

INVISIBLE **CONSTRUCTION** --- **CONFERENCE**

Conference Proceedings
November 17, 1998



**Institute for Civil
Infrastructure Systems**

Robert F. Wagner Graduate School of Public Service
New York University

INVISIBLE CONSTRUCTION CONFERENCE CONFERENCE REPORT

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ICIS gratefully acknowledges the assistance of The Sam Schwartz Company, the Conference producer, and the financial support of The Fort Miller Group (Benefactor), Con Edison and The General Contractors Association (Sponsors) and Brooklyn Union A Key Span Energy Company, Frederick R. Harris, The New York Building Congress, The NYC Department of Design and Construction, and Urban Age, The Global Magazine (Supporters).

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August, 1999

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INVISIBLE CONSTRUCTION CONFERENCE

INTRODUCTION

For most of the 20th Century, the professionals who planned, designed, constructed, and managed civil infrastructure envisioned their work principally as new construction. Federal and state policies and practices authorized and consistently reinforced the primacy of new construction. Federal highway programs and state departments of highways (later departments of transportation) were structured, strategically and operationally, to carry through on the commitment to build. Departments of water and sewer operated similarly. Maintenance and reconstruction was decidedly secondary for most infrastructure agencies.

In part due to the prevailing commitment to new construction and despite occasional policies intended to counter its negative impacts (for example, urban renewal and community development programs), cities suffered many decades of economic, social, and political decline. The pattern of concentric circular expansion outward from central cities and the abandonment of old buildings and infrastructure resulted in unlivable cities and inner suburbs and, as we are now beginning to recognize, unsustainable resource commitment to new construction.

Gradually the relationship between decades of unfettered growth and the decline of cities, environment, and the quality of life became hard to ignore. Impacted stakeholders mobilized to assert the interests of cities, neighborhoods, environmental quality, and open space preservation. They succeeded in gaining standing to participate in the process of infrastructure decision-making affecting specific interests. More often than not this participation took the form of blocking action, rather than altering the shape of the driving policies, which continued to be framed by federal and state pork barrel politics and the new construction mentality. Only with the passage of the Interstate Transportation Efficiency Act (ISTEA) of 1991 did a broader view of stakeholder inclusion gain a foothold in federal infrastructure capital investment programs.

This development coincided with a period of renewed interest in cities. Throughout the world the vitality and attractiveness of cities is being reasserted. Major cities, only recently labeled asphalt jungles and worse, are again engines of economic progress. Many are growing again after years of population loss. During the 1990s Boston, Cleveland, Los Angeles, New York, San Francisco, and Seattle and others boast impressive statistics on crime reduction, employment, tourism, and economic growth.

Lurking in the equations that add up to productive and attractive urban regions is the infrastructure variable. The economic and cultural advantages of cities cannot be realized and sustained without well-functioning conduits for people, goods, water, communications, energy, and waste. To achieve these in densely settled, built environments requires a sustained commitment to the reconstruction and maintenance of infrastructure. Infrastructure renewal is particularly urgent in many of the older cities of the U.S. since many of the transportation, water, and sewer systems are pushing the century mark and nearing the end of their useful lives. Of course, this renewal must take place in a political context that differs radically from the days when planners and engineers could decide and implement construction projects on their own.

Empowered and enabled by recent legislation that requires public participation in decisions affecting community and environmental values, neighborhood and environmental groups can no longer be ignored. Where state and local decision-makers have learned the advantages of early public involvement, outcomes are often positive. More typically, the process of decision-making is conflict-laden, prolonged and unsatisfactory.

As the situation now stands in many urban regions, the competing values in play have produced a conundrum whose elements are known but whose solution is elusive. One, the advantages of cities are again widely recognized, and civic leadership has a general desire to exploit them. Two, sound infrastructure is vital to the economic, cultural, and social success of cities, but it is aging and must be renewed and maintained. Three, the relative cost of construction and maintenance of infrastructure is higher now than when it was built, and this comes at a time when politicians are particularly reluctant to support additional taxes. Four, recent public policies have provided environmental and community groups a platform from which to assert their rights and values in decisions affecting their interests. Five, due to professional orientation and historical practice infrastructure decision-makers tend to assume the primacy of technical criteria—particularly true of engineers—over political and social criteria, and are unpracticed in and uncomfortable with a decision-process where the latter have equal standing. Six, even assuming that a decision for renewal of a major facility can be reached, it must be implemented in a way that minimizes disruption and inconvenience for users. Seven, conflict, stalemate, and a prolonged decision-making process commonly result. Unfortunately, delays in infrastructure investment carry the risk of failure for aging facilities and, more broadly as systems decline, a renewal of the cycle of urban decline.

NYU's Institute for Civil Infrastructure Systems (ICIS) is dedicated to developing a better understanding of the elements of the broad problem set outlined above. It is equally committed to exploring and piloting solutions to these problems. The Invisible Construction Conference explored the potential for more widespread introduction of a set of technical solutions to the problems of infrastructure renewal. In view of the conditions that now accompany infrastructure reconstruction and repair, the need for less obtrusive technologies is increasing.

The term “invisible construction” describes technologies that minimize the negative effects of infrastructure renewal. As Michael Fishman writes,

[t]hese invisible construction techniques ... have the ability to minimize gridlock, noise, duration, closures and other headaches typically associated with construction. They are also making it easier to save city infrastructure systems without rendering them useless in the process.*

*Michael Fishman, “New York’s Invisible Construction,” *Urban Age*, Autumn 1998, Vol. 6, No. 2, pp. 12-14.

The Invisible Infrastructure Conference examined new techniques for building, reconstructing, and maintaining bridges, rails, roadways, and the infrastructure for transmitting water and energy. The techniques considered ranged from trenchless technologies (permitting extensive pipeline maintenance from just two access points) to prefabricated bridges and bridge decks and innovations in the processes used for planning and implementing maintenance and reconstruction. Compared to traditional methods of reconstruction the approaches described here

share one or more of the following characteristics: less disruptive for users, less physically intrusive, less time consuming, more environmentally sensitive, and more cost effective over the long-run.

The sections of this report follow the organization of the conference. Section one looks at the experiences with the reconstruction of bridges and roadways. Section two provides an in-depth examination of the reconstruction of a critical bridge on the New York State Thruway. Section three offers the insight of key infrastructure leaders into the need for developing and employing “invisible construction” techniques. Section four focuses on “invisible construction” underground.

SESSION I: BRIDGES AND ROADWAYS

Repair of roadways and bridges, construction of key arteries, and full replacement of bridges account for a large percentage of the delays and inconveniences experienced by users. During the past decade a number of innovations, in both method and material, promise significant benefits in terms on convenience and cost. This session examined recent experience in New York State and Virginia and examined the potential of a new method for pothole repair.

Richard A. Maitino
Director, Region 11

New York State Department of Transportation

Three years ago, Governor Pataki started the initiative called ‘Smarter and Faster’. At NYS DOT, this means that each construction project is approached with the premise of minimizing disturbance and inconvenience to people. Conceding that that’s not always entirely possible, NYS DOT does utilize a number of tools to help ensure that their work is as ‘invisible’ as possible.

Incentive Bidding

Incentive bidding has not been used on projects like Boston’s Central Artery but in New York State, it has been a great success. The results have shown a 30% - 40% reduction in construction time and minimized disruptions of service. Incentive bidding is a two part bid where the contractor bids the cost of the work and also bids on the duration of the work. The duration is then multiplied by a specified dollar amount and added to the cost bid for a total bid. In the end, NYS DOT has not experienced much difference in the costs between conventional bids and incentive bids. Thus time savings are achieved at no additional cost.

Night Work

In New York State, night work is a requirement on highway work valued at over \$5 million. Night work also entails involving community groups. But sometimes and in some places, night time work is the only way to get work done while not destroying a great deal of traffic, especially rush hours.



Beam Placement on the 48th Street Ramp. Completing work at night help to void costly and time consuming congestion during commuting hours.

ITS (Intelligent Transportation Systems)

New York State is increasing its use of ITS on construction projects. Generally, 60% of highway delays are connected to construction related incidents. NYS DOT has implemented ITS systems such as video cameras and real time information systems to monitor the roads involved in construction projects. This has allowed much quicker reaction times to respond to and clear any incidents that occur. NYS DOT has also constructed a Central Command Center directly adjacent to New York City's facility in Long Island City allowing for coordination of response.



Traffic command centers now monitor traffic near construction zones improving incident response times.



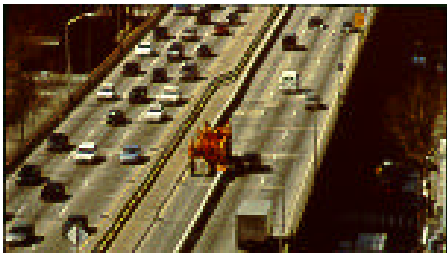
Use of electronic sign boards helps NYS DOT manage traffic flows around construction zones.

Increased Awareness

Typically, whenever NYS DOT would present a construction schedule to a community, NYS DOT often met with disbelief. Recently though, NYS DOT has implemented outreach procedures to inform and involve the communities in which projects take place. For example, having fulfilled our promises and stuck to the schedule on the West Side Highway, NYS DOT can take other community leaders to the West Side to hear from the groups that we worked with on the West Side Highway. This generates an increased tolerance of our work, particularly any disruptions among groups and the press.



Showing progress on highly visible construction projects helps build public trust and increases their tolerance of disruption.



Use of moveable barriers is one way in which improved technology can help to speed construction.

Technology

NYS DOT has been implementing improved technologies on projects not just for improved designs but also to speed construction. This includes the use of pre-cast materials that can be constructed off-site, moveable barriers allowing better traffic flows, and increased use of E-Z Pass technology.

Inter-Agency Coordination

NYS DOT has been looking forward 10 or 12 years with other agencies, including NYCDOT. The result is that we have been able to coordinate or sequence work. For instance, NYSDOT had to do some work on a Williamsburg Bridge ramp. But the City also had plans to do work on the bridge which required closing one lane. Through coordination, both agencies were able to do their projects simultaneously thereby reducing the duration of the lane closure. This minimized impact on the users and nearby communities.

M.L. (Leland) Caldwell P.E. Vice President and Chief Engineer MTA Bridges and Tunnels

While the ‘invisible approach’ to construction is impossible in New York City, TBTA tries to use innovative techniques and new technologies to make their work as transparent as possible to the host communities and users of their systems.

On TBTA’s seven bridges and two tunnels, there are more than 700,000 crossings per day. TBTA provides the conduits that link to the major roadways such as the Gowanus, the BQE and the Henry Hudson Parkway. TBTA’s facilities, however, are all aging; 3/4 are more than 50 years old and are reaching the end of their useful life. So there is a lot of work to be done by TBTA in the near future.

TBTA’s work includes major deck repair and replacements, major structural steel replacement, major electrical upgrades, major coating/painting replacements, not much of which is ‘transparent’. TBTA’s capital budget increased to \$1.2 billion for almost the last ten years and is likely to be that much for the next five years also. How will we get around delays, detours and slowdowns?

The TBTA tries to do its work by staying focused on three areas. One, we look at our projects from the point of view of the customer, the tollpayers. Two, we stay concerned with the communities and neighbors - those neighborhoods connected by our bridges and tunnels. We have active public relations programs in those communities. Lastly, but maybe the most effective has been partnering with our designers, contractors and construction managers to stay innovative and thinking smart.

EXAMPLES OF PROJECTS

Throgs Neck Bridge Ramp Rehabilitation

The TBTA tries never to have a lane closure during a rush hour; we rely on a lot of night work. Unfortunately, the Throgs Neck ramps required a shutdown for a duration of 13 months. The community immediately voiced concern. So in cooperation and coordination with the designer, the construction manager, the contractor, and the community, we were able to implement innovations that would allow us to speed up construction, shortening community impact. Among the steps we took were the following:

- 1) modified construction methods, such as stay-in-place forms and use of a hoe ram in extraordinary circumstances

- 2) posted additional traffic agents in the community to help residents with finding alternative routes (but as it turned out, they didn't need the agents)
 - 3) potential use of a temporary ramp (also never used)
 - 4) most importantly, a bonus incentive offered to the contractor to finish early
- The final result was that the ramps were finished and open more than two months earlier than the deadline. The contractor received almost \$1 million in bonus for early completion.

Triborough Bridge - Queens Approach Rehabilitation

The contract was to last 28 months with the work being done at night with two or three lanes closed. The lanes would be opened for rush hour. There were several alternative methods for the rehabilitation; cast-in place, concrete filled grating or pre-cast panel. Through partnering with the contractor, an innovation was developed using pre-cast panels and moveable barriers to add a lane where the existing sidewalk was and to cantilever a new sidewalk. This innovation helped to eliminate much of the night work, making for a safer job, and allowed TBTA to keep all four lanes open to traffic during construction.

Marine Parkway-Gil Hodges Memorial Bridge - Rehabilitation and Deck Replacement

This current rehabilitation is to take 45 months and entails the complete replacement of the bridge deck. Due to concerns over the duration of traffic disruption, we changed the project to a pre-cast panel in lieu of poured concrete, which allowed the panels to be floated up the river to the site, speeding up the entire project. Also, to lessen the impact on users, the load restrictions were relaxed during construction allowing for heavier traffic. And due to the loss of the sidewalk, TBTA provided van service for the many bicyclists who normally use the bridge.

Triborough Bridge - Prototype Deck Rehabilitation Construction

TBTA is currently spending \$4.5 million to test different methods and innovations that will help TBTA be smarter and faster on their future \$500 - \$600 million efforts. Innovations included lightweight steel panels, long span pre-cast panels and constructability reviews, among others. This represents valuable experience, since TBTA will learn from the successes and scrap the failures.

Vincent J. Roney
District Supervisor
Virginia Department of Transportation

PUSHING THE LIMITS OF STEEL BRIDGE PRE-ASSEMBLY
THE GEORGE P. COLEMAN BRIDGE FLOAT-IN

Background

The George P. Coleman Bridge carries U.S. Route 17 over the York River between Gloucester Point and historic Yorktown, Virginia. This 3,750-foot structure has two 500-foot swing spans making it the second longest double-swing span in the world.

The existing bridge was built in 1952, for \$9,000,000. At the time, it was the largest bridge project ever built in Virginia.

The original two lane bridge at Yorktown was designed to carry 15,000 vehicles per day. Currently, it carries 28,000 vehicles per day with traffic projections of 43,000 vehicles per day in the year 2015. The four-lane approach roadways transitioned to two lanes across the bridge. This condition generally resulted in severe traffic congestion during the morning and evening rush hours. With the intent of alleviating the congestion, VDOT initiated a study in 1986 to improve the traffic capacity across the York River.

Alternatives

Initially, preliminary studies included 17 alternative crossings. Based on the results of these studies, widening of the existing bridge was the alternative selected. It was the best alternative to meet current and future traffic demand, with the least environmental impact, and was the only option that could reasonably be funded. The York River is substantially wider above and below the existing bridge site so crossing at the existing site would be less costly than anywhere else. In addition, the four-lane approach roadways already existed. However, widening of the existing structure could only be accomplished through the use of light weight concrete, high strength steel and a substantial residual capacity within the existing substructure. This would also mean closing the bridge to traffic during periods of construction.

To lessen the impact of the bridge closures, the Department evaluated different ways of maintaining traffic during construction. A ferry boat system was one method that was considered. However, this was very expensive, sensitive to weather conditions, slow, and would involve operating numerous ferries and buses through the construction area.

A more reasonable alternative of maintaining traffic during construction was to install a \$19,000,000 temporary floating bridge adjacent to the existing structure. However, when the 1993 General Assembly approved the bonds for the project, the temporary bridge was eliminated as a means of reducing the toll. As a result of this action, VDOT had no choice but to detour traffic 75 miles around the proposed construction site. We also knew that it was imperative that the heavily traveled Coleman Bridge be closed for as little time as possible. To minimize this impact, a scheme was developed for floating into place the new structure. The approved plan called for swapping out the 2240 foot truss system in two 12 day periods.

In October 1993, a 3 year \$73,000,000 contract was let to widen the George P. Coleman Bridge. Much to VDOT's surprise and satisfaction, the Contractor's plan of operations indicated that the trusses would be swapped out in one 12-day period in lieu of the two 12-day periods stipulated in the contract.

Construction Phases

Widening of the bridge was accomplished in five construction phases. Phase one consisted of widening the substructure. New piles were driven adjacent to the existing land piers and the piers were widened. Also, the river pier caps were enlarged using post tensioning cantilever construction.

During phase two, new approach spans were constructed on each side of the existing bridge. During the first two phases, normal traffic continued to use the bridge. Also during this phase, false work was constructed approximately 30 miles away from the bridge site at Norfolk International Terminals (NIT) to facilitate construction of the 6 new truss sections. Pre-assembled sub-sections were delivered to NIT by truck and placed on barges for transporting to the nearby false work for erection. Truss sub-sections were erected on false work set at an elevation matching the final construction elevation at Yorktown. Steel erection for the 6-truss units was accomplished in 12 months between Sept 94 and Sept 95.

During phase three, the fixed and swing trusses were floated off of their temporary supports at NIT and swapped with the existing trusses at Yorktown. This work occurred between April 3 and May 11, in 1996. The following is a sequence of events as they occurred:

On April 3, the 210 foot, 1,300 ton suspended span, the first of six truss sections for the new bridge, was floated from NIT and anchored just down river from the old bridge. The barges carrying the new span then began their 30 mile journey to Yorktown with the help of two tugboats. Two other spans joined the smaller suspended span anchored near the bridge. The other three sections remained in Norfolk until barges could return. Everything was in place waiting for the shutdown.

A comprehensive traffic management plan for the 75-mile detour was in place. VDOT crews began uncovering signs marking the detour at 1:00 a.m., Saturday, May 4th. Four-and-a-half hours later the bridge was closed. Construction crews started immediately and by noon, the Yorktown side swing span was removed and ready for its trip to Norfolk.

Then, the first problem occurred. Pins holding the existing suspended span closest to the Yorktown shore had corroded. While crews worked to free the span, the tide slowly ebbed. The pins were finally removed, but the tide was too low to float the section away. The Contractor waited and floated the section out at 1:00 a.m. The last Yorktown span, the anchor span, came out easily and was floated away at 11:30 a.m. on Sunday.



An existing bridge span is removed and floated away for off-site demolition

Next, construction crews began preparations to float the new Yorktown spans into place. The small suspended span was brought in first, but it had to wait until the anchor span was set onto its pier. As workers began moving the anchor span from its mooring, a severe thunderstorm stopped work for the night.

On Monday, crews worked throughout the day. By 8:00 p.m. both the anchor and suspended span were in place. On Monday night, weather was once again a problem for construction crews. Wind gusts of up to 50 m.p.h. created unsafe conditions, and the Contractor waited until Tuesday morning to move the swing span into position. Fighting strong wind and rainy conditions, construction crews began moving the span into place at 8:30 that morning. Extra tugs were needed to steady the 8.5 million-pound span.

Meanwhile, the old sections of the bridge arrived at the Norfolk International Terminal. They were placed on the temporary false work where the new bridge was built to await demolition. Barges also began removing the new Gloucester end truss sections from NIT.

Work to remove the Gloucester sections of the existing bridge began Wednesday night. The suspended span was removed at 3:00 a.m., followed by the swing span at 4:30 a.m. on Thursday. Later that afternoon, workers removed the existing anchor span. The new suspended span and anchor span were moved into place early Friday morning. Crews worked throughout the day to set them into place.



A section of the new bridge span is floated into place. The complete replacement of all bridge sections caused the closure of the bridge for only nine days.

The last new section, the swing span, was brought into place on Saturday afternoon. Construction crews got the swing span into place just in time as another severe storm passed through the area Saturday night. The storm delayed work for a few hours, but crews were soon preparing the new bridge for traffic. At 8:30 Monday morning, May 11, 1996, three days ahead of the 12 day schedule, the bridge was reopened for vehicle traffic.

In phase four, traffic was shifted to the new outer lanes allowing the two inner lanes of the existing approach span superstructure to be demolished and replaced. During the fifth and final phase, the toll facilities were completed. After 34 months of intensive effort, at 12:01 a.m., on August 3, 1996, the bridge was opened to 4 lanes of traffic on schedule.

Peter L. Anderson, P.E.
North East Regional Manager
The Reinforced Earth Company

Reinforced Earth was invented by Henri Vidal in 1963 and the first significant uses of this technology appeared in Europe in 1967 and in the US in the early 1970's. The first structures used elliptical shaped galvanized steel facing elements and galvanized steel reinforcing. today, most facing elements are constructed of precast concrete panels but the galvanized steel reinforcing is still used due to the materials high strength, cost and demonstrated durability.

The first significant application in the US was for Hwy 39 in the Angeles National Forest which still remains in good condition today.

Reinforced Earth is constructed of reinforcing strips joined to the facing panels and embedded in the granular fill. Its structure is quite analogous to concrete, except without cement. Reinforced Earth has been used as retaining walls along highways, retaining walls supporting highways, bridge abutments, slide buttresses, deflector walls, railroad support structures and even reinforced earth dams. There have also been many industrial uses.

NYS DOT jumped on the technology twenty years ago and still continues to use it today. Reinforced Earth has been successfully used throughout the state.

Leo Mara
Inventor,
Sandia National Laboratories

RAPID ROAD REPAIR VEHICLE

A report issued last September from the Surface Transportation Policy Project (STPP) and the Environmental Working Group (EWG) asserted that the cost of repairs to vehicles due to damaged highways in the United States is four times what governments spend on fixing the roads. The report concludes with recommendations for a "Fix it First" policy, calling for restricting new highway development until states can certify that 90 percent of their highways are in good condition.

Leo Mara of Sandia National Laboratories has created an innovation that can help to address the problems of road repair while greatly reducing the impact that repairs can have on commuters, travelers and our communities in general. The Rapid Road Repair Vehicle is a revolutionary new approach to the repair of paved surfaces. It would quickly analyze and repair surface imperfections in roads at speeds as high as 37 MPH. It would be computer controlled, self-contained, constructed of mostly commercial off-the-shelf components, and use very rapidly setting road-patching materials that provide a long lasting repair.

Where a crew of workers in time-consuming hand labor presently repairs roads, one operator with the minimal skills of a truck driver would conduct the repairs. They would be accomplished

using one piece of equipment that could be operated any time of the day or night. Roads would be fixed much faster, much cheaper, and much more safely, with little or no disruption to traffic or loss of travelers' time.

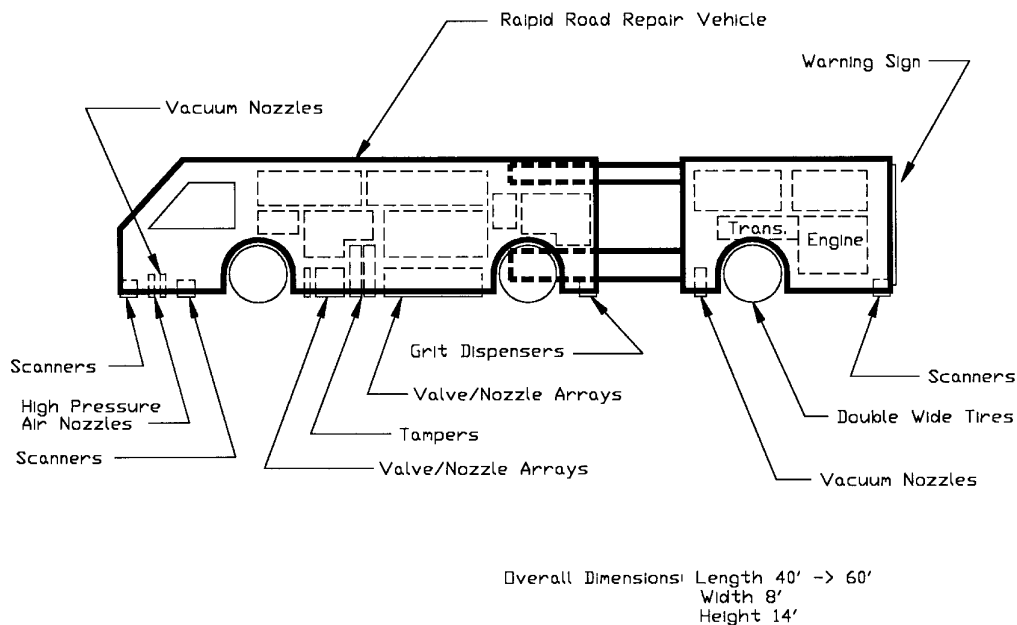
Problems Addressed And Cost Savings Provided By The RRRV

- It would lessen traffic congestion and avoid prolonged road closures during repairs.
- Because it is so easy to use, it would be utilized to detect and fix small roadway irregularities early and often, avoiding their escalation and lowering the cost of road maintenance and repair.
- The vehicles use would eliminate damage to, and reduce the wear of, the components of vehicles that encounter potholes.
- It could help save lives by avoiding accidents due to poor road conditions.
- The 3RV would eliminate many of the dangers encountered by road repair workers today, e.g. the physical threat of being hit by a vehicle, exposure to toxic road repair materials and high concentrations of auto emissions.
- It would save the costs of tens of thousands of lost labor hours from drivers and passengers delayed by repairs. It would reduce traveler stress, which in turn affects mental health and business productivity.
- This machine would decrease the cost of delivering goods by minimizing delays caused by road repairs.
- It would reduce the fuel consumed and the pollution produced by vehicles whose wheels would have been misaligned by potholes. Similar savings would be realized by allowing traffic to flow more smoothly during repairs.
- The use of the 3RV would result in savings to municipalities from the costs of litigation and out of court settlements, for cases involving vehicles damaged by potholes.
- And, although the cost of rapidly curing patch material is high, it would be offset by the greatly reduced cost of labor and inefficient repair procedures, which combined, account for 95% of the cost of road repairs today. It is estimated that there are 50 million potholes in our nations highways at any given time. The projected cost of fixing a pothole with the 3RV is \$25.00, compared to the current \$100.00 price tag. That's a potential savings in the hundreds of millions of dollars.

Functional Description

The idea behind the 3RV is to fix cracks before they become potholes. The cost of repairing cracks is far less than that of repairing holes. Cracks don't destroy vehicles, require far less materials and take less time to fix.

The 3RV would be variable in length to accommodate the differing curing times of the various repair materials it might dispense, as well as its own maneuverability and stability. The vehicle would be short for self-transport and use on city streets. The operator could easily lengthen it for use on highways. The 3RV could be equipped with foldable or removable side-wing panels. This would allow for easy transport, as well as the repair of three differing road widths.

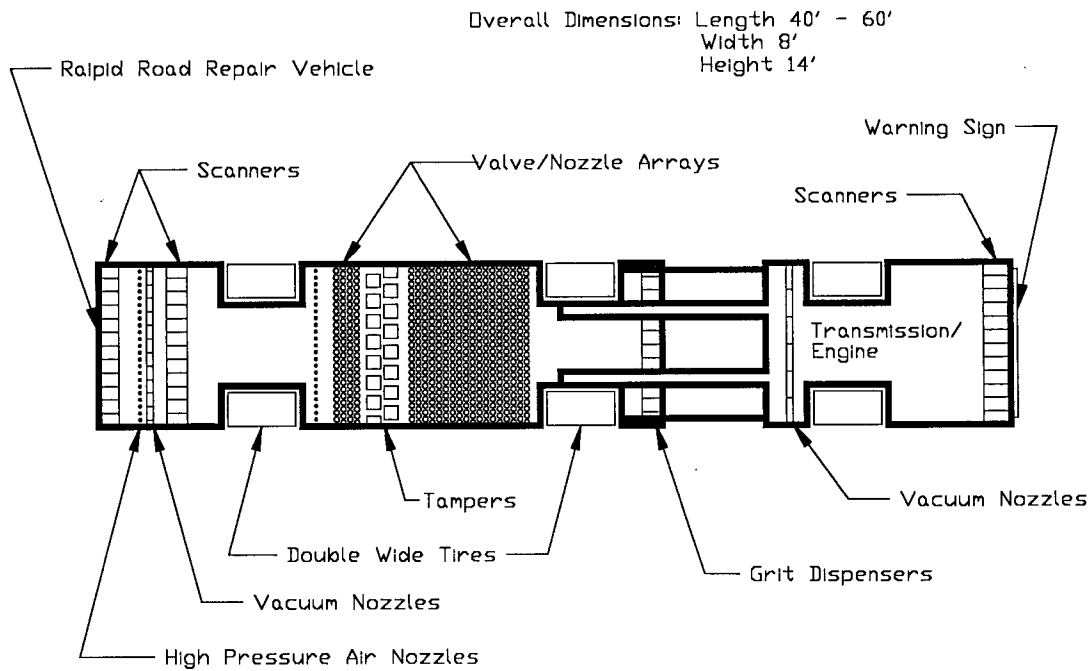


Mounted just under the front bumper, a lane-wide set of scanners provide a visual inspection of the surface of the road. Computers determine the location of any damaged areas and also locate landmarks to be avoided such as manholes. Secondary computers then determine the volume(s) and the location(s) of any affected area(s).

Affected areas are then cleaned with high pressure air and/or a vacuum and debris is collected and stored. A second set of scanners re-measure the affected areas and compare to the initial measurements. The Main Computer, which also monitors the vehicles speed and attitude, determines the appropriate course of action to be taken by the 3RV. This action might be: heat the hole or crack to dry up moisture; apply a priming coat; fill the hole or crack with the appropriate material(s); or choose not to repair the damage and simply record it.

The secondary computers then control a variety of valves, material dispensers, and heaters to prepare the surface, apply primers or aggregate and other repair materials as determined by the

Main Computer. If fitting, the correct tamper(s) would then be brought to bear, to ensure a smoothed to grade finish. If the Main Computer determined the application of a finishing coat, sealer or grit was required, it would then be applied from dispensers. A final cleaning of the repaired area(s) would then be performed using the selected vacuum Nozzles.



The final function performed by the 3RV involves a third set of lane-wide range scanners, which check the repair(s) and provide feedback to the Main Computer on the overall performance of the 3RV. A map of the road's surface would be created using the data gathered by the 3RV's sensors. This map would be recorded on the data storage devices for future analysis, trending or maintenance records.

One immediate use of such information might be to determine the speed of the vehicle itself. If, for example, 45% of the imperfections were not being repaired, the Main Computer could suggest to the operator that the vehicle's speed be adjusted to increase the percentage of repairs. Another use might be to instantaneously inform the "home base", through radio communication, of a problem that is both beyond the scope of the 3RV and needing immediate attention.

SESSION II: NEW YORK STATE THRUWAY BRIDGE

In 1997, a tanker explosion and fire rendered unusable a key bridge on the New York State Thruway. This session explored in depth the innovations that quickly restored service to Thruway users and permanently replaced the damaged bridge.

Mark J. Kulewicz, Director of Traffic Engineering and Safety Services, AAA Automobile Club of New York

Keith Giles, Executive Director, New York State Thruway Authority

H. John Marcelle, The Fort Miller Company, Inc.

Peter J. Smith, P.E, The Fort Miller Company, Inc.

Andrew Baker, Mabey Bridge and Shore, Inc.

NYS THRUWAY BRIDGE STORY



Emergency crews responding to the tanker truck explosion under the New York State Thruway bridge in Yonkers, NY.

Background

The significance of the story of the New York State Thruway bridge reconstruction is that it exemplifies how Invisible Construction methods can provide solutions to a situation that otherwise would have caused much more extreme social disruption. On October 9, 1997, a tanker truck explosion and fire damaged the NYS Thruway bridge over Central Park Avenue South in Yonkers, New York, and by February 25, 1998, all seven lanes of traffic were back in service on the permanent deck.

This is a prime example of how the concepts and practices of Invisible Construction can be used to not only minimize impacts on the users and the surrounding community, but also to expedite the construction process itself. This case history describes the bridge reconstruction process as a successful example of the use of Invisible Construction techniques.

The Case

The area affected by the damaged bridge is both residential and commercial, and more than 130,000 vehicles per day pass through this interchange. Shortly after the accident occurred, the emergency response team quickly realized that the Thruway (I 87) had to be closed. The media and all the regional transportation agencies were contacted in an effort to divert traffic away from the site of the accident. Detour routes were established for both northbound and southbound traffic, and a unified command center was set up at the site to coordinate the response and repair efforts. All of the agencies in the jurisdiction cooperated in this effort.



The day after the tanker truck disaster, NYS Thruway authorities and local officials assessed the extent of the damage to the bridge.

The bridge was badly damaged, and contacts were made with bridge suppliers and contractors almost immediately. It was determined that the use of temporary bridges would be the fastest way to respond to the immediate emergency situation, as well as be the best way to accommodate traffic while a permanent bridge was under construction. The superstructure was removed within days of the accident, and excavation was begun for the temporary replacement bridges. Mabey Bridge and Shore, Inc. was chosen as the supplier for the temporary bridges, which were shipped from Baltimore within a few days as well. The temporary bridges were open for traffic eleven days after the accident, and they provided for four lanes of traffic, where originally there had been seven lanes. The temporary bridges were 147 and 155 feet long in order to span over the abutments, so that future work on the permanent abutments could be done without interfering with the traffic above. Both the use of temporary bridges and their placement are examples of how Invisible Construction techniques played a role in the reconstruction of this Thruway bridge.

Construction of the new permanent bridge moved swiftly as well, and the time frame in which the entire process occurred is as follows:

- October 9th -- the accident occurred.
- October 20th -- the temporary bridges were in place.
- October 22nd -- permanent plans were available for contractors to bid on.
- October 27th -- a pre-bid meeting was held with the potential bidders.
- October 29th -- there was a letting.

- October 31st -- contract documents were signed, purchase orders were issued to the supplier, and a consultant was designated to do the construction management on the job.
- November 1st -- the contractor was mobilized.
- December 10th -- southbound traffic was back on the permanent deck.
- January 12th -- northbound traffic was back on the permanent deck.
- February 25th -- the permanent seven lanes were completely back in service. One of the techniques used was offering bonuses to contractors for finishing early.
- March 13th the entire project was finished.

This is record time, and it shows that a highly visible construction project can be turned into a relatively invisible one that is completed quickly and minimizes the impact on the public in a number of ways.



By using temporary bridges, traffic was moving again within eleven days of the accident.

This case demonstrates the importance of public/private cooperation, since it required extraordinary cooperation by private firms and local and state government to make the bridge reconstruction a speedy success. The Thruway Authority and local officials worked with the local businesses in the area in order to provide access to these

commercial and retail areas during the busy holiday shopping period. Some work was done at night in order to minimize the disruptions during regular business hours.

Andrew Baker, of Mabey Bridge and Shore, Inc., explained how quickly they were able to respond to the Thruway disaster, and he also described the design of Mabey's temporary bridges. He emphasized that Mabey uses some new technologies, but essentially the temporary panel bridges come from designs developed during World War II, in which the British military would rebuild bridges almost overnight. A ten-man crew assembled the temporary bridges used in Yonkers, and the "launch" of the bridges was done by using stationary launch rollers and a crane. The crane actually lifted the bridges directly into position.



With the help of a crane, a ten-person crew assembled and positioned the two temporary

The Fort Miller Co., Inc. was chosen as the supplier of the permanent bridge, and Peter Smith described some of the technical and detailed aspects of the pre-cast process as well as the major benefits to using it. He said that, “The most significant benefit to using this process is the fact that within a few minutes after the structures are erected, they can be used by traffic.” Other benefits of using modular units include being able to build the composite superstructures in warehouses away from the job-site, and also the ability to install them in the middle of winter--during snowstorms if necessary. John Marcelle, also of the Fort Miller Co., quoted a *New York Times* Editorial that summed up the success of the Thruway case. The editorial described some of the key Invisible Construction techniques that were used on the project including the use of prefabricated components of concrete and steel, the offering of contract bonuses for beating deadlines, and the use of the two temporary bridges. The editorial ended by saying that, “This is one construction project that was handled in ways that truly minimized the inconvenience.”

General Commentary

John Marcelle of the Fort Miller Co, Inc., underscored the need for trying out Invisible Construction techniques, which are based on new technologies, methodologies and philosophies. He discussed the concept, rationale, challenge and solutions of Invisible Construction during a panel on the NYS Thruway Bridge Reconstruction. He described the concept of Invisible Construction as the ability to perform new construction or to rehabilitate existing construction with minimal disruption and/or inconvenience to the travelling public and surrounding community. He said that Invisible Construction truly can be unobtrusive. It can be done “seamlessly,” and in fact, the techniques have been used to do work between trains, on weekends, and in snowstorms. Invisible Construction takes an innovative approach to infrastructure repair that actually creates a positive public response. It can evoke positive and supportive media attention, and it utilizes new and existing methods and materials.

The rationale for Invisible Construction is related to a responsibility of protecting the public. Marcelle said that, “We must provide safe, economical, convenient, reliable methods and materials for building and maintaining our infrastructure system. The public trust is placed in our hands, and implicit with that trust is the obligation to ‘look ahead’ to the next generation to be sure they can effectively maintain and rebuild that which we have reconstructed.”

Consequently, the value of shortening time with respect to saving money and reducing exposure to injury can not be ignored.

The challenge for Invisible Construction is that the public, motorists, straphangers, and local businesses will no longer tolerate inconvenience during construction. New methods and ways of doing things have worked and will continue to work. The NYSDOT has recognized this challenge and has adopted the phrase Smarter and Faster. The hope is to deliver the project in less time in order to shorten the process. There is a need to develop productive public-private partnerships that will help deliver these projects Smarter and Faster by utilizing innovative methods and materials. Marcelle added that, "There must a realization that the way we have done it before, just may not be the way we have to do it tomorrow."

Some of the solutions for Invisible Construction involve bringing together owners, designers, contractors and suppliers in order to design innovation, flexibility and modularity for future replacement and speed into the project from the very beginning. There is a need to take the initiative to use timesaving, pre-fabricated, shop-manufactured, better quality and longer lasting systems.

Marcelle described a current Major NY Toll Bridge Project in which a change to Modular-pre-cast components from the as designed, cast-in-place method shows a projected total savings of \$89 million and 11 months of construction time. The break-down of the projected savings is as follows: \$51 million savings for the users of the bridge; \$16.4 million savings in detoured traffic costs; and \$21.7 million savings of lost toll revenues. All it takes for this to happen is a willingness to make it happen. In his conclusion, Marcelle said, "We must recognize that we can no longer continue to take the 'business as usual' approach to infrastructure construction. We must take advantage of the proven successes and find ways to incorporate them into our projects."

Andrew Baker
National Sales Manager
Mabey Bridge & Shore, Inc.

TEMPORARY BRIDGES

Background

Temporary bridges have increasingly been used to successfully carry out major construction and reconstruction projects more "invisibly." The Invisible Construction techniques related to temporary bridge technology and use have proven to speed up the response time in emergency situations, increase the speed at which projects can be completed, as well as minimize the level of impact on both the traveling public and the surrounding communities. For example, the use of temporary bridges after the October 9, 1997, NYS Thruway Bridge disaster enabled traffic to be moving again within eleven days of the accident.



Design and Specifications

- The design of temporary bridges is similar to the panel bridges developed by the British military during WWII, which enabled them to rebuild bridges almost overnight
- New steel products, robotic welders and the latest galvanized coatings are used to construct the bridges.
- The bridges can span up to 300 feet, and they range in width from one to four lanes.
- More panels can be added to strengthen the bridges.
- 32 feet is needed for a two-lane bridge, since the trusses are on the outside of the traffic flow.
- The bridges utilize a system of braces and nine-inch thick deck units.

Uses

- Emergency work (Southern Mexico, Bosnia, NYS Thruway).
- Planned construction detours.
- Utility bridges (for pipes and other utilities).

Advantages

- The bridges are prefabricated, and so they can be shipped from an inventory warehouse and put into working operation within days.
- A 10-man crew can assemble the bridges.
- The “launch” of the temporary bridges is done by using stationary launch rollers and a crane. The crane actually lifts the bridges into position.
- These bridges are heavier and stronger than earlier models and can handle AASHTO’s heaviest highway loadings.

- The temporary bridges can keep traffic moving while construction is being done on permanent structures.
- The bridges can be re-used on future projects with minor modifications.

SESSION III: PERSPECTIVES ON INVISIBLE CONSTRUCTION FROM TRANSIT, UTILITIES, AND CAPITAL INVESTMENT

Problems produced by the deterioration and reconstruction of infrastructure extend well beyond surface transportation. Large urban regions, particularly the older ones, confront serious performance issues with aging utility conduits and railways, essential to the functioning of urban economies. Service can rarely be halted for the time needed for major reconstruction. This session explored approaches to reconstruction of subways and gas pipelines, as well as the broader perspectives of agencies with capital investment opportunities.

Lawrence Reuter
President
New York City Metropolitan Transit Authority

THE LENOX AVENUE INVERT

Background

The MTA is the country's largest public transportation agency with over 43,000 employees (10% less than when Mr. Reuter joined the agency). The agency is currently experiencing a growth in ridership, a new fare system, and continues to be the largest infrastructure project in New York City. Before coming to New York, Mr. Reuter worked in Florida, California and Washington DC.

The Lenox Avenue Invert illustrates the way the MTA overcomes unique and difficult circumstances in an effort to minimize the impacts repair and new construction project have on the public.

This project illustrates the importance of creatively managing service delivery on major construction projects so that customers are inconvenienced as little as possible.

Reconstruction Issues

MTA projects are not "invisible" per se, but the agency does make an effort to minimize the impact of these projects on the public. The unique circumstances of the New York City subway system make this hard to do.

- It is the only large subway system in the world that runs 24 hours a day 7 days a week, leaving the question, When do you do maintenance and repair work?
- It carries 6 million people per day, making it hard to be "invisible."
- The system is almost 100 years old and has been neglected in recent decades. It, therefore, needs a lot of work.

But there are advantages to its complexity:

- There is a lot of flexibility in the system, resulting particularly from the fact that it is actually the conglomeration of three originally independent lines. This permits us to reroute trains on many lines and provide alternate options for riders.

- The MTA has a lot of experience running capital programs and therefore has had time to learn from mistakes and discover innovative ways to achieve their objectives.

Most subway repair and maintenance work is done on weekends and evenings. The problem with this system is that work continues for an inordinately long period of time. The MTA is now using positive and negative incentives like paying contractors bonuses for every day ahead of schedule that they finish a project and penalizing them for lateness.

The Lenox Avenue Invert Case

A recent project, the Lenox Avenue Invert, illustrates the success the MTA has had in limiting the disruption created by maintenance and repair work. Water intrusion on the subway line results from the fact that the track, from 110th Street to 135th Street, which includes the 116th Street station, runs below the water table. This problem has been around most of the century (as revealed by a 1907 *New York Times* article commenting on the problem) and has been repaired numerous times.

90,000 people per day use this portion of the 2 and 3 lines in northern Manhattan. As a result, there was a lot of “local interest” from community groups in the area. Originally these groups were the MTA’s biggest impediment to the project, but ultimately became the agency’s greatest ally.

There were three options for how this project could proceed:

1. Work only on weekends and evenings. This would mean that the project would take over two years to be completed
2. Full closure of the line for the course of the project. This proposal was ultimately rejected because the rest of the system did not have the capacity to accommodate the diverted passengers.
3. Peak direction Service only.

The last solution was the one eventually chosen and required eight months to complete. Four free bus routes were established by the MTA to deal with non-peak direction traffic.

Planning for this project was one and a half years in the making. The effect on other lines, most notably the Lexington Avenue, was studied (as these lines could no longer be re-routed onto the 2/3 track when there was a problem on their line). The rest of the system, therefore, had to run as efficiently as possible.

Some of the measures taken included:

- Placing repair teams on site to respond to technical problem quickly at strategic locations so someone would be within 5 minutes of any potential problem.
- Putting extra police on the trains to ensure smooth customer flow.

- Putting nurses at key stations so that any person with a medical problem could be taken off the train and the train could continue its service. Medical problems are the greatest cause of delay. The program was so successful, in fact, that it is now being expanded.
- Track work was completed on the critical Lexington Avenue line prior to beginning The Lenox Avenue Invert reconstruction to make sure that it was in the best condition possible.

The MTA also worked with the community, holding over 200 meetings which resulted in many changes in the service plan. Because they were listened to, the community felt it was a part of the solution to this project. At the community's request, staff was deployed to give directions to the various bus lines. The MTA also published a lot of information on the project and alternative services.

There were three stages to the project itself. The first was the removal of what was essentially an underground river before the contractors could even get in to begin the work. This involved the construction of a "bathtub" around the station and the creation of 300 well pumps and a pumping station which passed 2000 gallons of water per minute into the city sewer system. The next step was the destruction of the old invert. To accomplish this, repair crews had to underpin the roadway running over the work site. This was particularly complicated as the roadbed, itself, was being repaved at the time.

Finally a new invert had to be constructed with new waterproofing. Getting the materials for this construction underground was "not an invisible task." The MTA decided to restore the station simultaneously, which is normally a 2-3 year project, in order to avoid a second construction project in the same station in the near future.

Despite all of these complications the project was finished ahead of time (by 16 days) and under budget (by \$14 million). Elected officials in the area complimented the MTA on their work.

Conclusion

There were four main reason why this project was such a success at limiting disruption to the public and being as "invisible" as possible:

1. Excellent planning
2. Great project management which included high level involvement by both the MTA and the contractor
3. Excellent contractor performance
4. Community involvement

Steven Newman
First Deputy Comptroller of New York City

NEW YORK CITY'S CAPITAL INVESTMENT NEEDS

Background

The New York City Comptroller's Office released a study in the fall of 1998 that inventoried and assessed New York City's infrastructure. The study revealed a \$92 billion cost for maintaining

and restoring the city's infrastructure to a state of good repair over the next ten years. A substantial gap exists between this estimate and the projected city budget for infrastructure projects over the same period. There are historic reasons for this gap and the current state of disrepair, and there are solutions to the problem.

Invisible construction techniques are needed not just for new construction projects but, perhaps even more significantly, for the restoration and repair of older systems. Because of the advanced age of many infrastructure systems in the United States and elsewhere the need to advance these techniques in the near future is particularly acute.

Capital Needs of New York City

The study took place over an 18 month period of time, looked at 20 agencies, and involved a couple hundred site visits. The aim was to determine the condition of the city's infrastructure and to try to assess the cost of getting that infrastructure into a state of good repair. The study did not investigate smaller agencies without significant infrastructure, technology projects or new projects like the proposed Second Avenue subway line. By "state of good repair" the study meant merely "adequate and functional" not "excellent."

The finding was that the cost would be \$92 billion over 10 years. The current New York City fiscal plan budgets \$45 billion over the same period. Minus technology and non-assessed agencies, the budget contains \$38 billion, but there is an additional \$14 billion budgeted for other government spending that brings the total up to \$52 billion.

How did we end up with such a gap?

1. Our infrastructure is very old (much of it over 100 years old and most schools over 50 years old)
2. There has been a failure to replace facilities as their useful life comes to an end
3. The fiscal crisis of the 1970's led to the elimination of the capital budget which when resumed was at a lower level than was required.
4. There has been a failure by the city to maintain facilities, as new projects are more politically appealing than maintenance of old facilities.

In fiscal 1997 the City spent 40% on maintenance vs. its need (according to KPMG Peat Marwick, an outside auditor). An illustration of this point is provided by the school system. Inquiries into private sector standards revealed a standard of spending 2% of the value of a given building on maintenance. The city actually spent half that amount. This amount is about to be increased following a teacher's union lawsuit for a 50% increase in spending and the board of education surplus will lead to a doubling of current expenses. But this is still inadequate.

The title of the report is "Dilemma in the Millennium," referring to the fact that the City does not have the resources to fill the gap. We cannot borrow our way out.

Solutions:

1. Use the expense budget for capital funds (whereas before we used the capital budget to fund the expense budget).
2. As the city periodically sells its assets, make sure that the money goes to the capital budget, not the expense budget (sell an asset to create a new asset).
3. Terminate Wick's law to make the capital program 15% more efficient.
4. Be smarter in the projects the city chooses. An example would be not closing schools in the summer. The Williamsburg Bridge is also an example of how the city did not choose its projects wisely.

Most importantly, however, is convincing Congress that the infrastructure of cities is a major national need. New York needs to get the money back from Washington that it sends there.

We must not continue to spend less of our GDP on infrastructure than any other industrialized nation. While we spend 1%, Britain spends 2% and Germany and Japan each spend 4-6%.

Conclusion

"Invisible Construction" methods are increasingly offering innovations to reduce the impact of construction, providing opportunities for efficiency as well. For New York City to maintain its international preeminence in the 21st Century, it must take advantage of every opportunity for choosing projects wisely and insisting on the most efficient means for reconstruction and maintenance.

Pascal Bocherel
Manager, Gas Research Technologies
Gaz de France

TRENCHLESS GAS BRANCH CONNECTION TECHNOLOGY

Background

Trenchless technology can help to minimize the disruption created by the installation of gas branch connections.

30 experiments with trenchless gas connection technology have been performed so far revealing a 60% reduction in the amount of soil excavated. These experiments also reveal how the technology addresses the problem of soil transport, open space use, traffic disturbance, access for city inhabitants, safety and environmental respect.

Trenchless Technology of Gaz de France

Gaz de France has been working with this new technology since 1993, installing over 200,000 branch connections per year. The new technology reduces the size of the excavation required for these connections, the nuisance created by the work, the time period required for the construction and the cost of the project. It also allows the excavation to be accomplished with only one person where two people were required only a few years ago.

Dry drilling is used to install branches under roadways without disturbing the roadbed itself. The attachment and fusion is then performed from the surface, reducing the number and possibility of work accidents on such projects.

30 experiments with trenchless gas connection technology have been performed so far revealing a 60% reduction in the amount of soil excavated. These experiments also reveal how the technology addresses the problem of soil transport, open space use, traffic disturbance, access for city inhabitants, safety and environmental respect.

73% of the clients served with branch connections are residential, representing 40% of the natural gas volume in total. The density of branch connection is very low at about 30 connections per square kilometer. 80% of the connections are in use.

As the major goal of the new technology is cost reduction, the project will be expanded if this is shown to be significant. For this purpose, Gaz de France has transferred research and files to the United States from Gas Metropolitan in Montreal and a partnership has been formed between Gaz de France and Gas Metropolitan. The biggest human investment so far has been the training program that occurred between July and November 1998.

Based on these experiences there may have to be some compromises on technical points in order to achieve sufficient cost reduction. In addition, some technical improvements still have to be made, for example drilling machine capacity will be increased.

The most difficult part of the project is changing people's habits to implement the new technologies. An additional challenge is in creating partnerships with state departments which must change regulations to allow, for example, the reuse of filling materials. A meeting is scheduled for spring 1999 to discuss this very point with the New York Gas Group, Consolidated Edison and the Brooklyn Union.

Luis M. Tormenta, P.E.
Commissioner
New York City Department of Design and Construction

THE NEW YORK CITY DEPARTMENT OF DESIGN AND CONSTRUCTION

Background

The New York City Department of Design and Construction is the city's newest construction agency. The DDC combines the Department of Environmental Protection's water main and sewer work with the department of transportation's construction work into one entity that oversees all non-residential building work in the city.

The DDC promotes invisible construction by streamlining the contracting of construction work in New York City. The DDC allows integrated project delivery which means that the disruption created by two separate projects – for example the repair of a burst water main the repaving of the street above it -- can be minimized by combining the two projects into one.

The significant improvements in project and service delivery fostered by the creation of the DDC reveal the importance of comprehensive and coordinated project administration as an invisible construction technique.

Administration Reform

The DDC was created because the city's capital program was quite fractured and a better way was needed to work more efficiently within limited resource constraints. There are now 1400 employees in the DDC, which has been in operation since 1996 and has a budget of \$3 ½ billion. It undertakes \$1 billion of work each year.

When considering invisible construction, we need to think about more than technology but how we contract out construction work. The DDC allows integrated project delivery – when the city fixes a sewer it also fixes the street over it. Previously the city repaved only the trenches, leaving a scar on the road where the work occurred. Now entire streets are repaved. This means that the disruptive memory of the repair is also removed from people's minds after the work is done. With the DEP/DOT consolidation the city is able to install pedestrian ramps with catch basins providing access to the water front while providing an important environmental service.

One of the goals of the DDC is to develop a more sophisticated GIS system to keep track of project and thereby facilitate the coordination of work both within the DDC and between other agencies. This will be particularly helpful with small, low visibility projects.

Some initiative of the DDC include: gun lining sewers, slip lining water mains (rather than replacing old structures new structures are slipped into the old); jacking and micro-tunneling (although this cannot be done in Manhattan it is quite efficient in the outer boroughs); high/early strength concrete which dries quickly and allows major intersection to be reopened more quickly after construction.

The DDC is also trying to find more sensitive ways to do sewer projects without destroying the natural characteristics of the land, but rather take advantage of them. The Office of Sustainable Architecture is also encouraging "green building" projects. The projects are pushing the envelope of design.

Since all construction work is contracted (the DDC does not do any of the work itself) the agency has gone to great lengths to select contractors properly. Among the measures taken are various bond revisions. With performance bonds it used to take 10 months to change contractors when the original contractor had defaulted. There is now a 25 day assuery. This has significantly reduced the amount of stress projects have on the public as an inactive project is a major moral and physical drain on the city.

SESSION IV: UNDERGROUND CONSTRUCTION (TRENCHLESS TECHNOLOGY)

Despite the title of the conference, most of infrastructure is of course quite visible. Bridges and roads are prominent parts of the public space. Underground infrastructure, however, is unseen for the most part. Pipes, wires, and trains have been submerged to make the world simpler, at least in appearance. With these elements of the infrastructure system underground, more room is available for living space and, to some degree, they are protected from damaging and corrosive forces. Ironically, because they are unseen, these parts of the infrastructure have become more and more taken for granted or even completely forgotten about—that is, until they fail or must be repaired.

Unfortunately, maintenance and eventually replacement are inevitable for all infrastructure, and underground placement greatly complicates matters. The inconvenience and ugliness that repairs and even planned maintenance and replacement bring are major frustrations for the average person in a place like New York City. Excavation causes traffic jams and threatens disruption of the many utilities found underground (gas, electrical, water, waste). This is where trenchless technology offers great advantages. This session examines a number of techniques and technologies that have been invented and implemented during the past 20 years.

George Greenwood – Moderator

Director for Customer Service Environmental Operations

Con Edison

Background

Con Edison has been around for 175 years. They have pipes that are as old as 100 years old, so they are faced with a great deal of maintenance, repair, and replacement work. They are trying to do this work invisibly—i.e., with the least disruption to the public as possible. Trenchless technology has recently become a major part of this effort. Figure X1 provides a list of the techniques used by Con Edison:

Technique	Explanation
Pipe Splitting	Old pipes split; new pipes pulled in open space.
<u>Rolldown</u>	New pipes are rolled down to temporarily smaller size, inserted in old pipe, and re-expanded within to meet sides of old pipe.
<u>Subline</u>	New pipes are folded into “C” shape, inserted into old pipe, and reformed into larger size for secure fit.
Robotics	Various functions, from inspection to cutting to welding, carried out using remotely-controlled robotic instruments.
Insituform	Soft membrane inserted into pipe and cured into hard replacement pipe.

Robert Zlokovitz
Manager of Gas and Steam Research
Con Edison

Background

For the infrastructure managers at Con Edison, it is important to know a variety of trenchless technology techniques so that each can choose the best methodology for every situation. Underground New York is a very complicated world as a result of years of placing pipes and other important parts of the infrastructure underground; Con Edison is not the only user of the underground. Figure X2 shows how complicated it was as early as the 1920s at such places as the intersection of William and Wall Streets in downtown Manhattan.



While underground building was meant to simplify life above ground, it has made for maintenance and rehabilitation challenges. In the 1970s, Con Ed's motto was "Dig we must." In the 1990s, the advent of trenchless technologies has changed it to "We must not dig." Although the first form of trenchless technology was to lower an employee into the ground headfirst (Figure X3), the technology has advanced and there are now numerous techniques used for various purposes.

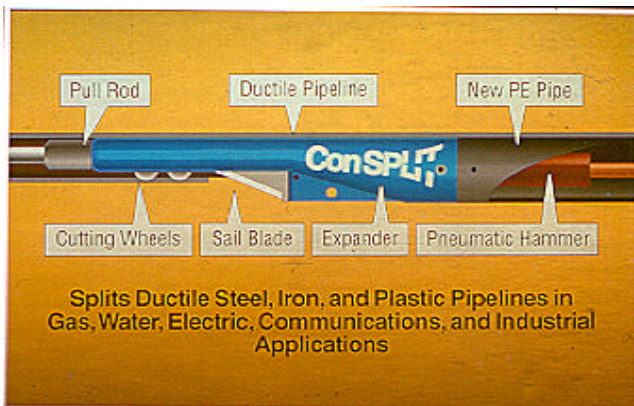


Pipe Splitting

Pipe splitting (called ConSplit at Con Edison—they have a patented system that won an international award in 1991) is a technology that splits old pipes and pulls new pipes into the resulting space. Pipes of all materials and sizes can be split—the most recent Con Edison version pulls at a force of 120,000 pounds, splitting pipe at three to five feet per minute. The replacement pipe is generally made of polyethylene (PE) and is pulled in right behind the splitting. The Con Edison splitting head is a set of inexpensive, easily replaced cutting wheels that act like a can opener.

As of November 1998, Con Edison was splitting 300 to 500 feet of pipe per day. At a given job site, they are generally able to get all customers back on service within an eight-hour workday or less. For a time, a protective thin liner was inserted with the new pipe to protect it from damage. Recent changes have made this unnecessary, making the technique even more economical. PE liners have an assumed life of over 50 years; some engineers at Con Edison believe they can last over 500 years. One major concern for liners has been the loss of capacity from pulling a smaller pipe into a larger one, but there are now thin wall versions to minimize the loss.

2 ConSplit (pipe-splitting) images:



Schematic of pipe splitting



Photo of pipe being split by Con Edison

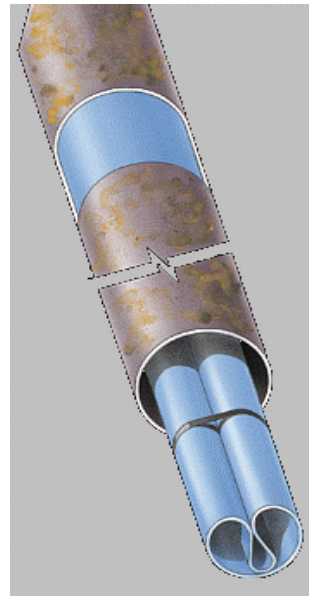
Subline

Subline, a product of Subterra that Con Edison uses, is a thin wall PE liner that is put in place in a different way than pipe splitting. On the site of the job, a close-fitting PE pipe is folded in on one of its convex exterior sides to form a “C,” with a concave side. The pipe is then pulled into the old pipe and returned to its “O” shape to complete the job. This technique can offer reduced costs, particularly on high capacity pipes. The first Con Edison jobs were done in 1997, and two months of work were saved from the time that would have been required using other techniques. Since then, increasing lengths of pipe have been pulled into place. In a project in Queens (NY), the longest unexcavated segment was 1100 feet.

The technique involves a number of steps. The old pipe is inspected for defects that could catch on the new pipe and damage it. The 50-foot lengths of pipe are soldered joined into a larger single pipe. The pipe is then made into a “C” and it is banded to retain this shape. The old cast iron main is then lubricated with environmentally sound lubricant. The new pipe is inserted, still in a “C” shape. The bindings are then broken with water pressure and the new pipe is secured in place.



Picture of subline process actually in use, with folded, banded pipe being inserted into older pipe



Schematic of subline process showing folded, banded pipe on the lower part of the picture and cutaway of resulting unbanded process in place at the top

Robotics

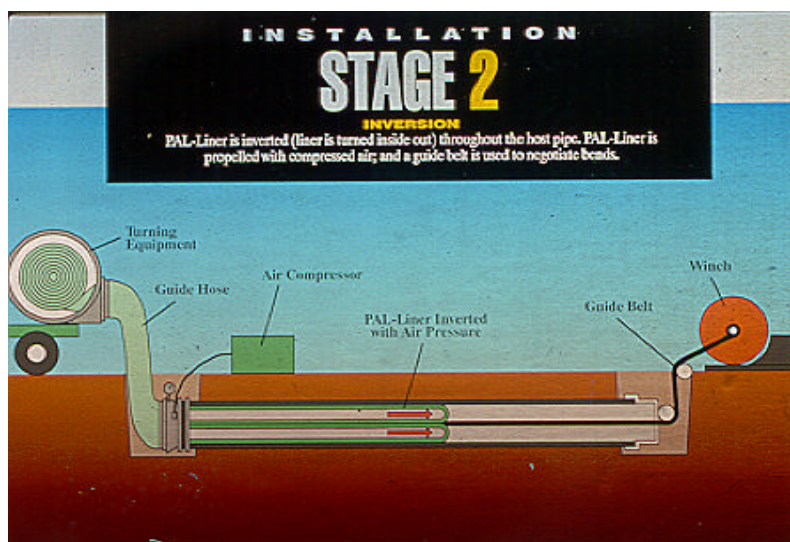
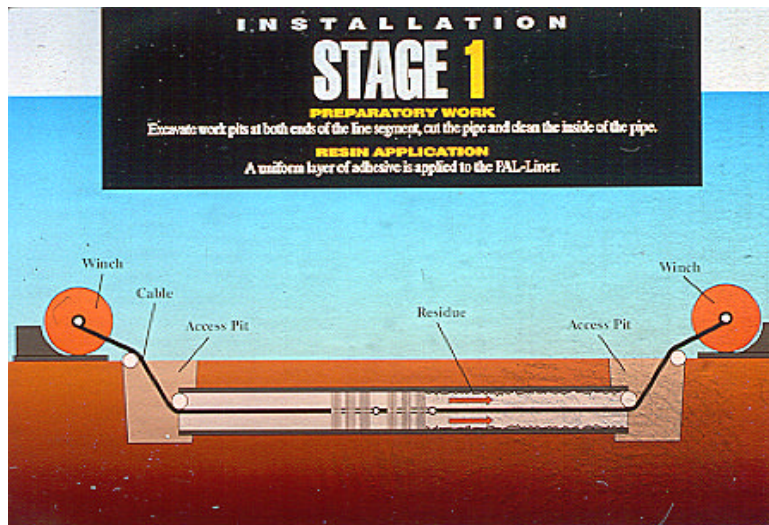
Robotics is becoming a key part of trenchless technology. Con Edison will begin using robots in 1999 to seal joints by going up to 150 feet in each direction from the point of entry. The robot is placed inside a pipe at an entry point, a camera is then used to find the joints, and another instrument injects sealant from tubing. Consumers Gas of Toronto has used a robots for over 1000 joints.

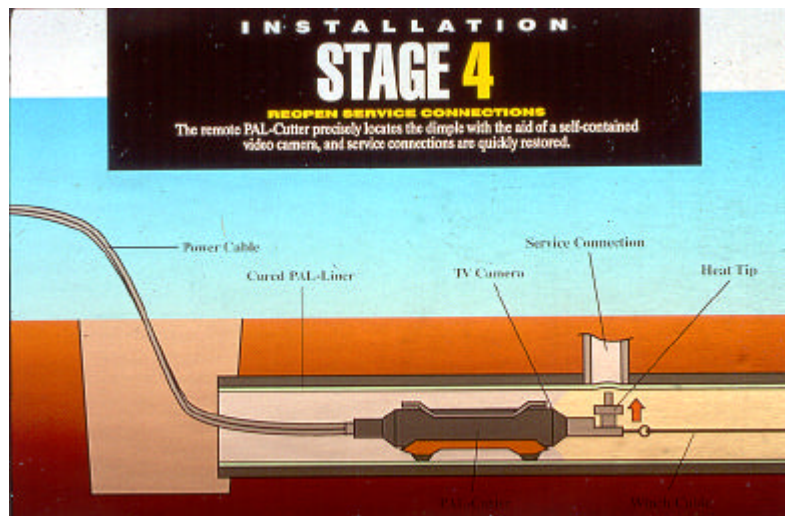
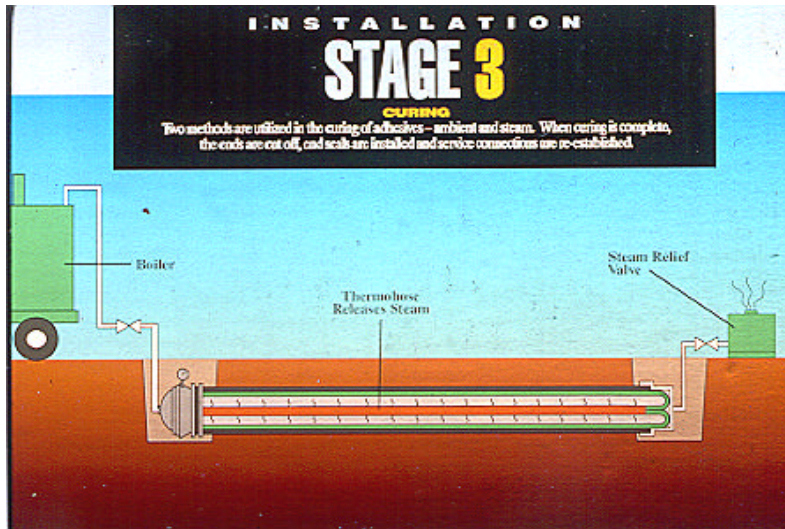
George Neumann
Managing Director
Insituform Metropolitan

Background

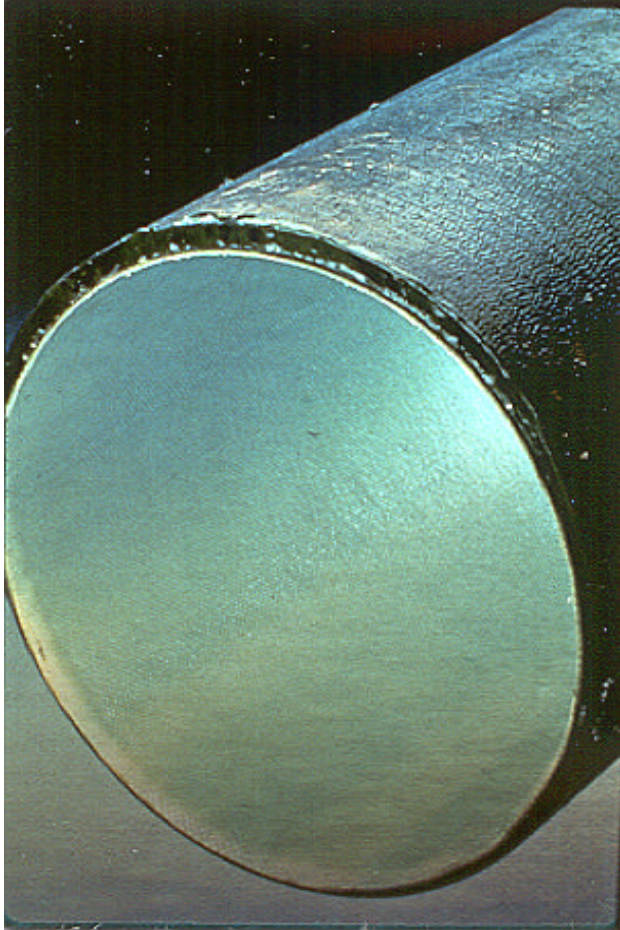
The Insituform process was developed in the 1970s by Eric Wood and used in the United States since 1981. It was first used in New York City in September 1982 in the Bronx. The Insituform epoxy resin lining process uses a soft membrane in an uncured state to rehabilitate pipeline. The membrane is installed through an existing opening, such as a manhole, into a pipe and then cured into a hard, durable plastic pipe by the application of heat (pumping hot water through the line). The membrane is polyester felt saturated with polyester resins similar to those used to manufacture fiberglass. After hardening, robotic cutters are used to reestablish any openings in the pipe.

Schematics of the Insituform process, from preparation to insertion of membrane to curing and finally reopening connections.





Actual picture of membrane being unfurled in a pipe that is being repaired with Insituform.



Picture of cross-section of a pipe with a new Insituform liner.

An actual job can often be done without the any disruption of service—typically a job can be done in less than eight hours. Some of the projects that Insituform has recently been used in, and which illustrate its value, include:

- The Times Square area: rehabilitation of pipeline in under six hours, prior to the start of rush hour.
- Downtown Manhattan, near the Stock Exchange: successful weekend repair of sewage pipes that threatened a Monday morning opening of the Exchange and neighboring buildings.
- Queens Midtown Tunnel: repair of sump pump discharge line that started 13 stories down at the center of the tunnel under the river; stopped exfiltration into the river.
- Park Slope: Insituform process made plans for open cut repair of sewer lines unnecessary, saving 100 year old trees on street and minimizing overall disruption of course.

Dr. Mark Hoffman
Overseas Business Development Manager
Subterra – UK

Background

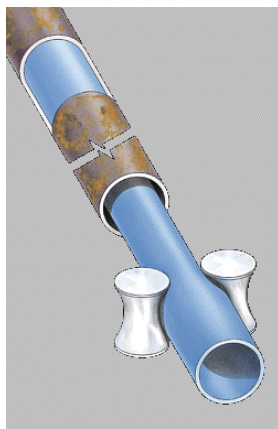
Dr. Hoffman pointed out that leakage creates many risks: fire, disease, environmental damage, loss of scarce resources, sinkholes. Trenchless technologies, what he called “no dig

technologies,” can increase the rate of repair and reduce the cost of each job. Subterra has three pipe rehabilitation processes to try to reduce the occurrence of leakage:

- Close-fit PE lining: rolldown
- Thin-wall PE close-fit lining: Subline
- Epoxy resin lining

Close-fit lining: rolldown

This technique was developed to overcome the loss of capacity created by conventional slip lining, where a new, smaller, pipe is simply pulled into an old pipe. In rolldown, the initial outside diameter of the liner is greater than the host pipe's. The new pipe's diameter is temporarily reduced by passing it through rollers, after which it is slipped into the host pipe. Using cold water pressurization, the in-place liner is then reverted to its original size for a close fit with host pipe. This technique can be used for pipes ranging from 4 to 20 inches in diameter and in lengths exceeding 4,000 feet (normally in lengths from 1,000 to 1,300 feet) and negotiate bends of up to 11.25°. It is now beginning to be used in the United States, but mostly has been used in the United Kingdom and elsewhere in Europe.



Schematic of rolldown. Lower part of the picture shows pipe being rolled down in size. Upper part of the picture shows re-expanded pipe in place in old pipe.

Thin-wall close-fit lining: Subline

[As discussed above,] this technique was developed to introduce benefits of close-fit PE liners to larger diameters and to improve pipe bend negotiation capability. The liner pipe is folded into a heart (“C”) shape and temporarily secured in this new smaller size with restraining bands. It is then slipped into host pipe and the liner is reverted to a close fit with host pipe by cold water pressurization, which breaks the bands. Subline is available in diameters of 4 to 48 inches, lengths exceeding 3,000 feet, and can negotiate bends of up to 22.5°. The technique has been used in the United States by Con Edison and the NYC Department of Environmental Preservation.

Epoxy Resin Lining

This is an in-situ lining process for potable water mains. It creates a thin, smooth durable barrier coating inside old pipes to enhance flow capacity and stops internal corrosion. There is no negative effect on water that flows through the pipe and minimal service disruption. The process can be used for pipes from 3 to 24 inches in diameter in lengths up to 500 feet in the following process:

- tuberculation (boring/scraping pipe);
- flushing out pipe to remove debris and standing water;
- inspecting pipe with CCTV;
- inserting spinner head and applying to pipe in minimum of 1 mm thickness;
- curing of resin; and
- inspection, disinfection, and final flushing before return to service.

Sini Stojicic
Vice-President, Corporate Development
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Early trenchless technology goes back to 1960s, when public utility departments started using what is known today as slip lining. Slip lining methods pull a smaller pipe into a bigger one. This extends the service life of the underground pipes but also significantly reducing the capacity of the line. Advances in technology in the 1970s led to cured-in-place pipes, which are still widely used today. Soft liners are inverted or pulled in place and then cured. Also, fold and form liners made from Polyethylene or PVC were developed for similar applications. All these systems need to be applied from manhole to manhole.

Several statistical investigations showed that, on average, only 6% of all pipes in sanitary sewers and storm sewers are damaged, so that complete relining was not necessary for many applications. With this in mind, Link-Pipe in 1978 developed the first patented trenchless technology for mechanical spot repair of localized damage. Stainless steel is normally the material used because its mechanical and long-term durability properties are well known and defined. Buildings have been built with stainless steel exteriors for the same long-term performance reasons.

The stainless steel sleeves reinforce the pipe they are rehabilitating. The sleeve is pulled into place between two points as far as 500 feet apart. A sealant on the outside of the sleeve ensures that cracks in the pipe are sealed and the sleeve is anchored to the host pipe. The liner has a rigid body and creates a new thin pipe inside the host pipe. Generally the host pipe has been properly back-filled and thus is capable of carrying the load of the soil. It is important to make sure this is the case. The choice of materials will have a significant effect on the life of the repaired pipe. Link-Pipe is working with Con Edison and LILCO to test their methodology.

CONCLUSIONS AND IMPLICATIONS

Concerns in four broad problem areas framed the cases, techniques and issues that were examined at the Invisible Construction Conference. One, sound infrastructure is critical to the economic, social, and cultural functioning of urban regions. Indeed the productivity advantages that urban regions offer depend heavily on the capacity of infrastructure to make possible travel, goods movement, communications, transactions and environmental services. However, the importance of effectively functioning infrastructure systems to the livability and sustainability of urban regions is poorly understood by the public and most public officials alike.

Two, the quality of infrastructure in the U.S., especially in the older urban areas, continues to deteriorate and, in many jurisdictions, civil infrastructure is nearing the end of its useful life. In New York City and its sister cities of similar age across the U.S., many components of vital infrastructure have exceeded or are reaching the end of their useful lives. Land and water bridges, sewers, water mains, as well as train and transit tracks are due for major reconstruction. While some rebuilding is already taking place, need far outstrips actual plans and secure means of finance.

Three, neither public policy nor capital investment practices reflects an appreciation of this situation and its consequences. A report by New York City Comptroller, Alan Hevesi, that was presented at the conference, estimates a \$38 billion shortfall in the budget for repair and reconstruction in New York City alone. Unfortunately due in part to the long time frames for major capital investment, most current public officials opt for short term solutions, leaving for some unlucky future office holders the problem of large scale and more expensive reconstruction.

Four, policies and practices intended to alleviate the impact of reconstruction and new construction on communities and the environment frequently produce stalemate and inaction on infrastructure projects genuinely needed for regional benefit. Since impact must be considered, new construction and reconstruction must be planned and executed with regard to environmental, user and community concerns and preferences. Recent experience has shown that agencies responsible for infrastructure renewal continue to behave as if traditional ways of doing business are still possible. Experience also shows that environmental and community considerations can no longer be ignored, and in fact, the cost of doing so is counted in serious time delays and a higher price tag.

The conference demonstrated that there is no shortage of creative methods and technologies to dramatically reduce the impact of construction on the public and environment. Most of the innovations examined at this conference have been tried and were successful. Few of them are normal practice, however. Many of the techniques demonstrate the remarkable creativity of civil engineers, planners, and public managers under conditions of emergency or intense political scrutiny. The New York State Thruway overpass and the Coleman Bridge in Virginia show how the use of imaginative planning, coordination techniques, new materials, and effective contracting can turn an emergency into a triumph. Both were completed in record time, under budget, and with minimal disruption to the traveling public. But each was a unique case. What is needed, and this is at the heart of the mission of ICIS, is to make such successful innovations

as these normal practice. The fact that valuable innovations struggle to gain widespread acceptance and, indeed, often remain interesting, but unique solutions, attests to the importance of addressing the organizational, cultural, and political aspects of infrastructure decision-making and implementation.

Political context. For all of their virtues pluralistic democracies have a great deal of difficulty dealing with policy issues that have long-term time frames. Infrastructure choices made earlier this century in a more authoritarian context (Robert Moses is the best recognized exemplar) still provide many of the capital assets on which current urban life depends. While the methods of Moses and his ilk are no longer acceptable, satisfactory new forms of public decision-making and finance for building and renewing infrastructure are not in place. State and local jurisdictions have a particularly difficult time making costly decisions on infrastructure renewal when the fruits of these decisions will not be realized in the political lives of most incumbents. Interestingly, political and policy agendas rarely place a high priority on these concerns. The practical and conceptual issues involved in this area need the sustained attention of enlightened practitioners and academic researchers.

Organizational context. The success of several of the cases described in this conference depended substantially on effective coordination between the focal organization and other organizational players (e.g. MTA Bridges and Tunnels and the Coleman Bridge). Most infrastructure agencies, however, continue to view the world through narrow organizational lenses. Administrators and professionals continue to work in organizations that feature standard bureaucratic structures, centralized decision-making, standardized operating procedures, low quantity and quality of communication (internally and externally), and performance criteria that focus on conduits, arterials, and vehicles rather than customers and service delivery systems, involving important, but messy, social costs and benefits. They are reasonably effective at maintaining existing forms and levels of finance and expenditure, but very weak in developing new forms of finance. They are effective at applying existing technology and standards to familiar problems, but are risk averse and slow to experiment with and adopt new technologies. While a substantial body of literature exists on organizational innovation and adaptation, little of it has been focused on infrastructure agencies. The need for documenting successful innovation and generating new standards of practice is clear.

Public context. While individual communities and the broader public (as users and impacted parties) are deeply affected by civil infrastructure, the average person knows very little about capital planning, financing, construction, and maintenance. This leaves the individual voter or user of services in a weak position to participate in public debates about infrastructure investment and community impact. In part this reflects the tendency of both the media and educators to treat infrastructure as basically a technical, often tedious, subject that merits little attention. As public concern over the quality, cost, and impact of infrastructure increases, the gap in public awareness and understanding grows in significance. Like the innovations described in this conference, solutions to the public awareness problem are being developed in isolated locations but are not being widely reported or adopted. It is the job of institutions such as the Institute for Civil Infrastructure Systems to identify, document, and publicize successful community involvement methods and educational innovations and to work with community leaders and professionals to incorporate new knowledge and methods into practice.