**Assessing The Underworld**

**An Integrated Performance Model of City Infrastructures**

**Work Stream 2: Vibro-acoustics**

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**Objectives**

- To use a pipe vibration method to assess the condition of buried pipework
- To investigate a variety of ground excitation methods to interrogate both the ground and the buried infrastructure
- To explore a tree excitation method to determine the location of tree roots in order to identify areas of pipe network at risk of damage
- To develop vibro-acoustic methods to measure relevant wavespeeds (including variation with depth) *in situ*

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**Pipe Excitation Technique**

Detection of holes & cracks

- Waves propagating along pipe will radiate to the ground surface
- Axial dependence of waves in pipe mirrored in ground surface response
- Reflections from discontinuities in pipe (holes/cracks) manifest as more or less subtle changes in ground surface response
- Monitor changes over time

**Tree Excitation Method**

- Wave energy travels from the trunk excitation location down to the underground root network
- Vibrating roots excite waves in soil which, measured at the ground surface, can be used to estimate their location and extent
- Within WS2 we studied wave propagation in exponentially tapered rods, to understand the phenomena expected in real tree roots and explore the waves can be used to estimate root extent and depth.

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**Road and Soil Characterization**

- Modelling & experimental work has been undertaken to
  - Develop methods to determine soil elastic properties *in situ*
  - Detect and locate cracks in road/pavement surfaces
  - In particular
  - A range of soil excitation methods to excite different wave types examined
  - Combining vertical & horizontal ground vibration responses to increase resolution and accuracy of spectral images
  - Information gleaned from electromagnetic & seismic methods compared
  - Wave decomposition method for crack detection investigated
  - Use of inversion methods to extract near-surface wavespeed information in both homogeneous soil and layered ground carried out
  - Different source-to-asphalt couplings examined

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**Recent Papers (2018):**

7. M Muggleton, MK Kalkowski and E Rustighi, An experimental approach for the determination of axial and radial wave numbers in circular exponentially tapered bars, review received (editor requires revisions), Journal of Sound & Vibration.

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