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URL: www.waterpipe-eu.org

WATERPIPE NEWSLETTER no. 1 (January 2008)

WATERPIPE Overview and Aim of the Newsletter 1

Many EU cities are experiencing increasing problems with their water pipeline infrastructure. The cost of replacing these old, worn-out systems, if left to deteriorate beyond repair, is astronomical and clearly beyond the resources of many communities. Replacement, however, is not the only choice, as many of these systems can be rehabilitated at 30 to 70 percent of the cost of replacement. Accordingly, resources allocated to address pipeline rehabilitation management issues are increasing. Due to the emphasis on sustainable management, risk-based approaches for the rehabilitation management of the water supply network need to be developed, as well as technologies for the inspection and evaluation of the pipeline conditions. This is the aim of WATERPIPE project.

WATERPIPE project contributes to the topic II.3.3 "Advanced Technologies for Locating, Maintaining and Rehabilitating Buried Infrastructures" of the "Global Change and Ecosystems" thematic sub-priority of the FP6, by developing new, reliable technologies for water distribution -incorporating also performance and risk based approaches- for locating assets, identifying defects and leaks, monitoring and rehabilitating the buried infrastructures. The main aim is to improve operation, rehabilitation, serviceability, pollution prevention and safety and thus minimising direct and indirect costs, including the environmental and socio-economic ones.

This Newsletter 1 aims to introduce the general context of WATERPIPE project in terms of objectives, undertaken activities, plans for the future and partners. Moreover, a section is dedicated to dissemination activities carried out at EU level in order to make the project and the developed technologies known.

WATERPIPE Newsletters are sent to all the members of the WATERPIPE Mailing List, composed of stakeholders and operators of the water sector who have to deal with water pipeline infrastructure and decision making processes. Anyone interested in the WATERPIPE topic is invited to register to the WATERPIPE Mailing List (see Contacts section).

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WATERPIPE Aims

Water demand is increasing each year by two to three percent while global warming may lead to a significant shrinkage of the groundwater content. At the same time a considerable amount of the water provided by EU companies is lost to leakage. Water lost through leakage means higher abstractions and an even greater strain on the water environment.

Several water utilities do not make any attempt to locate leaks other than those that appear on the surface and are easily visible to staff or members of the public. Other water utilities use, in the overwhelming majority of cases, acoustic equipment to locate leaks. Although acoustic equipment is generally considered satisfactory for metallic pipes, its application to plastic and asbestos cement pipes is often problematic.

Fig. 1: A damaged pipeline

WATERPIPE equipment will detect leaks that are not visible and are applicable to both metallic and non-metallic pipelines. Their use will reduce water loss through leakage and promote a water efficient, environmentally sustainable water industry and will mitigate the impacts of global change.

The high cost of new reservoirs means that other avenues, including leakage reduction, must be explored within existing resources. This project results in water savings through leakage control and thus promotes economic efficiency.

Research undertaken under WATERPIPE intends to strengthen the scientific and technological capacities needed in Europe to control the impact of global change. The project develops devices, methodologies and decision-support tools for achieving an integrated management of water supply systems taking into consideration socio-economic and technological aspects of water use.

WATERPIPE promotes a pro-active approach in the management of the underground pipelines of water utilities that conserves water and energy. Moreover, by extending the life of the pipelines it conserves raw materials. WATERPIPE helps establish Europe as the international scientific leader on issues of sustainable development in respect to the water cycle.

WATERPIPE Background

State-of-the-art of the Equipment for Water Pipe Location and Pipeline Damage Identification

An accurate inventory of assets is the first step for the sustainable management of the water supply system. Yet, parts of the existing network of water utilities was built several decades ago, when there were no computers, and is poorly documented. As contractors usually rely on utility companies to mark the area where pipes are buried, these parts run the risk of being accidentally damaged during construction digging. To avoid expensive damage to these ‘phantom’ pipes and to be able to maintain them a number of utility detection techniques are currently in use. They include destructive subsurface investigation and non-destructive/geophysical methods. The latter methods introduce a wave or signal into the ground. The response is affected by the physical properties of the object located in the ground. Thus, it is being analysed in order to infer information about the properties of the buried object and its location.

In December 2000, a workshop was conducted in US with the goal to improve underground utility locating technologies. It was concluded that there is no system currently under development capable of locating urban utilities and responding to the following requirements:

- Is a single multi-sensor system
- Locates all types of pipes (conducting and non-conducting)
- Does not require prior knowledge of approximate location or access to utility
- Can operate in urban conditions (beneath urban streets in all types of soil conditions)
- Covers the necessary range of depths and utility diameters
- Has acceptable cost

It is important for water utilities to gain a better understanding of the condition and performance of their buried assets. Significant costs and disruption of supply to customers can result from the failure of water supply pipelines. Following below are existing or under development techniques for leak and damage detection.

Leak location through acoustic leak detection is carried out using the sounding stick (which is used either as a simple acoustic instrument or one which is electronically amplified), ground microphone, or 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 relies on the velocity of the sound made by the leak as it travels along the pipe wall towards each of two microphones placed on conveniently spaced fittings (maximum 500 meters apart). Hydrophones can also be used to enhance the leak sound in plastic pipes or larger pipes. The latest versions of the correlator can generally accurately locate a leak in metallic pipes. However, there are some leaks which the correlator has difficulty in locating, notably pipes which are low pressure, large diameter, non-metallic (including plastic pipes which tend to replace the other pipes in the future), and with infrequent contact points for microphone placement.

There are a number of other location methods, both acoustic and non-acoustic, which are usually used when the acoustic methods described in the above paragraph fail to find the leak. The most commonly used alternative is gas detection. In this method an inert gas is injected into the pipeline, and is traced as it comes out of solution at the leak point. Because of the equipment needed to inject and trace the gas, however, it is more cumbersome than correlation, and is usually carried out by a specialist contractor. The most common tracer gases used are sulfur hexafluoride (SF_6) and industrial hydrogen (95% nitrogen, 5% hydrogen).

High-resolution temperature measurements, utilising infra-red cameras have also been used to detect leaks. The principle behind the use of thermography for leak detection is that water leaking from underground pipe changes the thermal characteristics of adjacent soil and in turn makes it a more effective heat sink relative to the surrounding dry soil. Infra-red scanners are used to detect thermal anomalies above pipes, which may be taken as an indication of water leaks. Available scanners can be hand-held, vehicle-mounted, satellite or aerial mounted. Demonstrations using commercially available, well tested equipment have shown that not all leaks appear on the surface or can be detected on the surface and even subsurface detection from high levels shows that many leaks result in the water draining downwards.

Additional leak detection techniques include in-pipe acoustic location, where a microphone is inserted into a pressurised main through an air valve. The microphone cable is calibrated to measure the distance from the entry point to the leak. Drawbacks include the risk of disturbing the sediment, and high cost. Moreover, the trace wire has to be inserted into the bore of the pipe, leading to a possible contamination risk. Hygiene care needs to be taken when using the trace. The trace will not pass sharp bends or Tee's. When obstructions are met the pipe has to be excavated and cut and the trace be re-inserted.

Ground-penetrating radar (GPR) has been used to locate pipes and identify leaks in buried water pipe. One of the partners in WATERPIPE (ICCS), has developed the following two such techniques as part of project LEAKING: (a) a microwave radiometry-thermography sensor technique to provide the temperature distribution and the conductivity profile of the soil as a function of depth and (b) a ground penetrating radar using microwaves which can offer an improvement over ground penetrating radar using acoustic energy because it can offer a higher Doppler shift. Technique (a) above did a very good job in identifying leaks in dry soil while technique (b) did a better job than the acoustic methods in identifying leaks in pipes including plastic pipes. However, civil engineers need more specific data on the location, size of cracks and deformation of the damaged cross-sections to be able to assess the structural safety of the pipeline. Moreover, the work in LEAKING has showed that it would be advantageous to combine several radar receivers in order to detect different reflections from the soil. This situation will increase the sensitivity of the receiver if the signals are combined properly. Also, an orthogonal array of similar receivers will detect the whole wet area in addition to the certain leak point on the pipe. This might give some qualitative outcome for the volume of the water loss. Data fusion techniques based on inverse scattering algorithms should be used in order to combine the received signals properly.

Uncontrolled leakage inevitably leads to the collapse of pipelines which can create flooding, accidents, damage to building foundations and streets and forced outage. Information on the location and size of open defects and deformation is indispensable for an assessment of the structural safety of the pipelines.

A consortium of United Utilities, Severn Trent and Thames is trialling an ultrasonic pig which travels inside the pipe under pressure and detects defects, longitudinal cracks, circumferential cracks and leaks as well as pipe lining and the remaining metal thickness. This pig is designed to survey water mains under pressure without taking them out of service at all. There are two main problems with this: the internal survey equipment disturbs the sediments in the mains and causes discoloured water to customers, and the under pressure launch and retrieve assemblies are quite expensive to deploy. Therefore, it may be preferable to take the main out of service, but still pressurised, for a survey.

The oil and gas industries have developed intelligent pigs which can be 'flushed' through pipelines taking a CCTV picture as well as various measurements as they move forward. These are expensive to operate, they disturb the sediments in the water mains and cause discoloured water to customers and being designed for use in unobstructed smooth bore steel pipes, are not suitable for inspection of water mains with a high surface roughness or where valves prevent free passage.

Passing expensive equipment inside the pipe is labour intensive, time consuming and costly and this is why the market has not accepted them.

Ground Penetrating Imaging Radar (GPIR)

Utilities are looking for a ‘one-stop-shop’ for one-off or periodic surveys of pipelines that would locate pipes, where needed, and would also identify leaks and locate and describe defects in order to rectify them before they cause real problems. A single piece of equipment that could provide all of the above services would result in significant cost savings.

Based on the above a high resolution GPIR is proposed that, from the ground level, is able to locate pipes, locate leaks, identify damage and describe damage in terms of type, location, and size permitting a structural assessment of the pipeline. This equipment should be usable in all types of pipeline materials, should obviously not disturb the sediment, be affordable and user friendly and provide the required information in a speedy manner.

During the last 30 years several efforts to develop GPIRs have been carried out. The early efforts were based on the use of nanosecond duration pulses using based band spectral energy distribution of the transmitted signals. Wide band Transverse Electromagnetic Horn Antennas were used to transmit and receive signals. Because of the lack of advanced digital processing capabilities at that time, direct correlation methods were used by using a mixer unit driven directly by the received signal with a delayed replica of the transmitted signal. The delay was induced by a variable length coaxial line. The drawback of such systems has been the low spatial resolution and also the very slow measurement procedure. The most important problem though, which is still a challenge, was the very strong clutter generated by the ground medium which is interlaced between the target object to be imaged and the earth surface where the antennas of GPIR's are placed.

Figure 2: How the proposed equipment will look like

An alternative method of GPIR's has been the use of FM-CW techniques. The very fact that FM-CW GPIR' s needs less processing speed makes them attractive taking into account the fact that in most GPIR the observed media are stable or at least stationary.

Recently the old ideas of using very short pulses (subnanosecond duration) have found wide interest in the research community based on the use of advanced signal technology. These systems aim to solve short range communication and sensor problems. The acronym used in describing this technology is UWB=Ultra Wide Band. Contrary to the earlier base band short pulse techniques mentioned above, the present UWB systems utilize the frequency region of 1-4 GHz by using pulse shapes having zero spectral amplitude components at low frequencies. At present time the availability of several new UWB technologies that can be combined either with fast mechanically scanning antennas or with phased array antenna techniques (using switching true time delay elements for each antenna element) provides the opportunity for developing high performance Ground Penetrating Imaging Radars (GPIR). The use of phased array techniques avoids the necessity of using mechanical scanning which is expensive and complex. In this context the use of inverse scattering coherent electromagnetic methods is imperative to cope with the high ground clutter exhibited in images to be developed as a speckle noise. Inverse scattering methods should utilise electromagnetic analysis methods of scattering phenomena taking place within the earth because of the external illumination by the radar transmitter. Especially the analysis of circular cross section metallic of dielectric cylindrical structures embedded into ground medium consisting of stratified layers provides the opportunity of developing inverse scattering based imaging methods optimised for detecting pipes, leaks and damages in water supply pipes and then also imaging the damage region.

WATERPIPE Objectives

The overall objctives of the WATERPIPE project are:

TO DEVELOP a novel, high resolution imaging ground penetrating radar for the detection of pipes, leaks and damages and the imaging of the damaged region and evaluate it at a test site.

TO PRODUCE an integrated system that will contain the equipment above and a Decision-Support-System (DSS) for the rehabilitation management of the underground water pipelines that will use input from the inspections to assess, probabilistically, the timedependent leakage and structural reliability of the pipelines and a risk-based methodology for rehabilitation decisions that considers the overall risk, including financial, social and environmental criteria.

TO FIELD test the equipment and the DSS.

To accomplish the above, specific objectives of WATERPIPE project are:

1. To develop a high resolution Ground Penetrating Imaging Radar (GPIR) for detecting water pipes with their dimensions and material, for detecting leaks and damage in such pipes and for imaging the damaged region and to evaluate the performance of the above GPIR in a laboratory.

The above GPIR will be able to detect water pipes made of all types of materials. It will also be able to detect leaks and damages in water pipelines of all types of materials. It will have a penetration capability of up to 2 meters into the ground. The image resolution capabilities of the damaged pipe will be less than 5cm. The survey time (detection and imaging) will be 10 sec/meter along the pipe axis. It will take 2.8 hours to survey a kilometer of the pipeline.

The GPIR will be mountable on a 4X4 wheel car. A lap top computer will also be inside the car while the antenna system and transreceiver-analog/digital signal processing units will be placed in the front car. The antenna will be of a square shape of 1x1 m2 in horizontal dimensions while the thickness will be about 10 cm. In each position, the system will be able to survey a length of 5 meters along the pipeline. Thus, to survey a pipe length of 100 meters, the car must stop at 100/5=20 points along the line of pipe.

2. To develop a methodology that will use the results of inspection with the GPIR to assess the flow rate of leakage at the time of the inspection and predict, probabilistically, the flow rate of leakage durign future operating periods taking into account the evolution of the size of defects. Such evolution is based on the accumulation of leakage and the structural condition of the pipe. This prediction is updated when new data from inspections on the size of the defects become available using a Bayesian updating procedure.

3. To develop a methodology to assess probabilistically and as a function of time the concentrations of pathogens and other contaminants due to loss of physical integrity of the pipeline based on the evolution of the size of the derived defects and the location of the pipeline.

4. To develop a methodology that will use the results of inspection with the GPIR (horizontal and vertical cracks and deformation) to assess the structural reliability of the pipeline at the time of the inspection and predict, probabilistically, the structural reliability of the pipeline during future operating periods taking into account the evolution of loads, the evolution of deterioration by the various dergadation mechanisms and uncertainties. Forces on a cross-section vertical to the pipe axis will be analysed in order to assess the probabilty of crushing failure (bursts). Forces along the axis of the pipe will also analysed in order to assess the probability of bending and joint failure for each pipe material. Structural limit states will be determined in terms of allowable stresses and strains. Probability of structural failure will be taken to mean probability of exceeding the above limits.

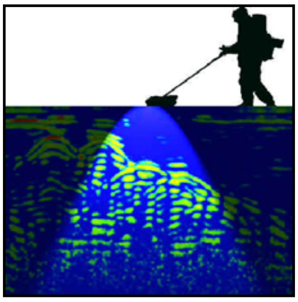
5. To develop a risk based methodology for the rehabiliation management of the trunk and distribution water mains. This methodology will attempt to answer the following questions: Which of the leaking and/or structurally deteriorating pipelines should be rehabilitated? When, each one of them? How, each one of them? When should individual pipelines be re-inspected?

6. To produce an integrated package that will contain the GPIR and a DSS for the rehabilitation management of water pipelines. The output of the GPIR will feed automatically the DSS for an assessment of leakage, contamination and structural adequacy and based on these for a selection of the method and timing of rehabilitation. The DSS should include:

- a software implementation that determines, probabilistically, the flow rate of pipe and joint leaks over time (point 2 above);

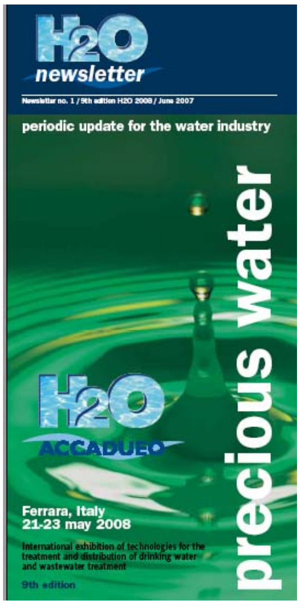
- a software implementation that provides a prabalibistic, time dependent assessment of the concentrations of pathogens and other contaminants because of loss of physical integrity of the pipeline (point 3 above);
- a software implementation that determines, probabilistically, the time-dependent strucutral reliability (and thus, also, probability of failure) of pipes and joints (point 4 above);
- a software implementation that allows water utility managers to decide which of the pipelines to rehabilitate, when and how and when to re-inspect each pipeline based on the expected risk levels (point 5 above);
- expert system technology for the integration of the different modules and a flexible user interface;
- a GIS module to help taking into account the effects of pipe location, soil type, etc…and to facilitate the user to examine specific areas of pipes and evaluate the resutls in a visual manner;
- a database that will serve as the repository of all protected related data;
- a data manager which is the only access point to the database and provide a customised view for each particular module providing access control mechanisms and assuring the data integrity in the database.

7. To field test the integrated package above on the networks of water utilities in the group. Included will be field testing of the GPIR in blind tests and evalua-tion of the DSS are included for ease of use,user-friendliness, relevan-ce, completeness, and cost effectiveness.



WATERPIPE Partners	
Microwave and Fiber Optics Laboratory - Institute of Communications and Computer Systems (GR)	
IRIDE ACQUA GAS (IT)	
Compania AQUASERV (RO)	
Pipehawk PLC (UK)	
HUBERG (IT)	
HYDROSAVE (UK)	
TECNIC (IT)	
RISA Sicherheitsanalysen (DE)	
Advanced Microwave Systems (GR)	
Istanbul Technical University - Environmental Engineering Department (TR)	

Dissemination Activities (Future, Ongoing, Past)



Leakage Technology Conference, ACCADUEO Ferrara Fair, 21st - 22nd May 2008. The Conference is being held in Ferrara, Italy 2008 at the premises of ACCADUEO Fair. It is being organised by the Italian Water Convention in partnership with Fondazione AMGA and the International Ferrara H2O Fair. In such an occasion WATERPIPE project and its progress will be presented.
(Contact: Eng. Nicola Bazzurro, AMGA Foundation General Secretary and WATERPIPE Dissemination Manager, E-mail: nicola.bazzurro@iride-acquagas.it)

WATERPIPE web site: The web site of the project is available at the URL www.waterpipe-eu.org.

WATERPIPE Mailing List: IRIDE ACQUA GAS, as responsible for the project dissemination, is maintaining a WATERPIPE Mailing List of stakeholders and operators in the specific field. All the registered contacts are informed about project progress and results through the WATERPIPE Newsletters.
(Contact: Eng. Nicola Bazzurro, WATERPIPE Dissemination Manager, E-mail: nicola.bazzurro@iride-acquagas.it).

WATERPIPE participation in Conferences and Events: in the first project period WATERPIPE partners presented the project at the following international events:

- FederUtility Workshop "Effective management of water distribution systems" held at the University of Perugia in September 2007.
- IWA WATERLOSS2007 Conference, Bucharest, Romania, 23-26 September 2007.
- EWRA Conference on Water Resources Management New Approaches and Technologies, Chania, Crete (Greece) 14-16 June 2007.

WATERPIPE Clustering activities with other Projects and Networks: several dissemination activities are addressed to foster initiatives of cluster with other groups. In particular the already established contacts consist in:

- Association and specialists group operating in the specific field (such as Water Loss Task Force of International Water Association, Gruppo Ottimizzazione Acquedotti).
- Project Consortia (ASAP Life project, VESTA-GIS Leonardo project, TRANSCAT project, CITY-NET).
- Thematic Networks and interest groups (TECHWARE Special Interest Group, WATER-GIS Network).

Events

- ACCADUEO, International exhibition of technologies for the treatment and distribution of drinking water and wastewater treatment, 9th edition, 21st - 23rd May 20008, Ferrara (Italy)
- Second International Conference - Water Loss Management, Telemetry and SCADA in Water Distribution Systems, OHRID, Fyrom, June 9th - 10th, 2008

Contacts

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