



# Pipe Profiling Innovation At T

Water and wastewater pipelines are prevalent, important, valuable, unnoticed and often in a state of disrepair. Pipeline inspection is essential for effective management of water and wastewater systems, and is now mandated by many municipalities complying with the Governmental Accounting Standards Board Statement 34 (GASB 34) and EPA regulations.

GASB 34 requires accurate and repeatable assessment techniques for municipal assets including water and wastewater pipelines. New regulations passed in 2006 by Florida's Department of Transportation require laser profiling to verify whether proper installation methods were used by contractors for new flexible walled pipes.

Consulting firms in the U.K. are recommending that all flexible walled wastewater pipes be laser profiled before they are adopted for management by local governments. These and other recent developments have spurred new research and development into pipe inspection techniques at the Trenchless Technology Center (TTC) at Louisiana Tech University.

## Recent developments in pipe inspection technologies

Pipe inspection robots are routinely used to inspect underground pipelines for cracks, deformations, leaks, blockages and other anomalies to prevent catastrophic failure and to ensure cost-effective maintenance and renewal. Several pipe inspection technologies have been developed including CCTV vehicles, infrared cameras, microwave sensors, nuclear sensors, ground penetrating radar, crack detectors, soil void detectors, electric probes, sonic hammers and pipe profilers.

Most existing pipe inspection robots utilize CCTV technology and collect images of internal pipe wall condition. This leaves much of condition assessment open to subjective interpretation. Research has shown that the human eye is not suitable for assessing pipe deformations of less than 5 percent and that TV monitors can easily

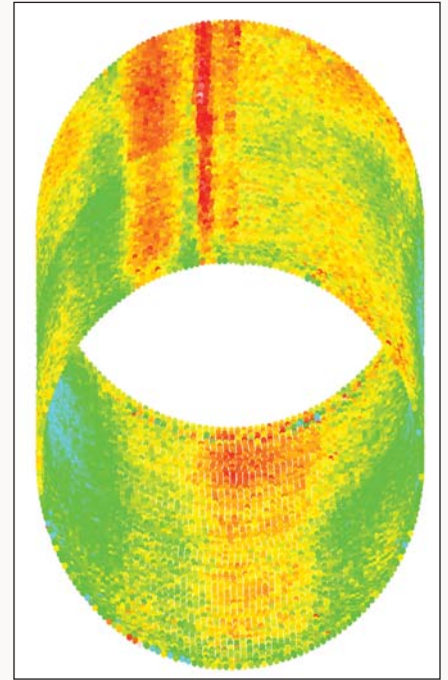


*Figure 1 - Corrugated Polyethylene Pipe Data from a Prototype Profiler at the TTC.*

produce picture distortions of up to 10 percent. CCTV operators are often paid per foot inspected which can serve as a disincentive to take the time needed for an accurate condition assessment. These and other limitations of current inspection methods are causing new technological development to help objectively quantify pipe parameters.

Pipe profiling technology has recently been introduced to allow for measurement of the internal coordinate geometry of pipelines. Pipe profilers utilize several emerging technologies and are outfitted with advanced sensors to measure pipe radii. Pipe profiling technologies include video calipers, optical triangulation, laser interferometry, sonar beacons, tactile probes and various methods of autonomous navigation.

Accurate radial measurements permit the calculation of several important pipe parameters which aid in the determination of pipe condition, prediction of time to failure and verifying whether proper installation methods were used for new flexible walled pipes. Pipe profiling data can also be used to create three-dimensional wireframe models of pipes, calculate ovality, flow parameters



*Figure 2 - High Resolution Pipe Data from a Prototype Profiler at the TTC.*

and, by scanning the same pipe several times, the rate of deformation. Three-dimensional models of pipes are helpful when the deformations in the pipe are associated with a color gradient. This allows one to visually see the areas of impending failure that need repair. Ovality measurements of the host-pipe are used in the design of thin walled pipe liners and in the determination of the quality of backfill around a new plastic pipe installation. A pipe's flow parameters are vital in the evaluation of a sewer system's capacity, and tracking the rate of pipe deformation can help determine the life left before the pipe fails. (See Fig. 1 and 2)

## Improving pipe profiling techniques

Pipe profiling is a very promising tool for the future of condition assessment. There have been many profiling techniques and sensors developed over the past decade which allow for accurate and precise pipe measurement. However, each profiling method has its limitations and drawbacks, and it is the goal of the Trenchless Technology Center to develop the next generation pipe profiler by utilizing new sensor

# The Trenchless Technology Center

By Andrew Dettmer Ph.D., Louisiana Tech University

technology and developing customized algorithms designed to account for much of the measurement error pipe profilers can exhibit.

Obtaining accurate pipe profiles is the subject of much research and the objective of several commercially available pipe profilers. One of the key aspects of obtaining accurate profiles is the relationship between the measuring device's coordinate system and the real world coordinate system. Whenever a two or three-dimensional graph of a pipe is presented, it should reference a certain coordinate system. Most often, people are the most interested in what the pipe looks like relative to real world coordinates. This enables one to make a determination of the pipe's shape and location within the ground. Therefore, it is necessary for pipe profilers to include techniques to transform the radial measurements made within the pipe to the real world coordinate system. However, if a pipe profiler does not include an algorithm or sensors to determine its position and orientation relative to the pipe, then the profiler will report inaccurate measurements when attempting to report a graph or ovality relative to the real world coordinate system. Two situations are shown in Figures 3 and 4 where a pipe profiler is misaligned with the pipe and thus causes inaccurate pipe measurements. (See Fig. 3 and 4)

Researchers at the Trenchless Technology Center have recently developed two prototype pipe profilers which incorporate the use of digital cameras, line laser modules, tri-axis accelerometers, linear potentiometers and other custom sensors. New algo-

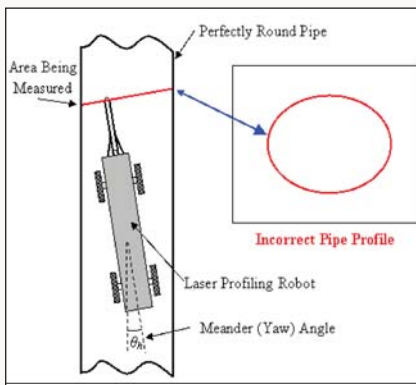
rithms have been developed to correct for the robot's misalignment with the pipe axis and have been demonstrated on a working prototype robot. These algorithms are capable of accurate estimations of the the robot's position and orientation relative to the pipe wall and have been verified experimentally. The next generation of pipe profilers will almost certainly include similar navigational techniques or methods to resolve the true dimensions and shape of the pipes and their actual position in real world coordinates.

## Future of pipe profiling

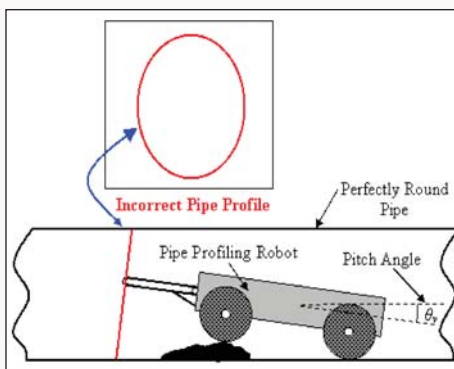
The new pipe inspection and pipe profiling regulations passed in recent years have served to motivate researchers to develop new tools and techniques to accurately measure pipes. However, standard calibration, verification, reporting and analysis practices must be developed for pipe profilers if coordinate profiling data is to be effectively included in the long term management of pipeline assets. Research into these areas continues today at the Trenchless Technology Center, and the pipe profilers developed there over the past two years are intended to provide prototypes of how sufficiently accurate measurements of pipe alignment and dimensions might be made in the future.

**FOR MORE INFORMATION:**  
Trenchless Technology Center,  
(800) 626-8659,  
latech.edu/tech/engr/ttc/

**Figure 3 - Top View of Robot Meander and Resulting Erroneous Ovality.**



**Figure 4 - Side View of Robot on Bump or Offset Joint and the Resulting Erroneous Ovality.**



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