# WATER LOSS DETECTIVES

Romanian leakage magazine
December 2018, year VIII / no. 11
www.detectiviiapeipierdute.ro

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**www.detectiviiapeipierdute.ro**


Apariţie anuală
**ISSN 2457-6999**
**ISSN–L 2457-6999**





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# Five obstacles in Reducing Water Losses

Alin Anchidin

Many Utilities and several high income countries have successfully made significant reduction in water losses in the past 20 years, achieving ILIs close to 1, see http://www.leakssuite.com/ili-overviews-by-country/ , but it's clear from  http://www.leakssuite.com/global-ilis/european-ilis-2/  that many others have not yet begun that journey,.

We ask ourselves what unbeatable barriers might be, when there is interest and resources to reduce water losses. As with any obstacle, solutions to overcome losses can be found, provided, the problem is well known. So, let's talk openly about the losses! Here are five reasons that we believe, impede the effective approach and also solving the loss issues. Perhaps not by chance, most of the time, the restrains comes from the way we think, from our perception.

1. "Expensive!" It is considered that non-revenue water solutions (short NRW) are too costly and therefore often do not make a careful assessment of  NRW. Investments in new pipelines, water meters or new fittings are really costly. But these have to be compared with the long-term losses resulting from the use of defective assets or with expired period of service. Recovering losses thus they transforms in a new source of revenue by reducing maintenance expenses (operating expenses). It should also be mentioned here that the public perception of the cost of water is also false. Consumers believe the tap water price is high, but at the same time they are willing to pay thousands of times more for bottled water.

2. Speaking of the cost barrier, it has to be said that the incentives to overcome are few. There are no funding programs devoted to this issue that are available and demand results. Such performance-based loans could be the key to the problem.

3. The specialists are also stimulated. Their performance evaluation and approach in the context of the NRW reduction does not sufficiently encourage better results.

4. "We're sweeping them under…" Water companies sometimes are reluctant to talk about the poor condition of water networks, especially when they are an unwanted "legacy." It's an understandable fear, and the problem can be perceived by the public as a performance-related one.

5. And finally, the NRW analysis is not a widespread practice, also not perceived as a necessity. The benefits that water loss management can bring should be looked at in more detail.

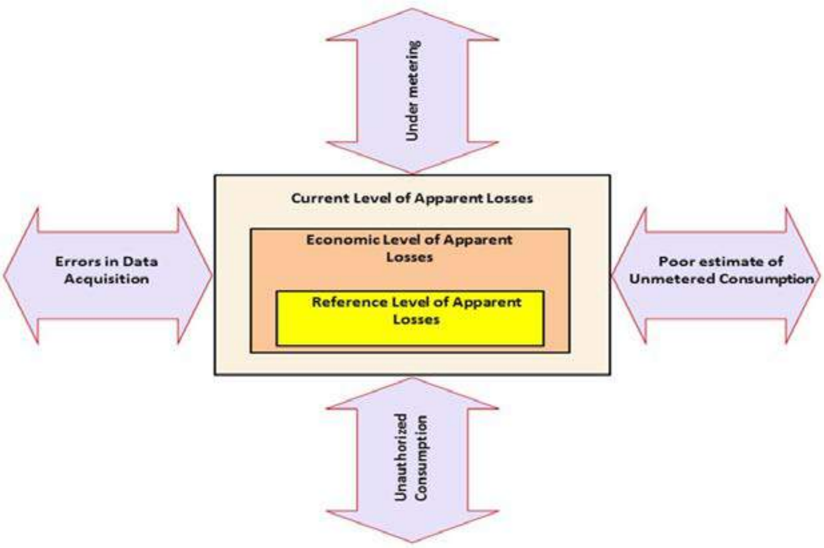
# Guidance Notes on Apparent Losses and WLRP move to Malta MCAST website

Alex Rizzo

The Apparent (Commercial) Losses component of NRW tends to receive less attention, with fewer easily accessible publications, than Real (Physical) losses. These Guidance Notes on Apparent Losses and Water Loss Reduction Planning seek to reduce that imbalance. They represent the collective experience and sustained efforts over a 10-year period of six international specialists who are committed to the 'free to all' dissemination of good practices in management of Non-Revenue Water. They are accompanied by 9 separate Appendices which are designed to be easily updated with new material from time to time.

The Guidance Notes are divided in two parts. The first part concerns Apparent Losses. The second part deals with Water Loss Reduction Planning, as a whole: it introduces some new approaches such as the Dynamics of Water Losses and the Change Management adapted to sustainable water loss reduction. The Appendices provide more detailed information and good practices on specific issues related to apparent losses and other related topics:

- *Appendix 1:* Non-Revenue Water and Large Water Meter Calibration
- *Appendix 2*: Non-Revenue Water and Unbilled Authorised Consumption
- *Appendix 3*: Customer Meter Errors
- *Appendix 4*: Apparent Water Losses generated by Unauthorised Consumption
- *Appendix 5:* Non-Revenue Water and Errors throughout the Data Acquisition Process




- *Appendix 6*: Non-Revenue Water and Revenue Collection Ratio: Review, Assessment and Recommendations
- *Appendix 7:* An Action Planning Model to Control Non-Revenue Water
- *Appendix 8*: An Overall Dynamic Approach in Water Loss Reduction

*Appendix 9*: Change Management as an indispensable component when planning for NRW control

The Guidance Notes, Appendices and papers/presentations were first posted in a newly created Apparent Losses section of the LEAKSSuite website http://www.leakssuite.com/guidance-notes-app-loss/ in September 2015; 21 papers and presentations by specialist authors in these topics have been added since then at http://www.leakssuite.com/apparent-losses/outreach-app-loss/ .

By June 2018, pageviews of the LEAKSSuite Apparent Losses section had grown to 8000, representing around 5% of overall LEAKSSuite pageviews, and it was recognised that the Apparent Losses section should be relocated in a centre of excellence of its own to flourish and grow. With the agreement of all authors, arrangements were made to transfer the Guidance Notes, Appendices, Papers and Presentations to the website of Malta College of Arts, Science and Technology (MCAST), where Dr Ing Alex Rizzo, one of the original authors of the Guidance Notes and presently Head of MCAST's University College, chairs the MCAST *Water Research & Training Centre*, which aims to be a centre of excellence for training in Water Loss Management.

The Guidance Notes, Appendices and Papers are now freely accessible at http://www.mcast.edu.mt/227, or by simply searching the net for MCAST and then scrolling down to locate the 'Apparent Losses' banner. www.leakssuite.com/apparent-losses/ is now simply a portal which directs users to the MCAST website. Many practitioners in Utilities aren't aware of, or don't have free access to, much of the material which is currently published internationally as copyrighted papers and reports; nor do they have the means to pay Open Access fees to publish their experience and knowledge. So Allan Lambert and LEAKSSuite webmaster Barry Griffiths are pleased to have provided the first step in the growth of this specialist free-to-all Apparent Losses and WLRP website.

The MCAST initiative represents a real opportunity for all international specialists in Apparent Losses reduction planning to continue this process by contributing their expertise to disseminating free-to-all material on practical developments in this important topic. Anyone interested in actively contributing to this initiative should contact alin.anchidin@gmail.com or James.Decelis@mcast.edu.mt , the MCAST webmaster for this topic, for further information. Interested parties are also encouraged to follow the MCAST website for information on its forthcoming conferences and workshops on Water Losses and Water Efficiency drives.

Thanks to Guidance Notes authors; Michel Vermersch, Fatima Carteado, Francisco Arregui, Edgar Johnson, Allan Lambert, Alex Rizzo, all the authors of the papers and presentations, and webmasters Barry Griffiths and James Decelis for their permissions to disseminate their knowledge and their many contributions to getting this initiative up and running.


MCAST – INSTITUTE OF APPLIED SCIENCES

## WATER RESEARCH AND TRAINING CENTRE

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Malta has the lowest water resources index and highest water competition index in the whole of the Mediterranean basin. Given this, challenges are placed for the nation to be in the forefront of both water technology and in the skilling of water operations and management, whilst operating within challenging socio-economic conditions. It is within this setting that the **Water Research and Training Centre** holds strong potential. The centre focuses on water enterprise, as it aims to embody the application of creative ideas and innovations to practical situations in the water field, as well as solving the challenges that are encountered locally.

The **Water Research and Training Centre** is set to follow a number of aims which serve to outline the more immediate targets that have been set out. These aims focus on the three main themes which characterises the Centre.

The Malta College of Arts, Science and Technology (MCAST) has access to over 10,000 higher and further education students, and some 500 highly qualified academic staff. It hosts 10 specialist institutes, with half of these in technological areas such as engineering, sciences and ICT. The most recent institute to be launched is the Institute of Applied Sciences (IAS), which has over 20 programmes that include water-related themes such as the Higher Diploma in Environment and Water Technology and the B.Sc. in Environmental Engineering. The IAS runs 12 advanced science labs and also hosts personnel that are experts in the water industry and have worked closely with the International Water Association (IWA) for many long years, with a range of research achievements and publications.

MCAST's strategy for the implementation of its **Water Research and Training Centre** is one of close collaboration with various local and international stakeholders. Main contributors are the Maltese Water Services Corporation (WSC), the UK Chartered Institution of Water and Environmental Management (CIWEM) and the International Water Association (IWA).

***KEY CONTRIBUTORS:***

CIWEM | MCAST Malta College of Arts, Science & Technology | Water Research and Training Centre | WATER SERVICES CORPORATION | IWA the international water association

# IWA Water Loss Specialist Group Biennial Conference 2018

Ronnie McKenzie

David Pearson

## Background

The IWA Water Loss Specialist Group, together with the City of Cape Town, held the biennial Water Loss Conference and Exhibition from 7th to 9th May 2018 at the Century City Conference Centre and Hotel in Cape Town, South Africa. A preconference workshop was held before the conference on 6th May. This was the second time that Cape Town had hosted the biennial event, the first being in 2009. The City of Cape Town in South Africa is one of the largest cities in Africa and a premier tourist destination on the continent. It was very opportune that the conference was held in Cape Town this year as the city was suffering from a significant drought, estimated to have a return period of some 1 in 200 years, that has severely depleted reservoir stocks and driven the need to reduce customer and water losses, in addition to starting to build a number of de-salination plants.

Cape Town supports a population of around 4 million and is regarded as the most progressive city in South Africa with regard to water loss management, even before the current drought. Cape Town boasts two of the world's largest advanced pressure management installations including the well-known Khayelitsha installation which was the largest of its type in the world when first commissioned in 2000. Through many forms of water loss management, the City has managed to curtail its water consumption roughly to the levels experienced in 2000 despite the doubling of the population between 2000 and 2017. At the time of the conference, the city was under Level 6 water restrictions which were the most severe on record. The target domestic capita consumption was 50 litres per person per day, although this was not being achieved.

When the conference was being planned it was predicted that the key supply reservoirs would fail in the month of May and what was being termed "day-zero" might well occur at the time of the conference. This would have potentially meant rota cuts in the city. As it happened complete failure of the water system was avoided through the severe water restrictions and other measures being implemented by the city. Since then there has been some slight respite due to some rain and the situation is being held without the need for rota cuts.

It was therefore highly opportune that so many of the world's leading water loss specialists were in Cape Town at the time and could experience the water saving initiatives first hand. The area where the conference was held is in a new "eco" city where all the toilets in the buildings and hotels are fed with water recycled form the sewage works. In addition, all the showers in the hotel had a timer device. Occupants were asked to keep the time of a shower down to less than 2 minutes. The water loss conference and Expo took on a whole new significance as the international event had never coincided with such a severe water situation before.

## Introduction to WaterLoss 2018

The IWA Water Loss Specialist Group 2018 Conference and Exhibition was one of the largest water loss events of its type in the world. It was organised by the then chairman of the Water Loss Group, Ronnie McKenzie. The management of the conference was led by Caryn Seago who put together a small team in order to ensure everything from the programme, to registration of delegates, organisation of the exhibition, the opening and closing events and the coordination of the many session chair persons went incredibly smoothly. The event attracted over 420 delegates from over 50 countries. Figure 1 shows the attendances at the water loss conferences since the first one was held in Cyprus in 2002.

Over 200 papers were submitted for consideration in the conference programme and from this, approximately 100 were selected for oral presentation at the Conference. The sessions took the form of 3 parallel streams with a full morning plenary session at the opening of the conference as well as a short plenary session to close the event on the afternoon of the third day. Papers were grouped into different aspects of water loss management and the following issues were discussed:

- Cities that have experienced the "day zero" scenario and lessons learned with a full morning session concentrating on the Cape Town water crisis (see short description of this session)
- Pressure management and reducing leakage and demand through advanced pressure control
- Reducing water losses in schools
- Identifying leaks through latest technology
- Identifying leakage and wastage in business and communities
- Water loss reduction interventions – case studies
- Use of technology in the battle against water losses
- Community awareness, education and public involvement in saving water
- The issue of intermittent supplies

Many of the world's leading experts in the field of non-revenue water management were present at the event

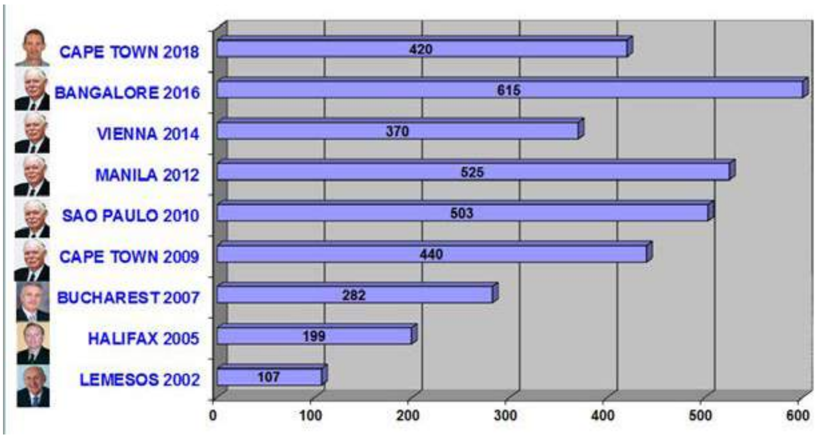


Figure 1: Conference Statistics: Number of delegates

and discussed the latest developments, strategies, techniques and applications of international best practices as well as successful case studies.

In addition, Ken Brothers from Canada and Mbalie Matiwane from South Africa organised a 1-day pre-conference workshop on 6th May 2018 to provide an introduction to the issue of Non-Revenue Water Management and an overview of the latest IWA Methodology for reducing water losses from municipal water supply systems. This event was supported by former Chairman Tim Waldron from Australia and David Pearson from the UK. The event was very well attended and there were lively debates at the end of the sessions – with the presenters showing their different perspectives on the issue of water loss management. All of the sessions were recorded and they have been posted on the internet as part of the legacy of the event (http://www.waterloss2018.com/final-programme/)

The exhibition was supported by almost 50 companies from around the world supplying various items of equipment to assist municipalities and individuals to assess, control and reduce their water losses. These were relevant to all delegates but especially to the City of Cape Town which was wanting to learn what was available for them to be able to reduce water losses because of their supply situation.

## ISSUES FROM THE CONFERENCE

### The Cape Town Crisis Session

Nearly a year of news reports made the City of Cape Town synonymous with 'water crisis.'

Widespread headlines and televised broadcasts portrayed it as "the first major city in the world to run out of water," and left the impression that its water shortage was worse than anything faced elsewhere in the world by any other major city.

But was it true? And if so, what lessons can be learned?

Against the gloom and doom backdrop, the Biennial International Water Associations Water Loss Conference in early May offered a detailed assessment of the water supply situation in Cape Town. Among the highlights of the presentations (http://www.waterloss2018.com/final-programme/) we can place the various issues and assertions in perspective.

It turns out Cape Town was neither the first municipality to contend with scarcity, nor did it suffer a complete water supply system failure.

Such statements sell news, but are a far cry from the truth. While Cape Town did indeed come within several months of water rationing (that is, imposing city wide intermittent supply), there are many examples from around the world where extensive intermittent supply is either the norm or has been introduced during severe drought events.

Francisco Paracampos from Brazil described Sao Paulo's recent water crisis as it struggled to supply some 20 million people. SABESP, the city's water company and one of the largest in the world, experienced its worst drought on record and had to take extraordinary measures to avoid their own "day-zero". The city's main reservoirs dropped below "dead storage," the level at which the normal abstraction points cannot access the remaining water. For four months, massive pumps had to pump out the remaining 140 million m3 of water in the reservoir. It came within five days of the cut-off, where residents would have to collect water from collection points.

Reinforcing the point, Bambos Charalambous offered first-hand experience of the water crisis that several years ago engulfed the island of Cyprus. The island did face its "day-zero," at which point decision makers chose to implement wide-scale intermittent supply, against recommendations from the technical managers. The situation grew so bad that water had to be transported to Cyprus by tanker ships from Athens in Greece.

For two years, the southern coastal city of Lemesos, Cyprus had to operate on intermittent supply, with water cut off completely for hours or days at a time and the supply restored for short periods on a rotational basis. The net reduction in the supply into the system during the drought was only 10%; when restored to continuous supply, the system input volume increased to 10% above the pre-drought levels, due to the increase in burst pipes. Charalambous, a strong critic of intermittent supply, now chairs IWA's Intermittent Water Supply Specialist Group. "It takes a day to introduce intermittent supply," he warned, "and two years or more to recover from the damage caused to the system. Don't go there!".

Tim Waldron described the Millennium Drought that gripped Australia's Eastern seaboard. He detailed how major cities such as Sydney, Melbourne, Brisbane and Adelaide grappled with and recovered from their worst drought on record, reducing their daily per capita demand across all usage sectors to less than 140 litres per person per day.

Closer to home, Peter Flower, as head of Water Services in Cape Town, has the unenviable task of steering the "Mother City" through its current drought, already the worst in over 200 years and still far from over. On his watch, Cape Town reduced its annual average daily water use to less than 950 Megalitres -- with summer peaks not exceeding 1,200 Ml/day – in spite of an increase in population from 3 million to 4 million.

How? The city saved water through both technical and social measures. It had earlier introduced among the world's largest pressure management installations at Khayelitsha and Mitchell's Plain, which supply almost 500 000 residents each. More recent water restrictions in 2016, focused mainly on the social and behavioural changes, halved summer daily water use from 1,200 to 600 Ml/day in November 2017. Technical measures – accelerated pressure management implementation across the city and leak location and repair – saved a further 50 Ml/day to bring the demand down to around 550 Ml/day.

So how does Cape Town compare to its counterparts?

The city reduced its pre-drought water demand by more than 50%, without resorting to intermittent supply. Sao Paulo achieved 30% reduction, while in Cyprus the overall reduction -- after introducing intermittent supply – was less than 20%. Cape Town's per capita consumption was halved to approximately 115 litres/head/day, compared to the 140 litres/head per day achieved in Australia.

The city's own daily target -- 50 litres/head per day -- referred only to the domestic consumption after the consumer meter; this should not be confused with the publicised higher values, which include all other sectors of the water use in the city including water losses, industrial and commercial use.

Not all conservation effort is comparable. California recently celebrated it having reduced average daily per capita consumption from 500 litres to 400 litres, a laudable 20% reduction in demand. Yet imagine the howls of protest if, say, Los Angeles had to lose another 100 litres each day starting from just 220 litres – the point at which Cape Town began.

As with weight reduction, shedding the first kilos is initially easy, while those last litres are the hardest to lose. And now, having 'slimmed down' our cities on a rigorous water diet and healthy regimen, our challenge looking ahead is "how to stay fit and keep off the fat"?

### Some key findings

- Discourage (or avoid at all cost!) intermittent supply
- Highlight that water consumption can be halved through aggressive technical and social interventions without resorting to intermittent supply
- Cape Town has achieved a great saving without resorting to intermittent supply.
- We should try to avoid confusion on the use of per capita water figures. The Cape Town example highlighted that their overall per capita use of 115 litres/person per day is not comparable to the 50 litres/person per day being targeted by the City which only refers to the "after meter" use.
- A team should be established to provide support to other cities around the world that experience potential "day-zero" scenarios. The depth of experience shown at the conference was significant and shows that there are many individuals who have experienced this problem before and can assist other cities in future.

### Other sessions

There were 26 other sessions covering the whole gambit of non-revenue water losses.

These could be considered to fall into four generic groups:

*Approaches to understanding and managing NRW:*

- Theory – important to know
- Pressure management (two sessions)
- Transmission mains
- Performance based contracts NRW reduction contracts (two sessions)
- Importance of geo-spatial information
- Hydraulic modelling and DMAs
- Metering (two sessions)
- Latest technologies (three sessions)

*A look at NRW around the world:*

- Global look at NRW
- Case studies from around the world (two sessions)
- Very different NRW issues
- Workshop on the Danish "No-Drop" programme

*Issues in the host country:*

- Focus on South Africa (four sessions)

*Challenging our views:*

- Top speakers from around the world
- Different ideas – a controversial session
- Is this the future?

### Presentations

All presentations are available at http://www.waterloss2018.com/final-programme/.

## New technologies – the future?

A number of papers covered the new technologies of drones and satellite imagery and how these might help us locate leaks. Watch this space (apologies for the pun)!! And we look forward to a paper at the next conference on the use of a sniffer dogs in locating leaks which is being trained in a UK water company!!

# Seek the Leak 2019 – the 12th edition

Silviu Lăcătuşu
Consilier ARA

The Romanian Water Association with support of the regional water utilities organize annualy a regional **Leak Detection Competition** in Romania.  From the first until the last edition, the number of participant teams have constantly increase, these day having around 25 teams in competion.

In the last edition, in Drobeta Turnu Severin city, between **5 and 7 of September 2018** the operational teams (with their own autoloboratories) from regional water utilities gathered  to find out who could track down leaks most accurately and with the greatest speed.

The competion consist in evaluation of 4 routes, in a delimited time of 30 minutes per each route. All the teams evalaute each of the four rout and at the end of the day all the teams indicate the possible leaks on each route. The organizers based on the results of all the teams, established the digging points on each route (in average 2 digging/ route) and the host dig the selection location. Based on real leaks indentified in the field, each team get points depending on the distance from leak and their indication. The teams which gather the most points become winner of the competion and get the first prize – a new equiment.

Beyond the promotion of best practices among the specialist, this annual competition helps raise awareness about the significant problem of water loss that is shared by utilities around the region, and provides a great opportunity for them to learn from one another.

- After the competion, we organise a seminar for the participant, when together with our partners , the SebaKMT company, we presented the new equipment developed to tackle the water losses from the distribution network

During the seminar, we achieved to bring together the main actors in the field of the leak detection:

- the regulator: Mr Cosmin Lungu – member in the jury of the contest
- the academia: Mr. Alexandru Aldea – member in the jury of the contest
- the suppliers: Mr. Bogdan Ardeleanu, General Director from Seba Dynatronic Romania presented the new equipment developed by SebaKMT to tackle the water losses from the distribution network
- the practicians: teams from water utility which their daily task is to identify the hidden leakages from the distribution network

The winning team in 2018 was from Ecoaqua Calarasi (Romania). They have identified most of the leaks with the lowest average error. We have to underline that with each edition, the teams are more skilled and the difference between top team are smaller and smaller. The next edition in 2019, will be host by the regional water utility ECOAQUA Calarasi.


## Water Loss 2020 will be held from 7th to 10th June 2020 in Shenzhen, China

# Interview with Mr. Roland Liemberger, international expert in waterloss management

**Please tell us some words about you: how do you come to work in this field? Who are your mentors – teachers? In how many projects/countries you worked as an NRW expert?**

It happened in 1997. An Austrian company was looking for a project manager for a small water loss reduction project in Kathmandu, Nepal. I accepted the challenge and went there for half a year – this was the beginning of my career! I did not do any other work than NRW reduction since then!

**You are also the creator of the popular WB-EasyCalc software. Can you tell us how you come to create this software? What are your plans about WB-Easy-Calc in the future?**

I was doing training courses on NRW management and saw how wrong the participants got the most basic calculations in excel wrong – so I thought we need a free tool to help engineers around the world!

**What books do you recommend regarding water losses? Are there any seminars/workshops or conferences that you can also recommend us?**

Books: the best is learning by doing! Only years of field work will make you an expert! Lots of books – but read this publication which is for free! https://www.adb.org/contact/liemberger-roland

**Who is Miya and what is their area of expertise?In Romania ?**

Miya is a global solution provider to help to make water utilities more efficient – particularly NRW reduction. Miya has no experience in Romania

**What can you tell us about the Performance Based Contracts in regard to NRW? For example what are the main benefits of this type of contracts and what are the costs and implications?**

The answer could take me a two day lecture. But to keep it brief and simple: the job of a water utility and all its staff is to supply water. (Nearly) nobody has time and budget for NRW reduction. If you build a new pumping station you will get a contractor to do that. For the same reason you should get a contractor to reduce NRW!

**What are your recommendations about Performance Based Contracts? What are in your opinion the contractual terms that will ensure a win-win situation?**

Well, we need 10 pages in the next magazine to discuss this!

**Where did you managed to implement such projects? Also can you tell us something about the challenges that you encountered and the results that you obtained.**

Around the world. Brazil, Vietnam, Malaysia, Philippines, Bahamas … just to mention a few. Results were always exceeding expectations and the challenges were pletiful!

**In Romania, the vast majority of water companies managed to acquire performing leak detection equipment trough European Funded projects. Some of these companies also managed to create DMAs in their water network, but the results are not quite satisfactory. What strategy do you recommend in this situation? Could a private team be a solution?**

Yes, certainly, but I don't know anything about the funding mechanisms so I can't comment.

**How the leak detection teams can be motivated? Is there a quota of how many mistakes are allowed to make?**

Give them a nice performance bonus! Making mistakes is not important – the only thing that counts is the volume of water loss reduction. Measure achievements in small DMAs!

**Can you make a prediction about the future of this field and what will be the next trends?**

I'm very pessimistic. I'm afraid that the global volume of water loss will stay the same or increase. Nobody pays enough attention.

**What "innovative" technologies did you test and recommend?**

Wrong question! With the OLD technologies you can solve 95% of the world's leakage problem!

**In your experience, what were the best decisions in NRW reduction that managed to yield good results in most of the situations? Also, what were the key mistakes that you almost always encountered?**

Another tricky question which needs many pages! Brief answer:

**Best decision: build small DMAs and find the leaks and repair them**

Key mistake: NATO – No Action Talk Only

**What is your favored quote?**

Engineers: We have ho leakage problem – it's all commercial losses

Commercial guys: We have no commercial losses – it's all leakage

Politicians: let's build a new treatment plant!

# EasyCalcmobile

If you have an Android phone you may want to check my new water balance and water loss PI App "EasyCalc mobile" which can now be downloaded from the Play Store. It is completely new and I would appreciate comments which will be considered in the first update.

This is what this App is all about:

EasyCalcmobile helps water utilities and consultants to establish an initial water balance and calculate water loss performance indicators.

For many years, Non-Revenue Water (NRW) practitioners have been using the free water balance software WB-EasyCalc (can be downloaded from www.liemberger.cc) for their detailed water balance and performance indicator calculations. For such an analysis a lot of information and data is required, but often not readily available.

The app EasyCalcmobile intends to bridge the gap between "no idea about the NRW situation" and a detailed water audit using WB-EasyCalc. The app will be most useful for example in initial discussions with a water utility manager when only most basic data are readily available and the app's default values can be used to fill the blanks. Rough estimates of potential 95% confidence intervals (+/- error margins) are integrated so that potential error range of the results can be easily understood.

Roland Liemberger

# Leakage Detection under Intermittent Water Supply Conditions

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There are many difficulties when conducting Active Leakage Control in areas of Intermittent Supply and many parameters that ought to be considered prior to starting any leakage activities. To illustrate this set out below are some simple case studies highlighting issues that could be experienced and should be considered when dealing with leakage under IWS.

## Case Study 1

An area in this city was on intermittent supply and there was a plan to move the area to 24x7 supply and to conduct leakage detection. The area was supplied with water for 4 hrs per day every 3 days. The consumers used roof tanks to store water, as is the case in most intermittent supply situations. Since the supply was erratic the consumers had no control valves in their roof tanks in order to ensure that they had their water tanks full and had a visual indication of that by observing that the roof tank was overflowing .

As part of transitioning to 24x7 it was decided that as a first step it would be appropriate to install ball valves in all customer roof tanks in order to control overflows and wastage. A team of plumbers was sent into the area to install ball valves and taps to the roof tanks. The process of ball valve installation was in full swing however by the end of the day the street was littered with taps and ball valves as the customers has removed them. The customer protested that for many years they were accustomed to the tanks overflowing and that was a sound indication and they knew that the tanks were full ensuring that they had water. To install ball valves the customers felt that they wouldn't have the usual visual indication that their tanks were full and this have made them nervous, disgruntled and wanted to go back to the old ways. After this leakage detection was postponed until a consumer awareness and educational campaign program was introduced showing the benefits of controlling water losses and the type of control devices used to do this as well as the benefits of transitioning from IWS to 24x7 supply and the project continued some months later allowing an leakage detection to take place. It is strongly recommended that communication with consumers is of the utmost importance and must take place early on in the project informing the consumers of the changes that will take place in the water supply regime and the benefits that these changes will bring.

## Case Study 2

This case study had a very similar water supply situation as in Case Study 1 but in this instance a different approach was adopted for moving forward with an Active Leakage Control (ALC) program. Instead of installing ball valves to customer roof tanks it was decided to manage the situation in a much different way and to temporarily isolate the supply to customers in order to deal with leakage in the mains and service connections. To do this all customer service connections were located and turned off on a day that the consumers were not to be supplied with water. The mains distribution system was pressurized allowing mains side leakage activities to take place and to locate leaks adopting a traditional approach for repair by the maintenance crews. The steps followed are set out below and should be adopted when working in a system that was on IWS and moved to 24x7:

- Conduct walk route of mains to look for any obvious leaks from fittings, connections or leaks that are now showing on the surface,
- Conduct an acoustic survey preferably with an electronic listening device but can be completed with a traditional listening stick and record areas of interest for follow up.
- Conduct a correlation survey to check areas of interest and to narrow down to smaller areas to use the listening device to pinpoint the position of leaks. If a correlator is not available then the surface above the pipe should be listened on every 1 metre listening for sound that would be transferred to the surface from the leak.

## Case study 3

In this case study the city was located in an extremely hot geographical area and water was scarce with intermittent regime being the normal supply situation. The mains and service connections were in relatively good condition and customer service connection to each property was fitted with a working isolating valve. Despite the network being in a good condition conducting an acoustic leakage survey was deemed to be impossible under the intermittent supply regime so the alternative of gas injection was used into the dry (empty) water mains. The process was such that all property connections were turned off and areas of the system under test were enclosed to control the area of the network worked in. Gas with a very low level of Hydrogen (welding gas could be used) was injected along with air from a compressor and the process to find leaks using this method was conducted. The methodology used as follows:

- The area to check for leaks was isolated to a length of pipe that could be managed
- The service connections were isolated
- The gas was injected into the main via an existing connection such as a fire hydrant or through a

Leak on a service connection identified through a visual inspection of the system

Walking the planned walk route

service connection
- A fitting at the end of the pipe was opened and a 'gas sniffer' device was held over the opened fitting to register gas presence
- The fitting was closed when gas presence was registered by the "gas sniffer" device indicating that the main was full of gas
- The 'sniffer' was placed on the ground every 1 metre maximum apart and wait for 10 seconds
- If gas was present an alarm was activated and the only way it made its way to the surface was via a hole or crack of some sort in the water main
- Gas will permeate through all materials including concrete
- Gas is expensive so it needs to be controlled entering the pipe and only use the smallest amount necessary
- Gas can be injected into a wet main and use the water as the carrier of the gas to the leak or if in a dry main then a compressor can be used to mix the gas with air – using gas alone would take large quantities
- There is no restriction to size of pipe or material when using gas

The process was successful in finding several leaks however it was not suggested that this would find every leak. This is a successful method of finding leaks in a dry system.

## Case study 4

The city was supplied by a very low pressure system, less than 5m pressure, and it was practically impossible to locate leaks with acoustic methods. What was tried with success in these areas was to locate areas of leakage using a step test locating the street that had the problem and then isolate the street from the system. With the use of a tanker lorry pump water into the street via a fire hydrant to pressurize the street to enable the leak to be located via acoustic methods. This was an extreme and difficult exercise but did allow the leak to be located with success. In areas of the system that has not been moved to 24x7 this approach can be used if there is not sufficient water for ALC. The main priority is to control the area, bring it down to a street level if possible, and not to try to use this approach in an open system.

## Case study 5

Pressure in this city was low and the system was relatively old with very few house connections visible.

It was decided that a visual leakage survey should be conducted in the first instance. The visual survey was conducted during the time that the network was supplied with water and relatively pressurised. This simple method identified numerous leaks from mains and service connections as well as leakage from open pipe ends. On average it was calculated that a leak was located at every 100m of main pipes. It is highly recommended that this procedure, visual survey of the network, is adopted in most cases as a first step before climbing the ladder of leakage identification and location prior to the introduction of any technology.

This procedure is simple, inexpensive and can be conducted with limited training and will identify many leaks.

Process of work is as below:

- Identify area that has water and is pressurized
- Identify a map and plan a walk route
- Walk the main checking for any visual leaks
- Check all house hold connections checking for leaks up to the meter of boundary
- Check the household for any internal leaks present
- Record all findings on a sheet and present for repair or to be dealt with using the company procedure

## Conclusion

It should be understood that when conducting leakage activities in intermittent supplies using acoustic methods it is imperative that the system must have some pressure and the higher the better. For mains that are shallow then a lower pressure of 5 metres will be sufficient to show water on the surface in many instances but on mains that are deep and are buried at least 1 metre deep then a pressure of at leaks 10 metres is desirable. This pressure will let the energy from the leak point along the pipeline transmit to the receiving acoustic equipment. All property service connections must be turned off or stop drawing water into the property otherwise it would interfere with the acoustic process indication showing that each property has a potential leak on it and would have to be investigated hence causing Active Leakage Control to be long and non-productive process. The water supply has to be in the system long enough to fill all customers tanks and each tank has to be controlled via a ball valve or other mechanism so that when full there is no flow through the customer service connection.

The method of gas injection is an alternative to the acoustic methods but it is more costly, requires a significant amount of gas to cover a system, is not readily available and requires experienced operators. Usually this service is provided by specialised contractors who have the appropriate equipment, technology and knowhow.

The alternative of visual leakage activity requires no experience and no technology and is probably always the 1st approach to be adopted and should only be carried out when the water is turned on as described in Case Study 5 above.

# Satellite Leak detection Project in Mitrovica, Kosovo

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## ABSTRACT

The article is focused on using the modern technology in finding leakages in water supply system of Mitrovica, Kosovo, financed by Lux Dev (Luxemburg Agency for Development Cooperation) and implemented by Aquasave ltd Skopje, with cooperation of Israeli company Utilis. This is the first project of this kind in the Balkan and wider region. The services under the project were set up to achieve the following objectives:

Assessment of the network in whole and deliver locations of leaks displayed on several user-friendly GIS interfaces to MRWC (Mitrovica Regional Water Company).

Check/confirm presence of leaks in some of the buffers defined by the particular leak Sheet in predefined period by means of different leak detection equipment.

Improve i.e. enhance the capacity of MRWC in implementation of own leak detection activities and its capacity to continue with confirmation of leaks within the buffer defined in the Leak Sheets which have not yet been visited and checked the Consultant.

The project has been divided in two tasks:

Task 1 - Leak detection by analysing spectral images from satellites

Task 2 - Leak detection - verification of the leaks on the field, including training of the RWC Mitrovica NRW staff

## INTRODUCTION

The specific objective of the Lux Dev project, under which the satellite leak detection project was carried out is to contribute to the achievement of a reliable and sustainable water supply to the population served by the Mitrovica Regional Water Company. One of the key areas of improvement is the reduction of non-revenue water (NRW). It is considered that there is significant room for improving on this indicator, as the NRW at approximately 75% is one of the highest in Kosovo.

The carried out satellite based leak detection project was expected to identify many possible leaks in the water supply system, with additional on-the-job support to the MRWC staff in using leak detection equipment, aimed at marking the leaks that the satellite leak detection project has identified.

## AREA OF INTEREST

The area of interest of the services under this project is limited to the water supply system of the RWC Mitrovica, all investigation, measurement, water audit leak detection and calculation have been concentrated to the area under responsibility of RWC Mitrovica (Mitrovica - exclude Nort Mitrovica, Vushtrri and Skenderaj).

## TASK 1 - LEAK DETECTION BY ANALYSING SPECTRAL IMAGES FROM SATELLITES

### Background

The first task of the project was carried out by Utilis, an Israeli based company. Utilis developed a unique technology for leak detection in urban fresh-water distribution networks. Using technology that is used to look for water on other planets, Utilis analyses satellite imagery to detect leaks. The result? Leak detection that covers thousands of square kilometres at once, and that can identify a saving significant resources associated with finding leaks with current methods.

Utilis uses spectral aerial imaging – taken from satellite mounted sensors – to spot leakage in subterranean treated water networks. Treated water is detected, by looking for the particular spectral signature typical to treated water. Eventually, the user is presented with a leak report overlaid on a map with streets and pipes.

In cooperation with Aquasave Ltd. Macedonia and LuxDev Project, Utilis has provided a leak report for Mitrovica water utility that also includes Skenderaj and Vushtrri.

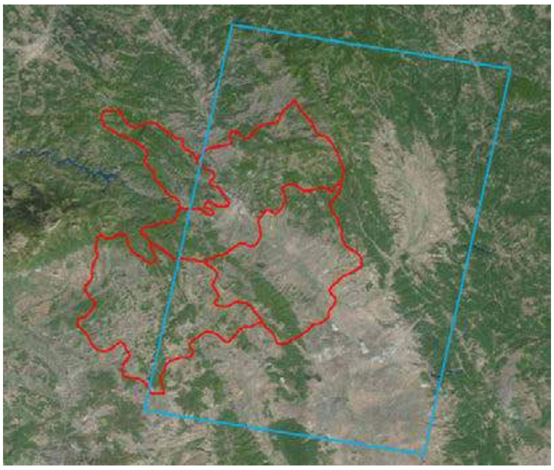
### Production of the leakage report (Images to be seen below):

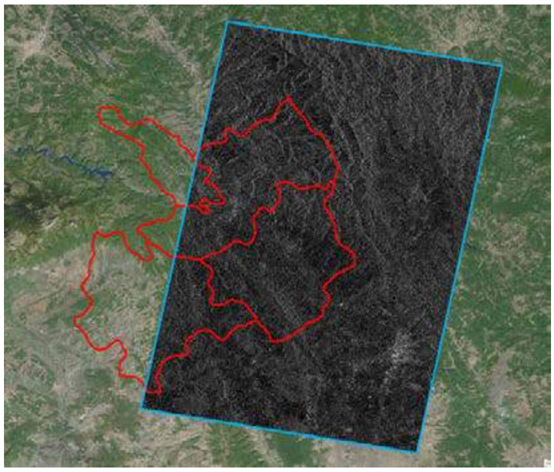
The Consultant Production Stages:

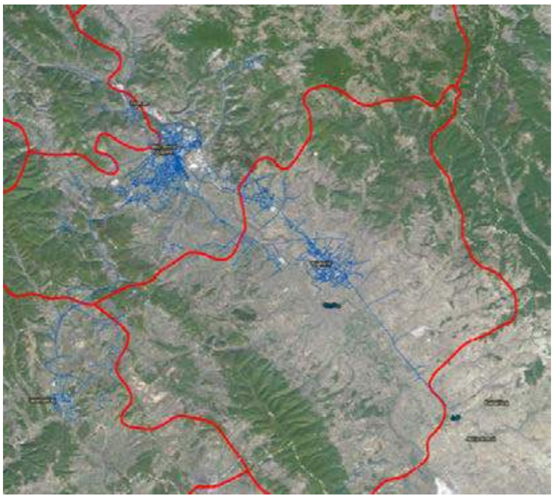
1. **Satellite spectral image acquisition:** raw images of the area taken based on AOI (area of interest) received from client (**Choose with the end-user the area of interest (AOI)**).

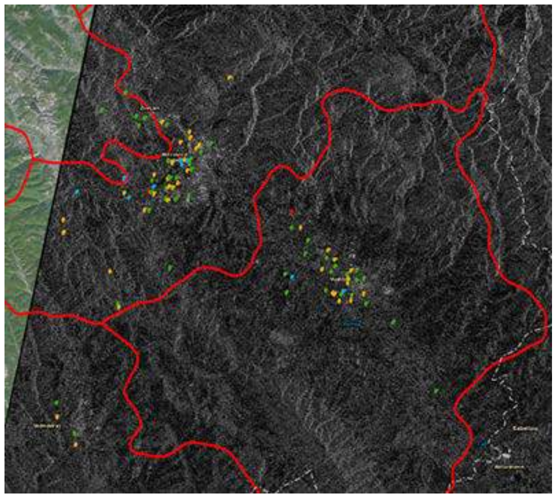
2. **Radiometric corrections:** The Consultant takes the raw data and prepares it for analysis, by filtering bounces from buildings and other manmade objects, vegetation hydrologic objects, etc.(**Acquire satellite imagery of AOI**).

3. **Algorithmic analysis:** using the Consultant advanced algorithmic analysis to track the spectral







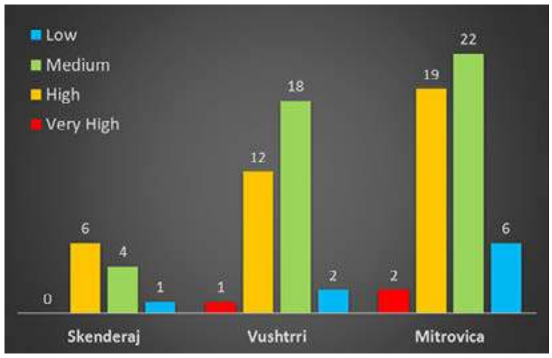


"signature" of treated water and its interaction with the soil. A corrected microwave image is then analyzed, with fresh water leaks identified. The size of the leaks is estimated by cross referencing the algorithm's output against local infrastructure (**Overlay of pipe layer (GIS)**).

4. **Delivery:** Normalized data is presented graphically with findings (leaks) displayed on a GIS web-based application. Field teams on the ground receive 'Leak sheets' generated by the Consultant system, to confirm and repair the leaks (**Supply suspected leakage locations**).

## Delivery

Based on the output of the algorithm the following suspected leakage sites were chosen for field verification of an acoustic team.




| | Low | Medium | High | Very High | no. Findings (Total) |
|---|---|---|---|---|---|
| Mitrovica | 6 | 22 | 19 | 2 | 49 |
| Vushtrri | 2 | 18 | 12 | 1 | 33 |
| Skenderaj | 1 | 4 | 6 | 0 | 11 |
| | | | | | **93** |

*the color coding indicates probability of finding the leak. The calculations of this legend are based on local parameters.

## TASK 2 - LEAK DETECTION - VERIFICATION OF THE LEAKS ON THE FIELD, INCLUDING TRAINING OF THE RWC MITROVICA NRW STAFF

The Task 2 of the project refers to the verification of probable leaks in the respective Leak Sheets, provided by Utilis, and delivered under the Task 1. The Consultant Aquasave carried out comprehensive leak detection activities according to the given Leak Sheet with its leak detection and monitoring equipment and the professional staff. In addition, those activities have been used for training purposes of the MRWC Leak-Detection (NRW) team. This approach has the advantage that during the intervention of the Consultant on site, MRWC staff received training on the job, by using, apart from the Aquasave's equipment, their own leak detection equipment.The consultant's inputs for Task 2 has been defined for three weeks (15 working days), from 04.09.2017 until 22.09.2017.

Taking into account the limited time frame given under the Contract, the services have been organised and carried out with a maximum flexibility, to visit/check as many areas/Leak Sheets as possible, particularly emphasizing the systematic examination of the networks and finding all existing leaks in the buffer, defined by particular Leak Sheet, instead of focusing and being satisfied with only one finding per Leak Sheet.

### Methodology and equipment used for flow monitoring and leak detection

**Daily preparation and activities**

Prior to start of the activities, the "leak sheets" provided by Utilis have been printed out and each copy has been distributed to Aquasave and to the RWC Mitrovica leak detection team. In addition, Aquasave team has downloaded the GIS Cloud map for the field verification on mobile devices (smart phones).

Each day the both teams have instructed their teams to answer the following questions:

- Which sites will be visited on that particular day?
- What are the materials of the pipes?
- What are the characteristics of the area? (mountainous /flat/residential/industrial)?

Upon arriving at the Utilis suspected location, leak sheets and GIS Cloud app were used in order to decide which pipes need to be checked. As a rule of thumb, both teams have checked every access point: valves, hydrants, private connections, yard taps, water meter boxes, etc. using all acoustic tools and recorded every water movement on the ground. All the findings have been notified into the Leak Sheets and photos and videos have been taken on each finding in particular Leak Sheet. The collected information was put in the predefined Utilis data collection report format (Data Form) whereas the project Team Leader was periodically briefed.

**Flow measurements**

The activities in the Project started with the effective metering at the inlet of the pipeline for Skenderaj and Vushtri, as an essential feature of network management, particularly for continuous flow monitoring for more than 24 hours by means of clamp-on ultrasonic flow meters with possibility to log flow data. Aquasave utilised the very latest technology in ultrasound flow measuring to accurately measure the flow in the existing pipelines for the client. The measurement was carried out from the outside wall of the pipe and without direct contact with the water column. There was no need to enter into the piping system or to interrupt the supply. The mobile ultrasound flow measuring device used in the project is UDM 200, SebaKMT-Germany.

The graphs from flow monitoring, including data statistics for Vushtri and Skenderaj are shown below:

According to the graphs, the maximum flow for Vushtri reaches more than 180 l/s during the night hours (supllied by Shipol Water treatmenat plant), whereas during the day the average flow is around 15 l/s. In case of Skenderaj, themaximum daily flow has been recorded to more than 100 l/s and minimun night flow amounts to less than 50 l/s (including the legal night consumption and reservoirs invlow).

**Leak localization**

***Sounding survey***

Upon detection of the potential leakage problem in a network, the "Sounding" exercise has been undertaken. Sounding of a particular water distribution system is undertaken using a Listening Stick-Contact Microphone, which is placed against all possible valves, hydrants and service connection or other accessible points on active piping, to detect noise emitting from possible leaks.

The objective is to detect the contact points where leaks can be heard and eliminate the contact points where leak sounds are not heard. The listening stick used in the services is a highly sophisticated electronic device that has many useful features to help the operator to find and pre-point the leaks. This approach would not identify the position of the leak but would normally indicate if there is a leak on a certain section of pipe. A sounding survey was carried out as the follow-up stage to a leak detection exercise, sounding on all accessible fittings.

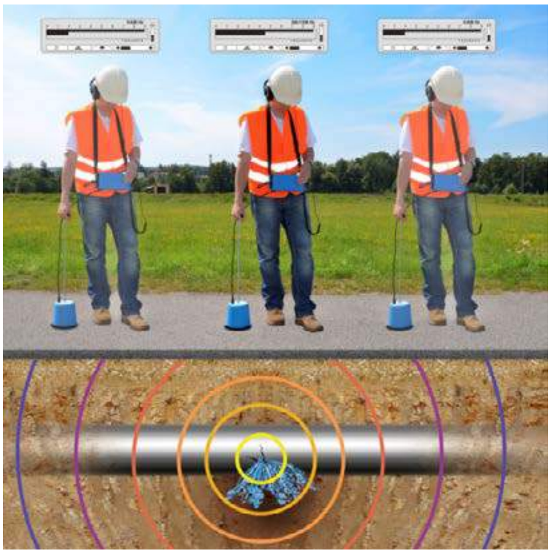
***Leak Location***

The leak location was carried out using the following pieces of equipment:

- Ground Microphone;
- Leak Noise Correlator.


*Ground Microphone*

The ground microphone is used to search for leaks along the pipeline between fittings. The technique involves placing the microphone on the ground at small intervals along the line of the pipe and recording the changes in the sound amplification as the microphone nears the leak position. The leak is pinpointed at the position of greatest noise intensity as detected by the ground microphone.



*Leak Noise Correlator*

The leak noise correlator is the most sophisticated of the acoustic leak location instruments. Instead of depending on the noise level of the leak for its location, it analyses leak sounds (including those inaudible to the human ear) and relies on the velocity of sound made by the leak as it travels through the water column and along the pipe wall towards each of two microphones placed on conveniently spaced fittings. The instrument is portable and it has the capability for frequency selection and filtering.

The correlator method is used instead of or as verification of the ground-microphone method. To use the leak correlator, the leak sound must be detectable at two or more contact points, and certain information must be entered into the correlator, including the linear pipe distance between the contact points, the water pipe material and size (diameter) of the pipeline.

Two electronically amplified microphones, connected to and powered by portable electronic preamplifier outstations, are attached to the selected contact points. The leak sound picked up by the microphones and amplified by the outstations is then transmitted to the correlator by a radio housed within the outstation.

## FIELD VERIFICATION SUMMARY REPORT

### Detection success rate

Over a period of three weeks the acoustic team of Aquasave along with the representatives of RWC visited 44 Utilis locations-Leak Sheets from 93 in total (from which 10 are located in North Mitrovica), 38 of them were positive and in total more than 60 leaks were detected in the field.

| | |
|---|---|
| Total leaks detected | 62 |
| Total suspected | 0 |
| Total quiets | 6 |
| Total visited findings | 44 |
| Total verified findings | 38 |
| Detection success rate | 86% |

Project Progress

| | |
|---|---|
| Total findings delivered | 93 |
| Total findings verified | 44 |
| Total findings unverified | 49 |

All the findings located in particular Leak Sheet are well presented by photos and videos and disruption in the supplying to this report are part of the Data Form and electronic folders. In addition, a map with all findings has been prepared to visualize the findings in the area covered in this project.

## NRW TRAINING TO RWC MITROVICA STAFF

### General notes

It is acknowledged that Water Loss Management is a multi-disciplinary activity that practically involves all operational and functional aspects of water distribution. Water losses could successfully be managed through a series of comprehensive activities covering many issues such as real and apparent losses, speed and quality of repairs, asset management, pressure management, employees' education, use of appropriate technology etc.

A key element in providing the right solution is to have capable water utility employees and without proper training, coordination and assistance it is extremely hard to expect positive results. A high level of continuous commitment, capabilities and active integration/application with appropriate knowledge is required from the water utility staff.

Therefore, the training of staff in skills and techniques features is very important in developing and implementing a leakage management strategy and for ensuring sustainability. It encompasses the motivation of staff, transfer of skills in the techniques and technology of leakage management as well as system operation and maintenance. There is a need to address the tasks, the problems and the constraints associated with introducing a leakage management programme at all levels within the company.

In order to further build the capacity of the MRWC staff in NRW Management, continuous training was carried out during the services. A classroom training given as a PowerPoint presentation provided an overview on the fundamentals of NRW management and strategy and dealt with the background and definitions of terminologies recommended by IWA and used in water loss management (non-revenue water, unavoidable annual real losses), performance indicators (ILI), with different approaches for real loss and apparent loss control and state of the art techniques and equipment used in leakage detection and control in the distribution system.

The training was continuous, during the entire duration of the services; it was organised as on-the-job training leaded by an expert from IWA Water Loss Specialist Group (Mr. Bojan Ristovski-Aquasave) and trained personnel from the Aquasave team, including use of various monitoring, tracing and leak detection equipment owned by Aquasave and MRWC.

Although the trained technical staff has shown good capabilities, it seems that they need more training days, especially when considering the exercises in the already established DMA's.

In any case, managers should consider establishing full equipped and trained team (consisting of, at least, two Leak Detection technicians and a plumber) who will be engaged only in everyday leak detection activities, with separate vehicle and support from the purchasing department in supplying the necessary batteries for the equipment on regular periods.

## Conclusion and Recommendations

Since in the Project no exact requirement or obligation was given to the consultant to visit/check all given Leak Sheets, significant efforts have been made in respect with the analysed and checked leak status of the buffer and of as many as possible Leak Sheets, whereas the MRWC staff was trained on NRW Management, with the intention of raising awareness to promote actions by the MRWC to address the problem.

Moreover, since full check/leak detection of all leak sheets was not really achievable within the timescales of the current project, this should further encourage the MRWC to continue checking the remaining leak sheets according to the experience gathered in the period of three weeks. Since NRW training has been provided to the MRWC, the next real step is to move towards implementing the methodology and techniques provided on training with respect of various leak detection activities on site.

Non-Revenue Water cannot be reduced unless there is a firm commitment within the MRWC to undertake a "Pro Active Policy" towards leakage detection activities. The establishment of an active Leak Detection Department and identification of an appropriate number of staff to work as part of a NRW action team is an absolute requirement in the first instance. There is a clear need to address the problems and constraints associated with introducing a NRW reduction programme within the MRWC. Tackling NRW requires a dedicated core of highly motivated and trained specialist personnel using own "state of the art equipment" and techniques. The use of local knowledge with an understanding of the day-to-day operation of the distribution system and water demand patterns is also essential.

### Conclusions

- Over a period of three weeks, the acoustic team of Aquasave along with the representatives of RWC visited 44 Utilis locations-Leak Sheets from 93 in total (from which 10 are located in North Mitrovica). 38 of them were positive with more than 60 leaks, in total, detected in the field. Statistically speaking, on average, it is possible in RWC to detect four leaks per day which is four times more efficient than the industry average of one leak per day,
- The largest number of leaks is located on connections, which correspond with the world statistics and practices,

- During the visiting of the sites, a lot of water meter boxes/chambers has been found filled with water,
- Most of the visited water meter chambers were without water meter or the already installed water meter was not functional. This means that there are a huge percentage of illegal customers without water meter or non-functional water meter, comparing with the number of visited sites.
- MRWC staff was trained on leak detection and NRW Management and enabled to use their own leak detection and monitoring equipment.
- The existing leak detection and monitoring equipment is generally in good condition, but it still needs to be upgraded in order to perform all required services.
- The existing flow and pressure monitoring DMA system is not operational. There were no possibilities to get all necessary information to evaluate the systems under responsibility of the company from the aspect of real losses.
- The GIS map provided by MRWC is not updated.
- According to the findings, we could conclude that the methodology is functional and that the project could be evaluated as successful.

### Recommendations

- All detected and notified leaks must be repaired immediately.
- The MRWC team should continue visiting the remain Leak Sheets with the existing equipment, notifying all detected leaks, taking photos and videos of all findings and filling the Data Form,
- Although the MRWC team is well trained, it still needs additional training, supervised and gained by experienced NRW engineer,
- To establish a full equipped and trained Leak Detection Team (consisting of, at least, two Leak Detection technicians and plumber) which will be engaged only in everyday leak detection activities, with separate vehicle and support from the purchasing department in supplying the necessary batteries for the equipment on regular periods,
- To equip the LDT with the necessary equipment,
- Availability of company funds for NRW activities
- Systematic field investigations for illegal connections on distribution pipes and possible bypass of water meters; Rotation of water meters/ controllers should be consider,
- Seriously tackling commercial losses by updating the customer data base and replacing the water meters,
- Put the DMA monitoring system under operation–at utmost importance in order MRWC to be capable for data collection and analysis on the technical aspects of NRW. With operational DMA monitoring system, the flow consumption on each DMA, could be monitored in order to better interpret the current leak status of each DMA and the system, as a whole. The fully operational DMA monitoring system could prioritize DMA's/networks with higher real water losses,
- Check if DMA is really DMA! Based on the information received, it seems that there are interconnections between the already established DMA's. Apparently, the DMA's are not fully isolated,
- In order to facilitate the DMA examination MRWC should update and complete their consumer data base in a way that all registered consumers can be located precisely on the ground, and thus their metered water consumption can be put into relation with the night flow measurement results, received by DMA monitoring system,
- Compile a quick top-down water audit for the fiscal year 2016 using the Free Water Audit Software package (which can be downloaded from the following web site- http://www.liemberger.cc/). This will quickly and easily provide a preliminary assessment of water loss standing, cost impacts and serve as a basis for comparisons with other water utilities,
- Once a preliminary water audit exists in the software, the methods explained in the training can be followed to form a NRW team, develop a more detailed worksheet and start bottom-up activities and interventions to more accurately quantify and control apparent and real losses,
- Update the GIS maps with related attributes,
- Develop and maintain Leak Location and Frequency Database/ Maps
- Visual inspection of entire water and sewerage pipelines is necessary.
- Repair additional leaks that could be found through visual inspection and additional leak detection on the remaining network indicated on the Leak Sheets. Repairing visible and reported leaks (preferably within 24 hours of being reported) is without doubt one of the most obvious and basic interventions that should be implemented as a top priority;
- Replacement of old and bad-condition pipes and galvanized iron service connections will assist in reducing Real water losses/Non-Revenue Water;
- Install pressure reduction valves on some critical locations in order to reduce the pressure and reduce variations during the day and night. See the possibilities to upgrade the existing DMA's to PMA by installing pressure reducing valve into the same chamber. Detailed pressure measurement at critical points should be carried out before.
- Develop a strategy and/or Action Plan for reduction of Non-Revenue Water;
- Further satellite based leak detection service should be offered on a multi-annual basis.

# INTERESTING ASPECTS IN THE FIELD OF REDUCING WATER LOSSES APPLIED TO S.C. HIDRO PRAHOVA S.A.

**Tema: Practici actuale în domeniul reducerilor de pierduri**

**Marius Bugan**

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## Company Profile S.C.Hidro Prahova S.A.

• Operating in 50 localities (12 cities and 38 villages), covering in proportion of 86% cities and 42% of the Prahova county villages.

• Ensures operation of 50 water supply systems, serving 222.137 inhabitants, as well as services of sewage/waste water treatment plant for 85.489 inhabitants, through the 18 sewage/treatment systems managed by this company.

## DETERMINING THE WATER LOSSES IN THE CITY OF CÂMPINA

Special note - the city of Campina is located on a triangle gravel composed of the rivers Prahova, Doftana and Cornu, so that the water from a damage to a water supply system comes out at the surface in 10 % of cases.

Depending on the supply and pressure zone, it were established DMA for about 1000 inhabitants. Sometimes it was necessary to monitor a subareas (even at the level of the network node) using mobile ultrasonic flow meters. The high pressure systems were monitored separately and with priority. Due to the fact that there were no manholes for these measurements of flow rates, it had to be executed positioned pits for these measurements. If these were not possible then the DMA was closed for the night and in the flow rate entered was calculated.

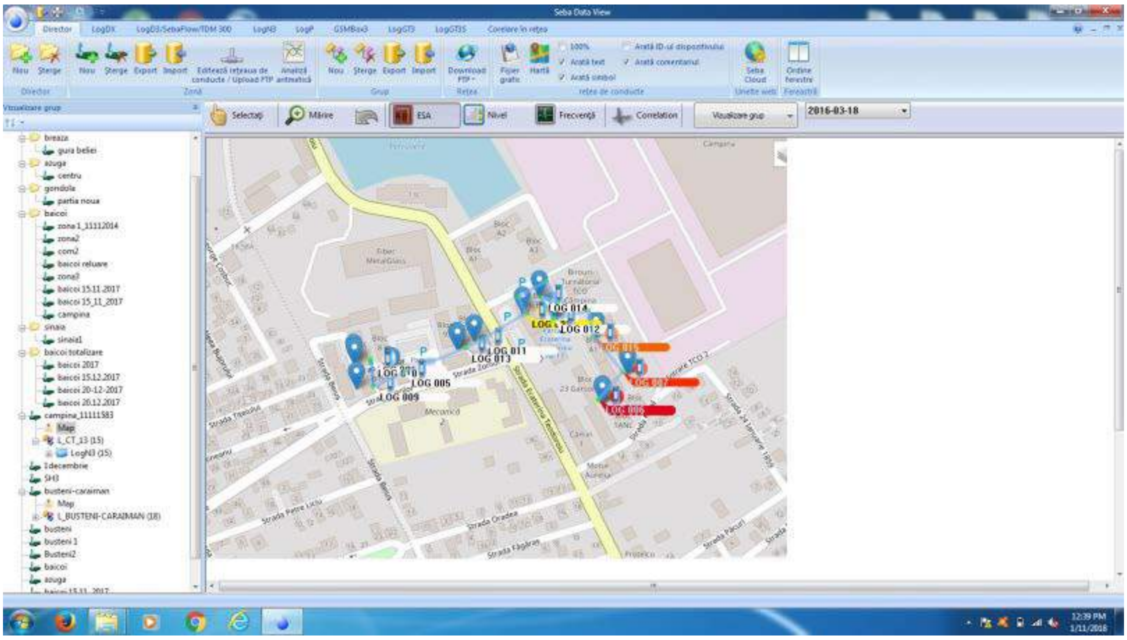
256 measurements of flow rates were totally made, excepting those for monitoring the DMA. It was verified the routing of the old supply pipes ( since 1939) and 12 damages were detected. The drainage and drainage of household water were monitored during the night and, by analyzing chlorine and aluminum, were identified 5 damages.

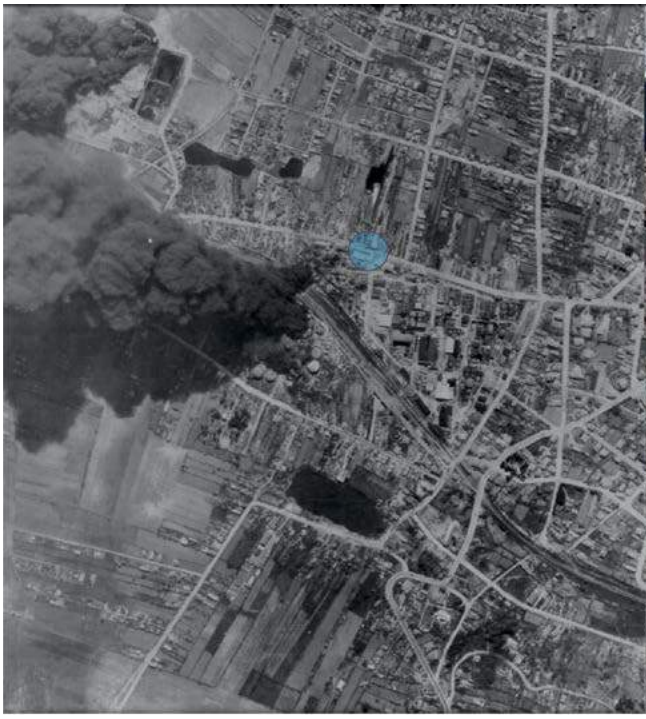
On the occasion of a wrong closing maneuver, lucky, a DN200 steel transport pipe was over pressurized, which led to the identification of 4 damages in the area ”Fântâna cu Ciresi”, unidentifiable from to the surface. The pipelines of large diameters were traced, identifying the routes DN500 concrete transport pipelines, the Voila transport pipelines and the transport pipelines Calea Doftanei Street. There were systematically assembled acoustic loggers of network on 500m steel pipes and 100m PEHD.

THE RESULTS: it has been reduced the amount of water entered into the system with 4973052 cubic meters/year

UNIQUE ASPECTS:

A damage has been identified after 72 years. A DN400 pipe has been affected by the RAF bombing on the refinery in 1944





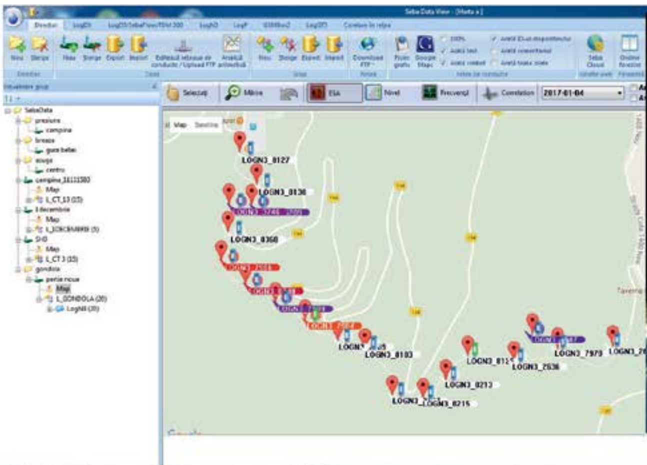
A 150 cubic meters water tank, sealed in 1944 by the German army, was discovered next to Campina

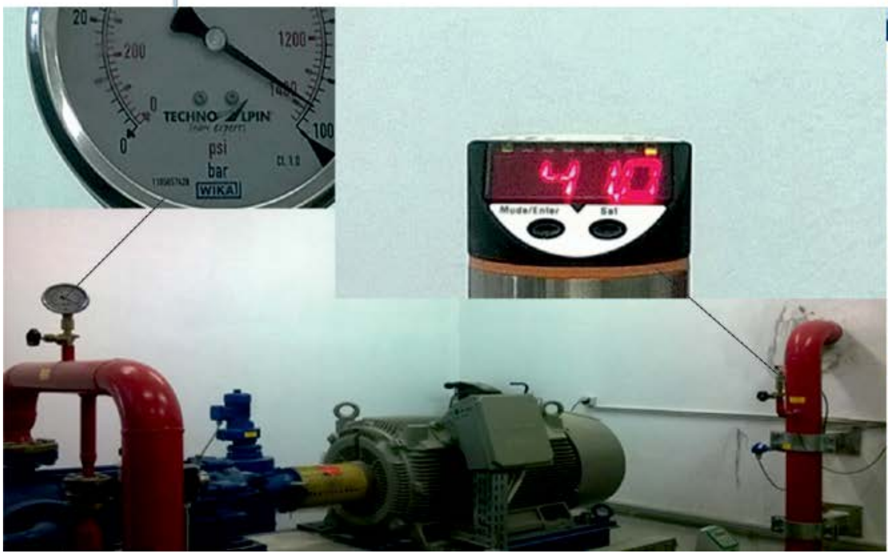
## SNOW GUNS WATER LOSS DETERMINATION

Due to the fact that the measurements were made with the existing snow layer, the acoustic devices were partially useless. The artificial snow installation which serves Sinaia new ski slope ”Pârtia Nouă” 1000-1400 mdm, provided with a DN63 pressure cast iron pipe, was unable to serve snow sprayers at 380-640 m elevations from the pumping station.

The company managers have requested help assuming that there was a damage at 380 m elevation (corresponding to the 38 bar pressure remained on the installation) especially because in that area there was a landslide. Acoustic loggers were used on each snow sprayer and the pipe was manually pressurized at 120 bar but could not be confirmed the presence of a leakage, the noise detected by two loggers was from the compressed air installation. Measurements were taken by pressure and flow, a difference in pressure between the pump relief showing 96 bar (Item 1) and point 2 located after the pressure regulator controlled





electronically, which shows only 41 bar (see figure), as well as the fact that the pneumatic valve on the pump 2 relief operate continuously, discharging to overflow.

At the installation of the artificial snow Dorului Valley, located at 1800-2100m altitude provided with a DN200 cast iron pressure pipe, leakage of 1930m altitude was assumed, corresponding to the pressure of 13 bar remaining in the plant after the snow cannons and the pump was shut after the guns and the pump were shut down. It was no leakage at this level.

The survey carried out at this dimension not found any leakage, so that it was done, in the absence of the acoustic devices for the determination of the failing with ultrasonic flow meters, using the bisection method.

The damage has been found, surprisingly, far below, at 1880 altitude and stemming from a seal which lose pressure at a pressure greater than 4 bar.

## WATER LOSS DETERMINATION IN CITY OF BUSTENI

11 DMAs were established, taking into account the fact that the city is located between 790-1300 mdm and has 8 sources of water supply. There were installed 59 acoustic loggers, 242 flow measurements were performed using ultrasonic flow meters.

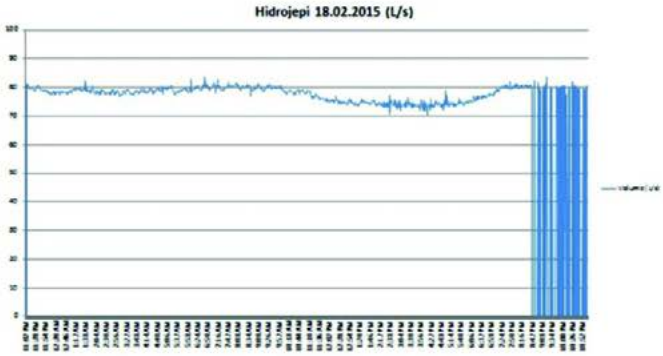
8 damages, a locked feed line, a defective pressure regulator and incorrect system settings were detected, being linked to groundwater sources at different elevations.

### THE RESULTS:

The flow on the total branch was reduced from 5264784 mc / year to 3927312 mc / year, saving 1337472 mc / year

The share of reductions was 18% loss from damaged pipes and 82% of system adjustments.

NIGHT OVERFLOW - NO WATER LOSS




AIR IN THE PIPES AT FULL SUPPLY

THE ASPHALT TRAP AND ITS CAUSE

“REPAIRED” PIPE

HYDRAULIC SHOCK EFFECT

DAMAGE DETECTE BY FLOW METER DIFFICULT TO ACOUSTIC DETECT

BUSTENI LOGGERS

# PIPA Pipepod Hydrostatic leak detection on newly installed mains

## Scope of Works

API was recently contacted by a leading water utility contractor in the UK. The client had identified a possible leak on a DI newly installed pipeline that had failed its hydrostatic testing. Due to the pipeline material and bury depth and using traditional techniques the client could not pinpoint tAhe leaks exact location.

## Project Challenges

The pipeline is 600mm DI poly wrapped and deeply buried.

The pipeline is a 600mm pipe with 12 bar pressure.

Test length of pipe is 1485 metres.

Pipe section has 14 bends including 90 degree.

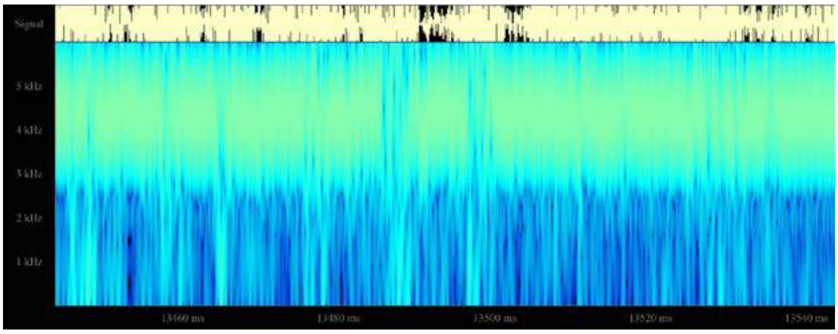
The pipe inlet is not accessible by vehicle.

The client utilised an in house leakage team and searched for leaks over a period of 5 months with the following methods:

- Noise correlators – no leaks identified (not accurate on large diameter metallic pipes)
- Listening stick- Pipeline was deeply sited below ground so this technique not feasible
- Tracer gas- This approach was openly discussed but not tried due to size of main
- The client approached 5 leakage industry experts all offering no solution due to pipe size and length of main

The handover delay had a major knock on effect, as the client could not proceed with a localised repair solution, also there was a strict deadline for chlorination and also this delays the scheme creating revenue to fund additional projects.

## Video stills of acoustic data



Leak identified on VJ fitting

## Images of site location



API uses PIPA Technology that includes a pressure rated capsule (PipepodTM) tethered to a 2000m water safe cable to give the operator audio data during an inspection. The system enters a pipeline via an 80mm riser, and is fully chlorinated during its insertion;

The technology is the latest live main inspection system on the market that offers a failsafe on all new pipe installations. The unique system is swabbed through a pipeline post installation, and can pinpoint leaks on all pipe sizes and materials.

The PIPA Pipepod Hydrostatic™ is the only solution in the world for accurate leak detection on failed new pipe installations up to 2km. The product works on all materials including Auatherm.

The product is an industry solution new for 2018.

## Survey results

- API successfully identified 3 leaks for the client (all verified)
- Tethered insertion technology system allows for precise location of the leaks to be identified
- Acoustic system is very sensitive and able to pick up small and large leaks
- Operator was able to identify no other leaks with joints identified in close proximately to each other
- System is portable and was carried 30 metres to the entry point, and is self-powered via batteries
- Complete survey completed in one insertion a distance of 1485 metres
- The cable and system successfully navigated around 14 pipe bends during the survey with no issues

## Conclusion

It would have been very difficult and expensive for contractor to find the remaining issues within the water main. The acoustic capability proved indispensable for locating issues and trouble shooting.

API completed the inspection in 1 working day, and in total successfully identified and located 3 leaks (now verified).

The contractor resolved the ongoing issue by removing the guess work at a fraction of the cost and time they invested in other methods in previous weeks.

*PIPA representative said*- The project was a great success, Ideal due to pipe location and material and also a great case study for our company and also API. The contractor had exhausted all other pipeline inspection avenues, and was more than relieved when we offered a solution.

API has also delivered successful projects with the majority of the UK water utility companies, and now offers the technology globally.

# Use Case: Driving Operational Efficiency and Reducing Water Loss

Covering a challenging area with a steep topographical terrain and serving about 500,000 people, Haifa's water utility company Mei Carmel has one of the most complicated water grids in Israel. The network includes 600 km of water mains and over 100 different pressure zones. In April 2016, Mei Carmel initiated a pilot with TaKaDu's Integrated Event Management solution to provide greater visibility of its water network and reduce water loss. Since deployment, TaKaDu has helped the Haifa utility to make huge improvements in its operations and efficiency levels and deliver significant NRW (non-revenue water) savings.

## Business Need

Founded in 2010, Mei Carmel spent the first three years dealing with malfunctioning infrastructure; the utility replaced over 120,000 water meters and established a control system.

A couple of years later, Mei Carmel started a Water Loss Reduction Process, led by Stav Avraham, Mei Carmel's COO. Stav implemented a multi-disciplinary program combining engineering, design, reorganization and technological steps focused on long-term water loss reduction.

Mei Carmel proceeded to take active measures to cut down on water loss. A dedicated team was established with a specific budget, defined assignments and scheduled weekly meetings. Mei Carmel set up main zone DMA (district metered areas) installations, meter transmissions, 'back to back' AMR (automatic meter reading) with supply connections and acoustic sensors for real data, including night flows and basic balance.

With access to real data, the team found the main causes for water loss to be the faulty measurements of water sources, unmetered landscape irrigation connections, water theft, unobserved pipeline bursts and incorrect consumer meter readings. Leaks were still mostly discovered through regular checks.

In early 2016, Mei Carmel took a decision to take further measures to improve its water efficiency. Although proud of its low water loss levels, it understood the value of harnessing data to gain further insights into network events. Mei Carmel turned to TaKaDu's Event Management Solution to enable them to monitor the water network automatically and provide early detection of 'incidents' without being dependent on manual feedback from the field.

Following a successful pilot, the utility signed a three-year contract with TaKaDu in June 2017. Today Mei Carmel has over 80 DMAs and control zones with the entire network covered by TaKaDu's integrated event management solution.

## Solution

### TaKaDu – the 'umbrella' management layer, managing the flood of data

Realizing that the huge amount of data, generated by several sources, could no longer be handled separately, Mei Carmel started using TaKaDu as its daily network management platform. TaKaDu oversees an implementation process involving different technologies, such as acoustic leakage sensors, meters, water balance and pressure monitoring, and a range of engineering decisions. Acting as the 'umbrella' layer for all events, TaKaDu provides in-depth insights into the network's events and incidents, including leaks, bursts, changes in water pressure and faulty assets.

Integrated at the highest level, TaKaDu enables every event and anomaly to be detected, analyzed, managed and resolved as quickly as possible. For example, TaKaDu has enabled Mei Carmel to detect hidden leaks (see the example below), extract nightline trends for identifying leaks before they turn into bursts and carry out individual water loss analysis by examining deviations from fixed patterns.

TaKaDu's software is also integrated with Mei Carmel's Customer Call Center and other departments, ensuring cross-organizational coordination on an ongoing basis. The TaKaDu system provides managerial dashboards, actionable insights and detailed reports to management teams, enabling smarter decision-making.

## TaKaDu Event Examples

1. **Hidden Leak Event** TaKaDu's software showed a major leak in the city of Haifa through a significant flow increase in one of the areas. A field team was dispatched to the area and they proceeded to find and repair two small leaks. Although it was assumed that the problem was solved, TaKaDu continued to report a flow increase. The field team was sent again to investigate more deeply. This time, they found a huge leak in a hidden creek outside the residential area – a place where no one usually goes – saving Mei Carmel approximately US$90,000.

2. **Pressure Decrease Event** TaKaDu detected a reduction in pressure in a PRV (pressure relief valve) located between two reservoirs. The valve needed to be opened to clean one of the reservoirs, but

Graph showing the start of the "hidden leak" (the hidden leak event) in TaKaDu.

The "hidden leak" (the hidden leak event) continued to show a flow increase even though repair teams were sent to the area, discovered two different leaks, and fixed them.

Graph showing the start of the "the pressure decrease event" in TaKaDu.

the maintenance team had forgotten to close back the valve and TaKaDu alerted to an anomaly in the behavior of the data. Mei Carmel thought that something was wrong with the meter, however, after checking the meter, they saw that it wasn't the problem. TaKaDu continued to send an anomaly alert. Mei Carmel then got another alert regarding an increase in the level of the reservoir, and, together with the TaKaDu alert, understood what happened. They sent a member of the team to open back the valves and the event was resolved.

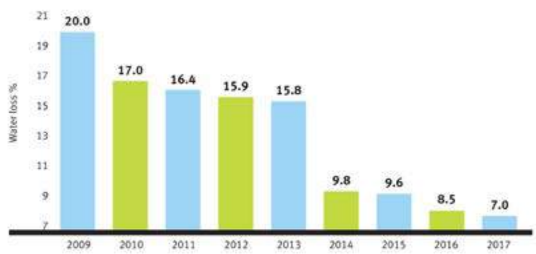
## Results

By taking a holistic approach to water efficiency, Mei Carmel has implemented an effective PPT (People, Processes and Technology) strategy using TaKaDu. Mei Carmel has made huge improvements in its operational efficiency levels and reduced its NRW loss.

Eventually, the main leak was found in a natural creek outside the residential area. Without TaKaDu, the leak would probably not have been discovered for another 6-10 months.

### TaKaDu's tangible and intangible benefits include:

- Repairs validation – ensuring that a leak has been successfully repaired by monitoring the event lifecycle from start to finish. Events are closed in the system only after TaKaDu has verified that it has been fixed and the usage pattern has returned to normal.
- Leakage awareness time – detecting small leaks within hours and trend leaks which wouldn't have been identified otherwise
- Reduction in analyst time – providing automatic alerts, an intuitive user interface and a variety of graphs and reports. Previously, Mei Carmel's analyst would have spent a full working day preparing a report with specific information per DMA.
- Avoiding collateral damage – detecting growing leaks before they become failures and bursts and reducing outages of critical facilities
- Improved network operations – identifying breaches between DMAs, saving pumping energy and detecting network operation failures via the detection of abnormal flows or pressures
- Visibility of network availability – increasing system up-time through the ongoing monitoring of sensors and telemetry
- Maintenance cost savings and shorter repair cycles – via the early detection of network inefficiencies and a centralized view
- Improved customer service and customer satisfaction – leading to reduced service interruptions and faster response times • Regulatory compliance – enabling objective visibility into KPIs, network metrics and operational activities through dashboards
- Cross-departmental coordination – information is shared with representatives from different departments
- Enhanced prioritization – enabled by the granular view of network issues and capabilities, events can be sorted based on priority and specific need




Graph showing the reduction in water loss at Mei Carmel (2009 – 2017)

# ADVANCED HYDRAULIC ANALYSIS AND CALIBRATION AIMED AT WATER DISTRIBUTION NETWORK MANAGEMENT

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## Introduction

Pressure-driven hydraulic modelling of Water Distribution Networks (WDNs) is mandatory in order to support efficiently the system management, considering both the pipe energy losses due to roughness and how these cause water losses in network as function of system pressures (Giustolisi et al., 2008a). Following the works of Giustolisi et al. (2008a;b), Giustolisi et al. (2011) developed a software package for WDN analysis, planning and management named WDNetXL. The accuracy of WDNetXL compared to other pressure-driven analysis approaches is much higher than standard commercial products since its "hydraulic engine" has been designed to be originally pressure-driven. The following examples has been accomplished by means of WDNetXL software package.

## Calibration based on mass concept and pipe unit hydraulic resistance

Therefore, a modern calibration (Berardi et al., 2017) must be extended and mainly based on mass concept. This means that, after the characterization of the user types in terms of average water demand values (at least) in a daily or weekly operating cycle, the inflows to the WDN from its water sources (tank and pumping systems) need to be metered. Through the calibration, these inflows are basic to split the component of water statistically delivered to users from the component of the water leakages, which depends on the average pressures in the pipes, as shown in the diagrams of Figure 1.

Figure 1 shows how the problem is the separation of these two main components that determine the mass balance in the WDN starting from the inflow measurement patterns of the system. Certainly, the separation cannot be performed without the calibration of pipe roughness (i.e. the hydraulic pipe resistances) and the evaluation of the average pressures in the network, which determine the water leakages in order to calibrate the values of β as realistic and accurate as possible from the available information (pressure and flow measurements). Operationally, calibration for management aims is a dynamic process that begins by assuming β as dependent on, for example, pipe diameters, but also on the pipe age and the number of private connections, when available. The consequent districtualization and sampling design of pressure and flow, allow refining the districts hydraulic model starting from the first calibration, while the initial model already allowed an optimal planning of districts (Laucelli et al. 2017). From the standpoint of pipe roughness, it should be noted that, while in WDN analysis models the pipe internal diameter could be considered as known, at management

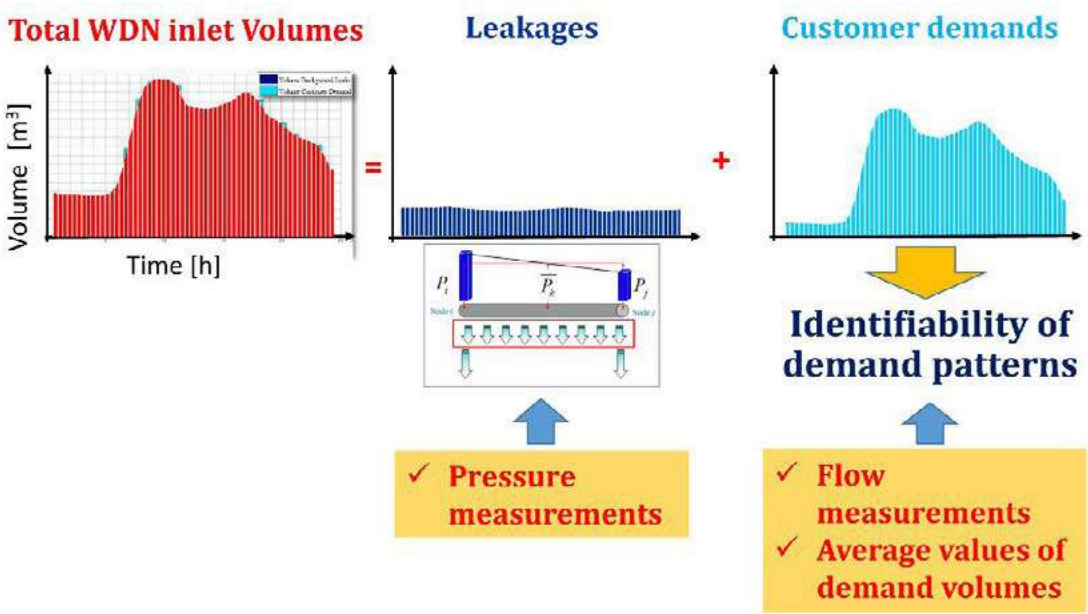



Figure 1. Components of the inflows measurement pattern.

level, i.e. for systems that have been in service for decades, the limit between pipe internal diameter and pipe roughness is vanishing. Therefore, assigning a single diameter to pipes becomes a too restrictive assumption, given the possible occlusions along the pipes path, any partially opened valves, etc..

It should be recalled that the evenly distributed head losses along a pipe (ΔH) can be calculated using the Darcy-Weisbach formula:

$$\Delta H = \frac{\lambda}{2gD^5} Q^2 L = K Q^2 L \qquad (3)$$

where λ is the friction factor that can be considered almost constant (wholly turbulent flow in rough pipe), Q is the water flow, D is the internal pipe diameter and K is its unit hydraulic resistance (per unit of length and capacity). The Eq. (3) clarifies that, for calibration aims of management WDN models, it is much more reasonable to talk about pipe unit hydraulic resistance, because is not possible to separate the contribution of pipe roughness due to the uncertainty on the actual pipe internal diameter, as said in service for decades, which also appears in Eq. (3) at power five.

## Background leakage reduction by optimal district metering areas design

A structured approach to managing complex networks, such as urban WDNs, requires the identification of districts as a step necessary to simplify control and planning tasks. In particular, district metering areas (DMAs) are commonly known as network portions delimited by flow meters or isolation valves for monitoring consumption and leakages into them. The basic idea is to reduce water losses in the network as consequence of lowering nodal pressures by means of closing isolation valves, thus modifying water paths with respect to the current state of the system. Recent studies investigated the potentialities of the integration of advanced (pressure-driven) hydraulic model with a network segmentation strategy that takes inspiration from complex network theory (Giustolisi and Ridolfi 2014a; b).

Therefore, the optimal strategy for DMA design, aimed at reducing water losses, consists into two conceptually distinct phases:

(A) ***Segmentation*** of the network by means of conceptual cuts that identify the edge of network portions, named segments or modules, while not installing any hydraulic device. The optimal design of segments is obtained by solving a two-goal optimization problem: (i) maximizing a modularity index adapted to the hydraulic networks (Giustolisi and Ridolfi 2014a; b); (ii) minimizing the number of conceptual cuts. It is noteworthy that, unlike what is proposed in the more general complex networks theory (Newman 2004), the modularity index developed for hydraulic networks takes into account of the infrastructural features of the system, such as the positioning of hydraulic devices at the end of pipes. Therefore, the strategy combines the robustness of a segmentation approach developed for and tested on complex networks, with the technical features of the system. Because of these two objectives are conflicting, the solution to the problem provides many optimal segmentation solutions, whereas each solution has a different number of conceptual cuts, which are the optimal location of possible flow meters or closed gate valves.

(B) ***DMA design aimed at reducing water losses***, starting from one of the segmentation solution obtained in phase (A). The conceptual cuts obtained in the first phase are considered as candidate positions for the installation of flow meters or closed gate valves. The selection of cuts that will put up valves or meters is achieved by solving a three-goal optimization problem: (1) minimizing the number of flow meters; (2) minimizing the volume of water losses; (3) minimizing the volume of unsupplied demand to customers due to pressure reduction caused by the closure of isolating valves. It is worth noting that minimizing the number of flow meters (1) allows reducing the costs of purchase and maintenance of the system, considering that gate valves are cheaper, and drive the search towards the installation of more gate valves on secondary water paths, thus limiting the pressure reduction. Moreover, it is evident that the evaluation of the objectives (2) and (3) necessarily requires a pressure-driven hydraulic analysis with a new generation hydraulic model. Given the conflict among the objectives, the procedure returns several alternative solutions, each corresponding to its own reduction of leakage rate due to the closure of isolation valves. For oversized networks, the procedure returns multiple solutions while easily satisfying the user water demand (i.e. no pressure deficits during the operating cycle). The procedure allows taking into account of valves and flow meters already installed during both phases, as well as obtaining nested districts for a growing number of devices, thus being flexible in terms of management needs and investment availability.

This approach to optimal DMA design was applied to the Exnet network (Figure 2a) (Laucelli et al. 2017). The salient data of the two-optimization phases are as follows:

• Phase (A) Segmentation: 59 solutions with conceptual cuts between 62 (26 segments) to 274 (94 segments). The solution chosen for the next phase B consists of 108 conceptual cuts (36 segments) for the installation of isolation valves or flow meters (Figure 2(b)).

• Phase (B) Districtualization: 80 optimal DMA solutions with a number of isolation valves ranging from 32 to 55.

The 80 optimal solutions, while varying the number of valves/flow meters, allow reducing water losses up to 25.8% (solution n. 78, 35 valves) of the original value, against a percentage of unsupplied user demands technically negligible, even considering the conservative hypotheses assumed for this investigation, equal to 0.00065%.

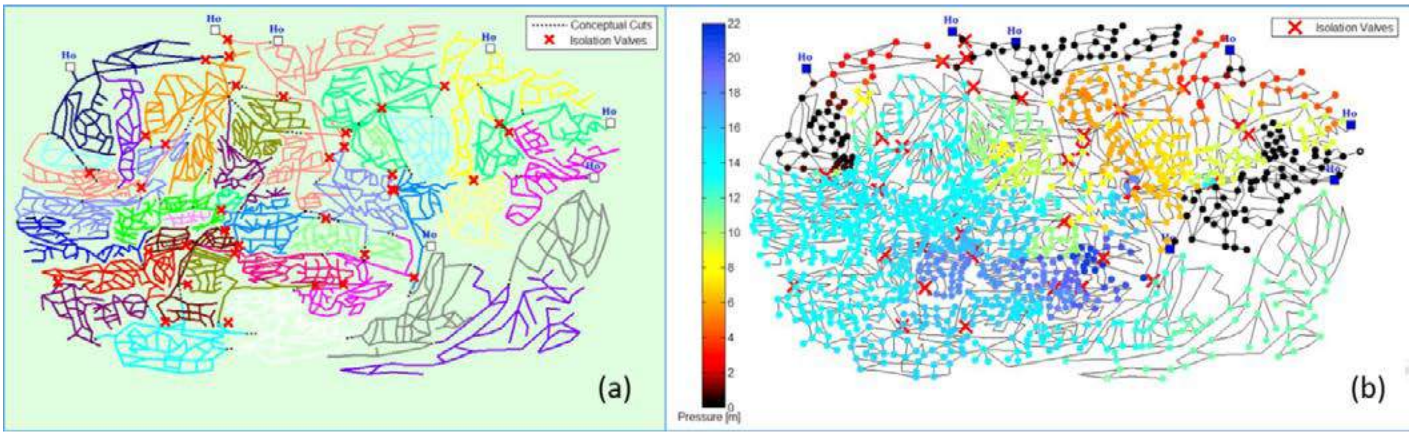



Figure 2. (a) Exnet WDN; (b) network segmentation: 36 modules using 108 conceptual cuts for the installation of flow meters or closed valves.

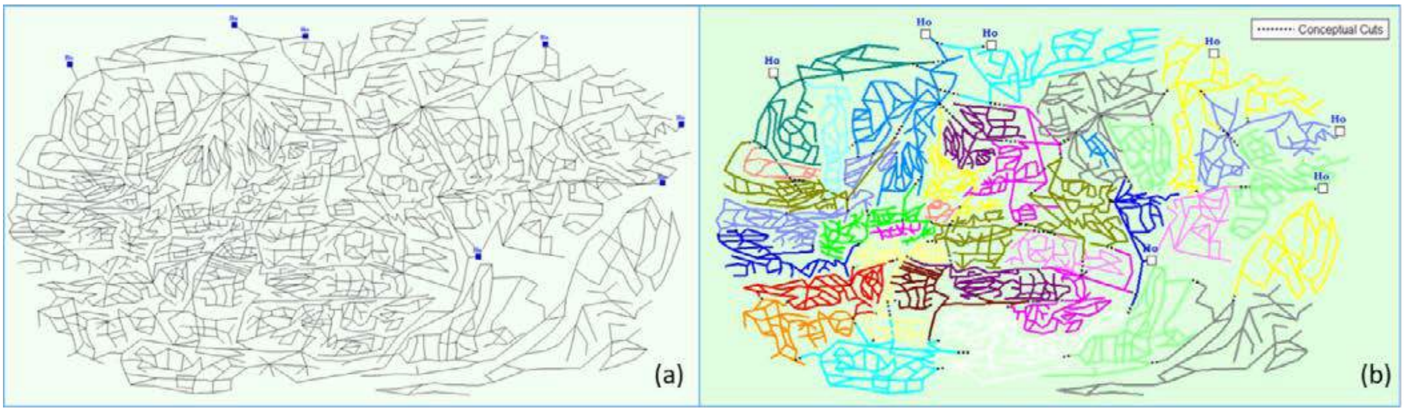



Figure 3. (a) Exnet Districtualization, solution n. 78 (b) Pressure Reduction in nodes du to gate valves closed.

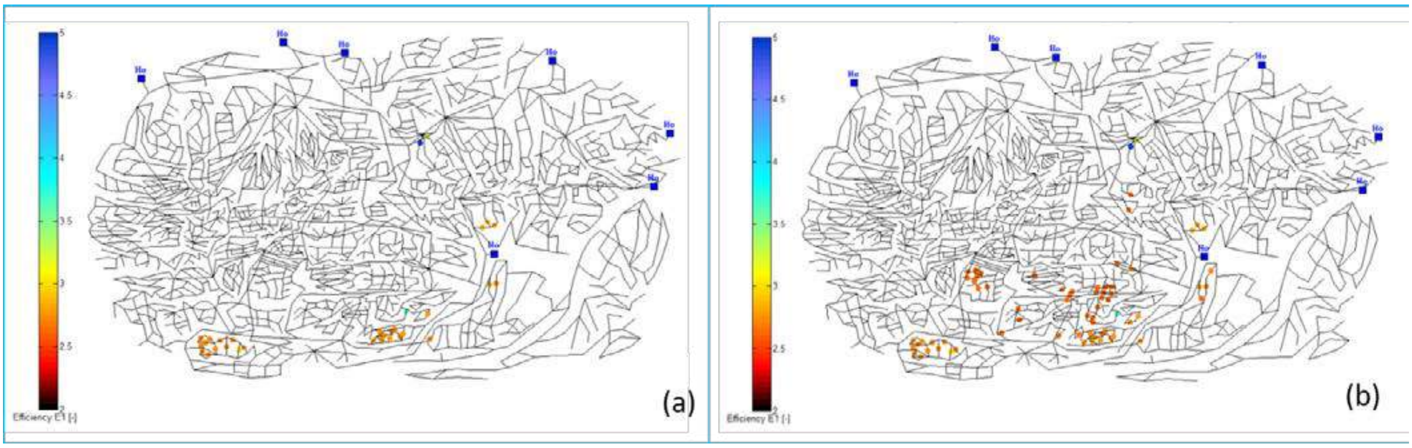



Figure 4. Exnet: (a) replacement of 0.5% of network cost; (b) replacement of 1.0% of network cost.

Figure 3(a) shows the configuration of the DMAs for the solution n. 78, as well as the position of the 35 isolation valves. Figure 3(b) shows, for the same solution, in colour scale the pressure reduction values compared to the operating conditions without closing the valves.

Efficient planning of rehabilitation works

Rehabilitation/replacement of WDNs pipes causes the change of their hydraulic resistance and deterioration conditions, thus affecting the hydraulic behaviour of the whole system (lower head losses and higher pressures). This implies that substituting pipes only on the base of deterioration indicators, such as the service life of the single pipe, may result in an increase in water loss rates in the rest of the system, even despite significant investments. Therefore, the efficient selection of rehabilitation works needs an advanced WDN hydraulic simulation for each replacing pipe, considering both the hydraulic capacity changes on the single element and the effects on water leakage in the system.

Fig. 4 reports the pipes to be replaced in the Exnet network, based on the expected impact on the entire system, assuming an investment equal to 0.5% (Figure

4(a)) or 1% (Figure 4(b)) of the capital cost of the entire network. In the first case, the intervention would result in an estimated reduction of 1.16% of the water loss volume; in the second case a reduction of 2.18%.

It should be noted that pipes selected as the most efficient in the case of lower investment (a) are also selected for the double investment (b), consistently with the impact of their substitution on the entire system.

## References

Berardi, L., Simone, A., Laucelli, D. and Giustolisi, O. (2017) Feasibility of Mass Balance Approach to Water Distribution Network Model Calibration. *Procedia Engineering*, Elsevier, 186.

Giustolisi, O., Kapelan, Z. and Savic, D.A. (2008a) An algorithm for automatic detection of topological changes in water distribution networks. *J. Hydr. Eng.*, ASCE, 134(4).

Giustolisi, O., Savic, D.A. and Kapelan, Z. (2008b) Pressure-driven demand and leakage simulation for water distribution networks. *J. Hydr. Eng.*, ASCE, 134(5).

Giustolisi, O., Savic, D.A., Berardi, L. and Laucelli, D. (2011) An Excel-based solution to bring water distribution network analysis closer to users, Proceedings of Computer and Control in Water Industry (CCWI), Exeter, UK.

Giustolisi, O. and Ridolfi, L. (2014a) A new modularity-based approach to segmentation of water distribution networks. *J. Hydr. Eng.*, ASCE, 140(10).

Giustolisi, O. and Ridolfi, L. (2014b) A novel infrastructure modularity index for the segmentation of water distribution networks. *Water Resources Research*, Wiley & Sons, 50(10).

Laucelli, D., Simone, A., Berardi, L. and Giustolisi, O. (2017) Optimal Design of DMAs for Leakages Reduction. *J. Water Res. Plan. and Management*, ASCE, 143(6).

Newman, M.E.J. 2004 Fast algorithm for detecting community structure in networks. *Phys. Rev.*, APS, E 69, 066133.

# Random Uncertainty exists in Leakage KPIs: Understand and Use it!

Allan Lambert

Leakage calculated from a Water Balance, and Key Performance Indicators derived from that leakage volume, are frequently quoted to 3 or more significant figures, implying a very high reliability of the calculations. However, all such calculations inevitably have limits of uncertainty. Practitioners who can use basic techniques of combining uncertainties in water balance and Key Performance Indicator (KPI) calculations can gain valuable insights into the confidence limits of many types of leakage calculations. They can also prioritise their data collection and quality control activities to reduce random uncertainty, with sensitivity testing to allow for local circumstances and data quality. Although overall uncertainty depends on several factors, it can be quickly assessed using customised spreadsheets, which may produce unexpected and counter-intuitive conclusions which are not yet widely appreciated.

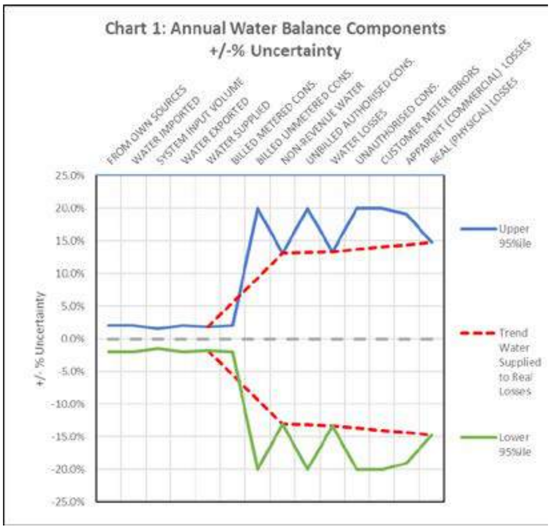
A recent addition to the Concepts section of the LEAKSSuite website http://www.leakssuite.com/random-uncertainty-in-leakage-kpis/explains the principles of calculating uncertainty in Water Balances and leakage KPIs in $m^3$/day, $m^3$/km/day, litres/connection/day, litres/connection/day/metre of pressure, Unavoidable Annual Real Losses (UARL) and Infrastructure Leakage Index (ILI). Uncertainty in leakage KPIs calculated from Water Balances tend to be dominated by +/- 10% to +/-20% (or more) uncertainty in Real Losses volume, even with good quality input data. This means that ALL leakage KPIs, including the most basic ($m^3$/km/day, litres/service connection/day) must have at least the same % uncertainty as the Real Losses volume. Also, it is found that more diagnostic leakage KPIs using additional key parameters (average pressure, length of private underground service pipes) with their own uncertainties do not seem to generally produce large increases in +/-% uncertainty of UARL and ILI, compared to the uncertainty of more basic leakage KPIs.

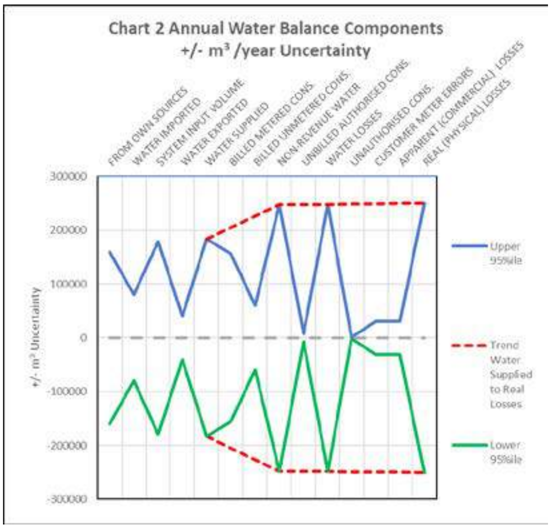
The LEAKSSuite article aims to de-mystify the topic of uncertainty in calculations of leakage KPIs, for practitioners with little knowledge of statistical theory, by minimizing the use of statistical terminology. Step-by-step explanations of the spreadsheet calculations are provided so that readers can develop their own spreadsheets if they wish*. The principles used are based on simplified Laws of Propagation of Uncertainty described in Appendix A of an IWA Manual of Best Practice (Alegre e al, 2006). The definition of uncertainty (below) in that Manual has been modified by adding 'assessment' in brackets, as many Water Balance components and KPIs are based partly on measured source data or sample data which are assessed or adjusted prior to the calculations.

*Uncertainty of a measurement (or assessment) is a parameter, associated with the result of a measurement that characterises the dispersion of the values that could reasonably be attributed to that which is being measured (or assessed)*

Uncertainty can be expressed as a +/- in units (of volume, or litres/connection/day or ILI for example); or as relative uncertainty in (+/-%). Both are used in the calculations.

In the example below from the LEAKSSuite article and software, Chart 1 (+/-%) and Chart 2 (+/- $m^3$) show how the Uncertainty of the components of Water



Balance changes as the calculation moves from the left-hand side (bulk metering) to the right-hand side (real losses volume). Uncertainty of bulk metering should always be low as +/- %, but are quite high in +/- $m^3$. Large increase in uncertainty in both +/-% and +/- $m^3$ occur when consumption is deducted from Water Supplied to obtain NRW; however, as the components of NRW are identified, the +/-% increases only slightly, and the +/- uncertainty in volume terms hardly increases at all.

In Chart 3, +/- % uncertainties of the infrastructure and average pressure data used in KPI calculations in the grey area at the left side of the Chart include +/-20% uncertainty for service connection length property line to meter, and +/- 7.5% for average pressure. The +/-% uncertainties of the volumes of NRW, Water Losses, Apparent Losses and Real Losses from Chart 1 are shown in the next 4 columns, the figure for Real Losses volume is +/-14.7%.

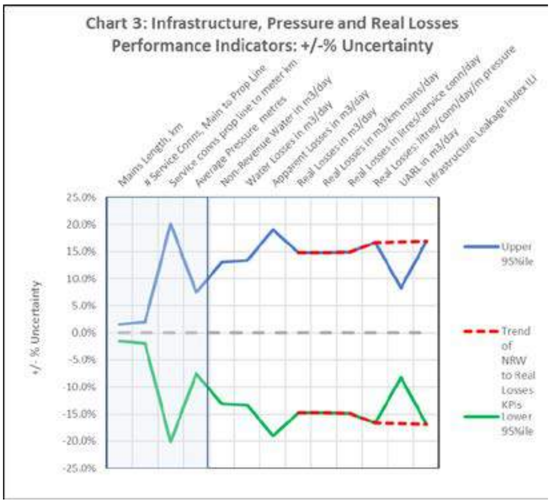
The uncertainties for the Real Losses KPIs shown in the next 5 columns are:

+/-14.8% for $m^3$/km mains/day, or +/- 0.1% higher than for Real Losses volume

+/-14.9% for litres/service connection/day, or +/- 0.2% higher than for Real Losses volume

+/-16.7% for litres/service conn/day/metre of pressure, assuming +/- 7.5% for pressure

+/- 8.3% for UARL volume, much lower than +/-14.8% for Real Losses volume. Surprise?




+/-16.9% for ILI, not much higher than +/-14.7% for Real Losses volume. Surprise?

The increases in % uncertainty of more diagnostic KPIs such as UARL and ILI, which use more infrastructure and pressure parameters, are relatively small because of the format of the mathematical equations for calculating uncertainty. The largest +/-% error is usually Real Losses volume, and this usually dominates the uncertainty calculations for all leakage KPIs.

* For further information on the software, see http://www.wlranda.co.uk/wbpiucalcs/

# Automation through Digitalisation in the Water Sector

Achim Hugger
Uri Gutermann

For many water engineers the day in the office begins with a look at the screen. They can analyse the results of the nightly measurements of their fresh water pipelines in a few minutes and make important decisions for the day. Are there any new leaks in the system? Using the information found, the water engineer can send his workers to precisely those points that the leak detection system has indicated.

## In the past regular field measurements had to be carried out manually

Without network monitoring finding leak was like searching for a needle in a haystack. Oftentimes the person responsible knows how much water is lost each year (frequently it is 25% of total consumption and more). But finding out where the leaks are located often needs the help of coincidence or a painstaking physical check of the pipeline network. Sometimes an alert member of the public reports a leak when they see water seeping out of the ground, sometimes an employee finds a suspicious spot during routine checks with the listening stick or noise logger. Weeks or months then often pass between the occurrence of the leak and its exact localisation. In the worst case, the small leak has become a bigger one or even a burst pipe. Depending on the nature of the ground, the water escaping from the pipe finds its own route over the course of time. This can lead to the undermining of roads or damp cellars.

## The entry of "Big Data" and "Cloud-Computing" into water supply management

The principle of permanent leak monitoring is known from many other application areas: a large number of sensors is distributed so it covers a large area of the system to be monitored, the measurement data and the associated information is collected at a central point and processed and analysed with intelligent algorithms which deliver precisely the results that are of interest to the user. Whether this is the pollen count or weather forecasts, intelligent car park management and Smart City: "Big Data" and "Cloud-Computing" here are not about personal data, but about the most efficient way of collecting and processing sensor information. The advantages are obvious:

- Systems are comprehensively, completely and automatically monitored
- Relevant results are available quickly and in a pre-processed form online or by email, without even having to be on site

- Automatic alarms reduce risks of damage to people and infrastructure
- Leak-related changes can be more easily identified by continuous measurements, and erroneous measurements (outliers) can more easily be identified
- Complex situations can be automatically synthesized to the relevant information and reports for management and for the repair teams automatically created

## How does Permanent Leak Monitoring work?

*When water escapes from a pipe, there are structural vibrations which spread along the pipe walls and in the water and spread out to both sides of the leak. Special noise loggers (accelerometer sensors) are attached magnetically to the outside of the water pipes. They transmit their acoustic measurement data daily to a server which analyses the data and passes the results via a secure internet connection to the water works. In the ZONESCAN ALPHA system of the Swiss company Gutermann with their R&D and production facilities in Baden-Württemberg, the measurements are taken with a very high time synchronisation. Using the laws of sound propagation the measurement data from the different noise loggers can be correlated. This has the advantage that the leaks can be located with very high precision, and false interpretations (false alarms) can also be reduced significantly. Furthermore, correlations are around 30 times more sensitive than normal noise level measurements and thus suitable for plastic networks. They frequently enable the detection of small leaks as they begin before they cause greater damage. The daily measurements of the noise loggers consist of correlation measurements, the noise spectrum and a noise level distribution. This information is linked to historical values in the leak database by an expert system on the server for calculation of the leak probability. Based on* *the correlation, the position of leaks can typically be determined with an accuracy of less than a metre and shown with an icon on a Google Map in the web browser.*

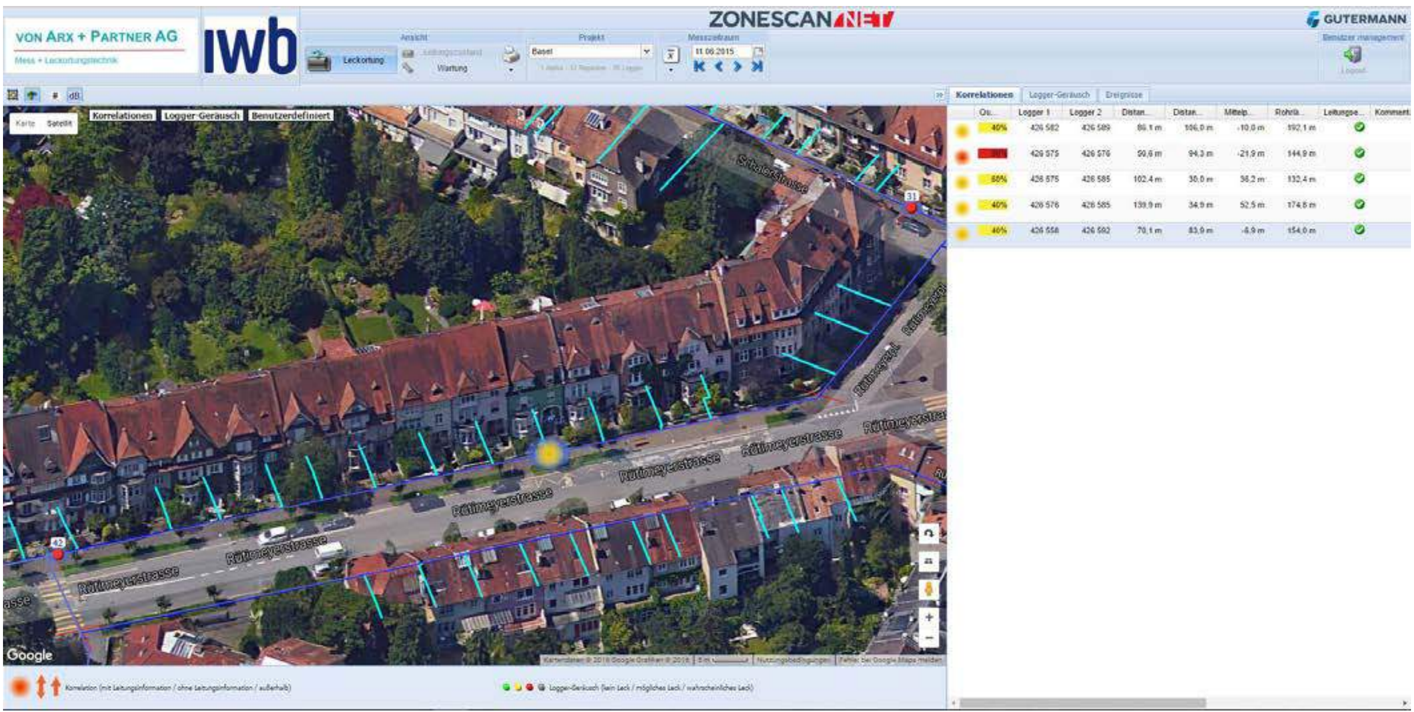
## Award-Winning Leak Detection Technology by Gutermann

Thanks to the product platform ZONESCAN, Gutermann has established itself worldwide as a technological leader and has already won nearly a dozen technology awards. Over 200 cities worldwide are now equipped with the Gutermann ZONESCAN ALPHA permanent leak monitoring system, sometimes covering parts of a city and sometimes with comprehensive coverage. The first systems in Germany were already installed at the start of this decade. Karl-Heinz Beisswenger of the Eislingen Zweckverband said "We tested ZONESCAN ALPHA for the first time in 2010. The losses through leakage in the test area were reduced by so much after only a few days that the purchase cost of the system was recouped after only three months." Since then the coverage in Eislingen has extended to nearly 1,000 measurement points. Frank Tantzky, the director for Asset Service at Albstadtwerke reports that in the area of Stetten administered by him there was a reduction in network losses of nearly 40% in the first year alone and of nearly 50% in operating costs. Losses of water in the town of Aulendorf were so high that purchasing a ZONESCAN ALPHA system for the entire water network was considered necessary on the grounds of costs, and since then crucial savings have been achieved. The cities of Trier and Benningen have also recently chosen permanent network monitoring with correlating noise loggers from Gutermann. In Switzerland, where Gutermann is based, dozens of communities are now completely covered by this sensing equipment. Many Swiss water engineers

see having their own water networks under control as a "Public Service" and so requiring the standards of quality of public services. Since 2015, the city of Lyon has been monitored over a large area by the world's largest water supplier Veolia using over 6,000 ZONESCAN sensors, whose data is collated by Veolia's AMI network and transferred to its own control system.

## More Efficient Data Transfer by the "Internet of Things"

Everybody talks about the "Internet of Things" these days. But what does that actually mean for sensor technology in the water industry? Correlating noise loggers pose particular challenges to data transfer: First of all, you must be able to transfer the data from the narrow chambers at some depth. Second, the quantities of data needed for the correlation are much greater than those required for normal noise loggers or even water meters. And third, precise synchronisation of noise recordings (below one millisecond) is also needed for correlation (see box). To meet all three conditions, specially optimised radio systems had to be used for data transfer up until now, partly involving so-called radio repeaters (as for example in ZONESCAN ALPHA installations). Due



to the rapid progress in the field of cellular LPWLAN-networks (Internet of Things), these networks can meet at least the requirements for data quantity and transfer quality. Gutermann is working on a new generation of IoT-loggers, which will also satisfy the requirements for synchronisation in a second phase. Here, the announced comprehensive implementation of LTE cat. NB1 (also known as NB-IoT) and LTE cat. M1 in many cities should be emphasised. These will allow the radio solution to be done away with, without impacting the quality of the results. Also the installation and maintenance efforts and expenses will be greatly reduced. This will make the decision in favour of a permanent monitoring system even easier for many water companies.

## Convergence of the der Permanent and Mobile Applications

Since comprehensive coverage with permanent leak monitoring may not always make sense financially or operatively, permanent leak monitoring and mobile network surveying can be skilfully combined today. With Gutermann, more and more data from individual devices like correlators and loggers can be uploaded into the same cloud solution. Thus, all measurements and their results can be permanently stored and clearly displayed graphically in the same user interface with Google Maps mapping facilities. Leak detection work has become more transparent and reproducible. More and more of these instruments are simply controlled by tablets, using attractive apps and automatic position display on free downloadable offline maps. The installation of permanent systems will soon also be possible simply using app and tablet or smartphone. Alarms about potential leaks or warnings about function faults can be quickly and conveniently investigated.

## Large Supply Pipelines are Now Being Monitored with the Help of Hydrophones

The latest development in the area of monitoring drinking water supplies is the extension of the existing system to larger transmission pipelines, so called trunk mains. The demand for this is especially large, but so are the technical challenges. Trunk mains connect the water works or reservoir with the distribution network. The pipe diameters are typically 300 to 1200mm. Whilst the damage caused by a leak around the distribution network or the house connections will usually remain negligible, the consequences of a failure in a trunk main could affect whole city districts or industrial areas. This is when early warnings and alarms are particularly needed.

To be able to detect even the smallest leaks in pipelines of these dimensions over long distances,

instead of the accelerometers fixed to the pipe wall from the outside, highly sensitive hydrophones are installed so that their membranes measure the acoustic signal directly in the water. The hydrophones are installed 600 to 800 metres apart. Gutermann for example is currently launching the product HISCAN, the development of which has taken five years and was partially funded by a grant of the Federal Ministry for Education and Research (BMBF). HISCAN enables permanent monitoring of main transmission pipes (or plastic supply pipes) through daily correlation of noise data. The first trunk main hydrophone loggers have already been installed in France, Australia and Saudi Arabia.

## The Future is Full of Promise

It is easy to imagine the data from the leak detection system being used for other purposes and combined with other data sources in the future: statistics about the frequency of leaks in specific supply pipeline sections could be used to inform decisions about necessary investment. In combination with smart metering (measurements of usage and through-flow) one can quantify water losses for individual leaks more precisely and so prioritise them. Alarms could be used to directly reduce the network pressure to limit subsequent damage. The more data is available, the more such a permanent monitoring system can be developed into an expert system that also allows projections about possible future leaks or about the remaining lifespan of supply pipelines. Gutermann has already been researching all these topics and will integrate appropriate solutions into their existing cloud software.

“Gutermann has been known for years as an innovative technology company”, says Frank Tantzky. “We are excited about the future product innovations and we will integrate useful technological enhancements into our network maintenance so that we can respond quickly and effectively to water losses even better in future.”

# Reducing water loss through continuous monitoring and pipe condition assessment technology

According to the American Society of Civil Engineers, 7 billion gallons of water are lost to leakage every day in the United States. The World Bank reports that water leakages around the globe amount to 8.6 trillion gallons per year. In the United States, 24% of the water produced is non-revenue-water – water lost by leakage, errant billing and theft. In other developed countries, non-revenue water is often between 40% and 50%.

The Israeli company, Aquarius Spectrum, has been working for several years to develop an innovative technology that will enable global water utilities to get control of their water losses, mange them and even prevent them from happening.

Aquarius' patented solutions enables Utilities to proactively monitor their water network, tracing leaks and pinpoint their exact locations automatically on daily basis. To date, the company has deployed more than 5,000 sensors installed on municipal water networks in major cities in Israel, the U.S. and Europe, covering about 2000 Miles of drinking water pipelines.

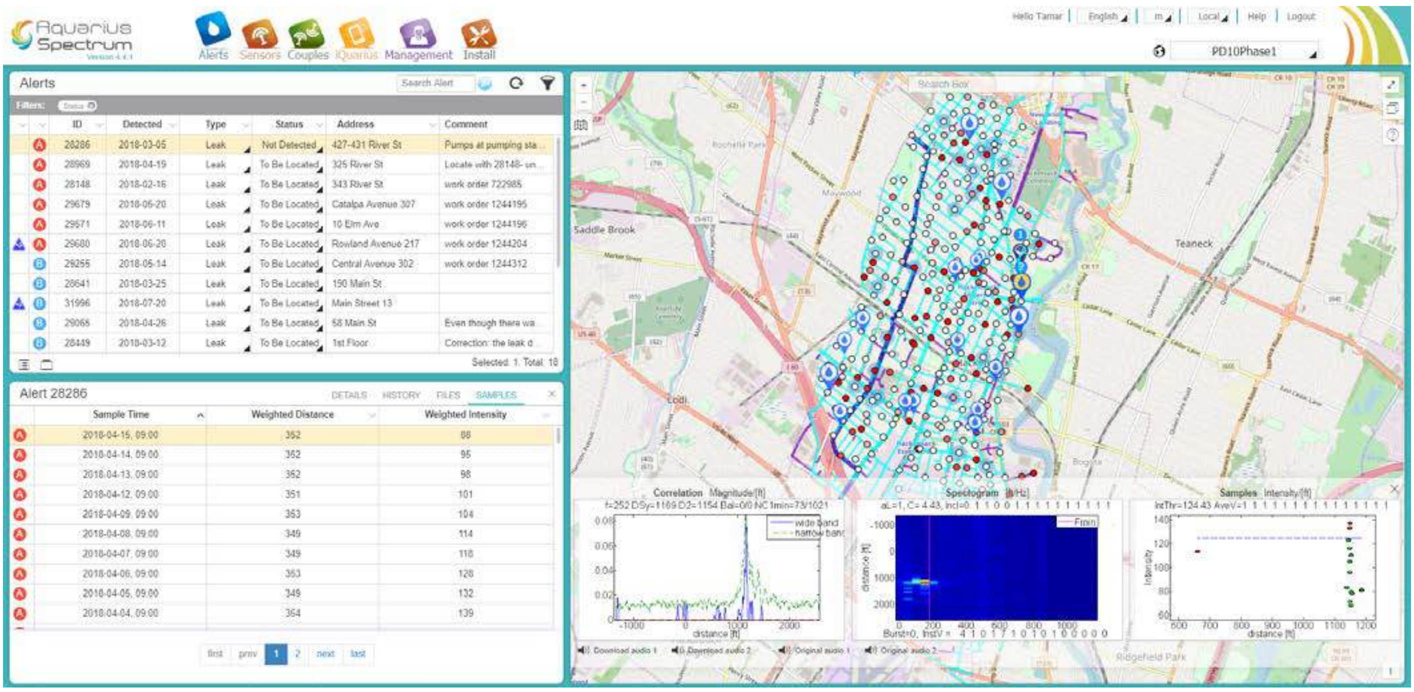
This technology helps Water Utilities reduce their Non-Revenue-Water (NRW) and their Maintenance & Operational costs by using highly sensitive sensors, management software and a mobile application.

## Continuous pipe monitoring and leak detection

Aquarius Spectrum introduces AQS-SYS for continuous water pipe monitoring and leak detection, using permanently installed vibration and hydrophone sensors. This system collects daily acoustic samples from its sensors that are monitoring the water distribution network and correlates them automatically. Highly sensitive sensors equipped with new-generation signal processing algorithms can monitor pipes of every type of material and diameter, with high efficiency and wide coverage, using typically 3 sensors per 1Mile of pipe (depending on the pipe material).

These sensors are equipped with cellular communication modems and state-of-the-art synchronization modules, capable of transferring large amounts of data and performing highly accurate correlations.

Aquarius' data analytics uses innovative learning algorithms that performs adaptive signal filtering and proprietary multi-spectral correlations for leak detection. This leak detection technology provides concise information on leak location and intensity. Proprietary methods, based on leak dynamics and



statistical measures, provide comprehensive pipe condition assessment information.

The AQS-SYS fixed correlated monitoring methodology identifies initial leaks when they are still small, hence reduces water loss and energy cost that is required for producing and distribute drinking water as well as costly emergency work (proactive monitoring and planned maintenance vs. reactive monitoring and emergency maintenance work). Furthermore, it detects malfunctioning equipment (e.g., valves, air vents, meters) and provides alerts on private leaks – avoid flooded homes and water contamination.

## Leak Detection via Smartphone

**iQuarius™** is a mobile leak detection system that connects to a Smartphone and uses a dedicated Android App, with an online connection to GIS maps, cloud-based data analysis and online expert support. It provides functionalities such as: listening to the leaks directly via a sensitive acoustic sensor, conducting a survey on pipes in a certain area, correlation for most accurate and sensitive pinpointing of leaks.

The iQuarius enables to survey large areas for leaks. Data is recorded and presented locally on a GIS map (Each point represents vibration intensity in pipes) and analyzed on the server. By using two mobile sensors you can perform correlation to maximize location accuracy and pinpoint.

The iQuarius can be used both as an independent solution for detecting underground water leaks and as a complementary method to the permanent monitoring system towards pinpoint.

## Trunk Main Pipe Monitoring and condition Assessment

In addition to its service monitoring system, Aquarius introduces its Trunk Main pipe monitoring that provides continuous monitoring of leaks, pressure surges and pipe condition assessment. Highly sensitive hydrophone correlating sensors enables to detect and locate leaks at large distances and alert on harmful pressure surges.

The system enables to monitor large diameter pipes of any material over large distances typically 600 meters between the correlation sensors. The system can be installed underground in pits on air vents, while over-ground installation version can be provided as well. The sensors are equipped with 3G cellular communication modems and state of the art time synchronization modules, enabling to transfer large amount of data for high quality correlation.

The system provides flexible and very cost-effective solution for pipe monitoring and leak detection, owing to 5 years battery operation and cellular communication. Addition Pressure sensor is optional for providing accurate pressure trending every 1-60 seconds and high-resolution recording of pressure surges.

## Hagihon Case Study

One of Aquarius' leading leak detection project has started to operate in Israel 5 years ago in cooperation with HaGihon Water & Wastewater Utility in the City of Jerusalem. Over 2,000 acoustic correlating sensors are covering the city's water distribution network. The deployment was done in a challenging urban environment in one of the oldest cities in the world (c. 4500-3500 BCE) that is characterizes in hilly and mountainous terrain.

About two years after the system was deployed in Jerusalem, there was 20% reduction in Non-Revenue-Water (NRW); more than 200 leaks were found and repaired, in addition to 60 private leaks and 265 network interferences detected by the AQS monitoring system.

## New Projects in Israel

Aquarius Spectrum is about to deploy 1,000 acoustic and hydrophone sensors during 2018 in two major cities in Israel (Tel-Aviv and Holon), after winning two leak detection and pipe condition assessment projects for distribution and trunk main pipes. Based on its AQS-SYS continuous monitoring system - Aquarius will help the water utilities to reduce the risk of pipe bursts by predictive maintenance using innovative techniques: leak development statistics and transient pressure wave analysis. The new technology enables the utilities to prioritize replacement of pipe segments by its actual condition rather than its age, and prolong the life of the existing pipes.

# U.A.V. - unmanned aerial vehicle

Alexandru Postăvaru

ApaServ
în fiecare casă

This paper summarizes the description, use, and results obtained with the UAV system owned by the County Company APASERV S.A.

The unmanned aerial vehicle (UAV), also known as drone, is an aircraft with no human pilot, being guided by a digital automatic pilot on board, or by a remote control from a control center on the ground or located in another piloted aircraft.

There is a diverse range of drones on the market ranging from toy-type nano drones to military and commercial semi-professional and professional type.


The system owned by the company is purchased from SenseFLY, being an Ebee RTK (real-time kinematic) used mainly for geodetic mapping.

The system performs aerial photographic capture to produce orthomosaics (a single image made of multiple georeferenced pictures) and 3D models with an absolute precision of up to 3 cm - without ground control.

The system is provided with two softwares, one for collecting flight data, with flight planning functions, telemetry tracking and one for data processing, that can create the 3D and orthomosaic model. Analysis can also be made, such as distance measurements, cross-sections and extraction of volume data can be done using software such as Pix4Dmapper, Global Mapper, Agisoft, Quick Terrain, MicroStation, ccViewer.

The export data can also be done to ancillary software in order to add GIS data or create customized maps in programs such as ESRI, ArcGIS, QGIS, StereoCAD, AutoDESK, Maptek.

The main features of this type of drones are: weight approximately 0.73 kg including camera, size 96 cm including wings, maximum load 120 grams, electric brushless motor 42000 rpm at 160 watt, battery 11.1 V / 2150 mAh, Sony 18.2 mpx camera system with OIS, GNSS/RTK L1/L2 localization system, GPS & GLONASS, maximum flight time under optimum temperature and wind is 40 min, maximum flight ceiling is 4500 m, speed 40-90 km/h, the maximum covered surface area on a single flight, depending on the weather conditions is 8 km$^2$, wind resistance is max. 45 km/h, ground-photo sampling (ground resolution, GSD) is 3 cm/px, maximum landing error is 5 m, wifi connection system up to 5 km and a TRACKER location system.

As a rule, in most UAV systems, assembling and commissioning until launch is an easy and fast operation.

The NRW Office uses the UAV system for various works and carries forward various requests from outside the company such as fraudulent consumer identification, damage pre-identification, and monitoring.

One of the cases was the verification of two allegedly fraudulent consumers, one in Boţeşti and one in the Roman town. The picture shows the orthophoto map made in Boţeşti to the consumer. The old water meter manhole is circled in yellow, the new water meter manhole is circled in white and red indicates the excavation performed in the backyard.

The consumer in the Roman town was also checked as a result of complaints from neighbors in the area, and besides the use of conventional equipment, the VlockPro and ground-penetrating radar, a drone was also used to provide a better overall view.

In the processed image you can see the existing water meter manhole circled in light-blue, with white is indicated the existing water network, and the manhole behind the courtyard is circled in white, which was "omitted" by the owner. These drones

inspections are performed only if there are suspicions of the location to be verified or when access to other property is not allowed with the user.

As a result of the on-the-spot checks, the presence of some anomalies in the field confirmed the damage to the water network.

Such a situation was in Târgu Neamţ where the orthophoto map of the main pipeline was carried out in the field and a detailed analysis revealed an anomaly as a rich vegetation grown in one place although it was a period of drought.

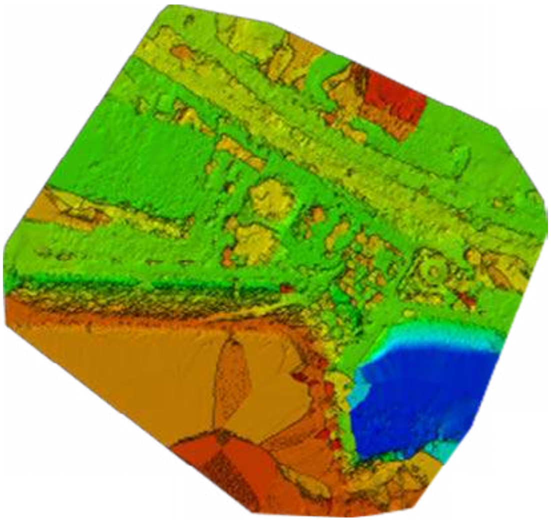
The verification indicated a damage near the existing main valve chamber.



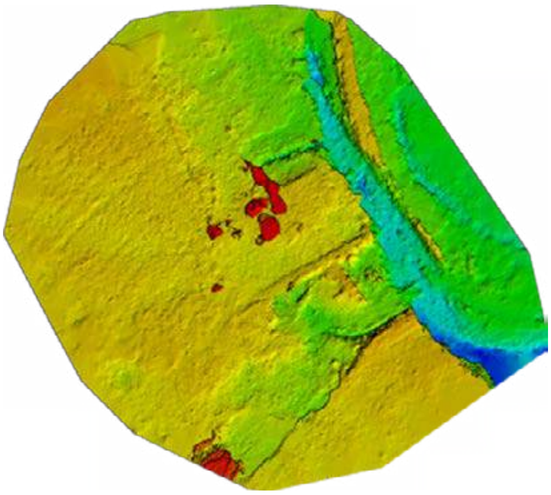
And the field images with the identified location.

In terms of monitoring, the NRW Office together with the GIS Office performs orthophotomaps at the water intake stations in the entire area served by the Company and building monitoring.

Bâtca water intake station

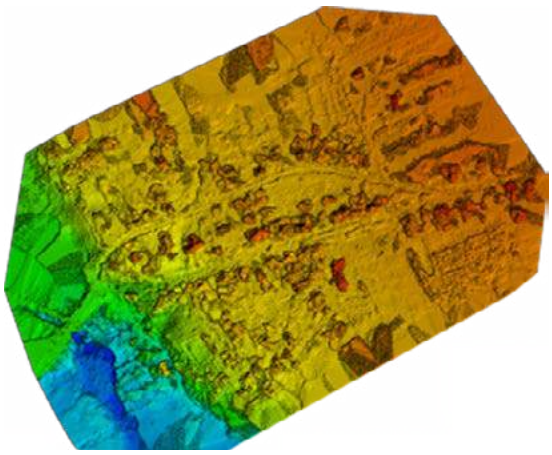


Preutești water intake station



The NRW Office also monitors the company's main wastewater treatment plants, namely Piatra Neamţ, Podoleni, Roman, Târgu Neamţ and Bicaz.

I will mention some external requests, one of them being from the COUNTY COMMITTEE FOR EMERGENCY SITUATIONS, where the NRW Office carried out various verification works in the Roman area. Scanning works were carried out with GPR STREAM EM, TR80 video inspection and also orthophotomap execution on the concerned area.



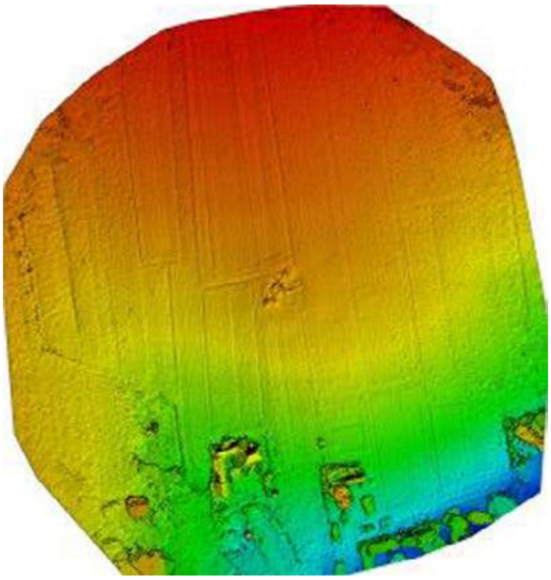
Aerial shooting with the UAV system was aimed to achieve the orthomosaic in the respective area as well as to observe from high altitude of other possible anomalies.

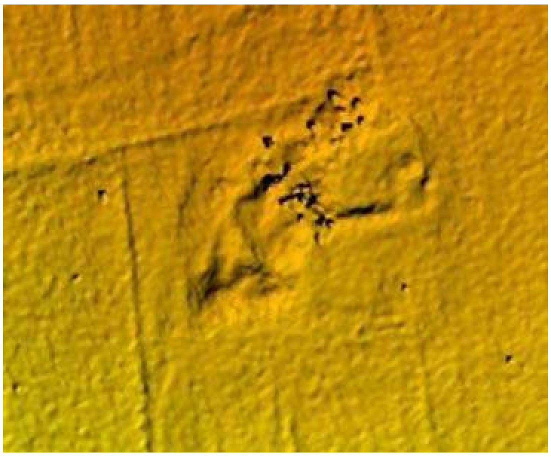
As a result of aerial mapping, the software highlighted several areas with level differences, but of all anomalies only a few should be checked by employees in the area in order to be eliminated or further investigated.

Following the Neamt County Museum Complex's request, we proceeded to investigate, using the GPR system, the vestiges of a medieval building in the commune of Grumazesti, Neamt County.

After that these investigations were superimposed on aerial photography performed with the UAV system in that area and the 3D elevation to observe altitude differences. The area covered was around 0.075 $Km^2$.

In addition to orthomosaic, DSM (Digital Surface Model) was also obtained, i.e. digital surface modeling before compression of the point-cloud.

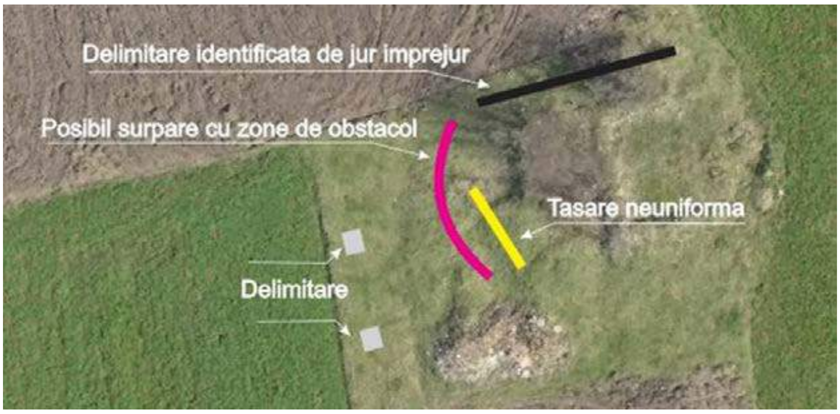


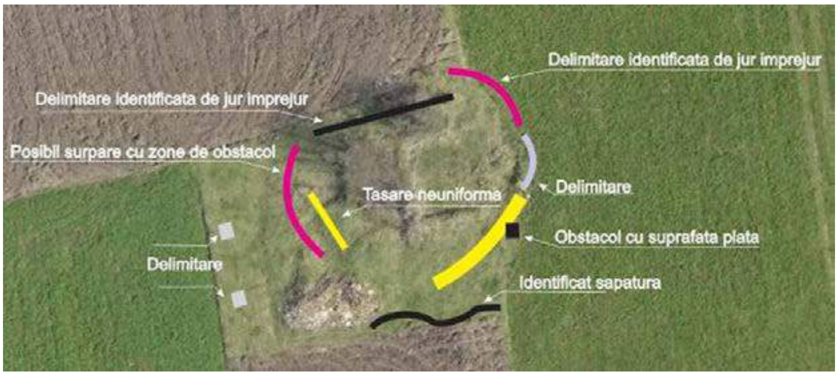


Thus, as a result of the area scans and the pictures taken with the UAV system, the overall picture below showed the areas with anomalies.

Similarly, we have an overview of the scans performed.

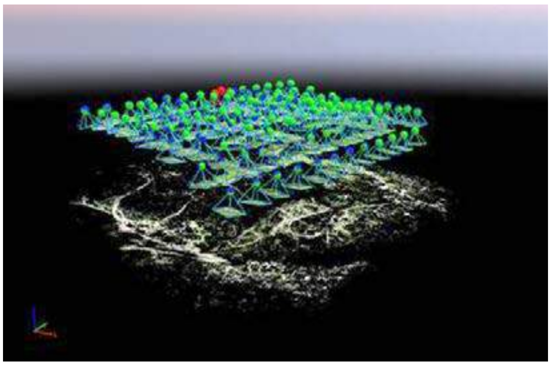
Following the performance of the exercise on the "Activity of the Inspectorate for Emergency Situations "Petrodava" in Neamţ county, in cooperation with other components of the emergency management system, a fire was simulated at the Varatec Monastery, with an extension to the forestry fund and the application of the Red Intervention Plan" we proceeded to the area monitoring action with the UAV system owned by the NRW Office.



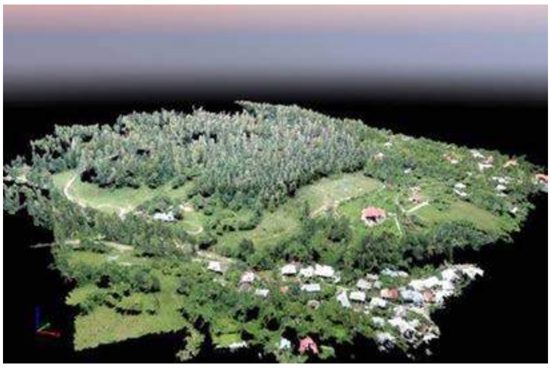




Thus, a total of 149 photos were taken by the service drone and processed, with a working time of 10 hours.

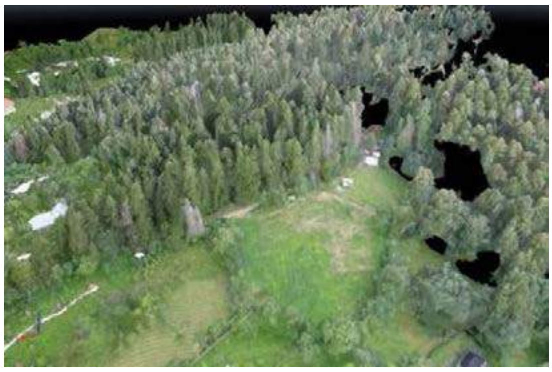
In the first phase, the software made the alignment of the images according to the pre-established flight plan and their arrangement according to the altitude in that area.



The next step was to process the pictures and GPS points received by the UAV system and get the next image.

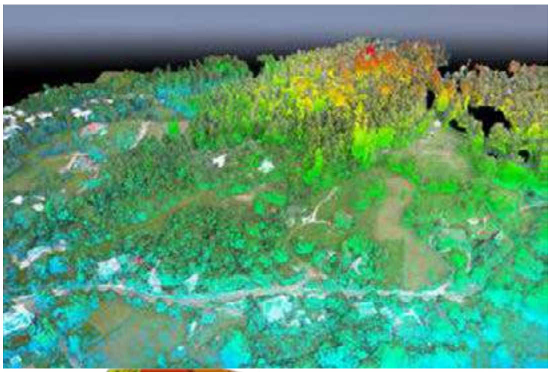


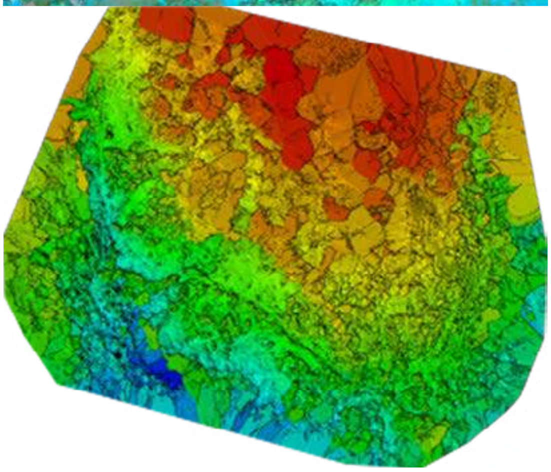
The next step was to cluster textures according to the 3D structure. Thus, on the basis of the drone's measurements, an overall 3D image with revelations on the level contour lines was obtained.



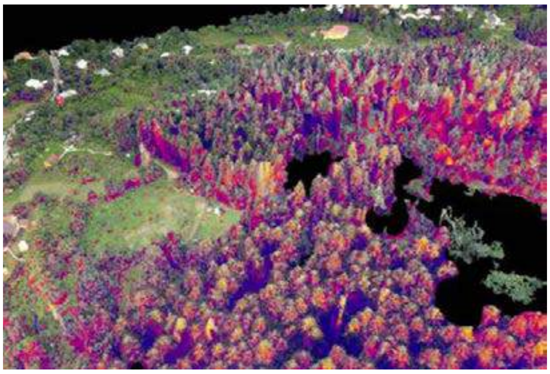
As a result of these processing with the software, various outcomes and values can be obtained.
An example would be the overall image of the photographed area (orthophotomap) as in the image below.

differences in altitude….

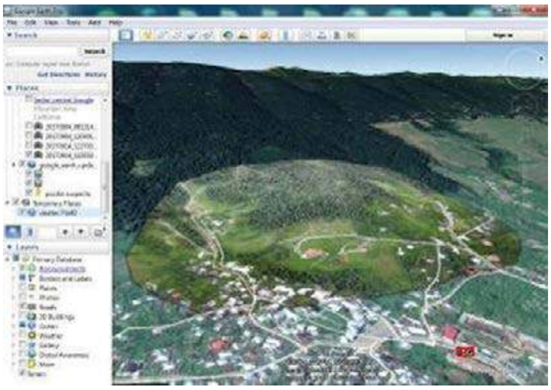


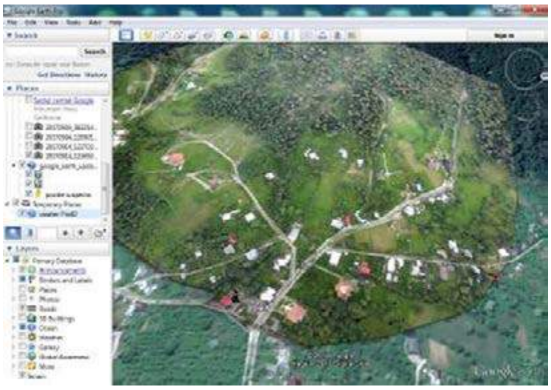


and also the possibility of thermal exposure to better highlight problem areas …



All these data can be exported to other mapping systems such as GIS, AutoCAD and Google Earth for better localization and viewing.





As a conclusion I will proceed with a section of questions and answers.

**Can I create orthomosaics from multiple images? Which is the minimum number required? Which is the maximum?**

Of course, this is the drone's purpose. The minimum in the processing software is 3 photos and the maximum depends on the computer performance.

**Can I take additional photos of the flight path also during the project?**

Yes, we can take additional photos with the UAV model that we have. The same flight altitude must be maintained and careful attention should be paid to the charge level of the battery, with the risk that it will consume energy in order to take additional photos, the area being calculated for the existing battery on the drone.

**What launching and landing area is required in a crowded environment?**

To reach the set flight height the drone needs a 70 m flight path with no obstacle. Similar, on landing.

**Can the drone be remote controlled during the project?**

Yes, it can be guided only from the computer. The drone also has a separate controller, but the remote control and the computer guidance cannot work simultaneously.

**Can be used in crowded environments (city)?**

Yes, it can also be used in crowded environments but more attention needs to be given to any obstacles that the drones could encounter on the chosen flight path and launch and landing area must be carefully selected.

**What would be the advantages and disadvantages of using this type of drone?**

As a type of airplane, it covers a larger area than a quadcopter (at least 8 $km^2$), the 18.2 mpx camera with OIS, the possibility of changing with another of 20 mpx or with a thermographic one, a full Ready To Go package (2 batteries, glue, chargers, spare propellers and gaskets), double localization in case of an accident, automatic on-board pilot with constant update possibility.

As a disadvantage, I would mention the need for a powerful computer (graphic workstation) for processing, it does not send live images and it does not take videos, minimum aeronautical knowledge is required - component parts, flight plan, and drone portability is difficult compared to some quadcopter models.

### What should be done and what should not be done during flight and if it is absolutely necessary for the drone to be registered?

First of all, the drone (regardless of type, brand and weight) purchased by any company regardless of the business profile must be registered with the Romanian Civil Aeronautics Authority (RCAA). The registration is simple, you need to follow a few clear steps from the delivery of the documents required for registration (invoice, application form for registration, payment and proof of payment of the registration fee as well as pictures with the drone), and going to the location of the institution that issues the certificate and the unique recording number and installs the drone's identity chip.

Then, to make a flight, it is necessary, depending on the area, to request permission, by phone, from the RCAA. I do not recommend drinking alcohol during flight. The last tip is to keep LOS (line of sight) during flight meaning to always keep an eye on it.

### What system is recommended?

It depends on what type of a UAV system will be used by the company that acquires it.

Thus, if the drone is acquired only for mapping and the areas to be mapped are very large then a RTK airplane type is recommended. If, in addition to mapping, the system will also serve for aerial video inspection then a quadcopter is required. As a rule, I recommend a quadcopter system with a RTK module fitted with both a thermographic camera (Flir) and a RGB camera with optical zoom (at least 10x).

The thermographic camera mounted on such a drone can help the team to inspect everything that is used for thermal differences, so for the team that investigates the spread of fire, for the team that monitors bridges and suspended crossings of any kind, for the team that monitors a solar park, for the team that monitors buildings and their roofs, for the team that checks the consumers regardless of the nature of the utilities, for the team that monitors tanks and usually for general maintenance. Like any equipment, this system is complementary to the equipment owned by the loss detection office and greatly depends on the business profile of that office.

It is usually advisable to purchase equipment that will be used daily in the field and the investment is viable if you have more equipment that can help you to make a clear and concise overview. It all depends on the person doing the data analysis and processing. Also for mapping, using drones regardless of model and type, I recommend that at the beginning of the procurement, besides the data acquisition software, to purchase with unlimited license also the software for data processing and 3D elevation, and seriously consider having in the company a high-performance graphic workstation.

## FORUMUL REGIONAL AL APEI DUNĂRE - EUROPA DE EST

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