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16. Abstract

This study focuses on traffic congestion, primarily that occurring on freeway corridors in metropolitan areas. Lack of coordination in the operation of various components of the system is often a major source of inefficiency, resulting in greater delays to motorists than what might be achievable with the existing physical infrastructure. Inefficiency owing to a lack of coordination may be the result of jurisdictional issues in terms of different entities having operational responsibility for different parts of the system. Typically, the respective control settings for the various subsystems in a freeway corridor are not designed to operate together in an integrated way. The consequences are particularly acute when incidents occur and where there is an attendant loss of capacity, accompanied by possible redistribution of flows; moreover, the control settings along likely diversion paths are not designed to react to accommodate the unfolding situation. The main objective of the study is to improve corridor network management by coordinating the various control elements in a freeway corridor, for both recurrent and nonrecurrent congestion situations.

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by

Hani S. Mahmassani
Didier M. Valdes
Randy B. Machemehl
John Tassoulas
James C. Williams

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CENTER FOR TRANSPORTATION RESEARCH
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THE UNIVERSITY OF TEXAS AT ARLINGTON

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IMPLEMENTATION RECOMMENDATIONS

The findings of this study can be used by traffic engineers, Texas Department of Transportation and Federal Highway Administration officials, and by cities in Texas to evaluate and reduce urban congestion. Final project implementation recommendations are provided in this project summary report (see pages 2-3).

This report was prepared in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

DISCLAIMERS

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation.

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Hani S. Mahmassani, P.E. (Texas No. 57545)
Research Supervisor

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PROJECT 1468
SUMMARY OF RESEARCH FINDINGS

This study is one of the first successful attempts to develop, apply, and demonstrate procedures to integrate and coordinate the operation of a complex freeway corridor network.

Intelligent transportation systems provide the technology and the architecture to achieve such integrated and coordinated operation. Advanced traffic management systems (ATMS), possibly coupled with advanced traveler information systems (ATIS), provide enabling technologies and hold considerable promise for better traffic management. However, realizing the promise of such technology requires operational strategies, operating concepts, and suitable methodologies for achieving traffic management objectives through specific practical actions that can be implemented in the field with measurable outcomes.

Advanced traffic management systems have evolved over many years and will continue to evolve. And over the years, different traffic control subsystems have been deployed and refined, creating a challenge in any attempt to coordinate and integrate their operation. While each subsystem and component has typically been designed to operate independently, and in some instances optimized on an independent basis, joint operation places different requirements on these systems.

This study has five primary accomplishments that are of direct significance to Texas Department of Transportation (TxDOT) urban district engineers and to other entities entrusted with traffic management responsibilities at an areawide level. These accomplishments pertain to:

1. A framework for integrated operation
2. Specific operating strategies
3. Tools for analysis, design, and evaluation
4. Specific implementable actions
5. Documentation of benefits

The fifth item—documentation of benefits—is critical in efforts to establish and confirm the rationale for integrated operation of a freeway corridor network.

A major accomplishment of this study, which enabled the other accomplishments, is the enhancement, application, and demonstration of a unique tool that had been critically missing from the toolkit of traffic engineers, namely the DYNASMART computer traffic simulation and assignment model. This tool is the only available such methodology to analyze, design, and evaluate integrated traffic management strategies. In this study, the model was adapted and greatly enhanced for the purpose of application to traffic corridors. DYNASMART was shown in this study to provide a key role as system integrator, which allows the traffic engineer to consider all traffic control elements in a freeway corridor network.

All the recommendations provided in the study are based on extensive testing conducted in a specially developed simulation test bed consisting of a portion of the I-35W corridor in Fort Worth, Texas.

The first major recommendation for implementation is the application of the strategies and procedures developed in this study. Such strategies and procedures can produce measurable benefits and improvement in terms of reduced travel time and delay to motorists, and generally better traffic flow during both recurrent and nonrecurrent congestion. The benefits can range from a few percentage points to upwards of 30 percent in some situations.

The second major recommendation is to avoid poorly conceived integration, which could worsen conditions. Hence, it is highly recommended that appropriate tools and strategies be developed and implemented as demonstrated in this study, to achieve the desired benefits of ATMS.

The system operation framework recommended for implementation consists of two integrated components: (1) traffic control elements, and (2) information supply aimed at route-guidance. The implementation of each one of these two components depends on the stage of deployment of ATMS capabilities on the corridor; however, the framework developed by the study can be applied at various stages of deployment, and is intended to accompany such deployment. A summary of the recommended strategies to be implemented in the illustrative Fort Worth corridor test bed with typical ATMS capabilities is provided below. For instance, in the test bed, available information dissemination media include VMS (both fixed and mobile), pretrip information through local TV, radio stations, and the Internet. In addition, drivers may obtain information through local radio stations during the trip. Furthermore, some of the strategies considered in the study also look ahead to the time when different degrees of market penetration of in-vehicle information sources, independent of a specific technology, will be achieved.

The integrated operational framework considers different levels of coordination with and between each of the system components. Within the traffic control component, strategies have been developed for implementation at (1) the local level (e.g., individual intersections and diamond interchanges); (2) at the arterial and frontage road level; (3) along paths identified specifically for optimum coordinated operation for a prevailing traffic pattern; and (4) at the entire network level.

At the local diamond intersection level, extensive testing under different incident situations resulted in various control schemes (phasing sequences, green allocation schemes, coupled with movement prohibition) that are optimized locally in response to (a) prevailing traffic patterns, especially turning percentages, (b) traffic queues, (c) symmetry between traffic volumes along the affected frontage roads, and (d) ability to prohibit certain movements. However, it is also shown that locally optimized performance at diamond intersections does not always result in better traffic conditions overall, unless it is an element of integrated operation strategies, as developed in the study.

The next level of control coordination considers both frontage road and arterial streets, and subsequently includes some paths through the entire network. The study results suggest the following important recommendations:

1. Under nonrecurrent congestion, it may well be more desirable from a network standpoint to maintain traffic-actuated signal operation rather than to implement a fixed coordinated timing plan based on a common cycle length and fixed green splits to

provide progression along the frontage road or the principal arterials. This recommendation is based on robust test findings under various traffic scenarios.

2. Some improvement over uncoordinated traffic-responsive signal operation can be attained through a new approach developed in this study (and made possible by the DYNASMART dynamic traffic assignment capabilities). This approach consists of identifying critically used paths (including turning movements), and providing progressive movement of vehicles along these paths by properly increasing the maximum green allowed for these movements. This approach combines the benefits of highly selective and carefully selected path progression, all the while retaining the vehicle-actuated character (and flexibility!) of the individual signals.

The strategies suggested by this study may be implemented incrementally according to the deployment of ATIS/ATMS capabilities. Immediate applicability is possible through the selection and study of plausible scenarios dealing with nonrecurrent congestion. Once the available corridor capabilities are determined, each scenario should indicate how to jointly implement control and route-guidance strategies.

In terms of information/route-guidance considering the capabilities available in the test bed used in this study, the following steps are suggested for each scenario:

1. Determine the VMS's to be activated and the messages to be displayed. For example, considering the incident characteristics, the VMS's located upstream of the incident location should display not only a message indicating the lanes closed, but should also induce drivers to take an alternate route according to the improvements made possible by applying the control strategies. Special consideration should be given to the message displayed in order to assure that the number of vehicles diverted will not overload other facilities. Therefore, it is necessary to monitor the number of vehicles diverted and to carefully select the type of message displayed under different diversion conditions.

2. Determine (by simulation or additional field studies) the most suitable paths to be taken by the vehicles diverted, with a view toward improving travel time and reducing the negative impact across the whole network. This is one of the most important steps, since the rest of the strategy depends on the results of this step.

3. According to the critically used paths, determine suitable locations for the mobile VMS to reinforce the use of those paths previously selected. The diversion paths should be monitored to avoid an excessive number of vehicles taking paths where the control is not prepared to handle the additional demand.

4. Determine the pre-trip information that should be disseminated to the available sources of information. This information should include the incident location and its

characteristics, but also may include the traffic conditions on alternative routes for those users that have not initiated their trips at the instant that the incident occurs.

5. Determine the en-route information to be disseminated to the available sources of information and appropriate delivery time. En-route information indicating alternative routes that vehicles already in the traffic stream might follow to avoid congested facilities should be carefully disseminated to eliminate the possibility of overloading other facilities.

In terms of traffic control, each scenario should take into consideration at least the following steps:

1. Determine the changes in diamond interchange control, taking into consideration the location of the freeway disturbance in order to implement phasing and timing schemes that favor the corresponding side of the diamond interchange. Specific guidelines to deal with this control situation are provided in section 2.4 of Research Report 1468-1.

2. Change the vehicle-actuated traffic signal parameters along the critically used paths determined previously. The main parameter to be changed is the maximum green time for the coordinated movements, with such a change allowing an increase in the throughput of the movements that receive priority.

With full deployment of ATIS/ATMS capabilities it would be possible to control corridor information/route-guidance and control elements by implementing a fully integrated real-time dynamic traffic assignment system. If, in addition, it is possible to incorporate the results of the real-time traffic control systems research that is in the developmental stages, a fully integrated system may be developed that truly reacts in real-time to the disturbances occurring in freeway corridors.

In conclusion, the experiments performed as part of this study suggest that, in order to obtain the benefits required by ATMS/ATIS strategies, the action should combine control and route-guidance strategies. Properly designed route-guidance alone can produce meaningful benefits. Control strategies alone produce only marginal benefits. In some cases control strategies produce benefits at the specific site that is improved, but the effect is not distributed over the entire network. In order to obtain meaningful systemwide benefits, integrated or combined strategies are required. It was noted in connection with these experiments that there exists a considerable difference between the "benchmark" for the system (as indicated by the experiments with 100% of vehicles following system optimal guidance) and performance simulated under most other situations. These large differences suggest meaningful opportunities for improvement in current system operations through properly designed information-based strategies and real-time control.