Fabian McNally
Associate Counsel
Legal Department

April 1, 2013

VIA E-MAIL

Hon. Jeffrey C. Cohen, Acting Secretary
New York State Public Service Commission
Three Empire State Plaza
Albany, New York 12223-1350
Email: secretary@dps.ny.gov

Re: Reporting Requirements for Research, Development and Demonstration Program: Case No. 98-G-1304

Dear Acting Secretary Cohen:

The Brooklyn Union Gas Company d/b/a National Grid NY, KeySpan Gas East Corporation d/b/a National Grid, and Niagara Mohawk Power Corporation d/b/a National Grid hereby submit their Three Year Research, Development and Demonstration Report for filing with the New York State Public Service Commission.

Please direct any questions regarding the enclosed report to either Joseph M. Vitelli, Principal Engineer, Gas Operations Research, Development and Demonstration at (516) 545-4400 or via email at joseph.vitellijr@nationalgrid.com or Serafino Catapano, Principal Engineer, Gas Operations Research, Development and Demonstration at (718) 982-7353 or via email at serafino.catapano@nationalgrid.com.

Sincerely,
/s/ Fabian McNally
Fabian McNally

Encl.

cc: Thomas Dvorsky, Director, Office of Electric, Gas, and Water (via email)
Joseph M. Vitelli, Principle Engineer, Gas Operations Research, Development and Demonstration (via email)

One MetroTech Center, Brooklyn, NY 11201
T: 718-403-2238 ■ F: 718-403-2809 ■ fabian.mcnally@nationalgrid.com ■ www.nationalgrid.com

National Grid

Three Year RD&D Report

Prepared for

The New York State
Public Service Commission

Albany, NY

Prepared by

Joseph M. Vitelli, P.E.
Principal Engineer
Gas Operations RD&D

Serafino Catapano, P.E.
Principal Engineer
Gas Operations RD&D

April 2013

Introduction

National Grid distributes natural gas to 2.3 million customers in Nassau and Suffolk Counties on Long Island and in Brooklyn, Staten Island and parts of Queens in New York City, and large portions of Upstate New York, including the cities of Albany and Syracuse. National Grid also distributes natural gas to 1.1 million customers in Massachusetts and Rhode Island.

In addition to its gas distribution business, National Grid owns and operates electric generation in Nassau and Suffolk Counties of New York State under contract to the Long Island Power Authority (LIPA) and provides – under contract – electric transmission and distribution services to LIPA. National Grid also distributes electricity to customers in Upstate New York, Massachusetts and Rhode Island.

Goals of the RD&D Program

National Grid's Gas Research, Development & Demonstration (RD&D) program is designed to improve distribution operations. Targeted operations improvements involve enhanced public safety, cost reductions, improved worker safety, and environmental compliance. Within these broad areas, National Grid's ongoing research program focuses on the following technical categories:

- Leak Location. Technologies that allow quicker, more accurate and less costly detection of leaks.
- Damage Prevention. Technologies that allow the accurate detection of hard-to-find underground facilities such as plastic pipe with inoperable tracer wire, sewer laterals, or joints on cast iron systems. Technologies that warn of impending damage to underground gas facilities, or detect obstacles in the path of directional drilling machines
- Live Maintenance and Repair. Live Repair technologies eliminate customer downtime by allowing repairs with gas mains in the live, operating condition.
- Trenchless Technology. Techniques that allow pipelines to be rehabilitated with minimal excavation.
- Integrity Management. Various technologies to facilitate Grid's compliance with the Pipeline Safety Improvement Act of 2002 and subsequent pipeline safety regulations.
- Environmental Technologies. New technologies that could be brought to bear on manufactured gas plant (MGP) site remediation, monitoring, and other projects related to climate change.
- General Operations Improvement. Various projects targeted at improving operational safety, efficiency and/or worker ergonomics.
- Gas Quality. The Company is engaged in various research projects to help prepare us for the expected changing picture in gas supply. The research is focused on the potential impacts that new supplies may have on our infrastructure and our customers.

Active Projects within these categories are described in the body of this report.

Execution of the Program

Most RD&D projects within these program areas are performed with a high degree of collaboration via the following research consortia:

NYSEARCH. NYSEARCH, whose members consist of 18 local distribution companies (LDCs) and one Pipeline Company in North America, is the research sub organization of the Northeast Gas Association (NGA). The NGA is a regional trade association focusing on education, training, research and development, operations planning and increased public awareness on natural gas in the Northeast US. NGA member companies collectively serve 9.5 million customers in eight states. NYSEARCH was originally created as a committee within the former New York Gas Group but has since become national in scope. In addition to the Northeast, NYSEARCH membership comes from the Middle Atlantic States, Mid-West and the West Coast. NYSEARCH focuses primarily on Operations projects. The NYSEARCH Staff of four project managers manage an active portfolio of projects within the program areas above. Member LDCs join projects at their discretion, commit funds according to their size, act as project advisors, and may host field demonstrations. For the NYSEARCH program, the Company's budget is set by first analyzing the projects that are approved. The project schedules are then established and a spending forecast is developed jointly with NYSEARCH. The company may contribute "in-kind" expenses towards a project in the form of field demonstrations and those costs are also considered. If a new project is still awaiting approval, a forecast is made of projected spending, again in conjunction with NYSEARCH.

Operations Technology Development (OTD). OTD consists of 23 LDCs throughout North America and is an Illinois not-for-profit (NFP) company administered by the Gas Technology Institute (GTI). GTI also performs project management services and researches about half the project portfolio. OTD focuses on operations projects. OTD Member LDCs join projects at their discretion, commit funds as they deem appropriate, act as project advisors, and may host field demonstrations. The OTD business model calls for an up front pre-determined (based on company size) payment of annual dues each calendar year. For the OTD program the Company's annual dues are $750,000. As projects are approved they are funded by the annual dues. Unused funds can be used to offset the following year's dues. The company exercised this option for 2012.

A sub-program within OTD, the Sustaining Membership Program (SMP) is a longer term GTI program focusing on basic science, which usually results in a proof of concept that which is further developed in the OTD program. National Grid terminated its participation in the SMP program effective January 2013.

In some cases, National Grid may choose to enter into development contracts with research providers jointly with other LDCs or by ourselves.

NYSERDA. The Company is assessed an annual amount of approximately $3.2 Million for the NY State Energy Research and Development Authority (NYSERDA). The Company has no say in which projects are funded through the NYSERDA program. However, the company monitors the various NYSERDA Project Opportunity Notices (PONS) and may elect to submit a proposal to NYSERDA for cofunding a Company RD&D project. Most recently, the Company received $188,000 from NYSERDA toward a cogeneration demonstration project that was completed in 2009.

Funding

Part of National Grid's ongoing RD&D program is funded via the "Millennium" Fund and surcharge, authorized by the New York Public Service Commission's February 14, 2009 Order in Case 99-G-1369 (the "Millennium Order") to replace the mandatory FERC pipeline research surcharge. A maximum allowable collection rate of $0.0174/dekatherm on firm transportation and sales is the source of funding for the program. National Grid currently collects $0.0128/dekatherm from its Downstate operations and $0.00539/dekatherm from its Upstate Operations. One reason for the difference in rates is National Grid Downstate is funding two large projects, the Cast Iron Sealing Robot (CISBOT), for repairing large diameter cast iron piping, and Explorer 3036, for inspecting large diameter transmission piping. These projects minimally benefit our Upstate territory and are not funded through the Upstate surcharge.

Unlike the phased-out Federal Energy Regulatory Commission (FERC) surcharge, the Millennium fund is controlled by National Grid and spent on eligible projects via NYSEARCH, OTD, GTI or other research providers at National Grid's discretion. As specified in the Commission's Millennium Order, in order to qualify for Millennium funding a project must be medium to long term in nature (i.e., projects that are at least twenty-four months or more from becoming a commercially deployable product); 80% of Millennium funds must be spent on co-funded projects and cannot be directed to fund natural gas appliance research or supply/storage projects. The projected budget for the next three years averages $2.7 Million. The Company realizes a high degree of cofunding from other participating LDCs, and from the US Department of Transportation (DOT) Pipeline Safety Research Program. Because of this, the Company's leverage is about 7:1, meaning for every RD&D dollar we spend we realize seven dollars of overall RD&D funding.

National Grid maintains an internal budget to fund projects that do not meet the criteria set forth in the Millennium Order. The budget is $263,000 and typically funds short term "quick hit" RD&D efforts, association (NYSEARCH) dues, and patent protection fees.

Attachment 1 shows actual and projected spending for the Company's Gas RD&D program, Internal, External (NYSEARCH and OTD) and the NYSERDA Assessment.

Program Management

The management and administration of the operations program is by National Grid's Engineering Standards, Policy and Codes Group within the Network Strategy organization. Subject matter experts throughout the company are used as needed when specific technical expertise is required on projects.

Selection of Projects

The Company uses four criteria to judge the merits of RD&D projects. The first is financial benefit; the Company uses a benefit/cost (B/C) ratio test to determine whether RD&D projects should go forward. Benefits are the net savings in operational costs that are realized via implementation of new technology. Costs are the project costs to fund and implement the new technology. In some cases R&D studies can also lead to operational savings and the same B/C test applies.

The second criterion is compliance with regulations. An excellent example of this is the transmission pipeline safety regulations. In the Pipeline Safety Improvement Act of 2002, Congress directed the US Department of Transportation to establish and promote a research partnership with industry to develop tools and techniques to improve pipeline safety. Ensuring the highest level of pipeline safety requires tools and techniques that have been developed over the last 10 years, such as the robotics program for internal inspection of unpiggable pipelines.

The third is increased knowledge about gas operations, which can lead to increased usage of materials, or better techniques for conducting daily operations.

The fourth criterion is safety. Some projects are undertaken to enhance the safety of workers in the field, or the general public.

Most projects have multiple benefits, for example, projects undertaken for worker safety can lower injuries and reduce sick time (thereby providing a financial benefit), and compliance with regulations can improve safety of the gas system. A project with a marginal financial benefit may also be approved if it meets one or more of the other criteria.

Benefits

National Grid, in collaboration with other funders, has been involved with bringing the following products or increased knowledge to market over the past few years:

- Keyhole Tools and Methods
- Pipe Splitter
- PFT Chromatograph for Leak Detection
- No-Interrupt Service Transfer (NIST) Tee
- Cured in Place Liner Improvements
- Butt Fusion Repair Patch
- Remote Methane Leak Detector (RMLD)
- Studies on Plastic Pipe Performance

- A Full Suite of Live Internal Gas Main Video Inspection Devices
- Risk Modeling Software
- Explosion Proof Light Fixture
- Guidance Document on Biomethane
- Explorer Suite of Inspection Robots
- Cased Pipe Annular Space Inspection Robot
- CISBOT
- Acoustic Pipe Locator
- Metallic Joint Locator

Active Project Discussion

Internal Budget – Non-Millennium – NYSEARCH Projects

Projects that do not meet the criteria set forth in the Millennium Order (i.e., medium to long term and no end use or appliance funding) are funded via National Grid's internal budget.

T759 - Ergonomic Study to Develop and Test a New Design Needle Bar. A needle bar is a manually operated tool used to make small diameter holes, called barholes, in paved or unpaved areas over gas mains to allow pinpointing of leaks. During a typical leak investigation as many as 15-25 such holes may be required. The repetitive up-down motion required when using the tool is often a source of soft tissue injury if the user fails to maintain an upright position when using the tool. An ergonomic needle bar with a ratcheting handle was developed. This tool allows the operator to remain in an upright position for the duration of time it takes to create a barhole. The drawback is that the tool is heavier. Field trials were conducted throughout the National Grid territory and the tool failed to gain universal user acceptance. However, these efforts have stimulated manufacturers to continue working independently working towards more ergonomic tool design. The benefit of this work is a reduction in soft tissue injuries.

T763 - PE Rock Impingement Study. A study was undertaken to determine whether the requirement for clean backfill around polyethylene (PE) pipe could be relaxed given the high resistance to slow crack growth demonstrated by modern PE materials. In many situations, a common practice is to truck in clean, screened backfill in lieu of using native materials, at an increased cost. Testing performed in Europe has demonstrated that modern PE materials have such superior resistance to point loadings that use of select backfill is no longer required. No such testing had been undertaken in the US so, through NYSEARCH, Jana Labs was commissioned to perform the tests. Medium density and high density PE pipe, which is representative of the PE pipe installed now at the Company, were subjected to extreme point loading to simulate contact with rocks which could be present in native backfill. (Test loadings were so severe that the indentation was visible at the interior pipe wall.) The sample pipes were then pressurized and hot tank tested (standard testing protocol – which compresses many years of testing into a relatively short time period). Tests have shown no harmful effects from extreme simulated rock impingement loading and the projected time-to-failure in normal

operating conditions is well in excess of 100 years. This work is an excellent validation of the superior toughness of modern PE materials. Significant cost savings have already been experienced in the Company's New York City Operation.

T764 - Auto Gas Lamp Field Evaluation. Working through NYSEARCH, the Company undertook an evaluation of a gas lamp for street lighting that was equipped with an igniter and a photo sensor which would shut off during daylight hours and reignite in the evening. Independent testing confirmed that the lamp and igniter system performed well in lab testing and several lamps were deployed in funders' territory. The benefit of the project is a savings of natural gas during daylight hours, a corresponding reduction of CO2 emissions, and improved customer relations and satisfaction.

T765 - Gas Interchangeability Study for Installed Residential Appliances. The addition of new gas supplies (imported LNG, unconventional gas) is expected to accelerate, leading to wider ranges of natural gas compositions. While the industry is expanding supply sources, to date there has been no standardized approach for evaluating the impacts of varying gas compositions on in-service residential gas appliances. The benefits of such a study are to determine the extent to which potentially sensitive appliances exist and to identify which specific appliances are affected based on type, vintage, adjustment practices, and maintenance characteristics. With that information, better decisions can be made about whether adjustments are necessary to those appliances in order to successfully accommodate varying gas compositions. The project consists of two phases; in Phase I, over 2400 appliances were visited in the field and firing rate, percent excess air, CO and NOx formation were measured and flame quality was observed. In Phase II, lab testing was performed on selected appliances (about 20) subjecting them to a wide range of future expected gas compositions to determine their performance. This phase of the study yielded important information about how typical appliances will perform over a wide range of gas compositions and benefits the company by allowing it to more effectively negotiate future tariffs and plan for remedial actions for more sensitive appliance types. This work is nationally recognized. Project results have been shared with the American Gas Association (AGA) and key findings will be incorporated into the next revision of "Bulletin 36," which addresses gas interchangeability concerns. Based on the results of this work an appliance assessment software tool soon will be launched on the NYSEARCH website.

T769 – Test Program for Picarro Leak Surveyor. In early 2012 the Company became aware of a new technology for leak survey manufactured and marketed by Picarro Corp. The technology is vehicle mounted laser based sensing of methane at sensitivity levels never achieved before by standard leak detection technology. Methane at 30 parts per billion (PPB) above background concentrations can be detected. Along with methane sensing, this vehicle based technology also records atmospheric conditions such as wind speed and direction, temperature, humidity and cloud cover. When methane is detected the Picarro technology plots out an area that should be investigated and pinpointed. The area to be investigated is based on the methane concentration that was detected, and the atmospheric conditions, such as wind speed and direction. This gives operators a good idea from which direction the methane is coming.

Through the NYSEARCH consortium, the company and others wanted to do a side-by-side comparison of Picarro technology to existing leak survey methods in use at the Company. A double blind test protocol was established and for two days the standard company leak survey procedure – which is a walking survey using Bascom Turner "Rover" leak detector – was run on the same days on the same streets as the Picarro mobile survey technology. Results of the comparative surveys for the Company and other project participants have been compiled and a final report is in preparation.

Millennium Program

NYSEARCH and OTD Projects

Damage Prevention and Pipe Location. According to the US Department of Transportation (DOT), third party damage is the primary cause of pipeline incidents on LDC distribution systems, accounting for over one third of all reportable incidents. Repair costs due to Third Party Damage are estimated at $10 Million annually, and often result in loss of service to customers. National Grid is funding the following efforts:

M2001-005 – Handheld Ground Penetrating Radar (GPR). GPR is high frequency electromagnetic radiation that has proven capabilities to detect underground features but no hand held GPR device exists. The goal of the project is to develop a user friendly GPR device that can be deployed by field crews when standard locating technology cannot precisely locate suspected underground facilities. The target application for this technology is plastic pipe with inoperable tracer wire. Such pipe cannot be located by standard "clip-on" locating technology. NYSEARCH worked with Pipehawk LLC, a UK company, to develop the technology but attempts to commercialize it in 2006 were unsuccessful. Another potential commercial partner, Sensors and Software, a recognized leader in both development and manufacture of GPR locating equipment, had been engaged to explore potential commercialization. This contractor is now assessing the feasibility and potential market for this technology. A successful device would provide company crews with the ability to quickly locate plastic pipe without tracer wire.

M2002-018 - Proactive Infrasonic Sensor This system consists of seismic sensors that can be installed near critical gas mains or other facilities and can sense activity near those facilities and send a warning to a control center or other company facility. The system is "trained" to distinguish benign threats (truck traffic, etc) from real threats. Comparable systems on the market now differ in one important distinction; they all require physical contact with the sensor, this system will detect activity as far away as 300 ft. Benefits of this project are reduced incidences of third party damage and associated repairs.

M2007-007 Advanced Video Surveillance (A-Gas) System. This project uses a video image approach to detect possible third party damage. Standard video cameras are trained on an area of concern and proprietary software is used to "learn" the scene so that normal activity can be discounted but abnormal activity alarmed. The A-Gas system is available for security applications. The research component of this project is to adapt the technology to the new concept of advanced warning to LDC operators of potential third

party damage. In a second phase of the project we are working with the vendor to develop an environmentally hardened version of the camera/software system which can be mounted outdoors without any special environmental enclosures. The benefits of this project are reduced incidences of third party damage and associated repairs.

M2008-001 – Advanced Development of PipeGuard™ – Proactive Pipeline Damage Prevention. This system by Senstar is technically similar to the Proactive Infrasonic Sensor system but is a commercially available system that is used for security applications. The goal of this project is to adapt this security based technology for use in the natural gas industry to be utilized in an underground surveillance mode to detect occurrences at or near the surface to alert the operator of third party activity, presumably excavation, in the vicinity of the installed sensors. Through NYSEARCH, the Company is hosting a demonstration site on Long Island to test this technology adaptation. The target goal for detection alarms for backhoe, pneumatic piercing tools, and pavement breakers is 250 feet from the sensing units. This will provide total monitoring coverage of 1000 feet along the pipeline run when two sensing units are installed. It is expected that detection distances for shovels and manual post-hole digging tools will be significantly lessened. Benefits of this project are reduced incidences of third party damage and associated repairs through proactive monitoring in advance of actual work performed by a third party.

M2011-005 – Fiber Sen System Development and Testing In the last 10 years advanced damage prevention technologies using fiber optic cable have been marketed. Most of these technologies are suitable for extremely long lengths of transmission piping and one system even uses satellite transmission of data to a central monitoring site in Europe. Systems such as this do not meet the needs of the Company. Through NYSEARCH, the Company became aware of Fiber SenSys Inc., who are interested in developing a shorter version of existing technology which would be more applicable to the needs of distribution companies.
Fiber SenSys proposed to develop a fiber optic cable which can be installed parallel to an existing gas transmission main, or alternately the cable can be incorporated into a new main installation. The system functions by detecting vibrations in the soil around the pipeline. The vibrations alter the characteristics of the laser light in the cable and can be detected and alarmed. Requirements are that the system be able to detect presence of commonly used excavation equipment, while recognizing and filtering out other acoustic signals that would be generated by benign threats such as truck or rail traffic. The system must perform in all types of soil that can commonly be encountered in the Company's territory. A NYSEARCH member company has offered a test site where a prototype system can be installed and tested. The target cost of the system, depending on length monitored, would be as low as $3000 per mile. The benefit to the Company is enhanced damage prevention and potential avoidance of a major pipeline accident due to third party damage.

M2011-008 – BioBall Test Program A NYSEARCH member company has worked with a technology company to develop a simple technical approach to accurately locate sewer laterals. The technical approach is to simply wind a length of copper wire on to a

biodegradable “spool” which can be flushed down a commode in a residence. The wire will unspool and standard locating equipment can be connected to it and the location of the sewer lateral can be determined. NYSEARCH member companies want to determine whether the idea is feasible and have funded a test program. The Company has conducted a week long field test program on this technology. Results were mixed; in many cases gaining access to the residence was problematic. In those cases access to the sewer lateral was through an outside cleanout. Where the bioball did deploy successfully, location of the lateral was determined within +/- 2 ft. Interest in this project is high because of a concern with “crossbores,” in which pipe installed via directional drilling inadvertently punctures a sewer lateral. The situation may not be detected for years until the sewer line clogs and a plumber is called by the homeowner, with potentially disastrous results. The benefit of this technology is accurate location of sewer laterals and subsequent avoidance of a crossbore.

OTD 1.8.f – Obstacle Detection by Acoustic Technology. This project involves use of acoustic sensors which can detect obstacles that are in the path of a directional drill. Noise from the directional drill head is transmitted to the ground surface in two ways, directly through the soil, and reflected off the surface of buried obstacles. The sensors are tuned to discriminate between the two sources of noise and will alarm upon detection of an underground obstacle. The system gives advance warning to operators of horizontal directional drilling (HDD) equipment of potential impingement of the drilling equipment on buried facilities in the drill path such as electrical conduit, water and sewer mains, or other gas facilities. A potential commercializer conducted extensive tests of the prototype equipment and has determined that more development and testing is needed.

OTD 1.h and 1.10.c – Hand Held Acoustic Pipe Locator. Plastic pipe without tracer wire remains a vexing problem for LDC locating crews because standard electromagnetic locating techniques will not detect plastic pipe. Ultrasonic waves are ideally suited for this application because they will travel well through solid mediums (soil) but are reflected off of voids, air pockets or lighter density materials. The acoustic locator has shown that it can reliably detect plastic pipe. A follow on to this project (described next) will target location of sewer laterals, an important issue lately as more LDCs are using directional drilling to install gas mains. Accurate location of our buried facilities is the main benefit of this project.

OTD 1.8.a – Excavator Encroachment Notification System. This project focuses on linking Global Position System (GPS) technology with digging operations to provide a warning system to prevent excavation damages to underground facilities. The objective is to develop and demonstrate a system to ensure that excavation activities are occurring within a valid “One-Call Ticket” area (which authorizes excavation) and are not encroaching upon underground pipes and facilities. The Company and other project funders are partnering with Virginia Utility Protection Service (VUPS), a “one-call” center for utility locates, that has been conducting pilot programs to demonstrate the feasibility of using GPS-enabled cell phones (Phase 1) and GPS-enabled locators (Phase 2), and excavating equipment (Phase 3) to call in excavation projects, access information, and prevent unauthorized excavations. The benefits of this project are more accurate and

smaller “white-line” (areas needing markout) areas, more accurate locating, and warnings to excavators if they are excavating in unmarked areas. All of this reduces the threat of third party damage. The company is participating in a follow on project to implement a similar pilot program in upstate NY, which is getting underway now.

OTD 1.11.a - Evaluation of Chemical Detection Methods for Detecting Sewer Lateral Crossbores. The Company and others funded a feasibility study with GTI to determine whether chemical detection methods could accurately detect a sewer lateral crossbore. The theory is that a chemical sensor affixed to the drill head of directional drilling equipment would immediately detect the presence of gases or other substances that would be expected to be in a sewer lateral. Some limited field testing was conducted and it was determined that this method of crossbore detection was not feasible.

OTD 1.11.e - Crossbore National Database and Risk Model. As crossbores are discovered, patterns emerge. For example, homes with sloping front yards and no basements may have sewer laterals that are close to the surface and therefore more likely to be intersected by a horizontal directional drilling operation. The objective of this project is to gather as many parameters as possible associated with crossbores actually identified in the field. In addition to the Company, other LDCs throughout North America are actively gathering data on crossbores. A few are doing this programmatically and are conducting field inspections on all known HDD installed main installations. By combining this data into a national database the company can identify those situations and field conditions where crossbores are more likely to occur in its own territory, and can prioritize and focus remedial action on the highest risk areas

OTD 1.12.b – Crossbore Detection Using Mechanical Spring Attachment
In the concluding phase of the above mentioned project OTD 1.11.a, “Evaluation of Chemical Detection Methods for Detecting Sewer Lateral Crossbores,” one of the project funders suggested a brainstorming session for innovative ideas to detect crossbores. The leading idea is to use a simple spring loaded sensor on a drillhead that would “snap open” upon encountering a void, such as would happen if the drillhead suddenly penetrated a sewer lateral.
GTI engineers will design and test a prototype, and at the conclusion of the project, commercialization activities will begin. A simple yet accurate method for detecting a crossbore in this fashion is a tremendous benefit to the company because crews are present to immediately rectify the situation.

Leak Location. Rapid and more accurate leak detection and location (pinpointing) has always been a research focus for the industry and for National Grid in particular. We are funding the following efforts:

OTD 1.9.a – GPS Based Leak Survey. The objective of this project is to develop and utilize a software application that automates the leak surveying with GPS. Using standard GPS receivers a leak surveyor’s route is automatically uploaded to company maps and a permanent record of the actual route surveyed is created and preserved. New leak detection equipment that is on the market will be linked via software to company maps or

images to automatically track routes of leak surveyors, thereby creating a traceable record of survey routes walked. The benefits of this project are reduced time for documentation and more accurate record keeping. National Grid funded an additional phase of the project to conduct an actual field trial of the technology in a select area in New York City. This field trial will be completed in 2013. Pending the results of the field trial an additional field trial may be undertaken in the Company's upstate territory.

OTD 1.11.c Methane Sensor The goal of this project is a low cost reliable methane sensor for in-home use or use in company facilities (gate stations etc.) to detect and alarm on the presence of methane in air. Instruments are available to do this but typically can be set off by non-methane hydrocarbons which could be present in a house basement, paint thinner or hairspray for example.
This project is in the beginning phases and an alpha prototype has been developed. Because of our concerns on the path forward of this project, National Grid elected not to continue this effort as well.

Integrity Management. The passage of the 2002 Pipeline Safety Improvement Act – which required detailed assessments of all pipelines operating at 20% or higher of specified minimum yield strength (SMYS) - is the driver for this research for National Grid. National Grid is funding innovative research in the areas of wall loss sensing for unpiggable pipelines and novel methods to assess the condition of cased pipe. These challenges have resulted in the Integrity Management area being the largest R&D spending area for National Grid. Within the overall category of Integrity Management there are three project areas:

Robotics: In line Inspection (ILI) using smart pigs is considered the most desirable method of pipeline inspection among the three methods (In line inspection, Direct Assessment, Hydrostatic Test) specified by the US DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA), yet many of National Grid's older transmission lines are not piggable. To meet this challenge we participate in the NYSEARCH Robotics program which is developing robotic, self powered sensors for 6" through 36" transmission pipe. These inspection tools are battery powered and are launched "live" into the pipeline and communicate via wireless signal. Pipe wall thickness measurements are either remote field eddy current (RFEC) sensing or magnetic flux leakage (MFL) sensing. The robotics program has received significant support and cofunding from the USDOT and other industry outside NYSEARCH; to date about $8 million has been received from the USDOT alone. The benefits of this technology investment is pipeline safety, ILI, as mentioned, is the most desirable of the three mandated inspection methods, and savings can be considerable, though highly site specific. In this reporting period the Company has funded the following projects:

M2001-014 - Explorer 2026 Robotic Inspection System for Unpiggable Pipelines using Magnetic Flux Leakage (MFL) Sensing. Explorer 2026 is a live entry, battery powered untethered robot designed to enter and inspect transmission pipelines 20 in. through 26 in. diameter at pressures up to 750 psi. Wall loss measurements are by industry standard MFL sensing. The design of the robot and sensor specifically

overcomes the restrictions that cause a pipeline to be designated “unpiggable.” These restrictions include short radius or back to back elbows, mitered bends, presence of plug valves (these are valves that do not have a full diameter opening and won’t allow a typical pig to pass through) or no/low flow conditions. The robot is launched “live” into a pipeline and travels under its own power along the pipeline taking wall thickness measurements along the way. Explorer 2026 is fully developed and has completed two of three field demonstrations at host LDC sites. It will be in full commercial operation later in 2013.

M2003-009 - Explorer 6/8 (Explorer II) Robotic Inspection System for Unpiggable Pipelines using Remote Field Eddy Current Sensing (RFEC). Explorer 6/8 is a live entry, battery powered, untethered robot designed to enter and inspect 6 in and 8 in diameter pipelines operating at pressures up to 750 psi. Wall loss sensing is through a novel sensor called “Remote Field Eddy Current” (RFEC) sensing. Development of this sensor was itself a separate R&D effort and the sensor represents advancement over state-of-the-art magnetic flux leakage (MFL) sensing. The reason this new sensing technique was developed is that traditional MFL sensing creates high strength magnetic fields and given the small diameter of these pipelines not enough robot power could be developed to overcome these forces and move the robot down the pipeline.

The robot is specifically designed to overcome obstacles that traditionally cause a pipeline to be classified unpiggable, such as mitered bends, back to back elbows, and low or no flow conditions.

The robot consists of drive modules, steering modules, cameras on front and back, and the RFEC sensing module in the middle. The robot is placed in a specially designed launch tube which is mounted on standard hot tapping equipment affixed to the pipeline. The robot is then launched into the pipeline under live gas conditions and travels down the pipeline under its battery power at about 15-20 feet per minute, collecting wall thickness measurements. After the conclusion of the “pig run,” data is analyzed and a report on anomalies found, if any, is made.

An important part of any R&D project is a serious and robust field demonstration phase. For this project, the Company served as a field demo site at its 6 in dia 473 psi gas transmission pipeline in Oneida, NY. During this 3 day demo, the Explorer 6/8 robot scanned over 4900 ft of this pipeline and found no anomalies.

This scan provided the company with added insurance that there are in fact no corrosion defects present in this high pressure gas main. This robot and its supporting technology has been licensed to Pipetel Inc, a robotic inspection services company in Buffalo NY, and is now in full commercial operation.

M2011-006 – Robotics Supporting Technologies. Modifications are being designed that will allow in-line battery recharging (to extend the range), new sensors to detect cracks, and a “rescue tool” that will allow a disabled robot to be retrieved.

In testing conducted to date, battery life is the factor most limiting the range of the robots. It was realized by the company and others that a more efficient way was needed to recharge the batteries than removal of the entire robot from the pipeline. The technology developer, Invodane Engineering Inc. conceived of an innovative method of recharging the robot via an “in-line” charging system. A charging cable will be inserted through a

small tap on the main and the robot can remain in the pipe while being recharged overnight.
Based on recent industry pipeline accidents there is increased focus on sensors that can detect cracks. Although less a threat than corrosion wall loss, crack sensing is the focus of new development efforts. The benefit of this technology is increased assurance of the integrity of the company's transmission system.
A rescue tool" will be developed that will assist in the retrieval of a failed robot. This will give the company greater assurance that the robots can reliably be placed inside its piping network. On some critical pipelines this may be a requirement before the robot is placed in the pipeline.

M2011-009 – Explorer 3036 Robotic Inspection System for Unpiggable Pipelines using Magnetic Flux Leakage (MFL) Sensing. The Company and two other LDCs are funding Explorer 3036 which addresses larger size transmission piping inspections in 30" through 36" pipelines. This project is still in the development phase and will incorporate all the features of the existing suite of robotic inspection tools such as live launching, plug valve and short radius bend negotiation, all in pipelines up to 750 psi operating pressure.

Cased Piping: Research into cased pipe assessments is an important part of the transmission pipe integrity management program. Transmission piping placed concentrically within a larger "casing" is a common practice when pipelines pass under major highways, railroads or bodies of water. Assessing the condition of these "carrier" pipes within casings can be difficult if the pipeline is not piggable. The company is involved in several research efforts to address this important issue. The efforts consist of software tools to evaluate casings, and inspection hardware to perform inspections. A very promising technology is "Guided Wave," in which an ultrasonic signal is propagated along a pipeline from a remote location revealing flaws in inaccessible areas of the pipeline.

M2001-003 - Cased Pipe Risk Assessment Model. This project involved the construction of a software tool program that prioritizes casings in terms of relative risk. The program considers inputs including, but not limited to corrosion rate, degree of cathodic protection, presence of moisture and wall thickness of the pipe and categorizes casings in terms of probability of failure. Casings with higher risk scores can be scheduled for further follow up inspections while those with lower scores can be monitored. Consequence of failure can also be added to the model, thereby producing a total risk score, which is the product of probability of failure and consequence of failure. Depending on the degree and accuracy of the data that is input into the model, the model can also calculate time to failure in years. A follow on to this project involved lab and field analysis of corrosion rates in various environments. With this information, a corrosion rate can be entered into the model which would be most representative of actual corrosion expected in the field, and not theoretical (overly conservative) rates. This project benefits the company by allowing it to prioritize inspections of riskier casings first and perform remedial actions, if required, on those riskier casings.

M2007-001 Mini-camera for cased pipe inspections. This is a crawler camera magnetically attached to the casing. It can navigate down the length of the carrier pipe returning video image of the pipe. The camera has been deployed successfully at several sites and a follow on phase to the project will incorporate ultrasonic sensors for wall thickness readings and humidity gauges to assess the presence of moisture (a key ingredient that can accelerate corrosion). The mini-camera does not, by itself, provide a complete assessment of the carrier pipe condition but is rather another "tool in the toolbox" when used with other assessment methods such as Guided Wave technology.

M2007-003 Multi Technology Validation Testing for Cased Pipe Applications. This is a testing program for various technologies, which may have promise for inspecting wall loss and other defects on carrier pipes within casings. Technologies tested were guided wave, magnetostrictive sensors (an in-situ type of guided wave), the casing camera, and Time Domain Reflectometry (TDR). Some of the technologies tested are commercially available and some are still in the development phase. The results of this test program gave the company valuable information on to the effectiveness of these various inspection techniques. The two most promising are guided wave and the casing inspection camera. The magnetostrictive sensors were not as sensitive as traditional guided wave, and TDR, although promising, will not be seriously pursued at this time. A new phase of this project has recently been authorized which will focus on more detailed testing of guided wave. All tests are conducted at the NYSEARCH test bed, which is a network of above ground and buried pipe containing machined defects. This is an effective way to compare technologies as all tests are on the same piping components, and defect locations are known only to NYSEARCH staff. However, the company took an additional step and developed a test program for guided wave on its own in-service piping. This project is more fully discussed later in this report.

M2007-005 - TransKor Remote Inspection Testing (Magnetic Tomography). The magnetic tomography method (MTM) is a commercial, non-intrusive, above ground method of pipeline inspection developed in Russia by TransKor. Through NYSEARCH, the Company became interested in this technology as an additional "tool in the toolbox" for transmission pipeline assessment. Although other above ground assessment techniques are in use today, they rely primarily on detection of coating failures. MTM measures the inherent magnetic field surrounding a metallic pipeline and detects stress risers in the pipeline by analysis of the pipeline's magnetic field. Stress risers are indicative of wall loss, welds, manufacturing defects, or mechanical damage such as dents or gouges. A test program is underway by the Company and other LDCs who are members of NYSEARCH to thoroughly test the capabilities and accuracy of the MTM. The ultimate goal of the test program is to evaluate the performance of MTM and have it recognized by PHMSA as an "other technology" suitable for transmission pipeline assessment. MTM could provide a significant benefit to the company's Integrity Management plan by providing a much less expensive and more thorough assessment method which requires only a simple walk-over of the transmission pipeline being assessed.

M2011-007 – Cased Pipe Inspection via Vents. National Grid has had success in its downstate territory with the mini-camera for cased crossings, described above, but the drawback to this technology is the requirement for costly excavations to gain access to the casing annular space at the end seal. An alternate approach is to gain access to the annular space from above ground, through small diameter vent piping which is present on casings. Technology to provide this visual inspection does not exist.
The technical approach on this project is to use commercially available camera technology and adapt it to travelling down through the vent piping until it reaches the casing annular space. Through a technology search for new technology providers, NYSEARCH has qualified a small robotics company, Honeybee Robotics, to perform robotics work, and they will perform on this project in a two- phased approach with a go – no/go decision point after Phase 1. Phase 1 will demonstrate the feasibility of adapting existing technology to the task of negotiating the vent piping to gain access to the casing annular space. Such access will be constrained by the small diameter and sharp ninety degree bends that are normally present in casing vent piping. Cleanliness of these vent pipes may also be an issue. If the testing reveals that access to most typical casings can be gained, then the project will proceed to development of a prototype system that can enter the annular space and obtain meaningful information. The benefit is compliance with pipeline integrity management regulations at a significantly lesser cost than traditional means of gaining access to a casing.

Other Integrity Management Research. Included here are various projects that contribute to our understanding of, or help us meet, transmission or distribution integrity management requirements.

M2009-001 - Holistic Review of Distribution Integrity Management Plan (DIMP) Risk Practices and Models. In 2010 the Pipeline and Hazardous Materials Safety Administration (PHMSA) issued regulations requiring operators of natural gas distribution systems to implement a formal distribution integrity management program. The regulations are not prescriptive and don't require specific types of inspections and assessments as do the transmission integrity regulations, but they require operators to risk rank their distribution system. The Company undertook this project to more fully understand exactly what type of risk modeling may be best suited to analysis of a gas distribution system.
Some of the projects' findings suggest that age of the distribution piping alone is not a complete indicator of risk, but other factors such as material type, location, and potential for operator error all factor into a relative risk ranking. Availability of data on the distribution system is also key to developing a reasonable and useful risk model. (For example, although age, material type and location of pipeline segments are certainly known, various component types or specific installation practices are not always known with the same certainty.) Conversely, overloading a risk model with too much specific data does not result in a useful risk tool either.
The final report on the project provides suggestions on a risk management approach and guidelines on making decisions on purchase or development of a specific risk model. The benefit is information and guidance to the company regarding the best method to risk rank its distribution network.

M2012-001 Development of a Corrosion Sensor Array. 2013 Estimate $1.6K. This project will attempt to develop a novel method of monitoring for external corrosion on a gas pipeline by installing an "array" of sensors on a pipeline. If successful, pipeline operators will have another "tool in the toolbox" for monitoring critical pipelines for external corrosion.

M2012-003 – Enterprise Level Assessment of Data Management Systems. This project addresses a relatively new requirement for gas distribution operations, namely to establish traceability – from initial manufacture to installation – of gas system piping components, and a means to track the location and installation parameters of these components, and integrate this information into existing company data management systems. The best methods of doing this, both from a hardware and software perspective, are being explored in this project. The company is funding this project to gain important information about this new industry initiative, but because we are conducting active field demonstrations via a similar OTD project (OTD 5.11.m) we will only be observers for this project.

OTD 4.7.g - Yield Strength Determination. Operators with incomplete records need a better way to determine the yield strength of their pipeline segments if it is unknown. Current regulations require that operators either take a full size cutout of the pipeline and subject it to laboratory testing, or assume a low value of 20,000 psi. Obtaining full size cutouts is disruptive to pipeline operations as it would require a full shutdown of the pipeline. Assuming 20,000 psi could result in the pipeline being in an (assumed) over pressure condition when in fact it may not be.
GTI developed a method to determine the yield strength of a pipeline through lab testing of "sub-size" samples. The samples can be obtained easily by using standard hot tapping equipment without shutting down the pipeline. A follow on phase to the project will utilize sophisticated statistical techniques to possibly lower the number of sub-size coupons required for given lengths of pipeline. The benefit to the company is a less expensive and less disruptive method for positive determination of yield strength, should any of the company's records be incomplete.

OTD 4.8.i - Extended Reassessment via Wax Fill of Casings. A proper wax fill of a casing eliminates the threat of external corrosion on the carrier pipe by removing any electrolytes in the annular space between the casing and the carrier pipe and replacing it with a dielectric medium (the wax fill) Although techniques for filling casings with wax are well known, there is no known technique for validating the effectiveness of the wax fill operation so that assessment intervals could be extended. For this project, corrosion monitoring techniques and techniques to determine the completeness of the initial wax fill operation will be developed. Casings were filled with wax and monitored to determine the extent, if any, of corrosion.
To simulate actual field conditions, water was left in some of the test sections prior to filling the annular space with wax. Upon examination, corrosion was noted, although at a lower rate than would be expected. More work is required to quantify actual corrosion rates and it is unclear whether the Company will continue to fund this project.

OTD 5.8.e Tracking and Traceability. One of the requirements of a Distribution Integrity Management program is to "know your system." But there is no industry standard for manufacturers to mark gas piping and appurtances with critical manufacturing information nor is there a standard for LDCs to record data when installing permanent additions to their gas systems. On the manufacturing side, date of manufacture and lot number need to be recorded in a standard fashion across industry, and installers need a standard way to record location of the installation and identify the crew doing the work.
For this project, GTI and a subcontractor formed a steering committee to identify which commonly used materials should be identified, and what pertinent information should be recorded. The steering committee consisted of manufacturers and LDCs.
An ASTM standard was developed to which capture the results of the Steering Committee's decisions and a bar coding protocol was agreed upon. A future phase of the project will develop methods to record, store, and retrieve, if necessary, data on installed components.

OTD 4.9.a Leak vs. Rupture Boundary. The current Pipeline Integrity rule requires that all pipelines operating at 20% or higher of the specified minimum yield strength (SMYS) are subject to the more stringent transmission integrity assessments. (20% is thought to be the lower limit of pipeline stress at which pipelines fail by rupture). However, there remained questions as to whether 20% is a realistic lower limit. With the support of the USDOT, investigations of past failures coupled with detailed mathematical modeling can confirm that the 20% limit is overly conservative and a more realistic lower limit may be 30%. The Company may then elect to designate certain pipeline segments as covered under the new Distribution Integrity Management rules.
GTI investigated over 20,000 pipeline failures worldwide and was able to draw conclusions as to the parameters that cause pipes to fail via leakage vs. rupture. Not only yield strength but also diameter, pressure, and toughness are factors that determine whether pipes fail by rupture or leakage. The project results showed that for most modern pipeline materials the leak-rupture boundary is more like 30%. Using the results of the project, operators can – with proper regulatory approval – place their pipeline segments in the appropriate integrity management program. The benefit would be that company resources can be directed to assessing the more important pipeline segments.

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OTD 2.11.d - RSD X-Ray. This non-destructive examination (NDE) method has advantages over traditional X-Ray. For example, radiation levels are reported to be lower, and resolution can potentially be higher. Additionally, images can be displayed in real time. As opposed to traditional X-Ray, which requires through-the-wall penetration from the radiation source to a film on the back side of the weld, RSD X-Ray works on the principle of backscatter, or reflection of the X-Ray signal. The detector can be outside the pipe, co-located with the source.
Before such a new technique is adopted it needs to be tested to demonstrate that it is capable of identifying flaws in welds with the same sensitivity and accuracy as traditional X-Ray. GTI will work with the vendor of this equipment to perform blind tests to demonstrate this. The results of the blind tests will indicate whether the project should proceed and whether equipment and techniques should be developed for practical applications in the gas industry. If successful, this method of non-destructive examination (NDE) could also be applied to pipeline integrity assessments of existing transmission pipeline segments via incorporation on to a pipeline pig, or a robotic internal inspection device.

T 768 (non-Millennium Project) and OTD 4.11.f - Understanding Threat Interactions. Part of an operator's Transmission Integrity Management program is a relative risk assessment of the various threats that could impact a pipeline. There are various risk models in use that can quantify the relative risk of pipeline failure via the threats that are present. What is not so well developed is a ranking methodology that accounts for threats that can interact, or occur simultaneously on a pipeline segment. For example, what is the additional risk to a segment if external corrosion occurs on a manufacturing defect, or if earth movement occurs in an area with a defective weld? This project will examine a realistic combination of multiple threats that can reasonably be expected and will calculate the additional risk of failure to a pipe segment due to the presence of these interacting threats. This is timely work since the Company and others have been questioned during safety audits by regulators on their methodology for addressing interactive threats. This benefits the company by allowing the most accurate risk ranking and subsequent assessment of the integrity of those segments. Because this is an important issue the Company funded two parallel projects. The first is a short term effort through NYSEARCH that focuses on (but is not limited to) evaluating interacting threats through the existing Kiefner Model, which many LDCs use today. The second is a longer term more theoretical approach by GTI which could provide more overall flexibility.
OTD 5.11.m – Intelligent Utility Installation Process. This project will develop methodology and suggest field processes for capturing data during new installations. It is a logical follow on to the requirements of recently enacted DIMP regulations which require operators to "know their systems." It also will provide the means to implement the results of the "Tracking and Traceability" project which created an industry standard for manufacturers to mark their products with manufacturing data. A key component of

the Intelligent Utility Installation project is to achieve standardization across industry. When this project is implemented the company will benefit by knowing precise attributes of its distribution system and will be able to quickly react to reports of possible defective pipe material or fittings.

OTD 4.12.b – Correlating Pipeline Operation to Potential Crack Initiation and Growth. Based on recent industry events coupled with new or proposed regulations, the gas industry is expected to increase the amount of pressure, or "hydrostatic" testing on existing pipelines. In addition to a standard pressure test (in which the pipeline is pressure tested to 1.5 times its operating pressure) there is the possibility that operators would be required to perform a "spike test" in which the pipeline is raised to 90% of yield strength (which could be significantly higher than a normal hydrostatic pressure test).
Such pressure testing, while having advantages over other integrity assessments, can cause cracks to initiate and/or grow. This has been observed in other industries (boiler tubes) but is not well understood in the gas industry. The Company is aware of the advantages of pressure testing but wants to understand the risks that could present themselves due to pressure and spike testing.
GTI will leverage previous work done in the boiler tube industry to develop a model to predict crack growth due to pressure testing. Validity of the model will be tested by subjecting actual pipe specimens to laboratory pressure cycling which can simulate years of pressure testing and/or pressure excursions in a matter of hours. The deliverable of the project will be a model that will relate historical and planned pipeline operations to potential crack initiation, growth and arrest. This benefits the company by insuring that pressure testing does not degrade the pipe segment being tested, with the associated possibility that the pipe could fail while in service.

Plastic Pipe Research. The bulk of piping added to LDCs' networks each year is medium or high density polyethylene (PE), or plastic pipe. Last year alone, the Company added over 500 miles of such pipe to our system. Working with NYSEARCH and GTI, the Company is involved in several research projects designed to improve our understanding of PE performance and develop new products.

M2000-001 - PE Repair Sleeves for Damaged PE Pipe. As an alternative to squeeze off and cutout of minor defects on PE pipe, the Company and others are developing, through NYSEARCH, repair sleeves to reinforce PE pipe in the area of the butt fusion joint, or along the length of the pipe. During routine operations such as new service additions or main extension, minor damage – not causing leakage - can be noticed on the existing PE pipe that is uncovered. The substandard conditions noticed can be either a scratch or gouge on the pipe itself, or a questionable appearing butt fusion joint. The solution, up to now, is removal of the defective pipe segment. Removal is usually accomplished by first "squeezing off" ahead of and behind the pipe segment in question, then cutting it out and replacing it. As an alternative, the PE repair sleeve can be fitted over the defective area in question and fused on to it. The fitting is designed to withstand line pressures up to 124 psi but will not be installed if an active leak is present. The benefit of this technology is lowered repair costs and improved reliability of PE piping systems by reducing the amount of "squeeze-offs" made. These repairs can also be made

without causing an outage, whereas a squeeze-off may require a short outage if the pipe is a one way feed.

M2006-002 – Butt Fusion Integrity. This project examines current butt fusion parameters such as pressure and temperature at the joint interface with an aim towards optimizing them. Through a novel test method, the "whole pipe creep rupture test" several test fusions are made and subject to this laboratory destructive test. This test more accurately simulates stresses that actual in-service pipe experiences, and results of these tests can serve to further refine butt fusion parameters and associated procedures.

M2008-010 – UV Degradation of PE Pipe. The Company wants to understand, through testing, what the real time limit for PE pipe to withstand UV exposure without a harmful effect would be. Current USDOT regulations specify two years but the current version of ASTM D2513 (the industry standard for manufacture and use of PE pipe) specifies an outdoor storage limit of 3 years for medium density PE pipe and 10 years for high density PE pipe. But this current standard has not been accepted by the USDOT, who recognize the previous version which limits outdoor storage to 2 years. This project was undertaken to demonstrate, through testing, that pipe stored outdoors longer than 2 years is still suitable for use. Both non-destructive and destructive tests have demonstrated that pipe stored outdoors for three years is suitable for use. The work now is to present the information to the USDOT and request a rule change. The benefit to the Company will be immediate; National Grid recently discarded over $300,000 worth of PE pipe that exceeded the 2 year requirement.

M2009-008 – Ultrasonic Inspection Device for PE Butt Fusions The aim of this project is to develop a field instrument to rapidly and easily examine butt fusions in the field, providing on-the-spot assurance of the integrity of a newly made butt fusion joint. A low cost user friendly butt fusion inspection device has been a goal of gas industry research for quite some time. Such a device gives greater assurance of butt fusion quality by allowing "on-the-spot" inspections by field crews or supervisors actually doing the work. The Welding Institute (TWI), located in the UK, is a leader in plastic pipe research and was selected to carry out this work in a phased approach. In the first phase, an instrument was configured to examine and return information on the presence or absence of flaws in the butt fusion. The next phase of the project is to determine which flaws can be accepted and which will cause the pipe to fail. This is done via destructive testing; fusions with varying degrees of flaws are subjected to testing and a "library" of flaws is developed and flaws are categorized as either "causes failure" or "does not cause failure." In its final form, the instrument will examine field fusions and compare them to fusions in the "library" and be able to give a simple "good fusion" or "bad fusion" reading. The benefit of this work is greater assurance of the quality of a butt fusion and increased safety and reliability of the gas distribution network.

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Live Inspection, Maintenance and Repair. The Company is always looking to minimize customer downtime or gas main shutdown during routine maintenance activities. The following projects help us meet this goal.

OTD 2.11.a - Above Ground Leak Repair Systems Testing The Company and other LDCs desire to qualify various repair products that are sold for repair of above ground leaks on natural gas piping as a permanent repair system. The application is for above ground meter piping on distribution systems. No use of these products on below ground piping is contemplated.
Two available products are being tested. Initial tests will be short term testing to establish the proof, or "burst" pressure of the repair system.
These tests are complete with burst pressures found to be well above (by an order of magnitude) normal operating pressures. Plans for long term testing are now underway.
A successful outcome of this project would be that these repair systems would qualify as a permanent repair thus repairs can be made more inexpensively than a shutdown and rebuild of meter piping, with the associated inconvenience to the customer.

Trenchless Technology. The Company's primary research effort in this program area is to find ways to complete maintenance with minimal excavation. These technologies will lower cost and result in less disruption to the customer.

M2010-001 – Service Tee Renewal The purpose of this project is to develop a means to renew a service tee under live conditions without an excavation. Gas mains can be rehabilitated via cured in place lining with minimal excavations. Steel service lines are routinely renewed by inserting plastic tubing, with no need to shut the main down. An alternate process, called "Renu" seals the interior of a steel service line with access gained at the meter. The weak link in this process is the service tee, usually made of carbon steel, which is not routinely replaced during the above mentioned gas main and service rehabilitation projects.
The Trenchless Technology Center, retained by NYSEARCH to conduct this research, focused first on an appropriate sealant that would effectively seal the interior of the service tee. Spray coatings, liners, and mechanical seals were investigated. A hybrid mechanical seal concept was judged the best of the three alternatives but significant design challenges existed, mostly related to delivery of the sealing system down the length of the service line to the tee (up to 100 ft in some cases). Because of the uncertainties associated with these approaches the Company and the other funders will request proposals for alternate solutions.

OTD 2.8.e - Structural Liners – Technology Search. Large diameter cast iron mains can be effectively rehabilitated by lining them and Ngrid has been using this technology successfully since 2003. The current approved liner for use on gas systems relies on the structural integrity of the host pipe. For this reason, lining is generally limited to cast iron or protected steel pipelines. If a liner could be developed that had structural properties (meaning it would resist external loads such as traffic loading) more pipelines could be candidates for lining.
Four liner manufacturers who make structural liners for other industries (water) were contacted and their products' capabilities were discussed. One manufacturer seems to have a product that may meet the requirements for gas service and further evaluations will be required. This project would benefit the Company by expanding the available

pipelines that could be rehabilitated by lining as opposed to replacement, resulting in lower cost and less disruption to the community and customers.

OTD 5.10.f – Cold Assisted Pipe Splitting One of the methods to renew deteriorated steel pipe is to split it by pulling a tool with cutters through it. A new length of PE pipe is attached to the rear of the cutter. When the cutter emerges from the pipe, the new length of PE pipe remains as the new gas carrier. This can be a cost effective rehabilitation method but many times the splitting operation is difficult because of the ductility of steel pipe. This project investigated whether liquid nitrogen or some other cryogenic liquid could lower the temperature of a steel pipeline to a level at which the pipe would transition into the "brittle" zone and be easier to split.
GTI Engineers determined that the quantities of cryogenic liquid required would be excessive, and further found that during testing; the cooling effect was not uniform through the length of the pipe. Since the project had reached a go / no-go milestone the Company decided not to continue further funding.

Gas Quality. The gas supply picture for the Company's service territory – and indeed for much of the nation – is evolving, and unconventional supplies such as LNG, shale gas, biogas, and gas from other geographic regions will soon be a part of our supply picture. While research into supply itself is outside the scope of the Millennium funding mechanism, the effect that these diverse supplies may have on our existing infrastructure is a new and growing R&D area for us.

M2005-005 – Gas Interchangeability for Installed Components This project studies the effect that a wide range of future expected gas supplies from non-traditional sources may have on installed infrastructure components such as gaskets, O-rings, seals, and diaphragms. Anecdotal evidence exists that suggests that gas supplies outside of normal expected limits may have been the cause of component failure in two east coast LDC distribution systems, but no definite conclusions can be reached, and no similar studies have ever been undertaken. This test program is designed to determine, through controlled laboratory testing at GTI test facilities, whether gas composition changes affect the performance of elastomer components mentioned above. Baseline and test gasses were agreed upon and procured, and infrastructure components were removed from the field and sent to the GTI lab for testing. Components are cycled through a "baseline" gas (the gas normally expected) and then cycled through several "test" gases (representing future expected supplies). During this cycling, pressure and temperature are also varied. The results of this test program will allow the Company to take action by removing and replacing components determined to be "at risk" or set new supply tariff limits with a scientific basis for setting them.

M2011-002 Storage Effects on Gas Quality A portion of the gas entering the Company's system comes from underground storage in geological formations. There is anecdotal evidence that gas leaving storage can have different properties than gas entering storage, for several reasons. These reasons can include presence of water or other substances in the storage formation, temperature variations in the formation (which could affect dew point), blending (or lack of blending) and others. None of this is well

understood or modeled. The Company would like to understand this better from the perspective of the ultimate effect on our distribution system. This would help us better negotiate tariffs for gas delivered that would not have harmful effects on pipe materials as well as gaskets, seals and diaphragms.
NYSEARCH commissioned a subcontractor for a two phase effort; the first phase is a literature search which will identify the key parameters that affect gas quality in storage. Assuming a successful outcome of the first phase, a second phase would develop a predictive model so that ultimate gas qualities can be more accurately projected. This benefits the company by enabling it to better predict quality, set tariff limits that recognize the potential for change in the quality of the gas in storage, and ultimately insure the integrity of our infrastructure.

M2011-003 – Odor Masking Odor Masking is a phenomenon recently observed in gas distribution systems in which the odorant, although present in the required concentrations, is not perceptible to the human sense of smell. It is manifested by no odor or a markedly different odor than is usually associated with natural gas. This is different from Odor Fade, in which the concentration of odorant is lowered due to its being absorbed by the pipe (common in new piping systems) or by trace constituents in the gas stream. The Company is concerned about this issue because absence of the characteristic gas odor will prevent recognition of gas leaks or other hazardous situations.
Odor Masking is not well understood but the Company and other NYSEARCH members are working with Cardiff University in the UK and a professor there who has done some research in this area.
It is known that pairs of compounds, called “antagonistic pairs” can act together to change the perception or intensity of an odor and that this reaction actually occurs in the human nose or brain. In Phase I of this project, researchers at Cardiff University have demonstrated that certain chemicals that can be present in a natural gas stream can mask the odor of some sulfur compounds that are commonly used in odorant. This was shown by actual tests involving volunteers at the university who ranked the intensity and pleasantness of these chemicals before and after mixing. The Phase 1 work will attempt to identify as many of these antagonistic pairs as possible. In Phase II, just beginning now, researchers will attempt to identify where this human response is taking place. This is important because it will lead to certain mitigative strategies depending on where the response takes place.
The ultimate goal and benefit of the project is a practical pipeline operator guideline on how best to mitigate this phenomenon. For example, the guideline could call for tariff limits on certain trace constituents be set at a lower level, or it could recommend the use of certain odorant types that are more resistant to masking. A successful project outcome would eliminate the situation where a gas leak goes undetected with potentially catastrophic results, such as the Texas school explosion in 1937.

OTD 7.8.a – Pipeline Quality Biomethane: Guidance Document for Landfill and Water Treatment Conversion. This is a national study and sampling program to determine acceptable gas quality for introduction of landfill and wastewater-derived biomethane into Ngrid’s distribution system. No such standard exists in the US today. Information was assembled on landfill and wastewater biogas production, treatment, gas

quality standards, and test protocols surrounding biogas production and use. A lab test program was executed testing raw and processed biogas samples for over 400 chemical species. A guidance document was prepared for safe interchangeable use of landfill and wastewater treatment biomethane in LDC networks. The results of this project show that these biomethane sources can be safely introduced into LDC networks.

OTD 7.9.c – Assessing Acceptable Siloxane Concentrations in Biomethane
Siloxanes are a class of compounds that are silica-based and found in many personal hygiene and health care products. As such, they enter waste streams and can be found in biomethane produced from landfill or wastewater biogas cleanup systems. There is evidence that siloxanes, when combusted, can result in excessive deposits of silicon dioxide on boiler tubes or gas turbine blades. The Company is also concerned because the effect of siloxane on standard infrastructure components is unknown.
GTI is assessing industry data and attempting to determine what levels of siloxanes in biomethane would lead to issues with end use equipment or pose indoor air quality issues. In addition to the acceptable concentration of siloxane, other unknowns must be understood, such as where, and at what ratio, the biomethane enters the LDCs' distribution systems, and what flows and velocities can occur at the end use equipment. This project fills an important knowledge gap and allows the company to prepare for the introduction of another non-traditional supply into our existing infrastructure.

OTD 7.10.a – Trace Constituents in Natural Gas Significant research to identify the complete range of trace constituents in natural gas has not taken place in 20 years. In that time span, non-conventional supplies are entering LDC systems and these supplies are expected to have trace constituents in them. The objective of this project is to build a database of trace constituents specific to current supplies of gas flowing into LDC systems. The Company will use this database to assess new gas supplies from unconventional sources such as shale gas to see whether these new supplies are compatible with existing supplies.
Routine analysis of natural gas supplies is an established practice. Heating value, specific gravity, hydrocarbon content, and some inerts such as nitrogen are measured periodically, but trace constituent analysis is not routinely done. A partial list of trace constituents of concern would include halocarbons, volatile organic compounds (VOCs), siloxanes, ammonia, trace metals, and bacteria. Comprehensive knowledge of the presence and amount of these constituents would allow intelligence to be placed on setting limits for these constituents in future supplies.

OTD 7.11.a – Gas Quality Resource Center
The Gas Quality Resource Center is intended to provide technical support necessary to identify and fill knowledge gaps regarding potential industry issues associated with changes in gas composition profiles in North America. The Resource Center will provide a centralized "clearing house" for information related to gas quality, analysis of current flowing gas supplies in North America, identification of constituent trends across identified regions, analysis of current technical regulatory trends associated with pipeline tariff negotiations and identification of research needed to help fill information gaps ultimately aimed at maximizing supplies while balancing the needs of pipeline integrity and end use concerns.

The resource center would maintain information on gas compositions and pipeline tariffs, and would serve to identify and launch research as appropriate related to gas quality issues. Issues such as odor masking or siloxane levels are examples of the types of research that could result from the Company's participation in the Gas Quality Resource Center.

OTD 7.11.b – Trace Constituents Sensors This project will identify candidate sensors or sensor technologies for measuring, perhaps in real-time, trace constituents in new gas supplies, such as landfill gas, biomethane derived from a variety of biomass sources, and unconventional supplies such as shales, tight sands and coal bed methane. The Company is aware that its future fuel mix will include renewable and unconventional gas. The need to understand the composition of a new gas supply and to monitor its components is increasing as the number and variety of sources grows along with their frequency of introduction into the natural gas pipeline network. The project will proceed on a phased approach, future supplies must be identified, and constituents of concern present in these supplies also need to be identified. For some new supplies such as landfill gas, research into gas trace constituents had already taken place, for others for example shale gas, less information exists. Once the constituents have been identified, instruments that can sense these constituents will be identified and assessed. The benefit of this work is the ability to monitor the composition of new gas supplies and the associated capability of protecting our distribution assets.

Environment. Projects in this area are focused on new technologies to more easily and cost effectively remediate MGP sites. A more recent focus in the Environment area is related to Climate Change Concerns.

M2001-002 – Management of Impacted Sediments The company formed and led this project, which was funded by other NYSEARCH members as well as a national consortium of industry and the US Navy. This project studied the correlation between polycyclic aromatic hydrocarbon (PAH) concentrations in manufactured gas plant (MGP) sites and the actual bioavailability of these compounds to living organisms, with the goal being more realistic guidelines for site remediation. Not all PAHs at MGP sites are actually bioavailable, and therefore harmful, to organisms and the environment. This project developed a new analytical method to determine actual bioavailability. Benefits include the potential of a greatly reduced remediation area. A final report has been submitted and accepted by the project funders as well as the USEPA, the NY State DEC and the NY State Department of Health. In February 2012 the NY State DEC issued a remedy decision based on the new analytical method for the city of Hudson NY (Water Street) company site. Savings realized for this one remediation are approximately $26M.

M2008-006 – Expanding the function of No Blow Tools. Tools to make "live" taps into gas mains are commercially available but during certain operations small amounts of blowing, or escaping gas are present. A set of innovative tooling was developed to enable plug insertion or removal, or insertion of stoppers. This benefits the environment by reducing the amount of methane (a greenhouse gas 21 times more potent than carbon dioxide) released into the atmosphere, and also contributes to worker safety. A second phase of the project developed an innovative method to reinject gas into an adjacent main segment rather than blow it off to atmosphere during a special test called a "flow test."

This method reduced greenhouse gas emissions and lessens customer concerns and complaints.

M2009-003 – Adaptation to Climate Change. The company and others recognize that there are two aspects to climate change, how we, through our methane and CO2 emissions, affect climate change, and how we, as LDCs, adapt to climate change effects and impacts that are certain to occur in the future. To meet this latter goal the Company and others commissioned a study that investigated a range of future climate models, predicted maximum and average expected temperatures and sea level rise, and developed a framework for estimating risk and remedial action to address those climate changes. The benefits of this project will be to give LDCs quantitative information on which climate effects and impacts to focus on and which portions of our natural gas infrastructure are most susceptible to those climate impacts. A final report has been issued and sea level rise has been identified as the main threat to a natural gas distribution system.

M2010-004 – Soil Vapor Intrusion The work in this project involves characterizing manufactured gas plant (MGP) coal tar vapors so that volatile organic compounds (VOCs) can be conclusively identified as either coming from an MGP or from some other source. For example, benzene, a constituent in coal tar, could also be present in a dwelling from common household sources. If compounds such as benzene are identified near a dwelling, current regulations require extensive sub-slab (below the basement or slab of a dwelling) sampling at a cost of $10,000 per dwelling. However, if MGP coal tar can be ruled out as the source of the contamination, less expensive investigations would be warranted.

M2011-004 – Carbon Calculator The Company has been voluntarily reporting fugitive methane emissions since the mid-nineties and is committed to reducing its carbon footprint. One component of that carbon footprint is carbon dioxide emissions resulting from normal construction activities. The intent of this project is to quantify the emission reduction that would result from choosing a less energy intensive method of construction. For example, there are two alternatives to installing a new gas main. The first is traditional open trench, where a trench 18 in wide by 3 ft deep is excavated along the proposed length of the installation. In an alternate method, the pipe may be installed via directional drilling. This latter method is quicker, uses less equipment for a shorter time, and eliminates the bulk of new paving that must be applied. But up until now there has been no way to quantify the reduction in emissions. This project involves quantifying the emissions that result from each step of the construction process.
NYSEARCH, together with the North American Society for Trenchless Technology (NASTT) is working with ETA/Environ, to develop the spreadsheet tool. In the first phase of the project, subject matter experts from the participating companies are quantifying types and time on the jobsite of various pieces of construction equipment used on various construction activities. Then, ETA/Environ will use the latest EPA “non-road” emission factors to compile emission rates for the various pieces of equipment. In the final step, ETA/Environ will create a robust, user friendly spreadsheet tool to enable

gas company managers to compare the carbon impact of alternative constriction practices.
There are several benefits from this project; determining the construction methods with the least environmental impact, validating the additional (environmental) benefit to public authorities who may be skeptical about the use of a newer or non-traditional construction technique; and it could allow the Company to be proactive in tracking and reporting (if required) these emissions.

OTD 7.9.d and 7.10.c – Improving Methane Emission Estimates for Natural Gas Distribution Companies. The Company and other LDCs have been voluntarily reporting fugitive methane emissions from their distribution systems under the US Environmental Protection Agency (EPA) "Star" Program since the 1990s. With the recent passage of EPA "Subpart W" LDCs are now required to report these emissions.
To report emissions from its piping network, which account for over 80% of the Company's fugitive emissions from its gas distribution system, the EPA allows the use of emissions factors, expressed in terms of cubic feet of methane per mile of pipe per year. Different pipe materials have different emissions factors. The factor is simply applied to the mileage of pipe in the system and total emissions are reported.
These emissions factors were developed in the early nineties via a testing and measurement program sponsored by the USEPA and conducted by the Gas Research Institute and subcontractors. The factors have never been updated and the Company and industry in general, are aware that the factor for plastic (PE) pipe is unrealistically high. For example, a similar study in the UK conducted in the early 2000s resulted in a leakage factor for PE pipe that is one half the value used in the US. PE piping systems are fabricated with improved materials and installed under better quality control than in the nineties, and the emissions testing program for PE pipe done then only contained six data points – for the entire nation!
Working through GTI and subcontractors, and with the knowledge of the USEPA, the Company and others are replicating the test methods from the previous study and attempting to develop a more realistic emission factor. Project funders (there are 18 LDCs participating) are identifying leaks in the field and the GTI team measures them. In parallel with conducting the leakage measurement (which involves exposing the leaking pipe segment) an alternate measurement technique is being applied which involves only surface measurement of leakage. If the two separate techniques agree, more field measurements can be taken with the less expensive surface measurement technique. Several field tests have taken place so far with others scheduled. After the PE leakage factor is revised, a second phase of this project will revise the factors for cast iron and bare steel pipe materials. The benefit of this project is more accurate reporting and a better representation of the company's contribution to greenhouse gas emissions.

Infrastructure Support. The following projects benefit overall company operations in areas such as safety, sensing and measurement, advanced material research, community and customer concerns, and general operations improvements.

M2002-008 – Oracle Project. Through the NYSEARCH research consortium, the Company and others fund a concept known as "Oracle." The purpose of this program is to look outside the gas industry for novel technology solutions to gas industry needs. In the past, technologies from the military, biomedical, and telecommunications industries have been tracked. More recently, our focus has been sensor technologies using fiber optics or nanotechnology, and material science advances. Applications from these industries, when identified, will be funded as separate projects.

M2009-002 - Mercaptan Sensor Development. To insure proper odorant levels in natural gas, LDCs are required to perform a periodic "sniff test." The human nose can detect odorant levels in the ppb range and if the gas is properly odorized this provides adequate warning to the public that gas is present at levels well below the "lower explosive limit" (LEL). However, sniffing by humans is subjective and technicians performing these tests can sometimes be desensitized to the odor of mercaptan. Also, the recently identified phenomenon called "odor masking" can cause the characteristic odor of mercaptan to change or disappear. This project aims to develop a sensor that can detect mercaptan in the ppb range. It would not replace the sniff test – which is required by code – but would supplement those tests, and would also be installed in areas where odor fade or masking is suspected, to verify that proper odorant levels are present.
The technical approach is a unique combination of standard gas chromatography and a relatively new technology called differential mass spectroscopy. This technology was discovered via the NYSEARCH "Oracle" project mentioned above. Feasibility testing has been successfully completed and a prototype instrument is being built. The benefit is advanced warning of possible odorant deficiencies.

M2010-002 – Methane MR Sensor. This project aimed to produce a novel type of methane sensor using the principle of micro-resonance. The theory behind the sensor is that micro-size tuning forks will vibrate at different frequencies when exposed to a methane/air environment than it would in free air. This concept was uncovered during a technology search undertaken as part of the "Oracle" project. The application for the sensor would be to alarm in a residence or industrial/commercial facility on high methane levels. The prototype sensor that was produced was not sensitive enough to be used for utility leak surveying operations. The company decided to withdraw from funding this project because of this, and also because the ultimate target price for the detector was too high to be able to reasonable compete with methane sensors on the market now. Very recently, the Company learned of significant progress made in the development of this technology that resulted in a target price significantly lower than was originally thought. Because of this development and because interest in this technology has been heightened by recent flooding events, the Company has rejoined the project.

M2010-003 – PCB Absorption in PE Piping. Every year the Company discards quantities of polyethylene (PE) pipe that have been removed from service because they have been damaged by third parties, or for other miscellaneous reasons. The Company ships such pipe to a special landfill that accepts PCB-contaminated pipe because there is no EPA-approved method for decontaminating PE pipe potentially exposed to PCBs. The Company determined that the same approved procedures used to clean and

decontaminate steel pipe may be applicable to PE pipe, if it can be proven that PCBs are not absorbed into the wall of PE pipe. Such testing has never been conducted for PE pipe. The Company, through NYSEARCH, engaged Jana Labs – a respected plastic pipe research and testing laboratory – to conduct this testing. The tests are underway with Jana. Pending a successful outcome of the test program, the Company will work with the USEPA to create a standard for cleaning and decontaminating PE pipe so it may be discarded in a normal fashion.

M2011-001 – Self Healing Pipe. Through the NYSEARCH "Oracle" Program, the Company has become aware of advances in material science through nanotechnology. Several concepts related to advanced materials were addressed and the two most promising were self locating pipe (pipe containing materials that would respond to conventional above ground locators, thereby solving the problem of broken or malfunctioning tracer wire) and self healing pipe. (Self locating pipe was discussed among NYSEARCH members and the group, after careful consideration, decided not to pursue that technology at this time.)

The Company and other NYSEARCH members want to explore further the concept of self healing pipe so this project was authorized. Our investigations indicated that the addition of different types of nanoparticles into polyethylene (PE) material can enhance its mechanical or electrical properties. One type of adder can actually induce self-healing capabilities in the base PE material. A crack in the material will release a bonding agent and lab experiments conducted by others show recovery of up to 75% of tensile strength of the base material.

The Company wants to pursue this further and feasibility discussions with manufacturers will commence. This is a long term project with ultimate benefits realized perhaps 25 years into the future. The project will be carefully monitored and will proceed in phases. Reduction in distribution pipeline incidents due to damage is the benefit of this research.

OTD 5.6.e – Portable Propane Air Temporary Residential Supply, Phase II

Many routine gas operations require temporary disruption of service to customers. Replacement of aging gas mains requires a brief interruption while the service is transferred from the old main to the new main. Meter change activities also require a brief shutdown. Rehabilitation techniques such as cured-in-place lining can require an outage lasting 12 hours or more. In such cases compressed natural gas (CNG) bottles can be used but they are heavy and cumbersome.

The propane air mixer has been under development since 2006. It mixes propane from a standard gas bar-b-cue tank with air and delivers the mix at the proper heating value. A prototype was built by GTI engineers and subjected to extensive operational and end use testing, including local field testing in Chicago. Tests were successful with the exception of results with one particular brand of water heater, which shut down on high flame temperature.

Phase II of this project will redesign the unit to produce a cooler flame and the testing will be repeated on a mix of appliances. Firing rate, flame temperature and emissions will be recorded. If the testing is successful (meaning all appliances performed within spec on all tests) then a new phase of the project will investigate commercialization of the unit. The benefit is better customer service using a more efficient and ergonomic method.

OTD 3.8.a - Addressing Jackhammer Noise Abatement. In urban areas of the Company's territory there is increasing pressure from city officials to lower the noise of commonly used construction equipment. Evening and weekend work, such as is required for emergency response work, only amplifies this need.
Pneumatic jackhammers are among the noisiest of commonly used construction equipment. National Grid, in New York City, experimented with insulated fabric jackets that are placed around the jackhammer and while these helped to reduce noise levels, a more permanent solution is desired. The Company and others are working through GTI to try to engage jackhammer manufacturers to examine the design of a typical jackhammer to see if there is any opportunity to reduce the noise produced.
It is recognized that noise from a jackhammer is produced from three distinct sources, the internal piston operating inside the cylinder, the air exhaust, and the bit striking the pavement.
The objective of the project is to engage manufacturers and determine whether they are open to a basic redesign effort of their tools to make them less noisy.
GTI identified several manufacturers but only one was willing to attend a meeting to discuss the intent of the project. As a result, the project will most likely not proceed to Phase 2, which would have involved detailed noise analysis and would have served as the basis for a redesigned jackhammer.

OTD 5.9.c - Mitigating Electrical Interference on Cathodic Protection Systems.
Electrical interference can impair or negate the effect of cathodic protection systems. The objective of this project is to understand the types of interference that can be present near pipeline systems and make recommendations to mitigate the effect of these interferences. Interferences can be steady state, such as would be present from adjacent high voltage power lines, or transient, caused by a lightning strike or power line surge.
To implement the project, GTI selected three host sites and installed data logging instrumentation on cathodic protection systems there. Transient events and steady state interference data is being gathered. The results of the data gathering exercise will be recommendations for enhanced equipment or better surveillance of cathodic protection systems to better protect them. Enhanced integrity of piping systems protected by cathodic protection is the benefit of this research.

OTD 5.9.f – Cathodic Protection Monitor. The objective is to develop and deploy a Cathodic Protection Monitor prototype that stores monthly CP readings. GTI has partnered with 3M to develop a completely encapsulated, direct burial monitoring device. A 3M handheld locator/reader is used to retrieve the readings electronically from above ground without requiring a direct connection. The data, consisting of 12 sets of monthly readings, can be downloaded from the handheld devices as tabular data. The first version of the CP Monitor has been successfully tested; as a result of testing additional product requirements were identified.
The objective of Phase 2 is to develop and test a modified CP Monitor prototype with some or all of the following features: ability to record AC potential readings to detect stray currents, increased data storage, improved range with the ability to capture readings from a moving vehicle, programmable data recording intervals, and ability to transfer

data to other handheld devices via Bluetooth for direct GIS integration. The benefit is improved monitoring of CP performance on protected piping, with the potential cost savings of making mobile readings

OTD 2.9.c - Field Applied Pipeline Coatings. Modern pipe materials are factory coated and these coatings stand up very well as long as they are not damaged by external forces. However, in locations where field welds or other field installed fittings are present, the necessary pipeline coating needs to be field applied. Field applied coatings vary in quality and are not always installed under ideal environmental conditions such as would be present in a pipe coating factory. This project tested the performance of several different types of coatings on buried pipe at Gas Technology Facilities in Chicago.
Throughout the world, a variety of generic coating systems are commonly applied to field girth welds, including the following: (1) fusion bonded epoxy (FBE), (2) heat shrink sleeves (HSS), (3) liquid applied coatings, (4) composite systems, and (5) tapes/wraps. Eighteen (18) manufacturers supplied seventy-five (75) different coating systems for the test program. The coatings were installed by the manufacturers on a network of 8" and 24" steel piping buried in rocky, sandy, and clay-like soils.
Coating systems were unearthed and examined at 2, 5, and 7 year intervals. Some coatings exhibited no rust on any of the pipes in any soil, and other coatings exhibited rust on pipe in all soil. A key conclusion of the test program is that strict adherence to the manufacturers' recommended installation procedures is absolutely necessary. A final report on project results has been prepared. The benefit is improved pipeline safety and assurance that superior products, from a long term performance point of view, are installed on company facilities.

OTD 5.9.j - Gas Distribution Model. With Distribution Integrity Management Program (DIMP) regulations now in place, operators will be developing data collection strategies to ensure compliance. One tool that could help operators in this process is a non-proprietary, industry standard data model for distribution assets and operations. A standard data model, the Pipeline Open Data Standard (PODS) model was developed to assist transmission operators in managing their data and ensuring regulatory compliance. The PODS model is an open, industry-standard data model that has successfully been used for over ten years to reduce the cost of implementing software and improve interoperability for the pipeline industry.
Now with DIMP there is a similar need for an industry-standard data model for distribution assets and operations. Gas Technology Institute (GTI) initiated a program to develop the Gas Distribution Model (GDM) to meet this need with three specific purposes. First, the model will be used as a data exchange function between operator data models and vendor's software products to reduce the need for customization. Second, the model can store both transmission and distribution data and will facilitate vertical data integration. Third, GDM could be used as the primary data model for operators to avoid the need for internally developing a model. The Company engineers and IS personnel felt that such a data model would benefit the business and also would facilitate transition to the new SAP system.
The GDM initiative brought together a diverse group of operators, vendors, and industry experts to collaboratively develop a GIS-neutral model that holds promise to reduce the

cost of software implementation and improve interoperability. GDM is a flexible model that will grow and expand with continued use and development.

OTD 5.9.k – Low Impact Marking Study. Prior to excavation, underground facility owners are required to mark out their facilities. In certain parts of The Company's territory there is significant pressure to remove these marks after the excavation work is complete. This study was undertaken to evaluate and select a markout paint that would fade on its own, thereby eliminating the need to return to the excavation site and physically remove the marks. A final report was issued listing various acceptable marking paints ranked by degree of permanence. If needed in isolated circumstances the company could select a less durable paint that would serve the purpose of markout but would fade relatively quickly and lessen customer complaints.

OTD 5.11.a – Dewatering System for Mains. Excessive amounts of water in gas mains can cause service outages. This "water intrusion" is particularly prevalent in low pressure areas where groundwater can enter into a gas main through leaky joints in high water table areas. The normal solution is to locate the area of water intrusion and pump the water out. This project is investigating novel methods to remove residual moisture that can be present even after water is pumped out. Two methods that have been investigated are dessicant and molecular sieve technologies that can more permanently dry out the interior of a gas main, and chemical additives such as methanol foam which can allow moisture to flow out of low points and not collect there. Once the feasibility of such methods is evaluated, the next step in the project will be to decide whether the successful technology can be adapted to installation on a gas distribution system. This project will decrease the amount of customer outages in areas prone to water intrusion.

OTD 5.11.n – Quality Control Procedure for High Potential Anodes. The Company recently has been experiencing quality problems with magnesium anodes as delivered from manufacturers. Anodes that appear – upon visual inspection – to be sound have been experiencing premature failures in the field. Quick and simple voltage tests may initially reveal that the anode is generating the required voltage potential but this may be indicative of good quality of the surface layer of the anode only. If the entire anode is not of the same quality and purity the anode will deteriorate prematurely. The standard industry test for measuring anode purity, ASTM G97, is expensive and time consuming and it is not practical to conduct this test for all new anodes received. Therefore, there is an industry need for a quicker test that can validate the requisite quality and purity of anodes. GTI has received anodes from project participants and is currently evaluating alternate methods of testing them that can give results similar to the G97 test. As an indication of the need for this project, GTI reports that the project has experienced delays due to the time consuming nature of the G97 test, which is being performed in parallel as a control. The benefit is better assurance of the quality of materials received and installed in the company's gas system.

OTD 5.11.w – Ignition Testing of Electronic Devices. When responding to or repairing a gas leak, company procedures require all electronic devices such as cell phones and pagers to be shut off if the device is not certified explosion proof or intrinsically safe. The

Company and others desired to know whether in fact such non certified devices could cause an ignition if they were operated in an explosive mixture of natural gas and air, which is anything between 5% and 15% gas concentration in air.
GTI obtained cell phones and pagers that are in use today at the LDCs who funded the project. Using an outside lab, the devices were all tested in an 8% gas/air mixture (8% is the optimal concentration for ignition). Devices were tested in both normal operating mode and in failure, or "short circuit" mode, such as would occur if a device were dropped and the battery became disconnected and generated a spark. No device caused ignition. The benefit of this work is increased knowledge of the risk of using these devices in hazardous areas.

OTD 5.12.b – Development of a Portable Flash Fire Suppression System. During live gas operations the potential for rapid ignition of natural gas (a flash fire) is present. Although workers follow strict safety procedures and are protected with fire retardant clothing and breathing air apparatus, bodily harm can occur within milliseconds if an ignition were to occur. A true industry need exists for a system that can rapidly detect and extinguish flash fires.
The project was initiated in GTI's Sustaining Membership Program (SMP). Two separate and distinct challenges were investigated, the ability of a sensor to detect a flash fire in less than ½ second, and the ability of a fire suppression system to limit injury as low as is reasonably achievable. In testing at GTI facilities both concepts were proven; a UV detector reliably detected fires within 30 milliseconds, and two separate suppression systems, high velocity air, and nitrogen extinguished the fire but each had some drawbacks needing further investigation.
The Company is extremely interested in this project and Safety Dept. personnel will act as advisors to the GTI project team. A successful outcome of the project will be a portable flash fire suppression system that will effectively detect and extinguish flash fires should they occur and be simple to deploy. Enhanced worker safety and avoidance of serious or even fatal injuries is the obvious benefit of this research.

OTD 5.12.g – Evaluation and Adaptation of Kleiss Inflatable Stoppers for the US Natural Gas Industry. Current line stopping equipment in the natural gas industry has been used since inception (~ 50 years) in the same trim without substantial re-design. This equipment certainly works but is heavy, costly to maintain, and is somewhat time consuming and labor intensive when the installation of the necessary components required are taken into account. New line stopping equipment that may reduce these problematic issues, while providing the same assurance of safety and performance, could contribute to substantial time and money savings when incorporated into day-to-day operations. Through a technology search such equipment was sourced. This apparatus is produced by a European Vendor, Kleiss and Co., and has shown promising performance. The objective of this effort is to evaluate these existing medium and high pressure inflatable stoppers as an alternative to currently employed stopping equipment for use on US natural gas distribution systems. GTI will test and evaluate this inflatable stopper suite of tools (capable of stopping off line pressures of 60 psig at pipe diameters up to 24-inches). Deliverables include the development of testing criteria and a program to evaluate the current offering. In addition, it will identify the necessary modifications to

the bagging system(s) and identify deployment fittings required to meet the US natural gas industry standards so that the system may be introduced and deployed for use in the US.

OTD 5.12.n – Advanced Tools for Improved AC Corrosion Prevention and Mitigation. Alternating Current (AC) corrosion is not common but can occur if gas mains are in proximity to railroads or overhead electric transmission lines. When it does occur, the corrosion rates can be rapid, thus the need for the Company to quickly identify and mitigate the occurrence of AC corrosion. The company is working with GTI on this project and they have proposed a two part solution, a model to predict rates of AC corrosion, and a calculator to determine the most effective mitigation measure. The project will draw heavily on existing work done by the National Association of Corrosion Engineers (NACE) and the Company's and other funders' experience. The final deliverable of the project will be the model and calculator, which can be used to prioritize inspections and gauge the impact of various mitigating measures on both new and existing gas pipelines.

OTD 5.12.o – Guidelines for Cast Iron Winter Operations. The Company and others want to know the best methods for determining when to initiate winter frost patrols on their cast iron (CI) piping systems. Simply starting the patrols when the ground temperature or air temperature reaches a certain limit may not be optimum. There are other factors, in addition to temperature, which may influence the propensity of CI piping to break in frost conditions. Some of these factors are diameter and pressure of the main, age, soil type, and presence of other adjacent underground facilities. The ultimate deliverable of the project is a practical guideline for operators as to when to initiate frost patrols.
GTI was selected to perform the study and is investigating – through examination of LDCs' records - the frequency of breaks in the presence or absence of the potential breakage factors. The study is not complete but has already determined that diameter is a key variable and that most breaks take place on smaller diameter piping and, at least for one LDC, there is no record of breakage for pipelines larger than 18" diameter. As more data is accumulated and analyzed patterns like this should emerge. The end result should be a fact-based guideline, based on the above parameters that affect breakage, stating exactly when, and for which segments, winter frost patrols should begin.

OTD 6.a - Sustaining Membership Program. The Sustaining Membership Program (SMP) is a program of long term research administered and performed by the Gas Technology Institute (GTI). SMP programs address basic, more fundamental research and the goal of SMP research is "Proof of Concept." SMP projects fall into three categories, delivery, or operations projects; environmental projects, and end use. The Company funds the SMP program through Millennium funds. Because of this, the Company does not direct any of its funding to any end use projects within SMP because end use research is specifically prohibited by terms of the Millennium Order 99G1369. Successful SMP projects may receive further funding through the OTD program to develop the concept into a commercial product.

Over the years (and prior to the Company's involvement) the SMP program research has resulted in over 40 patents issued. More recently, the Metallic Joint Locator, which originated in the SMP program, was commercialized and will be put to use in the Company's operations.
In the previous two years the Company funded the following projects:

1. Low power sensors that can capture and store data in remote areas where electric service is not available.
2. Flash fire extinguishing system that can sense and extinguish a gas ignition in milliseconds. Proof of concept was successful and this project has been moved to OTD to develop it commercially.
3. A sensor to detect coating disbondment on buried steel piping. Disbondment is a precursor to external corrosion and the detector could give advance warning of this
4. Options for repairing leaks on mechanical couplings that would not require that the coupling be cut out.
5. Investigations into wireless connectivity for the future gas smart grid
6. Remote condition monitoring of pipelines, consisting of sensors that can monitor cathodic protection levels, or detect vibration or impact to the pipeline, and transmit this data over long distances using the pipe as a signal carrier.
7. Investigations into chemical treatment of gas to mitigate odor fade in new gas pipelines
8. Investigation into a novel method of joining PE gas pipe by a method known as ultrasonic welding
9. Investigation into methods to internally "boost" the pressure in low pressure gas mains during periods of high demand
10. Early stage research into a method to convert CO2 into methane (environmental project)
11. Better methods to digest biomass (environmental project)

OTD 6.6.a - Keyhole Consortium. This GTI program develops continuous improvements and innovations to small hole (keyhole) technology. Keyhole excavations involve 18" diameter road openings to perform many routine operations that would traditionally require a 4 ft x 4 ft opening. Soil is vacuumed out and work takes place from street level using special long handled tools. This reduces paving costs and in many cases the 18" core is reused – set back in the excavation so there are no paving costs associated with the work.
The Keyhole Consortium meets twice yearly; Company representatives attend with other LDCs and manufacturers. At the meeting common issues and needs are discussed and new research ideas are generated.

National Grid Managed Projects

National Grid funds projects outside the NYSEARCH and OTD consortia and manages them ourselves or jointly with other LDCs. The following two projects are jointly funded and managed between National Grid Downstate and Consolidated Edison Co (Con Ed)

M2001-009 - Construction Interference Cost Reduction (CONCORD) Program. National Grid and Con Edison, along with the Urban Utility Center of Polytechnic Institute of New York, are working with New York City to introduce trenchless technologies to the city's construction program. Trenchless technology – as compared to traditional "open cut" construction – can save National Grid and Con Edison significant dollars by eliminating the need to relocate our gas facilities if they interfere with the city's new construction. We have introduced new trenchless technologies to the city's engineers, conducted training programs, performed lab testing, and these efforts have culminated in New York City's decision to rehabilitate two miles of a major water main in Manhattan via a trenchless method. This method involves insertion of a plastic liner into the existing cast iron water main and few adjacent gas facilities will need to be relocated. Con Ed estimates significant savings. If this program is successful and NY City adopts trenchless technology for future construction, the savings to National Grid and Con Ed could be significant for years to come.

M2002-015 Cast Iron Sealing Robot (CISBOT): National Grid and Con Edison jointly fund and manage this project to design, construct and test a live, tethered robot that will internally seal cast iron joints. National Grid has the highest inventory of cast iron pipe in the nation, over 6000 miles, with over 2600 miles in the State of New York alone (Source, US DOT report). Cast iron is a very durable material but over time the joints – mechanical connections packed with jute and lead – can dry out and are the source of leakage. National Grid's predecessor company, KeySpan, partnered with Con Edison of New York to jointly fund the development of CISBOT. The robot was built by ESI Corp of Toronto, Canada. Upon completion of the robot Con Ed and National Grid entered into an agreement with ULC Robotics, a small high tech firm located on Long Island, to 'commercialize' the device and ultimately become the service provider for the CISBOT services. This is a typical business plan for high tech deployment in the gas distribution sector; ULC Robotics performs this type of work as their main line of business. To date, National Grid has spent over $2.2 Million on the project, with a similar amount funded by Con Edison. CISBOT is designed to seal joints in 16" through 36" diameter cast iron gas mains operating at pressures up to 25 psi. An excavation will be dug at a convenient point along the gas main and a special fitting is installed on the main which allows a 12" opening to be cut into the main in "live" conditions with no shutdown required and no blowing gas. (This is a fairly common procedure in the gas industry.) The CISBOT robot is then inserted into a launch tube and the launch tube is attached to the fitting on the main. The launch tube is purged of air with nitrogen and then a valve is opened and natural gas fills the launch tube. The robot is then lowered into the gas main. A tether connects the robot with external power and communication, and a small tube in the tether contains the anaerobic sealant which is used to seal the joints. An operator drives the robot using onboard cameras as a guide and stops at the first joint. A small hole is then drilled into the joint at a predetermined spot. Once the hole is drilled, a nozzle is inserted up into the drilled hole and anaerobic sealant is pumped into the hole, saturating the joint. Cameras on the robot are positioned to view the wicking action of the anaerobic fluid and pumping is stopped when the operator judges that a particular section of the joint is filled with sealant. The robot is then repositioned to a different "clock position" around the

circumference of the joint and the drilling and sealing operation is repeated. Once the operator judges that the joint is sealed the robot will travel down to the next joint and the process is repeated.
CISBOT is undergoing an extensive program of field demonstrations over the past three years in New York City and Boston. Costs for the demonstrations outside NY State are borne by the area conducting the demonstration. In parallel with the demonstrations, the Company and Con Edison are negotiating a Commercial License with ULC Robotics. The cost of the service will be determined by ULC Robotics prior to their offering the service as a commercial business. National Grid NY and Con Ed will receive a discount from the stated list pricing. Because the final cost of the service has not yet been determined, it is difficult to accurately predict savings but assumptions can be made. The basis for our assumed savings of $2.5M annually is to assume that CISBOT is deployed to a main segment where 50% of the joints are or will soon be leaking. Per job that's about 15 joints at an estimated cost of $3000 per joint to repair, total cost $45,000. This figure can vary depending on the final pricing structure set by ULC Robotics. Standard repair including a tight sheeted pit is estimated at $20,000 per repair for total repair cost of $300,000. Actual costs for tight sheeted pits in congested urban areas have been reported as much higher but this is a conservative estimate. Based on these assumptions the net savings is about $255,000 per job. Assuming full successful deployment of CISBOT, 10 such jobs per year could be performed, resulting in annual savings of $2,550,000.
National Grid expects to deploy this technology in its large diameter cast iron mains in New York State and Massachusetts. Any royalties received will be returned to NY ratepayers through the Millennium Fund.

The following two projects are funded and managed by National Grid alone:

M2009-007 – Particulate Dispersion Study. Gas supplies entering pipeline systems from transmission companies have become substantially “dryer” over the past decade. While gas delivered to customers is “commercially free” of objectionable materials as defined in AGA Report 4A, mature distribution systems have been “drying out” resulting in the potential for trace amounts of dust to become mobile in the distribution. This phenomenon has been verified by observations of small amounts of dust and debris found in regulator station filters and in some isolated cases, in dirt legs and filters of some end use customers. When dust was sampled, in some cases, PCB contamination was detected in addition to other organic and inorganic materials. The goal of this project is to better understand the potential of dust migrating within a distribution system and ultimately reaching the customer. The project is essentially complete including a detailed risk assessment of the potential of dust impacting downstream combustion processes. In summary, this research and associated risk assessment has determined that trace amounts of dust pose no risk to downstream combustion processes, confirming similar results of that provided by the NYSDOH in the 1980s when assessing potential PCB gas liquid impacts at the burner tip.

M2010-005 – Guided Wave Test Program. The Company has been conducting research to evaluate the usefulness and limitations of guided wave testing for cased pipe. At the

onset of this evaluation, there was not a great deal of data available to determine when and where guided wave testing would be feasible. Our gas transmission system consists of a variety of casing applications most of which cased locations are unpiggable.
Prior research suggested that coating type is a limiting factor in guided wave results. Coal tar coatings in particular were suspected of being highly attenuating (with only 5-10 feet being successfully assessed).), Wax filled casings would also be particularly challenging to assess. The industry was hesitant to use guided wave based on previously available information and assumptions. As a result, the Company performed a study of various factors that may affect the length of pipe tested when using guided wave. Our main findings were that removing a circumferential band of coating and exposing the pipe surface down to bare metal before and after the casing ends extends the guided wave test range significantly. Pipe diameter, piping run configuration, spacers, fill, anomalies and ambient temperatures also impacts the testing range (length). Validation of test quality and results were developed into a formal procedure submitted to PHMSA as "Other Technology Notification" for the use of guided wave testing as an assessment method. The Company has completed the testing of over 55 cased locations with guided wave, with over 50 sites being tested over their full length. Successful tests ranged from a maximum of 190'-9" on a single shot between 2 sections cut from a single cased pipe on a 8" Xtru-coated pipe within a 12 inch casing, down to 17'- 11" test range from one side of a 20 inch thickly coated coal tar pipe inside of a 24 inch casing. Our conclusion is that guided wave can add significant value as a means to assess cased pipe; however, knowing the factors that impact testing ranges will help operators and industry to use it most effectively as a viable option for the assessment of cased pipe without service interruptions. This option is significant to completing integrity assessments on DOT transmission system and containing operators' and ratepayers' costs.

Attachment 2 shows spending for these projects described above.

Attachment 1

Attachment 1

National Grid Gas R&D Spending

Includes Ngrid Downstate (KeySpan) and Ngrid Upstate (NMPC)

Calendar Year Expenditures ($)

	Actual		Projected		
Year	**2011**	**2012***	**2013**	**2014**	**2015**
National Grid Internal Program					
Utilization	$ 15,018	$ 4,257	$ -	$ -	$ -
Operations	$ 241,322	$ 158,864	$ 263,000	$ 263,000	$ 263,000
TOTAL INTERNAL	**$ 256,340**	**$ 163,121**	**$ 263,000**	**$ 263,000**	**$ 263,000**
National Grid Millennium Program					
NYSEARCH Projects	$ 946,104	$ 1,632,544	$ 1,571,000	$ 1,687,000	$ 1,150,000
OTD Projects	$ 750,000	$ 480,000	$ 750,000	$ 750,000	$ 750,000
National Grid Projects	$ 996,142	$ 31,725	$ 650,000	$ 650,000	$ 450,000
TOTAL MILLENNIUM	**$ 2,692,246**	**$ 2,144,269**	**$ 2,971,000**	**$ 3,087,000**	**$ 2,350,000**
TOTAL MILLENNIUM AND INTERNAL	**$ 2,948,586**	**$ 2,307,390**	**$ 3,234,000**	**$ 3,350,000**	**$ 2,613,000**
NYSERDA Assessment	$ 3,565,124	$ 3,248,508	$ 3,250,000	$ 3,250,000	$ 3,250,000
TOTAL R&D PROGRAM	**$ 6,513,710**	**$ 5,555,898**	**$ 6,484,000**	**$ 6,600,000**	**$ 5,863,000**

*Note: Actual spend for 2012 reflects data through October 2012. The report will be supplemented when November and December data becomes available.

Attachment 2

Attachment 2
National Grid RD&D Report
Spending on Active Projects
Calendar Year

PROJECT NUMBER	PROJECT	START DATE	END DATE	TOTAL NGRID COMMITMENT	TOTAL SPEND 2011	TOTAL SPEND 2012*	TOTAL NGRID SPEND ALL YEARS
M-2000-001	Variable length sleeve - NYSEARCH	2000	2013	$ 147,356	$ 22,877	$ 4,407	$ 111,970
M-2001-002	Mgmt of Impacted Sediments - NYSEARCH	2001	2011	$ 396,370	$ 13,819	$ -	$ 430,061
M-2001-003	Cased Pipe Risk Assessment Model	2001	2011	$ 274,472	$ 38,071	$ 5,446	$ 184,501
M-2001-005	PipeHawk Hand-Held Pipe Locator - NYSEARCH	2001	2013	$ 435,090	$ 3,015	$ 38,578	$ 392,895
M-2001-009	Interference Avoidance/UUC Technology Demo Lab	2001	2010	$ 475,000	$ 36,000	$ 10,000	$ 446,000
M-2001-014	InspectionTool for Unpiggable Facilities - Automatika	2001	2011	$ 967,261	$ 118,646	$ 36,338	$ 959,781
M-2002-008	Technical Expert (Oracle) to ID Quantum Leap Technolog	2002	2012	$ 35,534	$ 10,494	$ 6,379	$ 29,396
M-2002-015	CISBOT-Live IP CI Joint Sealing (KSE/ConED/ESI/ULC)	2002	2011	$ 2,356,825	$ 825,102	$ 12,650	$ 2,219,476
M-2002-018	Infrasonic Sensor for Remote Pipeline Monotoring - NYSE	2002	2010	$ 129,711	$ 2,687	$ -	$ 104,858
M2003-009	Explorer II	2003	2012	$ 483,030	$ 255,746	$ 21,060	$ 451,452
M2005-005	Gas Interchangeability for LDC Infrastructure	2005	2014	$ 753,336	$ 41,144	$ 32,076	$ 644,948
M2006-002	Butt Fusion Joint Integrity	2006	2011	$ 70,198	$ 20,639	$ 13,035	$ 53,213
M2007-001	Mini-camera for Cased Crossings	2007	2012	$ 150,932	$ 44,108	$ 13,990	$ 228,563
M2007-003	Multi Technology Validation Testing for Cased Pipe Applic	2007	2013	$ 73,315	$ -	$ 1,147	$ 49,676
M2007-005	Testing Program for Remote Inspection-Transkor	2007	2012	$ 133,080	$ 33,031	$ 20,421	$ 75,901
M2007-007	Technology Advancement in Damage Prevention Tools ar	2007	2011	$ 91,973	$ 19,150	$ 7,488	$ 64,243
M2008-001	Third Party Detection - Magal	2008	2013	$ 58,297	$ 4,974	$ 7,457	$ 29,419
M2008-006	Expand Function of No Blow Tools to Reduce GHG	2008	2012	$ 122,329	$ 22,781	$ 31,040	$ 82,078
M2008-010	UV Degradation of PE Pipe	2010	2013	$ 14,125	$ -	$ 8,070	$ 8,070
M2009-001	Holistic Review of DIMP Practices and Models	2009	2012	$ 48,750	$ 28,342	$ 5,791	$ 44,409
M2009-002	Mercaptan Sensor Development	2009	2012	$ 330,462	$ 144,031	$ 33,429	$ 266,030
M2009-003	Adaptation Study	2009	2012	$ 23,500	$ 10,070	$ -	$ 23,500
M2009-007	Particulate Dispersion Study	2009	2011	$ 75,000	$ 12,832	$ -	$ 60,516
M2009-008	Ultrasonic Evaluation System for PE Butt Fusion	2009	2014	$ 133,700	$ -	$ 2,079	$ 2,079
M2010-001	Service Tee Renewal	2010	2012	$ 73,170	$ -	$ 20,118	$ 20,118
M2010-002	Methane MR Sensor Development	2010	2012	$ 27,545	$ 23,265	$ -	$ 23,265
M2010-003	PCB Absorption in PE Piping	2010	2013	$ 194,000	$ -	$ 121,228	$ 121,228
M2010-004	Soil Vapor Intrusion	2010	2012	$ 83,100	$ -	$ 43,877	$ 43,877
M2010-005	Guided Wave Test Program	2010	2012	$ 175,000	$ 121,361	$ -	$ 95,082
M2011-001	Self Healing Pipe	2011	2013	$ 89,320	$ -	$ 7,397	$ 7,397
M2011-002	Storage Effects on Gas Quality	2011	2013	$ 26,555	$ -	$ 12,628	$ 12,628
M2011-003	Odor Masking	2011	2013	$ 126,695	$ -	$ 23,158	$ 23,158
M2011-004	Carbon Calculator	2011	2012	$ 24,450	$ -	$ 12,236	$ 12,234

PROJECT NUMBER	PROJECT	START DATE	END DATE	TOTAL NGRID COMMITMENT	TOTAL SPEND 2011	TOTAL SPEND 2012*	TOTAL NGRID SPEND ALL YEARS
M2011-005	Fiber Sen System Development and Testing	2011	2012	$ 71,248	$ -	$ 6,316	$ 6,316
M2011-006	Robotics Supporting Technologies	2011	2014	$ 696,891	$ -	$ 152,941	$ 152,941
M2011-007	Cased Pipe Inspection via Vents	2011	2014	$ 146,135	$ -	$ 41,630	$ 41,630
M2011-008	BioBall Test Program	2011	2013	$ 37,630	$ -	$ -	$ -
M2011-009	Explorer 30 - 36"	2011	2013	$ 500,000	$ -	$ 435,500	$ 435,000
M2012-001	Development of Corrosion Sensor Array	2012	2013	$ 22,515	$ -	$ -	$ -
M2012-003	Enterprise Level Assessment of Data Management Syster	2012	2014	$ 33,900	$ -	$ -	$ -
OTD 1.11.a	Chemical Methods to detect crossbores	2011	2011	$ 2,870	$ 15,000	$ (12,130)	$ 2,870
OTD 1.11.c	Low-Cost MEMS Methane Sensor Platform Phase 1	2011	2011	$ 30,000	$ 30,000	$ -	$ 30,000
OTD 1.11.e	Cross Bores - National Database and Risk Model	2011	2013	$ 35,000	$ 20,000	$ 15,000	$ 35,000
OTD 1.12.b	Cross-Bores Detection Using Mechanical Spring Attachment	2012	2014	$ 10,000	$ -	$ 10,000	$ 10,000
OTD 1.8.a	Excavator Encroachment Notification System	2008	2012	$ 49,936	$ 25,000	$ 33,333	$ 134,269
OTD 1.8.f	Electromagnetic and Acoustic Obstacle Detection	2004	2011	$ 24,599	$ 11,594	$ -	$ 24,599
OTD 1.8g	Acoustic Sewer Lateral Locator	2008	2012	$ 39,002	$ 33,987	$ -	$ 72,989
OTD 1.9a	GPS Leak Survey Ph II	2009	2013	$ 30,000	$ 61,780	$ -	$ 121,780
OTD 1.h and 1.10.c	Hand Held Acoustic Pipe Detector and tech transfer	2003	2012	$ 287,260	$ 10,000	$ 5,300	$ 287,260
OTD 2.11.a	Leaks	2011	2013	$ 40,236	$ 15,000	$ 25,236	$ 40,236
OTD 2.11.d	RSD X-Ray for Metallic Pipe Assessment - Testing and Validation	2011	2012	$ 20,000	$ -	$ 2,632	$ 20,000
OTD 2.8.e	Structural Liners and Sleeves - Technology Search	2008	2013	$ 12,132	$ 2,132	$ -	$ 12,132
OTD 2.9c	Field Applied Coatings	2009	2012	$ 40,000	$ 20,000	$ -	$ 67,000
OTD 3.8a	Jackhammer Noise Abatement Issues	2008	2010	$ 20,000	$ 15,000	$ 1,463	$ 36,463
OTD 3.9a	Backfill Evaluation & Ecoroads	2009	2012	$ 24,295	$ 384	$ -	$ 30,869
OTD 4.11.f	Understanding Threat Interactions for Risk Analysis (GTI)	2011	2013	$ 30,000	$ 15,000	$ 15,000	$ 30,000
OTD 4.12.b	Correlating Pipeline Operations to Potential Crack Initiation Growth Arrest (GTI)	2012	2014	$ 30,000	$ -	$ 30,000	$ 30,000
OTD 4.7.g	Yield Strength	2007	2012	$ 25,172	$ 15,000	$ 10,172	$ 25,172
OTD 4.8.i	Extended Reassessment Interval Validation Through Dielectric Wax Casing Fill	2008	2012	$ 58,929	$ 2,467	$ 3,728	$ 58,929
OTD 4.9a	Leak vs. Rupture Boundary	2009	2012	$ 27,422	$ 2,700	$ 10,000	$ 68,048
OTD 5.10.f	Cold Assisted Pipe Splitting (CAPS), Phase 1	2010	2012	$ 46,615	$ 21,615	$ -	$ 46,615
OTD 5.11.a	Dewatering Systems for Mains	2011	2013	$ 66,927	$ 40,000	$ 26,927	$ 66,927
OTD 5.11.m	Intelligent Utility Installation Process	2011	2014	$ 68,953	$ 25,000	$ 43,953	$ 68,953
OTD 5.11.n	Quality Control Procedure for High Protential Anodes	2011	2013	$ 40,884	$ 33,118	$ 7,766	$ 40,884
OTD 5.11.w	Ignition Testing of Electronic Devices	2011	2012	$ 7,172	$ 7,172	$ -	$ 7,172

PROJECT NUMBER	PROJECT	START DATE	END DATE	TOTAL NGRID COMMITMENT	TOTAL SPEND 2011	TOTAL SPEND 2012*	TOTAL NGRID SPEND ALL YEARS
OTD 5.12.b	Development of a Portable Flash Fire Suppression System (PFFSS)	2012	2014	$ 20,000	$ -	$ 20,000	$ 20,000
OTD 5.12.g	Large Diameter Medium Pressure Inflatable Stoppers Evaluation of Kleiss System for the U.S. Natural Gas Industry	2012	2014	$ 20,000	$ -	$ 20,000	$ 20,000
OTD 5.12.n	Advanced Tools for Improved AC Corrosion Prevention and Mitigation	2012	2013	$ 35,000	$ -	$ 35,000	$ 35,000
OTD 5.12.o	Guidelines for Cast-Iron (CI) Winter Operations	2012	2013	$ 60,000	$ -	$ 60,000	$ 60,000
OTD 5.6.e	Propane Air	2006	2013	$ 55,211	$ -	$ 20,000	$ 75,211
OTD 5.8e	Gas Material Traceability	2008	2012	$ 20,000	$ 17,500	$ 42,000	$ 77,008
OTD 5.9.f	CP Monitor	2009	2012	$ 25,000	$ -	$ 25,000	$ 25,000
OTD 5.9c	Mitigating Elec. Interference on Cathodic Protection Syste	2009	2012	$ 69,996	$ 10,556	$ -	$ 80,522
OTD 5.9j	Gas Distribution Model	2009	2012	$ 30,000	$ 43,600	$ -	$ 103,600
OTD 5.9k	Low Impact Marking Study	2009	2012	$ 25,000	$ 7,404	$ -	$ 50,261
OTD 6.6.a	Keyhole Consortium - GTI	2006	2012	$ 60,000	$ 20,000	$ -	$ 60,000
OTD 6.a	Sustaining Membership Program - GTI	2003	2012	$ 152,000	$ 44,000	$ 54,000	$ 152,000
OTD 7.10a	Trace Constituents in Natural Gas	2010	2013	$ 36,940	$ 50,000	$ 23,205	$ 78,205
OTD 7.11.a	Gas Quality Resource Center	2011	2013	$ 25,000	$ 25,000	$ -	$ 25,000
OTD 7.11.b	Trace Constituents Sensors	2011	2014	$ 27,610	$ 20,000	$ 7,610	$ 27,610
OTD 7.8.a	Pipeline Quality Biomethane: Guidance Document for Landfill and Water Treatment Conversion	2008	2012	$ 65,990	$ -	$ 990	$ 65,990
OTD 7.9.c	Assessing Acceptable Siloxane Concentrations in Boimethane	2009	2012	$ 52,972	$ 35,000	$ 7,972	$ 52,972
OTD 7.9.d and 7.10.c	Improving Methane Emission Estimates for NG Distribution Companies, Phase 1 and 2	2009	2014	$ 67,674	$ 11,583	$ 6,091	$ 67,674
T759	Ergonomic Study to Develop New Needle Bar	2005	2011	$ 29,889	$ 3,751	$ 3,277	$ 25,366
T763	Rock Impingement	2007	2010	$ 19,250	$ 8,319	$ 7,500	$ 21,100
T764	Auto Gas Lamp Evaluation	2009	2011	$ 27,500	$ 10,314	$ -	$ 10,314
T765	Appliance GasX Study	2009	2011	$ 111,158	$ 86,970	$ 4,335	$ 96,727
T768	NYSEARCH/Kiefner Interactive Threat Analysis	2011	2013	$ 22,335	$ -	$ -	$ -
T769	Test Program for Picaro Leak Surveyor	2012	2012	33,085	-	-	-

*Note: Actual spend for 2012 reflects data through October 2012. The report will be supplemented when November and December data becomes available.