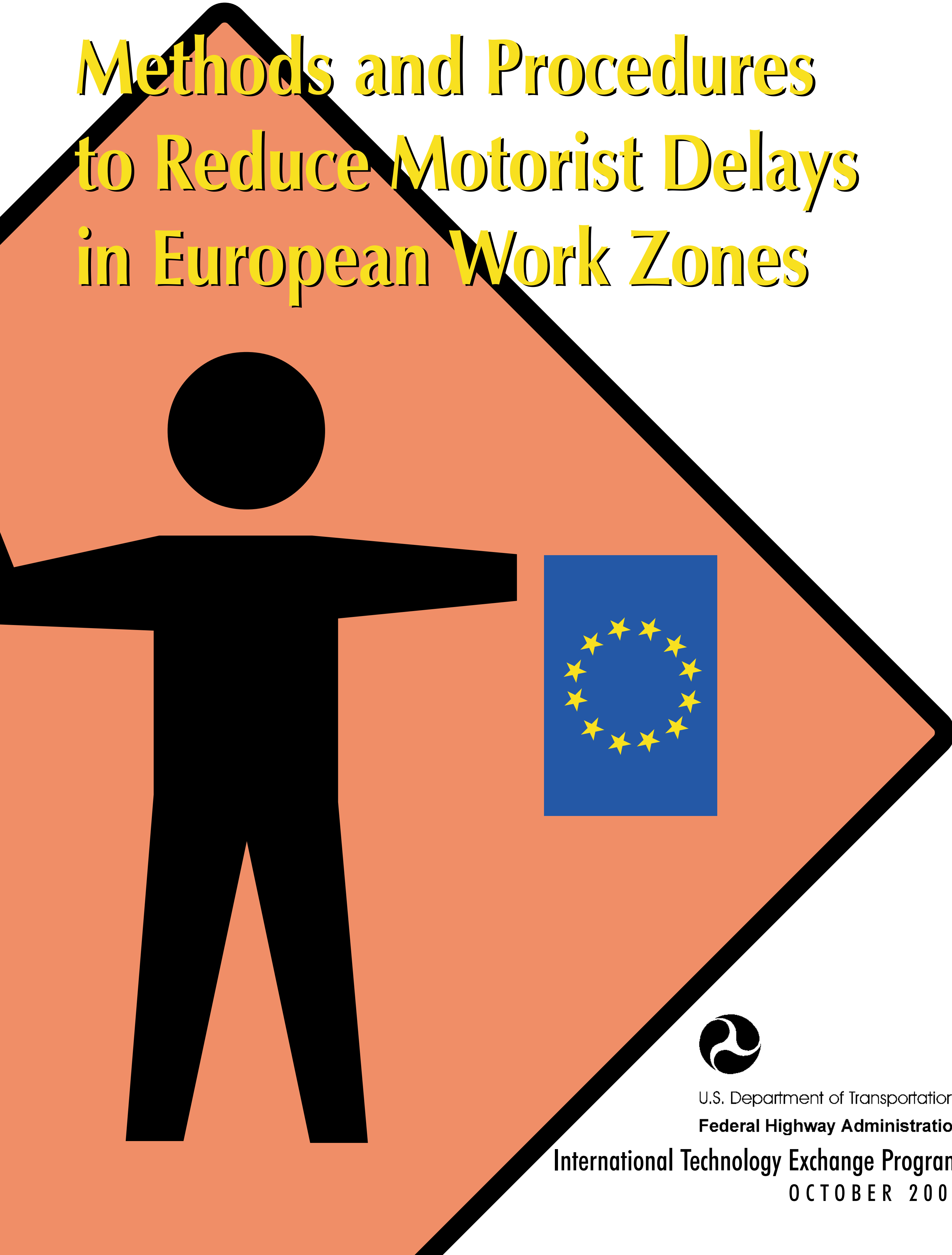
Methods and Procedures to Reduce Motorist Delays in European Work Zones



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16. Abstract

Reconstruction of the aging highway system in the United States is resulting in work zone delays, which are a growing irritant for motorists. The Federal Highway Administration and the National Cooperative Highway Research Program sponsored a scanning tour through Germany, the Netherlands, Belgium, Scotland, and France to look at how those countries manage traffic flow through temporary work zones.

The scanning team observed that highway agencies in those countries view the work zone as a marketplace, with drivers as "customers" who should be inconvenienced as little as possible. Emphasis is placed on developing a good communications plan and using Intelligent Transportation System technologies to keep drivers informed about roadwork projects.

The scanning team recommendations include shortening contract times; improving communication with motorists; adopting a coordinated policy, planning, and programming approach to work zone planning and operations; possibly reducing lane widths; designing for future maintenance; and evaluating the use of yellow markings in work zones.

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Methods and Procedures to Reduce Motorist Delays in European Work Zones

Prepared by the study tour team

Donald P. Steinke
FHWA
(Co-chair)

Len Sanderson
North Carolina DOT
(Co-chair)

James F. Byrnes, Jr.
Connecticut DOT

John Conrad
Washington State DOT
(Technical Writer)

Richard Forrestel
Cold Spring Construction Company

Kathryn Harrington-Hughes
Harrington-Hughes & Associates
(Reporter)

Ken F. Kobetsky
AASHTO

Stan Lanford
Lanford Brothers Company

Karla Snyder-Petty
FHWA

Dean Testa
Kansas DOT

Joe D. Wilkerson
FHWA

and

American Trade Initiatives, Inc.
&
Avalon Integrated Services, Inc.

for the

Federal Highway Administration
U.S. Department of Transportation
and
The National Cooperative Highway Research Program
(Panel 20-36)
of the
Transportation Research Board

October 2000

FHWA INTERNATIONAL TECHNOLOGY EXCHANGE PROGRAMS

The FHWA's international programs focus on meeting the growing demands of its partners at the Federal, State, and local levels for access to information on state-of-the-art technology and the best practices used worldwide. While the FHWA is considered a world leader in highway transportation, the domestic highway community is very interested in the advanced technologies being developed by other countries, as well as innovative organizational and financing techniques used by the FHWA's international counterparts.

INTERNATIONAL TECHNOLOGY SCANNING PROGRAM

The International Technology Scanning Program accesses and evaluates foreign technologies and innovations that could significantly benefit U.S. highway transportation systems. Access to foreign innovations is strengthened by U.S. participation in the technical committees of international highway organizations and through bilateral technical exchange agreements with selected nations. The program has undertaken cooperatives with the American Association of State Highway Transportation Officials and its Select Committee on International Activities, and the Transportation Research Board's National Highway Research Cooperative Program (Panel 20-36), the private sector, and academia.

Priority topic areas are jointly determined by the FHWA and its partners. Teams of specialists in the specific areas of expertise being investigated are formed and sent to countries where significant advances and innovations have been made in technology, management practices, organizational structure, program delivery, and financing. Teams usually include Federal and State highway officials, private sector and industry association representatives, as well as members of the academic community.

The FHWA has organized more than 35 of these reviews and disseminated results nationwide. Topics have encompassed pavements, bridge construction and maintenance, contracting, intermodal transport, organizational management, winter road maintenance, safety, intelligent transportation systems, planning, and policy. Findings are recommended for follow-up with further research and pilot or demonstration projects to verify adaptability to the United States. Information about the scan findings and results of pilot programs are then disseminated nationally to State and local highway transportation officials and the private sector for implementation.

This program has resulted in significant improvements and savings in road program technologies and practices throughout the United States, particularly in the areas of structures, pavements, safety, and winter road maintenance. Joint research and technology-sharing projects have also been launched with international counterparts, further conserving resources and advancing the state of the art.

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EXECUTIVE SUMMARY

Work zone delays are an increasing irritant for U.S. motorists. Throughout the nation, the aging highway system is undergoing unprecedented amounts of reconstruction and maintenance, creating detours and traffic jams that delay and irk travelers and shippers. Instances of "road rage" in work zones are becoming more prevalent.

Motorists often find work zones confusing and frustrating, forcing them to navigate changing traffic patterns and distractions. In 1997, more than 600 fatalities occurred in work zone crashes, at a high personal and societal cost.

Directing and managing traffic through work zones is an important, high-stakes task. If the task is done properly, motorists will able to travel safely and smoothly through the work zone and crews will be able to perform their work safely. If the task is done improperly, accidents will likely increase, traffic will back up, motorist frustration will grow, and goods shipments will be delayed.

The Federal Highway Administration (FHWA) and the National Cooperative Highway Research Program (NCHRP) sponsored a scanning tour to give U.S. highway agency and contractor representatives a first-hand look at how several other countries manage traffic flow through temporary work zones. The tour started in Cologne, Germany, and then went to the Hague, the Netherlands; Antwerp, Belgium; Edinburgh, Scotland; and Paris, France.

Directing and managing traffic through work zones is an important, high-stakes task. If the task is done properly, motorists will able to travel safely and smoothly through the work zone and crews will be able to perform their work safely.

The scanning team was led by Don Steinke, director of FHWA's Office of Transportation Operations, and Len Sanderson, North Carolina State Highway Administrator. The other members of the team were: James F. Byrnes, Jr., chief of the Bureau of Engineering and Highway Operations and chief engineer for the Connecticut Department of Transportation (DOT); John Conrad, assistant secretary for field operations support with the Washington State DOT; Richard Forrestel, chief executive officer and chairman of the board of Cold Spring Construction Company in New York; Stan Lanford, president of Lanford Brothers Company in Virginia; Karla Snyder-Petty, assistant division administrator for FHWA's Missouri Division; Dean Testa, construction and maintenance engineer and chief of the Bureau of Construction and Maintenance, Kansas DOT; Joe Wilkerson, division administrator for FHWA's Alabama Division; Ken Kobetsky, program director for engineering at the American Association of State Highway and Transportation Officials (AASHTO); and Kathryn Harrington-Hughes, president of Harrington-Hughes & Associates, who served as reporter.

In each country, the team members toured construction and maintenance work zones and met with, and heard presentations from, highway agency representatives.

GENERAL OBSERVATIONS

The team noted several general observations about how the five countries deal with traffic operations and safety in work zones:

- When planning rehabilitation or maintenance projects, the highway agencies focus a great deal of attention and resources on evaluating how the project will affect their customers—the highway users—and then on developing and implementing strategies to minimize those effects. Work zones are viewed as much more than construction zones; they are viewed, in a sense, as a marketplace, i.e., the highway agency wants to ensure that its goods (the highway) are pleasing to its customers and meet its customers' needs, even during construction and maintenance activities.
- Highway agencies place a great deal of emphasis on developing and implementing a communications plan to inform the public about work zones and provide alternative routes well in advance of the project start date, as well as on keeping the public informed about real-time traffic situations.
- Agencies and contractors extensively use ITS technologies to communicate with the public.
- Intra-agency and inter-agency communication links are strong, reliable, and effective.
- In Germany, France, the Netherlands, and Belgium, yellow pavement markings are used in work zones (in normal conditions, lane markings are white in these countries), as a visual reminder to the motorist that "something is different" and extra caution is needed.

RECOMMENDATIONS

After discussing and evaluating what they had seen, heard, and experienced in the five countries, the scanning team developed the following recommendations for improving traffic flow and safety in U.S. highway work zones:

1. *Shorten the contract time.* Lane rental charges can provide significant incentives for shaving time from construction projects and ensuring that construction is done right the first time.
2. *Improve communications with motorists.* Advance and real-time information flows can be enhanced through the use of ITS and other technologies.
3. *Adopt a coordinated policy, planning, and programming approach to work zone planning and operations.* Work zone operations should be considered early in the project development stage.
4. *Don't be afraid to reduce lane widths in work zones.* By narrowing the lanes in work zones, agencies can maintain the same number of lanes and thus minimize delays. Narrower lanes have the added benefit of encouraging traffic to slow down.
5. *Design for future maintenance.* In new construction, design and build shoulders to have adequate structural capacity so that traffic can be rerouted onto the shoulder during future construction and maintenance operations.
6. *Evaluate the use of yellow markings in work zones.* Yellow markings were effectively used to delineate traffic lanes in temporary work zones. (This

evaluation could perhaps be piggybacked onto an ongoing NCHRP study evaluating the use of all-white markings on highways.)

7. *Consider using highly visible traffic control devices and equipment to warn motorists of, and guide them through, work zones*. These devices include large truck- or trailer-mounted signs and portable sign gantries.

8. *Implement quality control/quality assurance programs for traffic and worker safety*. Safety audits, quality audits based on the ISO certification process, and job-specific traffic control plans can improve safety for both motorists and workers.

9. *Encourage innovation*. As exemplified by the Dutch “Roads for the Future” project, agencies should concentrate on long-term thinking and short-term action.

Chapter One
INTRODUCTION

Work zone delays are a growing irritant for U.S. motorists. Across the nation, the aging highway system is undergoing unprecedented amounts of reconstruction and maintenance, creating detours and traffic jams that delay and irk travelers and shippers. Instances of “road rage” are becoming more prevalent.

Work zones can be confusing and frustrating to motorists, who must navigate through narrowed, shifting traffic lanes, adapt to sudden changes in travel speed, and avoid being distracted by adjacent project work. In 1997, 658 fatalities occurred in work zone crashes in the United States, at a high cost to highway workers and highway travelers, as well as to their families, employers, and society.

Directing and managing traffic through work zones is an important, high-stakes task. If the task is done properly, it will allow motorists to travel safely and smoothly through the work zone and allow work crews to accomplish their tasks safely. If the task is done improperly, the result will likely be more crashes, more traffic backups, growing motorist frustration, and delayed goods shipments.

The Federal Highway Administration (FHWA) and the National Cooperative Highway Research Program (NCHRP) sponsored a scanning tour to give U.S. highway agency and contractor representatives a first-hand look at how several other countries manage traffic flow through temporary work zones. The tour started in Cologne, Germany, and then continued to the Hague, the Netherlands; Antwerp, Belgium; Edinburgh, Scotland; and Paris, France (Figure 1).

The scanning team was led by Don Steinke, director of FHWA’s Office of Transportation Operations, and Len Sanderson, North Carolina State Highway Administrator. The other members of the team were: James F. Byrnes, Jr., chief of the Bureau of Engineering and Highway Operations and chief engineer for the Connecticut Department of Transportation (DOT); John Conrad, assistant secretary for field operations support with the Washington State DOT; Richard Forrestel, chief executive officer and chairman of the board of Cold Spring Construction Company in New York,

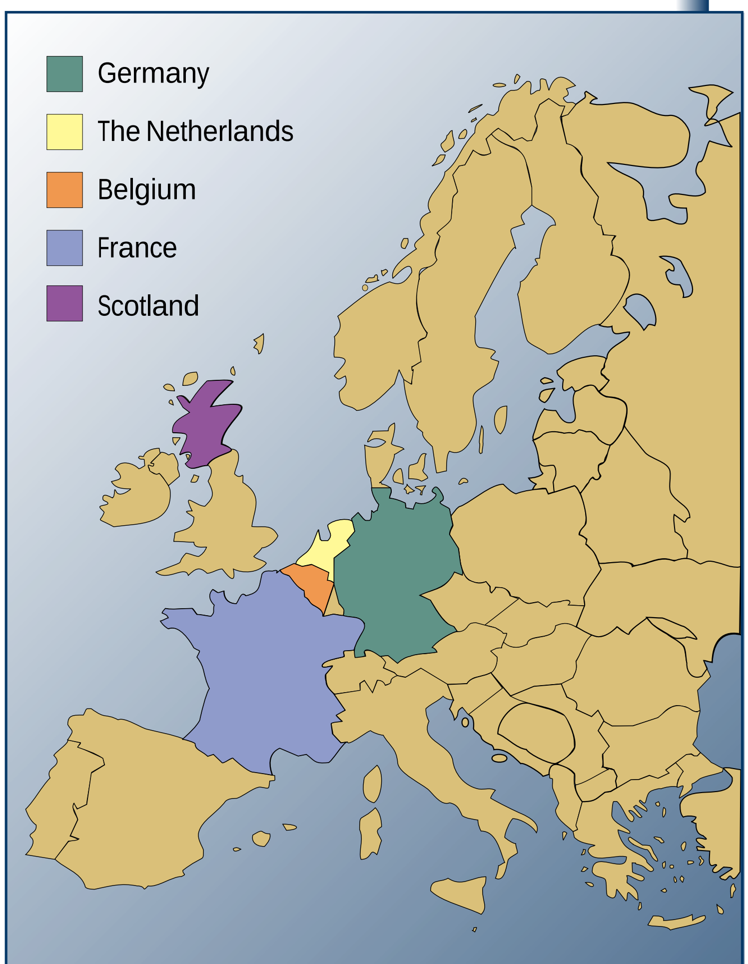


Figure 1. The team visited highway agencies and work zones in Germany, the Netherlands, Belgium, Scotland, and France.

who also represented the Associated General Contractors of America; Stan Lanford, president of Lanford Brothers Company in Virginia, who also represented the American Road and Transportation Builders Association; Karla Snyder-Petty, assistant division administrator for FHWA's Missouri Division; Dean Testa, construction and maintenance engineer and chief of the Bureau of Construction and Maintenance, Kansas DOT; Joe Wilkerson, division administrator for FHWA's Alabama Division; Ken Kobetsky, program director for engineering at the American Association of State Highway and Transportation Officials (AASHTO); and Kathryn Harrington-Hughes, president of Harrington-Hughes & Associates, who served as reporter.

The team members compiled a list of amplifying questions (see Appendix 5), which was sent to each country before the start of the tour. The highway agencies in each country were thus aware of the team's principal areas of interest. The team members toured temporary work zones in each country and met with, and heard presentations from, highway agency representatives.

The team members were charged with reporting back on innovative practices or technologies that merit evaluation or consideration in the United States. Their findings and recommendations are included in this report, which is intended to spur U.S. highway agencies to "think outside the box" and consider trying some of the practices and technologies used in Europe. The report is not intended to be a synthesis of European practice.

Chapter Two
GENERAL OBSERVATIONS

The five countries visited share some common key practices and policies regarding traffic operations and safety in work zones.

CUSTOMER FOCUS

In all five countries, the highway agencies focus a great deal of attention and resources on ensuring that the needs of their customers—the people who use and rely on the road—are met during construction and maintenance operations. The work zone is viewed as more than a roadway construction or maintenance site; rather, it is seen as a marketplace of sorts, and the highway agency wants to ensure that its goods (the roadway) are meeting its customers' needs, even during construction and maintenance operations. The agencies thoroughly evaluate how a maintenance project will affect the safety, travel, and convenience of their customers and then develop and implement strategies to minimize the effects of the work zone on their customers.

Several countries have established specific limits or goals regarding traffic operations in work zones. For example, France is striving to limit delays caused by construction and maintenance work to no more than a 6 percent loss of time over a 100-km stretch of roadway, and in the Netherlands, where 13 percent of all traffic delays are attributed to roadway work, the goal is to reduce the amount of work zone delays to 6 percent.

EFFECTIVE, EXTENSIVE COMMUNICATION PLAN

A great deal of emphasis is placed on developing and implementing a communications plan to effectively and extensively inform highway users about scheduled road work, alternative routes, and real-time traffic conditions. Every available means of reaching motorists is used, including Internet sites, leaflets, brochures, variable message signs, and highway advisory radio.

The agencies do not restrict their communications to those living and working in the immediate area. For example, France distributes leaflets to motorists in neighboring countries each year, as many of those motorists will travel on French highways to vacation destinations in the south of France.

EXTENSIVE USE OF ITS TECHNOLOGIES

Loop detectors, pole-mounted cameras, traffic control centers, variable message signs, and other components of intelligent transportation systems are in widespread use (Figure 2). The data collected are put to many uses, including ascertaining real-time travel conditions, calculating expected travel times, advising motorists, and determining lane-rental charges.

Figure 2. An extensive series of detector loops continually collects information on traffic volumes and speeds on the A6 highway in Scotland.

COMMUNICATIONS LINKS

Departments within highway agencies that in the past operated autonomously are now striving to forge and maintain intra-agency communications links. Where these links are strong, reliable, and effective, the result is improved coordination and leveraging of resources, which in turn means fewer delays and improved traffic management.

YELLOW PAVEMENT MARKINGS

In Germany, France, the Netherlands, and Belgium, yellow pavement markings are used to mark travel lanes in work zones. Permanent pavement markings in those countries are white, so the yellow markings serve as a visible reminder to motorists that something is "markedly different" and extra caution is needed. France and the Netherlands remove the existing white markings in work zones, so that only the yellow markings are visible; Germany and Belgium, however, do not believe this is necessary, as motorists have been "trained that yellow takes precedence over white" (Figure 3).

Figure 3. Germany uses yellow markings to delineate travel lanes in work zones; the white markings are left in place, and motorists are taught that yellow markings take precedence over white markings.

Chapter Three
KEY FINDINGS

SHORTER CONSTRUCTION PERIODS

"Get in, stay in, get out, and stay out" is an approach common to all five countries visited. In their bidding processes, the highway agencies encourage proposals that minimize the duration of the work zone and hence minimize the amount of motorist delays.

Germany uses incentive and disincentive payments to encourage contractors to shorten the duration of the roadwork; the higher the average daily traffic on the road, the higher the bonus or penalty. The payments are staggered based on the conditions actually experienced by motorists (number of restricted or closed lanes, capacity, average speed, etc.). German contractors are required to provide a warranty on all projects (typically for 2 to 5 years).

In Belgium, contractors must be certified as capable, based on prior experience and quality of work, before being allowed to bid on a roadway project. Only the most qualified contractors are allowed to compete for the more complex projects. Monetary incentives are provided for contractors to finish ahead of schedule.

Scotland uses lane rental charges to hasten the completion of roadway work. The aim is to reduce delays to the traveling public by encouraging the contractor to carry out the work as quickly as possible without compromising safety. The most common type of lane rental is a bonus/charge system. The highway agency determines a value for each "lane occupation" (i.e., a lane closed for construction and maintenance work); this figure is provided to all bidders prior to the bid deadline. Each bid must include the number of lane occupations that will be required during the construction phase and the maintenance phase. The highway agency then calculates the cost of each bidder's proposed lane occupations and considers that information when evaluating the proposals. The offer with the lowest combined cost (project cost plus lane occupation cost) is determined to be the most economically advantageous offer.

> In their bidding processes, the [European] highway agencies encourage proposals that minimize the duration of the work zone and hence minimize the amount of motorist delays.

If the contractor takes longer than proposed (i.e., the actual number of lane occupations exceeds that proposed in the bid), the highway agency "charges" the contractor for the difference; when the value is lower than proposed, the agency pays the difference ("bonus") to the contractor.

"The lane rental charges provide the single biggest benefit," says Ian Anderson, senior engineer with the Scottish National Roads Directorate. "The competitive nature of the industry encourages contractors to want to do a quality job in an incredibly short time frame. We've found that lane rental charges provide an excellent incentive for contractors to do it right the first time—we're seeing major work done in 6 to 8 days." The savings in delay costs far outweigh any increase in contract price.

The lane rental charges are determined by the time of day and the number of lanes affected, and are set in proportion to the value of the contract. QUADRO, a software program (Queues And Delays at ROadworks), is used to calculate the cost of motorist delays. The bonus/charge amount is normally set at half the QUADRO daily rate, plus the Scottish Roads Directorate's daily cost to supervise the project (rounded to the nearest L1000). Bids are evaluated first by quality of prior work, and then by price.

Scotland recently opened its first privately designed, built, financed, and operated highway—the AutoLink (M6) highway (Figure 4). The AutoLink, which serves as the primary link between the central and southern parts of Scotland, is maintained and operated by a consortium of private companies. The consortium also built 37 km of the 100-km route. The public sector (highway agency) defines the service required, and the private sector (the consortium) delivers the service and assumes all risks. The key objectives of this project are to identify and eliminate problems at an early stage and to "get it right the first time."

Figure 4. The M6 highway, known as AutoLink, is Scotland's first privately designed, built, financed, and operated highway.

The contract between the highway agency and the consortium includes incentives to ensure that the road is built and maintained to specified standards. The contract calls for the consortium to keep the road in a safe condition and to carry out all repairs and maintenance, including clearing snow and ice from the motorway, dealing with accidents, maintaining signs, cutting grass, and landscaping.

Traffic counts, collected by detectors embedded in the pavement, are used as the basis for "shadow tolls," which the Scottish highway agency will pay to the consortium for 30 years. If the road requires an inordinate amount of repairs, causing lanes to be frequently closed, the traffic counts will drop, and so will the tolls—providing a powerful incentive for roadwork to be done right the first time.

In addition, the consortium is assessed lane rental charges for any lanes closed for whatever reason (maintenance, crashes, etc.)—again, a powerful incentive for performing work efficiently and effectively. The consortium must make itself known as the road operator (through signs, advertising, and other means) and must post its telephone number on roadside signs.

In France, contractors are assessed a penalty for every day that a project extends beyond the agreed-upon completion date. Typically, the daily penalty is 0.3 percent of the project cost.

Figure 5. Sign prevalent in German work zones. "Renewing the Line until September 2000. Length 7 km. We Build for You."

BETTER COMMUNICATIONS WITH MOTORISTS

All five countries do an admirable job of communicating with motorists, both before and during construction and maintenance work.

German roadworks are heralded by "We Build for You" signs (Figure 5), which clearly indicate that the work is being done for the benefit of motorists. The signs state the reason for the roadwork, as well as the duration and length of the work zone. The German highway agency also hosts a website that includes information on current and planned maintenance and construction projects; the site is updated weekly. Germany makes extensive use of variable message signs to reroute traffic as necessary; the signs are part of an areawide signage and information system, including permanent orange trailblazers that indicate alternate routes that travelers can take to avoid work zone delays.

Overhead signs are more prevalent in Europe than in the United States. European drivers are much more attuned to looking upward, to overhead signs, for guidance and advice on road conditions. The overhead signs are hard to miss, as they are directly in the driver's line of sight. When roadside signs are used, they are often placed on the left side of the roadway, in the median, where they are less likely to be obstructed by trucks (which are typically barred from the left lane). For example, on German motorways, permanent overhead sign gantries are routinely used to post signs over traffic lanes. Signs posted over each lane convey information about speed limits, and signs between lanes post information about work zones and detours. A similar situation exists in the Netherlands (Figure 6).

Figure 6. Overhead signs are extensively used in the Netherlands to communicate with motorists. Speed limits change in response to actual travel conditions.

Most of the countries extensively use symbols/pictograms on warning signs, instead of text, whenever possible. In Germany, for example, words are allowed only on signs warning of crashes or fog conditions. Symbols are considered much easier to recognize, especially in areas where drivers hail from numerous countries and speak

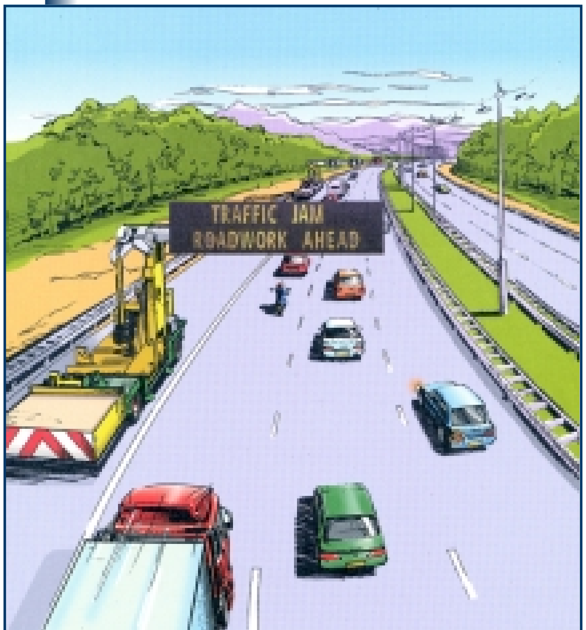


Figure 7. Currently 24 Mobile Lane Signalling Systems (MRS) are in use in the Netherlands, where they are installed as needed to warn motorists of work zones.

various languages. France is considering increasing its use of pictograms on signs because of the growing number of non-French-speaking drivers.

The Netherlands uses portable sign gantries to advise motorists of road conditions in advance of a work zone (Figure 7). The signs, which cost approximately $150,000 each, can be towed to the work zone and set up along the roadside; the gantry is then swung into place over the lanes. Installation takes 15 minutes, and it is not necessary to halt traffic during installation. Placed approximately 5 m above the roadway, the signs are visible at a distance of 800 to 1000 m.

Messages warning of traffic delays focus more on the duration of the delay rather than the length of the backup (for example, the sign might warn of a 20-minute queue, rather than a 2-mile queue); similar messages, couched in time rather than length of delay, are used in France and Scotland. As explained by a French highway agency staff person, motorists don't necessarily change their route in response to such a sign, but "they are calmed." Trailer-mounted signs, with multicolored fiberoptic lights, are also used in temporary work zones.

Germany is implementing an in-vehicle system, similar in size and appearance to a pager, which can receive messages concerning local traffic conditions.

When a section of the ring road around Rotterdam (with an average daily traffic count of 200,000 vehicles) was scheduled to be reconstructed, necessitating that the road be closed in both directions for a 2-month period, the Dutch highway agency funded an aggressive, $4 million public relations/outreach campaign. Three hundred thousand informational booklets were distributed, providing alternate routes and offering free use of public transportation during the duration of the construction project. Motorists were advised: "If you have to be in Rotterdam, take public transportation, or take your time."

Motorists were skeptical at first, and the result was chaos during the first week. According to the highway agency, it took motorists 4 hours to travel 6 miles. But people soon changed their travel behavior. And despite the enormous congestion and inconvenience, motorists said that they were "happy to be informed." The highway agency reports that only one major crash occurred during the 3 months when the road was completely closed. Staff members say this experience has taught them the value of good communications with the public; the costs are all on the agency's side, and the benefits are all on society's side.

The additional agency *costs* totaled $2.15 million ($0.25 million for detour signage, $0.40 million for free public transportation, and $1.5 million for public relations), but the effort resulted in $0.25 million less in motorist claims (for a net agency cost of $1.9 million). The estimated *benefits* in the form of reduced motorist delays totaled $4.3 million. When agency costs are subtracted from user benefits, the agency determined the net benefit to be $2.4 million. The public relations campaign accounted for 10 percent of the project cost (and 1 percent of that was spent before the project even got under way); in the future, the highway agency believes it can devise and implement an effective public outreach program for much less than 10 percent of the project cost.

Belgium has added the numeral "1" or "2" to signs on all major roads leading to the ring road around Antwerp. In the event that Antwerp-bound traffic must be rerouted because of work zones or incidents, motorists can be advised, through radio, variable message signs, and the Internet, to follow the "1" or "2," which indicate the two main alternate routes. On its trailer-mounted signs, Belgium uses red and yellow light-emitting diodes on the top half, and yellow light-emitting diodes on the bottom half.

To keep motorists advised of real-time conditions and smooth traffic flow, Belgium installs portable queue detectors in work zones. The detectors consist of video cameras mounted on poles on a series of trailers parked at designated points in advance of the work zone; variable message signs are also mounted to the rear of the trailers. The cameras transmit lane-occupancy data to a central computer control system, which is linked to the trailer-mounted variable message signs. The system monitors traffic speed and lane occupancy; when it detects a slowdown, indicating the formation of a backup, it automatically posts warning messages, such as "FILE [Queue] 500 m" and "FILE 1000 m" on variable message signs located 500 m and 1000 m in advance of the work zone (Figure 8). If the backup continues to grow, the system posts additional warning messages at 1500, 2000, 2500, and 3000 m in advance of the work zone—thus ensuring that motorists are given ample advance warning to slow down and thus avoid rear-end crashes. The highway agency reports that the use of this system cut rear-end crashes at one location by 60 percent.

Figure 8. Trailer-mounted variable message signs are linked to video cameras in Belgium; as traffic slowdowns are detected, a warning is posted on the sign.

Scotland has found that signs announcing the number of people ticketed for speeding in work zones in the previous week are a very effective means of reducing speeds in work zones. Cameras are also extensively and effectively used to detect speeders and thus slow traffic in work zones. Tickets are automatically issued to speeders caught on camera. Although only one-tenth of the cameras are actually operational (i.e., loaded with film) at one time, all cameras are set to periodically flash so that motorists will not be able to discern which cameras are "off" at any time.

Scotland relies heavily on brochures that are routinely distributed to motorists across the country. The brochures cover such topics as advice for drivers, safe

Figure 9. Safety brochures are widely distributed to Scottish drivers.

winter driving, roadside variable message signs, and the meaning of traffic signs (Figure 9).

Each year for more than two decades, France has distributed 11 million free calendars, showing when and where roadway projects are scheduled, as well as 13 million free roadmaps showing recommended alternative routes during the duration of those projects. This information is also now available on the Internet.

In all cases, the public perceives the information provided, regardless of medium, as credible.

COORDINATED POLICY, PLANNING, AND PROGRAMMING APPROACH FOR WORK ZONES

Early involvement and coordination by all public-sector agencies and private-sector organizations involved in roadway work pays big dividends, according to the highway agencies visited. Working together, they can ensure that all operations are coordinated, that the maximum gain is made of the work zone (i.e., scheduling several projects simultaneously, rather than sequentially, in the work zone whenever possible), and that inconvenience to the public is minimized. For example, the agencies and organizations might concurrently schedule guardrail maintenance, bridge repairs, and a pavement surface treatment.

In the Netherlands, the responsibilities of all involved in, or affected by, the construction and maintenance operations are clearly delineated and communicated. The *work planner* is responsible for deciding exactly what is to be done, where, when, and how. His or her choices will affect traffic flow and safety. The *local road authority* is responsible for putting the plans into practice, inspecting the work zones and equipment, and verifying the proper use and placement of devices and signs. *Road workers* are responsible for wearing the proper clothing, behaving responsibly, knowing their rights, and never relying on routine (always expect the unexpected). *Road users* are expected to adhere to speed limits, behave responsibly, follow instructions, and be informed. A pocket-sized training booklet explains these responsibilities to highway agency and contractor staff.

Each country sets performance goals in work zones and then works with all members of the project team to ensure these goals are met. For example, Germany's goals include reducing motorist delays by maintaining the same number of lanes in work zones whenever possible (i.e., by shifting traffic onto the shoulder or onto contraflow lanes) and by severely restricting the number of roadway projects that can be carried out on holidays. A computer model is used to calculate traffic flows during the work period; if, for example, the roadway carries more than 105,000 vehicles per day, no lane can be closed for roadway work, to prevent backups. German highway agencies also strive to limit roadway projects to no more than 6 or 7 km in length (with an absolute maximum of 15 km).

Table 1 shows adjustment factors for heavy vehicles and grades, which the German highway agency applies to traffic flow calculations when computing the amount of traffic that can be expected to reasonably travel through a work zone.

Table 1. Adjustment factors for heavy vehicles and grades used when calculating the amount of traffic that can be reasonably expected to traverse a work zone.

	TERRAIN		
	Level (<2% grade)	**Rolling (2-4% grade)**	**Mountainous (>4% grade)**
Adjustment factor (relative to passenger car units)	1.5	3	6

Source: G. Kellerman, BASt

Table 2 reveals the adjustment factors and capacity values for various traffic elements or work zone situations that have an impact on the traffic flow in work zones.

Table 2. Capacity values and adjustment values for traffic elements or work zone situations that have an impact on traffic flow in work zones.

Capacity Value (C_{work}) pcphpl under various constraints in work zones		**C_{work} (pcphpl)**	
	Adjustment Factor	**$W_{L, Truck} \geq 3.25$ m or $W_{L, Car} \geq 2.75$ m**	**$W_{L, Truck} \leq 3.25$ m or $W_{L, Car} \leq 2.75$ m**
Capacity value (basis) depending on lane width	1.00	1830	1720
Reduced capacity explained by:			
CR or RNL	0.95	1740	1630
CR and RNL	0.95*0.95	1650	1550
NC	0.9	1640	1550
NC and CR	0.9*0.95	1560	1470
NC and CR and RNL	0.9*0.95*0.95	1480	1400

pcphpl=passenger cars per hour per lane
CR=crossing median
RNL=reduced number of lanes in front of the work zone
NC=less than 50 percent commuters

German highway agencies do not request traffic enforcement in work zones, as they believe it would increase the risk of crashes. The contractors working on the project are responsible for ensuring the safety of the work zone, and they are held accountable for any crashes that occur. All traffic sign messages are stored in a database at the German Federal Highway Research Institute (BASt); this makes it easy to improve the message graphics (typeface, wording,) as needed, and sign manufacturers can access these data to produce signs of uniform size and design.

The Netherlands—which has three equal goals: minimize delay, maximize safety of road users, and maximize safety of road workers—has determined that it can often be cost-effective to close down a road for maintenance or reconstruction.

To ensure that all road maintenance and construction projects are coordinated among the various highway and public works agencies in the country, the Dutch have developed a national computerized planning system for roadworks and related lane closures (known as the Meldwerk system, or “report works”). More than 40 planners in local road authorities and 30 consulting companies use the system, which includes information on more than 2,000 roadwork projects (including daily maintenance projects) planned each month nationally. The system provides a uniform means of collecting and using traffic information. It also serves as an aid for traffic operators (who consult the Meldwerk system to determine the appropriate overhead signs warning of roadworks) and for better traffic management (during a traffic incident, a highway agency can easily review the location of roadwork projects and thus determine optimum alternate routes). By allowing adjacent jurisdictions to track each other’s planned and ongoing roadworks, Meldwerk helps ensure that neighboring agencies will not conduct road projects in the same area at the same time and that nearby roads will be ready to handle diverted traffic.

The Netherlands is developing a computer model that can be used to reduce motorist delay. The model will also be used to solicit opinions from the public—for example, as to whether it would be better to close a road entirely for a short period, or to leave the road open, but disrupted by roadway work, for a longer period.

Scotland’s goal is to design and plan projects to minimize site occupancy and traffic interference. To help meet these goals, and to reach consensus on the details of the following week’s work, weekly meetings of all involved in the project are held. Two police inspectors also attend every meeting. Each agency has a roadworks coordinator who serves as a single point of contact, making coordination and cooperation easier.

To cut down on the amount of traffic in work zones, Scotland provides alternate routes; assists travelers in planning their routes; provides temporary park-and-ride lots, where motorists can switch to public transportation; and coordinates ridesharing programs.

In an exceptional example of reaching out to motorists and asking their opinions, France conducts user-satisfaction surveys at motorist rest areas. The surveys assess the users’ satisfaction with the motorway and provide “food for thought” for the road authorities. Each year over a 10-year period, 20,000 drivers are surveyed. To augment these surveys, user forums, which allow road administration representatives to hold in-depth discussions with a small group of motorists, are also held.

Figure 10. Both lanes have been narrowed in advance of a work zone in Germany, and trucks are restricted to the somewhat wider right lane.

NARROWED LANES IN WORK ZONES

To avoid backups in work zones, the five countries strive to maintain the number of lanes in work zones. To do this, they convert shoulders to traffic lanes and create new traffic patterns, and the lanes are narrowed as necessary. In Scotland, for example, lanes that are normally 3.65 m wide are reduced to 2.5 m or 3 m wide in work zones. Typically, one of the two lanes in work zones is wider than the other, and trucks are restricted to the wider lane. In Belgium, work zones typically consist of a 3-m-wide lane that is open to all vehicles and a 2.5-m-wide lane that is restricted to automobiles. The French highway agency, which narrows its 3.5-m lanes to 2.5 m in work zones as needed, says that narrower lanes also serve as a traffic control device, encouraging motorists to slow down and pay attention.

Figure 10 shows the narrowing of lanes preceding a work zone operation in Germany. Both the left and right lanes have been narrowed; trucks are restricted to the somewhat-wider right lane.

Figure 11 shows the results of a German highway agency study, which found that narrow lanes do have a slowing effect on speeds.

The German highway engineers report that narrower lanes are also effective in getting drivers' attention and encouraging them to slow down as they approach a crossover on a motorway (i.e., where one lane of traffic crosses the median and then operates as a contraflow lane in the other direction of travel) (Figure 12).

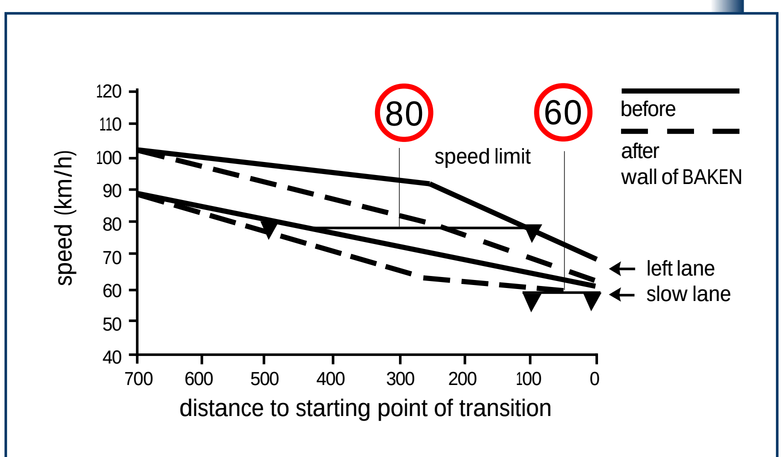


Figure 11. As lanes narrow, speeds drop, according to a German road authority study.

DESIGNS THAT ACCOMMODATE FUTURE MAINTENANCE

Highway agencies in the five countries visited are designing new roads and upgrading existing roads to accommodate future maintenance needs. Whenever possible, for example, they are building or rebuilding their shoulders to be strong enough to serve as traffic lanes during maintenance work.

Figure 12. Narrowed lanes help slow traffic approaching a crossover in Germany.

These agencies say that the higher upfront costs are more than offset by the efficiencies gained later, when traffic can be shifted onto the shoulders so that a travel lane can be closed for maintenance.

The European countries are also incorporating long-life pavement designs and ensuring that the width of roadways and bridges is sufficient to allow for travel lanes to be maintained during maintenance.

YELLOW MARKINGS IN WORK ZONES

In four of the five countries visited (all but Scotland), yellow pavement markings are used exclusively in work zones, and pavement markings in all other cases are white (including those for centerlines and left edgelines).

In Germany and Belgium, the original white pavement markings are not removed from the pavement when the yellow markings are applied. According to the German highway agency, the mix of white and yellow markings does not cause problems for drivers, as they are taught that yellow markings supercede white markings. Delineators are also used to indicate the boundaries of the travel way. In France and the Netherlands, the white markings are removed from the pavement in work zones, so that only the yellow markings appear.

HIGHLY VISIBLE TRAFFIC CONTROL DEVICES AND EQUIPMENT

Portable fiberoptic or light-emitting diode signs and technologies can be very effective in guiding motorists safely through work zones. Trailer-mounted variable message signs can be used to display symbols and words relaying real-time traffic information. The bright colors and real-time information are intended make these signs more effective than static "Work Zone Ahead" signs, which are customarily used in the United States. The European practice is to use larger, much more visible and understandable signs, particularly overhead signs.

Germany is evaluating a new vertical panel developed in the Netherlands, which is intended to clearly convey to the motorist the correct travel path.

To improve safety and work quality and efficiency, the Netherlands requires its contractors to install lighting in work zones. In many areas, the lights are left on during the night, even when no work is in progress, to assist drivers in navigating through the work zone.

The Netherlands uses Andreas strips (portable rumble strips) to provide a final warning to motorists that they have intruded into a work zone and that they should be following a new traffic pattern (Figure 13). For example, when traffic is shifted so that the left lane can be closed for maintenance, three Andreas strips are placed 150 m before a truck parked at the beginning of the work zone. The rubber strips are 2 m long, 20 cm wide, and 4 cm thick. They are spaced 5 m apart, in the lane that is closed to traffic, and at right angles to traffic. The driver feels a series of jolts as the vehicle travels over the strips, which serve as a final warning that the vehicle has strayed into a closed travel lane. The Andreas strips are similar in concept to the portable rumble strips developed by the U.S. Strategic Highway Research Program, but they are smaller and are placed in a lane that is closed to traffic, making them more effective.

Figure 13. Andreas strips placed in closed traffic lanes and perpendicular to traffic flow provide a very noticeable warning to drivers in the Netherlands.

The Netherlands also uses many more traffic cones in work zones, positioning them much closer together than is the custom in the United States.

On heavily trafficked roads with poor sight distance in France, a series of hinged barriers or gates is sometimes used to close lanes (forming a merging taper) as necessary in response to an incident or roadwork. The barriers can be operated by hand or by remote control. The barriers are expensive, but effective, reports the highway agency, with an average installation price of 50,000 French francs (approximately US$7,600) for manually operated gates and 1 million French francs (approximately US$153,000) for remote-control gates.

A 12-m-long moveable metal barrier, marketed as Safeguard, is also used to separate traffic from work zones in France. The barriers can easily be shifted from one side of a lane to another (to accommodate peak-hour flows) using a machine that operates at 6 km/hour. The barriers can be positioned without closing a traffic lane. The machine's design has its roots in big-wheeled vineyard equipment.

Germany uses metal barriers in lieu of cones. Similar in shape to the U.S. Jersey barriers, but offering less protection in a crash, the barriers provide guidance, not protection. Trucks are barred from traveling in the lane adjacent to the barriers. The barriers are marked with reflectors every 1 m, supplemented by occasional flashing yellow lights.

QUALITY CONTROL/QUALITY ASSURANCE PROGRAMS FOR TRAFFIC AND WORKER SAFETY

Quality control and quality assurance (QC/QA) programs are effectively used in the five countries to improve traffic and worker safety.

Scotland uses safety audits, conducted by an independent evaluator, together with the ISO certification process, to ensure safety in work zones.

In its alternative tendering initiative, Scotland holds the contractor responsible for a quality plan that meets ISO 9001 conditions, which is a “fairly onerous” task, says David Mustard of the National Roads Directorate. But industry had already taken steps in this direction, realizing 10 years ago that ISO accreditation was necessary to compete in the marketplace.

In France, highway agencies establish a separate, job-specific traffic control plan, and then allow contractors to tailor it as necessary.

AN EMPHASIS ON INNOVATION

For highway agencies saddled with growing maintenance needs, it can be difficult to think beyond the tried and true. But as is evident in Europe, innovative solutions require investments of time and resources. The Netherlands, for example, has established a “Roads to the Future” program, which focuses on “long-term thinking and short-term action.” Currently, 14 pilot projects are under way, including one focusing on maintenance without obstruction. As explained by the road agency, innovation means constantly looking ahead, creating support, explaining why, and staying flexible.

In Belgium and Scotland, replacement bridges have been built offline and then are “slid” into place over a weekend, minimizing inconvenience to motorists.

France uses a software program to provide roadway bridge designs in a 2-day period. The agency enters the span length and type of bridge required, and the software program produces a complete, standardized design. The agency saves time and money.

Since 1992, the French Directorate of Roads has encouraged innovation through its “road innovation charter.” Each year, the Director of Roads determines the priority needs for the national road network, and companies then prepare proposals for addressing those needs. Once a solution has been tested, evaluated, and found acceptable, it is then “certified,” as means of encouraging agencies to try new products. “Innovation is always more expensive at the start, so we help out by certifying the proven innovations,” says the agency. Out of 10 certifications awarded to date, two concern innovative ways to speed up maintenance work.

The Forum of European Highway Research Laboratories (FEHRL) is sponsoring a research project to determine best practices for reducing road closures through improved maintenance procedures. The main objective of the project is to redirect practice from an engineering approach to a user-cost approach in order to reduce the number and duration of road closures.

Chapter Four
RECOMMENDATIONS

Based on what they saw and learned on this scanning tour, the team members recommend that U.S. highway agencies consider taking steps to accomplish the following goals.

Shorten the contract time.

Lane rental charges can provide significant incentives for reducing the duration of construction and maintenance projects and ensuring the work is done right the first time. This will minimize motorist delays and improve traffic safety.

Improve communication with motorists.

Communications should be a high priority when planning and conducting any construction or maintenance project. Motorists need ample warning before the project starts, and then continuous, credible, easily accessible information once the project gets under way. This will allow motorists to choose alternate routes or to plan for additional travel time on the route under construction. Advance and real-time information flows can be enhanced through the use of ITS and other technologies. The German highway research center (BASt) has prepared a matrix showing various measures, depending on expected traffic impact, that should be taken to communicate with motorists (see Table 3).

Table 3. Measures for advising motorists of expected delay in work zones.

Difference between peak-hour capacity and demand	Traffic Condition	Communication Measures
≤100	No delay.	None.
≥100 and ≤200	Delays are expected.	Newspapers, radio stations, and television stations should be informed.
≥200	Strong impact on traffic flow.	Newspapers, radio stations, and television stations should be informed; variable message signs should be posted in advance of the work zone, and should include alternative routes/options.

Source: G. Kellerman, BASt

Adopt a coordinated policy, planning, and programming approach to work zone planning and operations.

Early involvement in work zone operations can pay dividends. While a roadway section is being reconstructed or rehabilitated, agencies should maximize the use of the project site by concurrently scheduling any other necessary work. The work plan should be shared with all agency departments and with local jurisdictions, the media, and the police.

Don't be afraid to reduce lane widths in work zones.

By narrowing the lanes in work zones, agencies can maintain the same number of lanes and thus minimize delays. Motorists will accept narrower lanes, provided they are amply marked and trucks are restricted from those lanes.

Design for future maintenance.

U.S. highway agencies typically do not build shoulders with sufficient structural capacity to carry traffic when a lane must be closed for maintenance, nor do they typically rebuild the shoulders to carry traffic during a maintenance project. To minimize traffic delays in work zones, U.S. agencies should strengthen shoulders in new construction projects so that the shoulder can serve as a traffic lane during future maintenance projects.

Evaluate the use of yellow pavement markings in work zones.

In the United States, both white and yellow pavement markings are used to direct traffic. Yellow pavement markings are, however, used only to indicate the left edge of the travel way (centerlines and left edgelines). In the countries visited, yellow markings were used to demarcate traffic lanes in temporary work zones. Although the use of yellow markings in work zones is counter to the U.S. *Manual on Uniform Traffic Control Devices*, the use of yellow or other color markings in work zones deserves further study. A draft proposed research problem statement is included as an appendix to this report. (This recommendation was also made in the report from the Innovative Traffic Control scanning tour, conducted in 1998.)

Use highly visible traffic control devices and equipment to warn motorists of, and guide them through, work zones.

U.S. agencies should consider using large truck- or trailer-mounted signs and portable sign gantries to direct traffic in work zones. U.S. agencies should also consider shortening the gap between reflectors or lights on barriers and evaluating the use of lightweight steel barriers, such as those used in Germany and France, in situations where cones would normally be placed to direct traffic and mark the edge of the travel way. (This might require that U.S. crash test procedures be revised.)

The new vertical panel being evaluated in Germany could have application in the United States. Vertical panels currently used in the United States have stripes that begin at the upper right side and slope downward to the lower left indicating "right," and panels with stripes sloping downward to the right indicate "left." Most motorists, however, do not understand these meanings and cannot distinguish between the two.

Implement QC/QA programs for traffic and worker safety.

U.S. highway agencies customarily use QC/QA programs for pavement construction or similar projects. Safety audits, together with the ISO certification process and job-specific traffic control plans, can improve safety for both motorists and workers.

Encourage innovation.

As exemplified by the Dutch "Roads for the Future" project, agencies should concentrate on long-term thinking and short-term action. U.S. agencies should encourage thinking “outside the box” to find solutions to work zone delays. A first step might be to participate in the Forum of European Highway Research Laboratories’ project on reducing road closures through improved maintenance procedures.

Chapter Five
IMPLEMENTATION

To ensure that this information is disseminated within the U.S. highway community and that the recommendations receive attention, the team members have committed to making presentations at professional meetings. Already, several such presentations have been made, including at meetings of the AASHTO Subcommittees on Maintenance and Construction and the AASHTO Standing Committee on Research, the AASHTO annual meeting in October 1999, and the annual meeting of the Transportation Research Board in January 2000.

The team is concerned that the materials (brochures, notes, videotapes) collected during the scanning material not be "lost" to future researchers. The team recommends that the materials be turned over to the Work Zone Safety Clearinghouse sponsored by the American Road and Transportation Builders Association and the FHWA.

The team has also requested that the team leaders send a copy of this report to each of the AASHTO subcommittee chairs, with a letter pointing out the relevant findings and recommendations. The goal is to find a "home" and champion for each of the recommendations in an AASHTO subcommittee, to ensure that they receive adequate review and that they lead to action, where warranted.

The goal is to find a "home" and champion for each of the recommendations in an AASHTO subcommittee, to ensure that they receive adequate review and that they lead to action, where warranted.

The problem statement included in Appendix A will be submitted to the AASHTO Subcommittee on Traffic, for review and, it is hoped, eventual submittal to the Standing Committee on Research.

Chapter Six
CONCLUSION

Highway agencies in the United States are grappling with growing travel demand, aging highways, and reduced staffs. At the same time, their customers are demanding smoother roads, less congestion, fewer work zones, and safe, unimpeded travel. The innovative strategies described in this report could play a role in overcoming those obstacles and in meeting their customers' needs.

The scanning team members (Appendix B) strongly recommend that the innovative ideas described in this report be considered and evaluated for use in the United States, as they could improve service and cut delays in work zones, reduce motorist frustration, and improve safety for both highway workers and travelers.

The true value of any scanning tour is when the information is brought home, shared, and critically evaluated. That is the challenge ahead—to find "homes" or "champions" for this information, in the hopes that U.S. highway engineers and managers can benefit from the experiences of their peers in other countries.

The scanning team members strongly recommend that the innovative ideas described in this report be considered and evaluated for use in the United States, as they could improve service and cut delays in work zones, reduce motorist frustration, and improve safety for both highway workers and travelers.

Appendix A
RESEARCH PROBLEM STATEMENT OF THE SUBCOMMITTEE ON RESEARCH

I. Problem Title—Special Pavement Marking in Work Zones

II. Research Problem Statement

There are notable differences between roadway markings in work zones in the United States and Europe. The Methods and Procedures to Reduce Motorist Delays in Work Zones Scanning Tour team members recently observed that pavement markings in five European countries are typically all white, with yellow markings, of various widths and patterns, reserved for use in work zones. This system allows drivers to instantly recognize a work zone.

In the United States, yellow is used only to denote two-way traffic in the United States, serving as the centerline or the left edgeline.

III. Research Objective

Conduct an in-depth review of work zone pavement marking practices in the United States and Europe. This review shall seek out information on the effectiveness of those practices in controlling and managing traffic through work zones. The researcher should consider the use of a special color, such as orange, and should experiment with the use of different colors to determine how easily they are understood by drivers and the overall effect they have on driver behavior.

IV. Estimate of Problem Funding and Research Time

12 months $100,000

V. Urgency, Payoff Potential, and Implementation

The Federal Highway Administration is currently in the process of revising the *Manual on Uniform Traffic Control Devices (MUTCD)* to enhance the mobility and safety of road users in work zones. This will promote uniformity of traffic control applications and incorporate technology advances into work zone traffic control. The data gathered from the ongoing NCHRP project on all-white markings would provide a basis for including *MUTCD* standards for pavement marking in work zones. The urgent goal of this study is also to recognize safety concerns in the work zone.

VI. Person Developing the Problem Statement

The team members on the scanning tour for motorist delays in work zones (held May 1999).

Appendix B
TEAM MEMBERS

Donald P. Steinke, Co-Chair, is Director, Office of Transportation Operations for the FHWA in Washington, D.C. He is responsible for the nationwide administration and direction of highway operation technologies, construction and maintenance work zone operations, the *Manual on Uniform Traffic Control Devices*, and weather response, including winter maintenance, emergency management, and highway capacity. Mr. Steinke has 30 years of program administration and technical experience with the FHWA. He has held assignments at many diverse U.S. locations, ranging from being a project engineer on construction and directing the Federal-aid Highway Program within a State, to his current national position. Mr. Steinke holds a B.S. degree in Civil Engineering from the University of Nebraska-Lincoln. He is a licensed Professional Engineer. He serves as a member of the AASHTO Winter Maintenance Policy Coordinating Committee and is Chairman of the FHWA Highway Operations Research and Technology Coordinating Committee. He recently served as the Secretary of the AASHTO Subcommittee on Construction.

Len Sanderson, Co-Chair, is the State Highway Administrator for the North Carolina Department of Transportation. Mr. Sanderson currently directs the planning, design, construction, and maintenance of the 78,500-mile State highway system in North Carolina. His areas of emphasis are work zone safety and dissemination of information to motorists. Prior to his appointment as Highway Administrator, he served as the Construction Branch Manager for Statewide operations. Mr. Sanderson is a graduate of North Carolina State University and holds a bachelor's degree in Civil Engineering. He is a licensed professional engineer and serves on several AASHTO committees.

James F. Byrnes, Jr., is the Chief of the Bureau of Engineering and Highway Operations and Chief Engineer of the Connecticut Department of Transportation. He directs the Department's programs in design, rights-of-way, and construction of roads, bridges, facilities for rail and bus transportation, aviation, and ports. He has particular interests in issues relating to traffic management during highway construction and maintenance, balancing congestion, motorist safety, and worker safety. Mr. Byrnes holds a Bachelor of Civil Engineering degree from Cooper Union, New York City, and a Master of Science degree in Civil Engineering from the University of Connecticut. Mr. Byrnes is the chairman of the joint Highway Research Advisory Council at the University of Connecticut and a member of the American Society of Civil Engineers, the Institute of Transportation Engineers, and AASHTO. In AASHTO, he serves on the standing Committee on Highways, the Special Committee on International Activities, and as Vice Chair of the Highway Subcommittee on Design.

John Conrad is the Assistant Secretary for Field Operations Support with Washington State Department of Transportation in Olympia, Washington. Mr. Conrad currently directs the Department's precontent, construction, maintenance, materials testing, traffic operations, employee safety, architecture, and capital facilities programs. Prior to being appointed to his current position, he served as the Chief Maintenance Engineer and with the Department's Seattle Region as Planning and Operations Engineer. Mr. Conrad has a Bachelor of Science degree from the University of Nebraska and a Master of Science degree in Transportation Planning from Kansas State University. He is a registered professional engineer in the States of Washington and Kansas. He is chairman of the TRB Committee on Maintenance and Operations Management and has authored several papers. Mr. Conrad is also a member of the AASHTO Subcommittees on Maintenance and Construction and is chairman of the SHRP Implementation Task Force.

Richard Forrestel is Chief Executive Officer and Chairman of the Board of Cold Spring Construction Company, in Akron, New York. Mr. Forrestel currently oversees job execution, including the building of interstate highways, both concrete and superpave asphalt, as well as the attendant excavation and bridge work involved therein. He has been actively involved in highway construction for more than 50 years. Mr. Forrestel is a graduate of the University of Michigan and holds a Bachelor of Science degree in Chemical and Metallurgical Engineering, along with a Juris Doctor Law degree. He serves on several committees of the National and State Associated General Contractors, the Road Information Program, and the National and Northeast chapters of the American Concrete Pavement Association.

Kathryn Harrington-Hughes, Reporter, is president of Harrington-Hughes & Associates, Inc., an editorial and marketing services firm in Washington, D.C. She researches, writes, and edits newsletters and magazine articles, as well as reports, brochures, scripts, and other publications, on highway safety, construction, maintenance, and operations. She is the editor of FHWA's "Focus" newsletter and TRB's "TranScan" newsletter, as well as the "Superpave Models" newsletter. She previously served as director of communications and marketing for the Institute of Transportation Engineers and as director of communications for the SHRP. She has a Journalism degree from the University of Maryland, and she is a member of TRB Committees A5001 (Conduct of Research) and A5012 (Technology Transfer), the Institute of Transportation Engineers, the Communications Committee of the Highway Innovative Technology Evaluation Center (HITEC), the National Press Club, and the Construction Writers Association.

Ken F. Kobetsky is the Program Director for Engineering for AASHTO in Washington, D.C. In this position he serves as liaison for AASHTO's Standing Committee of Highways, Standing Committee of Research, and technical subcommittees of Design, Maintenance, and Materials, plus several task forces. The position also requires coordination with many of the technical committees and task forces in the production of engineering and related professional publications and responses to technical inquiries on publications. The National Transportation Product Evaluation Program (NTPEP) and the Snow and Ice Cooperative Program (SICOP) technical services programs are also under his supervision. Mr. Kobetsky has 30 years of experience in a State highway agency in traffic operations, design, and construction. He holds a Bachelor of Science degree in Civil Engineering from the University of North Dakota, a graduate degree in Traffic Engineering from Yale University, and a Master of Science degree in Engineering from West Virginia College of Graduate Studies. He is a registered engineer in two States, is currently the chairman of the National Committee on Uniform Traffic Control Devices, and is active in many technical committees of the TRB.

Stan Lanford is president of Lanford Brothers Company located in Roanoke, Virginia. Lanford Brothers has about 150 employees who are regularly involved with construction and maintenance work zones on interstate, primary, and urban highways. The work consists of repairing more than 100 bridges per year and removing over 4 million square yards of asphalt pavement for recycling. Mr. Lanford is a graduate of the University of Virginia, where he received a degree in Civil Engineering. He is Chairman of the American Road and Transportation Builders Association, effective March 1999, and has served on various committees for the NCHRP and for the Virginia Department of Transportation.

Karla Snyder-Petty is Assistant Division Administrator for the FHWA, Missouri Division, in Jefferson City, Missouri. The Missouri Division is responsible for delivering the Federal-aid Highway Program in the State of Missouri. A current effort in Missouri is to explore and evaluate methods for reducing motorist delays during construction. Before joining the Missouri Division, Ms. Snyder-Petty was directly involved with the development of the Regional Advanced Transportation Management System and transportation demand management strategies in Atlanta, Georgia. She has a Bachelor of Science degree in Civil Engineering from West Virginia Institute of Technology. She is a licensed professional engineer and is a member of the National Society of Professional Engineers and the Society of Women Engineers.

Dean Testa is a construction and maintenance engineer for the Kansas Department of Transportation and serves as the Chief of the Bureau of Construction and Maintenance in Topeka, Kansas. Mr. Testa currently develops policies and specifications and administers programs in the construction and maintenance areas for the Kansas DOT. Mr. Testa has a degree in Civil Engineering from the University of Kansas. He is a licensed professional engineer and serves on several committees of AASHTO and TRB.

Joe D. Wilkerson is the State of Alabama Division Administrator for the FHWA. He is responsible for directing the Federal-aid Highway Program in Alabama. Mr. Wilkerson has more than 40 years of technical and program experience with the FHWA. He graduated from the University of Tennessee in 1959 with a B.S. degree in Civil Engineering. He has held a variety of engineering and engineering/administrative positions during his career with FHWA, including engineering positions in Tennessee, FHWA's former regional offices in Atlanta, North Carolina, Alabama, and the Georgia Divisions before being assigned to his current position as Division Administrator.

Appendix C
HOSTS

BELGIUM

ir. Patrick Debaere
inspecteur-generaal
afdelingshoofd
ministerie van de Vlaamse Gemeenschap
departement Leefmilieu en Infrastructuur
administratie Wegen en Verkeer
afdeling Wegen Antwerpen
Copernicuslaan 1, bus 12
2018 Antwerpen Belgium
Tel: (03) 224 69 22
Fax: (03) 224 69 05

ing. A. De Bie
adjunct van de directeur
ministerie van de Vlaamse Gemeenschap
departement Leefmilieu en Infrastructuur
administratie Ondersteunende Studies en Opdrachten
afdeling Elektriciteit en Mechanica Antwerpen
Copernicuslaan 1, bus 11
2018 Antwerpen Belgium
Tel: (03)449 38 95
Fax: (03)449 38 93

Dr. ir. L. Cypers
ministerie van de Vlaamse Gemeenschap
departement Leefmilieu en Infrastructuur
administratie Ondersteunende Studies en Opdrachten
afteling Elektriciteit en Mechanica Antwerpen
Copernicuslaan 1, bus 11
B-2018 Antwerpen Belgium
Tel: +32.3.224 66 11 or +32.3.224 66 16
Fax: +32.3.224 66 05

Eric Kenis
Traffic Engineer
Ministery of the Flemish Community
Environment and Infrastructure Department
Graaf de Ferraris—5th floor
Emile Jacqmainlaan 156, bus 8
B1000 Brussels, Belgium
Tel: 32-2-553-7810
Fax: 32-2-533-7805
Email: ericjm.kenis@lin.vlaanderen.be

ir. Willy Frans
hoofdingenieur-directeur
Ministerie van de Vlaamse Gemeenschap
Administratie Ondersteunende Studies en Opdrachten
D.E.E.M. Antwerpen
Copernicus
Copernicus 1
2018 Antwerpen Belgium
Tel: 03-224-60-11
Fax: 03-224-66-05

Armand Rouffaert
director-graduate engineer
divisional manager
Ministery of the Flemish Community
Environment and Infrastructure Department
Roads and Traffic Administration, Traffic Division
Graaf de Ferraris, 5th floor
Emile Jacqmainlaan 156, bus 8
B1000 Brussels, Belgium
Tel: (32) 2 553 7801
Fax: (32) 2 533 7805
Email: armandjp.rouffaert@lin.vlaanderen.be

FRANCE

Gilbert Batac
Technical Adviser for ITS
Service d'Etudes Techniques des Routes et Autoroutes (SETRA)
Ministère de l'Equipement des Transports et du Logement
46, avenue Aristide Briand
BP 100 - 92225 Bagneux Cedex - France
Tel: +33 (0)1 46 11 34 16
Fax: +33 (0)1 46 11 31 69
Email: batac@setra.fr

Jocelyne Le Boudec
International Activities
Service d'Etudes Techniques des Routes et Autoroutes (SETRA)
Ministère de l'Equipement des Transports et du Logement
46, avenue Aristide Briand
BP 100 - 92225 Bagneux Cedex - France
Tel: +33 (0)1 46 11 31 05
Fax: +33 (0)1 46 11 36 50
Email: leboudec@setra.fr

Othman Gaddhoum
Ingénieur des T.P.E.
Direction Departementale de l'Equipement de l'Essonne
Service Travaux Routiers et Autoroutiers - TRA 1
Route de Lisses - 91100 Villabé - France
Tel: 01 60 91 70 79
Fax: 01 60 86 21 26

Patrick Jacamon
Directeur de l'Exploitation
Société des Autoroutes Paris-Normandie
Echangeur des Essarts
B.P. 7 - 76530 Grand-Couronne - France
Tel: 02 35 18 31 01
Fax: 02 35 18 31 96

Denis Laville
Chef de District
Société des Autoroutes Paris-Normandie
District de Gaillon
27600 Saint-Aubin-sur-Gaillon - France
Tel: 02 32 77 36 00
Fax: 02 32 77 36 09

Gilles Robin
Chef de Service
Direction Departementale de l'Equipement de l'Essonne
Service Travaux Routiers et Autoroutiers
Route de Lisses - 91100 Villabé - France
Tel: 01 60 91 70 50
Fax: 01 60 86 34 88

GERMANY

Dr.-Ing. Fritz Bolte
Baudirektor
Referatsleiter
Verkehrsablauf, Verkehrsbeeinflussung, Verkehrsstatistik
Bundesanstalt für Straßenwesen
Brüderstraße 53
51427 Bergisch Gladbach
Federal Republic of Germany
Tel: (0 22 04) 43 520
Fax: (0 22 04) 43 680
Email: bolte@bast.de

Dipl.-Ing. Jan grobe Beilage
Research Coordination, Research Programmes, International Cooperation
Brüderstraße 53
51427 Bergisch Gladbach
Federal Republic of Germany
Tel: (49 22 04) 43 443
Fax: (49 22 04) 43 148
Email: beilage@bast.de

Dipl.-Math. Gerd Kellermann
Referat
Verkehrsablauf, Verkehrsbeeinflussung, Verkehrsstatistik
Bundesanstalt für Straßenwesen
Brüderstraße 53
51427 Bergisch Gladbach
Postfach 10 01 50
51401 Bergisch Gladbach
Federal Republic of Germany
Tel: (0 22 04) 43 585
Fax: (0 22 04) 43 673

Dipl.-Ing. Walter Kretschmann
Baudirektor
Referat S 28
Straßenverkehrstechnik
Bundesministerium für Verkehr
Robert-Schuman-Platz 1, 53175 Bonn
Postfach 20 01 00, 53170 Bonn
Federal Republic of Germany
Tel: (02 28) 300-0/-5281
Fax: (02 28) 300-3428/3429
Email:
walter.kretschmann@bmv.bmv.bund400.de

Dipl.-Ing. Harald Lischwe
Department of Road Construction
Section StB 12
Construction Contracts
Federal Ministry of Transport
Robert-Schuman-Platz 1
D-53175 Bonn
PO Box 20 01 00
D-53170 Bonn
Federal Republic of Germany
Tel: + 49 (228) 300-0/-5122
Fax: + 49 (228) 300-3428/-3429

Dipl.-Ing. Günter Lukas
wiss. Angestellter
Referat
Schutz- und Leiteinrichtungen
Bundesanstalt für Straßenwesen
Brüderstraße 53
51427 Bergisch Gladbach
Postfach 10 01 50
51401 Bergisch Gladbach
Federal Republic of Germany
Tel: 0 22 04/43-547
Fax: 0 22 04/43-676

Dr.rer.nat. Hans-Hubert Meseberg
Referat
Verkehrsregelung, Wegweisung,
Lichttechnik
Bundesanstalt für Straßenwesen
Brüderstraße 53
51427 Bergisch Gladbach
Federal Republic of Germany
Tel: (0 22 04) 43 561
Fax: (0 22 04) 43 408

Dipl.-Ing. Hans Mundry
Division for Road Construction Research
and Development, International
Cooperation
in Road Construction
Federal Ministry of Transport, Building,
and Housing
Robert-Schuman-Platz 1
D-53175 Bonn
Federal Republic of Germany
Tel: (+49) 2 28 - 300 - 5142
Fax: (+49) 2 28 - 300 - 3428/3429
Email: Mundry@bmv.bmv.bund400.de

Dr.-Ing. Wolfgang Schulte
Leader of Section, Bituminous Pavement
Federal Highway Research Institute
Brüderstraße 53
51427 Bergisch Gladbach
Federal Republic of Germany
Tel: +49 (22 04) 43 750
Fax: +49 (22 04) 43 673
Internet: www.bast.de

Frank Süsser
Referat S28
Federal Ministry of Transport
Robert-Schuman-Platz 1
D-53175 Bonn
PO Box 20 01 00
D-53170 Bonn
Federal Republic of Germany
Email:
frank.suesser@bmv.bmv.bund400.de

THE NETHERLANDS

R.A.P. Jordens
Road Monitoring
Ministry of Transport, Public Works and
Water Mgmt.
Directorate-General for Public Works and
Water Mgmt.
Road and Hydraulic Engineering Division
P.O. Box 5044
2600 GA Delft
Van der Burghweg 1
The Netherlands
Tel: +3115699319
Fax: +3115611361

Michel M. Kusters
Consultant, Highway Engineering Division
Ministry of Transport, Public Works and Water Mgmt.
Directorate-General for Public Works and Water Mgmt.
Transport Research Centre (AVV)
Boompjes 200
P.O. Box 1031
3000 BA Rotterdam
The Netherlands
Tel: +31 (10) 282 58 95
Fax: +31 (10) 282 56 44
Email: m.m.kusters@avv.rws. minvenw.nl

Ben T.R.M. Mulderink
Director, International Affairs
Ministry of Transport, Public Works and Water Mgmt.
Directorate-General for Public Works and Water Mgmt.
General Directorate
Johan de Wittlaan 3
P.O. Box 20906
2500 EX The Hague
The Netherlands
Tel: +31 70 351 87 07
Fax: +31 70 351 80 87
Email: afdb@hdw.rws.minvenw.nl

dr. ir. Govert Sweere
Project Director
Strategic Highway Research Program
P.O. Box 5044
NL-2600 GA Delft
The Netherlands
Tel: +31 15 2518380
Fax: +31 15 2518555
Email: r.sitanala@dww.rws.minvenw.nl

John C.M. van Gent
Senior Expert, Division International Affairs
Ministry of Transport, Public Works and Water Mgmt.
Directorate-General for Public Works and Water Mgmt.
Head Office
Johan de Wittlaan 3
P.O. Box 20906
2500 EX The Hague
The Netherlands
Tel: +31 70 351 93 05
Fax: +31 70 351 80 87
Email: j.c.m.vgent@hkw.rws.minvenw.nl

SCOTLAND

Ian C. Anderson, BSc CEng MIEE MILE
Senior Engineer, Driver Information and AIP
The Scottish Office
Development Department
National Roads Directorate
Network Management Division
Victoria Quay
Edinburgh EH6 6QQ UK
Tel: 0131-244-0450
Fax: 0131-244-0492

Jake Dempster, IEng MIEIE MILE
Engineer, Lighting and Communications
The Scottish Office
Development Department
National Roads Directorate
Network Management Division
Victoria Quay
Edinburgh EH6 6QQ UK
Tel: 0131-244-0449
Fax: 0131-244-0492

Nick Fenton
Group Manager
Traffic Appraisal Modelling and Economics
Highways Agency, Room 4/37
St. Christopher House
Southwark Street
London 5EI 0TE UK
Tel: 0171-921-4128
Email: nick.fenton@highways.gsi.gov.uk

John Gooday, BSc CEng MICE
Principal Engineer
Network Manager Tay, Forth and Clyde
The Scottish Office
Development Department
National Roads Directorate
Network Management Division
Victoria Quay
Edinburgh EH6 6QQ UK
Tel: 0131-244-7177
Fax: 0131-244-0492

Robert A. Inglis
Network Manager (North)
The Scottish Office
Development Department
National Roads Directorate
Network Management Division
Victoria Quay
Edinburgh EH6 6QQ UK
Tel: 0131-244-0484

Neil B. MacKenzie, BSc CEng MICE MIHT
Deputy Chief Engineer
Head of Project Construction Division
The Scottish Office
Development Department
National Roads Directorate
Project Construction Division
Victoria Quay
Edinburgh EH6 6QQ UK
Tel: 0131-244-7168
Fax: 0131-244-7185

Bill McDowell, BSc CEng MICE
Senior Principal Engineer
CITRAC/NADICS
Roads and Transportation
Glasgow City Council
National Network Control Centre
32 Elmbank Street
Glasgow G2 4PF UK
Tel: 0141-287-9302
Fax: 0141-287-9288
Email: william.mcdowell@roads.glasgow.gov.uk

John P. Murphy, BSc CEng MICE MIHT
General Manager, Clyde Premium Unit
Clyde Local Authority Consortium
Roads and Transportation Services
4 Auchingramont Road
Hamilton ML3 6JT UK
Tel: 01698 452170
Fax: 01698 891679

David J. Mustard, BSc MICE
Project Engineer
The Scottish Office
Development Department
National Roads Directorate
Project Construction Division
Victoria Quay
Edinburgh EH6 6QQ UK
Tel: 0131-244-7165
Fax: 0131-244-7185

Hamilton Purdie, MSc IEng MIEEIE MCIT
Assistant Principal Engineer
CITRAC/NADICS
Roads and Transportation
Glasgow City Council
National Network Control Centre
32 Elmbank Street
Glasgow G2 4PF UK
Tel: 0141-287-9307
Fax: 0141-287-9288
Email: hamilton.purdie@roads.glasgow.gov.uk

Robin K. Rankin, BSc CEng MICE MAPM
Agent Manager, M6 DBFO
Scott Wilson Kirkpatrick & Co. (Scotland) Ltd.
M6 DBFO Project
Beattock Road, Moffat
Dumfriesshire DG10 9SD UK
Tel: (01683) 222 000
Fax: (01683) 222 019
Email: robin.rankin@m6dbfo.co.uk

Ian S. Ross, BSc CEng MICE MIHT
National Network Manager
The Scottish Office
Development Department
National Roads Directorate
Network Management Division
Victoria Quay
Edinburgh EH6 6QQ UK
Tel: 0131-244-0482
Fax: 0131-244-0492

Bill Valentine, BSc MSc CEng MICE
Project Manager
The Scottish Office
Development Department
National Roads Directorate
Project Construction Division
Victoria Quay
Edinburgh EH6 6QQ UK
Tel: 0131-244-7263
Fax: 0131-244-7281

Appendix D
PRODUCT MANUFACTURERS/VENDORS

Portable Sign Gantries (Mobile Lane Signaling System and Mobile Route Information System)
Kuiken Hytrans b.v.
Lemsterpad 56
NL-8531 AA Lemmer
The Netherlands
Tel: 31-(0)-514-56-24-15
Fax: 31-(0)-514-56-24-28

Mobile Queue Detection and Warning System
Abay TS
rue de Genevestraat 4
b 30, B 1140
Bruxelles, Belgium
Tel: 02-729-61-11
Fax: 02-729-61-61

Dynamic Route Information Panel
Brimos
4e Industrieweg 1
8051 CK Hattem
The Netherlands
Tel: 31-384-442-333
Fax: 31-384-446-428
Email: save@brimos.nl

Safeguard Moveable Barriers
TSS—Travaux, Signalisation et Securite B.T.P.
Siege Social
6 Avenue du 14 Juillet
Z.I. de la Gaudree
B.P. 30
91412 Dourdan Cedex, France
Tel: 01-60-81-52-00
Fax: 01-64-59-31-84

Appendix E
AMPLIFYING QUESTIONS

(Questions sent to the highway agencies in the five countries visited, prior to the scanning tour.)

SCANNING TOUR OBJECTIVES

Through international technology exchange, improve highway construction and maintenance operations to reduce motorist delay and improve worker/motorist safety by:

I. Discovering new methods and procedures,

II. Identifying areas for research, and

III. Developing a "best practices" scanning tour report, presentation package, and technology sharing plan.

Background Questions—To Be Addressed Before the Scanning Tour

- Are fuel and vehicle taxes dedicated to funding highway improvements? How are the taxes calculated and collected?
- How is roadway construction and maintenance funded?
- What percentage of your roadway system is composed of freeways?
- How many miles of roadway is your agency responsible for maintaining?
- What is your maintenance budget?
- How do you measure traffic volumes in work zones? (e.g., vehicles per lane per day?)
- What is the number of total annual highway fatalities? What is the number of fatalities in highway construction and maintenance work zones?

Program Development

1. Motorists in the United States complain about the prevalence of highway work zones and the resulting traffic delays and rough pavements. What do motorists in your country expect—and accept—as the percentage of time that roadways will be fully or partially closed for repairs?
2. When developing plans and proposals for highway construction and maintenance projects, what type of, and how much, planning is done to ensure adequate traffic flow and safety? At what point in the process is this planning done?
   - Is a preconstruction conference held to ensure that the contractor adheres to the plans?
   - Are cross-cutting and multi-agency teams used to develop corridor traffic management plans? How?

  - Are any prediction modeling or impact analysis activities performed for individual projects or corridors to analyze various improvement strategies? What models are used? What decision-making information is generated?

  - What management system is used to assist with the programming and scheduling of projects?

3. How are road user costs, economic impacts to the business community, and life-cycle costs used in the decision-making process?

  - Is reducing user delays and costs a high priority in your decision making?

  - How do you calculate traffic delays, impacts on business, and life-cycle costs?

  - Have you ever selected a higher-cost treatment or action because it will last longer and thus need fewer repairs and cause less disruption to traffic in the future?

  - How is the effect on traffic considered when deciding which treatment to apply or action to take?

4. To what extent are long-range corridor improvements (capacity, operational, periodic preventive maintenance, and structural strategies) used to reduce motorist delays?

  - U.S. highway agencies are increasingly following a "get in and stay in, and then get out and stay out" strategy when designing maintenance and construction activities in corridors. What strategy do you use?

5. Do you perform maintenance and construction at night, when traffic is lighter?

  - What percentage is done by your staff, and what percentage is contracted out?

  - Is noise a concern in adjacent neighborhoods? What steps are taken to mitigate the neighborhoods' concerns and reduce noise?

Project Development

6. Do you use lane-rental fees or other monetary incentives/disincentives to speed up completion of C&M work?

  - Do your bid specifications specify the amount of delay allowed?

  - If that amount is exceeded, do you impose any damages on the contractor?

  - Are requirements different for contractors than for your own work crews?

  - How are the incentives/disincentives calculated?

  - Do you use other innovative contracting procedures to expedite C&M work?

  - Are quality and timeliness of a contractor's past performance included in prequalification procedures?

7. Many of the impediments to innovative contracting in the United States result from restrictive laws, regulations, and policies. Do you encounter similar impediments? Have you developed any procedures that exempt experimental projects from those policies?
8. Do you use design/build contracting?
   - What are your experiences to date?
   - Does D/B affect motorist delays or work zone safety?
9. What types of innovative contracting techniques are used? Are there guidelines for their use? What problems have been encountered? Solutions?
   - Do your contracts include contractor warranties?
   - How successful is warranty contracting (compared with method specifications without warranties)?
10. When selecting a contractor for a project, to what extent are the following factors considered:
    - Past performance in moving traffic safely and efficiently through a work zone
    - Proposed traffic plan for the project
11. Which factor is more important in awarding a contract—lowest price, or best proposal?
12. Have you had success with using construction materials that significantly reduce motorist delay by accelerating the construction process?
13. Is contractor involvement/input sought during planning? Design? Construction? Maintenance?
    - Do you provide any incentive for the contractor to develop and employ innovative or challenging methods to reduce or eliminate motorist delay?
    - Who is responsible for developing plans for moving traffic through work zones? Are the plans based on standards/guidelines?
14. How is the safety of the work zone folded into the design of the traffic plan?

Operations

15. Are there any pavement markings, signs, or other devices that you have found to be particularly effective in moving traffic safely through construction and maintenance work zones?
    - What positive barrier systems are used to separate workers from traffic for various short-term and long-term construction and maintenance operations?
    - Do you use erasable/removable temporary pavement markings? Are they effective? Do they leave a discoloration or shadow on the pavement when removed?

- Are your traffic control devices tested to meet CEN standards? Can you provide names of manufacturers and specifications for these devices?
- Do you have any experience with intrusion alarms (i.e., devices that provide work crews with audible warning that a vehicle has strayed into the work zone)?
- If you use tall traffic warning devices (e.g., candlestick cones) to delineate lane reductions, how effective are they? Are they crashworthy?

16. Do you use intelligent transportation system (ITS) technology to communicate with motorists, monitor traffic operation, or improve traffic safety?
    - Which ITS techniques are used?
    - Are motorists provided real-time traffic information?
    - Are messages automatically posted on variable message signs to warn motorists of congestion ahead and/or to advise them to take alternate routes?
    - Is the ITS technology incorporated into the roadway system once construction and maintenance is compete (i.e., used to monitor/manage traffic flow or communicate with road users after construction is finished)?
    - How have motorists responded to the use of ITS technology?
17. What means are used to inform road users of delays caused by construction and maintenance projects?
    - Which means of communication seems to be the most effective?
    - Describe successful public relations/information efforts.
    - What methods have been useful in getting feedback from users?
    - Have your efforts involved partnership with the construction industry?
    - Have the media been supportive of your efforts?
18. How is the speed limit set in work zones?
    - What techniques are used to enforce this speed limit?
    - How effective is the lower limit in reducing traffic speeds?
    - Is the lower limit in place 24 hours/day, or only when work is in progress?
    - Do you impose higher fines for traffic violations in work zones?
    - Do the lower limits and other restrictions hold up in court? What percentage of cases is actually prosecuted?
    - Do you have police officers assigned to work zones? What functions do they perform? How are they paid?
    - Do you use ITS technologies to detect and photograph speeders in work zones? What methods do you use to warn drivers that they are under

surveillance and subject to ticketing? How has the public reacted? Any lessons learned?

19. Have you developed or used any automated/robotic equipment to perform high-exposure, short-term maintenance operations? Have you developed or used any equipment specially designed to operate in the tight confines of temporary work zones?

20. In developing public relations/outreach campaigns, how do you determine your target audience, as well as the best methods to reach them?

    - Are your public relations/outreach efforts tailored to each project or conducted on a national level?

    - What special programs do you have that incorporate public relations and education efforts into your construction and maintenance program?

Performance Measures

21. Have your efforts to reduce motorist delay and improve safety in work zones been successful?

    - What is the crash rate in work zones? What factors seem to have the most effect on the rate?

    - How are work zone crash data collected, analyzed, and used?

22. How do you evaluate innovative materials or methods (including innovative traffic control methods and innovative contracting) that may reduce the amount of delays?

    - Who does the evaluation? At what point in the process is the evaluation done?

    - Are computer models used?

    - Do you have short-term testing and modeling procedures for newly constructed highways that will allow you to predict long-term performance and service life? (For example, can you reasonably predict how long a particular asphalt mix design will perform under specified loads?)

    - Are standardized design details used to encourage greater use of precast materials?

    - Do you have any formalized evaluation procedures? Can you provide an example?

    - Do your project development and design phases include funding for innovative methods to reduce motorist delay and public information/ education activities?

23. What performance measures are used for traffic management?

    - Who measures the performance—contractor, contracting agency, or third party?

- Was the contracting industry involved in developing the measures?
- Has industry accepted the measures as an effective traffic management tool?
- How do you evaluate the costs versus benefits of ITS technology?

24. How do you obtain evaluation and feedback? Is this done by your staff or contracted out?
    - What do you do with the data obtained from the evaluation and feedback (are they used as the basis for new initiatives, to change existing programs, verify assumptions, etc.)?
    - Do you conduct independent reviews/evaluations of work zone traffic control?
    - What techniques are used to make these reviews effective?
    - Do you have any special program in place to recognize contractors who implement effective traffic control plans?

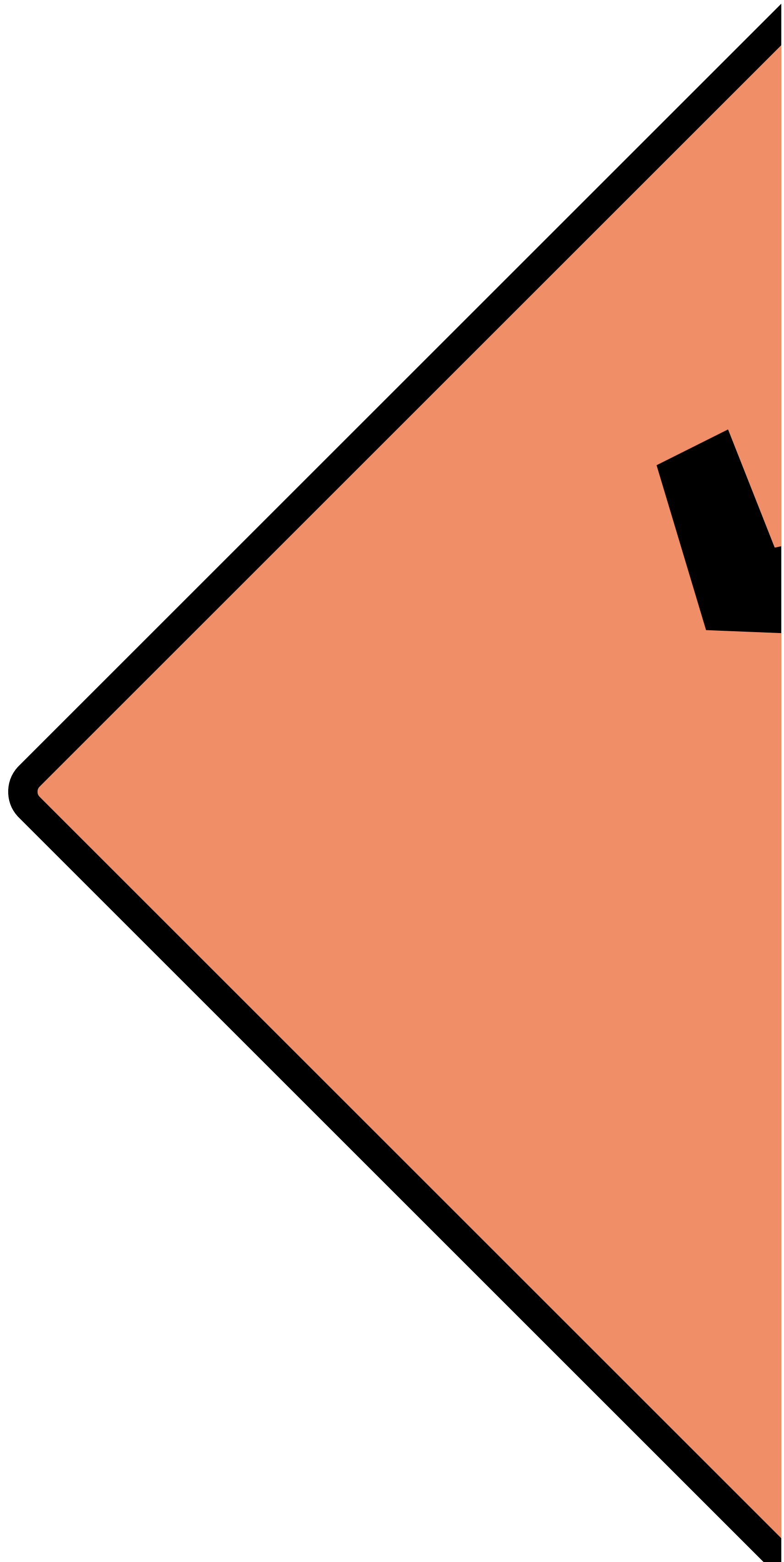
General Issues

25. Do your traffic plans include any special considerations for older drivers in work zones?
26. Do you have laws specifying maximum weights and dimensions for commercial vehicles?
    - How are vehicles that exceed these limits handled?
    - Is there a fine? How is the fine determined?
27. Can you share with us what has *not* worked, and why?

Office of International Programs
FHWA/US DOT (HPIP)
400 Seventh Street, SW
Washington, DC 20590

Tel: 202-366-9636
Fax: 202-366-9626

international@fhwa.dot.gov
www.international.fhwa.dot.gov



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