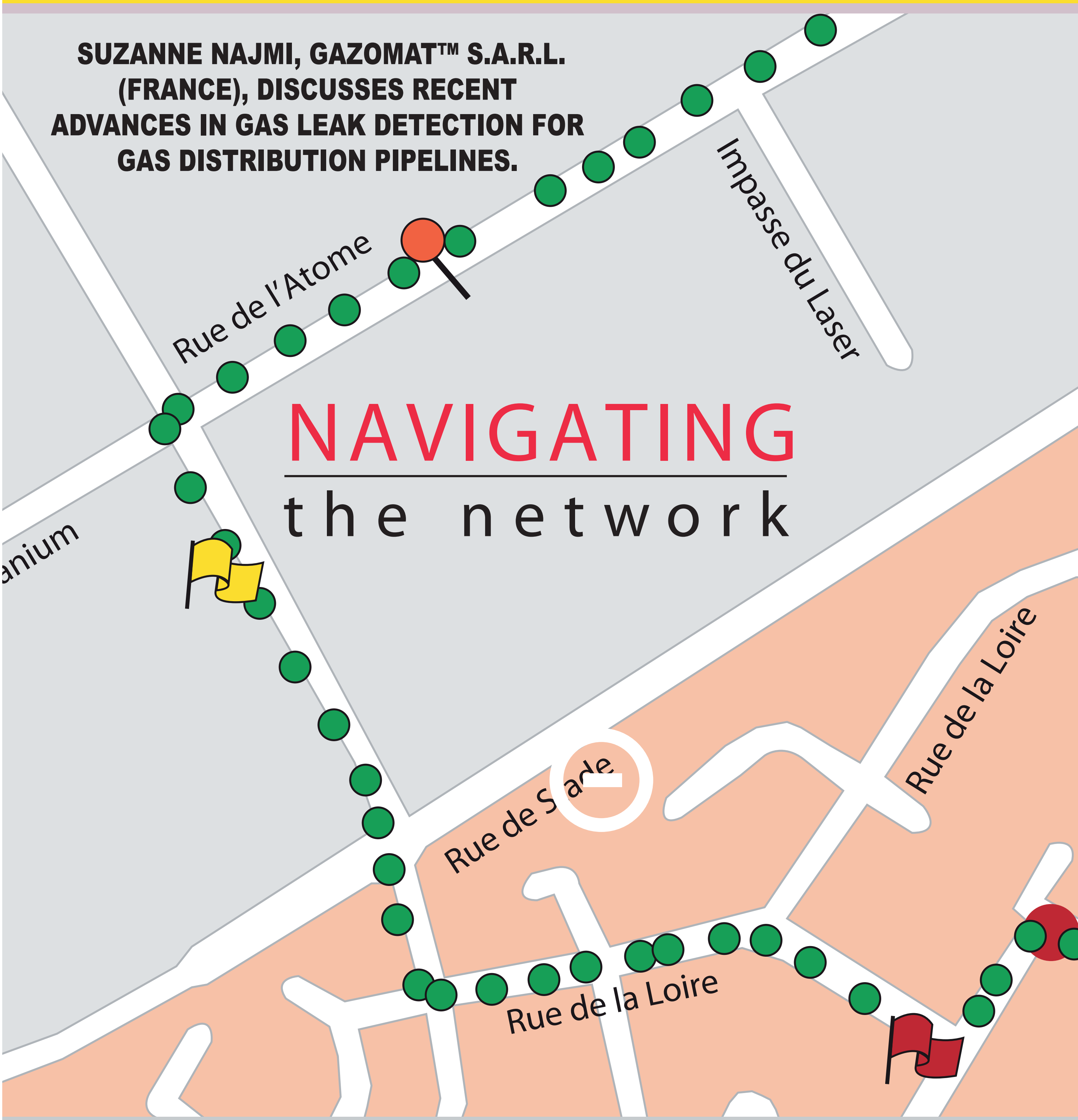
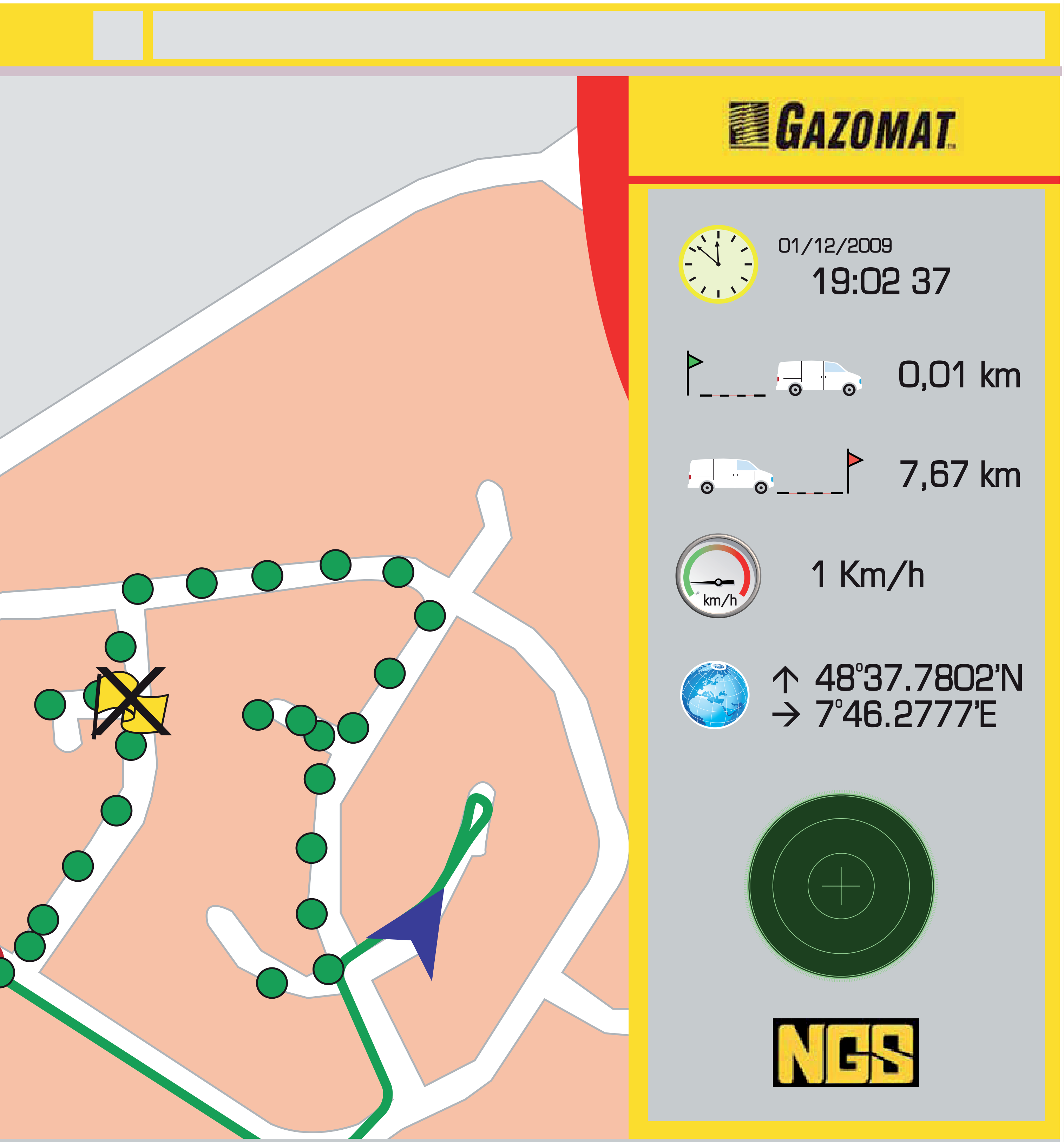
SUZANNE NAJMI, GAZOMAT™ S.A.R.L. (FRANCE), DISCUSSES RECENT ADVANCES IN GAS LEAK DETECTION FOR GAS DISTRIBUTION PIPELINES.

NAVIGATING the network



Gas distribution companies worldwide are required to survey their networks on a periodic basis. Depending on the country and type of gas, this can range from every six months to every three years, or longer. Additionally, new safety regulations in Europe put gas companies under an increasing obligation to guarantee traceability of their surveys by providing precise location and dating of gas concentrations measured. Systematic leak detection is therefore part of the overall safety policy of gas distribution companies.

Planned periodic detection programmes also allow gas companies to understand their network conditions and to define economical maintenance, equipment and systems renewal policies. Aimed at the early identification of any network deterioration, systematic leak detection enables timely remedial action. As such, network leak surveys are part of any maintenance policy



with the dual aim of increasing safety and maximising efficiency.

The main goals of gas leak detection are to identify potential gas leaks, confirm actual leaks and select those leaks that represent a threat to public safety and therefore require immediate repairs. Leak detection also strives to detect leaks at an early stage and prevent gas concentrations in air reaching the lower explosive limit (LEL) of 4.4% volume gas in air or 44 000 parts per million (ppm). At that level, the gas (usually methane) will ignite in the presence of a spark or flame.

Detection and classification

Gas leak detection can be divided into three phases: survey and detection, localisation and confirmation, and analysis and classification. The survey and detection phase is an effort to identify the areas on the gas distribution network

Figure 1. Foot surveys using portable laser detectors offer high precision but can be manpower-intensive and time consuming.

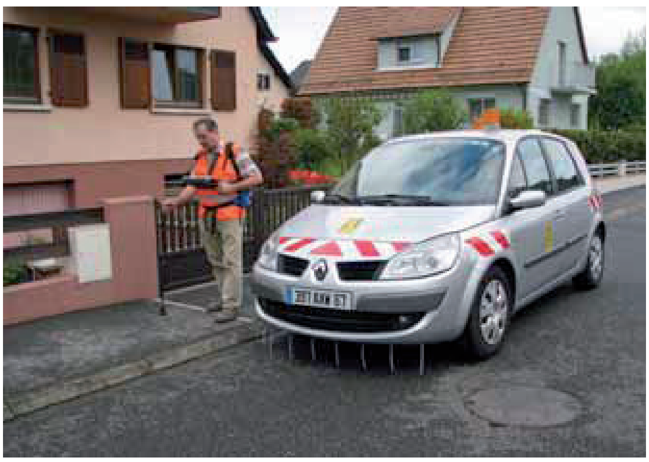


Figure 2. Leak survey and detection is usually accomplished using a road-driven vehicle. A vehicle survey offers the ability to quickly cover large areas, but not all areas are accessible to vehicles. A combination vehicle-foot survey is often employed.

Figure 3. The ECO INSPECTRA® vehicle was developed by GAZOMAT™for survey of pedestrian areas not accessible to a traditional network survey vehicle.

where leaks are recorded. Survey and detection is usually accomplished by means of a road-driven vehicle equipped with detection equipment. Survey data is recorded in a personal computer for later processing. A vehicle survey has the advantage of speed and distance covered; as much as 30 km per day per team may be surveyed. However, some areas inaccessible to vehicles must be surveyed on foot using a portable detector. The advantage of a foot survey is even greater precision, but the disadvantage is that they are manpower-intensive and time consuming, limiting distance covered to 6 - 8 km per day per man. A well-balanced combination of both methods will enable an efficient network survey.

The localisation and confirmation phase aims at determining, as precisely as possible, the position and the risk of a detected gas leak. Probe holes are used to isolate and better localise the leak. Gas comes to the surface using the shortest and easiest way. As a consequence, the spot where it is detected may not correspond to the actual leakage point on the pipeline.

Based on analysis of the survey results and localisation data, a leak is then classified as to severity and assigned a degree of urgency for the excavation and line intervention. Classification depends on several factors, including the geographical location of the localised leak, the nature of the environment, and the gas concentration level. Leak classifications vary throughout the global gas distribution industry but typically fall into three major categories:

- **Category 1** leaks require immediate intervention. They lead to an immediate investigation and then to the decision to either excavate immediately (unplanned repair) or to reclassify the leak into a lower category.
- **Category 2** leaks require repair work to be planned. No immediate intervention is needed, but the leak is entered into a scheduled repair programme (planned repair) and kept under periodic surveillance.
- **Category 3** leaks require no intervention, but periodical surveillance. These gas leaks present no danger, but must be checked within the planned survey programme.

Detection technologies

Leak detection technology has evolved considerably since the beginning of gas distribution. In the early days, visual inspection (for example, observing dead vegetation adjacent to a line) and a sense of smell were the primary indicators. The average human nose can detect gas concentration at a level of 500 ppm and beyond, but to make smell detection truly viable, combustible gases must be odourised. In some cases, the system itself can help. Specially designed systems can detect areas of pressure drops that could be associated with a gas leak. However, this approach is not effective in very low pressure systems (20 - 400 mbar). As distribution networks grew, it became clear that more sophisticated detection methods were needed.

Today's operators rely on information gathered by a variety of combustible gas indicator (CGI) technologies. What these devices have in common is a basic principle, which involves aspirating an air sample from the ground surface and bringing it into contact with a detector sensitive to gas molecules to obtain a gas concentration measurement. To be effective, detectors must meet a number of criteria:

- Stability. Detectors must be able to be calibrated and to hold that calibration.
- Sensitivity. Detectors must be able to detect down to the ppm range.
- Selectivity. Calibrated to one type of gas (generally methane for gas distribution networks), detectors must be highly selective, with no false measures due to other gases such as carbon monoxide, liquefied petroleum gas (LPG) or exhaust gases. They must also not interact with water.
- Response time. Detectors must respond as quickly as possible so as to provide the most precise leak location and to enable survey speed increase.

Depending on the precise need, multiple options are available across a price spectrum. For example, semi-conductor detectors are at the lower end cost-wise, but they are limited in terms of measurement stability, sensitivity and selectivity. Semi-conductor sensor detectors are fitted with special metal oxide semi-conductors that react to gas. At high temperatures, the sensor surface absorbs carbon atoms from the air sample, changing the electrical resistance characteristics of the sensor. This change is measured and gives the gas concentration. Semi-conductor detectors are easy to use, but they are sensitive to many gases and therefore not selective. They also require frequent calibration.

Explosimeters are another option. Explosimeters use pellistor sensors, which consist of a wire coated with a catalytic substance (platine). Based on its temperature, the electrical resistance of the wire changes. This resistance is measured and gives an image of the gas concentration. For the explosimeter measurement, the wire is heated by a current at 450 °C. Because of the wire's composition, the gas is oxidised. The reaction increases the temperature of the wire, changing its resistance. This combustion through an oxidising process requires oxygen. The technique allows detection of a concentration ranging from 100 ppm (maximum sensitivity) to 100% LEL (i.e., 4.4% volume gas for methane). If the concentration is higher than 100% LEL, the gas burns inside the measurement chamber and may

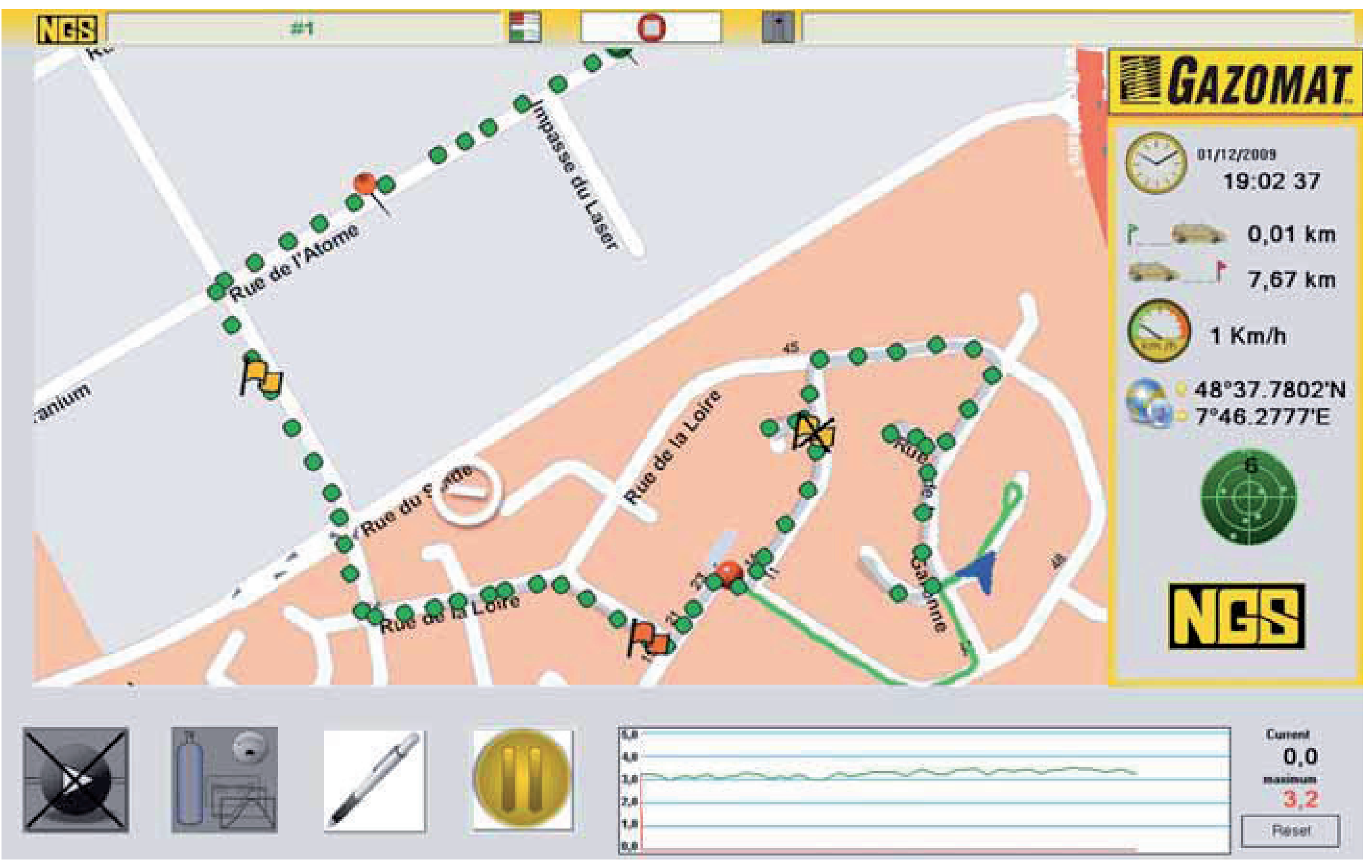


Figure 4. The NGS network survey software from GAZOMAT™ includes real-time visualisation of the survey mission with continuous display and recording of survey events along with associated GPS co-ordinates.

impair the wire. As a result, these sensors must not be used to detect concentrations above 100% LEL.

For higher concentrations, catharometer sensors are more suitable. The wire is heated at about 200 °C. At this temperature, the gas is not oxidised, hence no risk of damage due to combustion. This sensor relies on the thermal conductivity differences from one gas to another. For example, methane conducts twice as well as air. So when the sensor is in contact with gas, it will cool and its resistance will change. The measurement of resistance will give a concentration ranging from 1% volume gas to 100% volume gas.

Combining both sensor types in one unit (as in explosimeter-catharometer detectors, or ECDs) prevents damage to the explosimeter sensor. The main advantages are stability, precision, and insensitivity to humidity. The main drawbacks are that the combination unit is not selective, and that sensitivity is not as high as with other detectors. Explosion-proof explosimeter-catharometer units are used in hazardous environments for on-foot detection and localisation.

Low concentration and optical detectors

In response to increasing needs by operators, a number of other detection technologies have also been developed. For example, the flame ionisation detector (FID) has been the first low concentration detector widely used by gas operators. The gas passing through a flame (hydrogen) creates ions, which are collected by two electrodes. This generates an electric current between them. The current intensity is measured and translates to a gas concentration level. Flame ionisation detectors are sensitive, but they are not stable and require high pressure hydrogen gas (representing a safety issue). They can give false measurements in the presence of current-volatile compounds such as alcohol and benzene. Flame ionisation detectors are usually not explosion-proof, and they cannot be used indoors in an explosive environment.

Optical detectors have also found success in many areas. All optical devices are based on infrared (IR) absorption spectroscopy technology, which is based on a gas molecule's property of absorbing radiation. Working on the same principle as a fingerprint, the absorption spectrum of a molecule - which is specific to each gas - ensures indisputable identification of the molecule interacting with the light source, which might be an incandescent bulb, a microelectromechanical (MEM) system, a light-emitting diode (LED) or laser beam. The objective is to match the light source with a relevant portion of the electromagnetic spectrum of the molecule and to measure the strongest variation in intensity of the transmitted light.

Several leak detection techniques have been developed based on optical technology. One example is the open path barrier system mounted on a vehicle. This system uses an infrared light spread at the front of the vehicle. When combined with an optical filter, this enables gas detection at the ppm level and eliminates the need for sampling equipment. However, the detection device is dangerously exposed to shocks, and the optical sensor is exposed to dirt or mud. Measurements may not be correct and regular maintenance is required.

Another example is the multipass measurement cell, which multiplies the interaction between a gas sample and a laser beam. Laser technology offers both high selectivity (it detects only methane) and high sensitivity (below 1 ppm). Furthermore, its design ensures dynamics of measurement ranging from 0 ppm to 100% volume gas. Laser technology is also used in remote detection to make measurements on elevated pipeline sections, on bridges or any areas not easily accessible. If productivity gains are to be expected from this application, it will not measure methane concentrations below 100 ppm.

Simplifying the process

In partnership with leak detection equipment manufacturers, gas companies are increasingly focusing on solutions to accelerate the survey process using systems providing accurate, reliable measurement data as well as solutions ensuring traceability of network surveys over the years. Whereas gas leaks used to be manually recorded on paper maps of the network, the process has now considerably evolved with the advent of computer technology. Data collected during the survey are automatically saved in a personal computer, simplifying its further processing and analysis. Integration of global positioning system (GPS) technology also makes it possible to associate longitude and latitude coordinates to any gas leak indication recorded by the on-board analyser and to the vehicle's position along the survey route.

Additional network survey software has been developed, such as the newly introduced NGS software by GAZOMAT™ S.A.R.L., a French manufacturer of gas leak detection instruments. Priority has been given to ease of use for operators and survey traceability. Key features of NGS software include real-time visualisation of the survey mission with continuous display and recording of survey events along with associated GPS coordinates. This software also offers the ability for gas companies to download pipeline network map files and to generate reports compiling data at the end of each survey. The user-friendliness and simplicity of use of this latest-generation software makes it possible to extend its use to portable detectors and to small-sized vehicles for the surveillance of pedestrian areas. It also guarantees traceability of both vehicle and foot surveys, and it improves the speed and reliability of survey data processing, contributing to cost reductions.

As with all energy markets, the gas market faces critical challenges requiring a more proactive management approach. This fully applies to leak survey and detection, a domain in which technologies and equipment are constantly evolving to meet the increasing requirements of gas companies for technical and economical performance as well as safety. WP