SLEUTH

What is Pipe Sleuth?

Overview of Pipe Sleuth

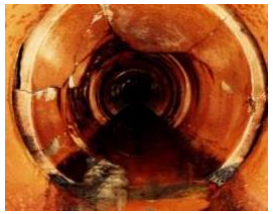
Wastewater Infrastructure Challenges

Challenges

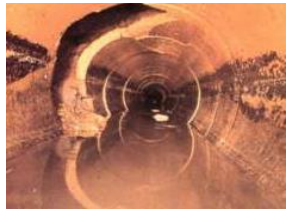
- Aging Pipeline Infrastructure
- Manual inspections are error prone
- Reactive maintenance and repair
- High cost of assessment
- Service interruptions and overflows
- Time Consuming

CRACKS

FRACTURE

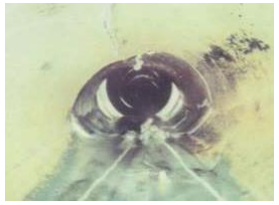


BROKEN

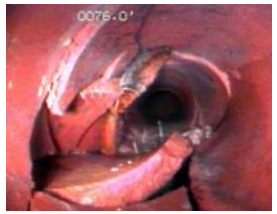


HOLE

DEPOSITS

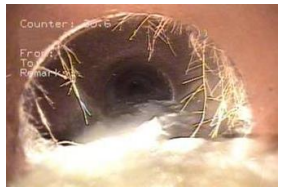


DEFORMATION



COLLAPSE

JOINTS



ROOTS

INFILTRATION

Pipe Sleuth – *Enabling Automated Anomaly Detection*

What is Pipe Sleuth?

- An automated anomaly detection solution
- Eliminates the need for detailed manual review and coding of underground sewer pipeline video scans
- Uses Advanced Image Processing and Deep Learning (AI) to automatically process video scans and identify, grade and score the overall pipe segment
- Follows NASSCO PACP and MSCC5 standards
- Generates a comprehensive inspection report

How does it work?

- Runs on-premise using a standard desktop running Windows 10. GPU card recommended to improve performance
- Consumes video formats of a wide variety
- Allows user to review individual defects
- Allows full access and playback to entire video stream

Pipe Sleuth – Workflow

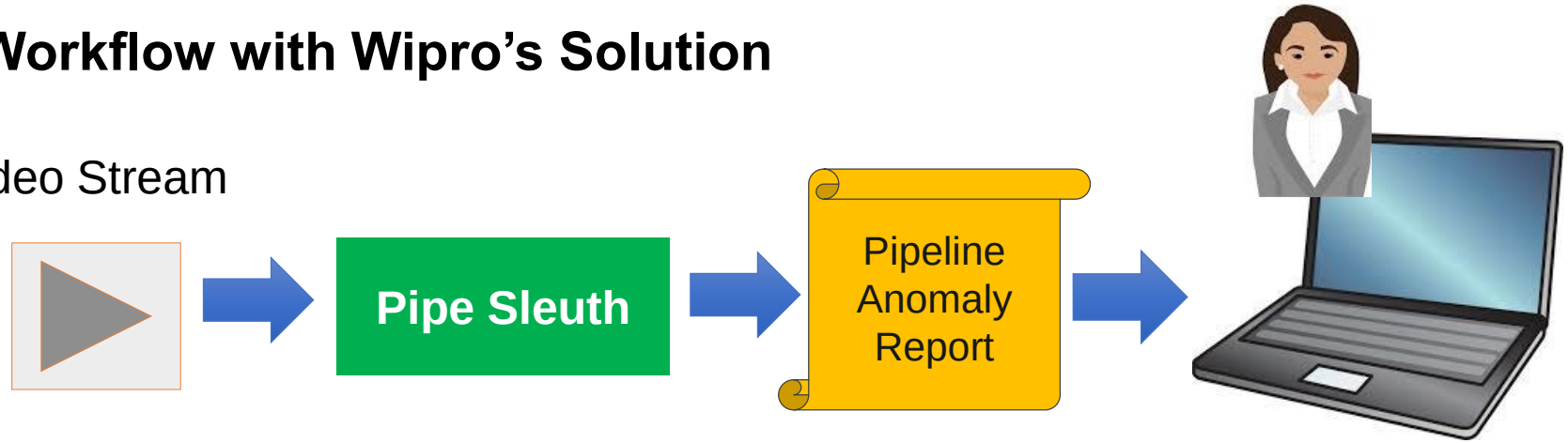
Current Workflow

Video Stream

- 1 hour of video = 2 hours or more of reviewing and tagging time + report preparation
- Not easily scalable
- Tedious, prone to fatigue, error and operator bias
- High cost

Workflow with Wipro's Solution

Video Stream



Optional Review

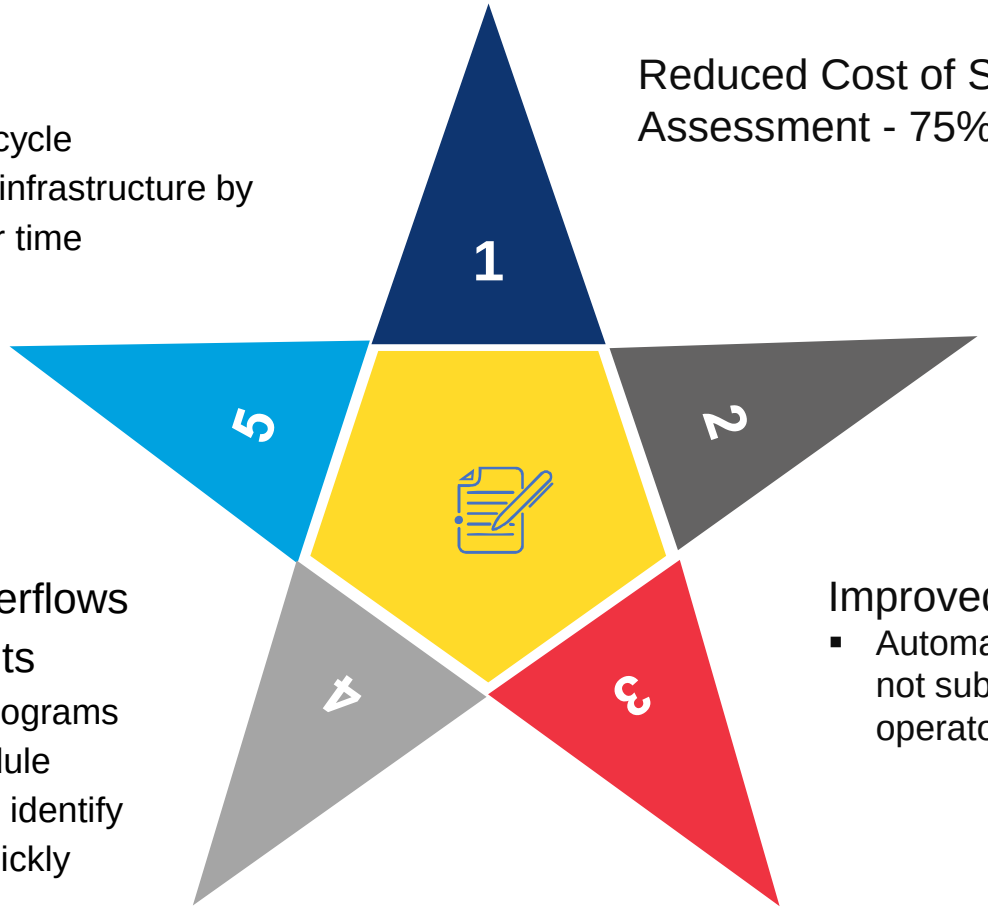
- ✓ 1 hour of video = 10 mins to detect and code defects
- ✓ 10 minutes to review selected videos
- ✓ Scalable
- ✓ Consistent assessment with no operator bias
- ✓ Low cost

Business Benefits

Extended Asset Life

- Apply repairs early in the lifecycle
- Tracks health of the pipeline infrastructure by easily comparing results over time

Reduced Cost of Scanning and Assessment - 75% savings



Reduction in Sanitary Sewer Overflows (SSOs) and Customer Complaints

- Frequent and targeted inspection programs rather than a simple calendar schedule
- Visualization of inspection results to identify potential problem locations more quickly

Improved Detection

- Automated computerized scanning is not subject to fatigue, distractions, operator bias or human errors

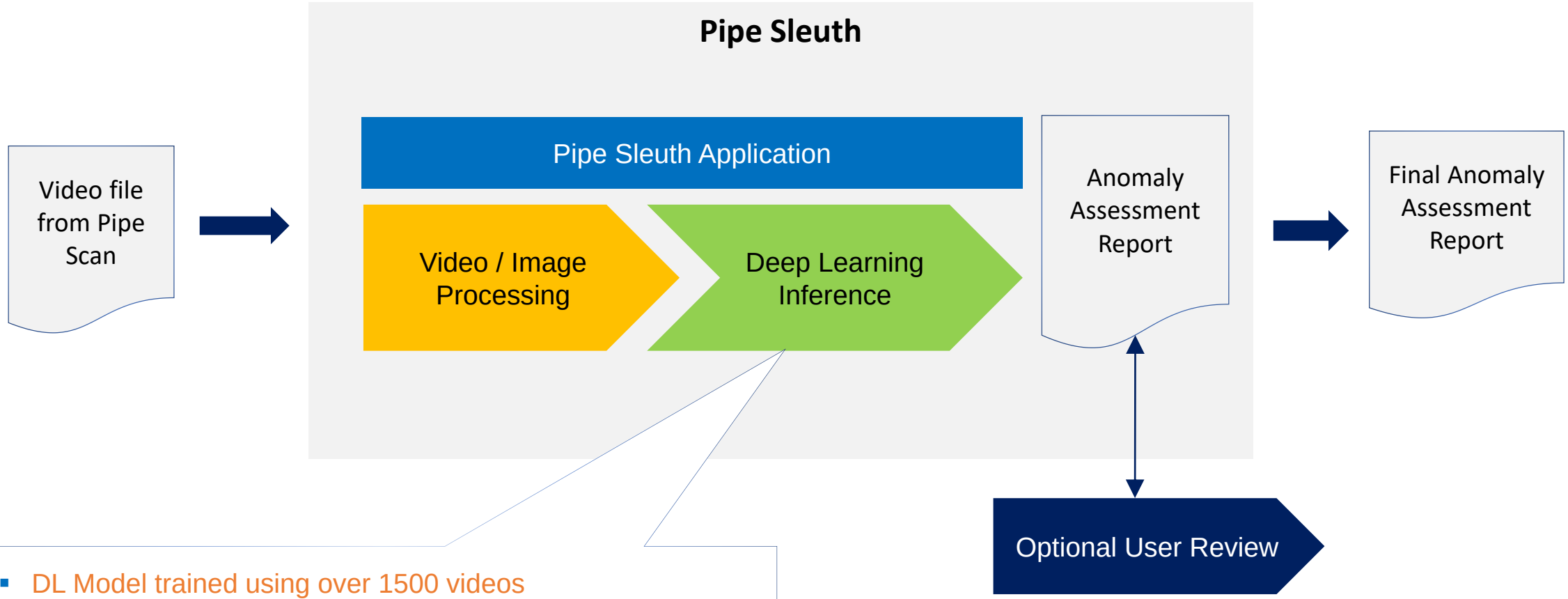
Improved Capital Investments

- Higher number of scans allows better allocation of limited resources to resolve most severe problems

Pipe Sleuth

Product Description

Pipe Sleuth Architecture



- DL Model trained using over 1500 videos
- Image dataset with over 182,000 images
- Accuracy up to 94%
- Detects 50+ anomalies and taps (connections)

Structural coding – PACP Compliant

	Structural Anomaly	PACP Code	Supported
Crack	Crack Longitudinal	CL	✓
	Crack Circumferential	CC	✓
	Crack Multiple	CM	✓
	Crack Spiral	CS	✓
	Crack Hinge	CH	✓
Fracture	Fracture Longitudinal	FL	✓
	Fracture Circumferential	FC	✓
	Fracture Multiple	FM	✓
	Fracture Spiral	FS	✓
	Fracture Hinge	FH	✓
Broken	Broken Soil Visible	BSV	✓
	Broken Void Visible	BVV	✓
Hole	Hole Soil Visible	HSV	✓
	Hole Void Visible	HVV	✓

	Structural Anomaly	PACP Code	Supported
Joint	Joint Offset Small	JOS	✓
	Joint Offset Medium	JOM	✓
	Joint Offset Large	JOL	✓
	Joint Separation Small	JSS	✓
	Joint Separation Medium	JSM	✓
	Joint Separation Large	JSL	✓
	Joint Angular Small	JSS	✓
	Joint Angular Medium	JSM	✓
	Joint Angular Large	JSL	✓
Deformed	Deformed Rigid	D	✓
	Collapse	X	✓

Operation and Maintenance coding – PACP Compliant

Operation and Maintenance		PACP Code	Supported
Deposits	Deposits Attached Encrustation	DAE	✓
	Deposits Attached Grease	DAGS	✓
	Deposits Attached Others	DAZ	✓
	Deposits Settled Others	DSZ	✓

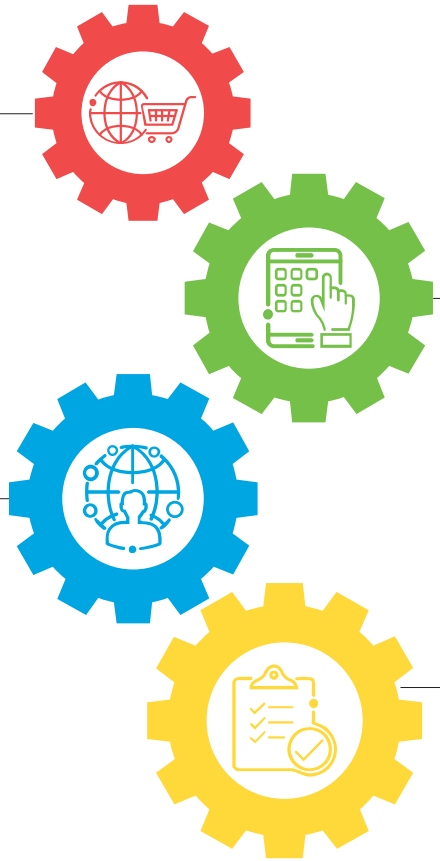
Operation and Maintenance		PACP Code	Supported
Infiltration	Infiltration Stain	IS	✓
	Infiltration Weeper	IW	✓
	Infiltration Dripper	ID	✓
	Infiltration Runner	IR	✓
	Infiltration Gusher	IG	✓

Operation and Maintenance		PACP Code	Supported
Roots	Roots Fine Barrel	RFB	✓
	Roots Fine Lateral	RFL	✓
	Roots Fine Connection	RFC	✓
	Roots Fine Joint	RFJ	✓
	Roots Medium Barrel	RMB	✓
	Roots Medium Lateral	RML	✓
	Roots Medium Connection	RMC	✓
	Roots Medium Joint	RMJ	✓
	Roots Ball Barrel	RBB	✓
	Roots Ball Lateral	RBL	✓
	Roots Ball Connection	RBC	✓
	Roots Ball Joint	RBC	✓

Pipe Sleuth Application - Features

Windows 10 GUI based application

- Ability to process multiple video files unattended
- Summary of anomalies detected and overall assessment score as each video is processed



User Review

- Allows user review of the anomalies detected
- Allows user to identify and tag missed anomalies
- Allows user to remove false positives
- Allows user to change detection code for individual anomalies
- Manual entry option for anomaly location (distance from the starting manhole)

Playback

- Playback of the video clip for each detected anomaly (5 second before and after the anomaly)
- Full playback of processed video file showcasing anomalies with bounding boxes
- Playback of selected frames for processing
- Video playback control (Play, Pause, Seek)
- Ability to add missed defects or change defect code

Report

- Condition assessment report automatically generated
- Report re-generation after the user reviews recommendations (saves original and updated report)
- Filter for selected anomaly review
- Report viewer
- Consolidated report (metadata.csv file) view with count of each anomaly detected

Input Requirements

- Pipe Sleuth supports the following image resolutions
  - SD (640x360 & 640x480)
  - DVD (720×480 & 720×576)
  - HD (1280x720, 1920x1080)
- Pipe Sleuth supports the following video file formats
  - .mpg (MPEG file format)
  - .avi (AVI file format)
  - .mp4 (MPEG4 or H.264 or XviD video compression)
  - .mov (MPEG4 or H.264 video compression)
  - .wmv (Windows Media format)
- Videos files can be stored locally, on the network or in the Cloud

Output

1. **Pipeline Assessment Report**
    1. Report Summary
        - Overall pipe rating
        - Structural rating
        - O&M rating
        - Structural Quick
        - O&M Quick
        - Structural Index
        - O&M Index
    2. Detailed listing of the anomalies found in the video including defect image and bounding box
        - Anomaly PACP or MSCC5 code where available
        - Description of Anomaly
        - Structural grade and O&M grade of each anomaly found
        - Video Timestamp within the video file at point where the anomaly is found
        - Distance from the starting manhole at point the anomaly is found
            - (*Only if the distance information is available from the video frame)
        - Start Clock and End Clock position of the anomaly frame or image
2. **Anomaly Metadata –** Consolidated report of each video file in CSV Excel format
3. **Log File** – Performance metrics (ex: time to process videos)
4. **JPEG images** (extracted images from the video) of anomalies detected with bounding boxes

System Requirements

- **Hardware Requirements**
  - Standalone desktop or laptop running Intel x86 CPUs
  - Minimum 8 GB RAM
  - Minimum 50 GB free HDD
  - Recommendation for
    - Reasonable performance – Intel Core-i7 CPU with 16GB RAM
    - Better Performance – Laptop / Desktops running a nVidia GPU card such as GeForce GTX or equivalent GPUs
- **Operating System Requirements** – 64-bit Windows 10 Operating System