Client assessment
Pipeception signal recognition

- Signals are very uniform and Repeatable
- Anomaly signals are reported In a table for further analysis
Variety of data – product composition

- Why? I2i sensors can give detailed data on the product within the pipeline. They know what type of fluid they are in!

- Impedance values tell you what the product is – % water

- Aim is to identify and locate the hydrate phase boundary within a pipeline in conjunction with providing the actual PVT profile of the pipeline

- Discovery Smart Pigs could detect
  - % of water in multiphase flow
  - Exact Pressure Temperature Velocity profile every 12m
  - Phase boundary of hydrates
  - Deliver inhibitors to the exact location of these phase boundaries

- Benefits
  - Improve or replace flow assurance modeling
  - Deliver localised chemical inhibition has significant cost & environmental benefits
  - Potentially more efficient to prevent hydrate formation
  - Having a mobile & retrofit solution may help older fields and better manage changing conditions
Way forward – Sensors on everything

- The same inspection capabilities as the foam pig but in a mandrel design
- Designed for longer inspection runs / more aggressive scale / wax
- Sensors are moulded into PU cups that can be attached to any size body
- Sensor arrays that are easily replaced if damaged / or worn
- Electronics and rechargeable power housed inside the mandrel body

Internal corrosion & cracking
Strain gauges for dents / debris / scale
Water in gas pipelines
Impedance values for product composition
Summary

- New Era of low oil prices means the Energy industry has to be creative and innovative and the pipeline industry is no exception.

- Simple operational tools – advanced sensors & new digital technologies, collect big data for preventative maintenance will improve efficiency and deliver cost savings.

- Discovery project had some early failures but now operationally sound.

- Smart Pigs offer significant advantages
  - Regular inspection with no down time to production
  - Anomalies can be monitored due to high frequency
  - No prior cleaning & no special launch / receive facilities
  - No speed restrictions, Min 1.5D bends, multidiameter (foam)
  - Image through wax / debris for internal corrosion & cracking
  - Integrate a number of tasks like cleaning and inspection into one
  - Significantly more data for analysis – predictive maintenance
    - Corrosion – Cracking - PVT – Debris – Dents
  - Data is reported within hours
  - Massive cost savings – expect 80% saving on current costs

Corrosion – Cracking – PVT – Debris – Dents

Massive cost savings – expect 80% saving on current costs