Predictive and preventive maintenance using SAB and Delta-t®

Introduction

- Locate weak pipes before rupture, accidents and leakage
- Utilize every section of pipes its full life time

Distribution Network

- Core in the District Heating business.
- Connection to the customers.
- Source of losses – energy losses higher than 10%.
- ”Buried assets”, which can work +100 years.
- Reduce balance sheet if the assets life time can be maximized.

Return on Assets

How to improve Return On Capital Employed?

ROCE

$$\frac{\text{Revenues} - \underline{\textbf{Costs}}}{\underline{\textbf{Assets}}}$$

Costs

- Poor insulation (wet) – energy losses.
- Loss of hot water – leakages.
- Failures, accidental leakages – emergency actions.

Assets - Capital

- Expensive and complex to replace

  80% of capex related to non-value added work (excavation, welding, etc)

- Loss of supply
- Blocked streets

Maintenance Method

1. Corrective: Repair/replace pipe after failure

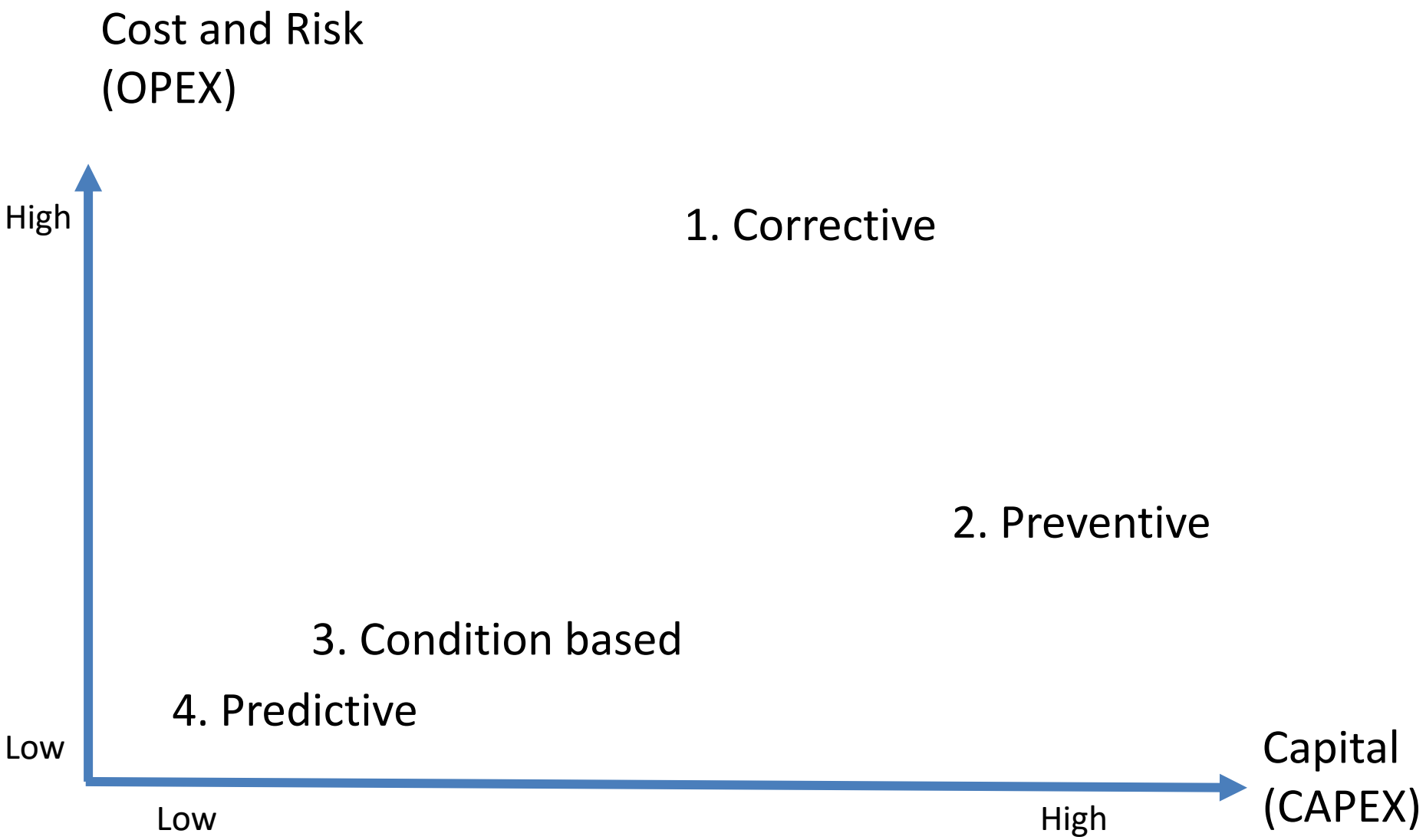
2. Preventive: Replace pipe before failure (and before full life time)

- Time Based
- Risk Based

3. Condition based: Replace when pipe condition is bad

4. Predictive: Timing of replacement of pipe is planned years in advance

Cost, Risk and Capital vs. Maintenace



Predictive Maintenance

- Reduce leakage, loss of hot water and degradation of insulation.
- Reduce risk of failures – large bursts causing consequential damages.
- Maximize utilization of pipes – minimize replacements of pipes.

Monitoring Methods DH-pipes

- Visual
- Alarm wires
- Thermography
- Listening Accoustics
- Correlation Accoustics
- Electro – impedance
- Ultrasound

Jensen Predictive Maintenance - JPM

Four levels of monitoring

1. Detect leakage
2. Locate leakage
3. Detect Weakness
4. Locate Weakness

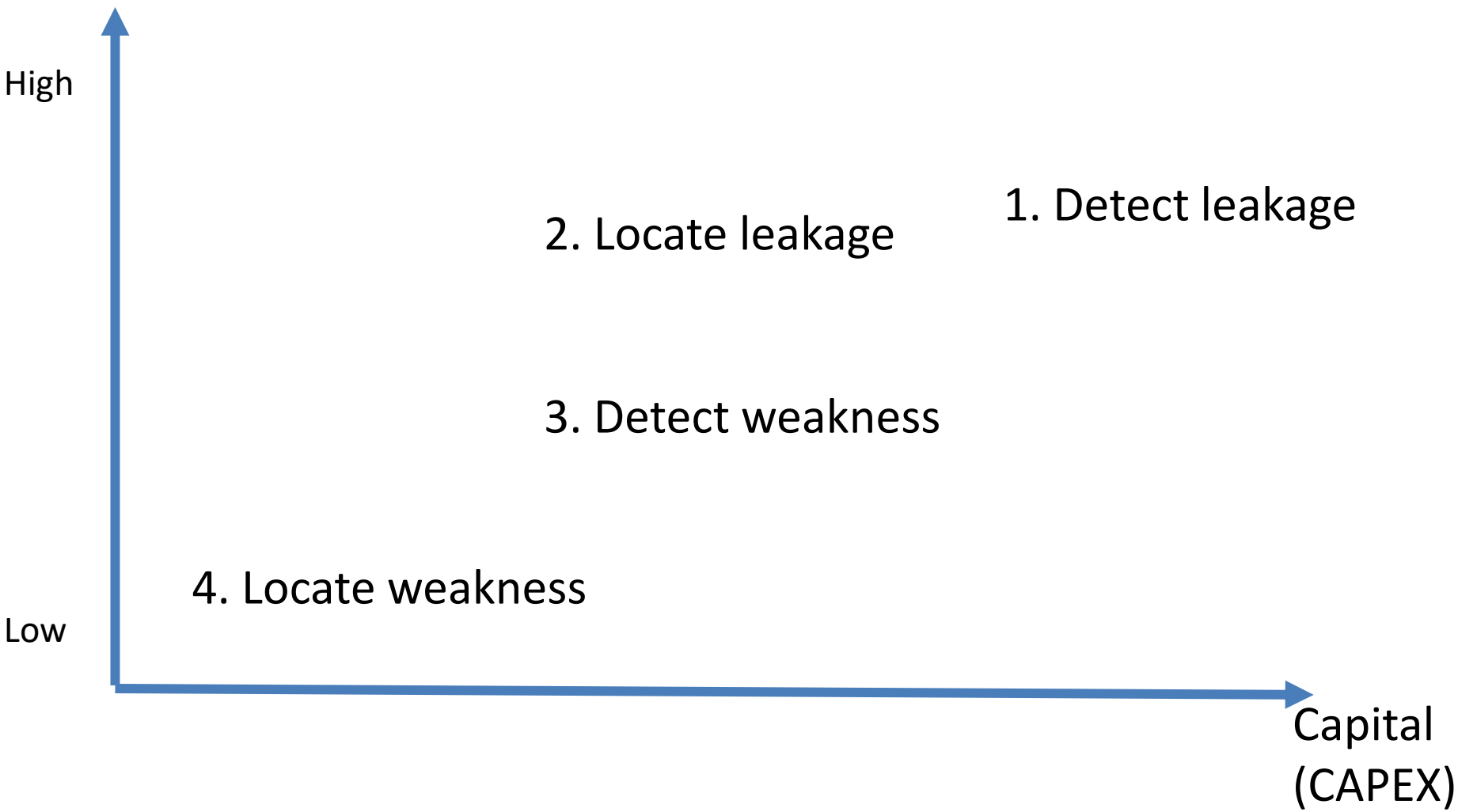
JPM with SAB Smart Active Box

1. IoT Sound/vibration amplifier
2. Actuator/Vibrator
3. Patented microphone (accelerometer)
4. IoT Sensorbox

5. Patented power Supply, heat-to-power

Installation Öresundskraft, Helsingborg

Cost, Risk and Capital vs. Monitoring



1. Detect Leakage

- Patented microphone and amplifier detects increased noise level (dB).
- Leakages cause higher noise (vibrations).

2. Locate Leakage

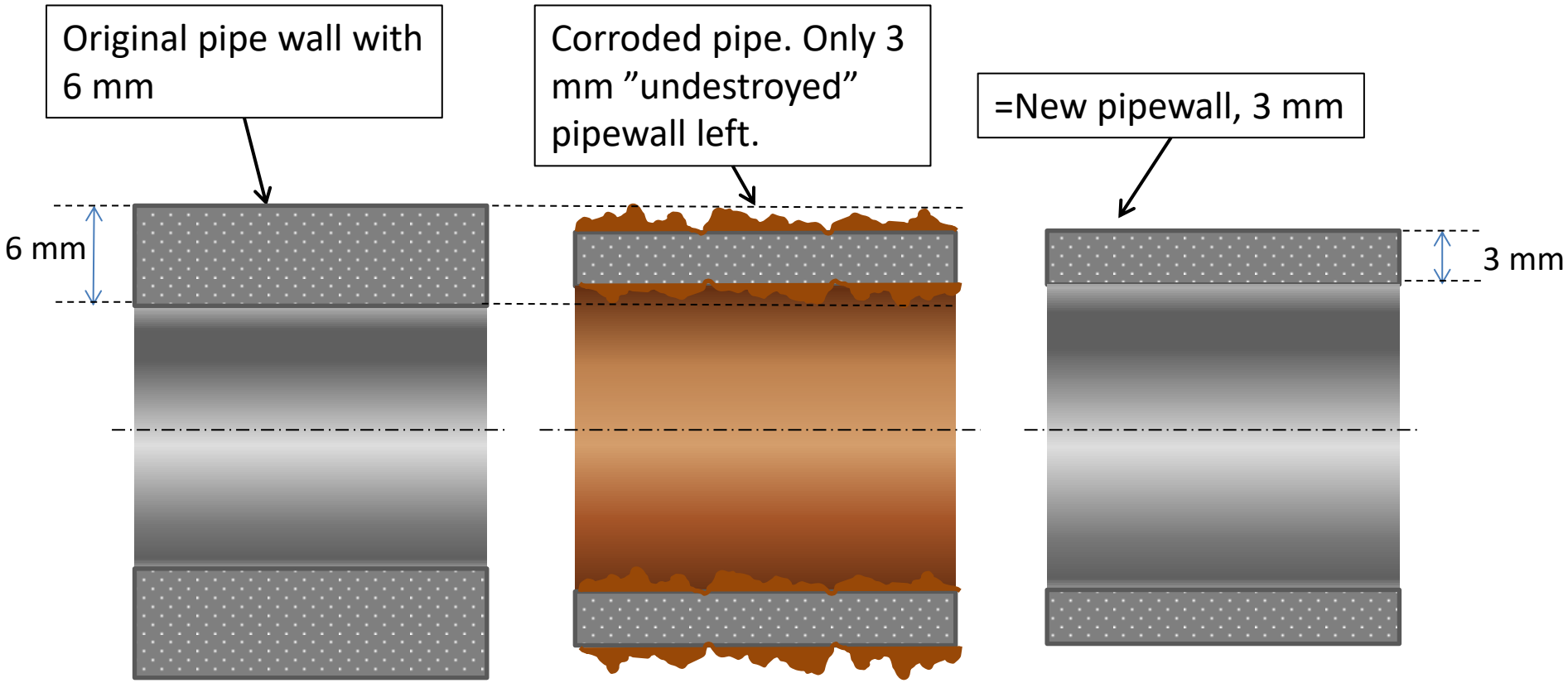
- Patented microphones and amplifiers record noise from two directions.
- Acoustic signal analysis – correlation – locate the leakage.

3. Detect Weakness

- Patented microphones and amplifiers record generated noise (acoustics).
- The average remaining strength/thickness of the pipe wall is a function of the speed of the acoustic wave propagation.
- Delta-t® (thickness) monitors average pipe strength beween two measurement points (~100 m) and predicts degradation (corrosion and/or mechanical wear.

4S- listening device in use during Delta-t® measurements (manual)

Delta-t® – Equivalent strength



The original pipewall has diminished by 50% from 6 to 3 mm. The pipewall has at present moment the equal strength of a new pipe with 3 mm pipewall.

Predictive Maintenance

- Maintenance actions

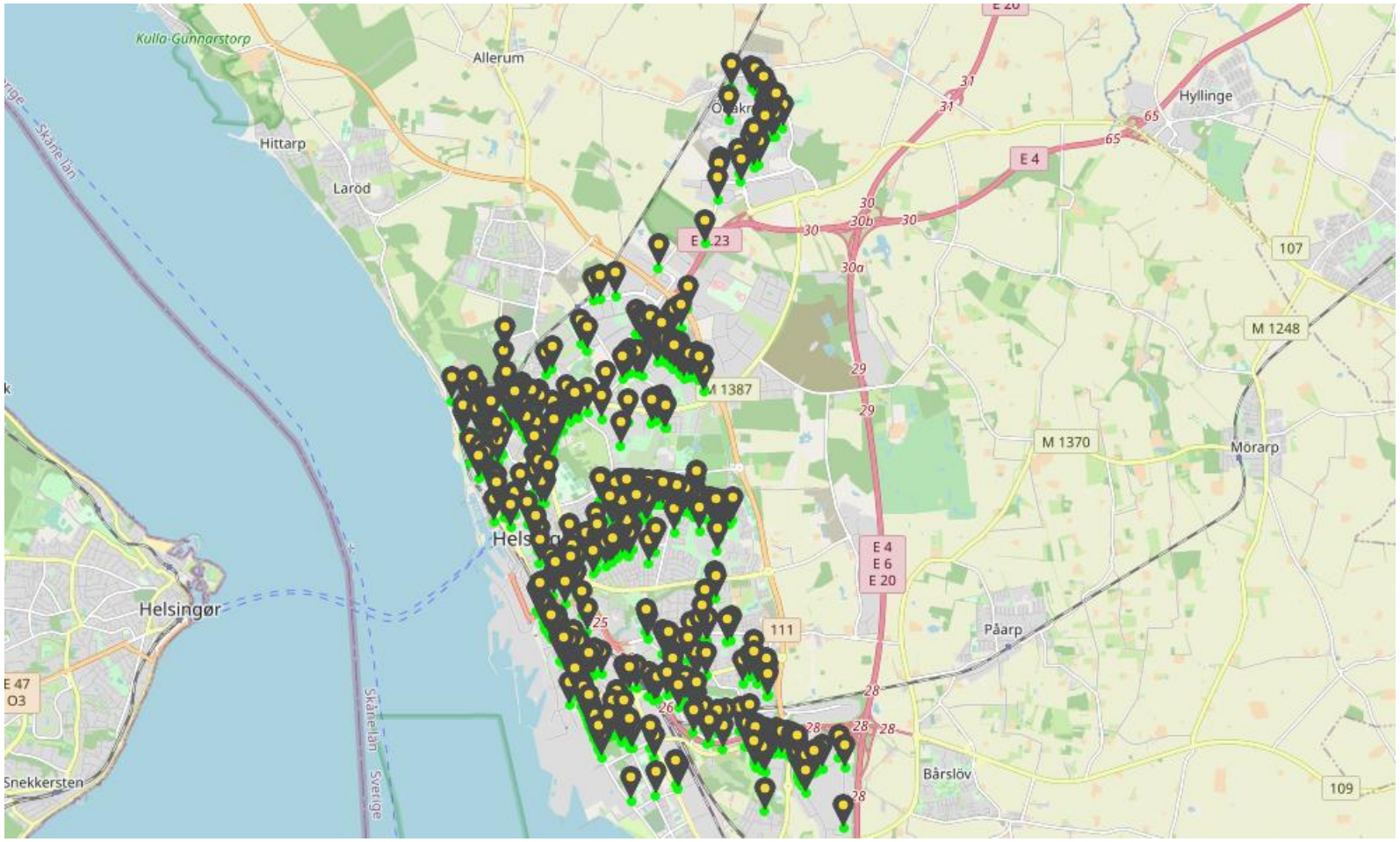
- Green: Pipe condition is good.

- Yellow: Pipe condition is acceptable but must be monitored. Plan repair within 3-10 years.

- Red: Pipe condition is bad. Plan repair within 1-2 years.

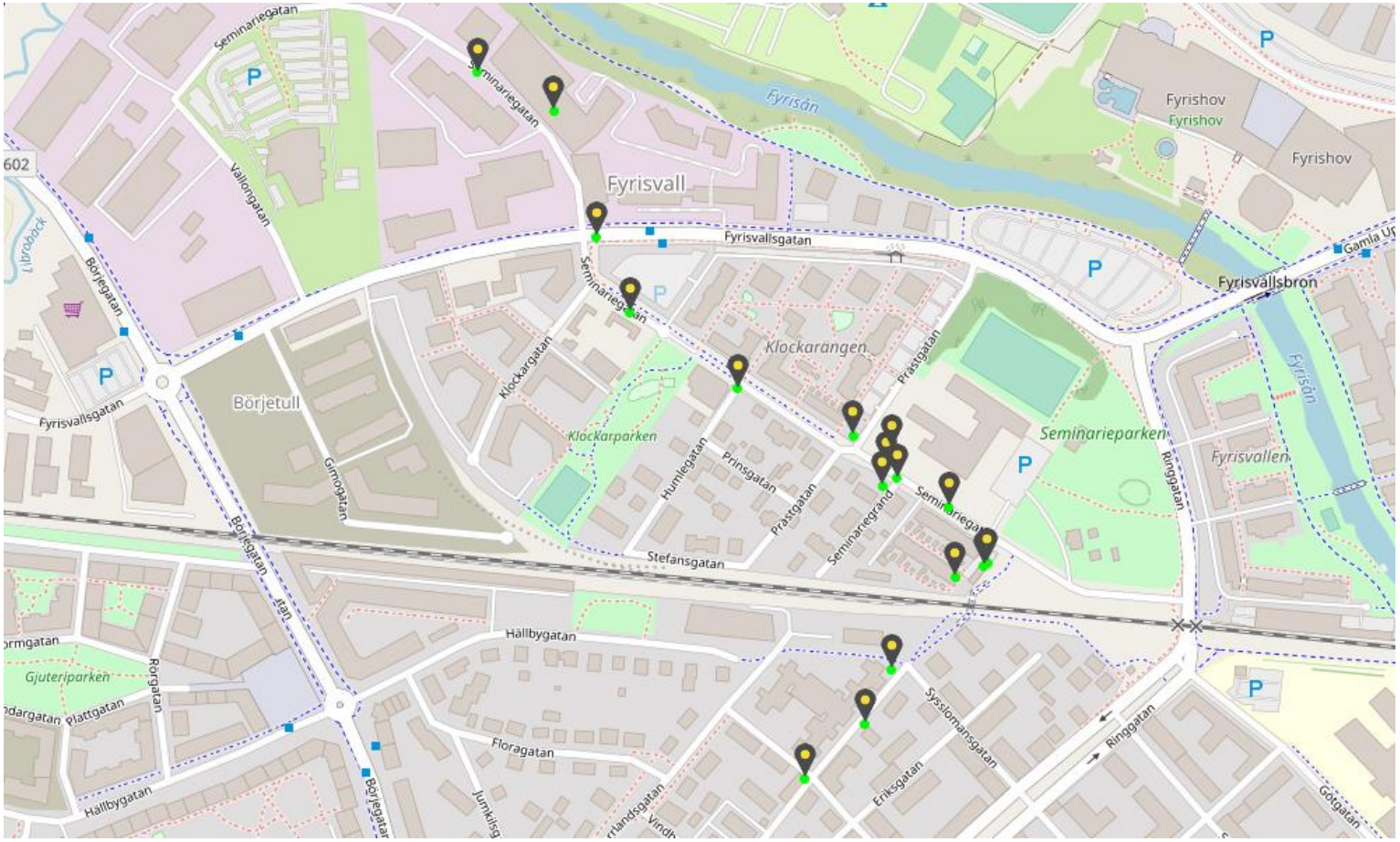
SAB installed in Helsingborg

Predictive condition monitoring, using SAB-system



SAB installed in Uppsala

Predictive condition monitoring, remaining life of pipes installed in the 1950-1960



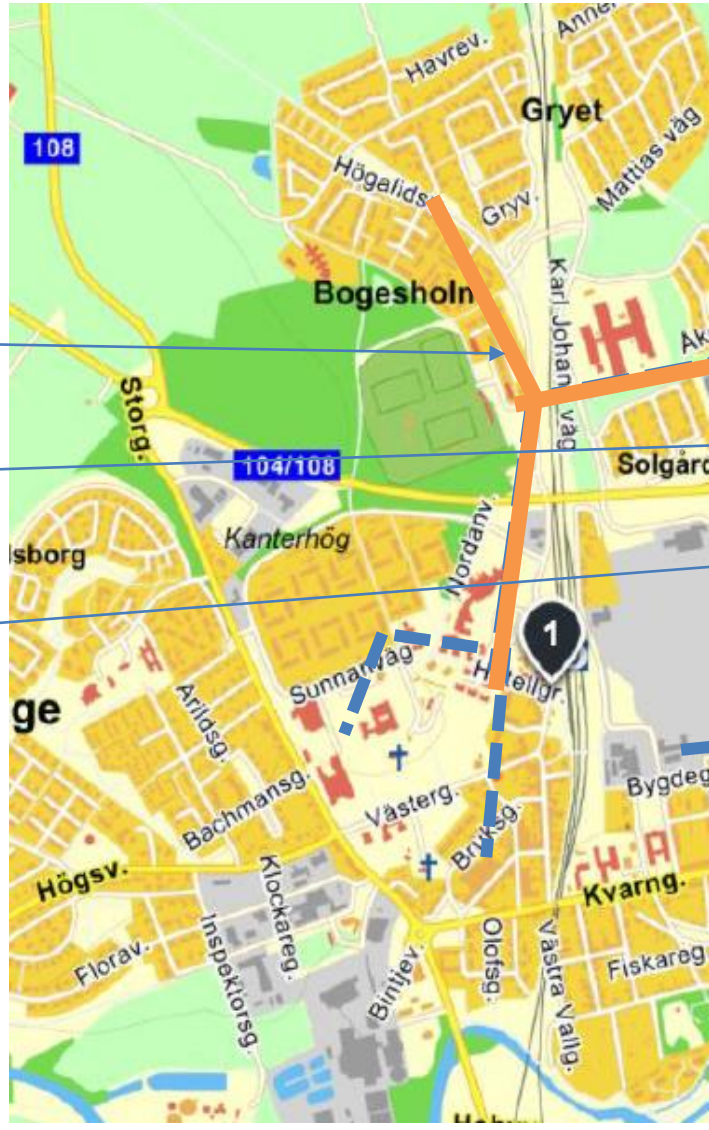
Visual GUI

Maintenance actions

Green:

Yellow:

Red:



4. Locate Weakness

- Under development.
- Accuracy will be 2-5 m.

SAB - system

1. Data Sources

Sensors
Internet-of-things

2. Data Handling

Mobile data com
GPS-clock
SQL-database

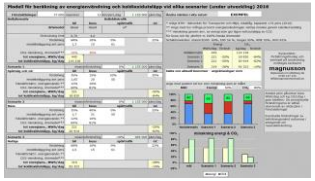
3. Remote Data Analysis

Condition Assessment
Prediction
Trend analysis
Big Data Analytics

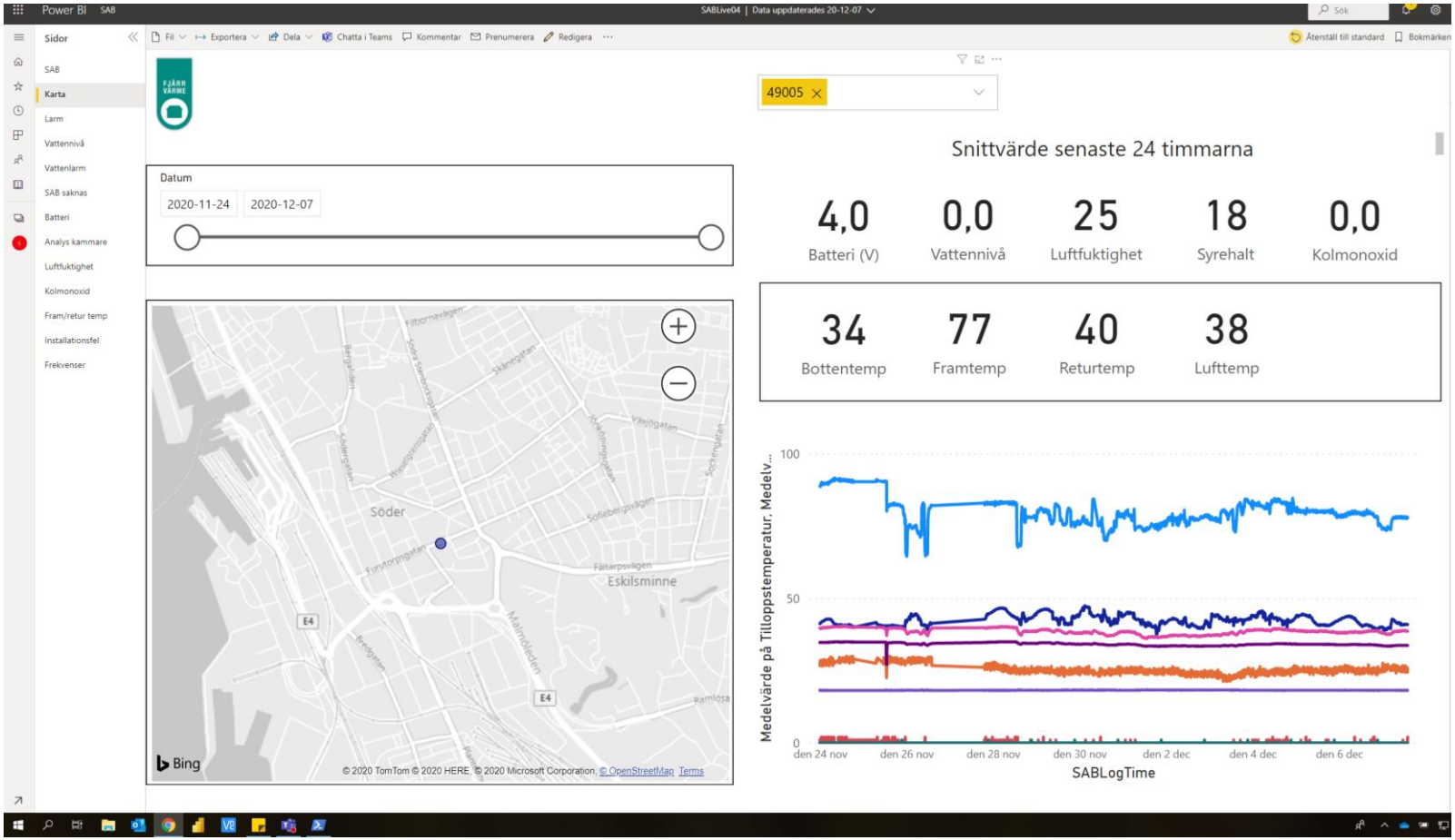
$$V = V_o \sqrt{\frac{1}{[1 + (D/e)\,(K_{water}/E_{pipe})]}}$$

4. Data Presentation

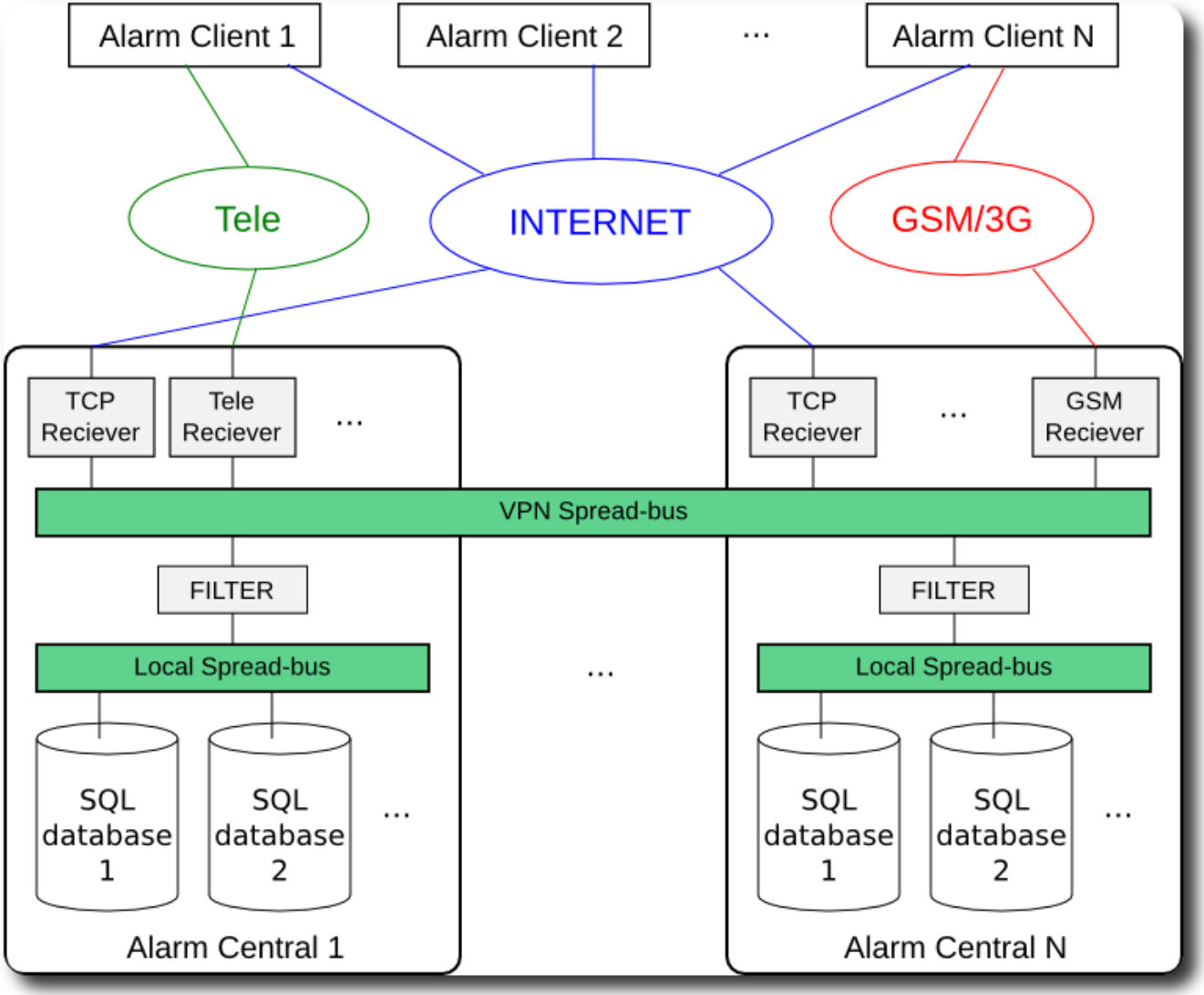
GUI
GIS system
Maintenance systems
Decision systems
ERP



Flexible and compatible with other GUI



rSCADA relation database



Data – improved operating efficiency

- Optional additional measured data available in semi real time

- -Temperature-in-pipe (forward and return)
- -Pressure-in-pipe (forward and return)
- -Temperature in chamber
- -Moisture in chamber
- -Flood alarm in chamber
- -Water level in chamber after flooding
- -Air quality (CO, O2, CO2)

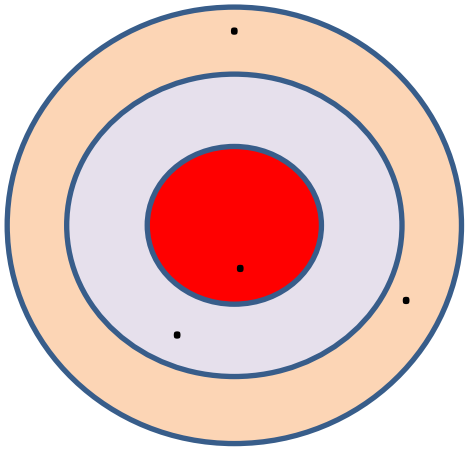
References SAB system and JPM

- Öresundskraft, Helsingborg
- Vattenfall, Uppsala
- Eon, Malmö
- Eon, Norrköping
- Jämtkraft, Östersund

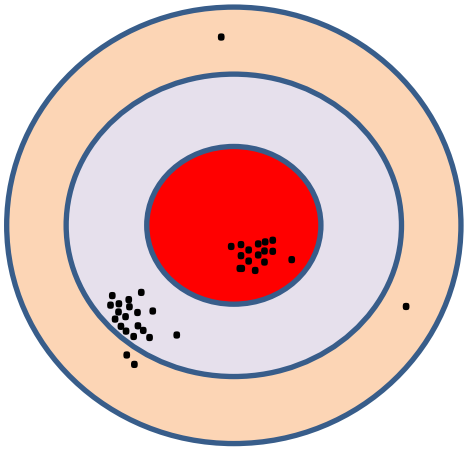
Extra material

- Images etc

The power of Big Data

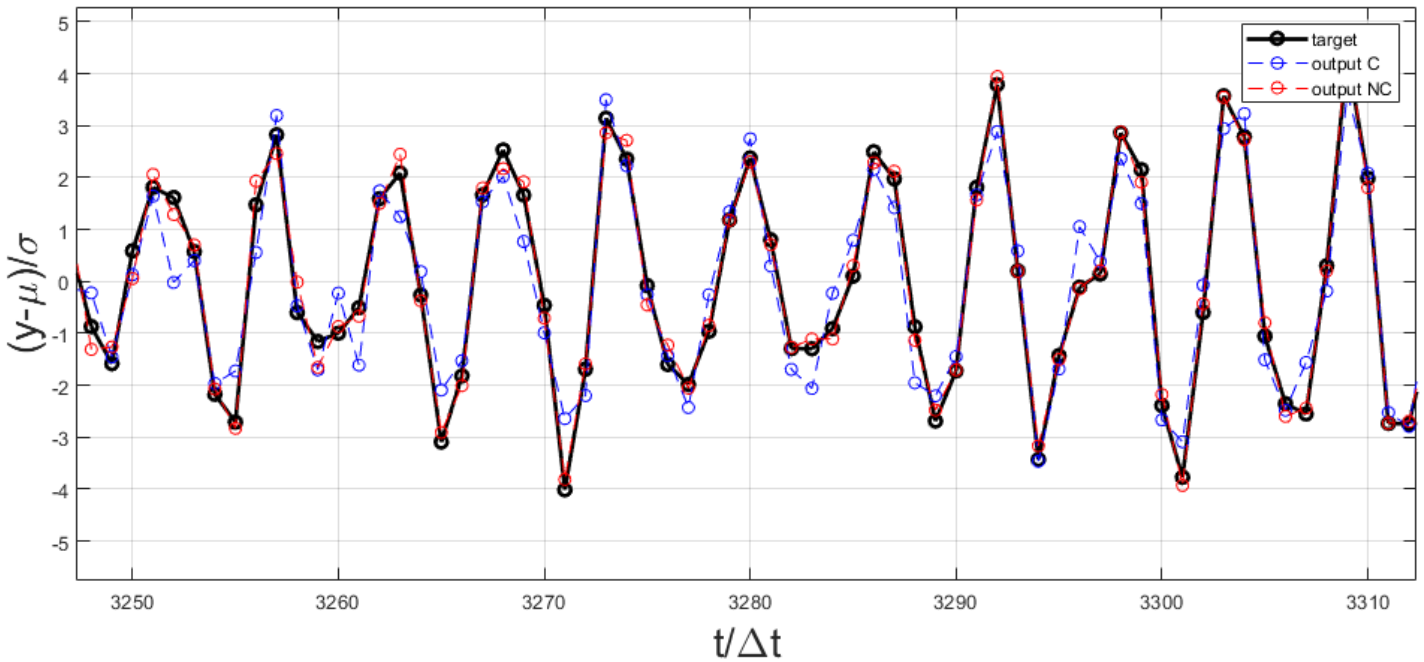


Single measurements

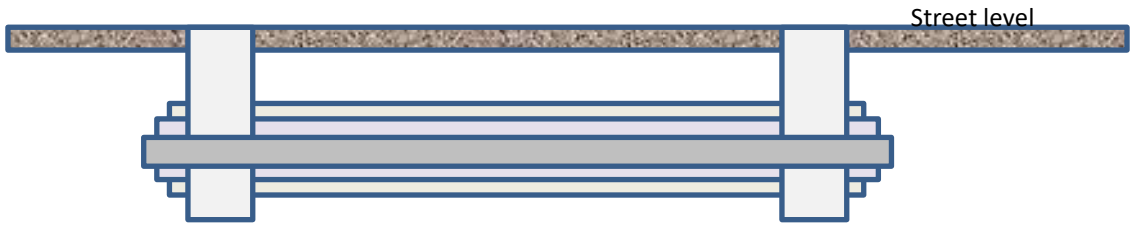


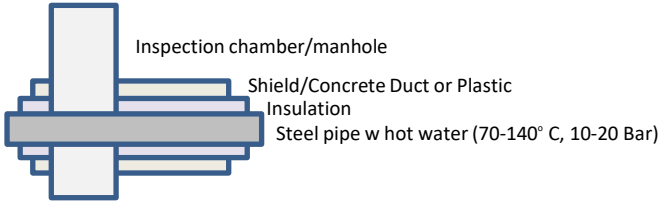
Many measurements
Trends and patterns appear

SAB/JPM correlated with AI/machine learning

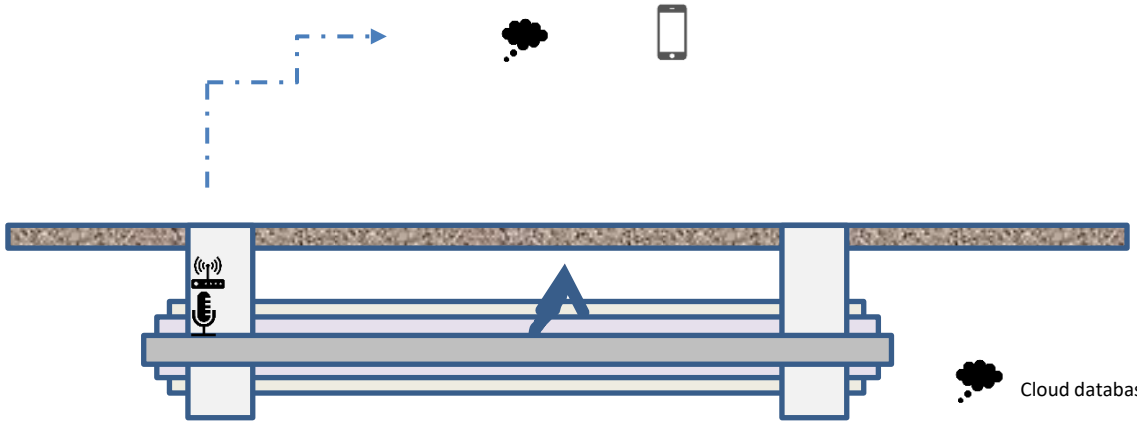


Section of district heating pipe





1. Detect leakage, noise detection (dB)



Cloud database

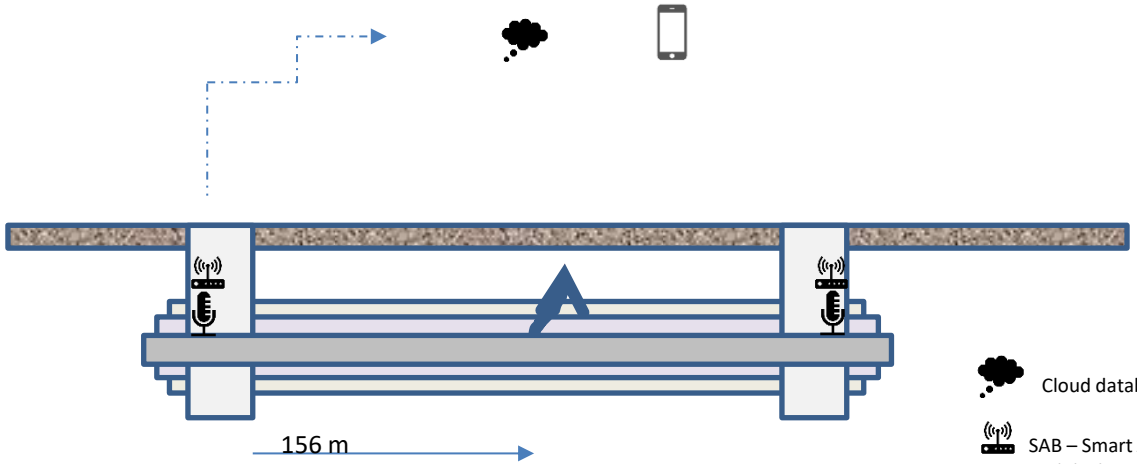
SAB – Smart Active Box, computer with I/O, sensors, mobile data comm, Heat-to-Power-Supply

Special, high sensible microphone, recorder

Acoustic impulse generator

Maintenance Manager

2. Locate leakage, accoustic signal correlation



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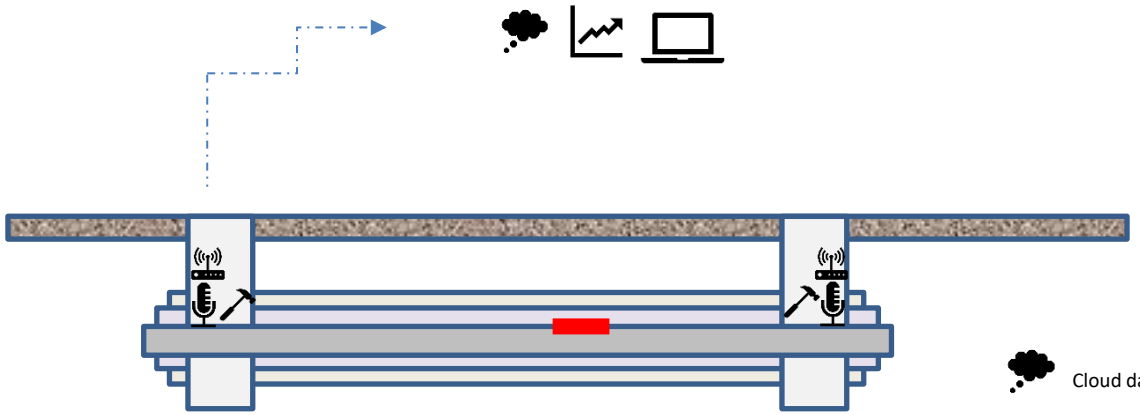
3. Detect Weakness – corrosion or wear on steel pipe



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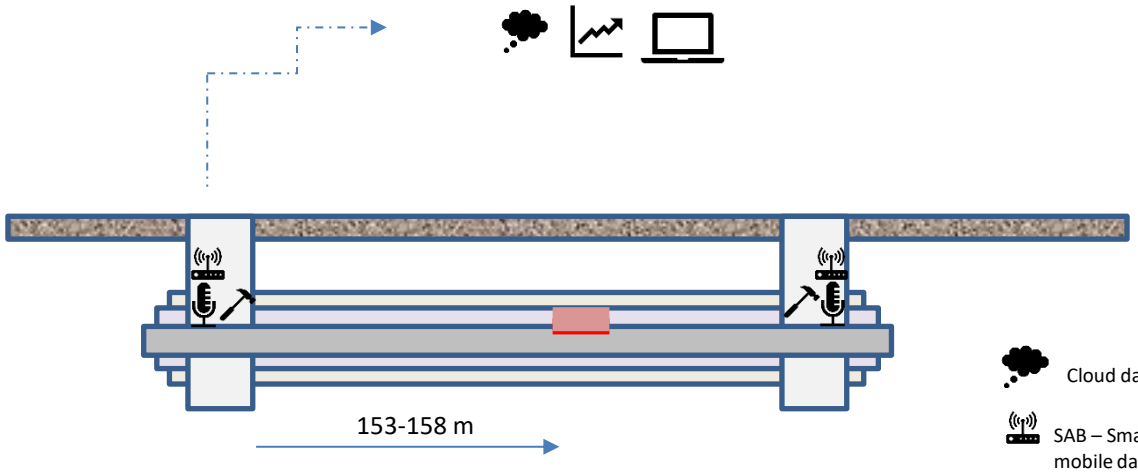
4. Locate Weakness – corrosion or wear on steel pipe, or degradation of insulation



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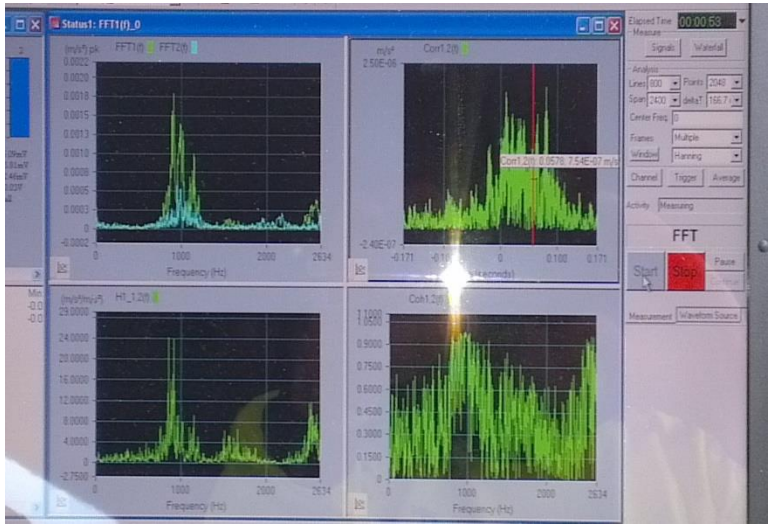
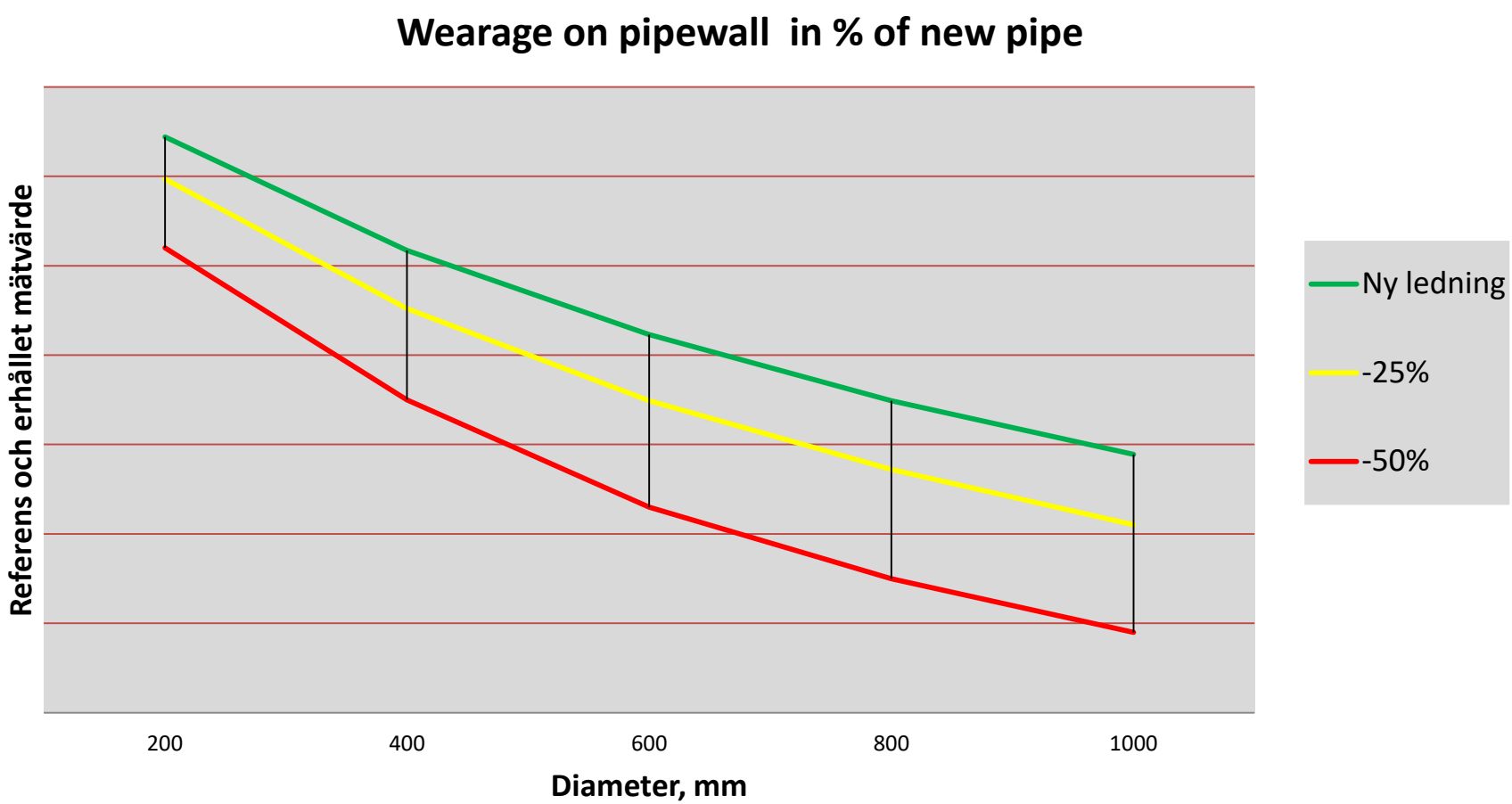
Fältmätningar



Delta-t

Evaluation of results



Grönt = OK. Gult = Håll koll! Rött = Byt!