Microwave Sensing and 3D Pipe Hydraulics

Stream

The Industrial Doctorate Centre for the Water Sector

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Dynamic Flow Technologies

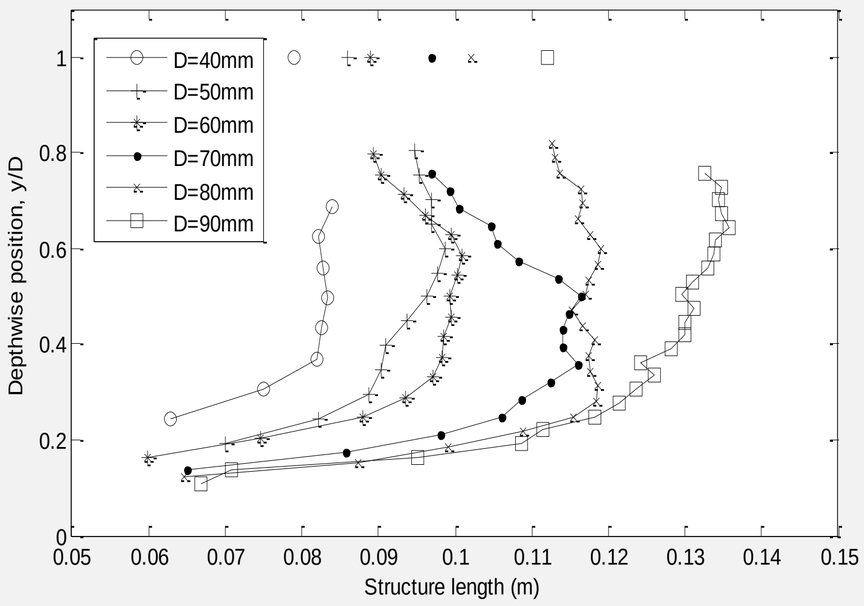
Sewer Problems

- Due to climate change, urbanisation and population expansion, our sewer systems are transporting **increasingly high volumes of water**, exacerbating issues related to pollution, sedimentation and flooding.
- Necessary to **optimise treatment procedures**, and to minimise the instances of sewer flooding, blockages and pollution events
- Important to gather information to enable efficient **pro-active management**.

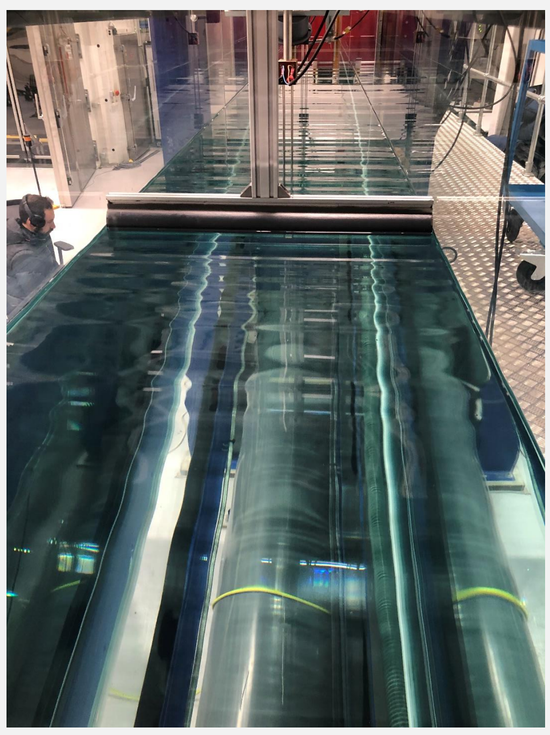
Existing methods

- **Intrusive methods:**
  - Costly with high maintenance requirement
  - Can cause a blockage itself
- **Non-intrusive methods:**
  - Relatively cheap
  - Estimate surface velocity and flow depth
  - Measurements of turbulence-driven processes are too expensive and energy-intensive for widespread deployment

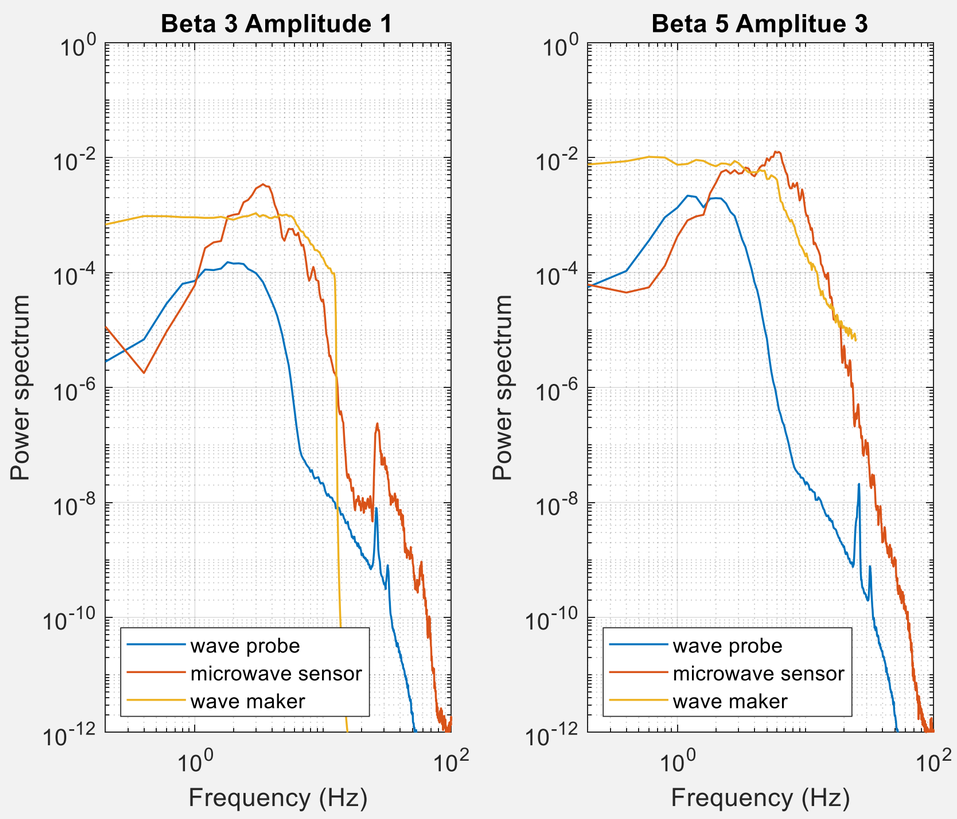
Scanning the 'Barcode' of Sewer Flow



Mean streamwise length of turbulent structures measured throughout the flow depth using the vertical velocity fluctuations (solid lines), and measured at the free surface using the LIF surface deformation data (individual markers) [1]



Millimetre-scale random wave generated by the wave maker



- Flowing water exhibits **a unique surface pattern** driven by the flow induced turbulence. This pattern appears to be a function of the underlying flow properties. These first tests examined waves made by a wave generator.
- A microwave sensor sent a signal to the water surface and received the reflected signal.
- As the water surface moved up and down, the phase of the reflected signal also fluctuated.
- The surface fluctuation can thus be recovered from the phase change.
- The power spectrum of the reconstructed surface from the microwave sensor is comparable with the original wave maker movement and surface measurement from wave probe.

Industry Impact

- **The Water and Wastewater Industry:**
  - More accurate and robust characterisation of turbulent flow processes.
  - Increased flexibility of measurement of flows and less dangerous maintenance required.
- **Environmental Industry:**
  - With more gathered information, able to take more efficient pro-active management.
  - Flood events can be mitigated and the resulting financial and environmental impact can be reduced.
- **Chemical and Food Industry:**
  - Transportation of chemical product and food always include the transport of solids in solution so it is important to find a balance between the clogging of the pipe and unnecessary diluteness. A clogged pipe will lead to overpressure or failure while unnecessary diluteness will cause generation of more waste product.
  - With better understanding of the turbulence intensity and mixing processes in the flow field, industry will be able to choose an optimum margin of safety for their fluid transportation to avoid clogging or unnecessary diluteness.

[1] Nichols, Andrew. 2014. "Free Surface Dynamics in Shallow Turbulent Flows." University of Bradford.

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