Appendix A - Natural Gas Leakage Abatement Best P

Revised 4/27/15 - Revised the information on Gas Leak Detection tab, Row 31, Odyssian Technologies and added

Economic Analysis of Methane Emission Reduction Opportunities in the U.S. Onshore Oil and Natural Gas Industries

3/1/2014
Prepared for
Environmental Defense Fund
257 Park Avenue South
New York, NY 10010
Prepared by
ICF International
9300 Lee Highway
Fairfax, VA 22031
Environmental Protection Agency (EPA)
Recommended Technologies and Practices

The following report is a valuable source of information to help determine where the greatest opportunities are for Methane reduction in the Gas

http://www.edf.org/sites/default/files/methane_cost_curve_report.pdf

Row 17 to Gas Leak Prevention tab

Appendix A - Natural Gas Leakage Abatement Best P

Revised 4/27/15 - Revised the information on Gas Leak Detection tab, Row 31, Odyssian Technologies and added

Environmental Protection Agency (EPA) Recommended Technologies and Practices

Natural Gas STAR partners share information on cost-effective methane emission reduction technologies and practices via submission of annual progress reports detailing their emissions reduction activities. To promote technology transfer and share industry best practices, the Natural Gas STAR Program provides information on cost-effective methane emission reduction opportunities through a variety of documents including *Lessons Learned Studies, Partner Reported Opportunities (PRO) Fact Sheets* , Technical Presentations, and *Partner Update* articles (to learn more, see descriptions of Natural Gas STAR technical resources below). *Lessons*

The following webpages are extremely valuable sources of information for the practical, cost-effective reduction of methane emissions in the natural gas industry:

Recommended Technologies and Practices

Technical Document Translations
Program Forms
Technology Transfer Workshops
Service Provider Directory
Natural Gas STAR Contacts

Appendix A - Natural Gas Leakage Abatement Bes

Revised 4/27/15 - Revised the information on Gas Leak Detection tab, Row 31, Odyssian Technologies and a

Gas Leak Detection Technology

Name	Technology
Picarro	Cavity Ring-Down Spectroscopy (CRDS) - Nearly every small gas-phase molecule (e.g., CO2, H2O, H2S, NH3) has a unique near-infrared absorption spectrum. At sub-atmospheric pressure, this consists of a series of narrow, well-resolved, sharp lines, each at a characteristic wavelength. Because these lines are well-spaced and their wavelength is well-known, the concentration of any species can be determined by measuring the strength of this absorption, i.e. the height of a specific absorption peak. But, in conventional infrared spectrometers, trace gases provide far too little absorption to measure, typically limiting sensitivity to the parts per million at best. CRDS - Cavity Ring-Down Spectroscopy - avoids this sensitivity limitation by using an effective pathlength of many kilometers. It enables gases to be monitored in seconds or less at the parts per billion level, and some gases at the parts per trillion level. (Source: Picarro website)

CHARM® – CH4 Air Remote Monitoring, i.e. helicopter- borne infrared laser-based (LIDAR) remote gas detection system	How does CHARM® work? Natural gas traces made visible; Detection of very low methane concentrations Natural gas detection systems used for monitoring the tightness of buried pipelines must be capable of identifying even the smallest traces of methane. The measurement method of CHARM® is based on the absorption of specific infrared light wavelengths by methane, the main constituent of natural gas. CHARM® generates two short infrared laser pulses, whose wavelength is adjusted such that the first pulse is absorbed by methane while the second pulse is not absorbed. A small amount of the light of both pulses is scattered back to the measurement system where it is focussed by as telescope onto a sensitive detector. Evaluating the ratio of the measured signal of both pulses directly gives the concentration of the methane layer. For more technology information refer to this link: http://www.open-grid-europe.com/cps/rde/xchg/open-grid-europe-internet/hs.xsl/1222.htm
Gas Camera	The Gas Camera was mainly developed at Hamburg University of Technology on behalf of industry with support by E.ON Ruhrgas, Gasunie, Fluxys and Snam Rete Gas. The Gas Camera is a remote detection system that provides video images of gas clouds displayed of the target (leak). It analyses infrared radiation that propagates from the background of the field of view through the gas cloud to the optical receiver and the sensing element. There are IR Gas Cameras sold by other vendors.

EyeCGas by Opgal	Gases have their own characteristic absorption lines in the IR spectrum. The use of a gas camera, with an appropriate sensitivity, allows gases to be visualized. Thermal imagers are sensitive to the absorption lines spectrum and are designed to have an optical path sensitivity in correspondence with the gases, in the spectrum area of interest. When the operating gas camera is pointed at leaking components, the emissions will absorb the IR energy, appearing as what looks like smoke on either a black or white background. (Source: Opgal Corp)
GasFindIR by FLIR	Specifically the FLIR GF 320 can be used to detect Methane and Volitile Organic Compounds (VOCs) by visually displaying the temperature of the escaping gas and surroundings on a video screen. It can make small differences in temperature visible. See the links to the right.

Optical Methane Detector	The vehicle mounted Optical Methane Detector *TM uses infra-red technology to specifically detect methane gas leaks down to levels of 1ppm without cross interference to other hydrocarbons. (Gas Measurement Instruments LTD.) The Optical Methane Detector's infrared light source is mounted on a crossbar at one side of a vehicle's front bumper and then aimed at an optical detector mounted at the other end of the bumper. When methane molecules pass between the source and the detector, they absorb energy from the light beam, resulting in an attenuation of the beam that is proportional to the amount of gas present. This attenuation affects the detector's reading and the driver is alerted to a leak. The concentration may then be observed, mapped and logged. The Optical Methane Detector is effective at detecting trace levels as low as 1 ppm of methane. Because only part of the infrared light beam is affected by partial obstruction of the light path (such as from deposits of dirt on the exterior or water) the unit can function in light rain and other non-ideal survey conditions. (Source: Lechtzer Inc.)
Heath Detecto Pak Infrared (DP-IR)	Infrared Controlled Interference Polarization Spectrometer. The HEATH Detecto Pak-Infrared (DP-IR™) is a highly advanced technology capable of detecting methane without false alarming on other gases. The DP-IR is the latest of a new generation of leak survey instruments from HEATH that will greatly improve the productivity and safety of a walking/mobile survey. The DP-IR functions by using an infrared optical gas detection system. **This instrument is intended to replace the current surveying equipment using the traditional Flame Ionization with next generation technology utilizing a simple light beam, eliminating the need for expensive gas cylinders and refill systems.** It is designed to be selective to detecting methane only, and will not false alarm on other hydrocarbon gases. (Source: Heath Corp.)

Remote Methane Leak Detector	The RMLD-IS does not have to be within the gas plume because it uses laser technology known as Tunable Diode Laser Absorption Spectroscopy. As the laser passes through a gas plume, the methane absorbs a portion of the light, which the RMLD-IS then detects. This technology makes it possible to detect leaks along the sight line without always having to walk the full length of the service line. (Source: Heath Consultants website)
Laser Methane Detector by Gazomat	The INSPECTRA® Laser is a natural gas leak portable analyser with laser spectroscopy.The measuring chamber of the INSPECTRA® Laser analyzer is fitted with a laser diode adjusted to the absorption wavelength specifi c to methane. In the presence of methane molecules, the laser beam is partially absorbed. Thus, only methane is detected. The device is insensitive to other hydrocarbon gases, chemicals,water vapours and pollution that may be present in the atmosphere. (Source: Gazomat Corp.)

GT Instrument by GMI	Uses a semiconductor sensor for methane detection (PPM)) and a catalytic bead sensor for the Lower Explosive Limit (LEL) (Source: GMI Website)
Combustible Gas Indicator - Gascope Model 60 by MSA	The Gascope Combustible Gas Indicator is prepared for operation by turning the switch to the ON position, and setting the selector switch for high or low scale. A sample is drawn in by squeezing the aspirator bulb. The instrument uses two different types of filaments: a catalytic combustion filament for the low range, and a thermal-conductivity filament for the high range. Concentrations on the low ranges are measured by the hot-wire, Wheatstone bridge method. The filament is one arm of the bridge. When a gas sample is passed across this filament, combustibles are burned, raising the temperature of the filament. As a result, resistance is increased and the bridge becomes unbalanced. The imbalance is proportional to the concentration of the combustibles, and is indicated on the low range of the meter. For measuring in or above the explosive range, a thermal-conductivity filament is used. Combustibles in the sample cool this filament, causing the Wheatstone bridge to go out of balance. The imbalance, proportional to the gas concentration, is measured by the meter and read as percent-by-volume. The filament is field replaceable. (Source: MSA)

Leakator 10 by Bacharach	This easy-to-use instrument detects acetone, acetylene, ammonia, benzene, butane, ethanol, ethylene-oxide, gasoline, hexane, hydrogen, industrial solvents, methane, naphtha, natural gas, paint thinners and propane. (Source: Bacharach Corp.)
Portable Flame Ionization Detector	The operation of the FID is based on the detection of ions formed during combustion of organic compounds in a hydrogen flame. The generation of these ions is proportional to the concentration of organic species in the sample gas stream. Hydrocarbons generally have molar response factors that are equal to number of carbon atoms in their molecule, while oxygenates and other species that contain heteroatoms tend to have a lower response factor. Carbon monoxide and carbon dioxide are not detectable by FID. **There is now a replacement for FIDs. It is called DP-IR see line 10 of this spreadsheet.**(Source: Consumer's Energy Presentation to AGA - 2011 and Wikipedia)

Combustion Gas Indicator (CGI)	Semi-conductor Sensor Probe connected to instrument with electrical harness or Standard Probe and Handle assembly using instrument integral pump with flow fail sensor. The sample path is protected by hydrophobic filter and automatic pump switch off. (Source: Heath)
Gas Rover by Bascom-Turner	The Gas-Rover™ uses a catalytic combustion sensor to provide sensitivity, speed of response, and accuracy needed for leak surveys on foot or by vehicle. The Rover can be used to replace a conventional FID with a significant reduction in cost and a substantial increase in convenience. (Source: Bascom-Turner Website)

Smart Ball	Free-swimming acoustic monitoring device. It can identify the sound of leaks. (Source: Technical Toolboxes Inc.)
Robots	**Design News** - Robot Can Detect Gas Pipe Leaks By Ann R. Thryft, July 18, 2014 In more than one US location gas pipes under city streets have exploded, causing damage and even death. Aging, failing underground pipes carrying natural gas can be notoriously difficult to troubleshoot. Now, a self-propelled robot developed by MIT researchers promises to detect leaks quickly and accurately. Researchers at MIT and King Fahd University of Petroleum and Minerals in Saudi Arabia say their prototype robotic system can detect very small leaks of 1 mm to 2 mm and at lower pressures. Existing leak detection methods tend to be slow and incapable of finding small leaks. They usually involve either leak detectors located inside pipes that use cameras for visual inspection, or acoustic sensors above ground that detect characteristic sound and vibration patterns. Other methods include hydrostatic or liquid natural gas testing and aerial patrols equipped with lasers. This system detects leaks by sensing a pressure gradient near a leak in the pipe using force-resistive sensors. The small robot has wheels to propel it through a gas pipe. A drum-shaped projection from the robot's body houses a membrane that forms a seal across the pipe's diameter. Liquid flows in the direction of a leak and pulls the membrane slightly toward it. This creates a distortion detected by the sensors, and their data is sent back using wireless communications. The system can detect leaks quickly and pinpoint their location. The robot can potentially go faster than 3 mph, a limit set by motor speed, not sensor speed.

Tunable Laser Spectrometer	By measuring the absorption of light at specific wavelengths, the tool can measure concentrations of methane, carbon dioxide and water vapor and different isotopes of those gases.
Portable Spectrometer	By measuring the absorption of light at specific wavelengths, the tool can measure concentrations of methane, carbon dioxide and water vapor and different isotopes of those gases.

Canines (Dogs)	Trained Dogs. A gas detection team consists of a handler and 2 gas detection dogs. The following is from the Maribo company website: "The teams are trained according to specifications established by Swedish authorities and Maribo. According to impartial experts, Swedish requirement specifications are among the most stringent in the world. The fact that Swedish authorities place significant demands on handlers and service dogs is primarily due to a low political acceptability for failure. High demands from authorities and the market drive development. Maribo develops detection functions in cooperation with customers who have cutting-edge skills in their fields. Examples of customers who have cutting-edge skills include Vattenfall, Orica Sweden, Eon Sverige, Eurenco Bofors and Fortum Corporation. The training of teams from Maribo comprises expert technical content. " (Source: Maribo website)

Canines (Dogs)	Trained Dogs

Canines (Dogs)	Trained Dogs - Locating leaks in oil and gas pipelines using highly trained leak detection dogs. Our dogs sniff out the specialized odorant that is injected into the oil or gas pipeline. The odorant then rises to the surface allowing the scent to be recognized and located by the man and dog teams. This method saves the oil and gas company time, manpower, equipment usage and money. We offer maintenance inspection packages on all existing pipeline. Our customers don't have to wait for a leak to occur but employ a standard inspection schedule of their pipeline, saving even more time and money. Our dog teams locate potential problems before they become a major risk. Monthly, Bi-Monthly, quarterly and six months maintenance inspection scheduling packages available. (Source: K9 Pipeline Leak Detectoin LLC website)

Aerial Leak Surveys Using Drones	Small remote control helicopters that can be fitted with cameras and a variety of sensors.

Patrols Using Helicopters, Fixed Wing Aircraft, Cars, Boats, On Foot or any combination of these.	All of the methods on the left, with or without cameras or gas detection devices.
Hyperspectral Imaging Cameras (Rebellion Photonics)	Hyperspectral imaging collects and processes information from across the electromagnetic spectrum. The goal of hyperspectral imaging is to obtain the spectrum for each pixel in the image of a scene, with the purpose of finding objects, identifying materials, or detecting processes. Much as the human eye sees visible light in three bands (red, green, and blue), spectral imaging divides the spectrum into many more bands. This technique of dividing images into bands can be extended beyond the visible. In hyperspectral imaging, the recorded spectra have fine wavelength resolution and cover a wide range of wavelengths. (Source: Wikipedia and the references mentioned therein)

Smart Pipeline Network - Pipe & Repair Sensor System	Odyssian Technology believes that the correct approach to eradicating or significantly reducing pipeline leaks is a smart pipeline system that has a collection of diverse (and evolving) technologies all integrated within a distributed, yet common communication and control platform. The technology developed in these PHMSA SBIR programs take advantage of recent technology advances and shifts in affordability of technology to develop and demonstrate what Odyssian believes will be our future national Smart Pipeline Network. Such technology advances include the advent of nano-scale and thin and thick film materials in conjunction with micro machining techniques that allow for the development of very small sensors and multifunctional systems having intrinsically embedded sensing functionality. These small devices and materials are being used to develop highly engineered smart systems that are capable of sensing their environment and often responding to such stimulus. Odyssian Technology has developed smart pipe and smart seal technology, originally targeted for use on airborne high-energy chemical laser systems. This DOT PHMSA SBIR program further developed and adapted this technology for use on pipelines to allow for the pinpoint location of leaks and in some cases emerging leaks (detecting an imminent leak before leakage occurs). The shift in affordability and proliferation of wireless and wired communication networks makes more feasible a Smart Pipeline Network that provides real-time operational status of pipeline transmission, distribution, and remote facility systems. Communication and signal conditioning circuitry was developed that is integrated within the system to provide a sensor network capable of pinpointing the location of progressing leaks through fittings, joints, valves, pipe, pipe repairs, etc. For more information see the Final Report found via the link to the right. (Source: Odyssian Technology)
Gas Insertion Sensor System	In 2013 JD7 commercially launched its live gas insertion sensor system. This technology incorporates not only high resolution CCTV camera sensors but also a highly sensitive hydrophone and high powered sonde system. The hydrohpone is used for precise leak detection and pinpointing purposes. The hydrophone and software is sensitive enough to detect the smallest of leaks within low pressure gas distribution systems. Full leakage acoustic signatures can be displayed graphically or using the conventional audio output as headphones and HD CCTV live images allow the operator to validate the full survey. The system includes a pressurised launch and feed system which allows safe and consistent feeding of the system during live insertion work. (Source: JD7 Inc.)

;t Practices

dded Row 17 to Gas Leak Prevention tab

Uses	Detection Sensitivity
The unit Is mounted on a vehicle and driven through neighborhoods to identify areas where methan is detected. (Source: Picarro website)	It enables gases to be monitored in seconds or less at the parts per billion level, and some gases at the parts per trillion level. It can 1 PPB detect up to 600' from the source. (Source: Picarro website)

CHARMS hardware is mounted on a helicopter to survey the gas piping system. The use of CHARM requires not only the hardware (helicopter, system), but also a detailed data analysis depending on the customer requirements. This is a service offered by Adlares GmbH of Teltow, Germany. It is able to inspect up to 350 km/day.Their service will be possibly available in North America in 2016. Since this is a contractual service, the pipeline operator does not need to employ CHARM-specialists.	Gas concentrations can be determined over a width of at least 7 metres up to 12 metres □ Even the slightest traces of natural gas can be identified during routine air patrols at a speed between 50 – 90 km/h at altitudes between 80 m and 140 m. It can detect a leak of 100 liter/hour (0.06 scfm) at wind speeds of 3 m/s (6,7 mph). Even at 6 m/s (13 mph)it can detect leakages of 500 l/h (0,3 scfm). □ The operational detection limit is less then 25 ppm·m at a high detection resolution. (Source: E-ON/RuhrGas and Open Grid Europe)
Can be a portable camera used to scan facilities or a stationary camera aimed at a gas facility or other target which can alarm if a methane leak is detected.	It is capable of safely detecting gas clouds with column densities as low as 150 ppm·m. (Source:Eon Ruhrgas)

Portable camera about the size of a normal video camera allow the operator to see and record gas leaks. (Source: Opgal Corp)	Only says that it can detect small leaks.
Portable camera about the size of a normal video camera allow the operator to see and record gas leaks. (Source: FLIR)	.8g/hr http://www.flir.com/thermography/americas/us/view/?id=30866

Mobile Leak Survey - Attaches to front of truck - Speeds up to 35 miles per hour. (Source: Consumer's Energy Presentation to AGA - 2011)	Range of 16' and detects down to 1ppm and < 1 second (Source: Consumer's Energy Presentation to AGA - 2011, Gas Measurement Instruments LTD and Lechtzer Inc. and Heath Corp.)
Walking leak survey. According to Heath, the manufacturer, you use it the same way as the Flame Ionization Detector. (Source: Heath Corp.)	0-1000 PPM: 1 PPM 1000-10,000 PPM: 5 PPM 1-100%Gas: 0.5%. For more information see the brochure: http://heathus.com/wp-content/uploads/dpir.pdf

Walking Leak Survey. Can be used from 15' to 100' away. Must have appropriate background target to reflect the IR beam (i.e. ground or building) Scan slowly over longer distances Avoid dark zones (Source: Consumer's Energy Presentation to AGA - 2011)	According to NYSearch it can detect 5 ppm from a distance of 200 feet. http://www.nysearch.org/commercial_products.php Can be used from 15' to 100' away. Must have appropriate background target to reflect the IR beam (i.e. ground or building) (Source: Consumer's Energy Presentation to AGA - 2011)
Walking Leak Surveys• ATEX Version: for use in explosive atmospheres (both inside and outside of buildings), suitable for any application requiring the measurement of natural gas concentrations (methane only) such as : • Survey of natural gas network (methane only) • Detection and localization of gas leaks (methane only) • Monitoring of natural gas compression plants • Monitoring of methanation plants • Monitoring of landfills • Measurements in laboratories, etc. • Non ATEX version : for use outside of buildings only and exclusively limited to NON ATEX areas presenting no risk of permanent presence of explosive gases. • Applications requiring natural gas concentration measurements (methane only). (Source: Gazomat Corp.)	Sensitivity of 1 ppm (Source: Gazomat Corp.)

Overview - Designed for the gas industry, the GT Series are multi-application instruments, satisfying all the needs of service technicians within a single unit. With 7 modes of operation, the GT Series is the most versatile instrument available for working with gas.The GT Series is suitable for the following operations: Leak test, Confined space entry, Barhole testing, Carbon monoxide, Purge, Sniffer, Pressure leak tightness. (Source: GMI Website)	0-10,000 ppm in increments of 1 ppm 0-100% LEL in increments of 1% (Source: GMI Website)
The Model 60 is designed for use by gas utility companies in routine testing for methane-in-air concentrations in manholes, sewers, curb boxes and other street openings. The unit reads 0 to 5% by volume methane-in-air, and 0-100% by volume methane-in-air. (Source: MSA)	The unit reads 0 to 5% by volume methane in air and 1-100% by volume methane in air. (Source: MSA)

Hand held light weight gas detector. This easy-to-use instrument detects acetone, acetylene, ammonia, benzene, butane, ethanol, ethylene-oxide, gasoline, hexane, hydrogen, industrial solvents, methane, naphtha, natural gas, paint thinners and propane. (Source: Bacharach Corp.)	20 ppm for Methane (Source: Bacharach Corp.)
Sensitive, economical, single purpose gas leak Flame Ionization Search Instrument. One instrument for walking, ATV and mobile surveys. Provides eight hours of continuous operation and can be refueled in one minute or less. Ideal for checking mains, services, congested areas, meter sets and risers. Weighs 4¾ lbs. Meter, audible alarm and LED flame out indicator provide the readouts. (Source: Southern Cross Inc.) Walking Leak Survey or Mobile Surveys. See the brochure for all of the uses of this instrument: http://heathus.com/wp-content/uploads/detecto-pak-4.pdf (Source: Consumer's Energy Presentation to AGA - 2011 and Heath)	In the search range, (50 ppm @ full scale), it is capable of detecting as low as one part per million (ppm) of hydrocarbons in air. A centering range, (5000 ppm @ full scale), is provided to assist in centering leaks. The meter indicates the presence of hydrocarbons. An alarm sounds at a preset point on the search range. (Source: Southern Cross Inc.)

The First Responder gas detector provides gas detection for first call and emergency response technicians in the gas utilities. It can be used as a Combustible Gas Indicator with LEL and % Volume ranges for leak detection and general safety monitoring. Additionally, the First Responder has a Carbon Monoxide range for internal atmosphere monitoring where odor call response is required. There are currently three CGIs utilized at SCE Catalina: GMI Acclaim, Impact Pro, and the Sensit HXG-2D. The GMI Acclaim is a portable combustible gas indicator that can detect the presence and concentration of combustible gases. The Impact Pro is a portable gas monitor designed to monitor the atmosphere continuously for hazardous levels of oxygen, combustible gas, carbon monoxide, and hydrogen sulfide. The Sensit HXG-2D is designed to detect combustible gases in both the PPM and %LEL range.	1 PPM (Source: Heath)
Use it to conduct gas leak surveys by foot or vehicle (Source: Bascom-Turner Website)	Measurements over the full range of gas from 1ppm to 100% gas, Survey mode provides a calibrated scale from 1ppm to 10,000 ppm, Barhole mode yields peak and sustained readings after a fixed time (Source: Bascom-Turner Website)

Rolls through pipes 4" and above, propelled by the flow of the gas. Used for routine leak surveys, including pin-hole sized leaks, emergency leak location, minimizing product loss and cleanup costs, validation of alarms generated by CPM systems (with leak location), acceptance testing of new pipelines, product theft detection, leak location during hydrotests.(Source: Technical Toolboxes Inc.)	0.1 liter/min.(Source: Technical Toolboxes Inc.)
Detects very small gas leaks	Detects very small leaks of 1mm to 2mm at low pressures. (Source: Design News - Robot Can Detect Gas Pipe Leaks By Ann R. Thryft, July 18, 2014)

It is used to find and pinpoint methane leaks	PG&E says it's 1,000 times more sensitive than the hand-held equipment it's been using to track down leaks. NASA says 1.3 parts per billion.
UC Davis is also using it to perform surveys of methane emissions from the air: The project is funded by PG&E and the Pipeline Research Council (PRCI):	Very sensitive but needs refinement to differentiate the signiture of pipeline methane from naturally occurring methane.

Find transmission and distribution line leaks	Performance is continuously monitored and results show that reliability is around 96%-97%. Chromatographs show that a gas detection dog detects values far below the PPB level. " (Source: Maribo website)

Find transmission line leaks	See the line above. Tests have shown that they can detect gas in the parts per billion (ppb) range

Find transmission and distribution line leaks	See the line above. Tests have shown that they can detect gas in the parts per billion (ppb) range

Drones are being tested now by SDG&E to inspect power lines and towers. In the future they may also be used to inspect gas lines and other infrastructure. One possibility is to fit the drones with miniature tunable laser spectrometers to detect gas (see the Leak Survey and Repair Methods tab on this spreadsheet).	N/A

Landslides or threatened slides. Erosion by streams, wave action, rain, etc.. Land subsidence that could affect the pipeline, Construction or maintenance work being done by others along the pipeline. Encroachments into the right-of-way by buildings, structures or the construction of levees, roads, wells, etc, for which no prior permission has been granted by the company. Evidence of gas leakage, by checking vents at RR crossings or as indicated by vegetation (See Procedure 5.02, Leakage Surveys), bubbles in surface water, odor, etc.. Needed repairs to company owned facilities, including fences, pipeline markers, exposed crossings, etc. Needed repairs to highway structures and other non-company owned facilities where public safety is a factor. Presence of survey parties or other indications of possible future work that might jeopardize the pipeline or effect a change in its class location. Any other factors affecting the operation or safety of the pipeline or other company facilities such as slope erosion, blocked culverts, casing vents, and access road washouts. Evidence of atmospheric corrosion that would indicate the need for repair and/or re-coating. Access roads used by others occasionally, or in areas viewed by the general public that may not be in a passable condition as established in accordance with existing agreements. Changes in population deensity. Any activity that could create an unsightly condition in aesthetically sensitive areas.	Usually patrols are visual however, they are becoming more sophisticated using gas detection technology.
Detecting Methane Leaks	1% methane leaks at 160 ft. (Source: Rebellion Photonics)

Detect leaks in gas transmission lines. In this program, smart pipes and smart composite repair having integrated leak detection micro-sensors will be further developed and adapted for pipeline use. Concepts and designs will be developed for a networked sensing system capable of sensing the pinpoint location of a leak or impending leak, as well as monitoring structural health. In Phase I, the scope will include the development of a Pipe and Repair Sensor System for use with petroleum-based liquids, with Phase II expanding the scope to include development of a system for use with natural gas. For more information see the Final Report found via the link to the right. (Source: Odyssian Technology)	Depends on the sensors used. Still in R&D Phase
Determine the condition of low pressure distribution piping and locate leaks in low pressure gas distribution systems.(Source: JD7 Inc.)	The JD7 website just says " The hydrophone and software is sensitive enough to detect the smallest of leaks within low pressure gas distribution systems."

Link to Manufacturer or Research	Cost
http://www.picarro.com/	Must contact the vendor

http://www.open-grid-europe.com/cps/rde/xchg/open-grid-europe-internet/hs.xsl/charm.htm?rdeLocaleAttr=en	This is a service offered by Adlares GmbH, in partnership with Open Grid Europe. Currenly, it is not available in the US but the company anticipates that it will begin to offer the service to North America in 2016. The pricing for the CHARM survey depends on many parameters, including Topology (structure) of the pipeline (straight ahead, many branches, …), Assigned mileage, Preparation costs (e.g. transfer from base to area of operation), Assigned additional services (e.g. photographic mapping) (Source: Matthias Ulbricht of Adlares GmbH)
http://www.tuhh.de/mt/ftir/project09.htm	N/A

OPGAL	Must contact the vendor
http://www.flir.com/cs/emea/en/view/?id=41663	Must contact the vendor

http://heathus.com/products/omd/	Must contact the vendor
http://heathus.com/product_category/gas/infrared-ir-optical-based/	Must contact the vendor

http://heathus.com/product_category/gas/laser-based/	Must contact the vendor
http://www.gazomat.com/Pages/INSPECTRA-Laser-Portable.aspx?language=English	Must contact the vendor

http://www.gmiuk.com/product/gt-series/	Must contact the vendor
There is no direct link to this device. It does not appear on the website of MSA, the manufacturer. Instead you must type "gascope model 60' into a search browser. One of the selections will be "media.msanet.com" Click on it.	Per Internet search - Approx $3000 http://www.superiorvalueproducts.com/MSA-Gascope-Combustible-Gas-Indicator-Model-60-465475_p_1944.html

http://www.bacharach-inc.com/leak-detection.htm	Must contact the vendor
Several manufacturers easily found on the interntet. One of them is Heath: http://heathus.com/product_category/gas/flame-ionization-fid/ Another manufacturer is Southern Cross: http://southerncrossinc.com/products/flame-pack-400	Must contact the vendor

http://heathus.com/products/first-responder-gas-detector/	Must contact the vendor
http://www.bascomturner.com/rover.php	Must contact the vendor. Supposedly cheaper than a Flame Ionization Detector (Source: Bascom-Turner Website)

http://www.ttoolboxes.com/Products/Smartball/	Must contact the vendor
http://www.designnews.com/author.asp?section_id=1392&doc_id=274104	N/A - Not commercially available yet.

http://trs-new.jpl.nasa.gov/dspace/handle/2014/42732	Possibly as low as $5000 per unit
http://www.sfgate.com/business/article/Methane-detector-tracks-pipeline-leaks-4071523.php	Fixed Wing Aircraft are much cheaper than helicopters using lasers. This equipment can be bought off-the-shelf for about $50,000 and easily mounted on an airplane.

http://www.maribo.se/gas-detection.html	Must contact the vendor

http://detectordogservices.com/oil%20and%20gas%20services.html	Must contact the vendor

http://www.canineoilpipelineservices.com/index.html	Must contact the vendor

http://3drobotics.com/	Each Drone costs $750-$11000, depending on the type of drone and options chosen

	Varies by vendor providing the service.
http://rebellionphotonics.com/	$2-3 Million for a mid-sized refinery

http://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=444&c=1&s=D92E98698A8F48E794162A2DE1106BD2	Must contact the vendor
http://jd7.co.uk/products/gas-insertion-system.php	Contact JD7. All products are available as a service, lease or sale.

Advantages

The Picarro Surveyor enables operators to survey gas secured mains and services at traffic speeds and automatically map and display results in real-time on a secure web browser. The user also has the option to perform a real-time analysis to distinguish between natural gas and other biogenic sources. The data is transferred stored, processed and mapped in the Picarro Processing Platform (P-Cubed). Picarro is able to locate and pinpoint leaks under varying environmental conditions, provide more efficient surveys to streamline operations and repairs, remove human error in reporting and provide a data-driven audit trail. Generates verifiable, traceable and complete records.
(Source: Picarro website)

What can CHARM® perform? Efficient and reliable pipeline inspections from the air.

The CHARM® system, developed by Open Grid Europe, is a highly efficient innovative procedure of monitoring natural gas grids. Because of the high sensitivity of the system as well as the automatically and extremely precisely beam control (autotracking), CHARM® can be reliably used even for complex pipeline topologies.

Key facts and benefits at a glance
Helicopter-borne infrared-based laser remote gas detection system
Detection of slightest traces of natural gas (at altitudes between 80 m and 140 m)
Recognized under DVGW codes of practice (Technical Rule G 501: Airborne Remote Gas Detection Methods)
Operational detection limit < 25 ppm•m
Automated documentation of pipeline inspection and real-time reporting of incidents
High efficiency in monitoring pipelines in built-up areas
Area-wide inspection of pipeline route (7 m up to 12 m)
Accurate geographic positioning with CHARM®-Autotracking (CAT)
100 double pulse measurements per second
Patrol speed 50 km/h (up to 90 km/h) (Source: Open Grid Europe). No capital investment. This is a contracted service provided by Adlares GmbH of Teltow, Germany, which is in partnership with Open Grid Europe.. (Source: Matthias Ulbricht of Adlares GmbH)
See also Presentations and Useful Files to the right.

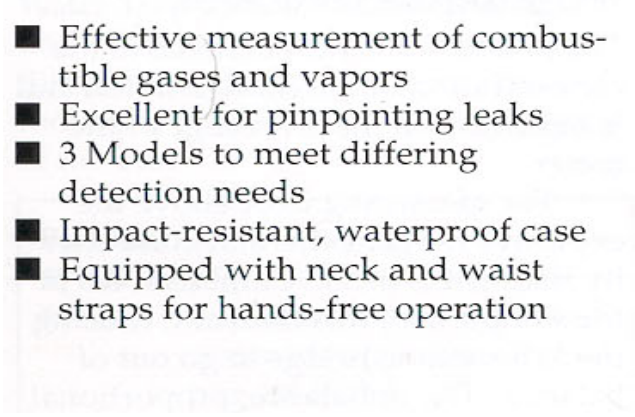
Detect gas at a safe distance. Can scan large areas quickly. Can provide video images of gas clouds

Detect gas at a safe distance. Can scan large areas quickly. Specially designed for the natural gas, oil and petrochemical industries, taking into consideration the requirements of the users. Very sensitive and detects smaller leaks than the existing optical imagers' portable solutions. Certified for use in hazardous environments (Class 1, Div.2 and ATEX II), allowing inspection at hazardous places in plants. Implements an internal video and audio recording device. Features a large color LCD display for image and text display. Rugged and durable by design to be used as a tool in the field. It's a portable camera about the size of a normal video camera allow the operator to see gas leaks. The camera also can record videos and audios of the leak and allow you to add commentary.. Only requires 1 hour of training. (Source: Opgal Corp)
Detect gas at a safe distance. Can scan large areas quickly. The FLIR GF320 is an IR camera for optical gas imaging (OGI) that visualizes and pinpoints leaks of VOCs, without the need to shut down the operation. The portable camera also greatly improves operator safety, by detecting emissions at a safe distance, and helps to protect the environment by tracing leaks of environmentally harmful gases. The GF320 is used in industrial settings such as oil refineries, natural gas processing plants, offshore platforms, chemical/petrochemical industries, and biogas and power generation plants. Can also be used to detect leaks in residential gas distribution piping. It's a video camera with IR capability. It can record videos or still pictures. Has GIS capability so you know the exact location of the leak. Optical gas imaging is an accepted leak detection technique in the Method 21 Leak Detection and Repair Alternative Work Practice (Method21 AWP) as well as the Green House Gas Reporting Rule.

Infrared technology, methane specific, instant response, very high survey speeds (to 50 kph), largely unaffected by rain or surface water, no pumps or calibration gases, GPS option (Gas Measurement Instruments LTD.)
The DP-IR operates under a variety of environmental conditions including cold or hot weather. Its rugged design will stand up to normal field use and operating conditions. The DP-IR has built-in Self-test and Zero functions that will assure that the instrument is operating properly. Using the internal calibration cell, the operator can perform the self-test as part of a daily start up routine. While in operation, the DP-IR continuously monitors several parameters to ensure that the instrument is functioning properly. Should any of these parameters go outside of the operational limits, an audible alarm will sound and a Fault/Warning error message will be displayed. (Source: Heath Corp.)

Works well in outdoor situations. (Source: Wikipedia) Using laser technology, remote detection allows you to safely survey areas that may be difficult to reach such as busy roadways, yards with large dogs, fenced-off areas and other hard-to-access places. Will only detect Methane, not other hydrocarbon gases (Heath Consultants website)
Small, portable, weighs 6 lbs. 2 measurement scales: • PPM scale from 0 ppm to 10,000 ppm • GAS scale: from 0 % to 100 % volume gas • Simultaneous display of double measurement range • Very short response time • Two sampling speeds: 35 l/hour and 70 l/hour. GPS Tablet system for total traceability of on-foot inspections. This device enables the operator to keep a computerized record of his/her detection operations: • Geographical positioning on a map of detected leak indications • Recording of concentration measurements • The operator may insert comments during the on-foot inspection • Inspection reports are generated (location, date and time, leak numbers, concentrations, weather conditions and operator comments).See the Gazomat website link for more information. (Source: Gazomat Corp.)

The GT range of instruments combine quality, ruggedness and advanced GMI Technology in a user friendly, hand held gas detector. • PPM, LEL and Volume Methane flammable gas ranges for leak detection • Manual and automatic datalogging • Loud audible and high visual 'ticker' (Geiger) on ppm range • Integral flashlight • Alkaline or rechargeable battery options • Charging via simple power cable or docking station • Rugged polycarbonate case, sealed to IP54 Bump Test & Calibration Station • Simple user interface • Full bump test and calibration options • Bump test and calibration results storage • Robust construction. It is also light weight at 1.7 lbs. (Source: GMI Website)



(Source: MSA)

10 bright red LED's and a speaker that provide visual and audible indications to the presence of gas •Three operation-status LED's that show power on, sensor operation and low battery • Simple thumb wheel on/off allowing for one-handed operation • Solid state plug-in sensor with typical five year life • 20 inch flexible probe for hard to reach areas • Operational status LED's in English and International systems • UL 913 Classified. Small and Light - Only 18 ounces - Detects many combustible gases, not just methane. Low Maintenance and relatively inexpensive. (Source: Bacharach Corp.)
Flame ionization detectors are used very widely in gas chromatography because of a number of advantages.Cost: Flame ionization detectors are relatively inexpensive to acquire and operate. Low maintenance requirements: Apart from cleaning or replacing the FID jet, these detectors require no maintenance. Rugged construction: FIDs are relatively resistant to misuse. Linearity and detection ranges: FIDs can measure organic substance concentration at very low and very high levels, having a linear response of 10^6. Life is eight hours with fully- charged battery and two fuel cylinders filled to 1,750 psig. (Source: Wikipedia) They are rugged and light and can be hand carried, mounted on an ATV or other vehicle. (Source: Southern Cross Inc.)

Portable, easy to use, easy to set up, fast, provides permanent repeatable measurements and records. Relatively inexpensive.(Source: Heath)

- Measurements over the full range of gas from 1ppm to 100% gas
- Survey mode provides a calibrated scale from 1ppm to 10,000 ppm
- Barhole mode yields peak and sustained readings after a fixed time
- Optional sensors for CO and O2
- Intrinsically safe design for indoor and outdoor use
- Visual and audible alarms for all monitored gases
- Optional GPS capabilities & Bluetooth functionality
- Optional 1 Gas Calibration
- Retrieve field and calibration data with DataLink4Access
- Use the Rover to become Method 21 Subpart W compliant
- Automatic calibration, stand-alone and/or in-network docking stations
- Automatic storage of mode and time-stamped data
- USB interface for data transfer and area network
- Two-speed pump automatically set for the job on hand
- Large, bright, backlit LCD display with short manual on-board
- Sturdy construction in an ergonomic 24 oz package

Supposedly, the Rover can be used to replace a conventional FID with a substantial increase in convenience. (Source: Bascom-Turner Website)

Easy to deploy and tack throughout inspection, long battery life allows for long distances to be inspected in one deployment, can detect 'pinhole' leaks as small as 0.016 GPM (0.06 LPM), which is typically several orders of magnitude more sensitive than some leak detection systems, maneuvers quickly and easily through a pipeline (the ball is smaller than the inside diameter of the pipe), light weight for easy shipping and tool preparation.(Source: Technical Toolboxes Inc.)
Fairly fast. It travels at least 3 MPH with the potential to go faster. Almost entirely automated.

Small, handheld and extremely sensitive. The laser and detector themselves are very small. The laser, the size of a quarter and the detector, the size of a penney. See the file in the Presentations and Useful Files column
You can survey large areas from the air. More accurate than looking for dead vegitation, especially in the summer when weeds and grass are brwon anyway.

Maribo GDD-Teams have cutting-edge skills and experience; reliability for detection performance is 96%-97%. Search tags (i.e. all substances GDD identifies) are made up of exclusive substances (not freely occurring substances) and Maribo teams can detect gas leaks in gas pipelines located above or below ground. A gas detection dog from Maribo can identify gas leaks in environments contaminated by gas. GDD-Teams have technical expertise in gas pipelines and expertise in drawings and maps. Maribo gas detection dogs can serve in any environment where people and animals live, and they demonstrate great insensitivity to normally occurring heights, tunnels, traffic, people, animals and sounds. GDD-Teams can operate in the temperature range of -8°C to +32°C. At daytime temperatures above +32°C detection is performed during the cool part of the day. GDD-Teams can operate in hilly terrain and urban areas in wind with a force up to 25m/s; in open flat terrain in a constant wind with a force up to 17m/s*; and in open flat terrain in a gusty wind with a force up to 12m/s*. Maribo gas detection dogs can work in moderate rain or snowfall (they do not perform detection where there is ice formation in soil) and can work for ten consecutive hours while maintaining reliability in detection performance. The average control distance per day is 5,000m (when working with detection only) and for maintenance inspections Maribo gas detection dogs average 32 valves per working day (when working with valves only). Gas detection services provided by Maribo GDD-Teams can fix discrepancies in the distribution system. All reports are provided according to instructions from clients.

* In open flat terrain there is some limitation when the wind is strong and/or gusty. (Source: Maribo company website)

This information is from the Detector Dogs International (DDI) webpage:

"When you use dogs for leak detection, you only have to dig once. Dogs can be used during leak audits and can also be used in pipeline maintenance, especially on lines that are 30 or more years old. This part can be critical to any company because the dogs are fast and in a situation where you do not want to shut down a line, the dog can be used to locate a leak on an active line. Dogs are wonderful detection tools, suited for use in even the most environmentally sensitive areas. The weight of the dog does not destroy sensitive flora or grasslands, as a huge mechanical shovel would. The dogs do not have to be brought in by huge trucks to a location – they are themselves self-propelling. And to date, no hi-tech machine can match the sensitivity of a dog's nose – it's that powerful! Dogs can serve as a powerful general maintenance tool to locate leaks on active lines before the leak can spread into small rivers and creeks or on to farmers' fields. DDSI employs specially trained dogs that are able to detect actual leaks to an accuracy of less than half a metre. Unlike mechanical devices, the leak detection success rate of healthy, properly trained DDSI dogs is 100%." No need to drag leak detection equipment into mountainous or rugged terrain. More cost effective than leak detection equipment. (Source: Detector Dogs International (DDI))

The company is K9 Pipeline Leak Detectoin LLC. According to their website, "Within the U.S. our handler and dog teams can be mobilized and on your job site within 72 hours after initial activation. Please call for Canadian mobilization time frame and other locations worldwide. Our Pipeline Leak Detector Dogs and handlers go through an extensive six week training course. Only dogs with extreme desire and stamina are selected as Pipeline Leak Detector Dogs. Our dogs can work in temp ranging from 32 degrees up to 95 degrees. A minimum of two Pipeline Leak Detector Dogs are used for each assignment up to four depending on circumstances." one dog can cover up to 5 miles per day in an open field and many miles of Neighborhood blocks if needed. Most jobs we use multiple dogs and trade them out as needed along with multiple handlers.

(Source: K9 Pipeline Leak Detectoin LLC website)

Inexpensive. In some cases, drones can get closer to infrastructure than humans or helicopters, especially in rugged areas.

Covers a lot of mileage in a relatively short amount of time.

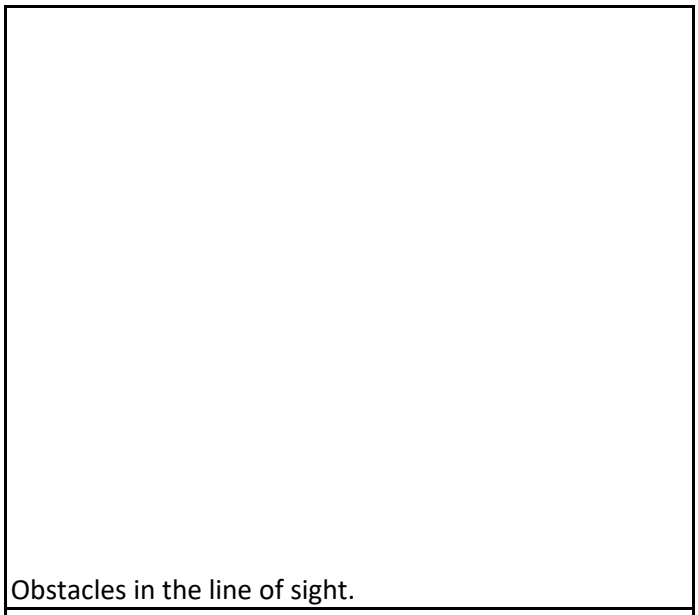
You can see leaks on live video. Color coding identifies the severity of the leak. Rebellion Photonics offers a Gas Cloud Imaging video camera that monitors, quantifies, and displays, using a false-colored image, explosive/harmful gas leaks with real-time (~30 fps) video and hardware-based zoom. The camera can be used as an alarm, with 0.5 second response time, to notify of potentially dangerous leaks and aid in safety management. With breakthrough optics technology invented at Rice University, Rebellion Photonics can offer Gas Cloud Imaging video cameras which provide several new possibilities in refinery/rig safety: Detect more explosive, harmful leaks earlier, monitor large sections of a facility in real-time, night and day, visualize gas clouds with powerful false-colored video, zoom in on leaks to better understand size and dispersal, repair leaks more accurately due to portability, save video for future analysis and safety management. Automated calibration with annual maintenance. Unaffected by the wind or temperature, fully automatic 24/7. (Source: Rebellion Photonics webpage)

Using a system of sensors along the pipe to create a "smart pipe", the hope is that leaks will be detected sooner. It is very difficult to detect a leak from the control room.

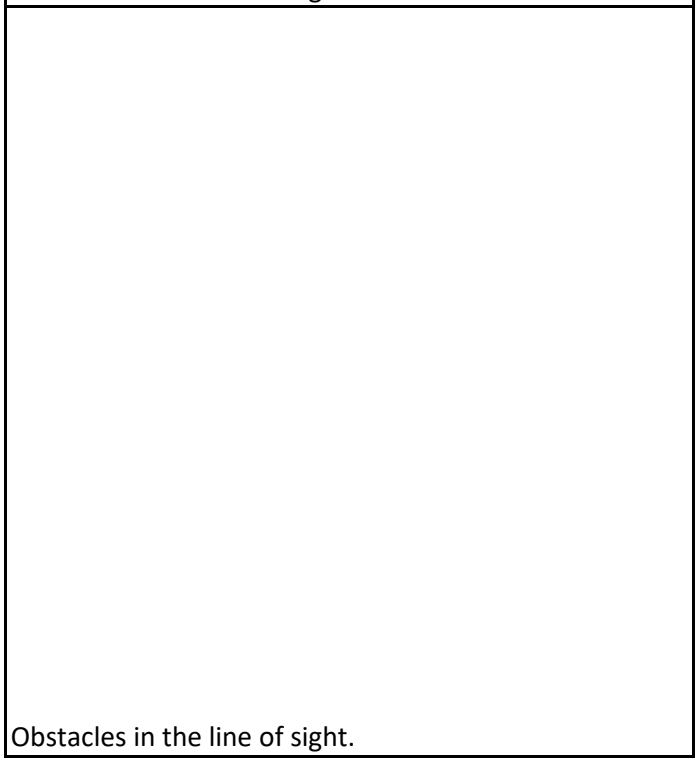
The distribution system can be inspected while in service. The hydrophone is used for precise leak detection and pinpointing purposes. Full leakage acoustic signatures can be displayed graphically or using the conventional audio output as headphones and HD CCTV live images allow the operator to validate the full survey. The system includes a pressurised launch and feed system which allows safe and consistent feeding of the system during live insertion work. (Source: JD7 Inc.)

Disadvantages
Results can be affected by weather, especially wind.

It cannot detect gas unless it is able to leak to the surface. It is currently unavailable in the US. It is scheduled to be available in North America in 2016.
Obstacles in the line of sight.



Obstacles in the line of sight.



Obstacles in the line of sight.

Open path detectors suffer downtime from anything that blocks the path of the beam, such as people, vehicles or thick fog. (Source: Wikipedia)
Cannot be used at a distance. Gas has to be sucked into the machine to be analyzed.

Open path detectors suffer downtime from anything that blocks the path of the beam, such as people, vehicles or thick fog. (Source: Wikipedia)
The probe must come in contact with the gas to sniff it. Not for locating gas leaks from a distance.

Must come in contact with the gas to sniff it.

Silanes, silicones, silicates and other compounds containing silicon in the tested atmosphere may seriously impair the response of this instrument. Some of these materials rapidly poison the catalytic combustion filament so that it will not function properly. When there is even a suspicion that such materials are in the atmosphere being tested, the instrument must be checked frequently (at least once every five uses). Calibration kits are available to conduct this test. Leaded gasoline vapors can also poison the catalytic combustion filament. To prevent this, an inhibitor filter (Part No. 47740) should be used to nullify their effect.

(Source: MSA)

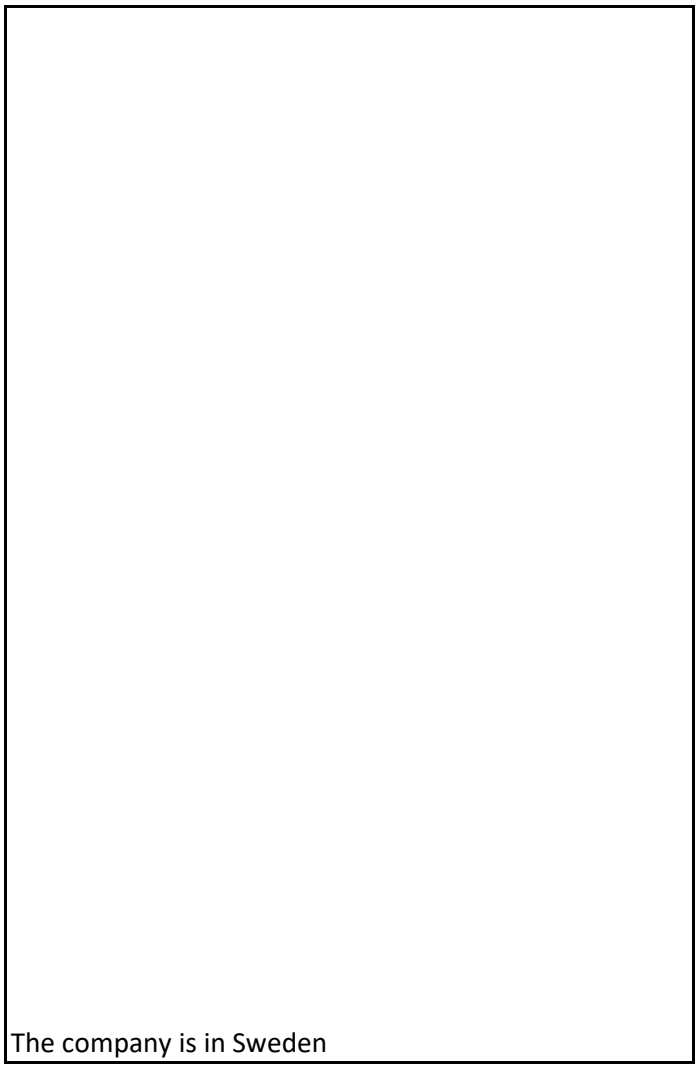
Cannot distinguish between Methane and other combustible gases. (Source: Bacharach Corp.)
1. Requires the use of High Pressure (1750 psi) Hydrogen / Nitrogen gas to fuel the flame. It can be dangerous if not used properly. 2. Must be able to come in contact with the gas to sniff it. 3. Requires maintenance and frequent calibration checks. 4. **Heath states that the Heath Detecto Pak Infrared (DP-IR) is the next generation of methane detection equipment and is the replacement for FIDs. DP-IR is next generation technology utilizing a simple light beam, eliminating the need for expensive gas cylinders and refill systems. See Line 10 of this spreadsheet.** (Source: Heath website)

It cannot detect gas unless it is able to sniff it so it has to be close to the leak.

Cannot be used in pipes below 4" in diameter. (Source: Technical Toolboxes Inc.)

It looks like the robot cannot adapt to different pipe sizes. In other words you would need a separate robot for each pipe size. Not commercially available yet.

It cannot survey widespread areas. - Not commercially available yet.
Currently in the research stage. Currently working to differentiate natural gas from pipelines from natural sources of methane,



The company is in Sweden

Optimal pipeline pressure of 1000psi or more. Less pressure takes longer for the dog to find the leak. The company is in Alberta, Canada

K9 :Pipeline Leak Detection is in Florida

The FAA has not yet approved the use of drones. SDG&E is the only utility approved to test them at the current time. Helicopter drone has 15-20 minute battery life. However, the fixed wing drones can stay in the air for 40 minutes. They cannot stay in the air as long as a standard helicopter or cover as much territory. It's best if drones stay within sight of someone.

Imprecise way to search for gas leaks. Basically the spotter is looking for dead vegetation
Not sure how portable it is. Wikipedia says it may require a lot of data storage capability. This is a highly pixelated digital video at 30 fps. Will require more investigation to determine if these disadvantages are accurate

In the R&D Phase - Not clear from the report
The company is in the UK.

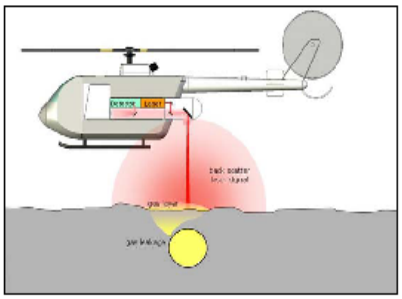
Presentations a
http://www.picarrosurveyor.com/

e·on | Ruhrgas marcogaz

CHARM®

Main technical features:

- Based on the differential absorption measurement principle (LIDAR)
- Gas clouds arte detected by tuning the laser wavelength to the spectral signature and absorption characteristics of the gas
- Gas concentrations can be determined over a width of at least 7 metres up to 12 metres
- Even the slightest traces of natural gas can be identified during routine air patrols at a speed between 50 – 90 km/h
- The operational detection limit is less then 25 ppm·m at a high detection resolution.



e·on | Ruhrgas marcogaz

Gas Camera – small traces of methane at process plants to be detected quickly and reliably

- The Gas Camera was mainly developed at Hamburg University of Technology on behalf of industry with support by E.ON Ruhrgas, Gasunie, Fluxys and Snam Rete Gas.
- The Gas Camera is a remote detection system that provides video images of gas clouds displayed of the target (leak).
- It analyses infrared radiation that propagates from the background of the field of view through the gas cloud to the optical receiver and the sensing element.
- It is capable of safely detecting gas clouds with column densities as low as 150 ppm·m.

Benefit:
- Proof of save operation or identificatio of explosion zones
- Fast and efficient leak detection

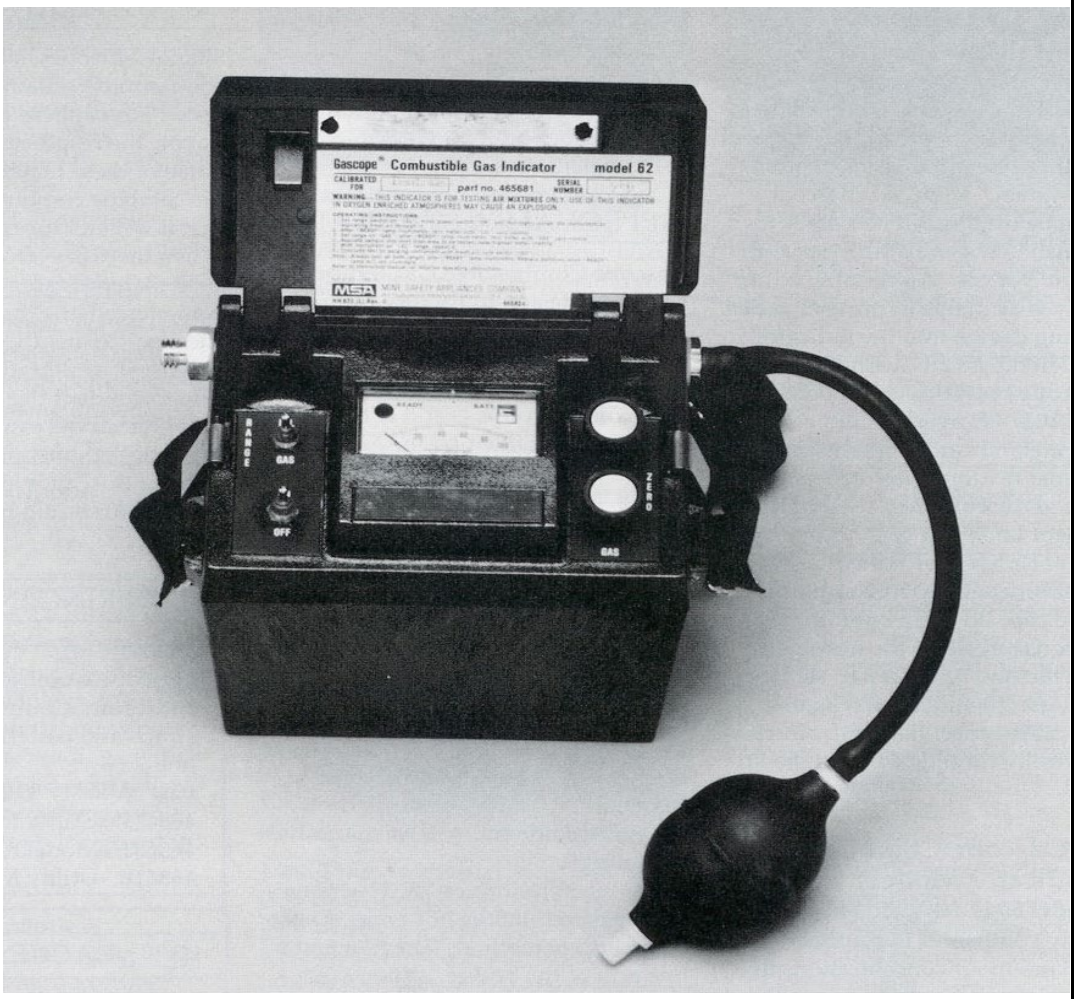
http://www.youtube.com/watch?v=tD6p9cAwxQo
http://www.flir.com/cs/emea/en/view/?id=41384

http://heathus.com/wp-content/uploads/omd.pdf

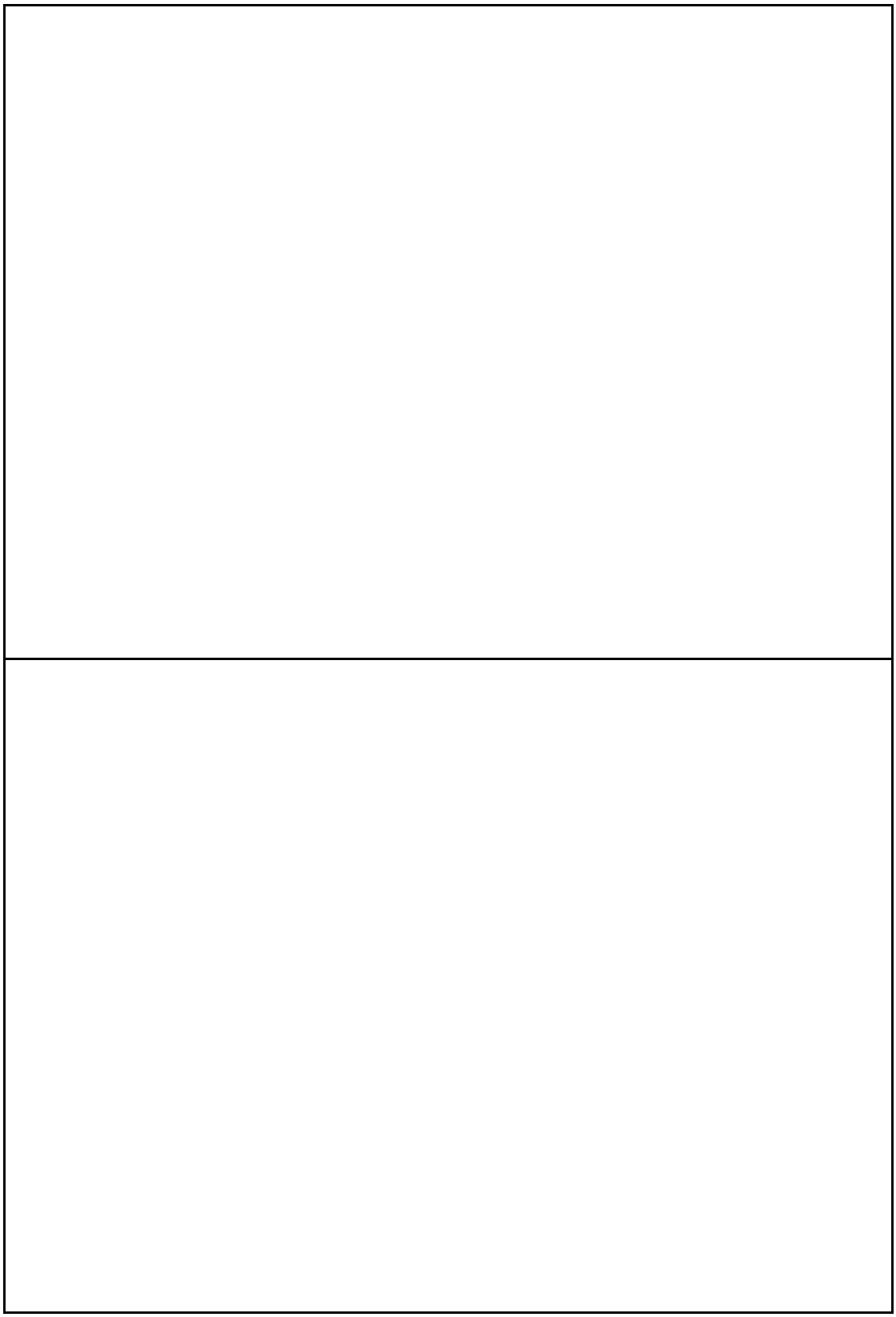
http://gasandoil.com.au/2013/01/17/heath-detecto-pak-infrared-dp-ir/

http://www.nysearch.org/commercial_products.php
http://www.gazomat.com/?language=English

See the link at the left for the manufacturer's website and brochure



http://www.bacharach-inc.com/leakator-10.htm
http://southerncrossinc.com/technology-products#



http://spectrum.mit.edu/continuum/robot-patrols-gas-pipes-for-dangerous-leaks/

Excerpts from KQED-FM - PG&E Tests Tech Adapted From NASA's Mars Rover - By Molly Samuel, October 2 Pacific Gas and Electric is testing a new device for detecting methane leaks. The sensor is based on a tool that's mounted on NASA's Mars Curiosity rover. NASA designed PG&E's new gadget, too, which the utility says is 1,000 times more sensitive than the hand-held equipment it's been using to track down leaks. The sensor is a small, ultra-sensitive device, mounted on the end of a pole, so that it looks a little like a golf club, explains Hailey Wilson, a PG&E spokeswoman. Inspectors can walk around with it, and it will notify them of leaks in real-time. Methane is the main ingredient in natural gas. "It helps us localize the leaks quicker," Wilson says. "So it's not like it's picking up leaks that we wouldn't find eventually, but it enables us to find it much more quickly and fix it much more quickly." PG&E currently monitors for natural gas leaks by helicopter, boat, car and foot along its nearly 48,000 miles of pipelines. The utility has begun using another ultra-sensitive methane detector, which is mounted on cars. While the Picarro car can sweep neighborhoods for leaks, Wilson says, hand-held devices are vital for pinpointing the sources. "There's a safety component, it makes sure that our system is even safer," Wilson says. "But there's actually that green component as well, with making sure that we eliminate as much methane emissions — which is a greenhouse gas — as possible." On Mars, the Curiosity rover is using the tool, called the tunable laser spectrometer, to search for traces of methane in the atmosphere. There, though, the methane wouldn't signal a leak, but would instead, perhaps, be a sign of life. "Anytime we can go out and find an application that addresses real world problems — in this case one that relates very closely to global climate change and greenhouse gas concentrations — NASA is very supportive," says Andrew Aubrey of NASA's Jet Propulsion Lab in Pasadena. "So in this particular instance, it's a Mars technology that we are translating to the needs of the oil and gas industry." Right now, PG&E is testing a prototype of the sensor. The company is planning to deploy more of them in the field in 2015.

http://www.power-technology.com/contractors/safety/maribo/

http://www.cepa.com/detector-dogs-sniffing-out-pipeline-leaks

We offer the sale of pipeline leak detection dogs to agencies and individuals and teach the process to include the chemical to students. You can visit our training academy website at www.k9pta.com

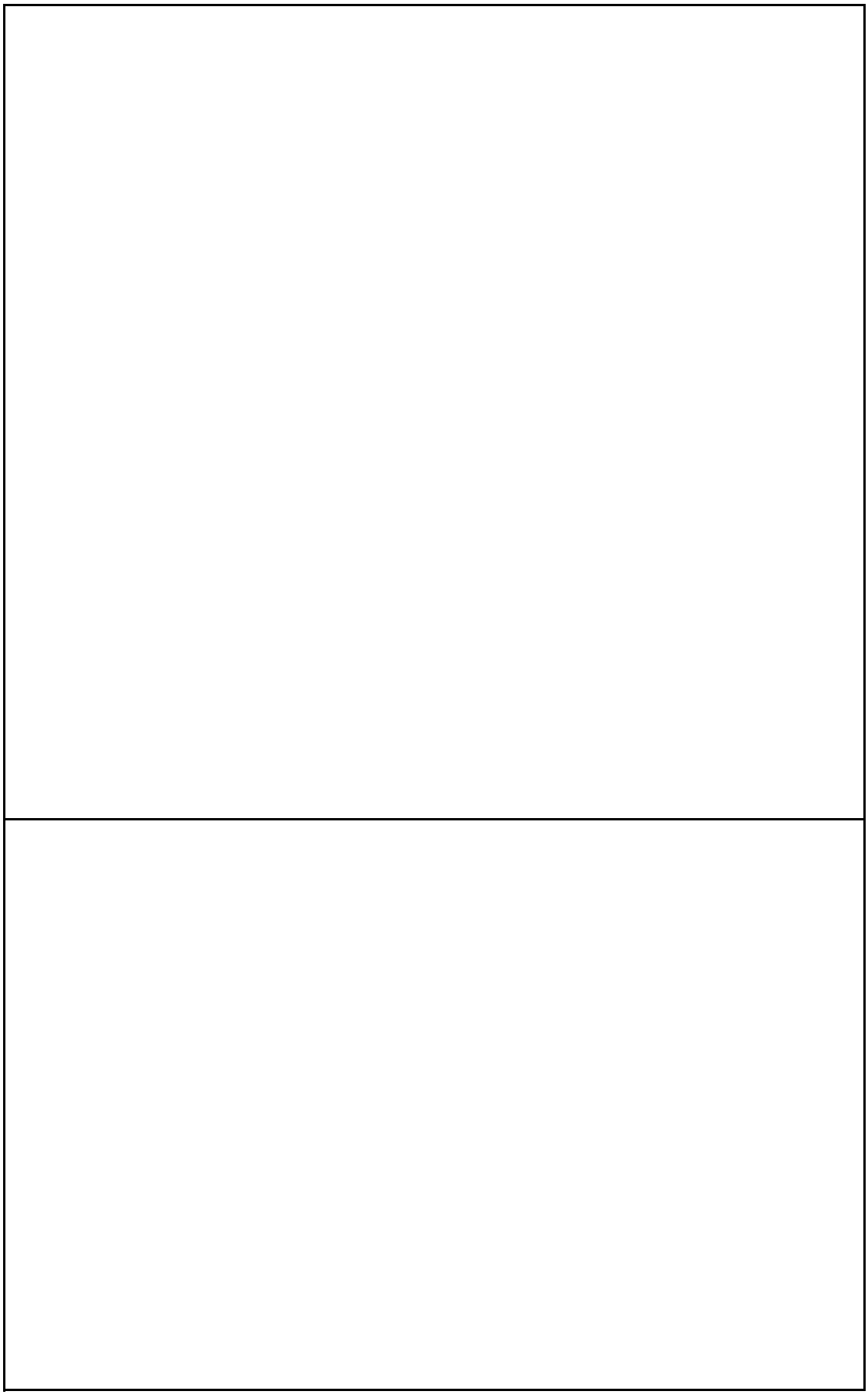
If you should have any further questions feel free to contact me at pnichol@atlantic.net or you can call me at 352 552-4855.

Thanks,

Paris Nicholson
President
K9 Pipeline Leak Detection
K9 pipeline Training Academy

Their website is:
http://www.canineoilpipelineservices.com/services.html

Inspections - Utility Gets FAA OK for Limited Operation - By Brad Graves, October 27 - Here in a utility yard near Interstate 805 in Serra Mesa, the two San Diego Gas & Electric Co. workers are pushing forward the utility's experiment of using small unmanned aircraft to inspect its sprawling network of electrical and gas lines. SDG&E, a unit of Sempra Energy (NYSE: SRE) is among many businesses preparing to put model-sized "whirlybirds" and fixed-wing aircraft to work, as a way of gaining new insights into their businesses and as a means of saving money. Whirlybird flights may one day replace inspections by manned helicopter. Putting a manned helicopter in the air is an expensive proposition, said Dallas Cormier , a project manager with the utility and the head of its unmanned system effort. Under federal law, businesses cannot yet use unmanned aircraft to do work in U.S. airspace. That may change by this time in 2015. For the present, the Federal Aviation Administration has made a few exceptions to its rule. One exception has been for certain movie studios working on closed sets. Another has been for SDG&E, which is the first utility to get permission to test such systems and train flight crews. The permission is limited to five specific patches of real estate. Of all the utilities in all 50 states, how did SDG&E get here first? The culture of safety had a lot to do with convincing the FAA, Cormier said. Cormier prefers to call the Little aircraft UASes, short for unmanned aircraft systems — or simply "birds." Today, Deering — a retired U.S. Navy pilot — has the control box. Ortiz holds the aircraft; he will keep an eye on it while it's airborne. "Coming on," Deering says, and the propellers start spinning. The machine buzzes like a swarm of insects. Soon it is flying at an altitude of 103 feet, beaming down images of a utility pole. "I'm going to go to the tower," Deering said, and the little aircraft darted south to a spindly metal structure. The unit is able to zip quickly from one spot to another in the 100-foot-diameter flying zone approved by the FAA. The utility flies the whirlybirds as if they were manned helicopters, following every rule and regulation, Cormier said. It has to file flight plans. Before showing off the capabilities of their quad-copter, Deering and Ortiz go through a pre-flight checklist. When it comes time to work on the aircraft, all maintenance



https://www.youtube.com/watch?v=yCtZs8_zb5A

http://digital.turn-page.com/i/406321?_cldee=Y2hhcmxlcy5tYWdlZUBjcHVjLmNhLmdvdg%3d%3d&urlid=100

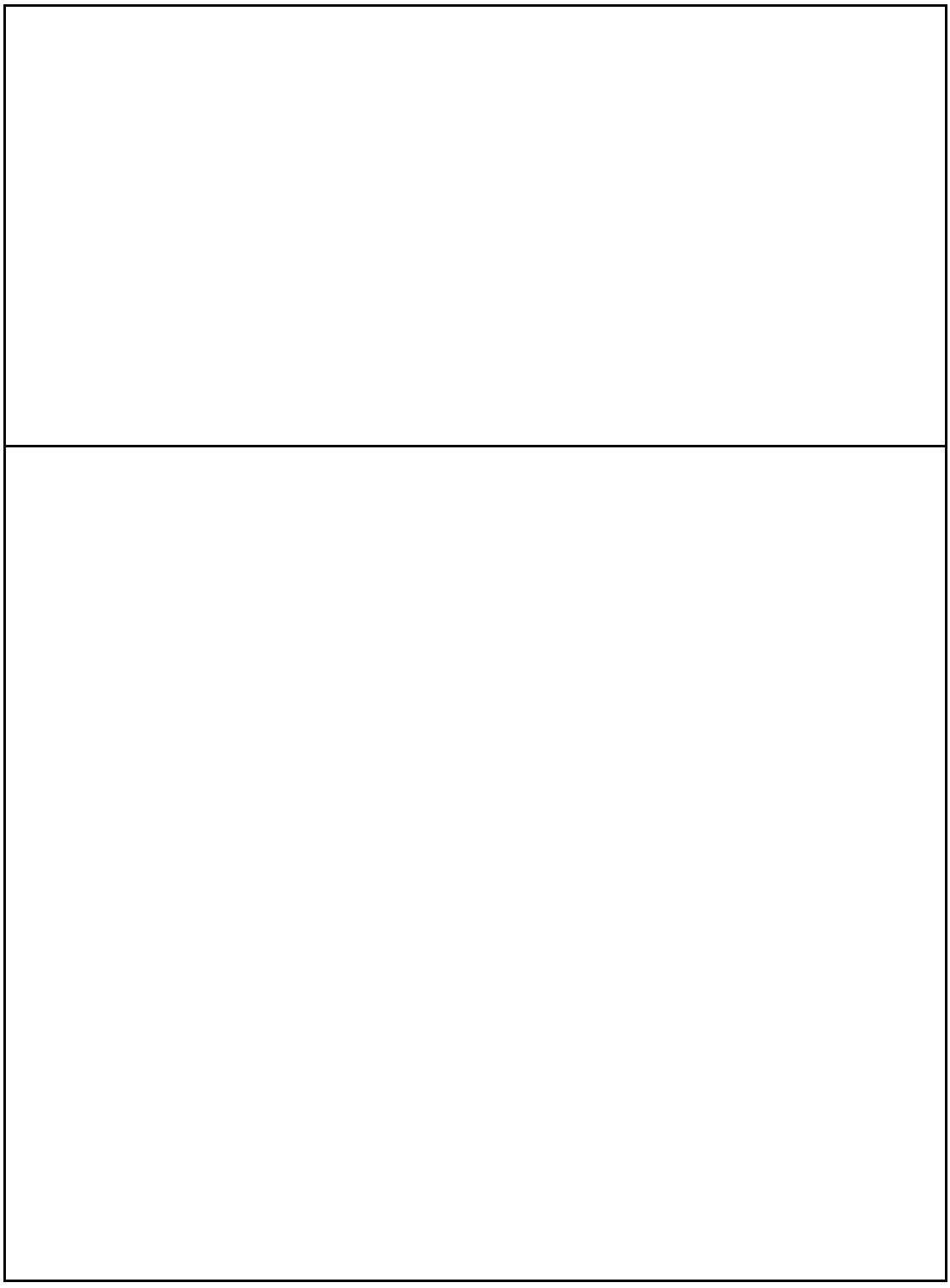
and Useful Files

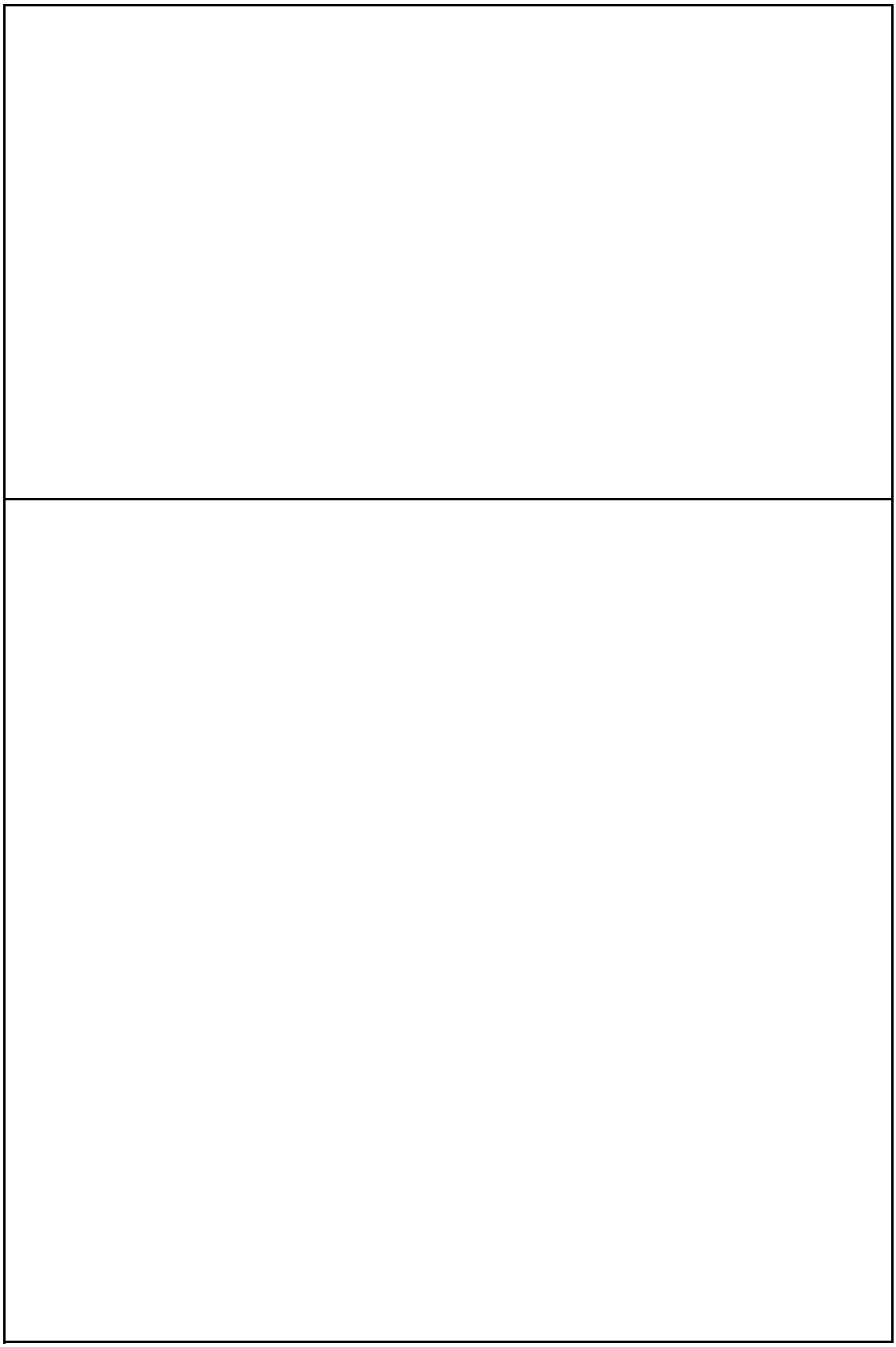
A research partnership with ITT led to integration and demonstration of GIS imagery, Midwave Infra-red cameras and Differential Absorption Lidar and resulted in near real-time data collection and processing improving from 3-4 weeks to one day. At the conclusion of this research, Route Generation can now be accomplished in the field and requires only 1 hour of effort to generate 100 miles of pipeline routes. This is a 30X improvement in speed. (Source: Government & Industry Pipeline Research and Development (R&D) Forum, Event Summary Report, Westin Arlington Gateway, Arlington, VA, July 18-19, 2012) See the entire presentation here: http://primis.phmsa.dot.gov/rd/mtg_071812.htm

http://www.tuhh.de/mt/ftir/lib/TUHH/Remote_IR.pdf

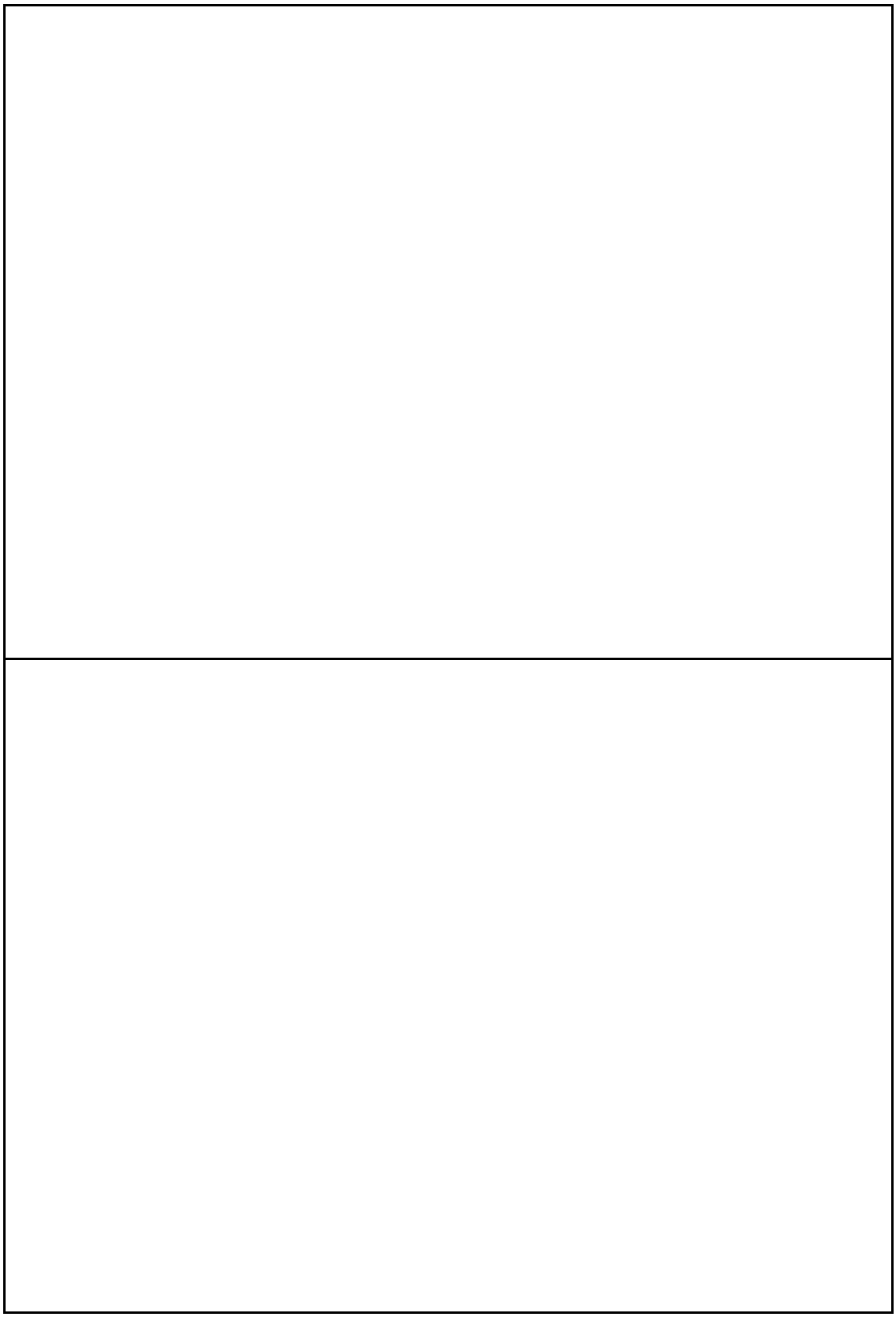
http://www.opgal.com/ABOUTUS/Overview.aspx
http://www.flir.com/cs/emea/en/view/?id=41529

http://undergroundconstructionmagazine.com/heath-consultants-detecto-pak-infrared

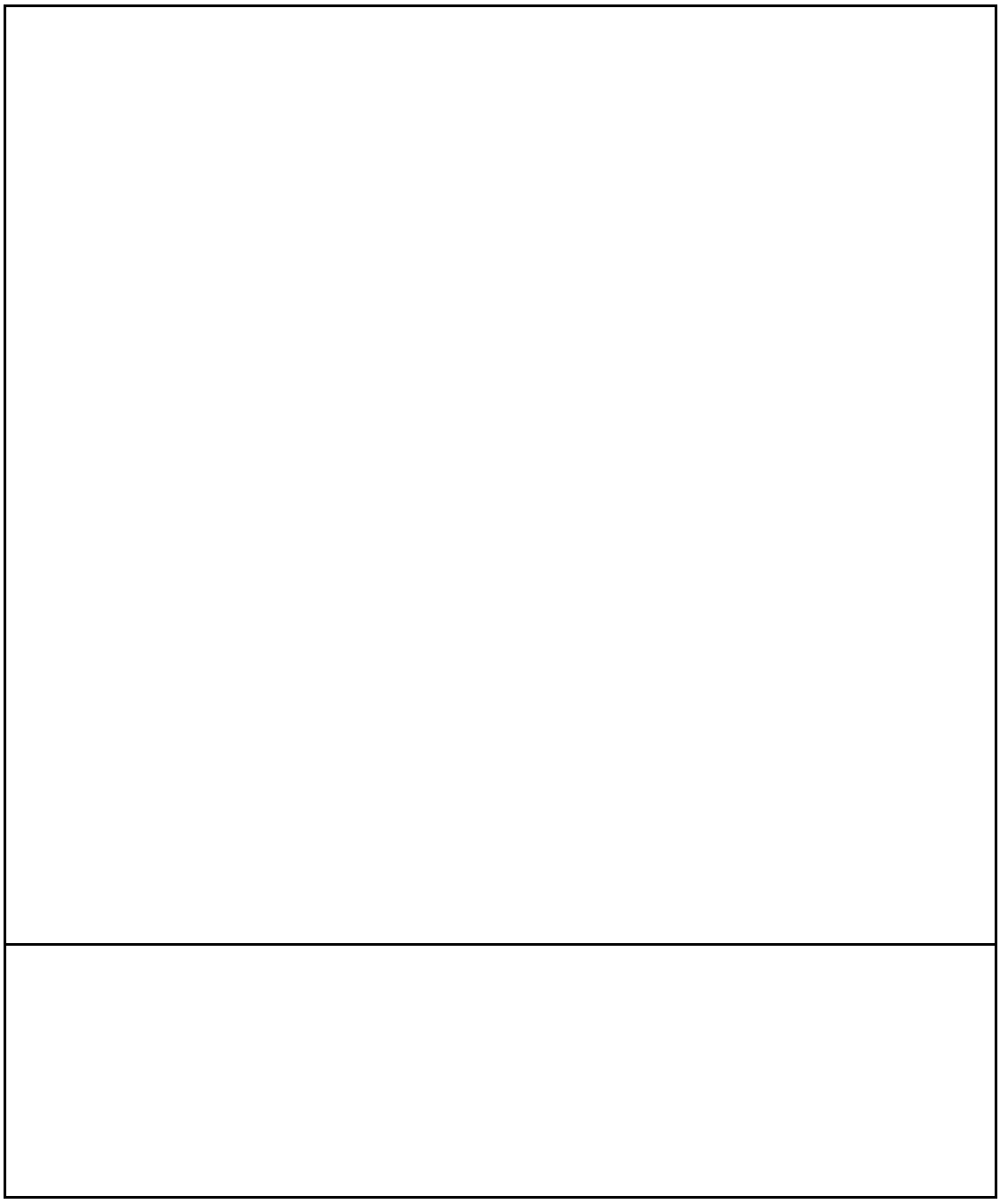




http://heathus.com/wp-content/uploads/detecto-pak-4.pdf



http://www.youtube.com/watch?v=eNg003mmmiU#t=12



Penspen Ltd, UK, and Newcastle University have been investigating the feasibility of implementing dogs as an additional leak detection tool to be used on onshore pipelines. Leak detection dogs were walked along a pipeline right of way, and also took part in extensive field trials on farm land. The right of way and farm land contained both buried and surface simulated leaks of jet fuel. The results of this research have shown that dogs can detect leaks as small as 5 ml, up to depths of 800 mm below ground, with an 86% success rate. Larger volume leaks would be easily and consistently detected by dogs. The research showed there is a 95% confidence that the dog would: 1. Find between 52% and 78% of extremely small leaks (~5 ml) on a pipeline, 2. Miss between 22% and 48% of these sizes of leaks on a pipeline and, 3. Incorrectly identify the presence of these small leaks between 5% and 15% of his total indications. The dogs would be particularly useful for 1. Inspecting areas where deep corrosion has been identified by in-line inspection. 2. Where coating problems have been identified by above ground surveys. 3. Un-piggable' pipelines. 4. Locations with poor cathodic protection (CP) coverage. 5. Where there are suspected 'illegal taps'; and 6. Detecting leaks during a hydrotest (using scented water). Using sniffer dogs, to survey areas like those mentioned above, can greatly increase the probability of finding any leaks. Also, it provides the operator with additional assurance if no leaks are found. Finally, the dogs are not only reliable; they are also cost-effective, and environmentally friendly. (Source: 'Using canines to inspect for leaks in buried pipelines' by Phil Hopkins, Presented at the 1st Australasian International Welding, Inspection and NDT Conference, iWIN2013. WTIA, Perth, Australia. 10-14th March 2013.

Contact Info: E-Mail: p.hopkins@penspen.com, Penspen Limited Unit 7-8, Terrace Level, St Peter's Wharf, St Peter's Basin, Newcastle upon Tyne NE6 1TZ. UK.)

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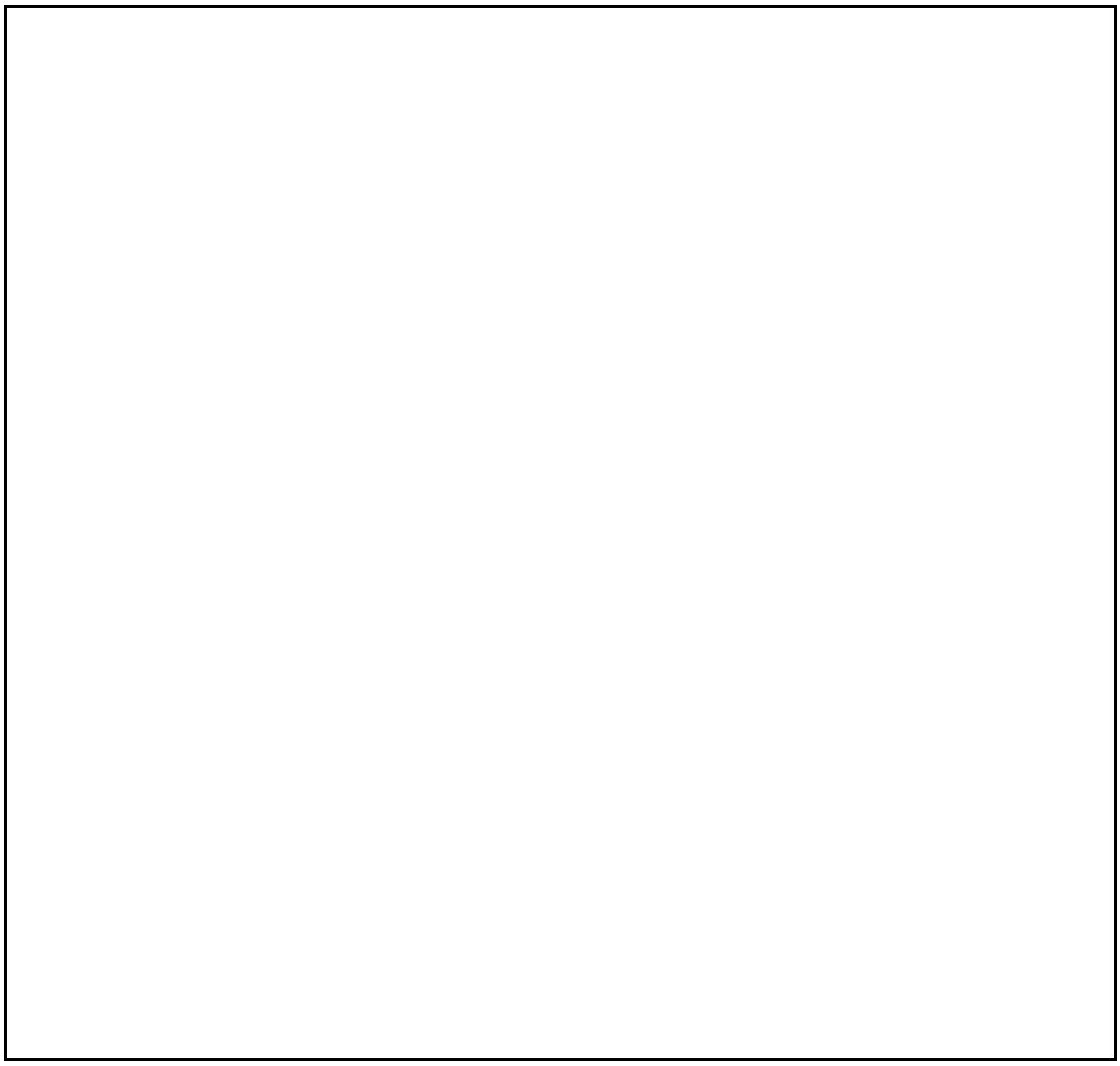

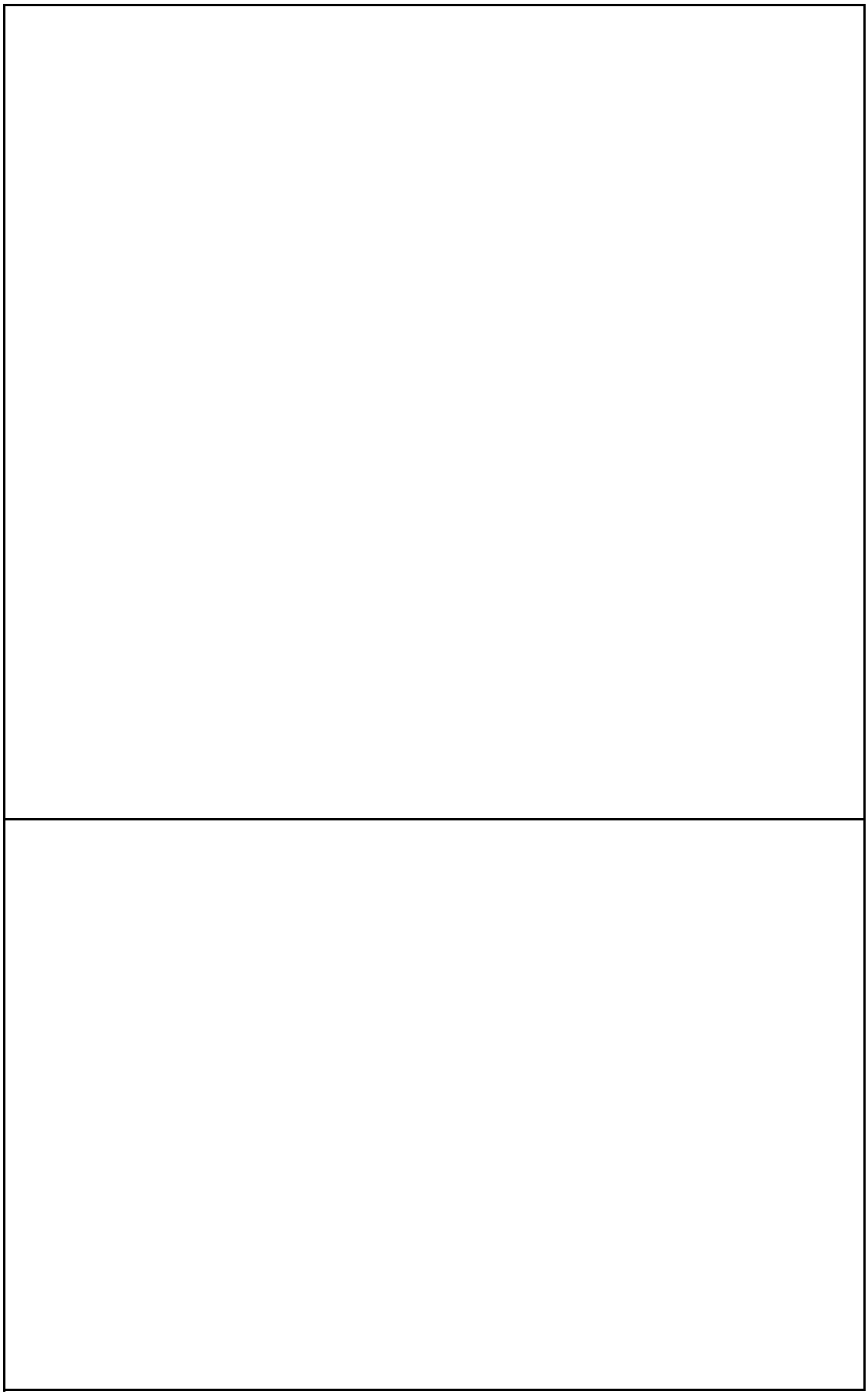

https://www.youtube.com/watch?v=YfFvhOHsCm0

http://napipelines.com/aging-gas-lines-hidden-threat/?_cldee=Y2hhcmxlcy5tYWdlZUBjcHVjLmNhLmdvdg%3d%3d&urlid=7

Utility Company	Location
PG&E	California

Open Grid Europe and E-ON/Ruhrgas(Europe)	E-On Ruhrgas and numerous others / Europe
Open Grid Europe and E-ON/Ruhrgas(Europe)	E-On Ruhrgas and numerous others / Europe

Not Known	Location of the company appears to be Israel
Unknown	FLIR is a worldwide company. Headquarters appear to be in Europe.

Consumers Energy, PG&E	Michigan, California
PG&E, Alpine, Sempra, West Coast Gas	California

Consumers Energy - Michigan, PG&E, Sempra, Dominion East - Ohio	Ohio, Michigan, California
Dominion East - Ohio, Sempra	Ohio, California

Sempra	California
Sempra	California

Sempra	California
Consumers Energy-Michigan, PG&E, Central Valley Storage, Gill Ranch Storage, Lodi Gas Storage, Dominion East-Ohio, Southern California Edison (SCE), Southwest Gas	Ohio, Michigan, California, Nevada, Arizona

PG&E, Alpine, Central Valley Storage, Lodi Gas Storage, Southern California Edison (SCE)	California
Southwest Gas	California, Arizona and Nevada

N/A	N/A
N/A	N/A

PG&E	California
PG&E	California

Numerous European Companies use their services	Europe

Numerous Canadian use their services	Canada

Numerous	U.S. and Canada

SDG&E - SDG&E is the first utility in th country to get permission to test the use of drones and train the crews to operate them.	California

PG&E	California
N/A	N/A

N/A	N/A
Several utilities in the UK	United Kingdom

Appendix A - Natural Gas Leakage Abateme

Revised 4/27/15 - Revised the information on Gas Leak Detection tab, Row 31, Odyssian Techr

Gas Leak Prevention Technology

Name	Technology
Starline 2000 Cured In-Place Pipe Liner	Fabric Liner blown into a line, then glued to the pipe wall with epoxy coating. In the US, Nysearch and Con Ed (NY) have been testing it. Recently, a line that was coated 10 years ago was examined. http://www.starlinett.com/products/star_2000_2.html http://www.nysearch.org/news-info_110514-1.php (Source: Starline Website and NYsearch website)
Starline 200 Cured In-Place Pipe (CIPP) Liner	Fabric Liner blown into a line, then glued to the pipe wall with epoxy coating. In the US, Nysearch and Con Ed (NY) have been testing it. Recently, a line that was coated 10 years ago was examined. http://www.starlinett.com/products/star_200_2.html http://www.nysearch.org/news-info_110514-1.php (Source: Starline Website and NYsearch website)

Nu Line by Nu Flow	The Nu Flow epoxy lining solution includes removing existing corrosion in the pipes and applying an epoxy coating without the need to dig or cut access points to underground, under-foundation or in-wall pipes. Unlike alternative epoxy barrier solutions, Nu Flow's epoxy and application process is effective in pipes from 1/2" up to 10" in diameter. The unique characteristics of the Nu Flow epoxy make it feasible to line longer lengths of pipe through elbows, tees and unique system constructs. The epoxy coating process restores flow and prevents corrosion which would otherwise lead to pinhole leaks. Prevents future leaks in hard to access areas such as under foundations or within walls and ceilings. Once completed, the Nu Flow solution ensures continued performance and long-term durability of the pipe system. Nu Flow restores gas systems using patented epoxy coatings. (Source: Nu Flow Corp)
No Dig Anode Installation	Anode installation on steel mains and services typically required utility companies to acquire a street opening permit and proceed to close off and excavate a large section of the street or sidewalk with heavy construction equipment. ULC Robotics was approached by a large gas utility in the Northeast US to see if it would be possible to install anodes by drilling through existing valve boxes or test stations. It was determined to be possible and is in commercial use. (Source: ULC Robotics)

PipeGuard Proactive Damage Prevention System --- Senstar calls the product FiberPatrol-PR	A research partnership between PHMSA/DOT, NGA/NYSEARCH and Magal/Senstar to develop and test an acoustic warning system to proactively report third party activity near pipelines. NYSEARCH completed several successful tests with alpha prototypes and is now completing with PHMSA further advances to the product through development and testing the of beta prototypes.
Guided Wave Ultrasonics	Four separate research projects addressing GWUT with NYSEARCH and Southwest Research Institute led to commercial improvements with multiple service providers. As a result software and hardware support longer inspection distances and better characterization of defects. This technology is widely applied to inspect cased crossings nationwide. Use of magnetostrictive sensor guided-wave technology was also benchmarked.

Micro-Magnetic Cased Pipeline Inspection Robot	New federal pipeline integrity rules require utility companies to evaluate thousands of gas mains buried beneath highways, railroad tracks and airport runways – each and every one cased inside a larger pipe. ULC Robotics imagined, designed and built a solution. The Micro-Magnetic Cased Pipe Inspection Robots defy gravity by magnetically attaching to the metallic casing pipe enabling them to crawl hundreds of feet into tight annular spaces. Front and rear mounted video cameras provide real-time, full motion video of the outer surface of the gas main. Pitch and roll sensors allow for remote navigation and provide the precise location of defects and anomalies. Includes laser measurement of defects. Temperature and humidity sensors continually monitor the environment inside the casing. An ultrasonic thickness sensor can be deployed to take spot wall thickness measurements. Using two forward projecting lasers, a video based measurement system may be used to take measurements of defects or objects within the casing annulus. (Source: ULC Robotics Website)
Variable Geometry Crawler – ULC Robotics, Inc.	Closed Circuit Television (CCTV) inspection of live gas mains

3-D Toolbox	Digital camera capable of photographing and providing detailed measurements of dents, corrosion or other damage on the outside of pipes. It was originally developed for the dental industry. (Source - 3-D Toolbox)
Explorer (Robot)	According to Pipetel's website - The Explorer's magnetic flux leakage (MFL) capabilities inspect for metal loss while caliper sensors provide data on dent and mechanical damage. It also uses laser deformation sensor to detect and measure out of round defects and dents. The robot was developed by NYSearch, a subsidiary of the NorthEast Gas Association. A company called Pipetel provides inspection services which use the device. They actually perform the inspections and provide reports to the utilities describing their findings. (Source: Pipetel website) Also see: http://www.pipetelone.com/demo.html
PHMSA R&D Projects	Various

Smart Pipeline Network - Pipe & Repair Sensor System	Odyssian Technology believes that the correct approach to eradicating or significantly reducing pipeline leaks is a smart pipeline system that has a collection of diverse (and evolving) technologies all integrated within a distributed, yet common communication and control platform. The technology developed in these PHMSA SBIR programs take advantage of recent technology advances and shifts in affordability of technology to develop and demonstrate what Odyssian believes will be our future national Smart Pipeline Network. Such technology advances include the advent of nano-scale and thin and thick film materials in conjunction with micro machining techniques that allow for the development of very small sensors and multifunctional systems having intrinsically embedded sensing functionality. These small devices and materials are being used to develop highly engineered smart systems that are capable of sensing their environment and often responding to such stimulus. Odyssian Technology has developed smart pipe and smart seal technology, originally targeted for use on airborne high-energy chemical laser systems. This DOT PHMSA SBIR program further developed and adapted this technology for use on pipelines to allow for the pinpoint location of leaks and in some cases emerging leaks (detecting an imminent leak before leakage occurs). The shift in affordability and proliferation of wireless and wired communication networks makes more feasible a Smart Pipeline Network that provides real-time operational status of pipeline transmission, distribution, and remote facility systems. Communication and signal conditioning circuitry was developed that is integrated within the system to provide a sensor network capable of pinpointing the location of progressing leaks through fittings, joints, valves, pipe, pipe repairs, etc. For more information see the Final Report found via the link to the right. (Source: Odyssian Technology)

ent Best Practices

nologies and added Row 17 to Gas Leak Prevention tab

Uses	Link to Manufacturer or Research	Cost
In Europe it has been used to rehabilitate 250 miles of natural gas distribution mains ranging from 4" to 24". It is good for gas pressures up to 90 psi. Can be used in cast iron, steel, asbestos and PVC lines. http://www.starlinett.com/products/star_2000_2.html (Source: Starline Website and NYsearch website)	http://www.starlinett.com/products/star2000.html	Contact the Vendor
Used to line natural gas service lines ranging from 1" to 2-1/2". It is good for gas pressures up to 60 psi. Can be used in cast iron, steel and PVC lines. http://www.starlinett.com/products/star_200_2.html (Source: Starline Website and NYsearch website)	http://www.starlinett.com/products/star200.html	Contact the Vendor

Applicable for use in host pipes consisting of metal, iron, steel, plastic, concrete and fiberglass in pipe diameters ranging from 1/2" to 10", with larger custom sizes available. (Source: Nu Flow Corp)	http://www.nuflowtech.com/Products/EPOXYLINING.aspx	Contact the Vendor
Installing anodes on steel gas piping	http://www.ulcrobotics.com/portfolio/no-dig-anode-installation/	Contact the Vendor

Proactively report third party activity near pipelines. Also used as a security system to protect utility piping and infrastructure from instrusion.	http://senstar.com/products/fiberpatrol-pr-formerly-fiberlr-for-pipelines/	Contact the Vendor
Inspect and assess pipe walls and coating on buried pipes.	http://primis.phmsa.dot.gov/matrix/PrjQuery.rdm?text1=guided+wave&btn=Modern+Search	Open each research project and refer to the commercial partners listed.

Provides video and sensor data for critical analysis of gas mains buried within cased pipe in high consequence areas. Determine the integrity of pipeline coating including delamination, holes and other defects. Determine the Integrity, composition and spacing of pipeline insulators. Measure the pipeline wall thickness. Measure atmospheric conditions (temperature, humidity) in the annular space. Determine the quantity and location of debris and water in the annular space. Determine the location of electrical shorts. (Source: ULC Robotics Website)	These tiny robots are manufactured by ULC Robotics and Honeybee Robotics. Their websites are; http://www.ulcrobotics.com/portfolio/micro-magnetic-cased-pipeline-inspection-robot/ and http://www.honeybeerobotics.com/portfolio/pipe-inspection-robot/	Contact the Vendors
Assessment and Evaluation of Pressurized PE, Steel and Cast Iron Gas Pipelines, Inspection of Pipelines to Locate Water Infiltration, Location of Pipeline Damage and Features; Joints, Taps, Branches, Service Lines, Stub Services, Valve Inspection for Proper Orientation, Setting and Type, Pre- and Post-Pipeline Rehabilitation Surveys, Locate Water Blockages in Live Gas Mains. Can inspect pipes ranging from 2" to 48" (Source: ULC Robotics Website)	http://www.ulcrobotics.com/energy-services/cctv-camera-inspections-of-live-gas-mains/	Contact Vendor

Photographic analysis of exterior pipeline anomolies	http://www.ttoolboxes.com/products/3dtoolbox/whats_new.cfm	Contact the Vendor
This is a robot that can inspect previously unpiggable pipes due to its flexible design. It can adapt to a range of pipe sizes. For example the same robot can inspect pipes ranging from 20 to 26 inches in diameter. In all there are robots which can inspect pipes from 6" to 36" in diameter. (Source: Pipetel website)	http://www.pipetelone.com/index.html	Contact the Vendor
Various	http://primis.phmsa.dot.gov/matrix/	Contact the Commercial Partners listed with each R&D Project.

Detect leaks in gas transmission lines. In this program, smart pipes and smart composite repair having integrated leak detection micro-sensors will be further developed and adapted for pipeline use. Concepts and designs will be developed for a networked sensing system capable of sensing the pinpoint location of a leak or impending leak, as well as monitoring structural health. In Phase I, the scope will include the development of a Pipe and Repair Sensor System for use with petroleum-based liquids, with Phase II expanding the scope to include development of a system for use with natural gas. For more information see the Final Report found via the link to the right. (Source: Odyssian Technology)	Depends on the sensors used. Still in R&D Phase	http://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=444&c=1&s=D92E98698A8F48E794162A2DE1106BD2

Advantages
Maintains gas-tightness even if the pipe breaks, misalignment of 7°, uniform bonding, i. e. no gas migration, new service tees can be installed using the utility's standard procedure, no significant reduction in pipe capacity. Cold-hardening system: The lines are cured overnight so that the pipeline can be put into operation again within 1½ working days. Warm-hardening system: Only a few hours are required for warm-hardening so that the customer can be resupplied with gas within 12 - 16 hours. Can be used to rehabilitate lines with partially deteriorated gas pipes, e. g. holes or gaps up to 4". (Source: Starline Website and NYsearch website)
The pipe doesn't have to be replaced. Depending on the size of the rehabilitation crew, three to four services can be lined per day if the warm-curing method is used. Thus, customers are promptly reconnected to their gas supply. The starline®200 technology is a cost-effective, fast, and safe rehabilitation process for gas services. starline®200 lines the pipeline uniformly and wrinkle-free, even in 90° bends, with the rehabilitated line having at least the same life as a new HD PE service. A special-purpose self-contained installation truck has been developed in the United States to facilitate the cost-effective performance of the technology. Can be used to rehabilitate lines with heavy corrosion possible, e. g. holes or gaps up to 1". (Source: Starline Website and NYsearch website)

The pipe doesn't have to be replaced. Existing interior corrosion is removed and new corrosion is prevented by the epoxy barrier. Can be used in pipes from 1/2" to 10" in diameter. The manufacturer says the epoxy withstands whatever pressure the host pipe can withstand(Source: Nu Flow Corp)
The commercialized process has been performed several thousand times and has successfully reduced the cost of protecting steel mains and services by eliminating the need for permit acquisition and heavy construction equipment. In addition, the improved process reduces the time it takes to install anodes. (Source: ULC Robotics)

FiberPatrol-PR is ideal for protecting pipelines and other in-ground infrastructure from Third-Party Interference (TPI). A single sensor can provide protection for up to 50 km (30 mi.) of sensor cable buried along the pipeline. FiberLR detects manual or machine digging, whether from intruders intent on damaging or tapping the pipeline or those accidentally digging near the pipeline's location. By providing an early warning and the precise location of an incident, the sensors helps responders prevent costly damage.FiberPatrol-PR accurately locates intrusions even when there are multiple simultaneous intrusions or in the presence of non-localized environmental noise that would overwhelm the location capability of other long-range fiber-optic sensors. FiberPatrol-PR's resilient design allows detection to continue right up to the point of a cut in the sensor cable. When installed in a redundant configuration, FiberPatrol PR protects the full perimeter even after a cable cut. (Source: Senstar)
Inspect piping and coating in place without excavating. Inspect non-piggable pipes.

The tiny robots can inspect pipes, casings and areas that were formerly inaccessible. They are magnetic and can therefore inspect the entire circumference of the pipe.

Live Gas Main Inspection Service Overview - Our live gas pipeline inspection services provides utility companies and pipeline operators with the comprehensive visual data need to assess pipelines for damage, signs of corrosion and take note of pipeline features that may not be recorded on utility maps. Information collected from our live gas main inspection services helps gas utilities prioritize maintenance activities by identifying the sections of main that may require more immediate attention.

Reduced Excavation, Permit and Street Restoration Costs: Our camera inspection equipment enters your live gas mains through compact pits or low-cost keyholes and can inspect hundreds of feet of pipeline from just one access point.

No Need to Shut Down Service: We remove the need to shut off service to customers, saving you the hassle and the cost of turn-ons and relights. Our service is also trenchless, which translates into less engineering and permit costs.

Advanced Inspection Equipment: Our crews utilize our patented PRX250 live gas main inspection camera system and our live gas main crawler systems to deliver a thorough visual inspection of your live mains.

Minimal excavation, the line can be inspected live gas mains up to 100 psi. Long tether - can inspect up to 500 feet of pipe through one opening. Can be used for Cast Iron, Steel, or PE piping. (Source: ULC Robotics Website)

Portable, easy to use, easy to set up, fast, provides permanent repeatable measurements and records.(Source - 3-D Toolbox)
Can inspect pipes which were previously un-piggable due to diameter changes, tight turns and geometry. Self propelled. Battery can be charged while the robot is inside the pipe. No need to remove it. One robot can inspect a range of pipes. Can detect metal loss, dents, mechanical damage, out of round. Also takes videos from the front and rear. Operates while the pipeline is in service. Wireless communication therefore no tethers necessary. According to Piptel's website - Pipetel's inspection service is the ideal inspection tool for natural gas pipelines with: limited or no flow, short radius or mitered bends, valves, back-to-back bends, vertical segments, and pipelines without pre-built launch capabilities. Pipetel also inspects cased pipelines, and pipelines located at difficult to access locations such as underneath urban infrastructure. (Source: Pipetel website)

Must contact the vendor

Disadvantages	Presentations and Useful Files	
Gas line is out of service for 12-16 hours	http://www.starlinett.com/products/star_2000_2.html	http://www.nysearch.org/news-info_080514-2.php
Unknown	http://www.starlinett.com/products/star_200_2.html	http://www.nysearch.org/news-info_080514-2.php

Takes time to cure. Unknown how long that is.	http://www.nuflowtech.com/Products/EPOXYLINING/ForcedAirLining/Applications/Gas.aspx	http:/americanleakdetec4.reachlocal.net/epoxy-pipe-lining.php

	http://primis.phmsa.dot.gov/rd/mtg_071812.htm	http://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=364

	http://www.ulcrobotics.com/products/cased-pipeline-inspection-crawler/	http://www.nysearch.org/news-info_111914.php
	http://www.nysearch.org/commercial_products.php	

	http://www.pgecurrents.com/2014/05/20/video-pge-using-new-tool-to-check-outside-of-pipeline-for-dents-corrosion/?utm_source=newsletter&utm_medium=email&utm_content=052214&utm_campaign=pgecurrents	
Cannot be used in pipes below 6" in diameter	http://www.nysearch.org/news-info.php	

Using a system of sensors along the pipe to create a "smart pipe", the hope is that leaks will be detected sooner. It is very difficult to detect a leak from the control room.	https://www.youtube.com/watch?v=YfFvhOHsCm0	https://www.youtube.com/watch?v=yCtZs8_zb5A

Utility Company	State
Con Ed, Public Service Electric and Gas and an unamed European Utility	New Jersey, New York, Europe
Con Ed, Public Service Electric and Gas and an unamed European Utility	New Jersey, New York, Europe

N/A	N/A
N/A	Somewhere in the Northeast U.S.

N/A Contact the Vendor	N/A Contact the Vendor
N/A Contact the vendors.	N/A Contact the vendors.

PG&E and National Grid	California and New England
N/A Contact Vendor	N/A Contact Vendor

PG&E	California
PG&E, Con Edison, Questar Gas,	New York, California, Utah, idaho, Wyoming
Various	

N/A	N/A

Appendix A - Natural Gas Leakage Abatement E

Revised 4/27/15 - Revised the information on Gas Leak Detection tab, Row 31, Odyssian Technologies

Record Management Technology

Name	**Technology**	**Uses**	**Cost**
Leak Survey Handheld Device	Programmable pocket PC of which there are many brands. Internal software can be custom written for the specific utility. (Source: Internet Search)	Used by gas leak surveyors to find gas services, record gas leak survey data and material condition, to conduct accurate, thorough and timely gas surveys, record appointments, plan gas leak survey path, track statistics, and be aware of on-the-job dangers.	Approx $100-$400 (Source: Internet Search)
Intermec CN3 - Discontinued - Replaced by Intermec (Honeywell) CN 70 or CN70e	Programmable pocket PC of which there are many brands. Internal software can be custom written for the specific utility. (Source: Internet Search)	Used by gas leak surveyors to find gas services, customer info, service info, record gas leak survey data and material condition, to conduct accurate, thorough and timely gas surveys, record appointments, plan gas leak survey path, track statistics, critical maintenance, hazardous conditions and on-the-job dangers. If a leak is found, the grade of the leak is entered and also the location of the crayon mark where the leak is. Takes 5-10 minutes to upload or download data. Leaks and identified conditions are tracked to completion. (Source WE Energy presentation to AGA in 2011).	Approx. $1500-$3500 depending on model chosen (Source: Internet Search)

Gas Survey and Maintenance Website	Web-based	Create, modify, view, and print survey route information for service surveys and valve inspections. View and print Street Opening / Main Leak Survey maps. All details of leak inspection shown. Maintenance repair order is linked to work management system to monitor repair order status. Select services and file is sent to billing system which prints and mails letters. Provides a summary of compliance dates. List is sorted by the closest compliance date for each office.For maintenance items that do not have a work order created. Use the drop-down menus to search for maintenance to process. Quick data extracts for specific needs. (Source WE Energy presentation to AGA in 2011).	
Maximo	IBM Maximo Asset Management is an enterprise asset management (EAM) software solution product produced by IBM. It is a solution which is used to operate, maintain and dispose of enterprise assets. (Source: Wikipedia)	Maximo has a work management module that can be used to generate and track work orders. It is also useful as a repository for equipment work history. Regarding gas leaks it is used to generate work orders for field personnel to evaluate and/or fix gas leaks and track the repairs. The software can also automatically generate new work orders where work is on scheduled intervals.	$1000 - $5000 per year depending on options chosen. See the link to the website in the column to the right.

SAP	SAP stands for Systems, Applications and Products. SAP applications, built around their latest R/3 system, provide the capability to manage financial, asset, and cost accounting, production operations and materials, personnel, plants, and archived documents. (Source: Whatis.com)	SAP Enterprise Asset Management allows you to analyze equipment performance, schedule work, generate work orders, order parts and track costs. Regarding gas leaks it is used to schedule, dispatch and generate work orders for field personnel to evaluate and/or fix gas leaks and track the repairs. The software can also automatically generate new work orders where work is on scheduled intervals.	SAP would not discuss pricing in general. Prices are only available from the Sales Team.

Best Practices

and added Row 17 to Gas Leak Prevention tab

Link to Manufacturer	Advantages	Disadvantages	Company	State
Many types and manufacturers	Creates an accurate record of a leak survey. Eliminates illegible hand written records. Can be uploaded to database and used to create work orders. Helps to prevent mistakes and missed surveys	Records can accidently be erased or the pocket PC may crash, wiping out records.	Consumers Energy	Michigan
http://www.intermec.com/products/cmptrcn70a/index.aspx	Speeds the leak survey process by automating some of the human preparation and recordkeeping, improves the safety of the leak surveyors by warning them of dangers and reduces errors by downloading or uploading data rather than using human transcription. Also see the link on the left	Possible to lose large amounts of data if the hand-held pc is damaged.	WE Energy	Wisconsin

	Eliminates the use of paper forms. Automated routing and sequencing of surveys. Provides relevant attribute and survey information to field technician. Eliminates manual data entry for inspections. Provides real-time inspection status to area managers and supervisors. Tracks leaks and maintenance to completion. Shares leak survey attempts and contacts with Customer Call Centers Automated processing with links to attribute systems. If service is retired, outstanding surveys and maintenance are completed. Automatically completes ABI and inside GSS if scheduled in same year to minimize customer disturbances. (Source WE Energy presentation to AGA in 2011).	Hacking and server crashing. Must have a backup server and files.	WE Energy	Wisconsin
http://www-03.ibm.com/software/products/en/maximoassetmanagement/	The data in Maximo can be used to perform analysis of crew work performance, create a work history for gas system components and track asset performance. Maximo can be programmed to automatically generate work orders on scheduled intervals. It can also be used to track assets and inventory	Hacking and server crashing. Must have a backup server and files.	Duke Energy	North Carolina, South Carolina, Ohio, Indiana, Kentucky

http://www.sap.com/pc/bp/eam/software/maintenance-operations/index.html	The data in SAP Enterprise Managment can be used to perform analysis of equipment performance, crew work performance, create a work history for gas system components and track asset performance. It can be programmed to automatically generate work orders on scheduled intervals. It can also be used to track assets and inventory and order parts and services from outside vendors. It can do much more than can be described here. You would have to go to the SAP website to learn more.	Hacking and server crashing. Must have a backup server and files.	Sempra	California