Expanding the Envelope: Developments At The Trenchless Technology Center

The Trenchless Technology Center (TTC) was initiated as the Trenchless Excavation Center in 1989 and formally established as the Trenchless Technology Center in November 1991. It was created to promote research, development and technology transfer in the trenchless industry. In addition to its research activities, a strong effort has been focused towards the education of engineers, contractors, government agencies and others about the availability and capabilities of trenchless methods for the solution of difficult underground infrastructure problems. The Center has also worked with various organizations in evaluating and developing new technologies for the industry.

Funding for the TTC comes from a variety of sources. In broad terms, Louisiana Tech University and industry base support each account for about 25 percent of the total funding for the Center. Gift monies and other income have provided about 10 percent of total funds, and contract research for federal and state agencies and industry groups provides about 40 percent. The Center is administratively a part of the Louisiana Tech University College of Engineering and Science. The university provides space for the Center and partial salary support for the TTC Director and other key faculty necessary for the administration of the Center. The university also provides support for graduate student research and other miscellaneous expenditures. Industry contributes financial support and expertise - principally through the Center's Industry Advisory Board (see sidebar, pg. 50). Other organizations such as the Contractors' Educational Trust Fund of Louisiana also play an important support role through their of the Construction Engineering Technology and Civil Engineering programs at Lousisiana Tech University.

Growth of the Industry Advisory Board and a New Strategic Plan

A key reason for the TTC success has always been its Industry Advisory Board (IAB). The IAB provides core financial support and direction for the Center in terms of identifying the most important problems to address in both user needs and industry needs relative to the use of trenchless technology. The IAB has grown significantly in the past several years and the increase in the number of public works members and consultant members on the board provides a strong balance among the different perspectives on trenchless industry issues. The Center currently has 29 full board members (six public works members, seven industry members, four association members, nine consultant members and three media members). A list of IAB members is provided in the sidebar to this article. The list includes many of the key participants in the advancement of trenchless technology.

The IAB typically meets three to four times per year with a two-day meeting held on the Louisiana Tech University campus so that as many of the faculty and students engaged in trenchless technology related research can meet face to face with the advisory board members. A key task over the past year has been to update the TTC's strategic plan for the next five years – a task that was completed at the last IAB meeting in October.

Unchanged mission

The Center's mission remains unchanged: *The mission of the Trenchless Technology Center is to serve as a trenchless technology focal point and leader. The Trenchless Technology Center will be an independent source of knowledge, research and education for industry, academia and consumers of trenchless technology.*

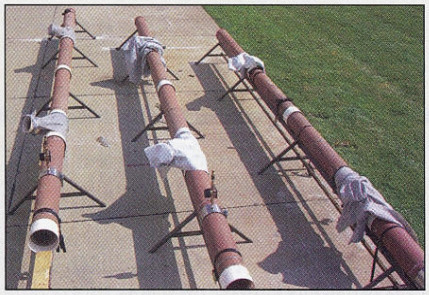
But a more detailed vision of what the TTC should strive to be by the year 2010 has also been developed as part of the new strategic plan:

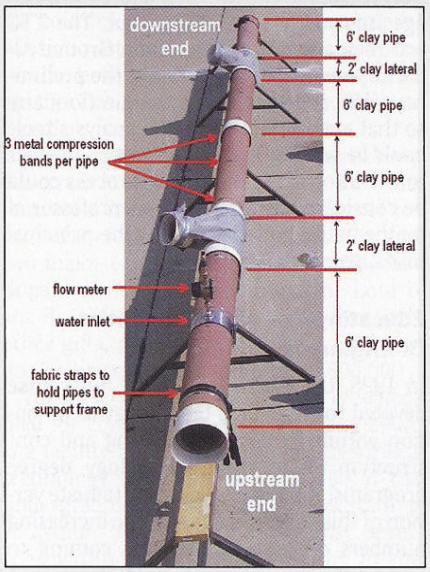
- The Trenchless Technology Center will be the premier national resource center for the design, engineering, construction and maintenance of underground utilities utilizing trenchless technology.
- It will stimulate, encourage and support innovation in the trenchless technology industry.
- It will be the place that private industry and government agencies come to develop ideas into working prototypes.
- It will offer a unique test facility and access to faculty expertise and technical resources unavailable in one integrated group anywhere else.
- It will be the place that cities turn to for research and education support in using trenchless technology.
- It will have a hands-on educational facility coupled with a distance learning program that will allow engineers, operators, inspectors and others to learn how to create successful trenchless projects.
- It will be a knowledge base for problems, solutions, technology and market information related to trenchless technology.

The key emphases in the updated strategic plan have been on the development of new research, testing and education facilities and the allied goal of providing a unique ability to help industry and municipalities develop technologies to meet the needs and opportunities in the trenchless technology field. As the following text notes, the Center will soon be breaking ground on a new research facility and is in the middle of development of a hands-on education facility for trenchless technology for use by Louisiana Tech students and external participants in trenchless technology courses. While the individual research and education facilities and testing equipment may be available elsewhere, the combination of faculty expertise and interdisciplinary research interest with the range of specialized facilities is intended to be unique in the U.S. – providing a partner for industry and government to develop open access and proprietary solutions and products for use in installing and repairing underground utilities.

An Interdisciplinary Approach

Louisiana Tech University began its thrust towards interdisciplinary research and education in the early 1990s by combin-





ing engineering and science into a single college and by eliminating traditional "departments" as separate administrative entities responsible for both research and education. The educational functions are still handled as "programs" – providing the same undergraduate degrees as before, but the research is now concentrated around several interdisciplinary centers. The Trenchless Technology Center, the Institute for Micromanufacturing, the Center for Applied Physics, and the Center for Biomedical Engineering & Rehabilitation Science are the principal research centers that have resulted and provide research nuclei for around 100 faculty in the College of Engineering and Science whose former research identities were spread across more than a dozen academic departments.

Later in the 1990s, the college moved to provide a common and integrated science and engineering core for most of its undergraduate engineering students. This is done to avoid the traditional problems of teaching only mathematics, science and liberal arts in the first two years of study which result in students not realizing how mathematics and science are used in solving engineering problems and often being discouraged by the lack of engineering content early in the curriculum. In the new system (now developed for nearly a decade), faculty from math, science and engineering coordinate their instruction so that mathematical techniques and science principles learned are immediately applied in solving engineering problems – even in the first year of study.

In the last several years, the interdisciplinary approach has extended beyond the College of Engineering and Science to include other colleges and particularly the College of Administration and Business with whom a collaboration on entrepreneurship in technology has been set up.

These difficult and extensive changes in university structure have provided a great opportunity for the TTC. Faculty from many different disciplines are working together in education and research on a daily basis and the issue of which "department" gets research credit is no longer an issue. The TTC has over 20 faculty that get involved in various aspects of the Center's research and their backgrounds cover the disciplines of: civil engineering, mechanical engineering, electrical engineering, industrial engineering, chemical engineering, physics, chemistry, computer science, mathematics, statistics and business. Support is also available for undergraduate and graduate students and external collaborators on entrepreneurship issues strengthening the Center's role in research to marketplace activities.

Supporting Trenchless Technology Development

The benefit of having faculty collaboration can be seen in many of the current research projects underway at the Center. It is not possible within a short article to list all of the research initiatives and projects completed or underway. The funding levels of projects at the TTC have risen substantially in the past two years and funding of around $1 million for research and equipment has been received in this period – most of this competitively won through national requests for proposals. Several current projects are described briefly to give a sense of the Center's research activities especially those related to technology development (in keeping with the TTC strategic plan).

Methods of Cost Effective Rehabilitation of Private Lateral Sewers – Millions of sewer laterals exist throughout the U.S. and many convey a significant amount of I/I into sewer systems. The laterals are often responsible for sanitary sewer overflows, increased cost of wastewater conveying and treatment, costly damage to private property, etc. Despite a growing awareness of problems related to laterals, many municipalities still don't know how much the laterals contribute to total I/I in their systems. This $300,000, two-year project, funded by the Water Environment Research Foundation (WERF), explores methods to identify sources and quantify I/I from the laterals, and reviews and evaluates methods to rehabilitate private laterals. Evaluation factors include cost, safety, installation, technical aspects, potential life of the rehabilitation, accuracy of grade and ability to avoid liability issues. The project also investigates the various methods for financing private lateral rehabilitation (including cost sharing with property owners) and dealing with legal and liability issues of private property work. Project partners are Black & Veatch,

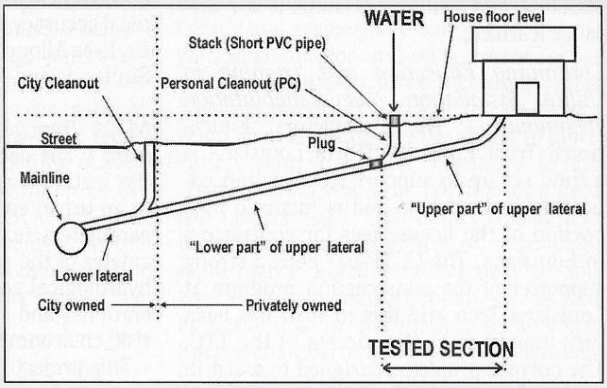


Figure: Hydrostatic testing of the "upper part" of upper lateral (Key West, FL)

Wade & Associates and Computer Solutions and Services. Key Louisiana Tech personnel are Dr. Ray Sterling, project principal investigator and Jadranka Simicevic, project manager. The project will conclude in April 2005 and the report will be made available through WERF.

Non-Disruptive Tools for Remaking Connections after Pipe Replacement – A key issue holding up the use of trenchless techniques for rehabilitation of water distribution lines is the lack of methods for the fully trenchless reconnection of water service laterals to the relined or replaced pipe. The TTC is assisting Boyle Engineering in a project for the American Water Works Association Research Foundation (AWWARF) in proof-of-concept testing and development of novel approaches for such reconnections. The project is due to be complete in the spring of 2005. TTC faculty members associated with the project are Dr. David Hall, Dr. Aziz Saber and Dr. Ray Sterling.

Visual Tools for Demonstrating Engineering Concepts in a Quasi-Realistic Simulation Environment – Dr. Erez Allouche has been involved in innovative educational approaches to infrastructure engineering for several years – having developed an infrastructure management educational module for sewers (Sim Sewer) while at the

University of Western Ontario. He has just received funding from the National Science Foundation to extend this simulation/game approach to a wider range of educational concepts and to build a computer platform through which engineering faculty could easily create simulation scenarios that require students to fully understand the controlling parameters in an engineering problem in order to be able to develop an optimum design or management approach. This approach will also be applicable to a wide variety of training needs at the technician/inspector level, providing an inherent approach to monitoring student understanding and being very suitable for distance learning.

Continuing Education and Training in Utility Installation and Rehabilitation Techniques – The Contractors' Educational Trust Fund (CETF) of Louisiana is a fund set up to support construction education in Louisiana and is financed by a portion of the license fees for contractors in Louisiana. The CETF has been a strong supporter of the construction program at Louisiana Tech and this in turn has been very important to the success of the TTC. The current project is designed to assist in the development and use of the education and testing components of the new trenchless facilities by supporting the creation of short courses in utility installation and rehabilitation techniques. These courses will combine the option of in-person or remote software-based instruction with a concentrated on-site, hands-on participation in the use of equipment and methods using the trenchless education laboratory and a utility locating test site. The first in-person courses are expected to be offered in mid-year 2005 followed by the availability of the distance learning modules later in the year. A number of TTC faculty, staff and students will participate in this effort.

Observation of Annular Space Flow Testing -- When Insituform Technologies modified their CIPP lining systems to include the option of an external polyethylene layer, they realized that it would be very helpful to know any effect of this external layer on the annular flow characteristics of the completed liner and in particular how this annular flow would compare to the earlier (1995) test results completed by the TTC and Tulane University in conjunction with the City of Baton Rouge. The TTC was contacted by Insituform Technologies to work with them to document, monitor and evaluate the new tests at the Insituform research facility in St. Louis. Dr. David Hall and TTC student John Matthews, worked together on the project in the summer of 2004 and the report of the testing is available from either Insituform Technologies or the TTC.

Enhancing Trenchless Service Installations through Keyholes: Review, Screening and Preliminary Evaluation of Technologies and Techniques – In this project, the TTC is working with the Gas Technology Institute to identify, evaluate and pilot test existing and emerging technologies/devices as well as steering mechanisms that will enable a piercing tool or a similar trenchless method to consistently hit common sizes of keyholes at a predetermined target elevation. The TTC has built an indoor test bed for steering trials and is constructing an outdoor test bed for further testing. Key issues in the technology development will be cost effectiveness and ease of use as well as technical accuracy. Key faculty participating are Dr. Erez Allouche, Dr. David Hall, Dr. Neven Simicevic and Dr. Ray Sterling.

NUCA Trenchless Method Selection Software – The decision of how to accomplish the installation or repair of a buried pipe in an urban environment involves tangible parameters (e.g., length, material and diameter of the pipe; depth of cover; soil and hydrological conditions; budgetary considerations) and intangible parameters (e.g., risk; environmental impacts).

This project involves the development of a comprehensive, yet straightforward and easy to use interactive software for the evaluation and ranking of alternative construction methods that can be employed in the installation, rehabilitation or replacement of buried pipes. The proposed model follows the updated NUCA Trenchless Construction Methods and Soil Compatibility Manual, and implements it in a generic and easy to codify algorithm. The approach selected emphasizes simplicity and practicality, and limits input data to those readily available to utility engineers at the design stage of the project. It will be compiled as a stand alone application compatible with common Microsoft operating systems platforms. Other key elements in the proposed software are the ease of expandability, updateability and customization. The user will be able to easily add new methods or pipe materials, and update the capabilities of existing methods as technology develops and new innovations are introduced into the trenchless market. The principal investigator for the project is Dr. Erez Allouche.

Enhancement and Testing of the Terra-Brute Restraint Joint – Following up on the earlier development by Dr. Allouche of the TerraBrute Restraint Joint, he is now engaged in developing additional variations of the joint system for new applications. This work will utilize the new experimental capabilities at the TTC.

Statistical Analysis and Interpretation of ational Damage Data – The Data Reporting & Evaluation Committee of the Common Ground Alliance has developed and implemented an internet based questionnaire and database for the purpose of collecting data relating to underground facility damage in the United States. The damage data collection project is called DIRT, short for Damage Information Reporting Tool. The TTC was then asked by the Common Ground Alliance to prepare an analysis of the preliminary data collected using the questionnaire so that appropriate statistical analysis tools could be selected and any necessary changes to the information reporting process could be considered. Dr. Raja Nassar, professor of mathematics and statistics is the principal investigator for the project.

Educating The Next Generation Of Engineers

In 1998, the TTC introduced a full course devoted to trenchless technology as an option within its civil engineering and construction engineering technology degree programs. It has since added a graduate version of this course to support the increasing numbers of graduate students coming to Louisiana Tech University to gain research experience and a graduate education related to urban infrastructure.

Since 1991, the Center has graduated 12 students with doctoral degrees, over 30 students with M.S. degrees and several hundred students with in-depth exposure to trenchless engineering in their undergraduate curriculum. Many of those students are still working in the field – as faculty members at other institutions, in consulting companies and municipalities, or in contracting or manufacturing enterprises. A list of student research theses can be found on the TTC website (see sidebar, pg. 50).

Most recently, the Civil Engineering program at Louisiana Tech in conjunction with the TTC faculty has developed an M.S. in Engineering curriculum with an emphasis on Urban Systems Engineering. There is little doubt that engineers with the right set of skills to upgrade and manage urban infrastructure systems (including roads, bridges, structures, environmental systems, and utility systems) will be in high demand in the coming decades. The topic fits very well with the faculty expertise needed for TTC research and students have the opportunity to get involved in cutting-edge research activities during their degree studies. The first students following the new program started in the Fall of 2004. Students interested in the program can contact Dr. Ray Sterling or Dr. Erez Allouche.

Developing A National Trenchless Technology Research Facility

In terms of experimental research, the TTC has always been known for its pipe liner

testing facilities developed in conjunction with the U.S. Army Corps of Engineers and its field experiments – both on prepared sites at the Louisiana Tech farm campus and in collaboration with government and industry at test sites and job sites around the country. The need for a more comprehensive national facility for trenchless research, however, has long been recognized by the Center and the Industry Advisory Board.

Major advances towards this goal have occurred in the past year. The TTC has received a major gift from Mike Garver toward the creation of a new test facility and two major equipment grants from the National Science Foundation and the Louisiana Board of Regents. These, together with other gifts, grants and matching funds for the facilities, amount to around $800,000.

The first development, which is scheduled for completion in the spring of 2005, is a facility aimed at enhancing trenchless technology education and research at the undergraduate, graduate and continuing education levels. The new facility, developed within an existing laboratory in the engineering building at Louisiana Tech, will consist of four stations:

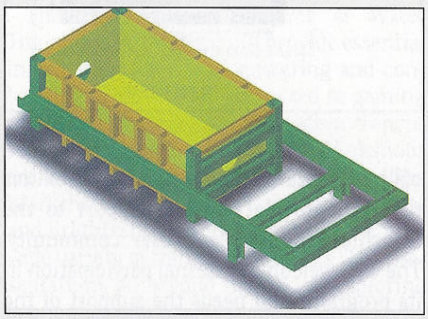
- A briefing/review/presentation station;
- A soil box (6 feet by 8 feet by 4 feet high) with a horizontally operated hydraulic actuator;
- An inversion chamber demonstration unit; and
- A rheology laboratory.

The new facility will be able to accommodate up to 40 students for class demonstrations at one time, spread among the four stations. TTC faculty members are currently developing an array of physical demonstrations that illustrate the inherent complexity associated with the design aspects of trenchless construction methods, such as horizontal directional drilling, pipebursting and pipe jacking. The ability to show students what is happening on the inside of an inversion chamber used for pipe relining, and the ability to demonstrate quality control issues, associated with cured-in-place-pipe rehabilitation method will represent a tremendous improvement in the current ability to provide students with a genuine understanding of these issues. The facilities will also be available for research purposes to complement the remainder of the TTC research equipment and facilities.

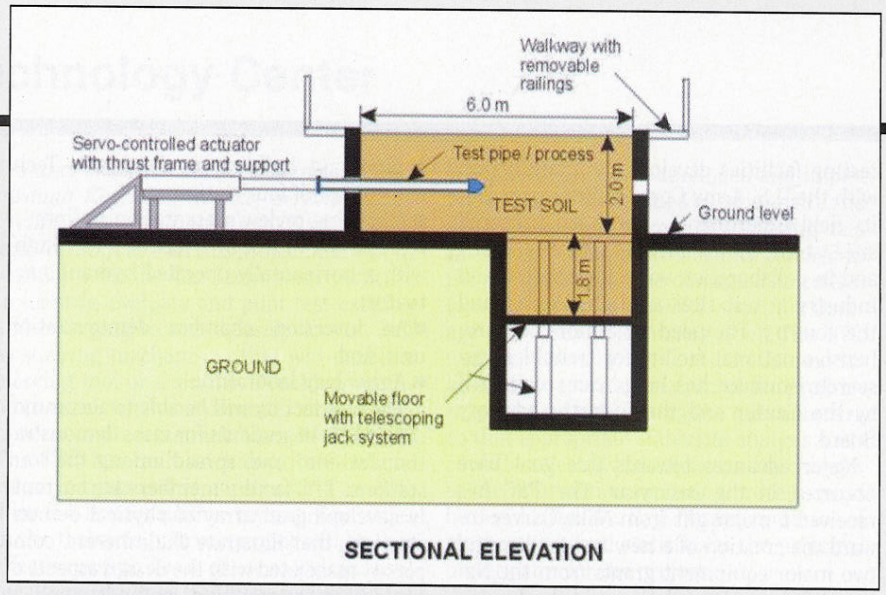
A larger award for major research equipment was received from the National Science Foundation in the fall of 2004. The facility was given the acronym L-STaR (Large-Scale Trenchless Technologies Research and Testing Facility). The centerpiece of the equipment is the construction of a major soil test chamber (see accompanying figure on pg. 50 for a conceptual sketch of the facility) that will facilitate academic and proof-type studies related to the design procedures, installation methods, short- and long-term performance, non-destructive testing and evaluation technologies and repair, rehabilitation and replacement methods of buried structures including pipes, conduits and utility tunnels. The key aspect of such a test chamber is the ability to more closely control the soil conditions in the chamber than would be possible in a field test environment. This allows researchers to build an understanding of technology performance keyed to differences in soil type, density, moisture content, etc. as well as variations in installation parameters. Such a chamber is a companion to studies in real field installation conditions rather than a replacement for field monitoring.

The soil box will have dimensions of approximately 20 by 20 feet by 6 feet tall and will be able to be subdivided into four sections for smaller experiments. One section will have a greater soil depth with the capability to vary this for different purposes. The walls of the facility will be designed to enable the insertion of drill rods, chains and pipe segments. This will allow the use of commercially available small diameter equipment such as pit launch horizontal directional drilling rigs and pipe bursting heads, piercing tools and microtunneling heads for studies of machine performance and soil-structure problems.

An important aspect of the development of the facility is that it can serve many needs for controlled testing related to buried infrastructure. Reflecting this potential, faculty from a variety of disciplines from within Louisiana Tech and faculty involved in trenchless technology research outside Louisiana Tech University participated in the proposal. They will be able to collaborate in setting up the kinds of experiments that can best be accomplished using a soil test facility with highly controlled testing conditions. It is hoped that more faculty across the country will join the group as the facility becomes available for research activities. The external faculty named in the proposal were: Dulcy Abraham, Purdue University; Sam Ariaratnam, Arizona State University; Alan Atalah, Bowling Green State University; Sanjiv Gokhale, Vanderbilt University;



Left: A 3-D Drawing of the Soil-Pipe Interaction box (box dimensions: 12'x6'x4' tall). Its loading frame will accommodate a 150,000 lb. servo-controlled hydraulic actuator.
Below: The TTC new Rheology Laboratory can accommodate 12 students at a time.



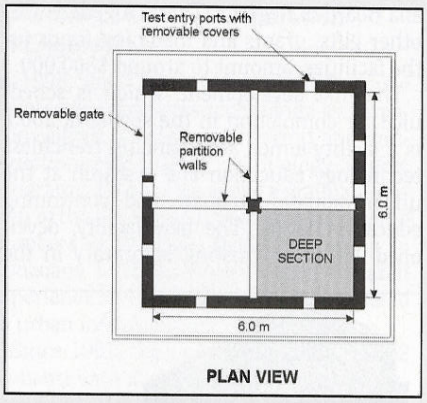
SECTIONAL ELEVATION

Mo Najafi, Michigan State University; M. Tumay, Louisiana State University; and C. Vipulanandan, University of Houston.

Although the facility will be adaptable to many different types of experiments, the following areas were identified in the proposal for use of the facility.

- Soil-Pipe and Soil-Fluid-Pipe Interactions: For example, improving the understanding of pipe/ground and machine/ground interactions so that the soil excavation /displacement processes and their effects on the surrounding ground can be better understood. Improving the understanding of soil/fluid/pipe interaction for various drilling media -- covering phenomena such as borehole stability; hydraulic fracturing; and, post-installation settlements. Improving design methods and construction specifications as related to installations of pipes using trenchless and open-cut technologies.
- Robotic and Remote Sensing: Development, enhancement and testing of innovative concepts and technologies that have the potential for monitoring and evaluation of pipe systems. These include Smart Subsurface Horizontal Investigation Probes, Laser-Based Devices for Monitoring the Ovality and Progressive Deformation of Pipe Liners, Obstacle Detection and Guidance for Horizontal Directional Drilling and Impact Moling, and Miniature Wireless Sensors for Monitoring of Buried Pipes. The facility will enable testing of these devices in a full-scale setting in which key parameters can be closely controlled and monitored.
- Non-Intrusive Locating Technologies: Experimental studies in the area of non-intrusive locating technologies to support current and future numerical work in this area. This work includes detection of buried utilities, propagation of nanopulses in geologic materials, and detection of voids adjacent to the walls of buried pipes.

Funding is sufficient to start the design and construction of Phase 1 of the facilities which will provide the high ceiling, large-span laboratory space to house the soil test chamber and some additional research equipment. A second phase is planned, when funds allow, to complete the facility and consolidate the university's trenchless research facilities in one location. The new facility will be built on the Tech farm campus less than a mile from the main campus and construction is expected to begin in the summer of 2005.



PLAN VIEW

The Way Ahead

The TTC is currently experiencing strong growth – especially in funded research programs and in the development of the specialized research and education facilities that can provide targeted support to the trenchless industry and user community. The TTC welcomes external participation in its programs and needs the support of the industry to flourish. Please contact the TTC if you would like to get involved.

TTC Industry Advisory Board

1. Bid Ocean, Inc.
   Tim Loncarich
2. Black and Veatch
   Richard Nelson
3. GCTA
   Todd Calvin
4. City and County of Denver
   Joseph W. Barsoom
5. City of Atlanta
   Troy Norris
6. City of Dallas
   Bob Johnson
7. City of Shreveport
   Michael G. Hogan
8. Gas Technology Institute
   Glyn Hazelden
9. GSWW, Inc.
   Leigh Cerda
10. Haley & Aldrich, Inc.
    Brian C. Dorwart
11. Halff Assoc.
    Anthony Almeida
12. Hobas Pipe USA, Inc.
    Rick Turkopp
13. Inliner Technologies, Inc.
14. Insituform Technologies, Inc.
    Lynn Osborn
15. Jason Consultants
    Robert Morrison
16. Kellogg Brown & Root, Inc.
    Michael Spero
17. King County
    Gunars Sreibers
18. Laughlin Thyssen, Inc.
    Cliff Tubbs
19. Malcolm Pirnie, Inc.
    Ronald T. Thompson
    Robert McKim
20. Parsons Brinckerhoff Quade & Douglas, Inc
21. re-Pipe, Inc.
    Steve Leffler
22. Rinker Material U-Liner
    Charles Curtis
23. S.E.A Consultants Inc.
    John J. Struzziery
24. Sanitation District of LA
    John A. Redner (ret.)
25. Trenchless Technology, Inc.
    Bernie Krzys
26. LA Contractors' Educ. Trust Fund
    Vic Weston
27. Ultraliner, Inc.
    L. Grant Whittle
28. *Underground Construction*
    Robert Carpenter
29. Uni-Bell PVC Pipe Assoc.
    Craig Fisher

Trenchless Technology Center
Louisiana Tech University
P.O. Box 10348
Ruston LA 71272 USA

Director: Ray Sterling
Assoc. Director: Erez Allouche
Secretary: Carol Hilton

Ph: 318-257-4072
Toll Free: 800-626-8659
Fax: 318-257-2777
Email: ttc@latech.edu
Website: www.ttc.latech.edu