

**THE PROCESS OF SOLVING A NATIONWIDE
TRANSPORTATION PROBLEM: TRAFFIC CONTROL SYSTEM
OPERATIONS AND MAINTENANCE**

by

Karen Kuenzer

Professional Mentors

Edwin Rowe, P.E.

S. E. Rowe & Associates

Walter H. Kraft, D. Eng. Sc., P.E.

Edwards and Kelcey, Inc.

Prepared for

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Course Instructor

Conrad L. Dudek, Ph.D., P.E.

Department of Civil Engineering

Texas A&M University

College Station, Texas

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SUMMARY

This paper narrates the process by which a nationwide transportation problem of such magnitude as the lack of maintenance and poor operations of traffic control systems is being solved. It demonstrates how local, state, and federal government, private firms, professional societies, and even private individuals are working together in the effort to mitigate a dilemma that affects all.

The process of solving the problem of inadequate operations and maintenance of traffic control systems began when the FHWA recognized the poor functioning of traffic control systems that they had funded, and developed and performed a survey to evaluate the extent of the problem. Once the results of this survey, performed by the FHWA's Office of Program Review, were compiled, and the magnitude of the problem was assessed, the FHWA organized both an internal and an external panel of experts to identify exactly what was keeping these state and local agencies from properly maintaining and operating their traffic control systems, and once these hindrances were identified, to develop solutions. The FHWA is currently acting on the recommendations of the Office of Program Review, the internal panel, and the external expert panel. One of the FHWA's biggest undertakings has been the hiring of the Institute of Transportation Engineers (ITE) to perform yet another survey of urban transportation center traffic control systems operations and maintenance. ITE has subcontracted the consulting firm JHK & Associates (JHK) to develop the survey which is being overseen by an ITE/FHWA project committee, Urban Traffic Engineering. JHK is currently in the process of developing mail, telephone, and focus group questionnaires. The results of the study will help the FHWA produce national guidelines regarding traffic control system operations and maintenance.

What's really keeping local agencies from properly operating and maintaining their traffic control systems has been the lack of funds available for such endeavors. The recent Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) has helped somewhat in making funds available for operations and maintenance; however, sufficient funding is still a deficiency. The author opines that the FHWA should concentrate its efforts on making the money that is currently available for the capital costs involved with the installation of traffic control systems more attainable for the on-going expenses that such systems incur later on.

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BACKGROUND

Operations and maintenance of traffic control systems is one of the most critical problems facing the national intelligent vehicle/highway systems (IVHS) program (1). A study performed by the Federal Highway Administration (FHWA) indicated that out of twenty-four surveyed traffic control systems operated by state and local agencies, only two met reasonable standards of operations and maintenance (2). Given this indication of poor performance, how does a transportation agency such as the FHWA go about solving such a problem?

In finding a solution to this problem, the FHWA is actually employing not only its own work force, but state and local governments, private industry, individuals with expertise on the subject, and a professional society, ITE, as well. All of these agencies are working together to solve the nationwide transportation problem of traffic control systems operations and maintenance.

STUDY OBJECTIVE

The objective of this study is to identify the process by which a nationwide transportation problem, the inadequate operations and maintenance of traffic control systems, is solved. Specifically, to:

1. review literature to identify the specific problems relating to traffic control systems and to determine what is being recommended to correct those problems;
2. interview FHWA and consultant personnel to learn the logistics of the problem-solving process; and
3. synthesize the information gained from the literature and through the interviews, make recommendations, and summarize into a report.

IDENTIFICATION OF THE TRAFFIC CONTROL SYSTEMS OPERATIONS AND MAINTENANCE PROBLEM

What are Traffic Control Systems?

The first electric traffic signal was installed in August of 1914 at an intersection in the city of Cleveland, Ohio (2). Since then, and mainly thanks to the aid of computers, traffic control systems have grown to include not only signal control of a single intersection, but synchronized signal control of entire networks of intersections, as well as freeway management systems such as ramp metering signals. The systems' increasing reliance on high technology has consequently led them to be dubbed "advanced," yielding the phrase "advanced traffic management systems" or "ATMS."

Traffic Control Systems Operations and Maintenance Problems

Operations and maintenance problems related to traffic control systems can generally be fit into one of the following four categories: 1) overuse of sophisticated control equipment, 2) inadequate inspection during installation, 3) nonstandardization of equipment, or 4) obsolete equipment (3).

Overuse of Sophisticated Control Equipment

As will be explained later, often funds are available for installation of traffic control systems, but the money is not available later when these systems need to be repaired or maintained. This frequently causes agencies to purchase very expensive, sophisticated systems whose maintenance require a great deal of technical expertise. Few people have this expertise, and those who do work at a high price. Consequently, instead of fixing broken systems, agencies will often set a system to a preset mode, which effectively makes it function no better than a much less complicated system. In the end, the exorbitant amount of money spent for the highly sophisticated system is wasted, for drivers experience none of its intended advantages.

Inadequate Inspection During Construction

Inspection problems include violations of codes and improper installation, both of which can be attributed to a widespread lack of installation inspection guidelines.

Nonstandardization of Equipment

The "low-bid" procedure of obtaining equipment has caused many traffic control systems to consist of parts manufactured by a wide variety of makers. This means that maintenance staff has to be kept up-to-date with the workings of all the different types of parts, and that a large stock of replacement parts must be kept. Because both of these conditions require money, something for which there is a great shortage when it comes to maintenance programs, it is likely that agencies instead will have uninformed maintenance staffs and will be lacking important replacement parts.

Obsolete Equipment

Problems arise when systems are so outdated that their replacement parts are no longer available. Older systems also may not be compatible with newer systems with which they need to be combined.

Consequences of Poorly Maintained Traffic Control Systems

The problems associated with poorly maintained traffic management systems cause increased motorist costs including time and fuel, increased maintenance and its related costs, and increased accidents and liability (3). Ironically, these are the very problems that traffic control systems aim to diminish.

Sparking the Investigation by the FHWA

Early in the year 1990, the FHWA's Office of Program Review surveyed the Administration's operational offices to determine the highest priority problems. Mr. Sheldon Strickland, Chief of the Traffic Management Systems Division, cited that his office had informally been receiving indication from state and local agencies for some time that problems regarding traffic control system operations and maintenance were rampant (4). As the Traffic Management Systems Division had recently hired a specialist on the subject, it appeared the time was ripe to initiate a formal review on the topic.

FHWA SURVEY OF TRAFFIC CONTROL SYSTEMS

The FHWA Office of Program Review initiated a survey of twenty-four traffic control systems. The findings of this survey are summarized in this section, and can be found in entirety in the document "Operation and Maintenance of Traffic Control Systems," which was published in September of 1990 (2).

Survey Approach

The purpose of the survey was to evaluate the performance of the states, counties, and cities in review in regard to the adequacy of their traffic control systems operations and maintenance. As previously mentioned, twenty-four traffic control systems were reviewed in the winter and spring of 1990. The review team consisted of one member of FHWA's Office of Program Review, one member of FHWA's Office of Traffic Operations, and one member of the Arizona Division Office of FHWA. The seven states chosen for review were selected to form a representative cross-section of practices. The states were California, Minnesota, New York, Pennsylvania, Tennessee, Texas, and Washington. The twenty-four traffic control systems surveyed included four freeway management systems operated by states, sixteen computerized signal systems operated by cities, two computerized signal systems operated by counties, one non-computerized signal system operated by a county, and one non-computerized signal system operated by a city.

Survey Findings

The survey team used four review elements to evaluate each system, including FHWA/state guidance, technical expertise and equipment, operations, and maintenance.

FHWA/State Guidance

Federal-aid Highway Program Manual (FHPM) 6-8-3-4 (1984) mandated that all traffic control systems installed with federal funds must have a feasibility study, which includes an operations plan. Despite this fact, only four of the eleven systems installed with federal funds after 1984 had feasibility studies containing an operations plan. Explanations for this include the fact that some of the systems installed after 1984 had feasibility studies that were actually conducted before the 1984 mandate. Lack of emphasis on the requirement, low priority, and a lack of understanding of the importance of an operations plan are other reasons for the low number of systems having operations plans. Of the four operations plans completed, only two were deemed satisfactory, meaning that they estimated work force and financial needs and also included an operations time table.

In the FHWA's survey of its division personnel, all of the seven states opined that sufficient guidance was available to competently review design, construction, operations, and maintenance of traffic control systems. The review team, however, found that only six of the seven states had adequate guidance to design and construct computerized traffic control systems, but even then, the state highway authorities did not provide sufficient guidance to the local agencies.

Overall, the review team found a general lack of coordination between state and local offices. One major disadvantage of this is that agencies are not able to learn from each others' mistakes and successes. Only one FHWA region had an organized workshop where operations and maintenance problems of traffic controls systems were discussed.

Technical Expertise and Equipment

Of the seven FHWA Division offices surveyed, the review team found that none of the offices felt it had the technical expertise to competently review the design or construction of traffic control systems, citing that normally designs have to be sent to FHWA Headquarters for review (where there was *one* individual reviewing traffic control systems designs and specifications). In general, the survey team found that the states reviewed have the technical expertise but are not sharing it with city and county governments. At the city and county levels, the review team found very little technical expertise on the subject of traffic control systems.

Fifty-percent of the computerized systems were using obsolete computers. One city was replacing a computer after only six months because it was not fast enough and lack sufficient memory. Another city was currently in the process of installing a system which was to use a obsolete model computer first built in the late 1970s.

Operations

Of the twenty traffic signal systems, only nine had signal timing plans that were updated on a regular basis. The other eleven signal timing plans were only updated when complaints were received from the police or the public. In all but one of the places where signals operated by state and local agencies were spaced closely together, the signal timing plans were not coordinated.

The review team found that of the twenty-four surveyed traffic control systems eight were understaffed relative to the system's size. Six of the twenty-four systems had staffs that were unknowledgeable of basic traffic operations. This included a staff with a maintenance supervisor responsible for a system's signal timing, and a staff with an assistant police chief responsible for signal timing. Neither had any traffic engineering education or experience. To make matters worse, seventeen of the twenty-four systems had no documentation to aid their staffs in operating their systems.

Maintenance

The review team found that many of the transportation agencies had well-defined maintenance guidelines; however, most states were doing little to monitor the maintenance efforts of city and county agencies, to whom they had delegated the maintenance task.

Due to the threat of lawsuits and liability, emergency maintenance response time was judged excellent by the review team in all areas surveyed.

Nineteen of the twenty-four systems reviewed had a preventive maintenance program, and eight of the systems had preventive maintenance checklists.

The ratio of intersections to technicians at the twenty-four review locations ranged from nineteen to one hundred ninety-five with an average of seventy-six intersections per technician. Although other references have indicated that the ideal ratio of intersections to technicians is dependent on the specific equipment (5), this average far exceeds the twenty-five to thirty-five intersections per technician maximum recommended by the 1984 NCHRP report "Management of Traffic Signal Maintenance (6)."

Review Team Recommendations

The findings of the twenty-four site survey prompted the review team to create a list of recommendations regarding the traffic control system operations and maintenance problem. The most pertinent of these nine recommendations are listed below.

1. Federal funds should be allowed not only for the installation of traffic control systems, but their continuing operations and maintenance as well.
2. FHPM 6-8-3-4, which mandates feasibility studies (including operations plans) for all federally funded traffic control systems must be enforced.
3. Guidelines regarding the contents of a traffic engineering analysis, the components of an urban traffic management system, and the items to be reviewed during the approval process should be widely distributed.
4. FHWA should begin programs to increase expertise available at all government levels regarding planning, design, construction, operations, and maintenance of traffic control systems.
5. FHWA Headquarters should reassess the technical expertise required and keep this in mind in future staffing decisions.
6. FHWA Headquarters needs to highlight traffic control maintenance during its annual maintenance program.

FHWA INTERNAL PANEL REPORT

Assembling the Panel

The discouraging findings from the Office of Program Review's survey induced then Federal Highway Administrator, T. D. Larson, to assemble an internal panel to address the FHWA's technical expertise and other internal needs. The panel consisted of nine persons, primarily field personnel such as Area and District Engineers. Three of the panel members' primary duties included traffic operations. Nine different FHWA regions were represented.

Panel Recommendations

After attending an exhaustive presentation regarding the findings and recommendations of the Office of Program Review report, the panel specifically addressed each of the review team's recommendations, making comments and further recommendations on each. The results of this panel's assemblage are fully recounted in the document "Traffic Control Systems Operations & Maintenance: Internal Task Force Report," which was published in March of 1991 (7). The panel's recommendations fall under four categories: staffing, expertise, guidance, and funding. They are summarized in the sections below.

Staffing

The internal panel recommended that individuals specifically responsible for traffic operations should be appointed at every level of the FHWA. FHWA Headquarters were further urged to hire traffic operations experts for their staffs, as well as to develop a pool of experts which could be employed on a part-time/short-term basis if the need happened to arise.

Expertise

The panel advised that specialists in the field of traffic operations should be developed at every level of the FHWA; while nationally recognized experts should be recruited for Headquarters. A "Traffic Operations" institute at a university was suggested to enlarge the pool of qualified traffic operations personnel. Furthermore, the panel thought that engineers should be avidly recruited for FHWA's eighteen and twenty-seven month Highway Engineering Training Programs, and that FHWA personnel should be encouraged to strengthen their technical skills through professional societies such as ITE, Transportation Research Board (TRB), and American Association of State Highway and Transportation Officials (AASHTO). Finally, the panel recommended that FHWA personnel should be given hands-on experience using traffic control systems through temporary assignments or sabbaticals.

Guidance

Because of the extensive disregard toward FHPM 6-8-3-4, which mandates a feasibility study for federally-funded traffic control systems, the panel recommended that a "Technical Advisory" be issued to clarify the document. The panel also suggested that a resource manual relating to traffic operations be developed and kept updated, and that guidelines for operational and maintenance reviews of traffic control systems be developed.

Funding

The panel encouraged expansion of eligibility of federal funds to include the cost of operating and maintaining traffic control systems after they are installed. Further, it advised that sufficient funds be made available to implement the recommendations in the Office of Program Review report as well as the recommendations of the internal panel itself.

Conclusions of the Panel

The panel's conclusions were simply that the Office of Program Review report should be widely circulated to FHWA offices as well as state and local agencies, and that all of the recommendations in the report should be implemented.

EXTERNAL EXPERT PANEL REVIEW

Assembling the Panel

In addition to an internal panel, FHWA Administrator T. D. Larson requested that an external panel of experts be assembled as well, to address the traffic control system operations and maintenance problems being faced at the state and local levels. The nineteen members of the panel were hand-selected by the FHWA, and were headed by Mr. Ed Rowe, who at that time was General Manager of the Los Angeles Department of Transportation and was selected because of the excellent operations of the traffic control systems in that city (4). The panel was comprised of "seasoned veterans (4)" from state, county, and city departments of transportation, FHWA engineers, an academician, and a president of a private consulting firm.

Panel Recommendations

The panel met on two occasions: once in Los Angeles in September of 1991, and again in Washington, D.C. in November of that same year. The panel analyzed the Office of Program Review's report of recommendations, and identified thirty-four specific recommendations which it thought should be implemented. These recommendations fell into five main subject areas: 1) development and maintenance of necessary expertise, 2) institutional barriers, 3) procurement procedures, 4) standards, and 5) funding. "Traffic Control Systems Operations and Maintenance: Expert Panel Report," published in March of 1992 (8), documents the findings from the two panel meetings, the recommendations of which are summarized below.

Development and Maintenance of Necessary Expertise

Training. The panel advised that nationally-uniform minimum standards of skills and knowledge for operations and maintenance of traffic control systems be set and distributed by the FHWA. Knowledge in this field should be further enlarged by the offering of classes through the National Highway Institute, university short courses, and self-instructing videotape or computer software, with certification being given to those who have completed course work. The panel suggested that hands-on traffic control centers simulating real-world conditions be established along with training programs at those centers. Universities, especially the established University Transportation Centers, should strengthen their traffic control systems curricula, especially in the area of operations and maintenance. Finally, the panel felt the use of funding for training purposes needed to be made more permissive.

Technology Transfer. The panel recognized that although a large amount of material is published regarding traffic control systems, the majority of it never reaches state or local agencies, where it is needed. The panel therefore recommended that the FHWA develop a new routing procedure to insure that these instructive materials reach the targeted users. Other ways suggested to transfer information were a national clearinghouse, an expansion of FHWA's Equipment Quality Assurance Program, the use of computer bulletin boards or electronic mail, workshops, and papers in the publications of professional societies. Through

all of these methods, problems and solutions regarding traffic control system operations and maintenance could be shared.

Staffing. The panel felt it was vital that the FHWA set national guidelines for the staffing of traffic control systems operations and maintenance, and that state and local agencies should be required to generate staffing plans for their traffic control systems projects before they could qualify to receive federal funds. The panel recommended that minimum staffing levels, job classifications, skill requirements, career paths, and recruitment strategies all be a part of the staffing guidelines.

Institutional Barriers

Fragmentation. Regional Traffic Management Committees, headed up by state and local agencies, should be formed to allow members to come together and discuss problems related to traffic control systems, as well as provide a forum for classes and workshops. The panel suggested that regional traffic control centers be identified, and that the FHWA should organize presentations and workshops for non-traffic engineers concerning traffic control systems.

Organizational Structure. The panel felt that all responsibility and accountability for the operations and maintenance of traffic control systems should be under the auspices of a single manager.

Procurement Procedures

The establishment of an FHWA task force to revise current traffic control system procurement procedures, including the use of new procurement techniques such as "design/build" was proposed by the external panel. The FHWA was also advised to insure consistency in procurement procedures among its offices.

Standards

Design Standards. The panel felt the FHWA should develop traffic control system design guidelines addressing costs, type of equipment, compatibility of equipment, documentation, and self-diagnosis programs.

Maintenance Standards. Traffic control system maintenance guidelines were suggested to include preventive maintenance, required staff, inventory, malfunctions, required diagnostic equipment, and quality assurance.

Operations Standards. The panel recommended the development of operations guidelines which would include signal timing plan updating, required staff, response to non-recurring events, coordination with other systems, and system performance.

Funding

The external panel felt that the FHWA's highest priority should be to take advantage of ISTEA in order to allow for the use of federal gas tax funds for the operations and maintenance of both existing and proposed traffic control systems. The panel also suggested that by making operations and maintenance of traffic control systems line items in state and local budgets, that their funding could be better monitored.

Conclusions of the Panel

Although the panel's report lists thirty-four specific recommendations, it highlights nine of them on which the panel felt the success of the program hinged. They are:

1. the allowance under ISTEA of the use of federal gas tax funds for traffic control system operations and maintenance;
2. the development of national operations and maintenance standards;
3. the development of national operations and maintenance staffing guidelines;
4. the development of operations and maintenance guidelines and model plans;
5. the development of national traffic control system design guidelines;
6. the establishment of a national traffic control system information clearinghouse;
7. the development of traffic control system operations and maintenance courses through the National Highway Institute;
8. the establishment of a FHWA task force to revamp procurement procedures; and,
9. the organization of regional traffic management committees.

The panel felt that these nine recommendations warranted immediate attention.

PLAN OF ACTION

In November of 1992, eight months after the publication of the expert panel's recommendations, the FHWA issued a document entitled "Traffic Control Systems Operations and Maintenance: A Plan of Action (9)." The aim of the document was to report the on-going and proposed actions in response to the expert panel's recommendations. The Plan of Action was to be updated periodically, with the next edition scheduled for printing in the summer or fall of 1994 (4).

Actions in Response to the Expert Panel Recommendations

The FHWA's Plan of Action listed each of the expert panel's nine priority recommendations along with the actions underway or planned actions for each. They are briefly summarized below.

The Allowance Under ISTEA of the Use of Federal Gas Tax Funds for Traffic Control System Operations and Maintenance (Recommendation 1)

As described in the paper "ISTEA Funding for Traffic Operations (10)," ISTEA has increased the number of uses for which federal funds could be spent on traffic control systems. Previously, federal funds were only allowed for capital improvements. Now, National Highway System (NHS) funds may be used by new traffic control centers for start-up costs and traffic operational improvement for up to two years. Surface Transportation Program (STP) funds allow federal funds to be used for capital and operating costs for traffic monitoring, management, and control facilities and programs, and has no time limitation. Congestion Mitigation and Air Quality (CMAQ) funds are available to air quality nonattainment areas for use in achieving air quality attainment. The funds may be used for operating expenses but funding is only available for two years.

The Development of National Operations and Maintenance Standards, Staffing Guidelines, and Model Plans (Recommendations 2, 3, and 4)

FHWA's response to these recommendations was to enlist the help of ITE to conduct a survey of the status and effectiveness of a number of urban transportation agencies. ITE subsequently contracted the consulting firm of JHK & Associates to develop and write up the results of the study, which will include a mail-back survey, a telephone survey, and the assemblage of focus groups (11). Although the Plan of Action called for the findings of this survey to be distributed in the summer of 1993, at the time of this writing (August of 1993), the surveys were still in the draft stage, and JHK was projecting an eighteen month project completion time (11).

The survey aims to collect information regarding the staffing levels, job classification and skill requirements, career paths, recruitment strategies, organizational structure and operations and maintenance model plans of various transportation agencies. An assessment of the proper level of operations and maintenance needed according to equipment complexity will also be accomplished by the survey. The mail-out surveys will be sent to

local traffic engineering agencies around the country, as they are primarily the personnel who perform the operations and maintenance tasks (12). The telephone survey will serve as a follow-up to the mail-out survey. The focus groups will be comprised of individuals from transportation agencies who will convene at an event such as the Transportation Research Board or ITE annual meetings. The purpose of the focus groups is to get transportation personnel together to discuss their agencies' problems and successes. The draft of the survey is currently in the completion stage, and with the report due to ITE in the summer of 1994, the survey will likely take place in late 1993 or early 1994 (12). Once the results of the survey are available, the FHWA plans to make them easily available to state and local departments of transportation.

As well as conducting the survey, the FHWA plans to organize presentations and workshops concerning traffic control systems, and also recommends that the 1984 NCHRP report "Management of Traffic Signal Maintenance" be updated in fiscal year 1994.

The Development of National Traffic Control System Design Guidelines (Recommendation 5)

The FHWA proposes to use the results of surveys of a number of successful systems (conducted in 1992 and 1993) to assess the adequate level of system support and maintenance needed for traffic control systems. Furthermore, an update of the handbook "Traffic Control Systems and IVHS" is scheduled to start in the fall of 1993, though no one has been selected to do the work yet (4).

The Establishment of a National Traffic Control System Information Clearinghouse (Recommendation 6)

Although the Plan of Action projected the clearinghouse to be operational by September of 1993, the clearinghouse and "hotline" was actually up and running by October of 1992, and in nine months had received approximately six hundred inquiries (4). The clearinghouse is being managed by ITE, which employs two individuals to answer questions concerning traffic control systems.

The Development of Traffic Control System Operations and Maintenance Courses Through the National Highway Institute (Recommendation 7)

Modules on operations and maintenance of traffic control systems have been added to two National Highway Institute courses, "Traffic Control Software and Signalization," and "Computerized Traffic Signal Systems." FHWA also points out the traffic control signals and systems courses offered at Georgia Tech and Northwestern University. Two new National Highway Institute courses, "Transient Protection, Grounding, Shielding, and Bonding of Electronic Control Equipment," and "Construction Inspection of Traffic Control Systems" are in the development stages (9).

The Establishment of a FHWA Task Force to Revamp Procurement Procedures (Recommendation 8)

The FHWA plans to inform state and local agencies that low bid is not the only procurement method acceptable by FHWA. Single source and life cycle cost are also permitted ways of procurement, and because operations and maintenance costs make up approximately fifteen percent of life cycle costs (4), a life cycle bid is probably a more accurate way of determining project cost. Some states, however, may be constrained by the low bid procurement method, and this should be changed. FHWA also plans to investigate the "design/build" procurement method, which is being used quite successfully in Europe.

The Organization of Regional Traffic Management Committees (Recommendation 9)

One traffic signal system support team has already been assembled in Albany, New York. Other teams like this one are being attempted in other FHWA regions. The FHWA also pointed to the traffic management center in Las Vegas, Nevada as an example to follow in other metropolitan areas.

Other Actions

In addition to the actions in response to the expert panel recommendations, the FHWA also reported other actions on which it was working. Both the Office of Program Review and the External Expert Panel reports were redistributed in October of 1992. The FHWA document "Guidelines for Successful Traffic Control Systems" was reprinted and distributed in November of 1992. An update of the handbook entitled "Communications in Traffic Control Systems" is being written by the Transportation Research Board, to be released in the fall of 1993. Edwards and Kelcey, Inc. has also been contracted by ITE to expand its traffic control system operations and maintenance guide (13). The guide will include ATMS, ATIS, IVHS, surveillance, and operations, and focus on all traffic systems, whereas the original ITE manual included only installation and maintenance (5). The guide is to be finished in the late winter or spring of 1994.

In July of 1992, the FHWA completed a series of video tapes and a field manual giving guidance on the design, installation, operations, and maintenance of traffic detectors. The tapes and manual were designed to work in tandem with the "Traffic Detector Handbook," a previously published document. One of the most successful responses to the traffic control systems operations and maintenance problem has been the DP93 training and demonstration project, "Traffic Control Software and Hardware." The exhibit is housed in a tractor trailer with expandable walls, the design and installation of which cost \$450,000 (4). The exhibit allows visitors hands-on experience on thirty different displays provided by traffic control system vendors (the vendors are not allowed to travel with the exhibit). The exhibit travels to conventions and meetings, making one or two stops per month. The demonstration project is currently booked up for the next two years (4).

CONCLUSIONS

The process of solving a transportation problem as immense as the traffic control systems operations and maintenance dilemma requires the cooperation of many different agencies. While the FHWA is conducting the investigation, state and local agencies must do their part by participating in the surveys, so that the real problems can be identified, and also so that what is working can be identified and used as a prototype. The FHWA has also gotten private firms as well as the professional society ITE involved in the investigation, by contracting with them to write guidebooks and to develop surveys. Even individuals have been recruited to form an "expert panel," lending their experience and expertise to the cause and making important recommendations.

What's even more astonishing than the number of people involved in this problem's solution is the amount of time such a process takes. The suggestion that the Office of Program Review perform a survey of the status of traffic control systems operations and maintenance was made in early 1990. That was when the problem was *identified*; agencies had been complaining of the lack of funds and technical expertise available for traffic control systems operations and maintenance long before then (4). The results of the second survey of transportation agencies, to be performed by JHK, are not slated to be finished until June of 1994 (12). Five years will have been spent merely identifying the problem. Once the results of JHK's surveys are available to the FHWA, the national guidelines will still have to be written and distributed.

While the FHWA has been waiting for the completion of the second survey, it has made great strides toward alleviating the traffic control system operations and maintenance problem. Most notably, ISTEA has expanded the allowable uses of federal funds for traffic control system projects. Training on the subject of traffic control system operations and maintenance has been facilitated through the writing (or reprinting) and distribution of manuals, the proposed expansion of National Highway Institute courses, and the development of instructional computer software. A national clearinghouse and "hotline" have been up and running since October of 1992. Finally, the "Traffic Control Software and Hardware" demonstration project, which gives field personnel hands-on training on state-of-the-art traffic control equipment, has proven successful and is in great demand around the country.

RECOMMENDATIONS

While ISTEA has helped somewhat in the availability of federal funds for traffic control system operations and maintenance, the funds available for such use are still very limited. While one manifestation of this problem has been the deterioration of existing systems addressed in this paper, another concern is that although funds are often readily available for the installation of traffic control systems, many cities are reluctant to install them because they know the money will not be there for operational and maintenance costs in the future. This is unfortunate, for the author believes that the limits of technology, and not the limit of funds, should be the restricting factor in the type of traffic control system a transportation agency installs, especially when the substantial cost benefit of a well-running traffic control system is considered.

As operational and maintenance expenses generally cost fifteen percent of the capital expenses of a traffic control project--a substantial amount--it is ridiculous that they are essentially considered negligible by the lawmakers who have placed such great restrictions on federal fund use. The importance of traffic control system upkeep, especially the price paid for a malfunctioning or altogether non-working system, needs to be made evident to those who make the laws concerning this subject. The author recommends that this task needs to be undertaken so that the real obstruction in the way of solving the traffic control system operations and maintenance problem, lack of funding, might be eliminated.

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Karen Kuenzer received her B.S. in Civil Engineering in May 1991 from the University of Virginia and is currently pursuing her M.S. from Texas A&M University in Civil Engineering. While pursuing her M.S. degree, she is employed by the Texas Transportation Institute as a Graduate Research Assistant. She worked for a year with Radian Corporation in Houston as an environmental consultant. University activities involved in include: Institute of Transportation Engineers, Chi Epsilon and Tau Beta Pi. Her areas of interest are in transportation planning, public transit, and intercity transportation.

