Jacobs Challenging today. Reinventing tomorrow.

AI for AI

How Artificial Intelligence and technology tools are addressing Aging Infrastructure

September 18, 2020

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Jacobs

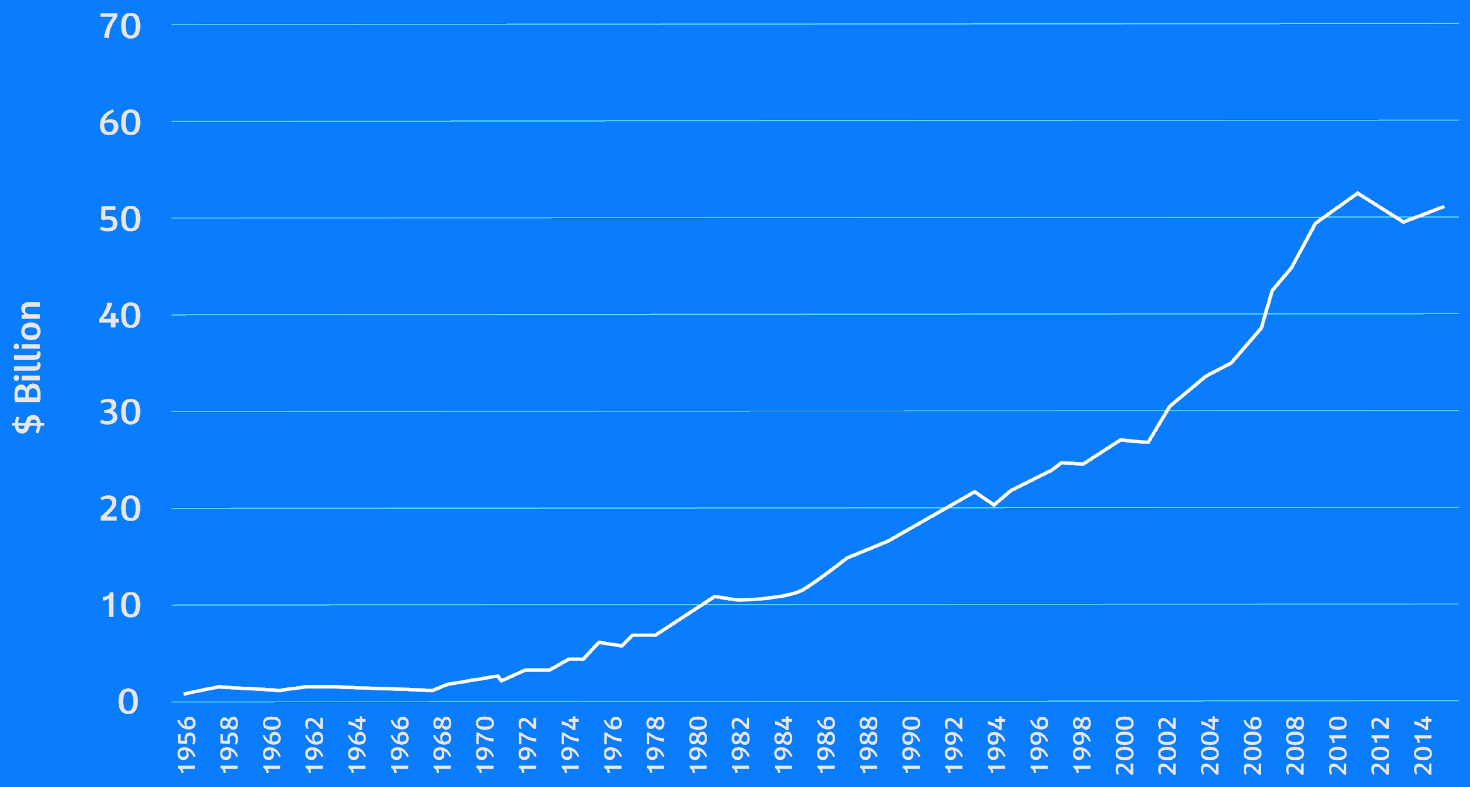
Challenging today.
Reinventing tomorrow.

Innovations in Artificial Intelligence for Sewer Asset Management

Sewer O&M is a $50B/yr Government Expenditure

- 800,000 miles of public sewer
- 500,000 miles of private sewers
- Earth-to-Moon is 238,900 miles
- CCTV'ing even 1% of this produces 38,133 hours (1,588 days) worth of video

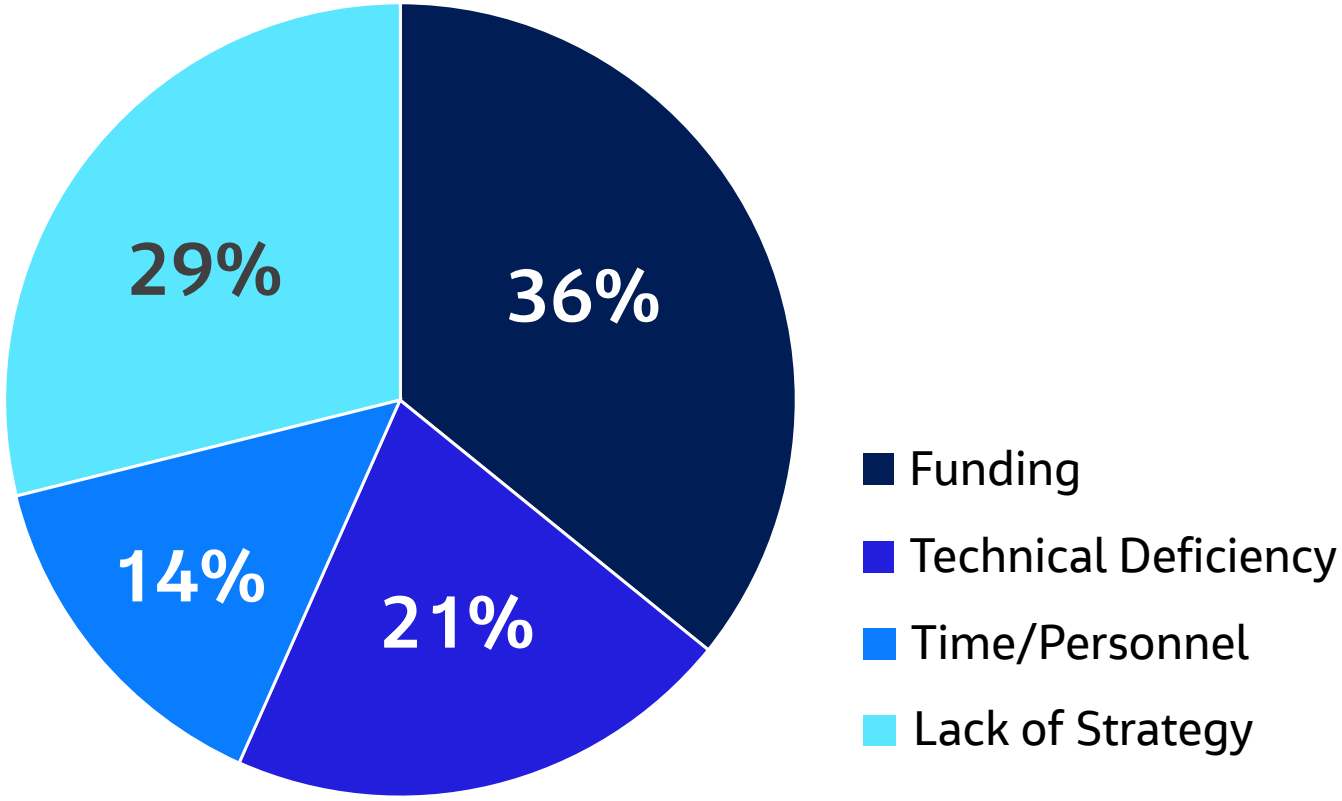
…which must be viewed by a human being



https://www.usmayors.org/2018/01/10/local-government-investment-in-water-and-sewer-2000-2015/

Infrastructure Renewal is $105B Behind Schedule

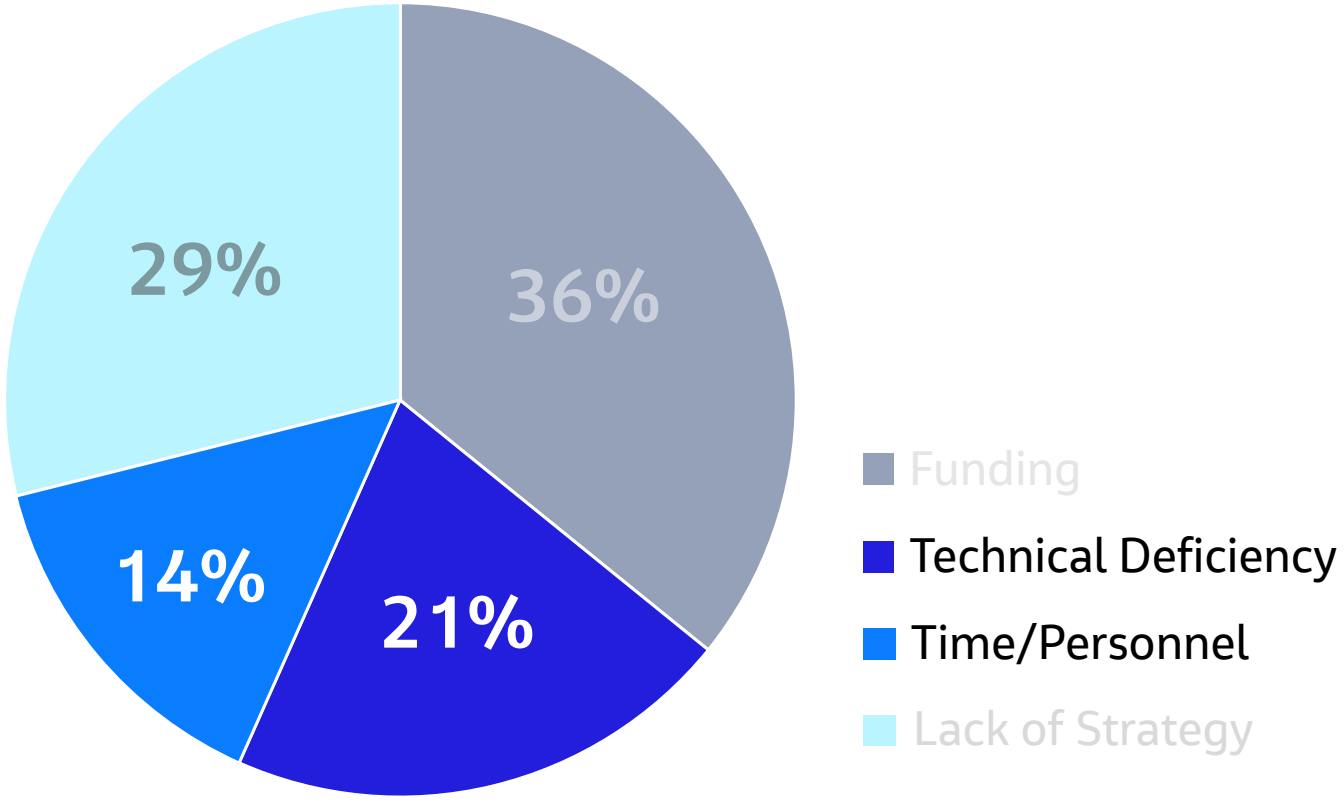
Impediments to Proactive Approach



Source: 2017 WRF Study on Proactive Cond Assessment and Renewal

The Status Quo for Sewer CCTV Condition Assessment Cannot Keep Up

Impediments to Proactive Approach

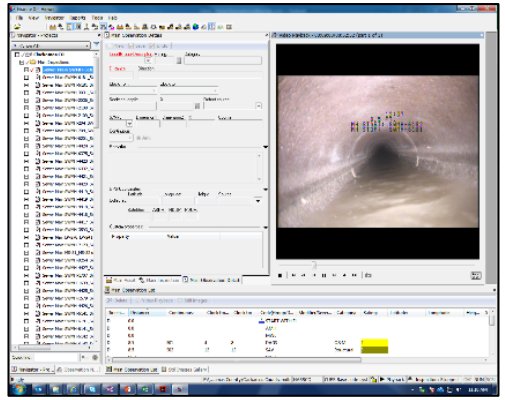


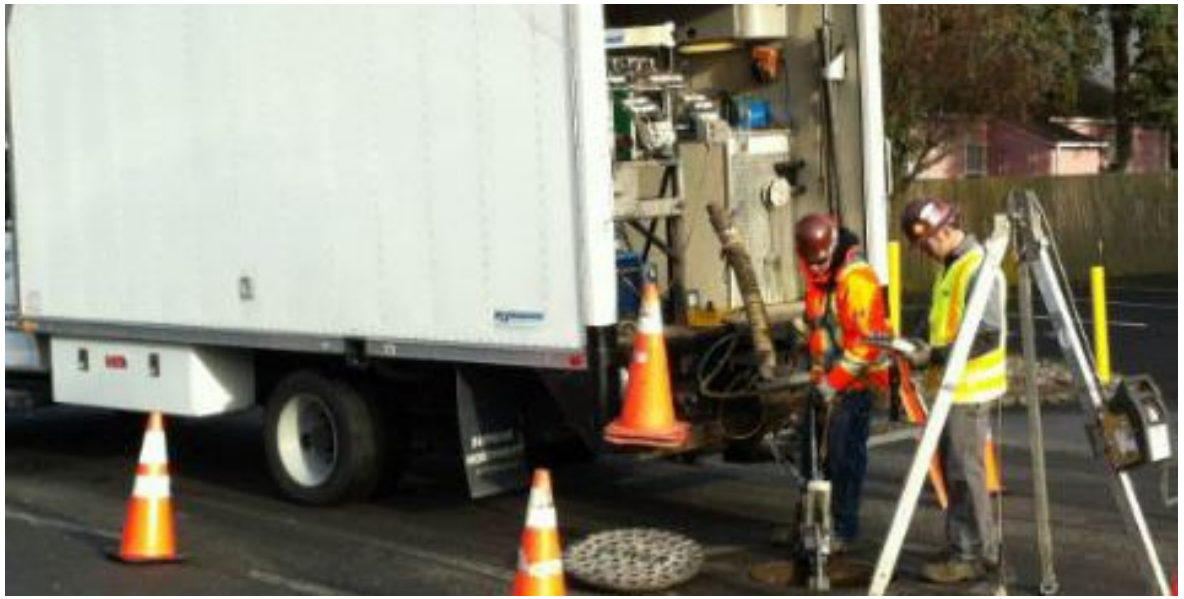
- Most cities conduct regular sewer CCTV inspections but still find:
  - Personnel don't have time available to focus on defect coding
  - Methods for defect coding are technically deficient
- In the life span of 1,000LF of sewer video: 2-6 hours (30-40% of the total acquisition time) is spent doing defect coding

What the CCTV Pipe Inspector has to worry about…

- Mobilization
- Finding the manholes
- Traffic control
- Setup
- Cleaning
- Inspection
- **Defect coding**
- Robot repairs
- Demobilization
- Emergency communications
- Data transfer

30-40% of the total time is spent coding…

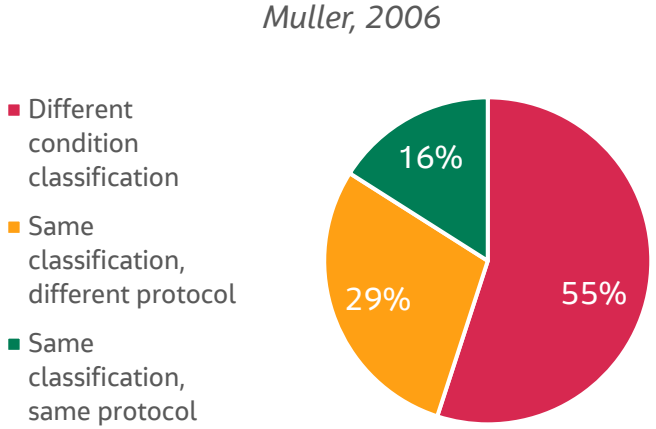


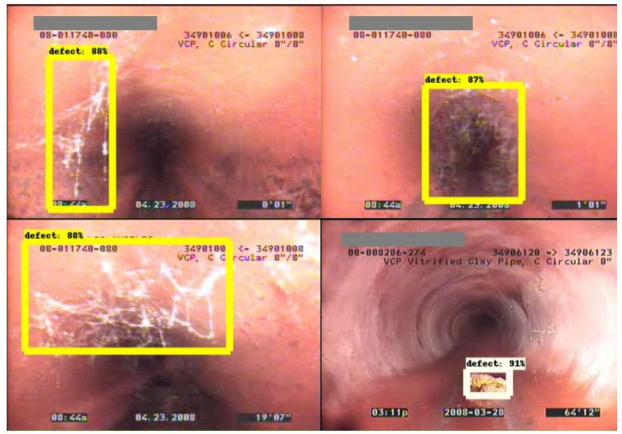


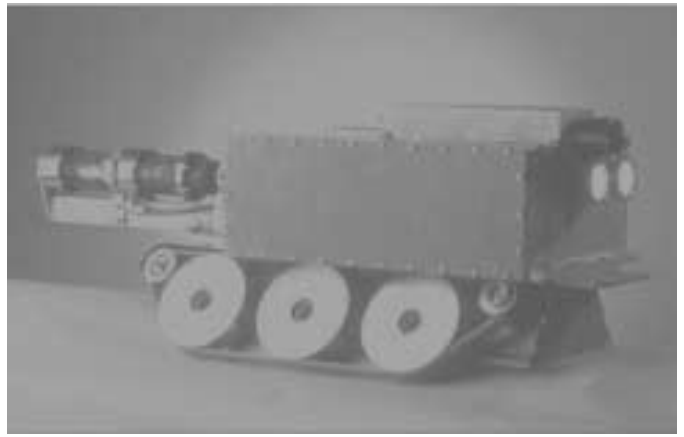
Prior efforts have improved the coding process, but not conquered it

- Training standards have reduced bias, but the majority of data is still heavily skewed
- Image mapping software programs worked in theory, but were overwhelmed
- Multi-sensor inspection quantifies defects, but is time consuming and diameter limited
- Most legacy sewer CCTV data will be 352x240 pix .MPG or .AVI files

Muller, 2006







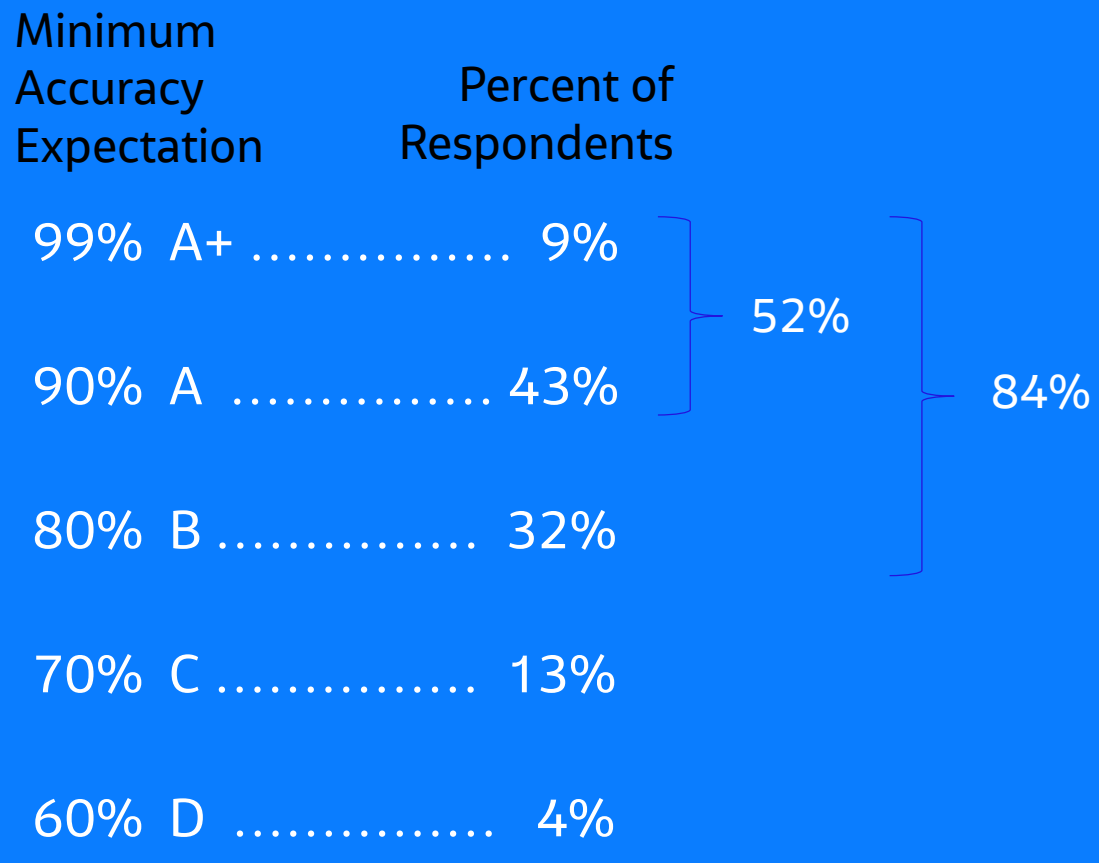
Automated Sewer CCTV Defect Coding

Case Study: Jacobs/Hitachi - AI Defect Discovery & Coding

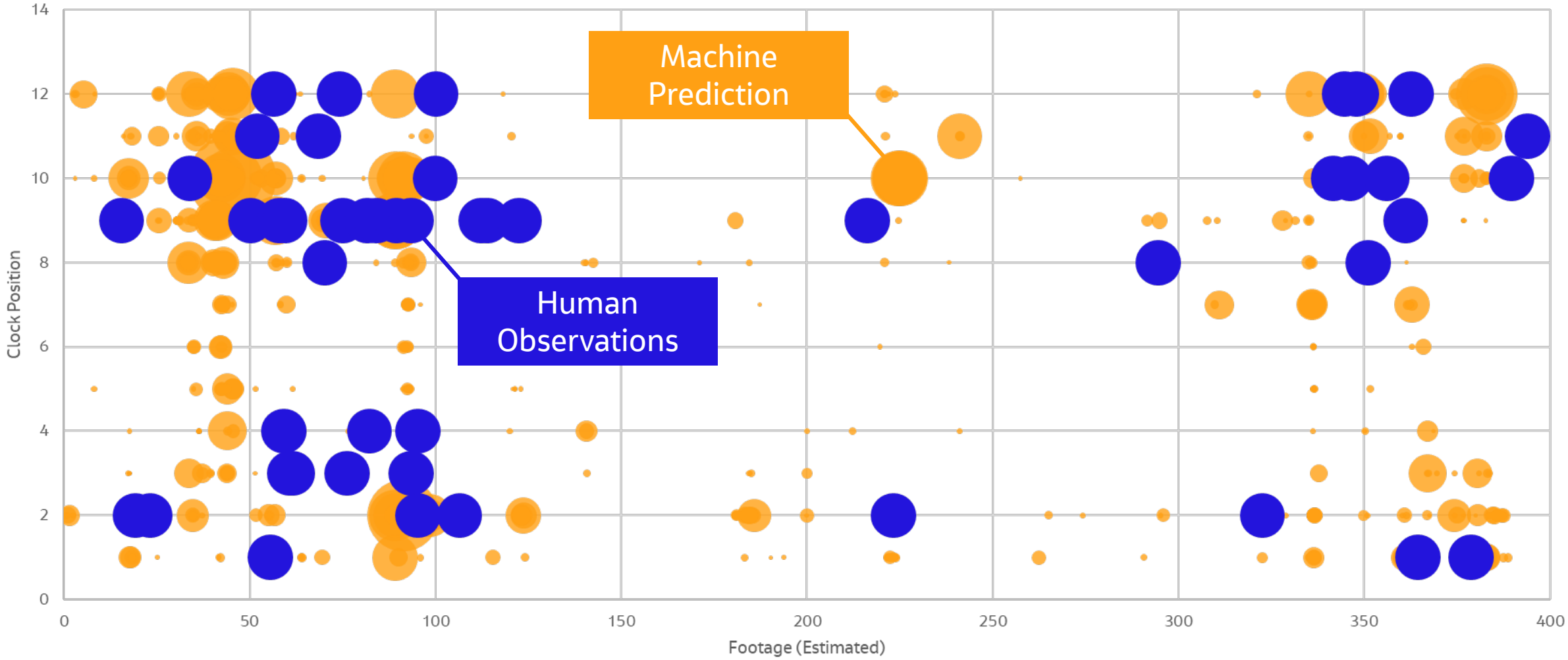
Accuracy Expectations

What level of sewer CCTV defect coding accuracy will the industry expect from a machine?

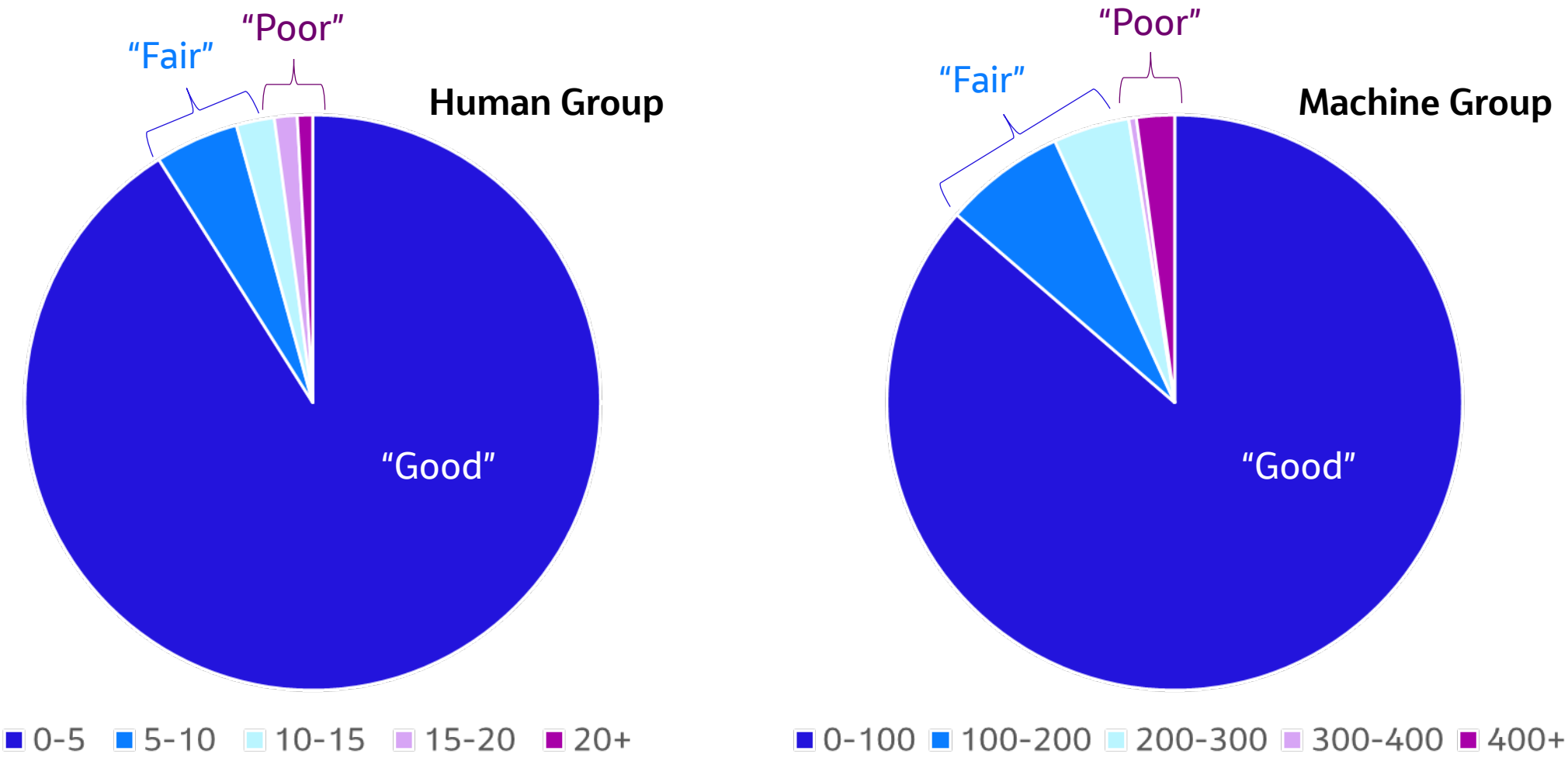
(consider that it would be consistent and complete)



“Under the Hood” Prototype Results: Individual Pipe Graph



“Under the Hood” Prototype Results: Defect Count Groupings/Rating

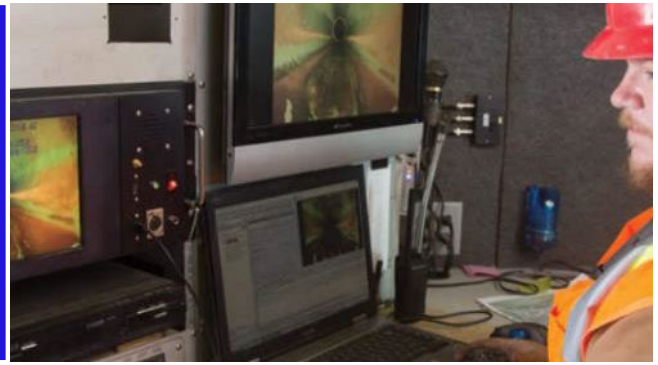


How will this help?

More complete data	Improved data consistency	Faster data processing
…machines never blink	…machines are not bias	…machines do not fatigue

Deployment alone is challenging enough…

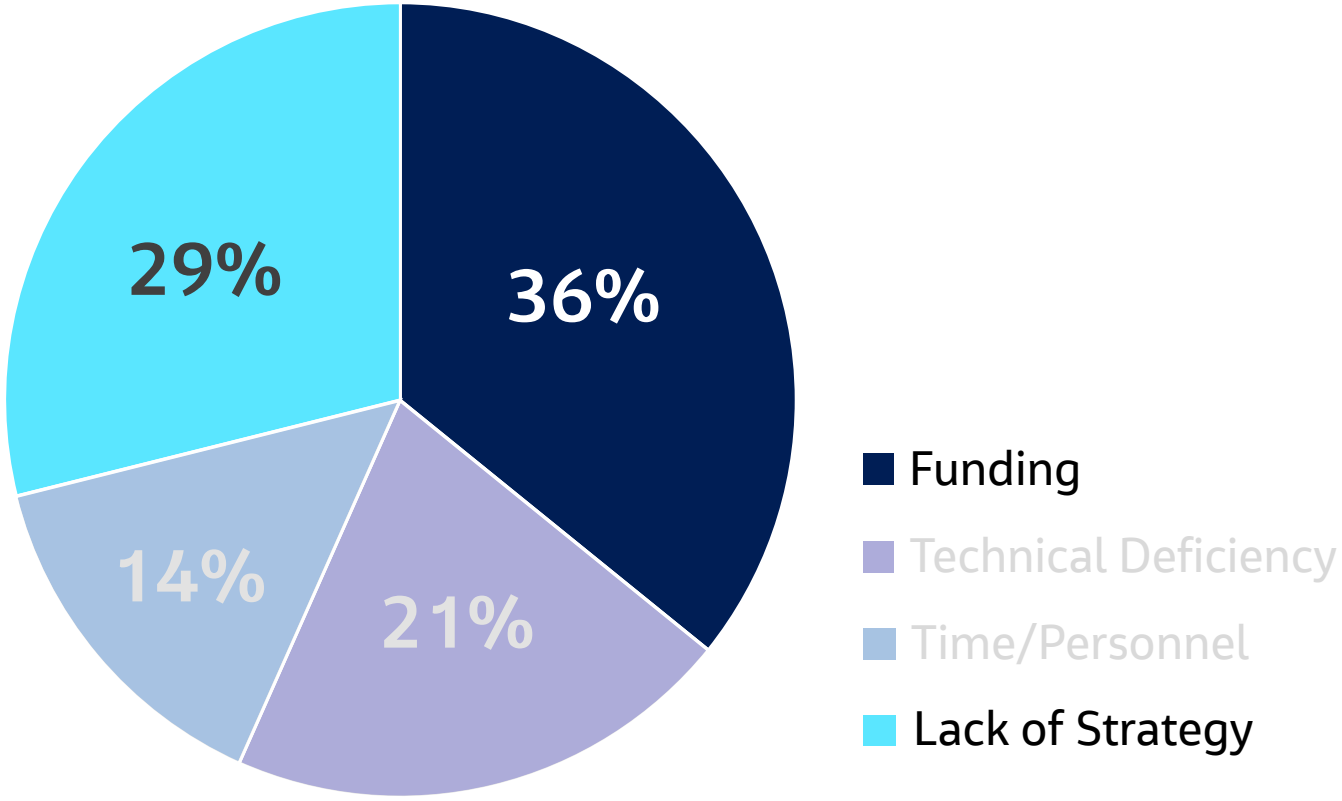
…leave the data cataloguing task to the machines



AI refined Service Life Predictions and O&M Optimization

Inefficiencies in Capital and Maintenance Planning have Big Impacts

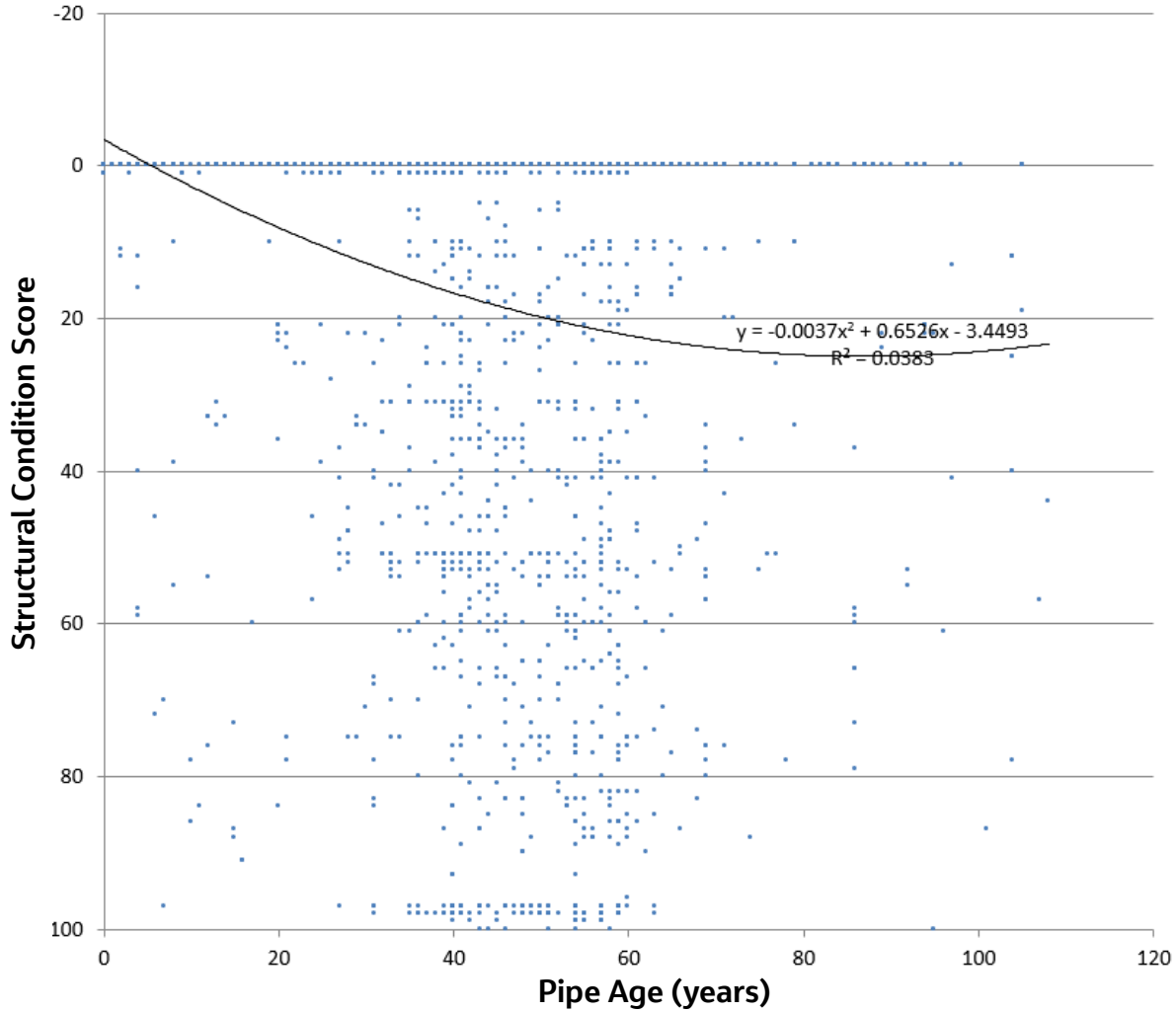
Impediments to Proactive Approach



- Two largest obstacles to an effective proactive management strategy are:
  - Insufficient Funding
  - Lack of Strategy
- An 10% increase in accuracy of structural RUL forecasts and O&M maintenance frequencies can result in reduced lifecycle cost by up to 25%.

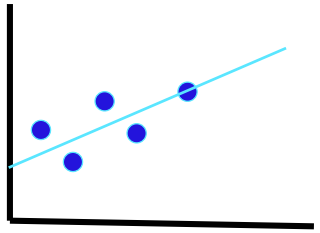
Past predictive models have fallen short

- Finding trends in a “sneeze”
  - Limited by human ability to see trends
  - Simplified into simple X-Y plots correlating some measure of “condition” with some measure of “time”
- Other predictive models used tree logic with “if/then” statements - very time consuming even to map out a few variables
- All to answer questions like:
  - When will the pipe fail?
  - How will it fail?
  - What is the best way to prevent failure?



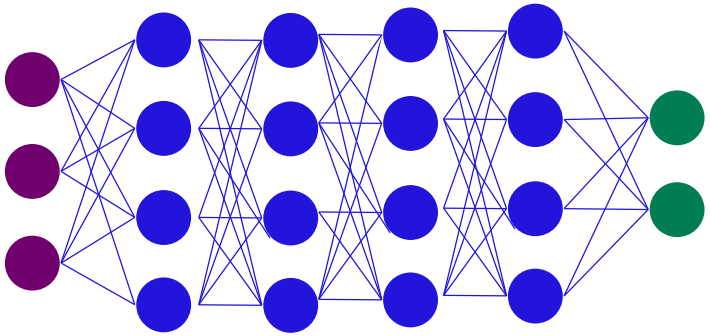
What Makes Machine Learning Different?

Mathematical or Statistical Models	Deep Neural Networks



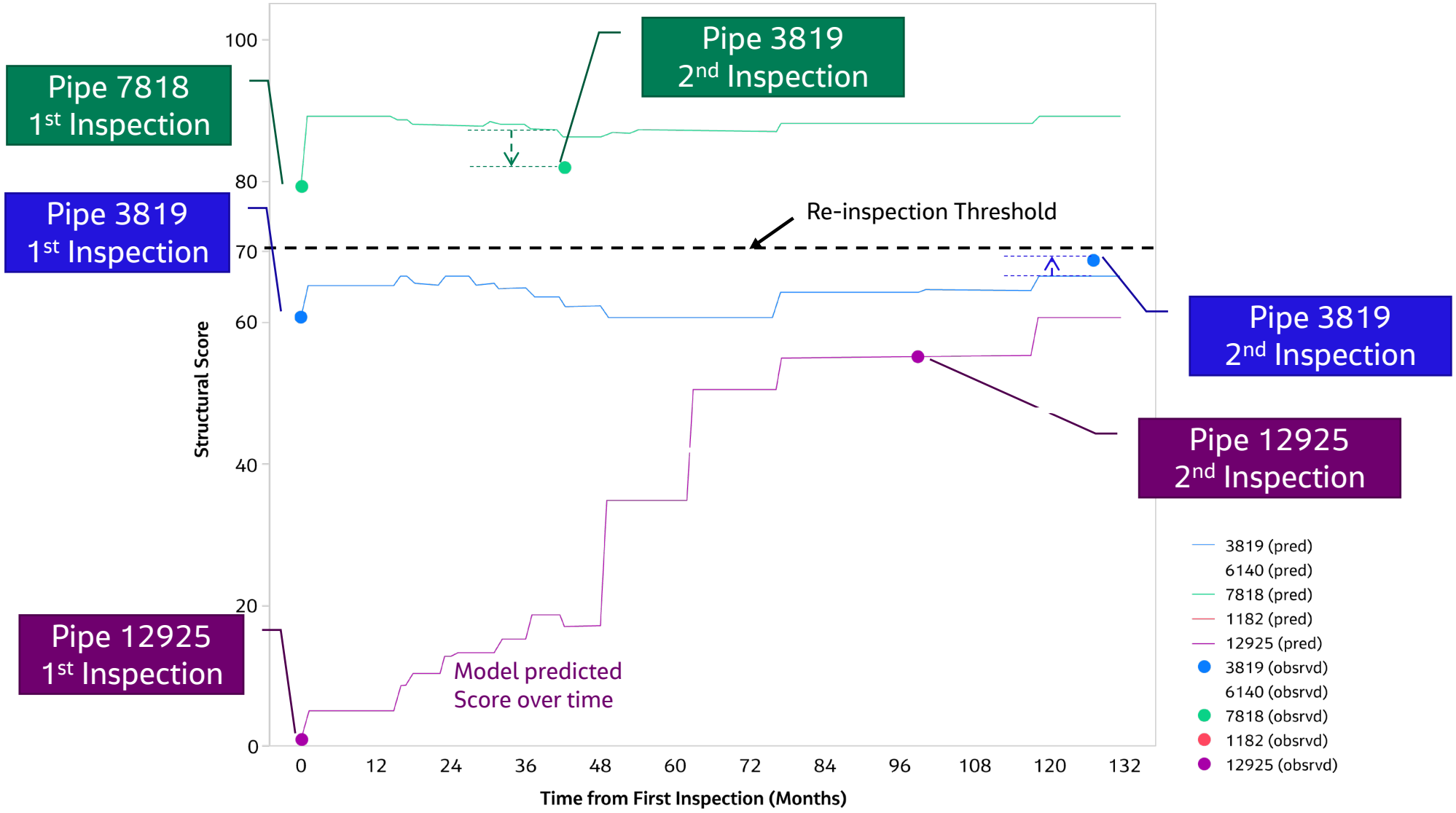
y = mx + b

VS

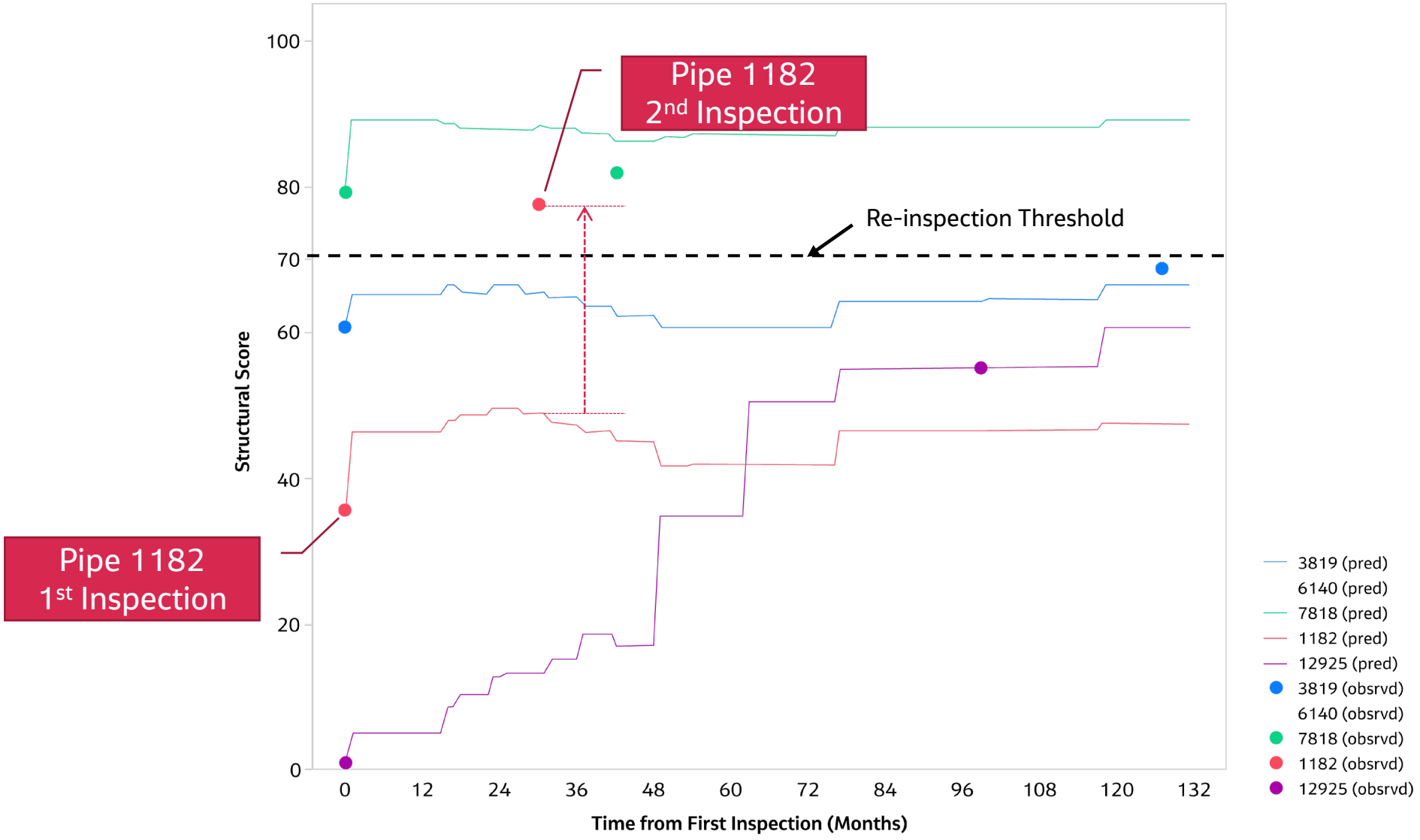


Pattern Recognition! …The ability for machines to predict outcomes without being explicitly programmed.

“Under the Hood” Prototype Results: Predictions that Matched Test Data

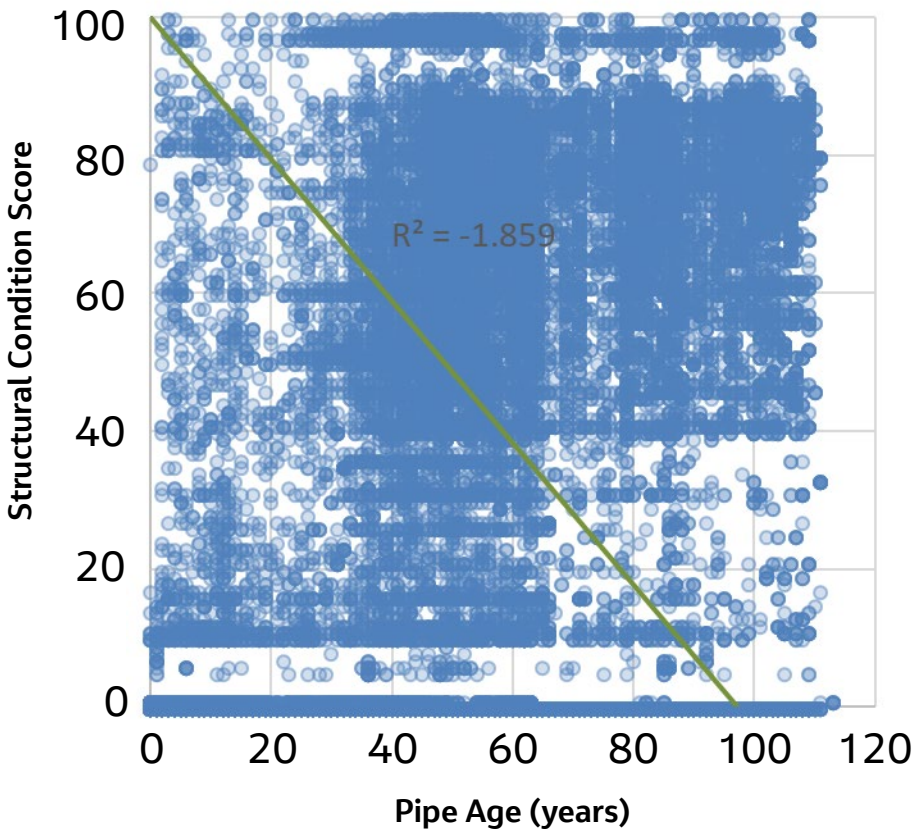


“Under the Hood” Prototype Results: Predictions that Missed Test Data

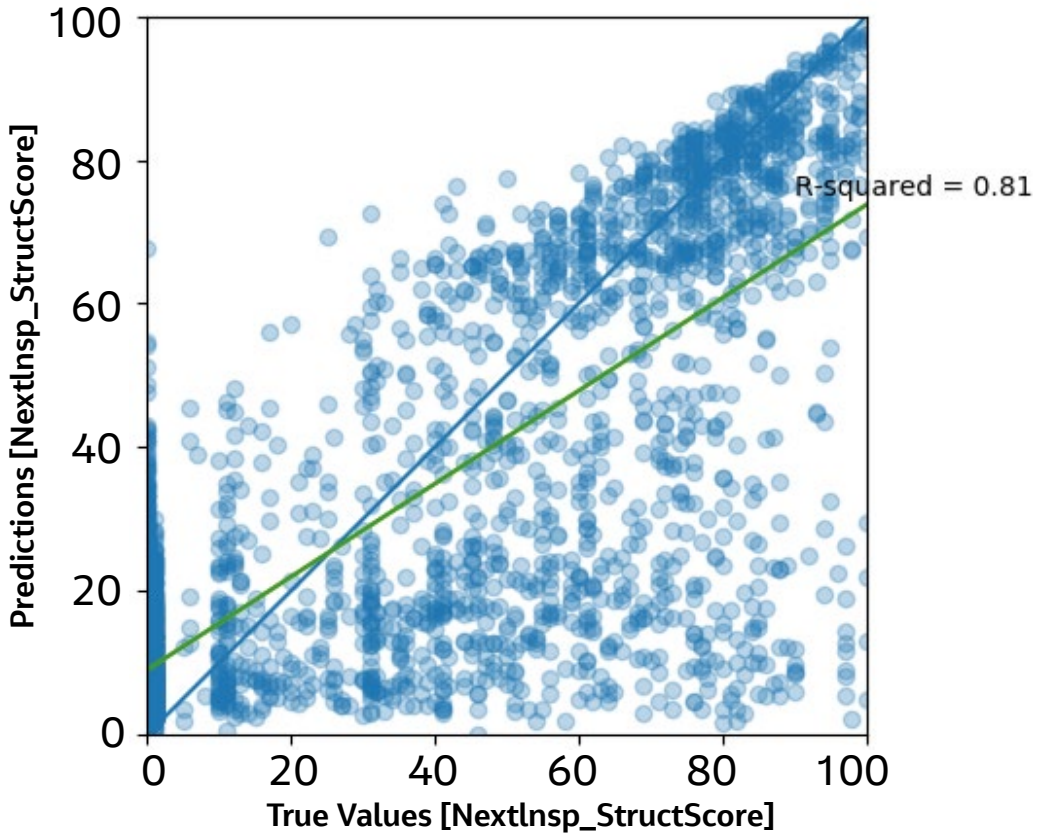


Output Accuracy Comparisons

Conventional Decay Curves



AI/ML Predictions



Benefits

→ Unique decay curves for each sewer pipe accounting for the unique combination of defects and asset info:
Example

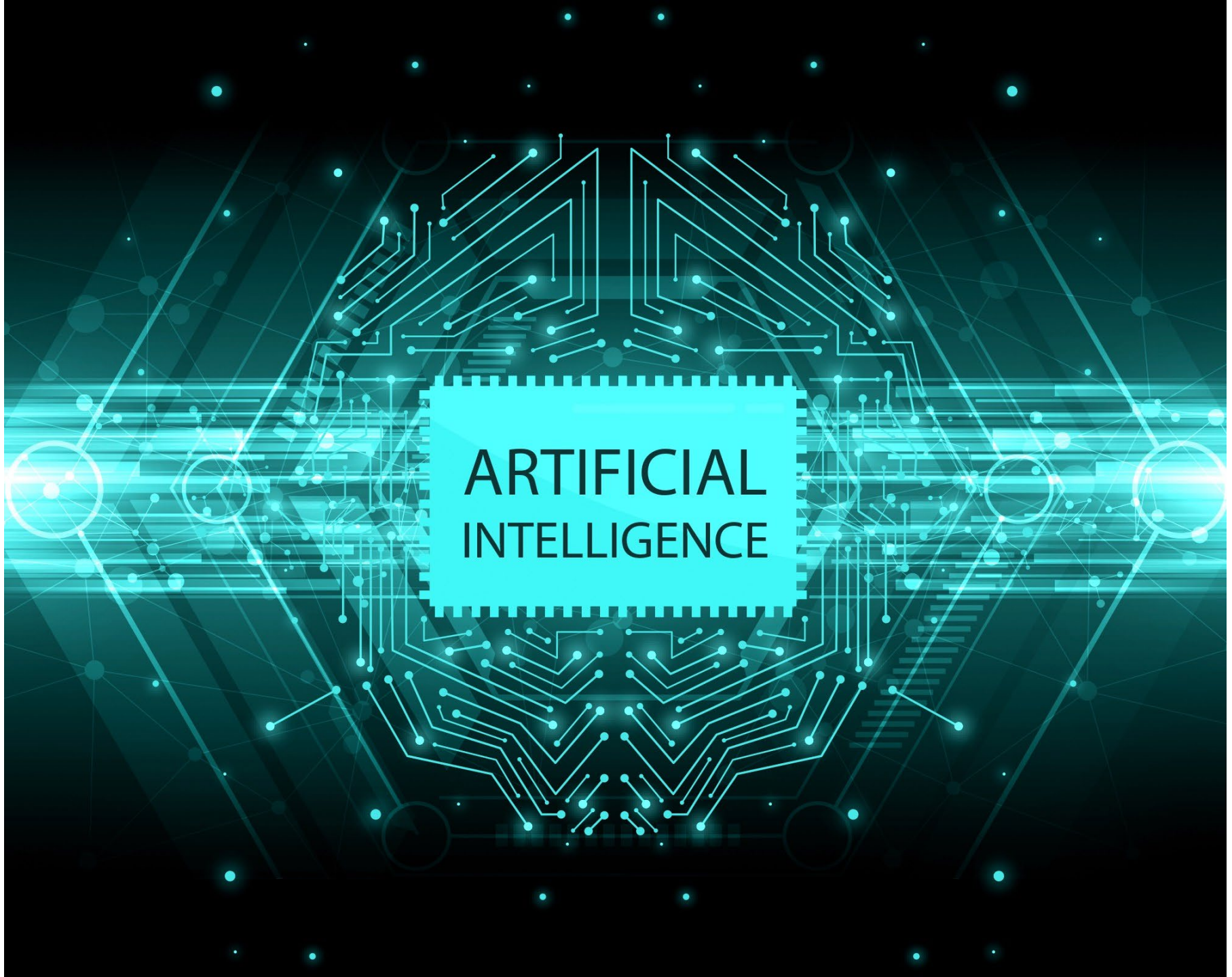
Pipe 1: Clay, with many cracks and some grease

Pipe 2: Concrete, with single large fracture and some sand

- Old Way with Scores: Both get the same numeric "Score". Which we then use in a traditional decay curve to predict the same RUL for both.
- New with AI: Different and specific RULs because the nature of their defects is different and the AI saw a stronger correlation to decay rate between one combination of defects over the other.

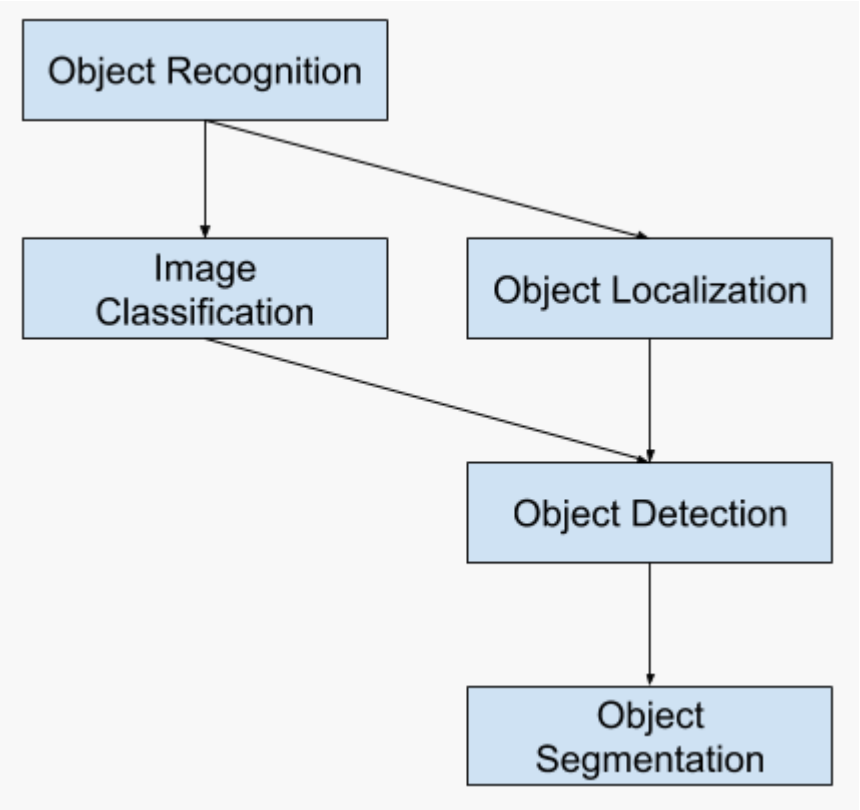
→ Can include parameters that before were not cost-effective to build into the analysis, but that can be very strong LOCALIZED predictors.
Example

- Installing contractor? Specific manufacture of pipe?



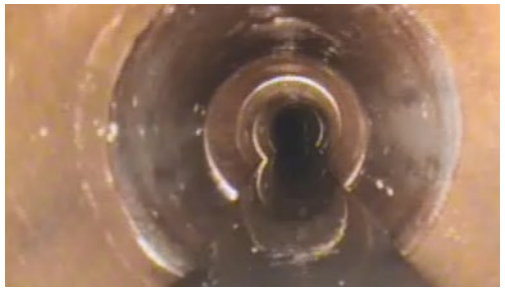
Wrap-Up

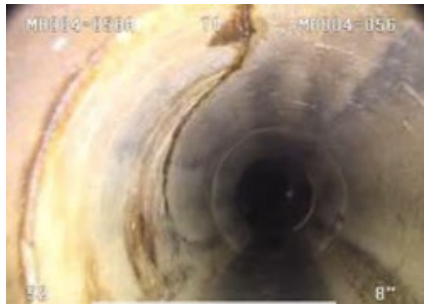
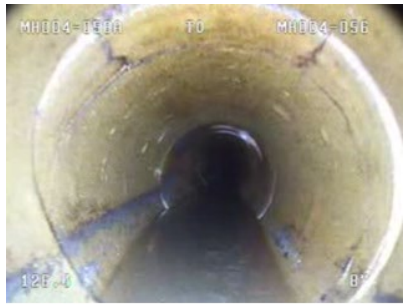
- The basic Tasks with AI powered Object Detection & Recognition



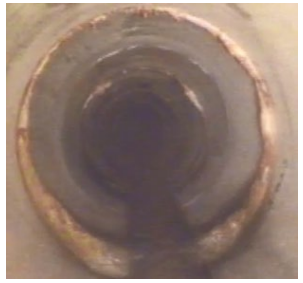
Pipeline Defects

(Cracks, Fractures, Broken, Deformed, Collapsed, Joint Offsets, Deposits Attached & Settled, Roots)

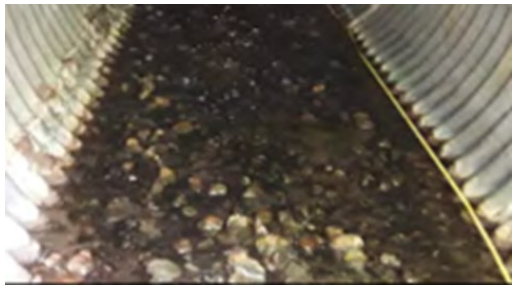


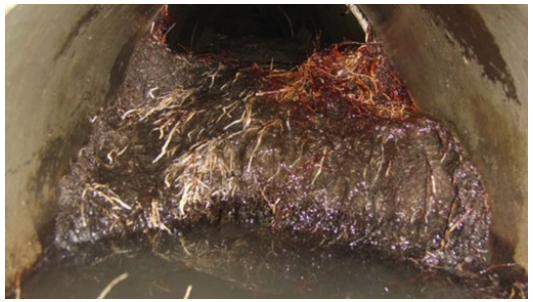








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