Background

The Challenge

In most developed countries, wastewater management is achieved via the use of a large, underground network of intersecting pipelines and, without regular inspection and maintenance, these networks can rapidly fall into disrepair, with pipelines becoming either partially or completely blocked due to cave-ins, tree root ingress or simply the accumulation of solid components from the media flowing through the pipes, e.g. silt deposits or the growth of fat-bergs.

All of the above scenarios can lead to flooding and, therefore, potentially have severe consequences for the asset holder including, but not limited to, loss of reputation, incurred responsibility for property damage, legal action and high financial penalties.

Current preventative measures include CCTV inspection combined with water jetting, both of which are time consuming and extremely costly.

The Solution

Tellus Utilities have developed an acoustic system, The ORCA (Obstruction Recognition and Condition Assessment), that can identify the existence, location and even the size of a blockage, in air (gas) filled pipelines.
**ORCA** - Acoustic instrumentation for the rapid detection of blockages in sewers, conduits and pipelines.

The ORCA uses acoustic reflectometry to identify and locate pipeline features. The ORCA comprises an acoustic source and sensor set that is securely mounted onto an extendable pole.

The sensor set is lowered down a manhole and directed towards the pipeline section requiring inspection. A 32 second coded acoustic signal is then emitted by the source and transmits down the pipeline.

Any inherent features of the pipeline, i.e. manhole chambers, laterals etc., and any foreign bodies, i.e. blockages, will result in a reflection, which will travel back towards the ORCA and be recorded by the sensor. The ORCA software will then identify the location of said features or blockages with near centimetric precision, allowing for the mapping of pipeline features and the detection of any unwanted blockages within the network. The average time taken to position the device, acquire the data and analyse the results is 10 minutes, and the achievable measurement range is of the order of 300 m from one location, depending on the condition of the pipeline.
Based on proven technology from the oil and gas sector.

Long range scanning capability.

System can identify laterals coming into parent pipe.

The system can be used to evaluate not only the location, but also the nature of the blockage.

Fully Submersible.

Adapted for small and large diameter pipes and sewers.

Rapid scanning solution: <5 minutes per operation (less if manhole cover is already removed). 10 – 20 times faster than CCTV operation.

Active management of sewer system, avoiding the need for blind high pressure jetting.

Surveys underway with a number of customers both in the UK and abroad.
Case Study 1 - Newcastle Upon Tyne, UK
Blockage Detection in Air-Filled Pipes

Results:

A controlled test was performed in a clean, air filled, circular storm drain with a diameter of 900mm. The pipe section under inspection was 78m long, and was connected, via a manhole, to a 34m long section of pipe which in turn, emptied into the River Tyne. The structure of the inspected pipeline section is described by Figure 2.

Baseline data were acquired, in the first instance, from the clean, air filled pipeline, after which an artificial blockage comprised of wooden blocks was introduced into the pipeline, at approximately 63m downstream of the point of entry. The blockage obstructed approximately 40% of the pipeline.

A second set of data were acquired after the introduction of the blockage, and the two data sets are displayed in Figure 3.

As one would expect based on the pipeline structure, the baseline data acquired from the clean conduit (green curve) display two clear reflection events, firstly from the manhole immediately downstream of the entry point, at 78m, and also from the outlet gate, further downstream at 112m.

Figure 2. Schematic describing the storm drain structure.

Figure 3. Data acquired before (green curve) and after (blue curve) the introduction of an artificial blockage into the storm drain.
Results:

After the introduction of a blockage at 63m, a clear reflection event is observed that corresponds to its position, demonstrating the sensitivity and accuracy of the ORCA for recognising and locating obstructions in a pipeline or conduit. If baseline data for a pipeline network is acquired, inspecting said network at regular intervals and subtracting the baseline from the newly acquired data allows any changes that occur over time, for example the build-up of a blockage, to be tracked. This method is known as time-lapse analysis. The subtraction of the baseline data will remove any reflection events that result from inherent pipeline structural features, i.e. manholes, laterals or outlets gates, and thus enhance the clarity of the reflection events from unwanted obstructions. Figure 4 displays the time-lapse data response of the data displayed in Figure 3.

Upon examination of the time-lapse response, it is clear that the reflection events from the manhole and the outlet gate have been completely removed, resulting in a clear, easily identified signal from the artificial blockage.

The test described above was repeated several times but with varying blockage sizes. Artificial blockages were inserted into the pipeline, with the proportion of the cross-sectional area being obstructed ranging from 10% to 50%. The time-lapse responses of the data acquired are displayed in Figure 5, and clearly show a direct correlation between the proportion of the pipe being obstructed and the amplitude of the corresponding reflection event.

Based on these data, and on more comprehensive tests that have been performed, the ORCA is able to clearly detect a blockage that is causing an obstruction of 15% or more within a pipeline.
This case study describes a trial that was performed in Toronto, Canada, where unusually large pipes, with diameters up to 2.5m, are required in order to withstand the deluge of water that is produced every spring as temperatures begin to rise and the mountain snow melts. The high volume of water flowing down into the city requires rerouting via the storm drains and sewers in order to prevent flooding, but as it journeys through the network, any material that is being carried by the water, mainly grit and gravel, is deposited in the pipelines and can built up to form significant blockages which will inhibit further flow. Tellus Utilities performed a trial with a Toronto based engineering company, who are contracted by Toronto Water to confirm the existence of these build-ups, identify their locations and then remove them. They currently achieve build-up confirmation and location via the use of CCTV inspection technology. However, when the pipeline under investigation is carrying water, it is not possible to run a CCTV camera through it. As such, a trial was conducted using the Tellus Utilities ORCA device with the aim of using acoustic reflectometry to assess the condition of flooded pipelines.

The structure of one of the inspected pipeline network sections is described by Figure 6. The manhole positions are marked by the numbers beginning MH. Each of the six pipe sections were partially flooded and as such, in each case, data were acquired from both the air-filled pipe section and the fluid-filled pipe section. Pipes sections 11, 12 13 and 14 were inspected twice, once from the manhole at either end of the pipe. The in-air data acquired from each section are displayed in Figure 7. The manhole positions and their reference numbers are also displayed in Figure 7.
Case Study 2 - Toronto, Canada
Blockage Detection in Air and Fluid Filled Pipes

Results:

Any significant build-up of silt within a pipe would result in a reflection event being observed but in the absence of build-ups or blockages, the only observed reflections will originate from the manhole chambers encountered by the signal. Examination of the data displayed in Figure 7 shows that there are many clear reflection events present within the acquired data (highlighted in red), all of which correspond to features within the infrastructure i.e. manhole, outfalls etc. No unexpected events are present that indicate the presence of any blockages and thus, it is reasonable to conclude that the air channels along this particular section of the network are free from obstructions, and that no silt build-ups are present. This conclusion is supported by earlier CCTV inspection data acquired along the air-filled channel.
Case Study 2 - Toronto, Canada
Blockage Detection in Air and Fluid Filled Pipes

Results:

The in-fluid data acquired from the same pipe sections are displayed in Figure 8. An examination of each of the ten acquired data sets confirms that no reflection events are observed, as one may expect from a series of pipes containing no obstructions. In this case, the manhole chambers are not observed as the acoustic signal is constrained within the fluid layer and thus does not encounter the structural features and the changes in impedance that would result in a reflection. The data acquired from the fluid layer in pipes 10 to 15 confirms that this section of the network is free from blockages, and that any silt build up that may be present forms a relatively flat layer along the base of the pipe.

The time taken to assess this section of the network was less than half a day, and the data acquired drew the same conclusions as CCTV inspection which took several days to acquire, representing a significant cost benefit to using The ORCA system for conduit inspection.
Summary

The data demonstrates the efficacy and sensitivity of the ORCA system when detecting blockages. Further, it has been demonstrated that the infrastructure, and other potential blockages, beyond the initial obstruction can be clearly identified.

The ORCA system provides a cost effective solution for the surveying of sewers and storm drains, and can detect blockages whilst at the same time mapping the features of the pipeline network.