Does Your Maintenance Department Need A Video Inspection Crawler? Find Out.

By Richard Lindner, President, Envirosight LLC

For as long as miniature cameras have been around, plant personnel have been sticking them into pipes to assess condition and troubleshoot problems. Over the years, camera delivery mechanisms have evolved to carry cameras deep into lines, helping them capture increasingly better images.

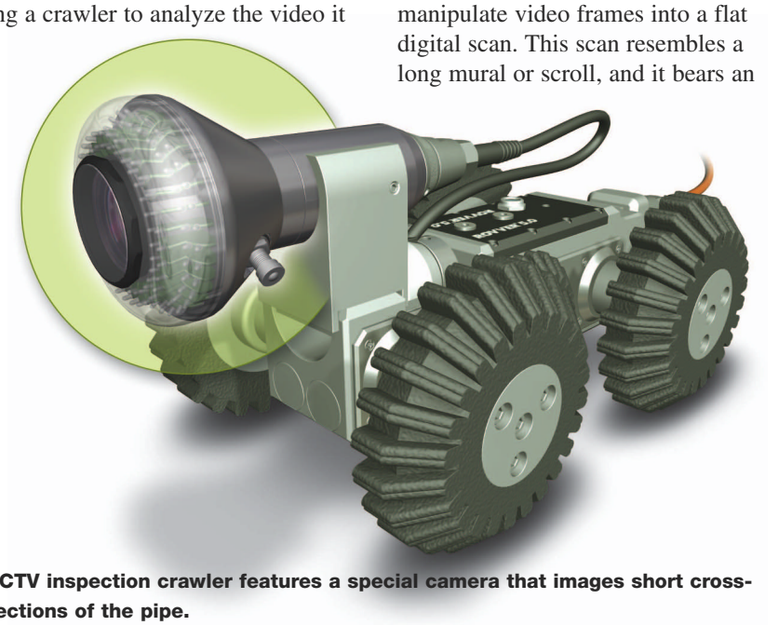
The most sophisticated of these delivery mechanisms is the video inspection crawler, a remotely operated vehicle that carries a robotically articulated camera head hundreds even thousands of feet down pipelines as small as a softball in diameter. These crawlers identify corrosion, deposits, and foreign matter in pipes, and also find cracks, deformations, offsets and sidewall erosion.

The drawback is operation versus analysis. Under normal conditions, an operator is too preoccupied driving a crawler to analyze the video it captures. In many instances, the operator isn't even the person most qualified to make the analysis. Furthermore, those who are best qualified, metallurgists, process chemists, and structural engineers, seldom have the time to review hours of video footage, footage which may still fail to deliver detail of problem areas. The most useful crawler then, needs to capture rich visual data independent of operator judgment, and then present it for review by those best qualified to make an analysis.

Digital Visual Sidewall Scanning (DVSS). DVSS relies on the proven inspection crawler platform to gather visual data from within a pipe. However, unlike traditional video inspection, DVSS implements digital image processing to deliver information in an easy format.

DVSS relies on software to manipulate video frames into a flat digital scan. This scan resembles a long mural or scroll, and it bears an image whose length corresponds to the length of the pipe, and whose height represents the pipe's circumference, from 0 to 360 degrees. These scans capture detail greater than conventional video. Rather than sitting through hours of inspection video, an analyst can review an entire length of pipe at a time, quickly pinpointing problem areas and making annotations and measurements on the scan itself.

This review is aided by software, which presents a thumbnail version of the entire scan for quick navigation to specific regions of the scan. When an area of the thumbnail is clicked, a detailed view of that region appears in the analysis pane, and a corresponding down-pipe view appears alongside it. In these panes, the analyst can scroll the view in either direction and zoom in. Using drawing and annotation tools, the analyst can mark-up the scan, identifying pipe features, highlighting regions, and posing questions.



CCTV inspection crawler features a special camera that images short cross-sections of the pipe.

Technology of DVSS. The crawler requires only three special features:

- A fish-eye camera lens that provides a field of view greater than 180 degrees
- Wide-angle lighting
- A wheel encoder for exact measurement of camera movement.

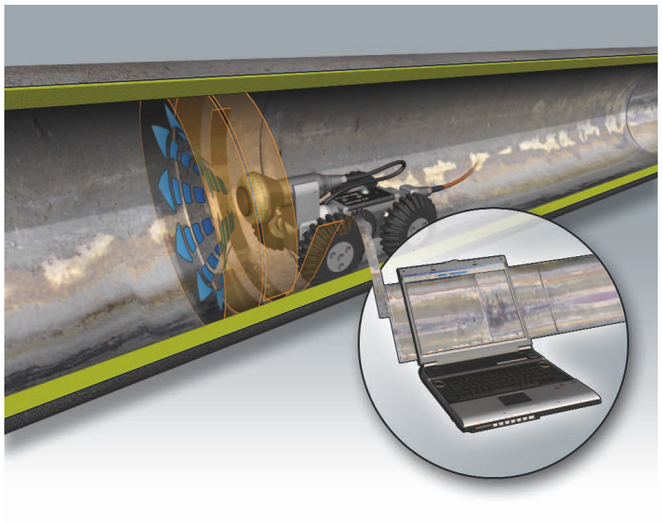
As the crawler advances, the encoder fires a signal every time the wheel rotates 50 degrees, corresponding to 1 in. of forward motion. (Measurements here are hypothetical; wheel rotation and scan intervals vary based on equipment.) With each signal from the encoder, the video camera captures a single video frame and transmits it back to the crawler CCU.

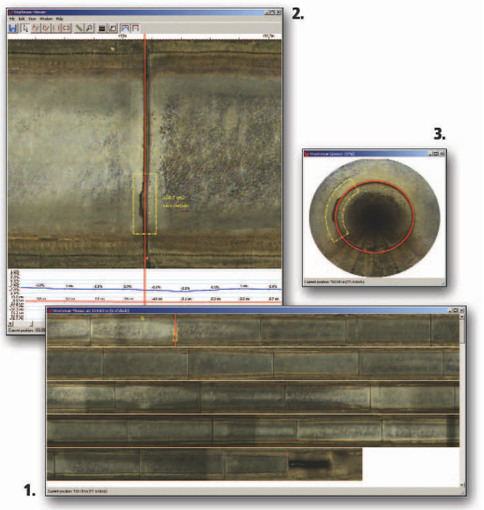
The CCU then relays this frame to a back-end computer, which digitizes it and then extracts a ring of pixels corresponding to a one-inch section of the pipe wall. Using a mathematical algorithm, the computer slices this ring at the bottom and unfolds it into a rectangle. As these rectangles are created from each subsequent video frame, they are stitched together into a complete sidewall scan. Building a good scan requires ample and even illumination, a camera whose view is centered in the pipe, and minimal terrain variation.

Typical DVSS Workflow. Because it captures data in an automated fashion, and because it relieves the crawler operator of having to analyze footage on the fly, DVSS improves the speed at which inspections can be performed. It allows an operator to concentrate on piloting the crawler through the line, while analysis of the visual data is left to the appropriate professionals. For this reason, there is no need to slow down at problem areas or articulate the camera to gain a better view. Likewise, there is no need to stop and backtrack when a potential

Consider these key differentiators when evaluating DVSS

- Real-time versus offline operation
- Storage bandwidth
- Equipment investment





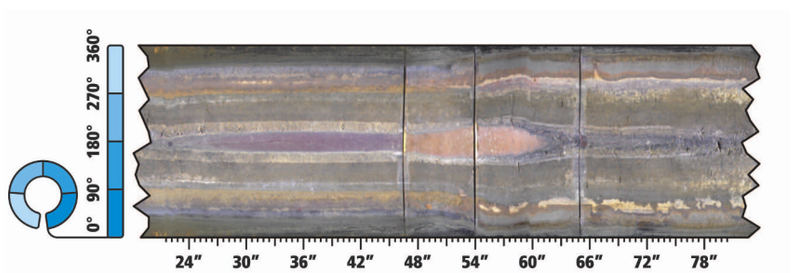
Illustrations conceptually showing pipe wall interior. These images are transposed into 1. high-res scan; and 2. and 3. software, presents a thumbnail version of the entire scan.

problem flashes by onscreen, or even to second-guess perceived anomalies. Observations are captured for post-inspection analysis, and captured at a pace that makes DVSS far more productive than traditional crawler inspection.

This same productivity carries over to the analysis phase. Presented with a single scan of the entire pipe interior, an analyst can quickly search for areas of interest, zoom in for greater scrutiny, and annotate the scan directly. Because the scan is dimensionally accurate, measurement tools also allow for the precise quantification of observations—crack length, tap diameter, and corrosion surface area, to name just a few examples. In most cases, other inspection data gathered by the crawler, such as inclination, elevation and temperature, can be plotted directly below (and in direct correlation with) the scan.

Consider, for example, a 200-ft. segment of pipe in modest condition. DVSS review can be completed in a few minutes. Compare that to the 10 minutes of video a crawler traveling at 20 fpm would generate, plus the time the operator takes to investigate problem areas, and the additional time a reviewer spends cueing, jogging and pausing the footage. Factor in the risk of the crawler operator failing to adequately inspect a particular problem area, and the benefits of DVSS become apparent.

Digitization of the visual data not only enables rapid analysis and robust annotation, it also allows an analyst to overlay archival scans to determine the speed at which pipe condition is deteriorating. Knowing that an area of corrosion is stable, for example, rather than spreading rapidly or varying as flow composition varies, provides information crucial to making maintenance decisions. Many higher-end packages take advantage of the digital format to perform rudimentary machine vision tasks, such as automatic identification of common pipe features like joints and taps. Finally, digitization improves storage density; you can document 7-10 times more pipe on a DVD-R using DVSS rather than with traditional digital video.



Sample scan generated by CCTV inspection crawler.

Implementing DVSS. Newcomers who are evaluating DVSS solutions should consider the following key differentiators.

• Real-time versus offline operation. "Real-time" DVSS systems build scans instantly as wall segments are extracted from individual video frames. "Offline" DVSS systems unwrap much longer segments captured by higher-resolution CCDs, but only after the inspection has been completed. Real-time DVSS is just that. You can view the scan as it is built, and upon completion of the line inspection the entire scan is immediately available for review by others. The DVSS equipment and operator, meanwhile, are free to move on to the next job.

Offline scanning purports to deliver a higher-resolution scan, but typically requires post-processing, which means the scan cannot be viewed as it's created, nor is it immediately available for review by others. Offline systems typically require a second computer (or occupy the primary computer) to perform the time-consuming image-flattening computations.

• **Storage bandwidth**. More resolution can be better, but a scan big enough to resolve insignificantly small features wastes the capacity of your computers, network and archival media. Scans should be viewable on a standard computer terminal with a standard video card; easily transmitted via wireless LAN; and readily archived in batches onto CD-R or DVD-R.

• **Equipment investment.** Some DVSS systems are standalone, which means you must purchase the DVSS camera, computer, and software, as well as a crawler, cable reel, and CCU, plus a vehicle in which to haul everything.

By contrast, other DVSS systems are modular, which means the DVSS camera, computer and software can be purchased to retrofit an existing crawler system. They also offer the versatility of switching between DVSS and standard video inspection, plus they are easier to upgrade. Modular systems typically leverage a crawler platform that is field proven and more robustly accessorized, making it better suited for a variety of pipe sizes, materials and conditions.

• **Ease of integration.** DVSS should complement your current inspection program, not upend it. Make sure the DVSS system you choose integrates with the inspection and asset-tracking software already in use. This means you should be able to link databased observations to regions of your scan, correlate scans to GIS/GPS data, and easily integrate those scans into reports.

•

Envirosight, LLC , based in Randolph, New Jersey specializes in video pipeline inspection. The company serves industrial facilities, municipalities, contractors, departments of transportation, and civil/environmental engineers. All Envirosight technical employees hold NASSCO PACP certification. Visit Envirosight online at www.envirosight.com.