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Street Works Position Paper
in support of
"Underground Technologies"

January 2009

Executive summary

Cities continue to function because their inhabitants' economic and domestic activities are facilitated by utility services (gas, electricity, water, sewerage, highway drainage, district heating, and telecommunications). These assets must be installed, maintained and renewed to enable the continuing delivery of these vital services; often this means disrupting traffic, because most of these assets are buried beneath our streets, out of sight.

The direct cost of utility street works and highway works in the UK alone is more than €1.5bn per annum, with indirect costs associated with waste materials, disruption, traffic delays, environmental pollution (extra greenhouse gas emissions, noise, etc) and a reduced quality of life for citizens and costs totalling around €8bn per annum (~ €1 million per hour). On a European level, the European Commission estimated that these annual costs will rise to more than €80bn by 2010 (~ €10 million per hour), based solely on a projection of increasing traffic volumes. It's worth noting that this excludes any assessment of the extra disruption caused by the increased amount of utility work required to replace ageing assets.

It's clear that what is needed is a significant European investment in innovative technologies to enable utilities and road authorities to identify, locate, inspect, install and renew buried infrastructure with minimum disruption to the street environment. It's only by minimising, or even eliminating, the length of time that utilities need to work in the street that we will see reductions in congestion and improvements in traffic flow.

Eighty per cent of Europe's population live in urban areas. Rome, a city of 3 million inhabitants, has more than 65,000 km of pipes and cables buried beneath its streets. In France, with 60 million inhabitants, there are more than 1.5 million km of cables and pipes, plus TV and telecommunication cables and optical fibres, which would more than double this figure, making it equivalent to more than 150m of pipe or cable for each household.

There can be no doubt that this is a European, indeed worldwide, problem with implications for a sustainable environment, energy efficiency in transport, citizens' health and quality of life and, as such, needs to be addressed in a European Forum. ESWRAC, the European Street Works Research Advisory Council, a forum of European cities, highways agencies and utilities is collaborating in an effort to resolve some of these issues and to identify its R&D priorities.

It's clear that:

- all street works stakeholders need better technologies to help locate and inspect buried assets accurately, so avoiding third party damage, reducing associated safety risks, and minimising disruption to the travelling public;
- a European approach is needed to develop and apply these new technologies to ensure that a sufficiently large market is created to encourage investment and to ensure adoption of best practices;
- a multi-million euro technology initiative is needed, overseen by a combination of road users, utilities and cities to ensure that the results of research are appropriately directed and applied.

The objective of the Position Paper is to identify the key research activities necessary to improve the safety and integrity of European pipeline systems.

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Introductory remarks

This paper has been prepared by GERG, the European Gas Research Group, a founding member of ESWRAC, the European Street Works Advisory Council. Details of members can be found in the Annexes.

ESWRAC is a strategic platform comprising European cities, highways agencies and utilities that seeks to frame and align various initiatives to provide momentum for realisation of the European street works practitioner's vision.

All ESWRAC members share a common mission: "to identify and develop opportunities for reducing the societal and environmental impact of street works".

ESWRAC members support the following views on the Commission's document "Towards a Thematic Strategy for the Urban Environment":

- modern cities can't survive without utility services;
- most utility services are buried, unseen and trouble free;
- some utility services will continue to need maintenance and renewal;
- street works practitioners need better tools to detect assets and minimize third party damage;
- new techniques and improved practice will minimize disruption to traffic and to citizens and will safeguard the environment;
- new technologies will ensure that future generations can locate buried assets easily.

And, finally and perhaps most important;

- this is an international problem, which should be addressed at a European level, if only to ensure that the scale is sufficient to encourage investment and adoption of best practice.

A European Utility R&D Programme

Extensive background research into performance of current technologies[1] identified shortfalls and this was followed by an international workshop which outlined the research programme to address the needs of the utilities. The workshop was attended by experts from the US and Europe representing utilities, contractors, manufacturers, research organisations and academia to identify potential research opportunities. The workshop output was developed into a basic research programme by an expert multi-sectoral group representing the transport sector, UK Government, the gas, electricity and water industries and academia. This programme was discussed in detail with ESWRAC members and supplemented in the light of wider European experience with a range of interested parties, such as utilities, transport organisations and city administrations.

The programme has six themes:

- Making the best of what we have currently.
- Improved future surface-based survey techniques.
- Below-ground survey techniques.
- Future developments and possibilities.
- Better construction methods.
- Better asset management.

It is based around the premise that, over time, we need to:

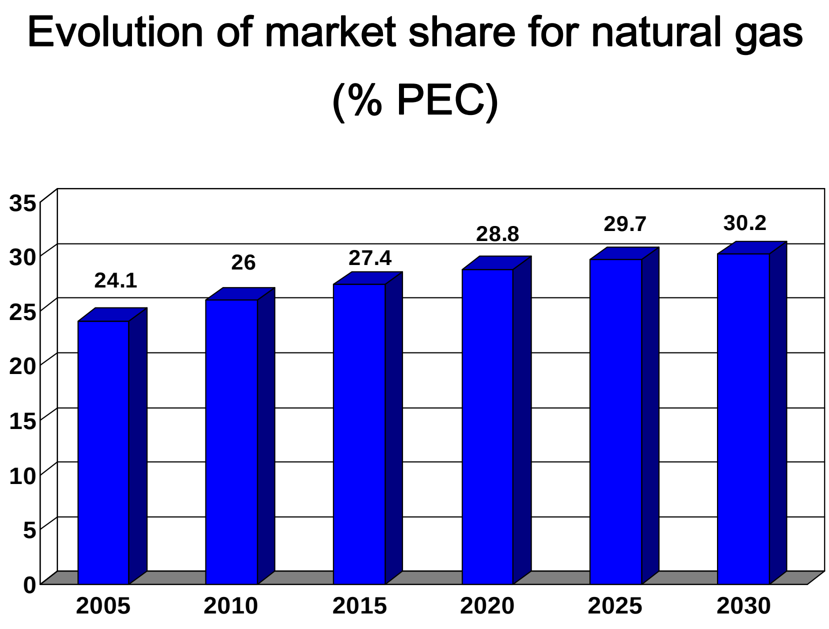
- develop a better understanding of user needs and the real costs and risks associated with installing and maintaining underground infrastructure;
- implement best practice and improve the skills base;
- move from open cut excavation to trenchless technology, to reduce impact on the above ground and underground environment;
- develop further existing location technologies and give us new location technologies that will reduce the time spent in the highway, and;
- develop radical longer-term solutions to the problems.

This supports the view of the Commission in their document “Towards a Thematic Strategy for the Urban Environment”.

[1] Ashdown, 2001; Chapman et al, 2001 and Weston, 2001

Importance of Natural Gas R&D to Europe

Natural gas plays an important role in satisfying the global energy demand. It makes up about 23% of the primary energy consumed in the European Union and demand has grown continuously since 1990 in all the main activity sectors (residential, commercial and industrial). Forecasts suggest that the proportion of gas could reach 30% by 2030, in particular because of the increasing demand for electricity[2].



Source: Eurogas

There is pressure on utility industries to maintain their high levels of safety and security of supply and to be more efficient. Increasing environmental constraints and the growing awareness of the need for a more sustainable energy and water supply systems demand a changing view on the future of the associated businesses. Hence the industries must re-evaluate business strategies to incorporate all these necessary aspects in a balanced way if it is to continue to deliver products in a satisfactory and acceptable manner. For these reasons it is of paramount importance that both industry and government, whether regional, national or European, continue to invest in R&D and even step up their efforts.

Demand for natural gas is set to grow across Europe and the development of safe, well controlled, reliable and cost effective natural gas networks will be essential for end users. The safety of gas infrastructures must remain the priority for future investment and for the existing systems (maintenance, ageing, training of operators, etc.). The European gas industry has an exceptional safety record[3]; with the exception of the recent tragic accident in Belgium (Ghislenghien pipeline accident), in the last decade the overall frequency of accidents causing an unintentional gas release has gradually reduced demonstrating the success of an increasing integration of safety in the total pipeline process, i.e. proper design and construction (including pipe manufacture), adequate maintenance, and safe operation.

Natural gas pipelines are constructed to the highest standards and are very well maintained. However rigorous the gas industry is in these processes, it is very difficult to mitigate for Third Party Interference (TPI) which remains the greatest cause of accidents on gas pipelines. As a result of advances in information technology, it is increasingly possible to acquire information more rapidly regarding the

[2] ‘Natural Gas Demand and Supply - Long Term Outlook to 2030’ EUROGAS, Nov. 2007

[3] GERG: Gas 2020 Vision (http://www.gerg.info/publications/vision%20_gas0904.pdf)

effectiveness of measures to increase the safety performance of the high pressure gas transmission system. This technology development must be pursued if the incidence of TPI is to be further reduced.

Efforts have mainly to be concentrated on maintaining and upgrading existing assets to increase the operating pressure for example. Most of the existing high pressure network in Europe will continue to be used for the coming decades, which means that degradation mechanisms will have to be very well understood. Proof of integrity of pipelines will also be essential and will demand new inspection techniques (especially for non-piggable lines) and rehabilitation techniques.

In addition, many households still need to be connected to the gas network and, as a consequence, the low pressure gas distribution system will be progressively extended by means of new pipelines. Hence, there will be a continuing requirement for new technologies to enable the installation of new house connections and also for the repair and renovation of parts of the more than 1.2 million km of existing low pressure distribution pipes in Europe (EU15).

Historically, location of underground plant and equipment has been based on record information held by utility companies. This information can sometimes be inaccurate, incomplete or out of date and it's worth noting that, in Europe, during new installations, about 90,000 incidences of third party damage to gas pipelines are reported every year and 100,000 in USA. There is little doubt that these instances of damage would be reduced by the use of reliable location techniques. There are technologies, such as Ground Penetrating Radar (GPR) that are very attractive in these situations but state-of-the-art GPR systems can provide unsatisfactory performance especially with regard to smaller targets and in difficult soils. So, without further research and development, this technology will remain of limited use.

Urban and suburban air quality is improving, but resident populations are still exposed to undesirable levels of vehicle-derived pollution. There would be undoubted benefits to the environment, to quality of life, resource management and fuel efficiency from minimising the amount of street-works, related to buried infrastructure, taking place in cities and in rural environments. Consequently, more R&D funding targeted at developing the technologies to minimise street works disruption would have a considerable positive influence on air quality, traffic noise reduction and citizens' state of mind (consider road rage). It must also be noted that this point applies to every utility: gas, water & sewerage, electricity and telecoms and, indeed, to all city administrations[4].

The following list illustrates some specific examples:

- €80 billion – annual cost of traffic congestion by 2010 (EU15) (~ €10 million per hour)

- 3,777,960 km road network (EU15)
- 1,370,000 km gas mains (EU15)
- 720,000 km water mains & sewers in Germany
- 170,000 km gas distribution system in France
- €45 billion – cost of repairing Germany's sewers (medium term)
- 65,000 km buried pipes & cables in Rome
- 500,000 holes dug by utilities in London in 2003
- €700,000 to repair a single optical fibre cable

Areas where a clean, quiet atmosphere can be experienced are being progressively reduced by the increased density of urban areas and growing mobility and, whatever rules and regulations exist in Member States, the number of European citizens that are irritated by environmental noise or have their air polluted by traffic congestion shows an ever growing tendency. In this context, it must be noted that, in the U.K. alone, road traffic is predicted to grow by 50% between 1996 and 2031[5].

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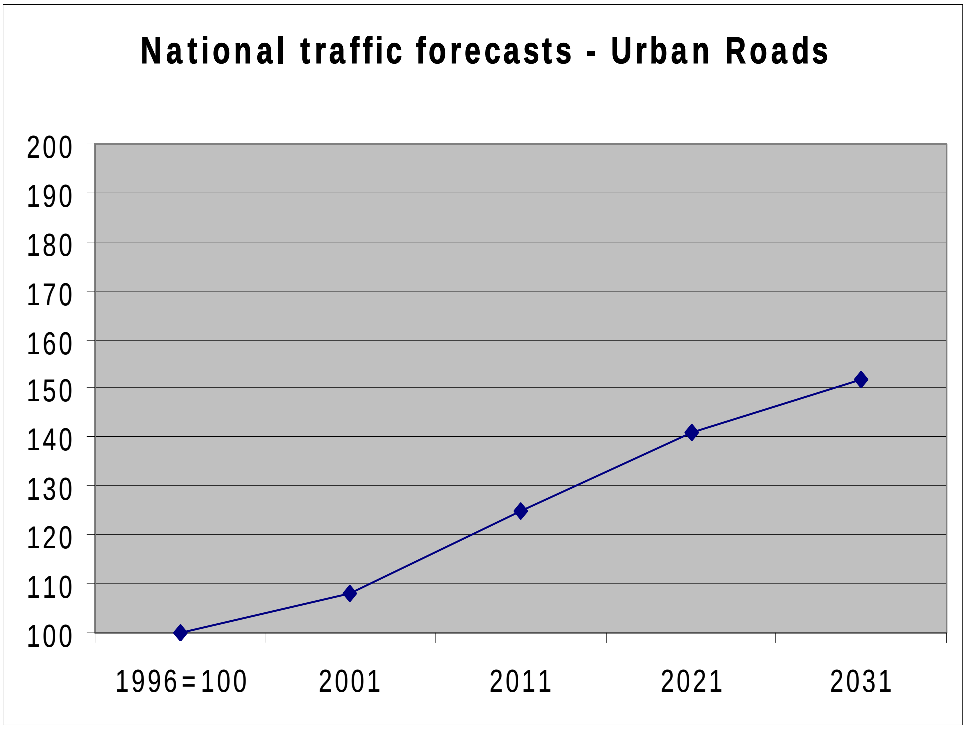
[4] Asset Management for sustainable urban water, WSSTP
[5] U.K. Transport Research Laboratory



UK Department of Transport; forecasts of urban traffic growth, 1996 to 2031 (+50%)

Existing pipelines will have to be modified and/or new pipelines will have to be built, with minimal disturbance to the living environment and this will require extensive investigation, extensive safety modelling and testing and development of new construction techniques.

Finally, the challenge to the gas industry is to ensure that existing infrastructure can be inspected, maintained, repaired or renewed at minimal cost and with the minimum of disruption to traffic, quality of life and the environment, set against a background where safety is paramount.

There is a wide range of possible technologies and both a need and an opportunity for the development of new tools and technical solutions in this area. For example:

- pipe condition assessment/determination - the development of non destructive testing tools should be a priority;
- No-Dig and Low-Dig techniques will require the development of new sensors and robotic systems capable of working inside small diameter pipes;
- smart materials, for nano-coating, and intelligent assets coming, for example, from the use of RFID and low energy sensors;
- real-time data acquisition on networks, gathered via multiple sensors placed strategically on the network, from pipe to meters;
- condition assessment tools which can provide data for asset replacement and modelling;
- a standardised approach for the characterisation of defects.

Such developments will improve the way networks are operated, reducing disruptions in the street and making city life easier to bear.

European cooperation will be essential to improve gas networks with new knowledge and technologies progressively made available in the following areas:

1. ***Minimising the social and environmental impact of urban works;***
2. ***Increasing European gas network integrity;***
3. ***Increasing European gas network durability;***
4. ***Improving robustness of the management and control of the European gas networks;***
5. ***Improving simulation tools for gas network management and control;***
6. ***Improving cost-effectiveness of gas networks.***

Gas Industry Priorities

The following complementary research themes are considered essential for the continuation of efficient European gas networks to 2030.

1. ***Minimising the social and environmental impact of urban works***

- New, low impact techniques for construction, maintenance, repair or renewal, including new maintenance and back-fill re-cycling techniques and the integration of composite materials to minimise environmental pollution.
- Development of techniques and technologies to enable small-dimensioned trenching and new, mechanised, network installation techniques – for security, for reduction of disruption, pollution, working time and cost.
- Accurate methods for locating and inspecting existing assets, such as:
    - Robotic techniques for inspection and repair of distribution pipelines;
    - Development or improvement of technologies, such as Ground Penetrating Radar (GPR) and trenchless (no-dig) technologies;
- New techniques/materials for installation, operation, repair and maintenance which reduce the environmental impact, such as:
    - Development of new excavation techniques that allow recycling and re-use of materials, with the aim of substantially reducing the consumption of natural resources.
    - Development of new construction techniques to reduce noise emission in specific installations, such as compressor stations.
    - Design and application of new technologies to reduce gas venting to the atmosphere.

2. ***Increasing European gas network integrity***

- Improve the proof of integrity of pipelines by developing new inspection and rehabilitation techniques
- Improve defect analysis and subsequent decision making to improve on integrity performance
- Develop and implement radically innovative approaches to gas network installation, maintenance and repair while minimising environmental impacts;
- Develop coordinated maintenance at European level, with undoubted benefits to the environment, to quality of life and resource management;
- Enhance the reliability of gas supplies into Europe, with new technological developments to:
    - prevent/detect Third Party Interference, whether accidental or malicious

- evaluate the impact of new protection schemes
- detect natural gas emissions
- monitor for landslides and subsidence
- monitor and control corrosion and material defects[6];
- take into account human factors in the loss of reliability of gas transport networks.

3. ***Increasing European gas network durability;***

Development of models, materials, monitoring systems, components, design and construction techniques able to:

- have a better understanding of material and network degradation mechanisms;
- predict, measure and prove pipeline integrity;
- develop new inspection techniques (especially for non-piggable lines);
- detect and reduce the vulnerability of pipeline networks to natural hazards (e.g. landslides) to guarantee the safety of the network.

4. ***Improving the robustness of the management and control of the European gas networks***

Develop sensors, tools and techniques for:

- remote sensing for application to network control
- monitoring gas network operations at EU level
- for real-time optimization of network management.

5. ***Improving simulation tools for gas network management and control***

The challenge here is to couple physical network behaviour simulation with wholesale market simulations to validate the ways of optimising transport and distribution.

6. ***Improving of cost-effectiveness of gas networks***

New technology, systems and standards throughout the natural gas industry will enhance cost effectiveness related to investment cost and operational capital expenditures.

Development initiatives aligned through GERG in this respect are aimed at:

- systems and standards that are consistent throughout the gas value chain;
- systems and standards that align the vendor industry;
- verification of technologies that improve energy efficiency, safety and cost.

[6] Natural Gas The Bridge to a Sustainable Future – Policy and medium term R&D programme , GERG

Initiatives for Immediate Research Collaboration

Amongst the more critical areas of R&D collaborative work, there are five key areas of European collaborative actions:

1. **Inspection technologies**
   - Automation of inspection
   - Sensing techniques
   - Robotic platforms

2. **Remote sensing**
   - Localisation and identification of existing networks
   - Leak detection techniques
   - Underground imaging
   - Third party damage

3. **Material development and long term behaviour**
   - Liner technologies
   - Smart pipes
   - Repair technologies and processes

4. **Operational technologies**
   - New Network Construction techniques (shallow trench)
   - Demand of more parallel pipe-laying in a progressively more occupied underground space
   - Increasing density of connections
   - Modelling tools for network management and market behaviours
   - Network asset design and management
   - Compressors
   - Better embedding and protection of pipes against traffic loading effects and traffic originated vibrations to the ground (as a result of larger trucks in recent decades)
   - Corrosion management
   - Decision tools to prioritize investments and operation costs
   - Additional No-Dig-Technologies for construction, repair, maintenance, replacement, reinforcement, with the lowest impact on traffic and the environment
   - More use of the advantages of No-Dig-Technologies (No Dig Best Practice)
   - New approaches to trenchless technology, to ensure minimal disruption and to minimise the use of natural materials
   - Prolongation of life-time of pipes by better materials and softer pipe-laying technologies
   - Compression plant reliability and maintenance
   - Metering techniques for transport and distribution

- Corrosion protection schemes and monitoring

5. **Cost-effectiveness of gas networks**
   - Efficient distribution techniques

Cathodic Protection monitoring in the presence of Alternating Currents
Validation of ECDA
Field joint coatings
Quantification of the performance of coating survey techniques
In-line tools to measure axial deformation
Techniques to reduce pipe-soil interactions
Test of existing in-situ material characterisation systems
Integrity and Security Operating System for preventing external threats on gas transmission networks
Simulation tools to identify critical infrastructure
Alternative materials for High Pressure pipelines
External microbial corrosion
More extensive use of mobile (GIS, etc.) technologies
Decision tools to prioritise investment
Geo-referenced systems (e.g. vehicles)
In-field measurement of coating quality
In-line inspection systems for non-piggable pipes
Long-range guided-wave inspection systems
Measurement of axial strain
Smart pipeline monitoring – UAV/satellites
Smart pipeline monitoring – optical fibres
High pressure pipelines in Europe (~200 bar)
New mobile technologies to optimise operational activities
Development of No Dig and trenchless techniques to connect service lines to mains
Development of methods to quantify methane loss from distribution systems
Gas-stop technologies in the European distribution activity
Advanced gas detection systems
Factors affecting the smell of natural gas from leaks in buried pipes
Elevated temperature testing for lifetime prediction of plastics pipes
Pipeline integrity of 1st Generation of PE pipes
Security of distribution networks
Migration/diffusion of natural gas in soil
Non-destructive test techniques polyethylene (PE) joints/components
Long-term integrity of electro-fusion joints in PE pipe systems
Determination of the effects of combined loading conditions on pipeline system integrity
Evaluation of new accelerated ageing test method for slow crack growth
Assessment of the "quality" of "aged-in-service" PE pipes
Smart networks
Intelligent condition monitoring (with or without robots)
Smart metering at low cost
Avoidance of TPI
Pipeline Integrity Management Systems (PIMS)
High pressure distribution system (10 - 15 bar)

1. PIRATE - Autonomous Inspection Techniques for Low Pressure Gas Distribution Grids

The investments necessary for transporting energy into our houses are large. A large part of the heating of buildings in many European countries is realised with the combustion of natural gas. The typical cost of this infrastructure is about 2000 € per building. The majority of these costs are made in the distribution grid, typically the gas mains of the last few km to the residential houses and other buildings.

This infrastructure represents considerable costs, it contains inherently a safety risk, it is slowly but steadily deteriorating and it should therefore be monitored carefully. Besides the regular leak survey (generally once every 5 years), there is no other cost-effective, routinely applicable method available to check the quality of the gas piping system under live conditions.

To design and implement such a method would be major undertaking, due to the complexities of the infrastructure that has been assembled over the last 50 years or longer. The benefits of such a method would also be large. The main benefit would be an improved and assured safety of the gas grid. But also the replacement costs of the aging network will be reduced significantly as the amount of replacement can be reduced or temporised. There exists a large but as yet not measurable difference in local degradation, even with seemingly similar materials and similar general historic conditions. An efficient method for locating the bad sections of the grid will enable to renovate the grid with surgical precision with lower cost, without compromising the long term safety.

Suitable sensors are available for inspection of some relevant aspects: i.e. cameras and microphones. We lack, however, the means to bring them all to the sites of interest at low costs in terms of supervision and manpower. Autonomous, self localising robotic platforms as part of a complete inspection system are the means to realise this. Developments in electronics ands software of the recent years lead to the assessment that this dream is no longer utopian but a realistic goal for the next few years.
Nevertheless, such an inspection system is extremely challenging from technological perspective and it will give a major boost to other applications where large scale and long term condition monitoring is required.

Benefits:

- better controlled safety level of the gas distribution system;
- lower replacement costs of the network by ‘just in time’ replacement;
- boost to new technology for autonomous inspection systems;
- stimulus for the development of new sensors applicable for in-pipe inspections
- better and assured localisation of piping system, materials and diameters
- continuous and complete quality assessment of the piping system

Impact:

- Reduction of above ground pipeline inspection activities by almost 100%. Assessment of corrosion of small gas pipelines can now only be done by the excavation of the pipe.
- Reduction of pipeline replacement activities. Currently most (typically 80% or more) of the low pressure distribution pipes are replaced prematurely from a pure material technical point of view.
- Autonomous inspections techniques is a required step before autonomous repair techniques. A combination that could eventually lead to a self sustaining underground infrastructure, with minimal disruption of the above ground activities.

2. Effective localisation and identification of existing networks

Working on buried plants and equipments involves traditionally digging a trench, doing the desired work, and reinstating the filled hole. In recent years, far more use has been and is being made of trenchless technology, which reduces the number and extent of excavations, thus helping reduce in particular the amount of indirect costs. Whichever method is used – trench or trenchless – there is an absolute need to understand the nature of the underground environment of the working area and its surroundings when planning new installations and when excavating to maintain existing infrastructure.

Underground sensing technologies (e.g. ground penetrating radar) are essential to reduce the risk for the safety of the operators and the citizens involved in such installation; researchers have been successfully working on this field over the last 15 years or longer and the performance of locating tools (in terms of detecting capability) has been largely improved.

There are however 2 further, main issues that need to be addressed in the future; they concern:

- The over-all effectiveness of the survey (both in terms of speed and consistency of the results)
- The education of operators running those locating equipment

- **Effective locating surveys**

Currently, ground penetrating radar (GPR) surveys must scan over a dense orthogonal grid (i.e. along two directions at right angles to each other), especially whenever a high density of utilities is expected in several orientations (e.g. in an inner city road junction). Thus, the time required for executing the survey can be large with an obvious impact on the global cost of the installation; moreover, the use of such equipment might produce traffic delays which are also costly. In addition the data analysis of such a huge amount of data might take up to several days (even if the surveyed area is relatively small, like a road junction) which can seriously influence the direct costs for utility street works.

Ideally, a GPR capable of being towed by a vehicle at a traffic speed and using a dense array of antennas to reconstruct a 3-D picture of the underground in a single scan, could solve this issue. The development of a real-time processor might also be helpful in order to produce, in the field, real time displays of the underground, which would be very easy to understand and analyse due to the use of advanced imaging techniques. This will also solve one of the major issues of this technology that relates to the improper use of the system (e.g. due to the use of unsuitable system configurations) and to the reliability/consistency of results which are often dependent on the skill of the operators.

A similar architecture could be developed and integrated in a trench mini-digger, in order to “automatically” install pipes in small trenches in the safest and fastest way. This would ofer a significant improvement over conventional installation technology where the risk of damaging existing infrastructure is very high.

The system should be integrated with an accurate positioning tool (GPS/navigation system) in order to provide accurately geo-referenced information, thus allowing the production of digital maps of subsurface utilities, to make the transfer or the survey information into the GIS a seamless and more reliable operation.

Benefits:

- Improved safety of asset installation;
- Improved efficiency of road works;
- Reduction of digging direct/indirect costs;
- support of the process of deciding the level of risk and the use of appropriate mechanised techniques (digging/mini-trenching and no-dig);
- Better and effective localisation of underground assets;
- Production of accurate digital maps of sub-surface utilities.

Impact:

As written above, this new underground asset locating tool offers the potential of (at least) the following significant improvements:

- improved safety level;
- decrease of the direct costs of a underground assets survey (by a factor 3);
- enabling of a safer and faster use of mini-trenching techniques;
- improved management of asset networks due to the production of accurate digital map of the subsurface.

3. Optimization of emergency response

The equipment and tools currently used for emergency responses to third-party aggression on gas pipes developing leaks were developed primarily for pressure of less than 1 bar. These include, for example, double bags or using sealing tape. These efficient techniques on steel or cast iron are not used for PE (polyethylene) networks operating at greater pressures (1 - 6 bar). The operation is done in this case either by shutting off the valves on the network or by squeezing the pipe.

The first solution requires a precise mapping of valves, a rigorous maintenance plan and often shutting off the gas to a large number of customers ...

The second requires the intervention of a team of workers, replacing or repairing the pipe at the site of the squeeze-off...

A comprehensive solution to optimize the emergency responses is needed to improve the effectiveness of the operators to shut off the gas and allow the repair of the damaged pipe. Programs for training and maintaining skills are an integral part of the project.

The project aims to study two main aspects:

(i) *In the immediate vicinity of the leak:*

- The security perimeter and the distances to be respected to intervene on the leak (taking into account projections according to the pressure, risk of explosion, ...)
- The protective clothing of operators during emergency responses
- The mechanical tools to be used remotely to intervene on the leak (temporarily sleeve, ATEX Zone ...).

(ii) *Beyond the security perimeter or if the exact location of the leak is not known*

- Definition of ways of stopping the gas flow by inserting a tool from the customer gas cabinet.
  This solution will allow a reduction in the flow of gas through the insertion of a mechanical device (bag type) introduced from the customer gas cabinet. It will block the main network, whatever the geometry of the connection, whether or not there is an Excess Flow Valve present.
- Development of tools to identify the network (GPR optimization, acoustic detection ...)
- Optimization of earthworks (keyhole, vacuum trucks ... ..)
- Optimization of gas stopping tools from a keyhole.

Advantages:

- Improved safety of personnel working on the network;
- Achieve a safer environment for people and surroundings faster;
- Reduction of number of customers who are without gas;
- Reduced time for reinstating services.

Impact:

- Minimised flaring of gas;
- Reduction of necessary excavations;
- Improvement of gas industry professionalism;
- Improvement of the company public image.

4. Increasing density of connections

To properly appreciate the possible routes to optimising the laying of a connection, it is appropriate to start by making a breakdown of the relevance of the various operations required:

- **The problem of the cut-out in the road surface**

  Innovative techniques, such as a circular cut-out in the surface, a technique developed, in particular, by UTILICOR (USA) and enabling a cut-out of about 60 cm (24 inches) to be made in the road surface, are a relevant response. The advantage of this technique, apart from an appreciable gain productivity, is the possibility of reusing the piece cut out to reinstate the surface after the backfill stage; this makes the presence of a connection practically invisible at the surface.

  This kind of material is efficient for the upper part of the trenches (asphalt and concrete)

- **Vacuum excavation**

  Once the cut-out in the surface is made, the dimensions of the excavation do not permit the use of a mechanical shovel. Suction excavators are therefore used to reach the main. The use of this method divides the volume of earth excavated by a factor of 4. Systems marketed provide excavation by suction while breaking up the ground with a high-pressure water jet.

  All this material works already on site, but should be improve to be more efficient (for example in a soil with clay). An important work will be done to develop better vacuum system, based on the technology already on site

- **Fitting from the top of the excavation**

  The dimensions of the excavation by suction are not compatible with the descent of a human operator. The connection operations must therefore be carried out from the surface

  In answer to all these problems, GDF SUEZ has developed a scraper and position that can be operated from the top of the excavation, as well as a set of attachment tools for carrying out the electro-welding operations.

  To further limit the protuberances on the network, GDF SUEZ has worked with a PE fitting supplier to develop and patent a connection branch that shows no protuberances as it works perfectly horizontally.

  All this material should be simplified to be accepted on the site. Working within the GERG framework projects should be launched to develop new kind of tools, based on the tools already existing . To simplify the tooling, a global decision should be take between all the utilities and PE supplier to have a standardization of fitting’s geometrical parameters.

- **Laying the service line**

  In 2000, GDF SUEZ had already developed with Tracto technic, a German supplier, a small drilling machine, working from the top of excavation. This machine was not really used for laying gas networks due to the lack of tooling to work from the top of the excavation.

  GDF SUEZ and its partner now aims at reduce the size of horizontal drilling machine to allow it to work from the top of a keyhole of 24 inches diameter.

- **Backfill with hydraulic materials**

  Backfill and compacting operations are very difficult to impossible in such a narrow excavation. To solve this problem, GDF SUEZ is developing a ready-to-use mortar solution for filling the excavation to the point where the surface cut-out can be put back in place. This ready-to-use mix can be put in place using a continuously operating hopper.

  Small trenches (thickness <20cm and depth <50cm) produced by mechanical means such as a trench mini-digger of the same type as used for certain optical fiber networks could be also used to lay the main line. The backfilling of such trenches with coloured self-compacting hydraulic binders whose rheology is adjusted to ensure the self-centering of the pipe in the backfilled trench is possible.

- **Impacts:**

  As analyzed and defined, these new laying techniques and other innovative approaches offer the potential of the following significant improvements: improved safety level;

  - increased speed of performance (by 2);
  - elimination of compacting operations thus gaining time and abating noise, for nearby dwellers and operators;
  - substantial decrease in the volumes of excavated material to transfer to the dump;
  - improved definition of the mapping of new networks.

Concluding Remarks

The developed world absolutely relies on utilities to deliver, usually unseen, and with little, if any, difficulties. As a result, utilities are mostly taken for granted unless something goes wrong. That they usually do deliver is not down to good fortune but rather to extensive and rigorous R&D programmes conducted at some time in the past. And it's clear that utility companies must continue such activities if their critical assets are to be maintained and improved so that they will be available to provide continued deliver of product into the future. Many countries are currently coping with their ageing infrastructure with a resultant increase in maintenance and replacement costs and an impact on customer expectations regarding system security and reliability.

Utilities are under pressure from waves of change brought on by deregulation, globalisation and restructuring, demands to optimize shareholder value, while at the same time having to meet stringent safety, and regulatory requirements and fulfil customer demand for high reliability in an increasingly competitive market. To achieve all of these objectives – whether measured in terms of shareholder value, revenue growth, profitability or customer satisfaction – companies must adopt more sophisticated asset management approaches that make it possible to inspect, maintain and manage diverse assets.

R&D will be necessary to if the existing assets are to operate as well as or better than those currently in the ground, which is characterized by a complicated and varied asset base, with numerous interacting assets and asset types, principally below ground.

It will require:

- an interdisciplinary approach, including integrated application of tools and techniques developed in such diverse fields as engineering, finance, economics, management, environment and social science;
- multiple stakeholder views and often conflicting goals (e.g., high levels of service versus low tariffs, social and environmental responsibilities versus financial ones);
- technologies to overcome the high level of uncertainty and a lack of information, especially with regard to the condition and performance of spatially distributed and, crucially, buried pipeline assets.

In addition, climate change and calls for more sustainable practices must be taken into consideration while fulfilling the industry's fundamental mission, which is to ensure security of supply into Europe.

Finally, it's necessary only to reiterate ESWRAC's view on the European Commission's document "Towards a Thematic Strategy for the Urban Environment":

- modern cities can't survive without utility services
- most utility services are buried, unseen and trouble free
- some utility services will (continue to) need maintenance and renewal
- street works practitioners need better tools to detect assets and minimize third party damage
- new techniques and improved practice will minimize disruption to traffic and to citizens and will
- safeguard the environment
- new technologies will ensure that future generations can locate buried assets easily.

And perhaps most importantly

- this is an international problem, which should be addressed at a European level, if only to ensure that the scale is sufficient to encourage investment and adoption of best practice.

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