These efforts will represent the initial stages of a comprehensive IVHS program in Houston. A plan for the Congested Corridors Program has been submitted to FHWA. This program encompasses a large area and includes a number of transportation improvements. These include advanced traffic management systems, advanced public transportation systems, and the use of advanced traveler information systems.

TxDOT is also examining the use of automatic vehicle identification (AVI) to supplement the computerized transportation management system that is being developed. The technology could be used on both the freeways and the HOV lanes to collect current traffic information.

These IVHS efforts are not just targeted at motorists. Commercial users will also benefit through the improved movement of goods and services in the Houston area.

One of the lessons we have learned in the Houston area is that communication, coordination, and cooperation are very important. Yet, in my opinion there also needs to be a master plan that identifies what the goals are, what is trying to be achieved, what funding is available, and what the responsibilities of each agency are. Although each agency has their own goals, it is important that a cooperative approach be taken that involves all agencies and organizations. Developing an overall plan will help in this effort.

In conclusion, the complete implementation and operation of these traffic management systems is still well in the future for the Houston area. It takes a long time to design and implement these systems. Thus it is important to start using the resources currently available to initiate elements of the program, such as the provision of real-time traffic information. This will provide the public with early benefits from the system and help build public support.

INFORM

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INFORM is a traffic information system for Long Island drivers. You may be wondering what a Long Island driver is. Although we don't tell them, anyone that drives on Long Island is a Long Island driver. INFORM grew out of an earlier public information effort known as IMIS (Integrated Motorist Information System). Because it took so long to implement the project, IMIS had developed a tarnished image. A public relations firm was hired and, working with some local people, developed the name INFORM. It is a nice name and has gotten very good press.

The INFORM corridor on Long Island is 40 miles long and about 5 miles wide. It goes from Queens in New York City, through Nassau County, and out into Suffolk County. At the far end is Hauppauge, where the control center is located. One of the things we have learned from the project is that the best location for the control center is not at the end of the corridor. In

the future, we will consider developing a system for the Southern State Parkway that could be integrated with INFORM.

I would like to provide you with a brief overview of the key system elements. Also, I want to summarize some of the major points from an evaluation of the system done by JHK & Associates. It was an independent evaluation funded by FHWA. Local staff members were not involved, other than for interviews and providing some information. I think the evaluation was very objective and well done, and provides some valuable insights that I would like to share with you.

The system covers 128 centerline miles. The backbone of the system is the Long Island Expressway, I-495. I think that one of the reasons it was selected many years ago for an operations demonstration project is its nearness to, and opportunity for diversion with, the Northern State Parkway, the Grand Central Parkway, the Jericho Turnpike, and the Veterans' Highway. The system also includes a number of north/south routes, and it keeps growing, which is a positive sign.

The operations center in Hauppauge has three minicomputers. There are 2,400 roadway loop detectors, and at last count we had 80 variable message signs. This number continues to grow. We are implementing the first HOV lane on the system and there will be a number of variable message signs associated with that facility. There are 75 ramp meter locations. We are also installing some stand-alone ramp metering to the east of Hauppauge. There are CB monitors, 160 miles of coax cable, and 25 closed-circuit TV cameras, with 9 planned. We seem to be having some bid savings here in New York State: contractors are cutting corners and bidding about 25 percent less than normal engineering estimates. This has allowed us to develop the system more that originally anticipated. We have 14 VTIP subscribers, which I will describe in a moment, and 126 arterial traffic signals. That's the system as it stands now, but it is constantly growing.

VTIP stands for Visual Traffic Improvement Program. It uses the 2,400 loop detectors to collect speed information, which is then transferred from the mainframe computer to PCs. Subscribers pay $200 for the software, but we will provide it to public agencies free. The system displays the speeds on the network, updated every minute. We are also hoping to start a limited scale demonstration that uses voice synthesis to broadcast this real-time information over the radio.

Before the INFORM system was implemented, we noticed that there were times when the Long Island Expressway was very congested and the parallel Northern State Parkway had very little traffic. Without the variable message signs and ramp metering, the motorists were unaware of the better conditions on the alternate route. Thus, the benefits of the system have been demonstrated to the public.

I would like to give you a brief idea of the cost of the system. The initial cost of the project was about $35 million, although it is probably closer to $40 million right now with all of the expansions and improvements made to the system. An interesting point is that the communications elements make up about 40 percent of the total cost. We are certainly looking for ways to save on this significant part of our costs for future projects. The system is mostly coaxial cable, which is not the state-of-the-art today, and there are some problems with it.

One of the largest headaches has been the annual operating costs of the system. A consultant operates the system for us and a maintenance contractor is used as well. The total cost is about $5 million per year, which is close to 10 percent of the construction costs. Ten percent has been used as a rule of thumb for the cost of operating a system like INFORM. Since this was our first big job in the state, our fiscal people did not realize it was going to cost this much. Every year we wonder what the funding will be like, and there are times that our operating consultant and maintenance contractor don't get their paychecks.

Last spring some people at the state level thought the new ISTEA legislation provided operations money from the federal government, so they took our allocation out of the state budget. When the new fiscal year started in April, we had no money to operate INFORM. People were working and not getting paid. To resolve this problem, we first met with the local FHWA representatives and worked out an agreement to fund a part of the operations costs, but not the maintenance expenses. The next step was to meet with the Region 10 office staff in Hauppauge and present our case to the MPO, where it was included on the TIP. We are very fortunate now that we are getting federal funding on an 80/20 formula basis. To me this is really a commitment from the MPO and the community, and I think MPOs have to become more involved. It isn't just $5 million for 1 year. If you look at it as a 5-year program, that's $25 million of blacktop that is not going to be put down.

Next I would like to describe the staff of the INFORM system. New York State DOT has 8 full-time people assigned to the project, 6 engineers and 2 clerical workers. The consultant has 18 full-time and 5 part-time people, and the system is operated 24 hours a day.

We are delighted with the recent evaluation report on the INFORM system. At the time construction was finishing up, it was decided that our department should evaluate INFORM. Then FHWA decided to do an independent evaluation of the project. I had confidence that our system would look good in the report, but if it hadn't, we probably would have turned it off.

With our variable message signs we generate 14,000 messages per year, 500 a day, and 50 during the busiest hours. Approximately half are manually generated. Incident related delay savings are 300,000 hours per year, about 1900 hours per incident. There are other benefits as well. In particular, we use the variable message signs during construction and maintenance activities and for major events in New York City.

One thing that the evaluation report noted was that the effective use and value of the variable message signs are highly dependent on the diversion potential of the corridor. This seems obvious: if there is no alternate route, you can't tell motorists to divert. Another main point was the importance of accurate information on the signs. It does not take long for motorists to disregard the signs if the messages are not believed to be accurate, so credibility is probably one of the most important things.

The results of the project provide a simple formula for diversion rules: the percent diversion increases as the directness of the alternate routes increases, and the percent diversion increases with the increased excess capacity on alternate routes. If you put those two together it makes sense. Of course, this assumes that the quality and accuracy of the information is sufficient.

The absence of traffic responsive capabilities on parallel arterials is the most significant detriment to the potential overall effectiveness of the diversion strategies. In other words: if there is no facility to divert to, they aren't going to help you out much.

At INFORM, operation of the variable message signs consumes about 80 percent of the operators' staff time. Between 5 and 10 percent of mainline traffic can be diverted when a variable message sign is in passive message. Passive message is when the sign is simply telling you that there are delays ahead, not where to go to avoid it. A rule of thumb is that if you give a diversion message, that percentage would double. So up to 20 percent can be diverted by giving a positive message.

During the design of an integrated traffic management system, the variable message sign locations should be associated with special route diversion opportunities. You need to think through where there is going to be an incident and where you would put the sign. When you place the sign, put it far enough in advance of the exit so the message doesn't get to the driver too late.

Maintenance of the quality of information on the variable message signs must be a top priority of the system operator. Our studies have found out that an automated sign control with human monitoring and refinement is the most effective way to do it. You just can't do it with a human control alone, and you can't do it by automation alone, so it is a combination of the two. That means you need to have people in the control center.

We found out that bracketing congestion areas—for example "delays from exit 34 to exit 37"—is more effective than identifying the length of the congestion—"delays next 3 miles ahead." If you had delays between these two exits, you could go back maybe four or five variable message signs and start giving the message ahead of time. We use exit numbers because some of the cross expressways or parkways have very long names that might not fit on a variable message sign.

We have come to the conclusion that all on and off ramps should be detectorized to properly evaluate the effect of variable message sign operations and provide feedback to the operators, even if it is not a ramp meter location.

During the implementation of the system, the variable message signs were installed by the contractor long before we were ready to turn them on. The result was a lot of motorists who thought the signs were not working, which is an image problem. Because of that experience, we have decided that it is better to continuously display messages on the variable message signs, even if there are normal traffic conditions ahead. If there is no message, the drivers may again start to think that the sign broken.

Another thing we do with the variable message signs that creates some problems is run public service announcements, like promoting seat-belt use or discouraging drunk driving. We have a committee set up to review requests for these messages. The problem is that they are not like traffic control signs where you have to get FHWA approval. This may be an area where research is needed to develop some standards. We may be getting ourselves in trouble because this is a very sensitive area, and there is a lot of pressure from groups to put their messages up, even ones that are not traffic-related.

As I mentioned earlier, one important thing is to minimize the time between installing the sign and turning it on. Another important element is to incorporate on-line testing and operator training with the software.

Several sources for inaccuracies in variable message sign information were identified in the report. First, information can only be bracketed to the nearest interchange, which are probably less than 2 miles apart. Second, there is a time gap for the motorist between encountering a sign and arriving at the incident location, so you might warn of delays ahead and when the motorist arrives it is already cleared out. Third, detector spacing is about a half mile apart, so you can be no closer in accuracy that half a mile. Finally, there could be failed detector stations, but I think our loop detectors are working very well out there, or at least I haven't heard of any problems. Of course there are also errors made by the system operators.

The ramp metering was also evaluated, but the process got kind of fuzzy. The original plan was to conduct a 5 week before and 5 week after study, but no one anticipated how long it would actually take to turn the ramp meters on. We were very concerned politically and wanted to be right there as each one was turned on. It took so long that they decided to measure the speeds once all the meters were on in March 1990, then they turned them off and measured the speeds again. There was an 8 percent increase over the non-metered case, but when the metered case was compared to 3 years earlier, the improvement in speed was 13 percent. One possible explanation for this is that INFORM has helped commuters plan their trips better; the variable message signs were not in operation in 1987, but they were in 1990. The p.m. peak wasn't quite as good during the 1990 comparison. The meter-on and meter-off speeds were essentially unchanged, but when compared to 1987 there was a 13 percent increase in speed.

To summarize, I think a true test for the project is the vehicle-miles traveled. During the 1990 analysis there was a 1 percent increase in VMT, and from 1987 to 1990 there was a 5 percent increase. That clearly shows that the ramp meters are working. There was a 7 percent maximum increase in the throughput at bottlenecks due to ramp metering. The average increase was 2 to 3 percent, and some locations were unchanged.

There have been some publications of congestion index numbers, although I think they were printed in a way that gave the wrong indication. The congestion index is based on the number of speeds less than or equal to 30 miles per hour. In the March 1990 comparison there was a 25 percent decrease in the index, but the number that was published was 50 percent. I guess you could say it was up to 50 percent from 1987 to 1990.

The phased turn-on of the ramp metering worked well. It allowed the necessary traffic engineering attention. Instead of turning several on at the same time, a traffic engineer evaluated and worked with them one at a time. Some of the ramp volumes doubled in the time between the feasibility study and the actual turn-on. I do not think anyone can be faulted for that problem—it just happened, and it is something to be aware of.

One of the biggest problems is the inability to manage queues that back-up on the cross streets from a ramp meter. I think the best approach is the use of 2-lane ramp meters. It is certainly a very efficient solution, and I believe we are beginning to use it for INFORM.

The public relations consultant that was hired for INFORM also conducted a study. It is interesting because what we as traffic and transportation engineers think is one thing, but this was an opportunity to find out what our customers think.

The first result relates to the perceived accuracy of the information. Seven percent indicated that they think the information is always accurate. I would not expect any more than that, but I think it's delightful that the "usually accurate" response got 56 percent, and when you add that to 7 you're up around 60 percent. The usefulness of the information on the variable message signs was the next question. It surprised me that "very useful" got 29 percent and "moderately useful" got 48 percent. When you add the two together you get 77 percent. Only 3 percent responded "never useful." I expect that in a normal sample you would get more than 3, so that looked pretty good. For the travel time comparison, 43 percent agreed exactly and 35 percent differed by only one interchange, which was pretty good. Another significant response was to a question about route changes. Forty-six percent indicated that they "sometimes" divert. I think that is very good for a system like INFORM where the drivers are not forced to divert.

Here are some of the things that were listed as threats to the evaluation. First is the occurrence of incidents. They should be screened out because they will create problems with the data. During the winter in northern climates there is no construction activity, but there is inclement weather. As soon as the weather breaks, road construction begins. This gives a bias to the evaluation. There were also time-related factors because the implementation took so long. The evaluation went on for 2 or 3 years, and is not as accurate as 5 weeks before and 5 weeks after would have been. Furthermore, there were seasonal factors, like daylight savings time and inclement weather, which added to the complexity and difficulty of an evaluation like this.

One issue that may not be that big of a problem is designing easy access to variable message signs. You don't want to have to block traffic lanes for the maintenance contractor to get in there.

One thing that is important is the construction phasing of high visibility devices like ramp metering and variable message signs. As I mentioned previously, they should not be installed and just sit there for 2 years before being turned on.

In any high volume corridor there are always going to be construction projects, which is both an opportunity and a threat. I think the people that run our system have been able to use those projects as opportunities to upgrade and improve the system, adding closed-circuit TVs and other elements.

Our department elected to hire a design consultant that helps integrate other corridor construction projects with INFORM. For example, if we have someone designing an interchange, we do not have that particular consultant design the INFORM features. Rather, we use one that works directly for our traffic people. They learn how to do it and they are very skillful at it. I think this has been a very positive element.

One of the problems that I think is a criticism of the consultant, and probably us for not catching it, has to do with replacement parts. The problem is when you design a project and there is no supplier 3 years down the road when you run out of parts. This is something that needs to be addressed.

The location of the control center probably, we now think, should not be at the east end of the job but towards the middle. I think we are going to be looking at the issue of moving the control center in the not too distant future. This might come out of some IVHS funding we are looking at in the Long Island area.

One of the big things that we did had to do with the communications cable. We had to cut costs when we let the job originally and could not afford to put conduits in, so direct burial was used. The first year of operation there were 200 cuts by our own contractors and maintenance people. We should have put it in conduit, I think that is a must.

In conclusion, I think that the bottom line is to look at the benefit and costs of the system. The benefit/cost for the March 1990 comparison was 1.82. When comparing 1990 to 1987 the benefit/cost was 8.27. Those estimates were made using $8 an hour delay time. The regional planning people in the Long Island area thought that the value should have been about $14 an hour, so I think the benefit/costs are even higher. Regardless, it is pretty obvious that the project is a success.

Gardiner-Lake Shore Corridor Traffic Management System

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The Gardiner-Lake Shore Corridor consists of an urban freeway (the F.G. Gardiner Expressway) and a parallel signalized arterial (Lake Shore Boulevard), which together form a major access route into downtown Toronto. Corridor traffic management systems have traditionally focused on freeway and arterial traffic operations, employing subsystems such as loop detectors, closed-circuit television cameras, changeable message signs, low power highway advisory radio, and ramp metering. However, the Municipality of Metropolitan Toronto Transportation Department recognizes that it is important to integrate other concurrently operating traffic management systems which are related functionally and geographically.

There are many good reasons for integrating traffic management systems. Foremost, integration serves to consolidate systems which would otherwise be isolated. Integration thereby allows for the coordination of activities and enables each system to take into account the operations, strategies, and capabilities of the other systems. Motorists, perceiving the road network as a seamless continuum, benefit from an integrated system which presents a unified package of information to assist them in making decisions such as route choice and departure time. Integrating several systems with similar functions enables operational efficiencies within the overall system. Interactions with external agencies are simplified and improved by providing a single point of contact with each source/user agency. Finally, by facilitating intensive cross-communication and cross-support among the linked traffic