UNIVERSITY OF TECHNOLOGY SYDNEY

Activity 4d: Enhanced Reliability of Emerging Technologies

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UTS

Presentation Outline

1. Summary Current State of Affairs
2. Summary Latest Progress
3. Understanding the technology
4. Analysis of DS pCAT
5. Analysis of PCA-Echologics ePulse

Summary Current State of Affairs

Aims:

- Exploring emerging technologies which have not yet been incorporated into the current research project in anticipation of the benefits they may bring

Background:

- What are the possible benefits of introducing these techniques in an in-between predictive framework?

Challenges:

- Understanding technology
- Validating data (particularly continuous screening techniques)
- Integration and evaluation

Latest Progress

1. An unsuccessful trial of the p-CAT (Detection Services) technology was carried out on the test-bed at the end of March 2015
   - The trial had to be abandoned due to excessive acoustic signal degradation apparently caused by dissolved gas in water

2. Incorporating the information provided by pCAT, ePulse or any other screening measurements within the proposed framework for in-between prediction is now straightforward

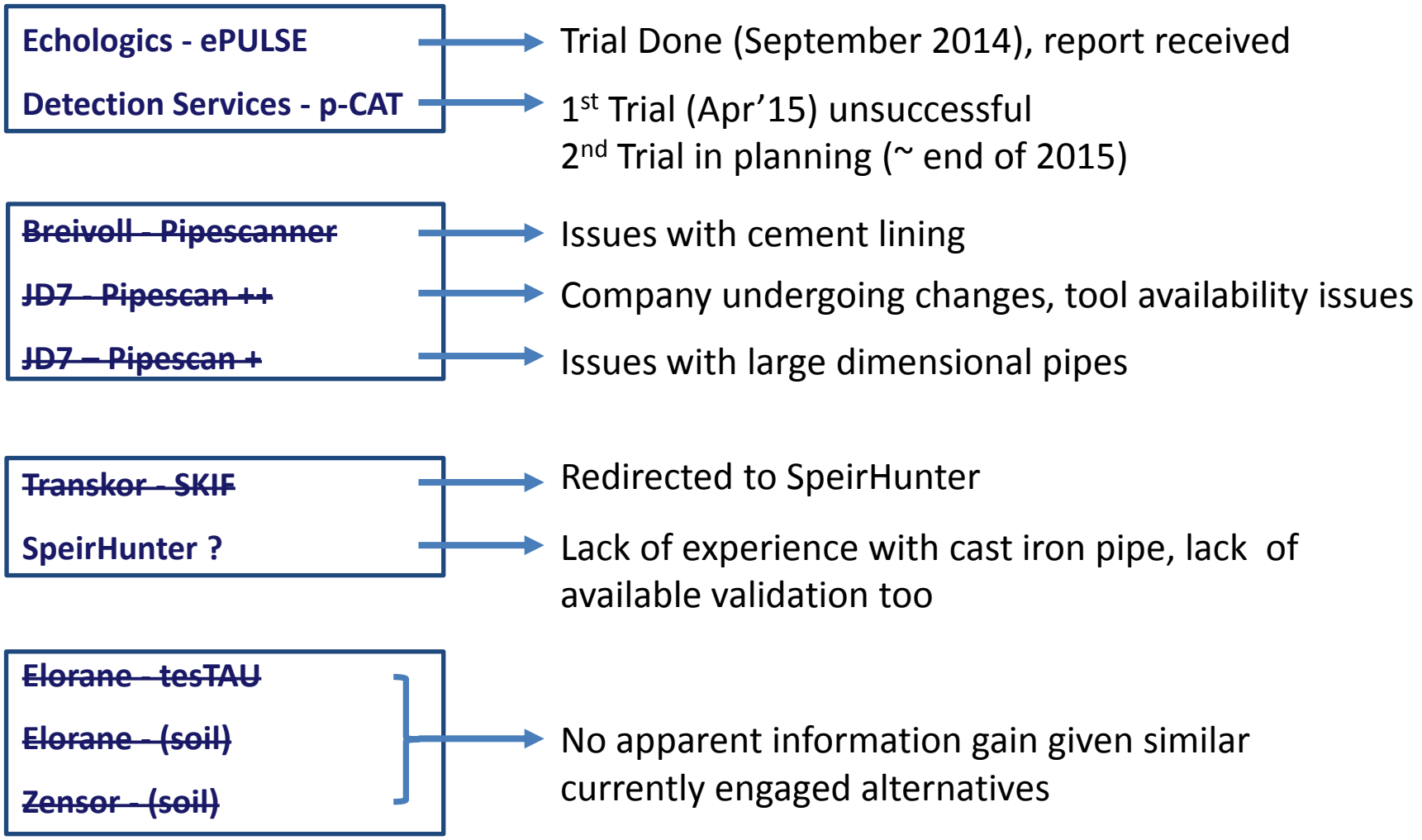
3. Validation is not

Reminder: Technology Screening

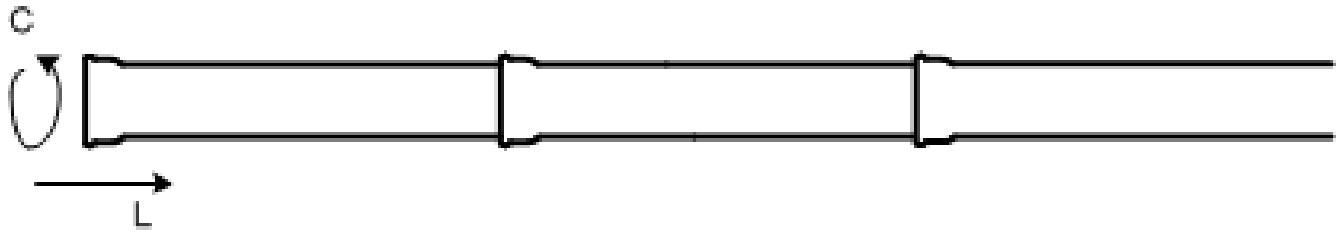
The research started with a desktop screening to review additional commercially available condition assessment technologies to narrow down possible options

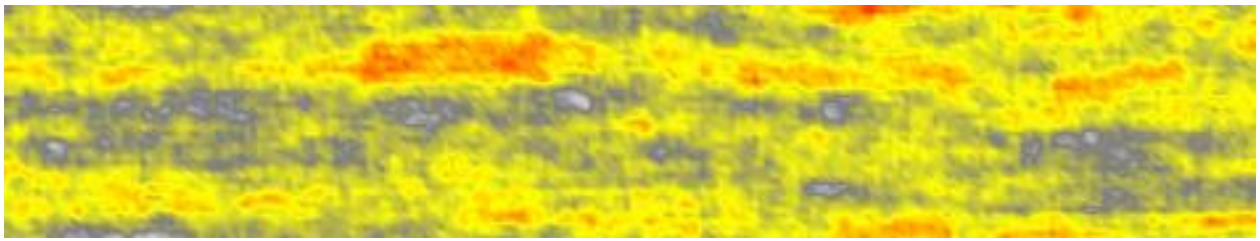
Echologics - ePULSE **Detection Services - p-CAT**	Group 1: Acoustics, non-dug-up
Breivoll - Pipescanner **JD7 - Pipescan ++** **JD7 - Pipescan +**	Group 2: Ultrasonics, in-pipe
Transkor - SKIF **SpeirHunter**	Group 3: Passive electromagnetics, non-excavation
Elorane - tesTAU **Elorane - (soil)** **Zensor - (soil)**	Group 4: Environmental analysis, non-excavation

Reminder: Technology Screening



Understanding the Technology





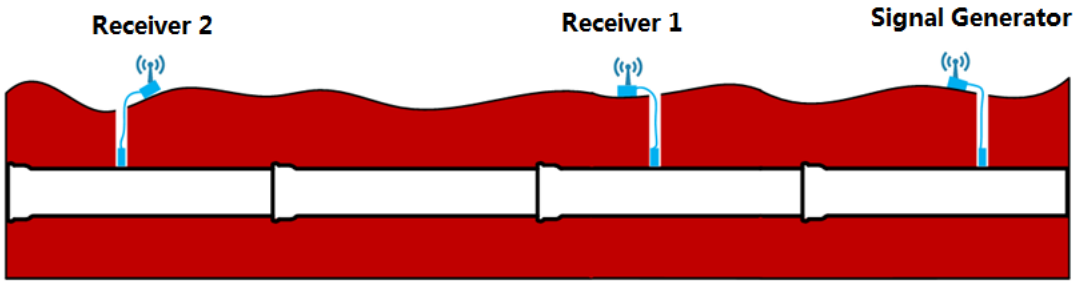
e.g. 10 Meters (joint excluded)

1. Average Remaining Wall Thickness (e.g. **pCAT**)
2. Maximum Pitting Rate -> Maximum External Pitting
   -> Minimum Remaining Wall Thickness (e.g. **LPR**)
3. Average Minimum Remaining Wall Thickness (?) (e.g. **ePulse**)

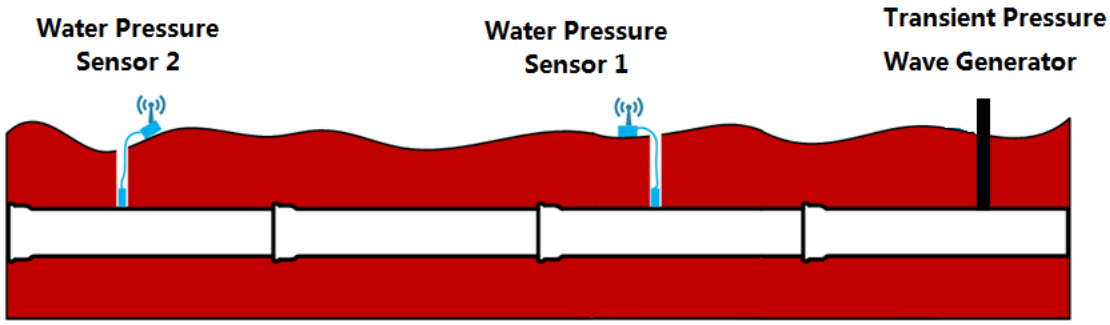
A common misconception: higher Tavg, higher global Tmin?

Based on the current data the correlation between Tavg and Tmin is 0.6 out of 1

Understanding the Technology



ePulse



pCAT

ePulse: Access the external pipe wall

ePulse: Average minimum wall thickness

ePulse: No sub-section information

ePulse: Smallest reliable coverage is 25 m

pCAT: Access the water

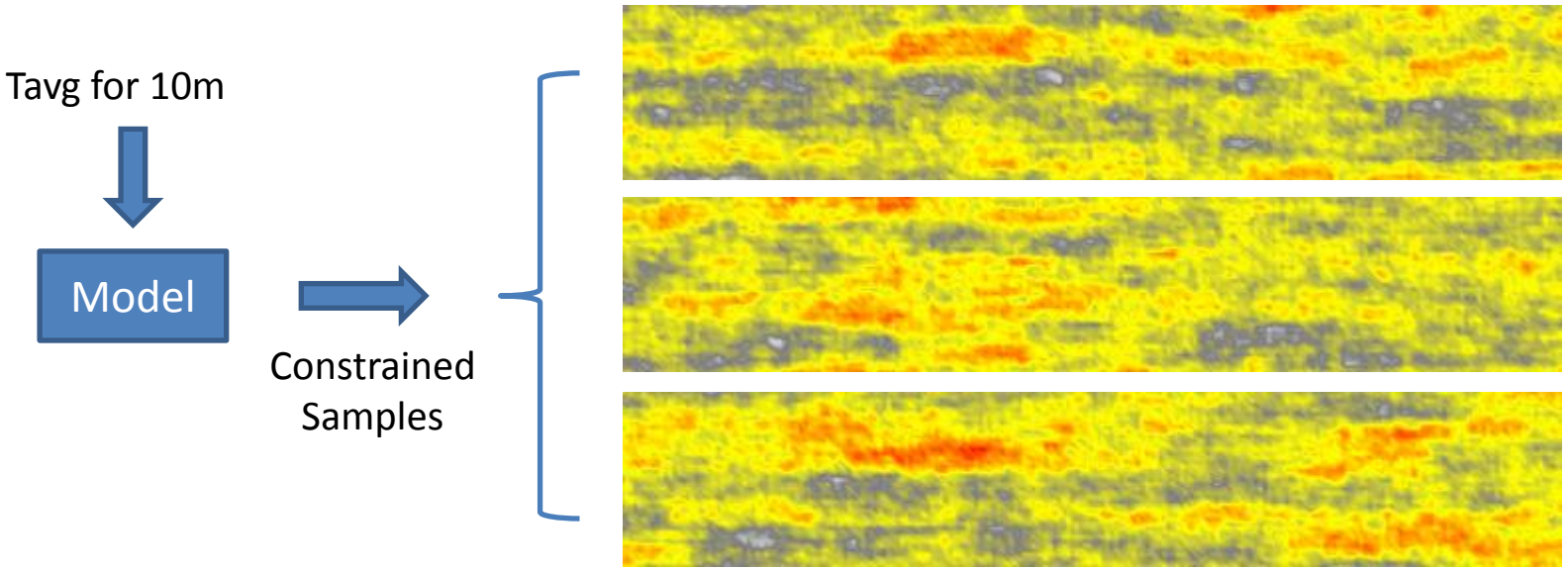
pCAT: Average wall thickness

pCAT: Sub-section information available

pCAT: Smallest reliable coverage is 10 m

Detection Services pCAT

- pCAT - acoustic technique: provides one measurement over long distances, e.g. 100 m
- It then reports average wall thickness every 10 meters (through data analysis)
- Incorporating these measurements for in-between prediction is theoretically straightforward within the proposed framework and will add value to it - <u>if accurate</u>



First pCAT Trial

- 31 March 2015 & 1 April 2015
- Abandoned due to dissolved gas in water
- Next trial under planning (~ by the end of 2015)
- Practical validation at this stage is not feasible given the short length of GT sections available

Fill test bed pipe

Pressure Sensor

Generator

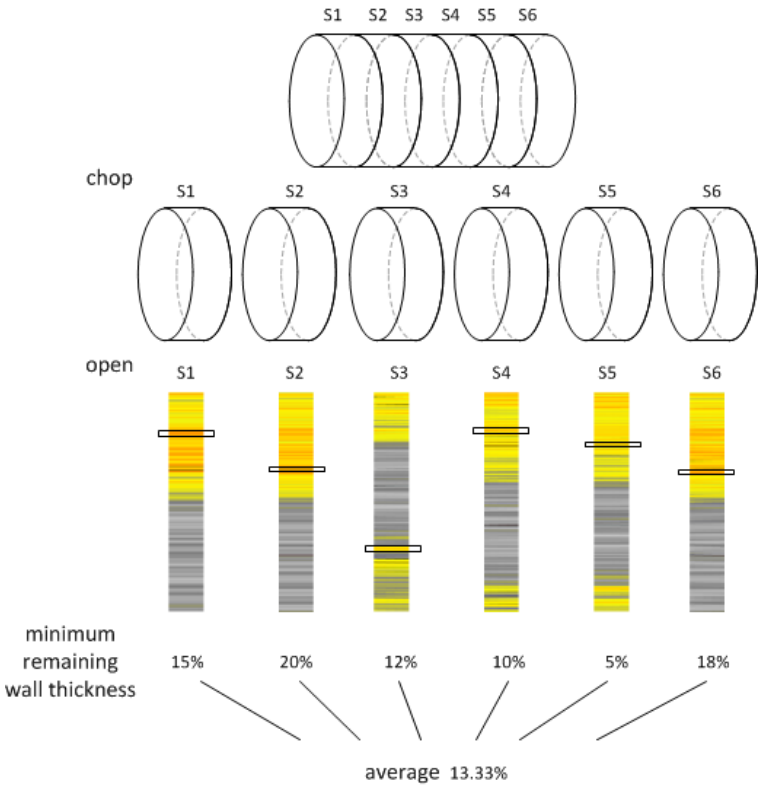
Milky Water

Reminder: Evaluation of ePulse

First upcoming technology trial - with PCA-Echologics - was completed during September 2014. This was planned at varying access point (higher than usual) spacing to better assess the influence of spatial resolution

Reminder: Evaluation of ePulse

- Theoretically, the measured **speed of certain acoustic wave** represents a measurement of the remaining wall thickness
- Many parameters need to be accurately fixed/known beforehand



Evaluation of ePulse

- ePulse measures “Average minimum wall thickness”, this can not be readily “validated”. PCA-Echologics cannot either
- Both PCA and UTS agree that the in PCA’s interpretation of the ePulse data there is an important parameter - spatial ‘ring’ resolution - which can significantly affect the result
- PCA-Echologics has limited confidence on sensor spacing results of less that 25 meters, and does not recommend it
- ePulse results are generally affected by air pocket in the pipe
- For measurements with > 25 meters sensor spacing, test-bed trial results from ePulse do not contradict the averaging results provided by Russell NDE (yet validation of the latter is still rather limited)
- The potential information gain by using these measurements in between assessed pipe sections is theoretically straightforward within the proposed framework, but practically difficult

ePulse Case Study 1: GT Not Available

Case Study 1: measurement covering 98.20 meters

$$v = v_o \times \sqrt{\frac{1}{\left[1 + \left(\frac{D_i}{t_r}\right) \times \left(\frac{K_l}{E}\right)\right]}}$$

- Theoretically if we introduce the following reasonable (small) errors in the formulaic parameters:

Distance	Young's modulus	Inner Diameter	Water Temperature
- 1.5 m	+ 2 GPa	- 3 mm	+ 2 degrees

- ePulse result will change from e.g. 23.13 mm to 20.15 mm

ePulse Case Study 2: with GT in Smaller Sections

- Case Study 2: Excavation 2 (3.56m)

  3m GT at very fine resolution: Tavg 21.56 mm, avg. of Tmin 13.83 mm

  3m GT at BEM resolution: Tavg 21.54 mm, avg. of Tmin 16.57 mm

  2m UTS BEM at BEM resolution: Tavg 20.21 mm, avg. of Tmin 16.76 mm

  ePulse reports: 18.94 mm

- Case Study 3: Excavation 1 (3.6m)

  1m UTS BEM at BEM resolution: Tavg 22.31 mm, avg. of Tmin 16.11 mm

  ePulse reports: 17.07 mm

- The higher resolution, the lower avg. of Tmin
- Tavg is robust to resolution change
- It appears ePulse's spatial resolution is lower than BEM's

Challenge in Validation of ePulse/pCAT

- To validation ePulse and pCAT, long GT sections are required, unavailable
- A proxy using BEM is under consideration

Current Progress and Future Goals

Goal	Status
Appoint personnel Selection of appropriate emerging technologies (on-going) Negotiate technology agreements (on-going)	Completed
Integration of novel techniques with proposed data-driven multi-resolution fusion network	In progress (50%)
Interim evaluation of potential information gain by use of measurements from novel technology with respect to ground truth	In progress (60%) (proxy from simulations)
Robust validation of potential information gain by use of measurements from novel technologies with respect to ground truth	In progress (30%) (proxy from simulations)