GROUNDWATER

MAKING THE INVISIBLE VISIBLE

BALKANS JOINT CONFERENCE AND EXHIBITION

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SHUKOS | SHUKALB

Smart solutions for identification and localization of physical losses in water distribution systems using digital twin models

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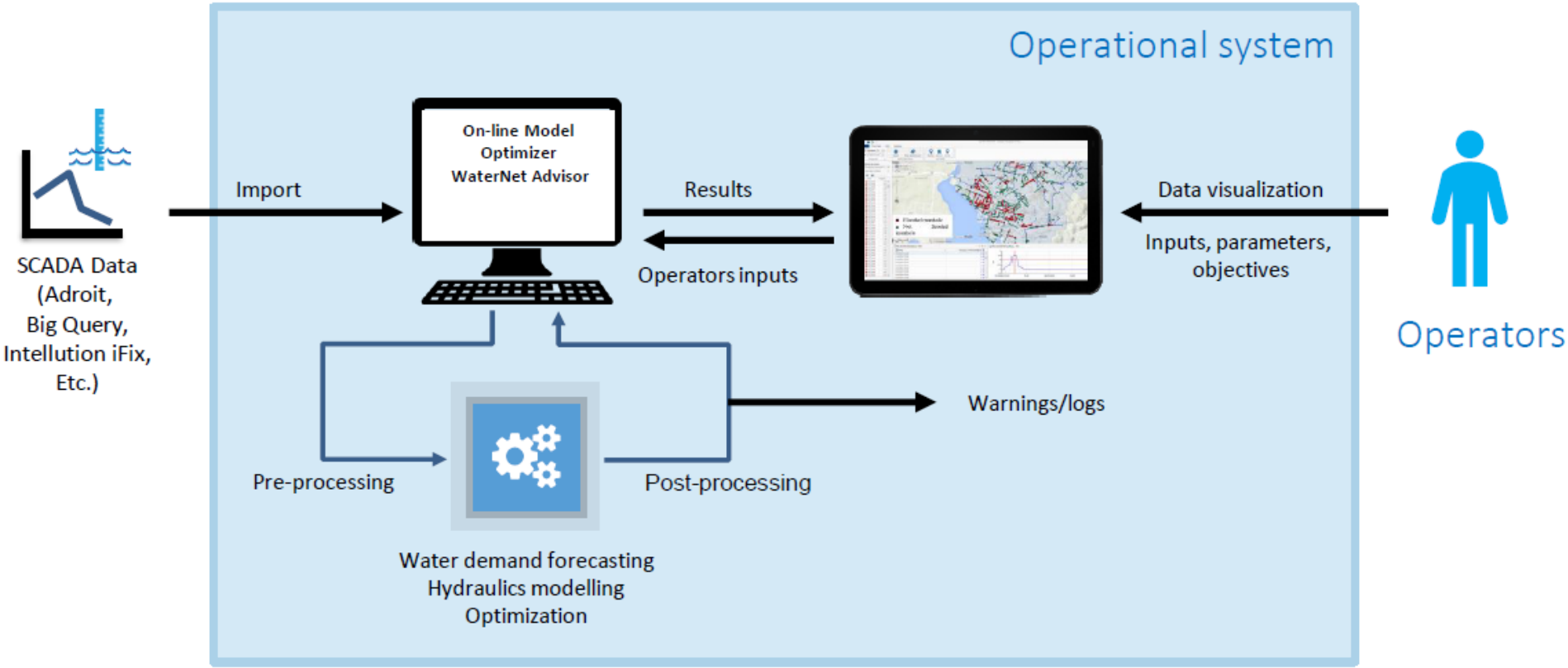
Water loss

- Water loss in water distribution networks is unavoidable, its volume and location vary and the actual water losses or non-revenue water (NRW) pose a continuous challenge for water utility operator to manage them efficiently. To understand reasons why, how, and where the water is being lost, utility managers must carry out an appraisal of asset conditions of the water distribution network and current operation practices.
- The IWA water audit is a must tool for an entire system, but identification of NRW components within each district meter area (DMA) is the next step.
- The system sectorization and development of DMAs, along with systematic monitoring of flows and pressure is a starting point for many water utilities to active leakage control and management.

Digital twin is a computer-based model of a physical system



Digital twin systems

- By using a digital twin, a computer-based model of a physical water supply system, system operators get an immediate picture of the actual flow and pressure conditions at any point in the water supply system.
- Coupled with an energy assessment of the system, a digital twin model provides instant energy auditing in terms of input energy, energy delivered, and energy lost due to various conditions of the water supply system including water loss.
- In this application, it assists in in smarter and faster detection of leakage.

Computer assisted leak localization

- This presentation illustrates a concept that is based on real-time pressure monitoring within the DMA and it uses advanced algorithms that will assist network operators to pin-point an area within the DMA where the likelihood of a physical leakage it the highest and thus shorten the time needed for the actual leak detection and pipe repair.
- This concept is part of a digital twin system that allows for a real-time analysis of the water supply system hydraulic conditions and that provides automatic and periodic evaluation of the minimum night flows within each DMA.
- It is a supporting tool that cannot and does not substitute the physical leak localization or systematic pipeline rehabilitation.

Computer assisted leak localization

Assumptions

- All DMA inflows and outflows are measured in a real-time
- Hydraulic model is developed and calibrated
- Reference pressures and flows are measured within the DMA at sufficient number of locations (*)
- Increase in minimum night flows triggers the alarm and triggers the leak localization

(*) Sufficient number of pressure monitoring points depends on the type and size of each particular DMA. Indicatively, a data-logger capable of pressure recording is required for every 200 properties within the model or area under investigation.

Computer assisted leak localization

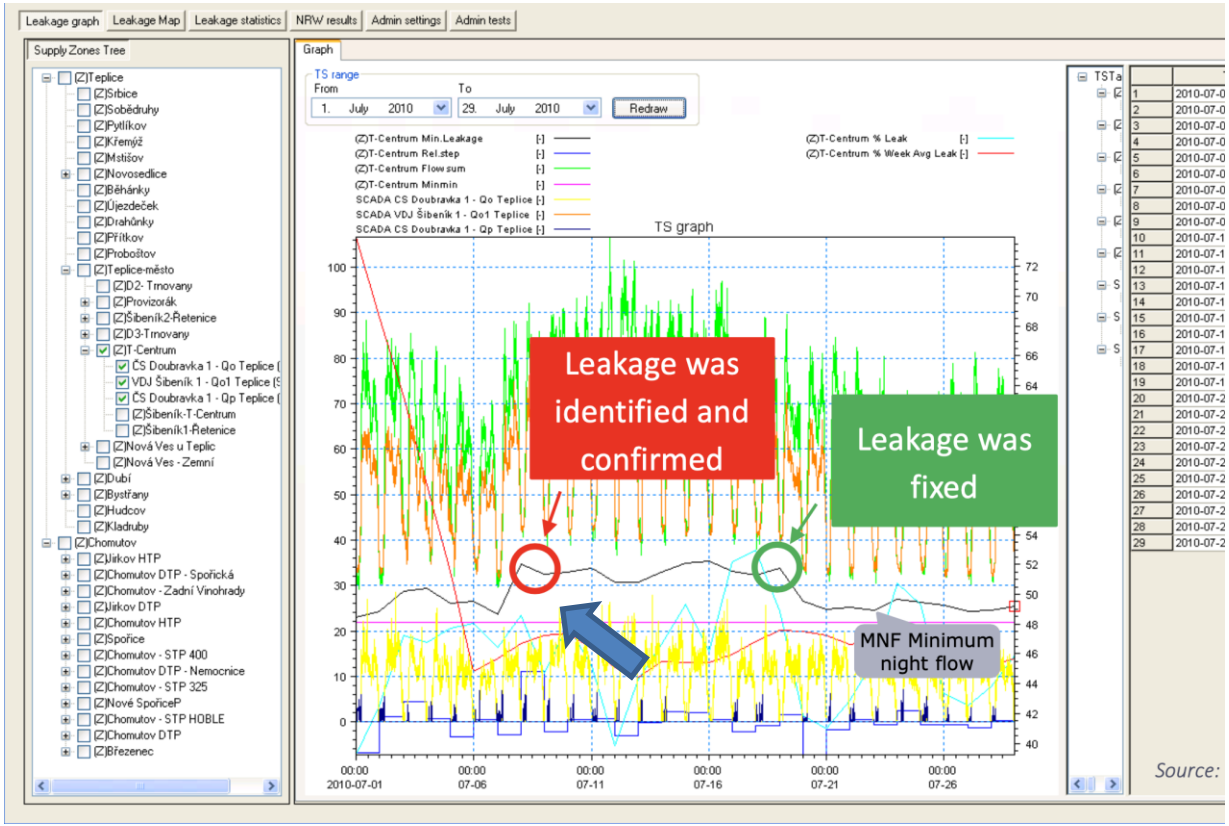
- Pisa, Italy, 300 km pipelines, medium diameter 80-130 mm (20-1000mm), total demand 290 l/s, 10 pressure sensors with 6 minutes intervals
  - Leakage test, 1.6l/s
  - Actual leakage 10 l/s
  - Actual leakage 140 l/s
- Agliana, Italy, 19.5 km pipelines, medium diameter 60-80 mm (25-180 mm), total demand 15 l/s, 4 pressure sensors with 6 minutes intervals
  - Leakage test, 1.5 l/s
- Gothenburgh, Strömmensberg zone, 5 pressure sensors, 5.5 km of cast iron pipelines.
  - Leakage test, 2 l/s increased by 2 l/s every 5 minutes up to 10 l/s. Repeated at 3 physical locations.

Computer assisted leak localization

Notes: Artificial leak of approx. 1.6 l/s was introduced by opening a drain valve May 29 at 22:00 till June 1, 08:00.
The artificial leak is clearly visible in the increased values of the minimum night flows.

A physical test was conducted in Pisa network to introduce an artificial leakage by opening a drain valve on May 29th, 2016 at 22:00 till June 1, 08:00. The graph below shows increase in the minimum night flow within the SMA (orange line).

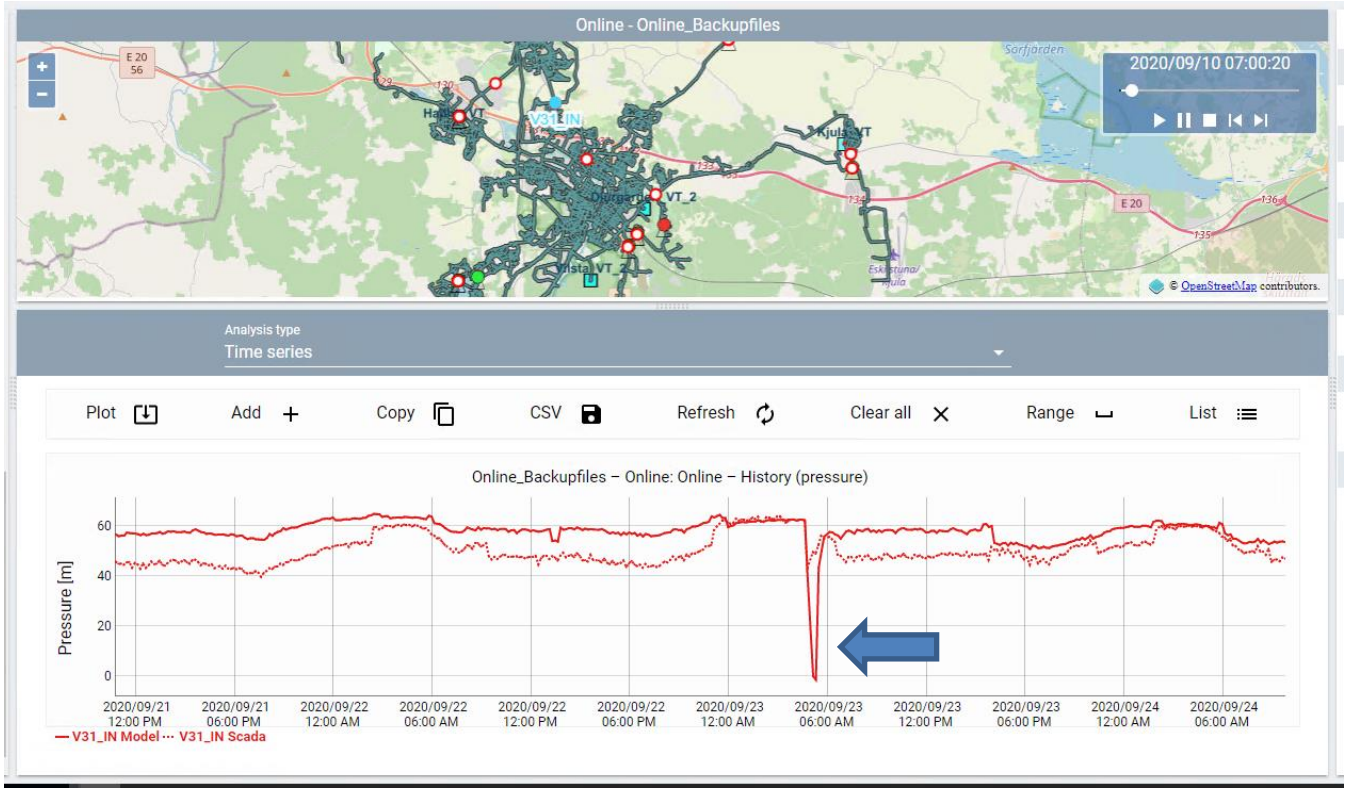
Computer assisted leak localization



Here is another example of a (near) real-time detection of leakages within DMA, indicated by a sudden increase of a minimum nigh flow(MNF).

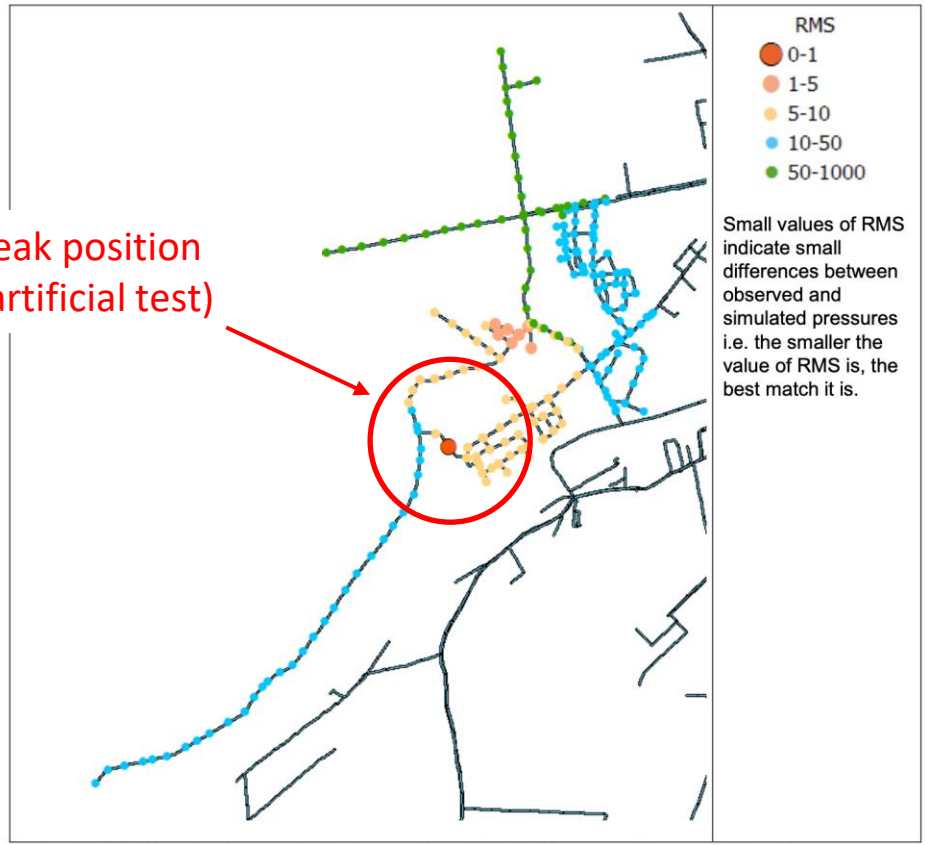
This particular leak was caused by a pipe break.

Computer assisted leak localization



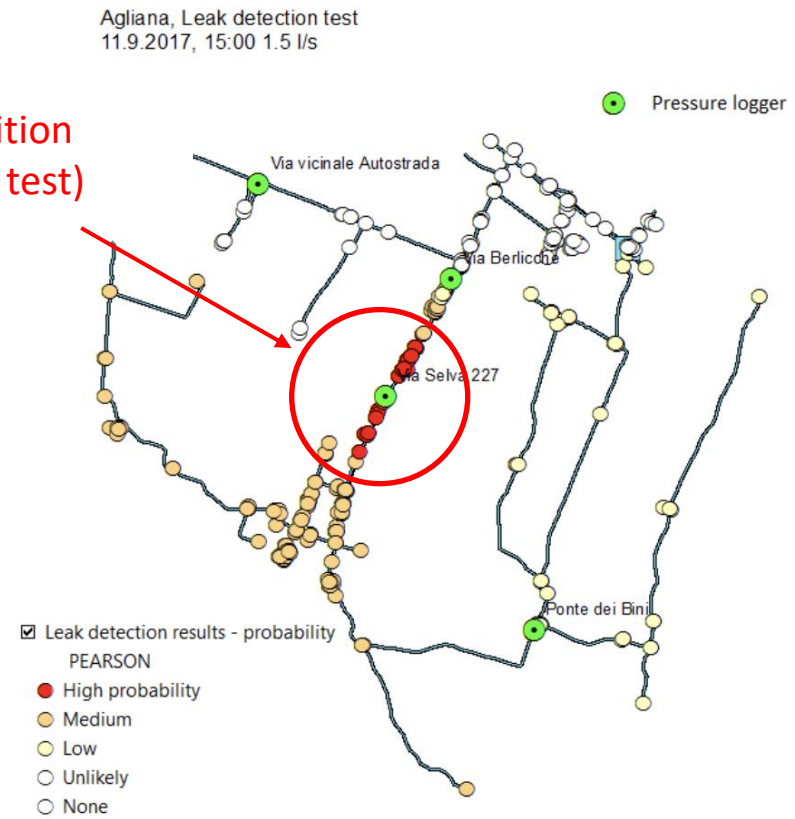
And this example is from a real-time system where the sudden loss of pressure was caused by a 300mm water main rupture.

Computer assisted leak localization



This example is for artificial leakage of 10l/s that was entered into the network node and the simulated pressures were used as observed pressures during the leak localization. In this particular run time series of observed and simulated pressures were compared during the 1-day time period.

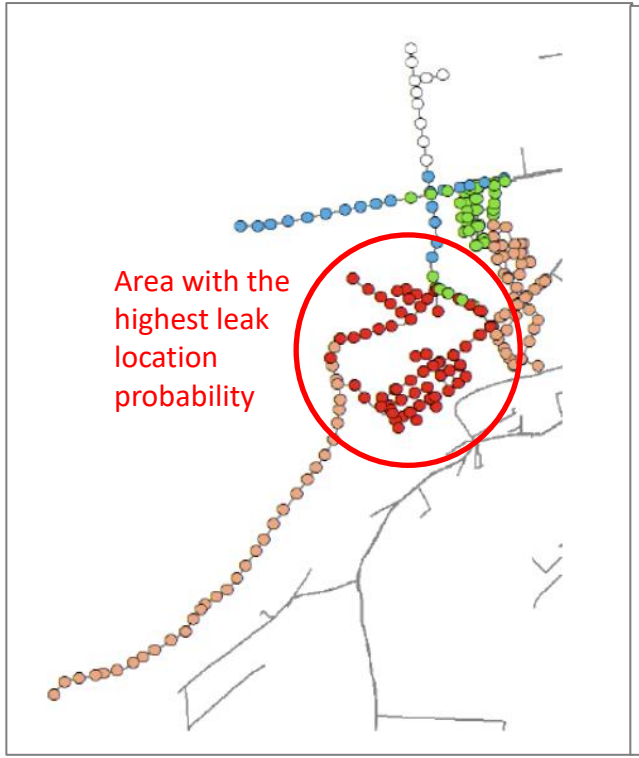
Computer assisted leak localization

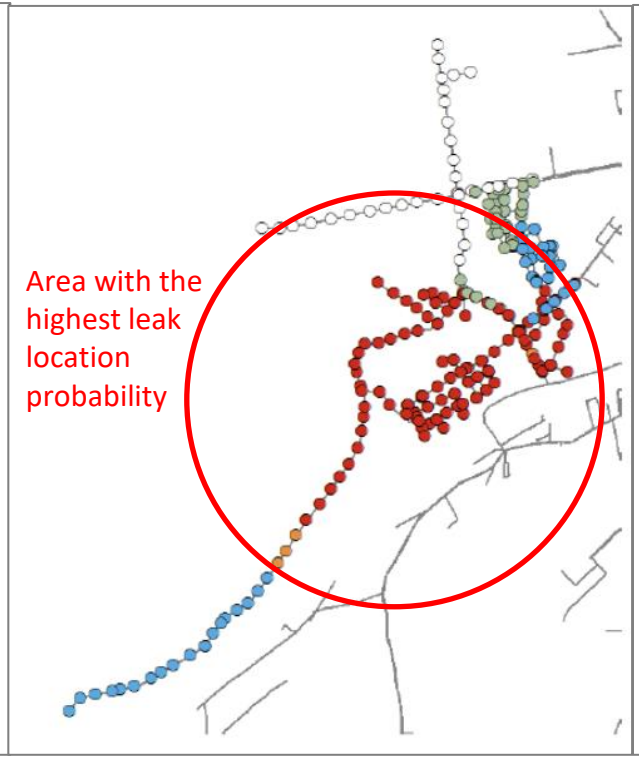


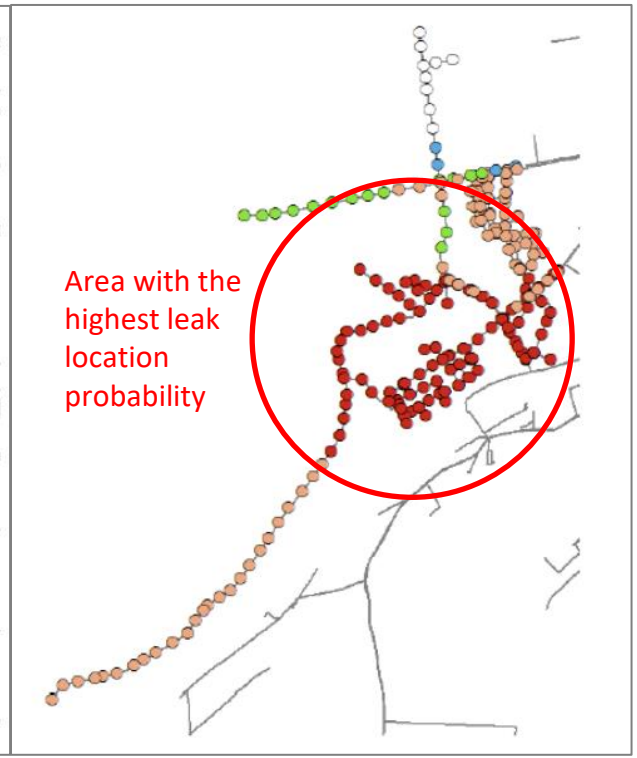
This example is for artificial leakage of 1.5 l/s using a drain pipe. Note, that leak of such a small magnitude would likely be near to impossible to localize or even detect using the minimum night flow monitoring.

Computer assisted leak localization

Comparison of different statistical and analytical methods for the leak localization using the same field data



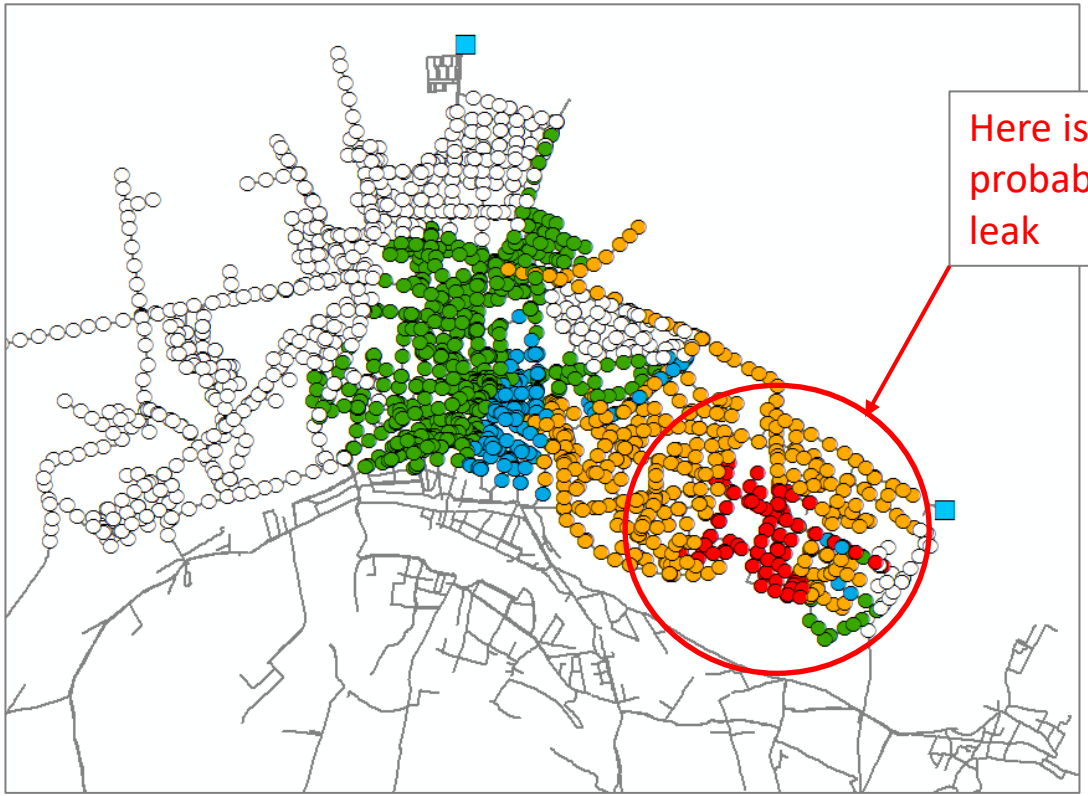


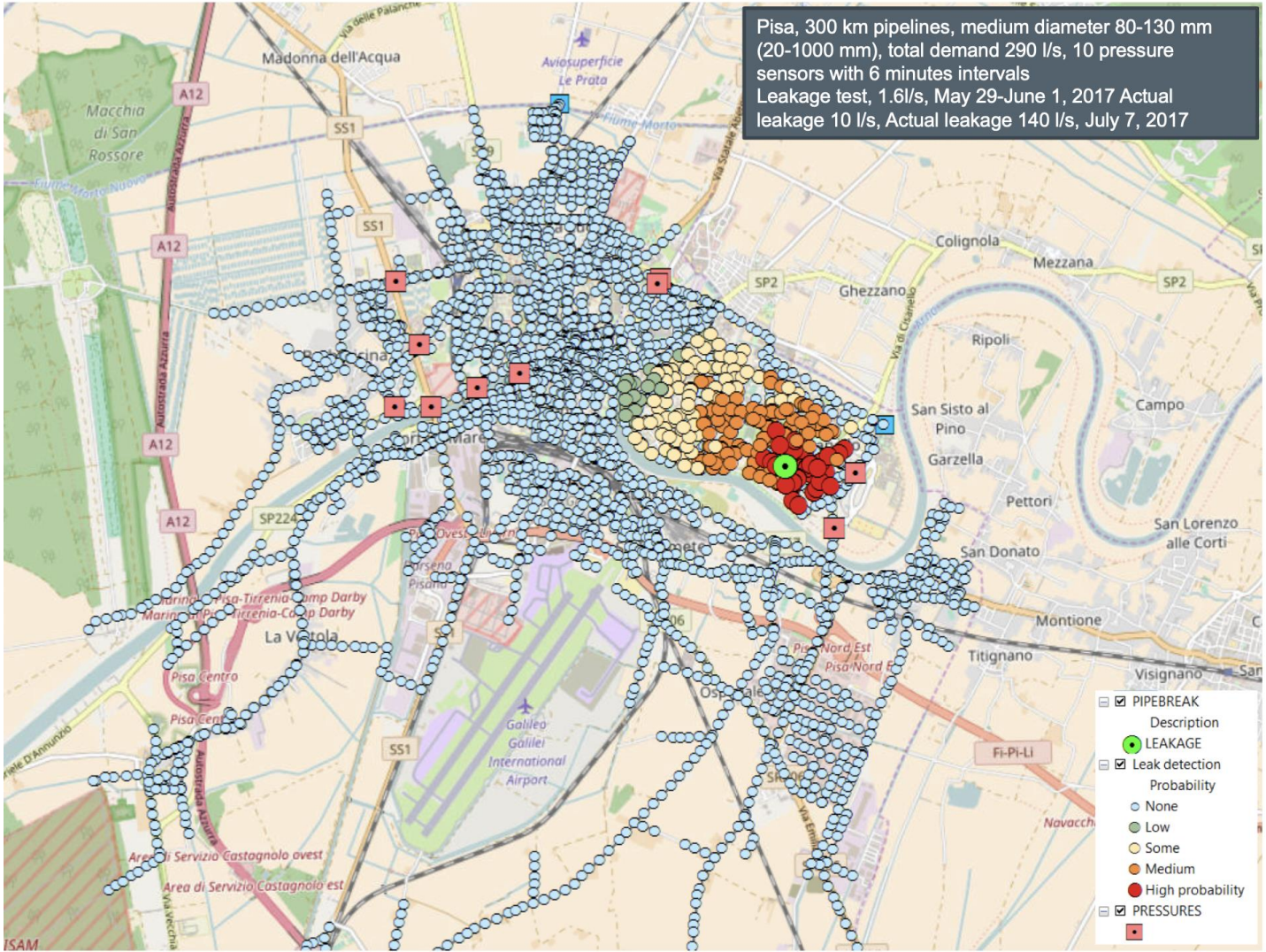


Computer assisted leak localization

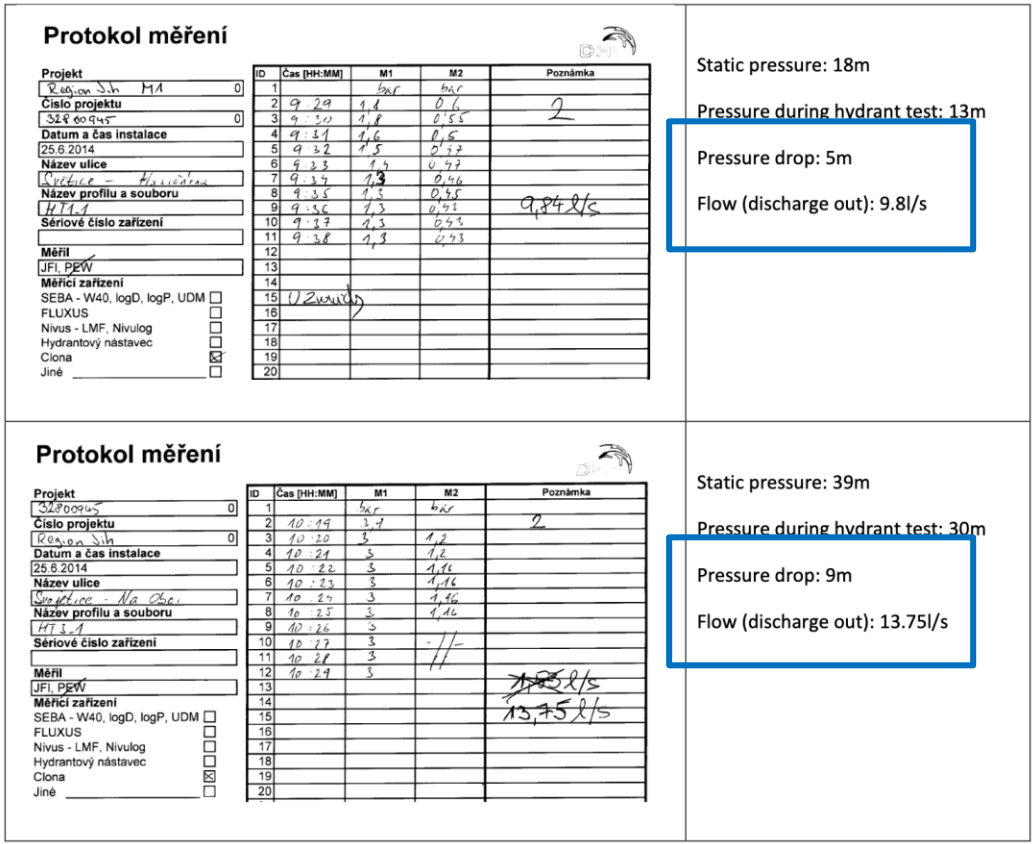
RMSxSTD.RMSxSTD_Average
- 2.595000 - 3.618000
- 3.618001 - 7.549000
- 7.549001 - 13.944000
- 13.944001 - 25.782000
- 25.782001 - 10000.000000

Different statistical and analytical methods can be used to provide the estimated leak location.




Pisa, 300 km pipelines, medium diameter 80-130 mm (20-1000 mm), total demand 290 l/s, 10 pressure sensors with 6 minutes intervals
Leakage test, 1.6l/s, May 29-June 1, 2017 Actual leakage 10 l/s, Actual leakage 140 l/s, July 7, 2017
Madonna dell'Acqua
Aviosuperficie Le Prata
Macchia di San Rossore
A12
SS1
SP2
Colignola
Mezzana
Ghezzano
Ripoli
San Sisto al Pino
Campo
Garzella
Pettori
San Lorenzo alle Corti
San Donato
Montione
Titignano
Visignano
SP224
La Vettola
Pisa Centro
Galileo Galilei International Airport
Fi-Pi-Li
Area di Servizio Castagnolo ovest
Area di Servizio Castagnolo est
PIPEBREAK
Description
LEAKAGE
Leak detection
Probability
None
Low
Some
Medium
High probability
PRESSURES

Computer assisted leak localization



Protokol měření

Projekt	Region Jih M1
Číslo projektu	328 00945
Datum a čas instalace	25.6.2014
Název ulice	Svatice – Hlavicatá
Název profilu a souboru	HT1.1
Sériové číslo zařízení	
Měřil	JFI, PEW
Měřicí zařízení	
SEBA - W40, logD, logP, UDM	☐
FLUXUS	☐
Nivus - LMF, Nivulog	☐
Hydrantový nástavec	☐
Clona	☒
Jiné	☐

ID	Čas [HH:MM]	M1	M2	Poznámka
1		bar	bar	
2	9:29	1,8	0,6	2
3	9:30	1,8	0,55	
4	9:31	1,6	0,5	
5	9:32	1,5	0,37	
6	9:33	1,4	0,47	
7	9:34	1,3	0,46	
8	9:35	1,3	0,45	
9	9:36	1,3	0,42	9,84 l/s
10	9:37	1,3	0,43	
11	9:38	1,3	0,43	
12				
13				
14				
15	(1) Zmuchly			
16				
17				
18				
19				
20				

Static pressure: 18m

Pressure during hydrant test: 13m

Pressure drop: 5m

Flow (discharge out): 9.8l/s

Protokol měření

Projekt	328 00945
Číslo projektu	Region Jih
Datum a čas instalace	25.6.2014
Název ulice	Svatice – Na Obci
Název profilu a souboru	HT3.1
Sériové číslo zařízení	
Měřil	JFI, PEW
Měřicí zařízení	
SEBA - W40, logD, logP, UDM	☐
FLUXUS	☐
Nivus - LMF, Nivulog	☐
Hydrantový nástavec	☐
Clona	☒
Jiné	☐

ID	Čas [HH:MM]	M1	M2	Poznámka
1		bar	bar	
2	10:19	3,7		2
3	10:20	3	1,2	
4	10:21	3	1,2	
5	10:22	3	1,16	
6	10:23	3	1,16	
7	10:24	3	1,16	
8	10:25	3	1,16	
9	10:26	3		
10	10:27	3	-//-	
11	10:28	3		
12	10:29	3		13,75 l/s
13				
14				
15				
16				
17				
18				
19				
20				

Static pressure: 39m

Pressure during hydrant test: 30m

Pressure drop: 9m

Flow (discharge out): 13.75l/s

A sensitivity analysis, either based on physical monitoring or simulated, provides information about the magnitude of leakages that can be localized by this method.

If the actual leakage is smaller than a minimum discharge (out of the system) that corresponds to the recognizable pressure drop then the leakage cannot be localized.

Conclusions

- This presentation illustrates a concept that is based on real-time pressure monitoring within the DMA and it uses advanced algorithms that will assist network operators to pin-point an area within the DMA where the likelihood of a physical leakage it the highest and thus shorten the time needed for the actual leak detection and pipe repair.
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