i2i PIPELINES
Simplifying Pipeline Inspection

Smart Utility



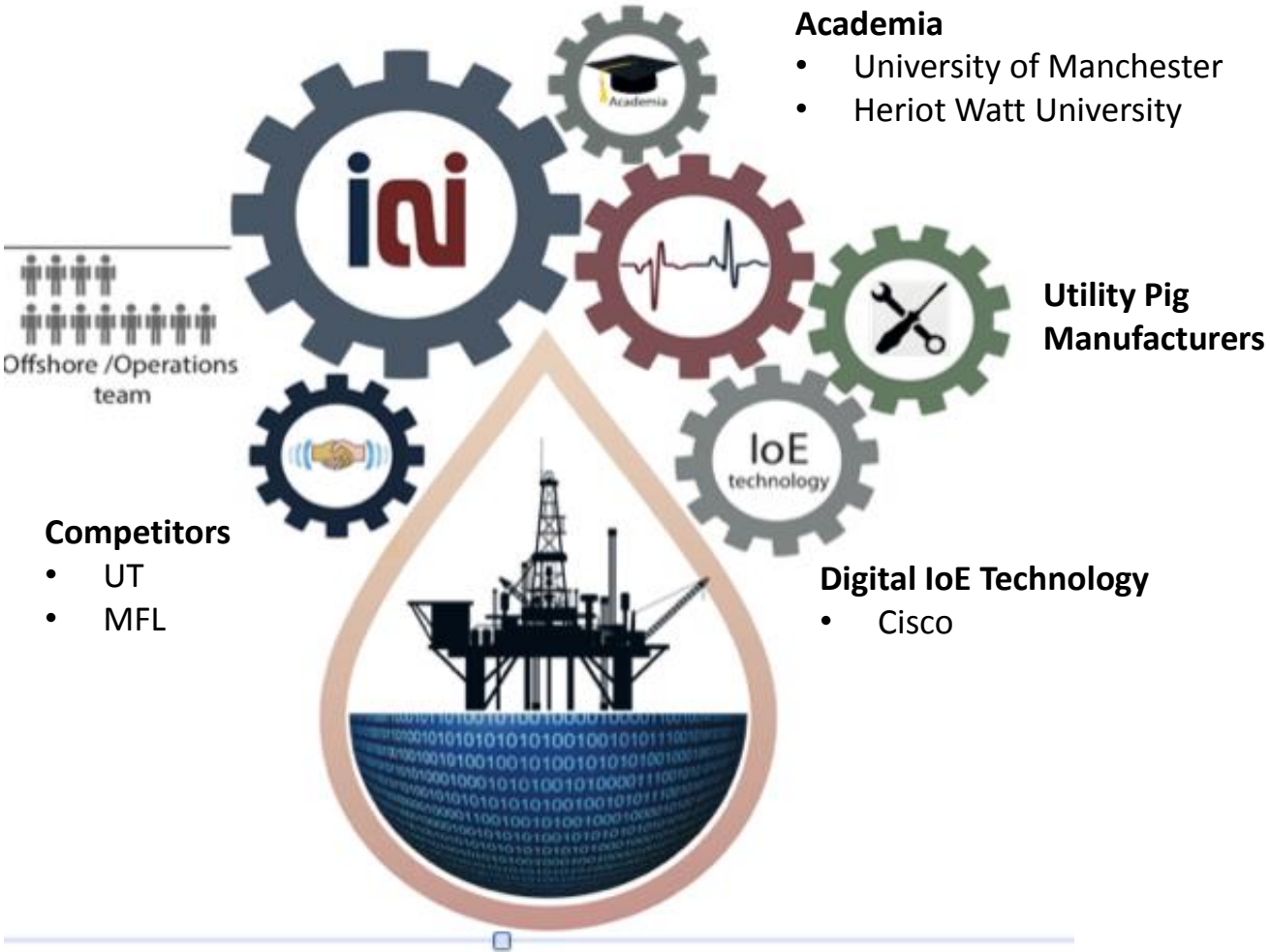
PPSA Seminar November ‘15

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

A Sensor Technology Company

- We are 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

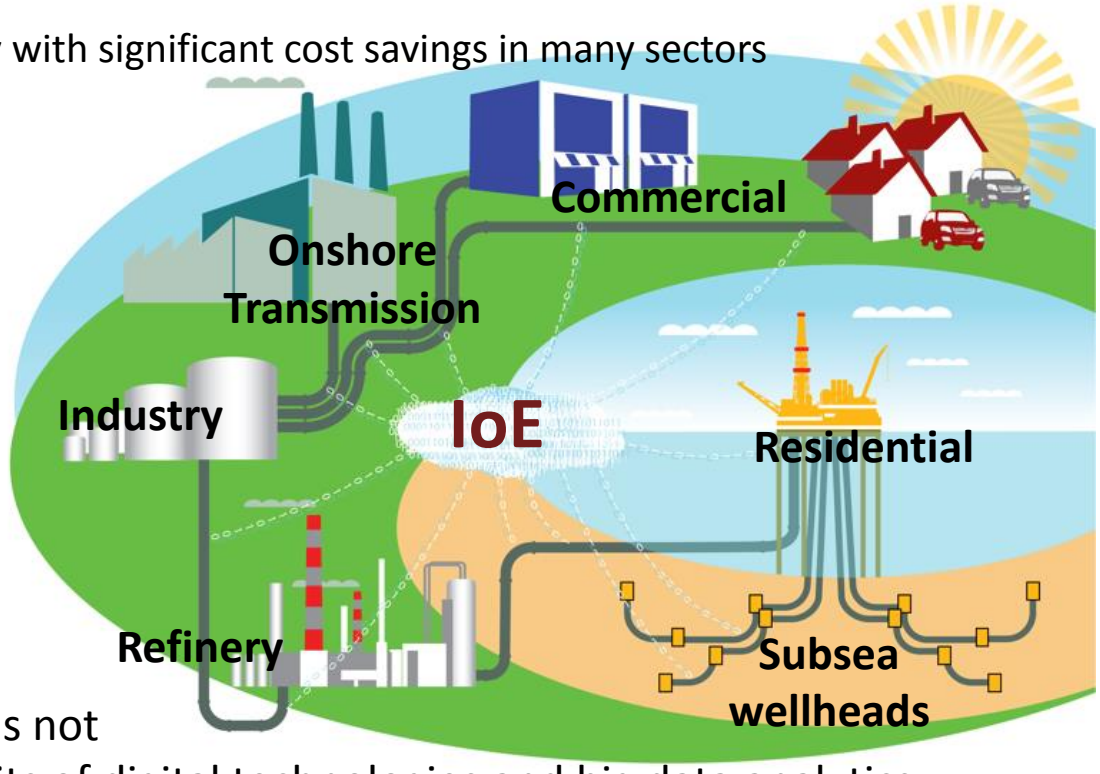
Competitors
- UT
- MFL

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

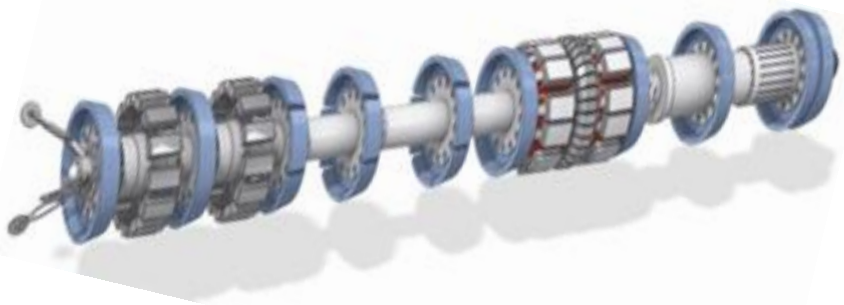
Why - Technology Gap

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

Used frequently but NO DATA ← 2 extremes → **Used 3-7yrs DATA is infrequent**

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

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**

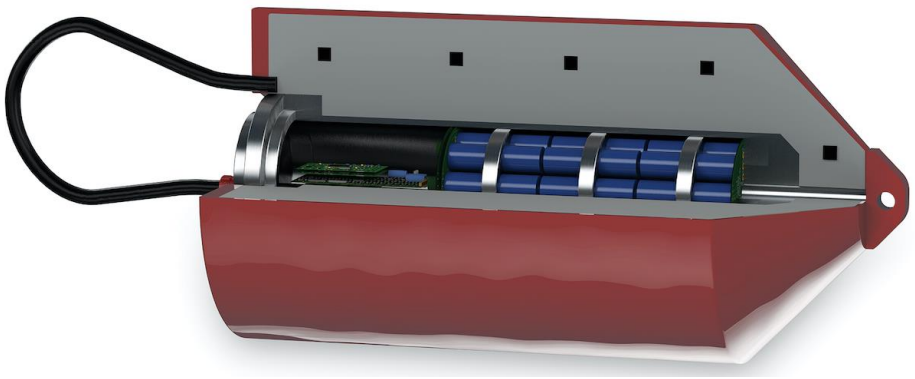
- Data to be analysed by software rather than personnel – data analysed within hours not weeks or months
  - **Velocity of data**

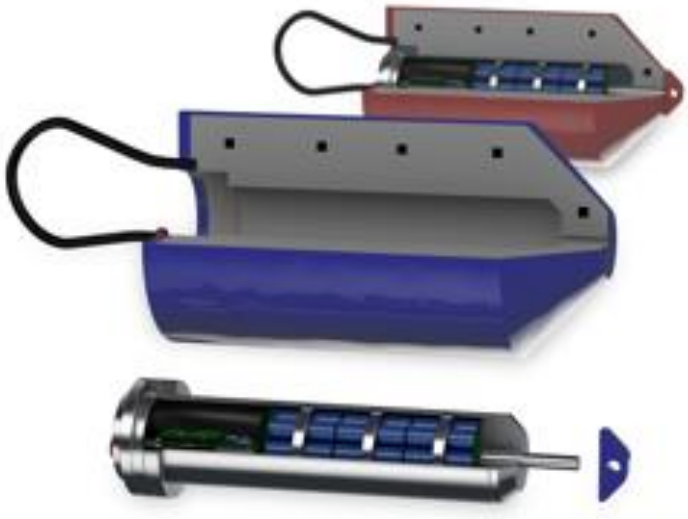
- Extra data can drive integrity management programs
  - **Better decision making – improved efficiency – significant cost saving**

- 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

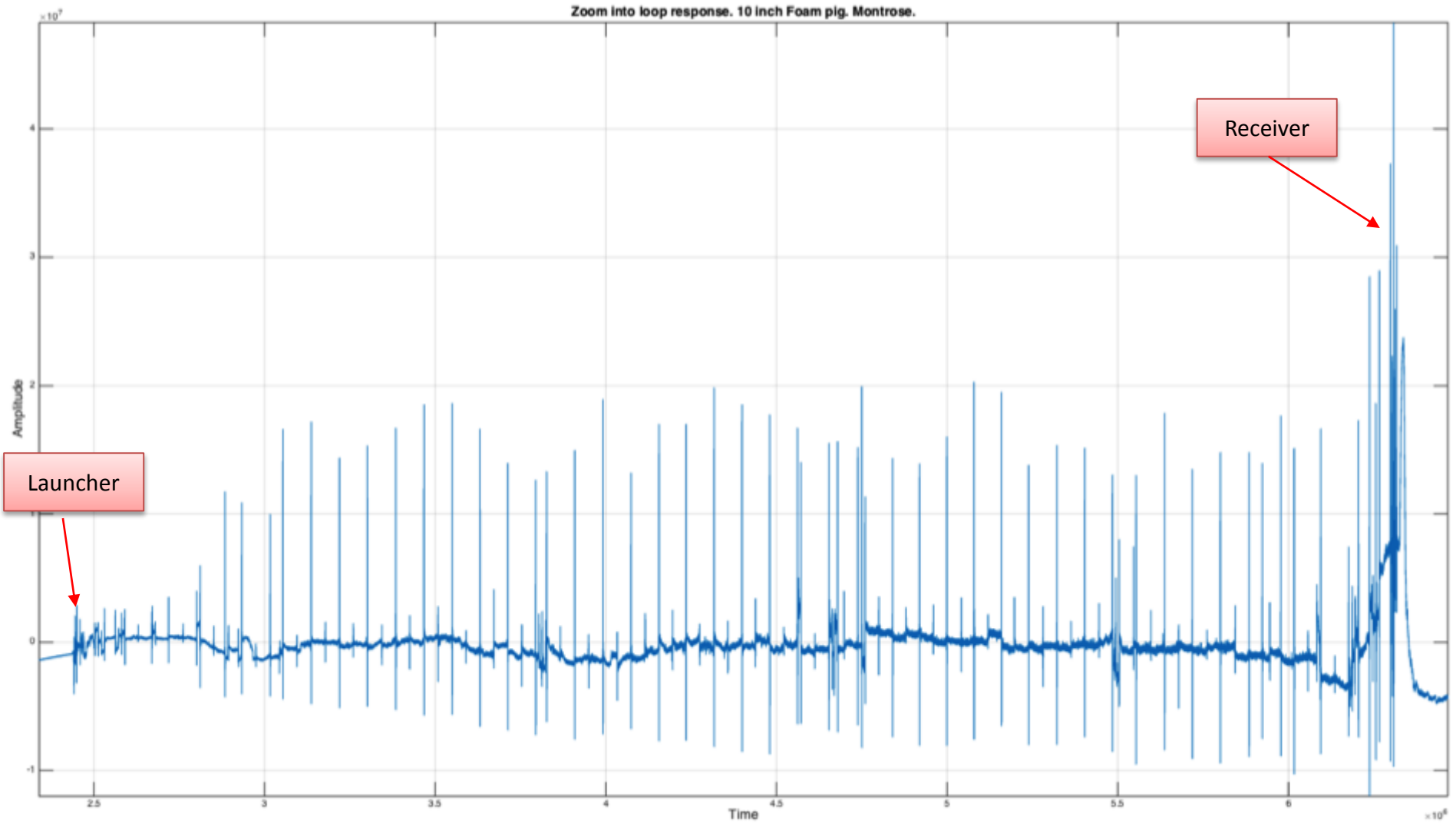
- Pressure vessel stays in place
- Sensors are manufactured and integrated in a way that they are embedded into the foam
- Result is a more durable pig that collects reliable and uniform data
- It’s a new hybrid pig – PU disk in the nose !
- The internal Pressure vessel is bolted to pigging disks front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

1km Test facility - Petrofac

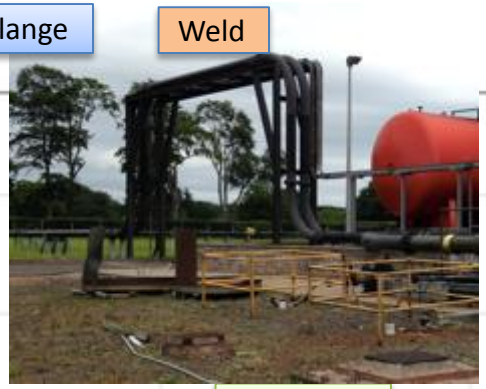
Launcher / receiver

Permanently pressurised system

Overview - 1km of Data



Data – Feature mapping = no odometer



Flange

Weld

Launcher

Top bends at road crossing

Bottom bends at road crossing

B 1

B 2

B 2

B 2

W

W

W

W

F

F

F

F

F

F

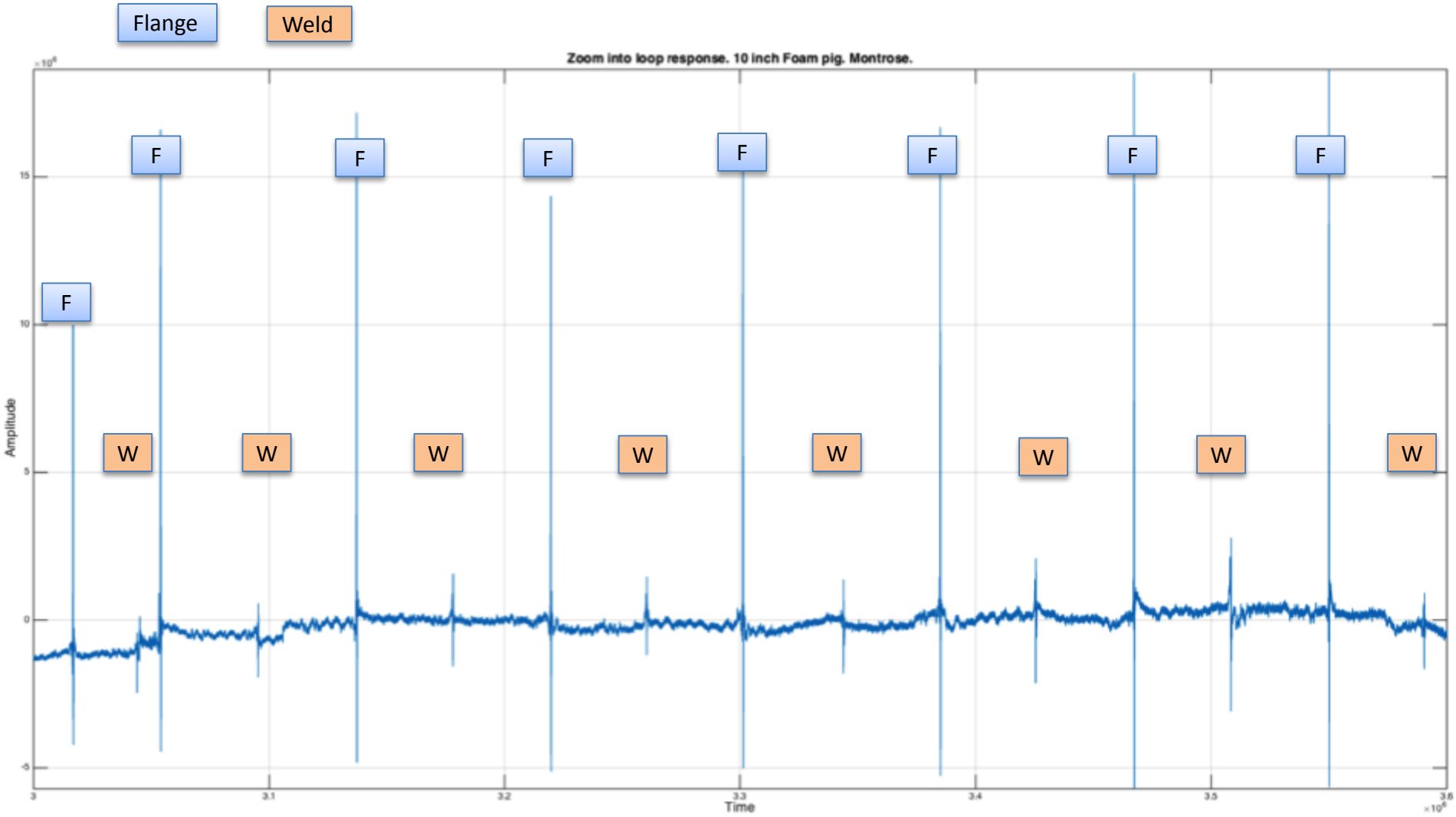
F

Slight drift in the baseline caused by water ingress into the sensor belt

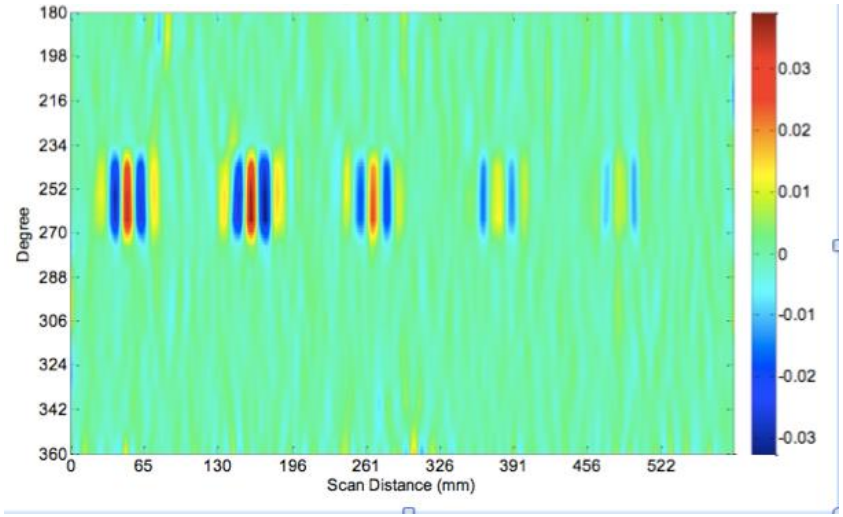
Amplitude

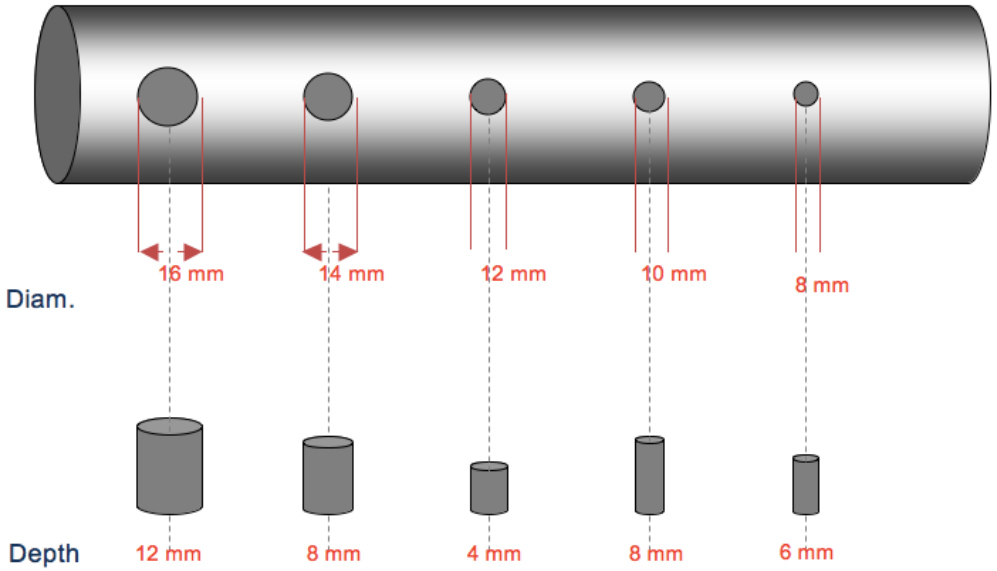
Time

Data – Uniform welds & flanges



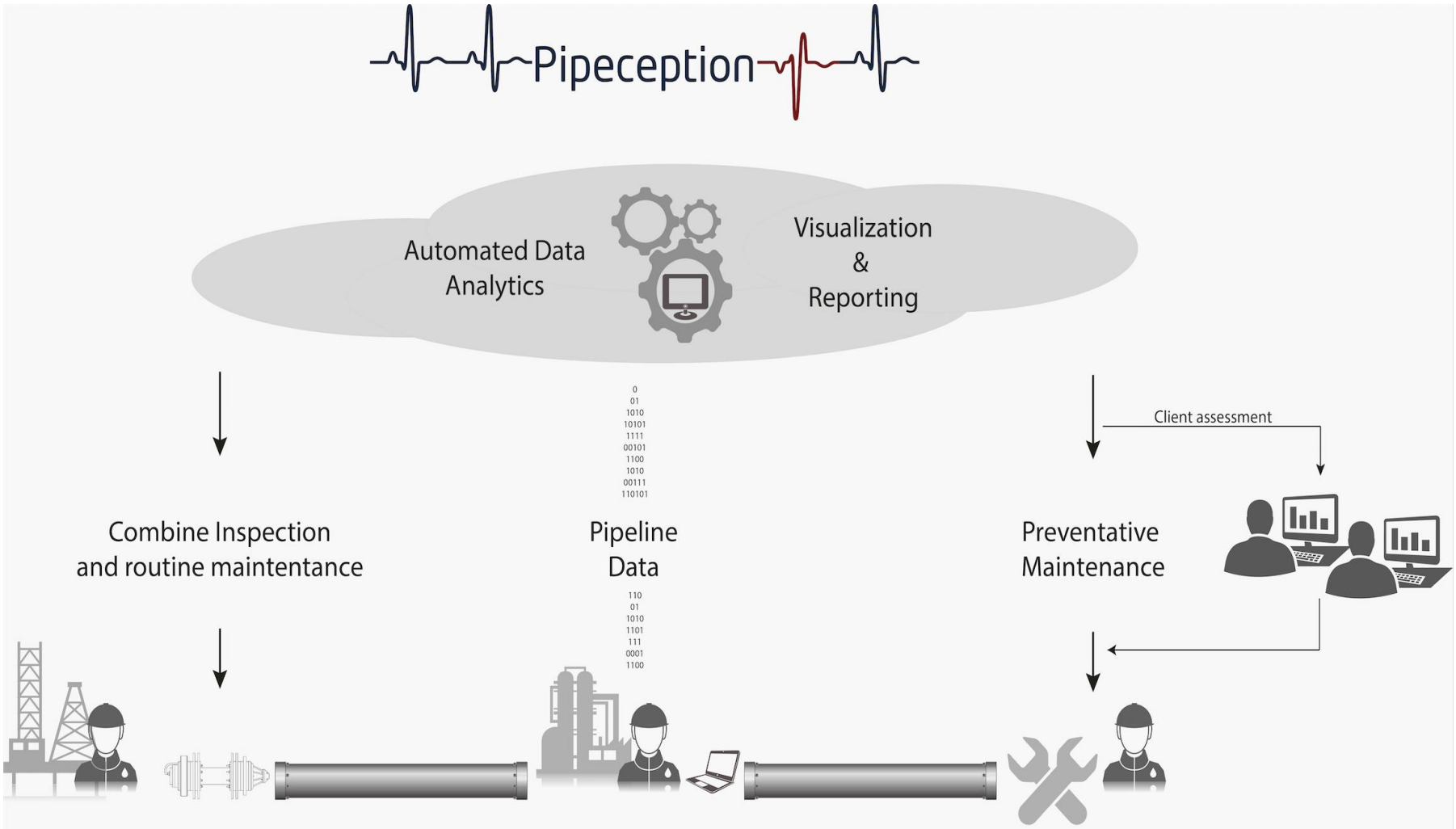
Defect sensitivity trials – test pipe



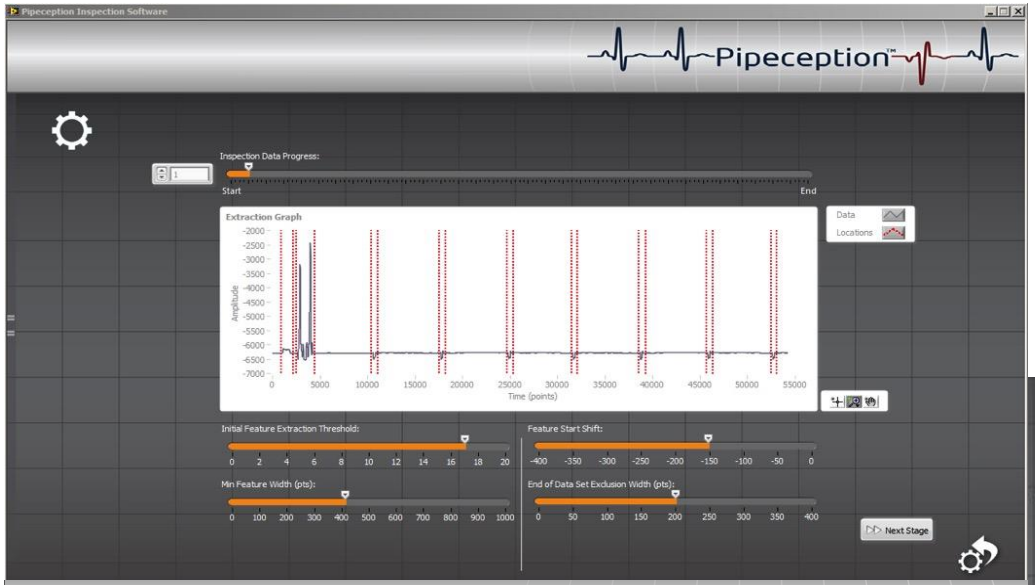


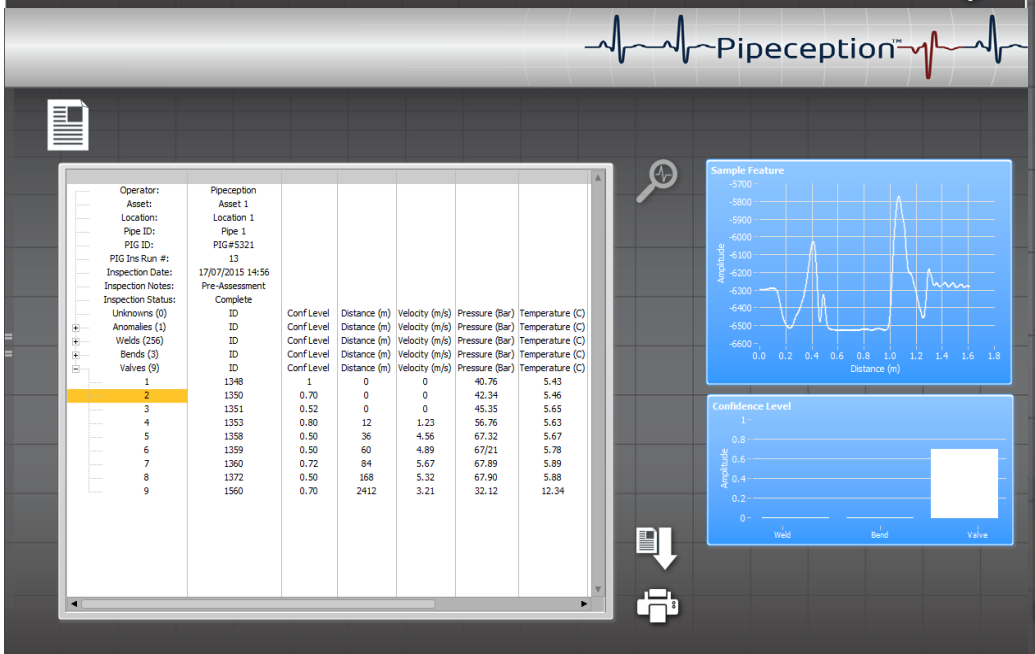
- The electromagnetic system used by i2i gives a better reflection on shallower but wider defects.
- No special conditions are needed fro inspection
- Max pressure is 250bar
- Max inspection speed is 5-8m/s
- Longitudinal separation is 45mm

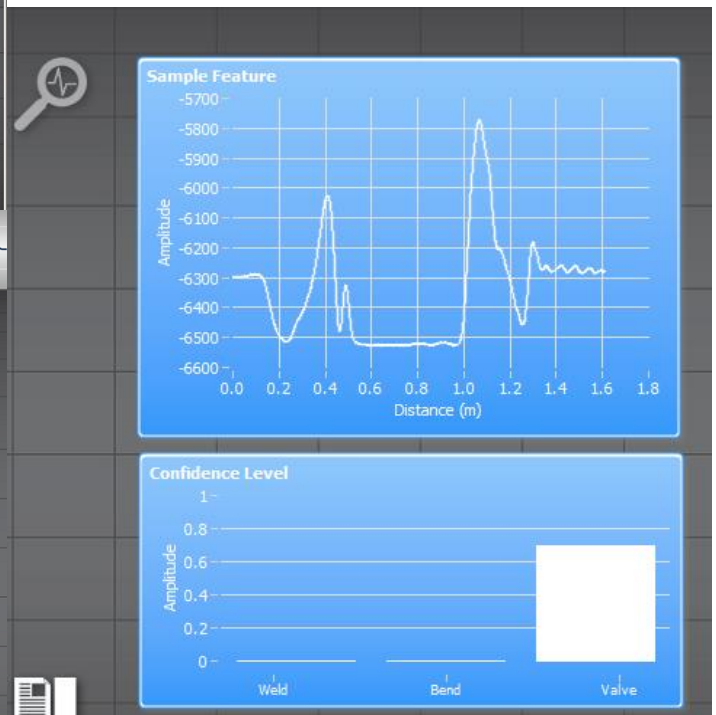
Velocity of data – Cloud reporting



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

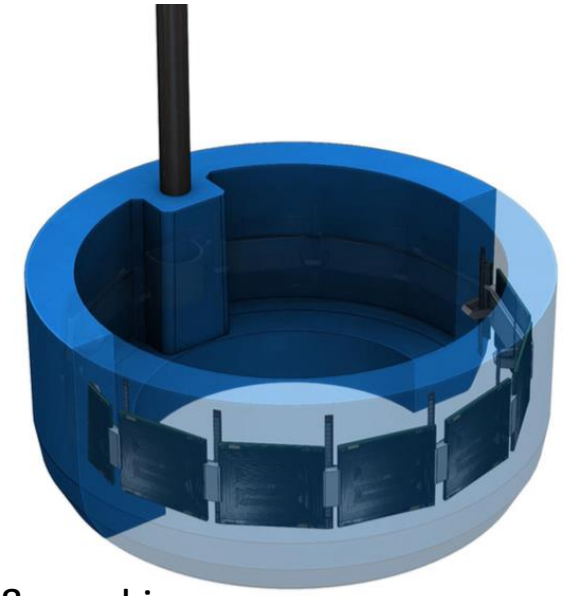
- Aim is to identify and locate the hydrate phase boundary within a pipeline in conjunction with providing the actual P V T profile of the pipeline

- 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 rechargeble 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**