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Program of Research for HOV Systems

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PROGRAM OF RESEARCH FOR HOV SYSTEMS

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PREFACE

This document establishes a national research program on HOV Systems. It has resulted from extensive deliberations by the members and friends of the High-Occupancy Vehicle (HOV) Systems Committee of the Transportation Research Board, presentations and discussions at open forums conducted at National HOV Systems Conferences, and from individual members of the Research Subcommittee charged with this assignment.

The program recommends the conduct of eighteen (18) separate research studies that are interrelated and coordinated to address current deficiencies in planning, design, operations, and enforcement of HOV facilities on freeways and arterials. The total cost of the research program is estimated to be $4.96 million as of 1994, and is expected to be completed within six (6) years.

One of the initial studies to be undertaken in the research program is the development of an HOV Systems Manual. It is proposed that the Manual be updated periodically, which will integrate current knowledge with the results of the completed research projects. This activity of periodic updating of the Manual will have two objectives. First, the results of research will immediately be converted into a guide for planning, designing, and operating HOV Systems. Second, the preparation of guidelines will improve the focus of proposed research to better meet the deficiencies in current knowledge, and permit reassessment and identification of overlooked research areas and address emerging needs.

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INTRODUCTION

HOV SYSTEMS COMMITTEE BACKGROUND

The Transportation Research Board Committee on High-Occupancy Vehicle (HOV) Systems is one of the most recently established committees of the Board and has developed a high level of activity and accomplishments. Because HOV Systems require an multi-discipline approach and involves many areas of research, the Committee has the responsibility to interact closely with other TRB committees.

Membership on the Committee consists of 25 members, and in addition, there are more than 46 friends of the Committee who contribute significantly to the Committee's activities. One of the early successes of this Committee was the development of a strategic plan which outlines the activities and objectives of the Committee and provides a schedule as to how to meet those objectives. The Committee also focused significant effort on providing information on HOV facilities and helping to coordinate the sharing of information between diverse groups. Examples of this sharing of information is their sponsorship of six national conferences over the past eight years and the publication of a semi-annual newsletter which is widely distributed.

The HOV Systems Committee is organized into four basic subcommittees. The Information Development and Dissemination Subcommittee is responsible for organizing the national conferences, the technical sessions at the TRB Annual Meetings, and developing informational material on HOV projects. The Marketing/Outreach Subcommittee is working toward the development of a marketing training manual and exploring ways to provide information to policy makers who make decisions on the implementation of HOV facilities. The Strategic Planning Subcommittee developed and has updated the Committee's Strategic Plan and is coordinating the Committee's activities with other professional organizations. The Research, Planning, Design, and Operations Subcommittee is responsible for identifying research needs, developing research problem statements, and preparing this research program for HOV systems.

RESEARCH SUBCOMMITTEE BACKGROUND

The Subcommittee on Research, Planning, Design, and Operations was established in mid-1992 with four task forces. The task forces included Research, Planning and Design, Operations and Enforcement, and HOVs on Arterials. At the 6th National Conference on High-Occupancy Vehicle Systems held in October 1992 in Ottawa, Canada, a plan for this research program document emerged. A brainstorming session was held at which time a large number of research needs were identified and classified into three groups: planning and design, operations and enforcement, and arterial street HOV facilities. The target was to prepare first draft research problem statements by the January 1993 meeting. The progress made by this Subcommittee was discussed at the meeting of the full Committee and a presentation also was made at the final session of the conference.

Some twenty-seven (27) initial draft research problem statements were prepared, reviewed, and initially prioritized by the Subcommittee in the fall of 1992. At the January 1993 meeting of the full Committee, the research problem statements were discussed and a plan adopted to work toward the publication of this research program document. A revised set of twenty-six (26) research problem statements was distributed to the Committee membership and friends in April 1993. Respondents were asked to recommend approval/non-approval, propose a priority level, offer suggested refinements to the statements, and suggest other research problem statements. Responses were received covering a wide range of professional interests within the Committee.

The Research Subcommittee again met during the 1993 mid-year meeting of the HOV Systems Committee and reviewed the research problem statement questionnaire results, discussed possible research funding sources, and defined in more detail the plans for the publication of this research program document. A presentation was made by the Subcommittee on activities to date and future plans, and the full Committee approved of the actions of the Subcommittee and encouraged the Subcommittee to proceed with the development of this proposed program of research.

During the fall of 1993, the research problem statements were modified in response to review comments and consolidated into eighteen (18) final research problem statements. The research program document was presented to the full Committee at its Annual Meeting in January 1994. The Committee adopted the research program and recommended the publication of this document.

PROGRAM OBJECTIVES

In addition to the completion and documentation of each of the completed research projects, it is proposed that initially a HOV Systems Manual be prepared and periodically updated. In this way, the updated manuals would integrate current knowledge with the results of the completed research projects. The intended purpose of the Manual would be to serve as a guide for those involved in implementing HOV Systems. The plan calls for continued attention to be given to the development of the Manual and it is anticipated that updated versions would be periodically published as the research program progresses. In this way, the results of the research would immediately influence the Manual and be available to HOV System professionals. This periodically updating of the Manual would also provide the opportunity to focus future research to deficient portions of this document. It is anticipated that the major portions of the Manual would provide guidance in planning, analyzing, designing, marketing, implementing, operating, and enforcing HOV Systems. The Manual would be applicable to all types of HOV treatments with special attention to freeway systems and arterial networks.

CURRENT STATE-OF-THE-ART

The Research Subcommittee initially undertook a literature search on HOV systems using the TRISNET system, and a large number of publications were identified. A small selected set of publications closely related to the work of the Committee will be briefly mentioned in the following paragraphs and are available from the Transportation Research Board.

There have been six national conferences on HOV systems held during the past eight years and conference proceedings are available for the past five conferences. Papers presented at the conferences and published in the proceedings cover almost all aspects of HOV systems. The Committee has also sponsored sessions at the Annual Meetings of the Transportation Research Board and these papers have been published in Transportation Research Records 1280, 1299, 1360, and 1395.

One of the most recent publications (1993), which provides a state-of-the-art overview of the entire field of HOV systems, is the NCHRP Synthesis Report 185 entitled "Preferential Lane Treatments for High-Occupancy Vehicles" prepared by Charles Fuhs. The major chapters in this synthesis report include an introduction, existing practice and issues, ongoing research, and conclusions and recommendations. The appendices include case studies, glossary of terms and abbreviations, and bibliographical references. Because of the importance and appropriateness of this publication to this research document, the executive summary of this synthesis report is reproduced in almost its entirety in the following paragraphs.

"Increasingly, preferential treatments for high-occupancy vehicles (HOV) are being studied and implemented to address urban roadway mobility. The emphasis of HOV is on promoting better person-moving efficiency. Preferential treatments prioritize travel conditions for HOVstypically defined as carpools, vanpools, and busesby providing a shorter and more predictable travel time to encourage modal shifts from single-occupant to multi-occupant vehicles. HOV treatments increase the operating efficiency of the roadway and transit operations, reduce or defer the need to increase roadway capacity, and promote improved air quality by reducing fuel consumption and emissions.

Priority treatments are usually dedicated lanes that bypass recurring peak-period corridor congestion. These treatments are frequently applied concurrently with a variety of support facility improvements that enhance collection and distribution, promote ridesharing, education, and marketing, and other transportation demand management measures to encourage use. Emphasis is often placed on serving longer distance peak-period commute trips, which represent the greatest potential market for increased ridesharing.

The three broad categories of HOV facilities include bus-only facilities, which meet specific transit needs and are usually located on separate rights-of-way or along arterial streets; long-distance HOV treatments within or adjacent to freeways serving a mix of users including carpools, vanpools, and buses; and short-distance treatments applied to bypass isolated traffic bottlenecks, such as toll plazas or ramp meters.

Research for this synthesis indicates that an increasing number of urbanized areas are studying and implementing HOV projects. In 1990, new projects or extensions to existing facilities were being planned or implemented in more than 20 cities in North America. Cumulative route-miles have been doubling about every six years. If currently planned projects are implemented as scheduled, mileage will increase between 100 and 200 percent by the year 2000.

The past decade has seen broadened understanding of the role of and extensive growth in applications of HOV systems in a number of North American cities. Some of this experience is being exported to congested roadways in Europe and the Pacific Rim. Consistency in practice is found increasingly, particularly in regional settings. Demonstration of various innovative strategies

that improve on safety, efficiency, and accuracy of expectations are continuing. HOV systems have emerged as one tool to encourage compliance with Clean Air Act requirements in nonattainment areas. The potential for IVHS applications and their compatibility with various HOV facility needs and characteristics have defined a trend for future HOV use, and it is reasonable to expect an improved understanding of the role HOV serves in corridors warranting intermodal solutions. HOV systems, as one operations management alternative to urban congestion, have come of age."

DOCUMENT ORGANIZATION

Following this introductory chapter, there are five remaining chapters. Chapter 2 provides the program highlights including key statistics and listing of individual research problem statements titles. A plan for implementation of the program is covered in Chapter 3 with emphasis on project priority, scheduling, financing, and publications. The final three chapters are devoted to the three main areas of HOV research: planning and design, operations and enforcement, and arterials. Contained in each of these three chapters are the research problem statements accompanied by an introduction, scope, and research issues.

PROGRAM HIGHLIGHTS

KEY STATISTICS

The most significant statistics related to this HOV Systems research program are number of projects, anticipated funding requirements, estimated time for completion, and proposed start and ending dates. These statistics are shown below.

• Total number of projects	18
• Anticipated funding requirements	$4.96 mil
• Estimated Time for Completion	6 years
• Proposed start date	July 1995
• Program Reassessment	1997,1999
• Estimated completion date	June 2001

A breakdown of the number of projects and anticipated funding requirements for the three areas of research are shown below.

• Planning and Design	(11)	$ 3.06 mil
• Operations and Enforcement	(4)	$ 0.95 mil
• HOVs on Arterials	(2)	$ 0.55 mil
• HOV Systems Manual	(1)	$ 0.40 mil

Undoubtedly, as the research program progresses, continuous reassessment will be required which may result in modifications in priority and proposed budget allocations.

PROJECT LISTING

The titles for the eighteen research problem statements and estimated project costs are listed below. This listing is not presented in priority order nor in order in which the projects should be undertaken.

Planning and Design

1. The Impact of HOV Improvements on Air Quality ($350K)
2. Predicting HOV Facility Demand ($250K)
3. Synthesis of Actual vs. Perceived Time Savings for HOVs ($100K)
4. Analysis of Factors Impacting the Effectiveness of HOV and TDM Strategies ($200K)
5. Developing HOV Systems to Improve Efficiency ($400K)
6. HOV Marketing Plans ($210K)
7. Effectiveness of State and Regional HOV Policies ($150K)
8. Guidelines for Determining the Feasibility of Lane Conversion Projects ($400K)
9. Improved Training and Documentation for HOV Planners ($250K)
10. Developing Guidelines for Improved HOV Facility Access, Egress, and On-Line Station Design ($500K)
11. Guidelines for Improved Design of HOV Facilities to Accommodate Mixed Vehicle Use, Especially at Access Points ($250K)

Operations and Enforcement

12. Safety Aspects of Various Lane Configurations ($250K)
13. Experience with HOV Eligibility and Operational Definitions ($200K)
14. Documenting Mode Choice on Existing HOV Facilities ($200K)
15. Effective HOV Enforcement Procedures ($300K)

HOVs on Arterials

16. Arterial Street High-Occupancy Vehicle Treatments ($350K)
17. Development of Evaluation Procedures and Data-Collection Techniques for Arterial Street HOV Treatments ($200K)

HOV Systems Manual

18. Development of Periodic Updated HOV Systems Manual ($400K)

IMPLEMENTATION PLAN

ESTABLISHMENT OF RESEARCH PROJECT PRIORITIES

The HOV research project priorities were established by conducting a survey of the Committee membership and friends in April 1993. Respondents were asked to recommend approval/non-approval of the original 26 research statements, propose a priority level, offer suggested refinements to the statements, and suggest other research problem statements. A total of 24 responses were received covering a wide range of professional interests. Of the respondents, ten were committee members and fourteen were active friends of the committee.

The survey responses were assessed in two ways. First, the priority scores were tabulated and stratified according to three possible criteria (1) Percent approval, (2) Average Ranking, and (3) Number of responses in top ten rating. Second, the comments regarding the problem statement contents and relative priority were summarized. Overall, the findings showed clear preferences for certain research problems in terms of immediate need, near-term need, and longer-term need. In addition, several statements had overlapping objectives and contents, lending themselves to consolidation.

REVISED RESEARCH PROJECT PRIORITIES

The research problem statements were modified and in a number of cases consolidated based on the review comments received. Once the research problem statements were revised, a scheme for prioritizing was developed in which the statements were classified into three levels of priority: immediate needs, mid-term needs, and longer-term needs. The projects under each identified level of need are indicated in the following list. The project numbers correspond to the project numbers indicated on the individual research problem statements included in chapters 4, 5, and 6.

Level 1 Immediate Needs

1. The Impact of HOV Improvements on Air Quality
2. Predicting HOV Facility Demand
12. Safety Aspects of Various Lane Configurations
14. Documenting Mode Choice on Existing HOV Facilities
16. Arterial Street High-Occupancy Vehicle Treatments
18. Development of Periodic Updated HOV Systems Manual

Level 2 Mid-Term Needs

4. Analysis of Factors Impacting the Effectiveness of HOV and TDM Strategies
5. Developing HOV Systems to Improve Efficiency
6. HOV Marketing Plans
13. Experience with HOV Eligibility and Operational Definitions
17. Development of Evaluation Procedures and Data-Collection Techniques for Arterial Street HOV Treatments

Level 3 Longer-Term Needs

3. Synthesis of Actual vs. Perceived Time Savings for HOVs
7. Effectiveness of State and Regional HOV Policies
8. Guidelines for Determining the Feasibility of Lane Conversion Projects
9. Improved Training and Documentation for HOV Planners
10. Developing Guidelines for Improved HOV Facility Access, Egress, and On-Line Station Design
11. Guidelines for Improved Design of HOV Facilities to Accommodate Mixed Vehicle Use, Especially at Access Points
15. Effective HOV Enforcement Procedures

PROJECT SCHEDULING AND FINANCING

The proposed time and budget schedule for the entire research program is presented in Exhibit I. A starting date of July 1, 1995 and a completion date of June 30, 2001 is assumed for the program. The 18 research projects are arranged in the order in which they would be initiated. For each project, the project number, the project title, the proposed years of project activity, the estimated annual budget requirements, and the estimated total project costs are indicated. The estimated total research program budget for the period 1995-2001 is shown across the bottom of the exhibit for each year and for the total research program.

An attempt has been made to suggest possible sponsoring agencies for each of the research projects. In some cases, several agencies have been suggested. Exhibit II lists the individual projects in original project number order, and with each, one or more possible sponsoring agencies are identified.

PLAN FOR HOV SYSTEMS MANUAL

Work on the initial HOV Systems Manual is expected to begin by early 1995, a draft prepared by mid-1995, and published by the end of 1995. The second version of the HOV Systems Manual is expected to be distributed in draft form for review purposes by mid-1997 and published by the end of 1997. The third revised version of the HOV Systems Manual is expected to be distributed in draft form for review purposes by mid-1999 and published by the end of 1999. The fourth and last version of the HOV Systems Manual is expected to be distributed in draft form for review purposes by early 2001 and published by mid-2001.

TABLE 1 PROPOSED TIME AND BUDGET SCHEDULE

Project Number	Project Title	1995 1996	1996 1997	1997 1998	1998 1999	1999 2000	2000 2001	Costs (1000'S)
1	The Impact of HOV Improvements on Air Quality	xx	xxxx	xx				350
2	Predicting HOV Facility Demand	xx	xxxx	xx				250
12	Safety Aspects of Various Lane Configurations	xx	xxxx	xx				250
14	Documenting Mode Choice on Existing HOV Facilities	xx	xxxx	xx				200
16	Arterial Street HOV Treatments	xx	xxxx	xx				350
18	Development of Periodic Updated HOV Systems Manual	xxxx	xx	xx	xx	xx	xxxx	400
4	Analysis of Factors Impacting the Effectiveness of HOV and TDM Strategies			xx	xxxx	xx		200
5	Developing HOV Systems to Improve Efficiency			xx	xxxx	xx		400
6	HOV Marketing Plans			xx	xxxx	xx		210
13	Experience with HOV Eligibility and Operational Definitions			xx	xxxx	xx		200
17	Development of Evaluation Procedures and Data-Collection Techniques for Arterial Street HOV Treatments			xx	xxxx	xx		200
3	Synthesis of Actual versus Perceived Time Savings for HOVs				xx	xxxx	xx	100
7	Effectiveness of State and Regional HOV Policies				xx	xxxx	xx	150
8	Guidelines for Determining the Feasibility of Lane Conversion Projects				xx	xxxx	xx	400
9	Improved Training and Documentation for HOV Planners				xx	xxxx	xx	250
10	Developing Guidelines for Improved HOV Facility Access, Egress. and On-line Station Design				xx	xxxx	xx	500
11	Guidelines for Improved Design of HOV Facilities to Accommodate Mixed Vehicle Use, Especially at Access Points				xx	xxxx	xx	250
15	Effective HOV Enforcement Procedures				xx	xxxx	xx	300

TABLE 2 POSSIBLE SPONSORING AGENCIES

Project Number	Project Title	FHWA	FTA	NCHRP	NCTRP	State Pooled Funds
1	The Impact of HOV Improvements on Air Quality	x				
2	Predicting HOV Facility Demand	x	x	x	x	
3	Synthesis of Actual vs Perceived Time Savings for HOVs	x		x		
4	Analysis of Factors Impacting the Effectiveness of HOV and TDM Strategies	x		x		
5	Developing HOV Systems to Improve Efficiency	x	x	x		
6	HOV Marketing Plans	x				
7	Effectiveness of State and Regional HOV Policies		x			x
8	Guidelines for Determining the Feasibility of Lane Conversion Projects	x				x
9	Improved Training and Documentation for HOV Planners	x	x			
10	Developing Guidelines for Improved HOV Facility Access, Egress, and On-line Station Design	x	x		x	
11	Guidelines for Improved Design of HOV Facilities to Accommodate Mixed Vehicle Use, Especially at Access Points	x	x	x	x	
12	Safety Aspects of Various Lane Configurations	x		x		
13	Experience with HOV Eligibility and Operational Definitions	x				x
14	Documenting Mode Choice on Existing HOV Facilities		x		x	x
15	Effective HOV Enforcement Procedures	x		x		x
16	Arterial Street High-Occupancy Vehicle Treatments		x	x	x	x
17	Development of Evaluation Procedures and Data-Collection Techniques for Arterial Street HOV Treatments	x		x		
18	Development of Periodic Updated HOV Systems Manual	x	x			

Other possible sponsoring agencies include EPA (projects 1 and 7) and NHTS (project 12)

PROGRAM SUMMARY FOR PLANNING AND DESIGN OF HOV FACILITIES

SCOPE

Since the 1970s, a growing number of urban areas have implemented HOV facilities as a means of maintaining or improving the mobility along many of their more heavily congested corridors. In recent years, as available resources come under greater scrutiny, both the transportation and environmental communities are demanding improved HOV planning and design processes to produce the most viable and effective HOV facilities. This chapter of the Program of Research focuses on these two critical areas of improved HOV system planning (e.g., HOV demand, travel time savings), and HOV system design (e.g., HOV access and egress). Although HOV facility operation and enforcement considerations are normally addressed during the planning and design phases, their specific research program activities are presented in Chapter 5.

The major research program areas identified in this chapter are those which encompass the development of new methodologies, guidelines, and procedures; and the evaluation of HOV program and policy effectiveness. Eleven research project statements (numbered 1 through 11) were developed to address these issues.

RESEARCH ISSUES

HOV System Planning

Despite the increases in HOV facility implementation over the last two decades, recent Federal and State legislation has fostered an even greater interest, and the need to better understand the nature of HOV facilities and their impacts. The Clean Air Act Amendments (CAAA) of 1990 and the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 now require HOV planners to provide improved analyses of not only the travel time and demand impacts of HOV systems, but also the impacts on air quality of various types of HOV facilities.

Although much planning rigor has been applied in the past, a real understanding of the complex nature of HOV system demand is incomplete, especially where the impacts on air quality are concerned. Research (Project No. 1) is therefore needed to understand the possible congestion/air quality tradeoffs of HOV facilities (e.g., line-haul, bypasses, conversion projects, transit only), and to develop much needed emissions models for HOVs. Similarly, the ability to predict long-term HOV demands (e.g., 20 years) is currently limited. Research (Project No. 2) is needed to develop and validate more accurate HOV demand prediction methods that are sensitive to time savings, occupancy requirements, general-purpose lane capacity, and HOV support facilities.

Although estimating time savings has long been a key factor in HOV analyses, it also presents some uncertainty in HOV system planning. This program (Project No. 3) intends to examine the differences between actual and perceived time savings for HOV facility users. Further research (Project No. 4) is also needed to examine the interrelationship between HOV facilities and some of the more traditional travel demand management (TDM) techniques, and to determine if these strategies may actually be counterproductive in some applications.

Experience has shown that applying HOV facilities in conjunction with complimentary treatments (e.g., park-and-ride lots and transit centers) can promote more effective use than the more traditional isolated HOV corridor project. Although a network of HOV lanes with corridor transitions would be expected to enhance HOV effectiveness, the trade-offs between expanded independent HOV corridors and HOV facility connectivity is not understood. This program (Project No. 5) seeks to examine existing HOV systems, and develop approaches to interconnect HOV facilities and integrate them with the whole transportation system.

HOV system success is often dependent upon the system's acceptance by users and non-users alike. Securing system acceptance has been perceived to require HOV marketing to begin at the earliest possible stages of HOV planning to provide the education and constituency building that is needed. This program (Project No. 6) will provide an evaluation of marketing strategies and the development of guidelines through case study analyses to assist the HOV planner in developing a proper HOV marketing strategy. In addition, as agencies pursue a more multi-modal focus, many are also developing HOV policies. Are such policies merely reactions to legislative mandates or are they truly effective? This program (Project No. 7) will examine the effectiveness of existing HOV policies, and will provide guidelines for developing truly effective policies in the future.

The controversy which began in the 1970s over the conversion of existing general purpose lanes to HOV restricted use lanes has increased in the light of clean air legislation. Many contend that freeway lane conversion for HOVs are a prescription for failure of HOV systems.

The mandates of the CAAA of 1990, however, make it necessary for those urban areas experiencing air quality non-attainment to at least examine the potential of lane conversion. Although insufficient data currently exists to conduct a proper analysis, this program (Project No. 8) recommends that as soon as sufficient case study experience becomes available, that an evaluation be conducted and that guidelines be developed for other urban areas faced with addressing the alternative of lane conversion.

Finally, agencies cannot expect their HOV planners to carry out their charge without the necessary technical resources. This program (Project No. 9) also identifies the training needs of HOV planners to meet both the mandates of current legislation and the users of HOV systems.

HOV System Design

HOV systems are essentially designed in a manner parallelling the design of most highway facilities. However, since HOV facilities are commonly retrofit projects, ensuring adequate facility design is very critical to overall HOV effectiveness. One of the key design HOV features is that of facility access and egress. This program (Project No. 10) will evaluate existing HOV designs and develop guidelines for access and egress design, on-line stations, as well as designs for mixed-vehicle uses (Project No. 11). This program (Project No. 5) also intends to examine the various design strategies, and to develop new approaches where appropriate to provide for HOV system connectivity and integration with either other HOV facilities (e.g., freeway to freeway HOV connections) or other parts of the transportation network (e.g., bus and rail connections).

RESEARCH PROBLEM NUMBER 1

The Impact of HOV Improvements on Air Quality

Impacts of HOV lanes on air quality are more complex and less well understood than HOV travel impacts. Research is needed to quantify the vehicle occupancy/congestion tradeoffs involved in HOV lane implementation, and model the impacts of HOV lanes on air quality. Issues to be resolved include:

- How to model HOV networks to estimate air quality;
- Impacts of HOV facilities on traffic operations and air quality (e.g., ramp metering bypass, toll bypass, HOV lane merge/diverge and weave impacts on mixed flow traffic);
- Effects of supporting HOV services on air quality (e.g., ride-matching services, park and ride lots, toll bypasses, ramp metering with HOV bypass, parking pricing);
- Impact on HOV facilities on air quality changes caused by land use patterns (e.g., trip length, density, sprawl);
- Effects of lane conversion compared to added HOV lane;
- Effects of HOV lanes compared to fixed rail transit systems;
- Effects of HOV lanes on transit (e.g., "casual" carpooling, diversion from transit to HOV);
- Effects of vehicle size and weight (e.g., vanpools, carpools) on air quality on mainlines, ramps, and arterials;
- Effects of elevated versus at-grade HOV lanes;
- Effects of "induced" trips on air quality; and
- Congestion-caused versus VMT-caused

Objective

Develop standard methodologies for evaluation of emissions impacts of HOV lanes and networks. Validate the method's accuracy through case study corridor measurements.

Key Words

Hydrocarbons, carbon monoxide, trip-end emissions, running emissions, park and ride, lane conversion, HOV lanes, air quality, congestion management, Clean Air Act.

Related Work

JHK & Associates, "Predicting the Impact of Transportation Control Measures on Travel Behavior and Pollutant Emissions"; certain project evaluations (e.g., TTI's "Evaluation of the Houston High-Occupancy vehicle Lane System", SYSTAN's evaluation of the Santa Monica Freeway Diamond Lanes); California Air Resources Board, "High Occupancy Vehicle System Plans as Air Pollution Control Measures"; MTC, "Air Quality Impacts of a Regional HOV System"; JHK &

Associates, "Travel Demand and Simulation Modeling for Caltrans".

Urgency/Priority

Immediate Need. The Clean Air Act has established deadlines that make this research critical. By law, air quality is a key element in future transportation decision-making, and accurate models are essential for projecting the impacts of transportation demand management decisions on air quality.

Costs

$350,000

User Community

State and local transportation planners; air pollution control officials; air quality analysts; traffic modelers; researchers; consultants; elected officials, Environmental Protection Agency (EPA), and Department of Transportation (DOT) officials.

Implementation

Details of the modeling process would be provided to state and local officials in urban areas so that county and regional transportation models can be improved and made consistent.

Effectiveness

Accurate models of the impact of HOV lanes on air quality will raise the quality of decision-making at state and local levels and improve the accuracy of air quality modeling, which is becoming increasingly important in transportation planning. This will influence major investment decisions with federal funds, according to ISTEA and CAA requirements.

RESEARCH PROBLEM NUMBER 2

Predicting HOV Facility Demand

It is widely accepted that HOV ridership is a function of travel time savings over travel on congested roadways. However, predicting the ridership on HOV facilities, especially on a 20-year horizon, is less widely understood. For instance, clean air laws have prompted legislation that requires employers to promote transportation demand management programs. The likely spread of these programs and their effects is just beginning to be understood. In addition, marketing studies could improve our knowledge of mode choice decisions made in the presence of HOV lanes. For instance, previous research has shown that people make transportation decisions based on their *perceived* travel times. The differences between perceived and actual travel times can mean that models wrongly predict shift and HOV lane usage. In addition, knowledge about the differences would be useful in marketing HOV lanes. More information is needed on the correlation between ridership demand and travel time savings (real and perceived) as well as other contributing factors. Impacts of different occupancy requirements on HOV ridership are also required.

Objective

Develop and evaluate methods to predict carpool and bus ridership on HOV facilities with sensitivity to general-purpose lane capacity, HOV occupancy requirements, peak period freeway congestion, transportation demand management programs, and better understanding of mode choice through market research.

Key Words

HOV demand, HOV facility planning, transit ridership, mode choice modeling, transportation demand management, market research.

Related Work

Many planning models include some mode choice routine for predicting carpool and transit ridership. A few deal specifically with the impact of HOV lanes. The 1982 model developed by Charles River Associates is in common use. There have been several studies of transportation demand management programs and their impact on mode choice, but little direct connection to HOV facilities.

Urgency/Priority

Immediate need. With the heightened emphasis on HOV lanes in the ISTEA legislation and Clean Air Act Amendments, inclusion of HOV lanes in regional transportation plans will only increase. More reliable methods of predicting HOV ridership must be developed

to aid in successful projects being selected for future construction.

Costs

$250,000

User Community

Federal Highway Administration (FHWA), Federal Transit Administration (FTA), state and local transportation departments, consultants, transportation researchers.

Implementation

Results of the research would be widely disseminated for integration into research and planning efforts.

Effectiveness

Improved HOV ridership predictions would aid in the determination of successful projects which in turn would result in more projects being implemented with greater utilization and impact on urban mobility.

RESEARCH PROBLEM NUMBER 3

Synthesis of Actual vs. Perceived Time Savings for HOVs

It has frequently been observed that people wrongly estimate their travel times. People who use HOV lanes tend to overestimate their time savings, and those who don't use them tend to underestimate the potential savings. Since previous research has shown that people make transportation decisions based on their *perceived* travel times, it is important to take this phenomenon into account. The differences between perceived and actual travel times can mean that models wrongly predict mode shift and HOV lane usage. In addition, knowledge about the differences would be useful in marketing HOV lanes.

Objective

The primary purpose of this research will be to conduct a synthesis of the amount of misconception of travel time in HOV lanes, and what determines these misconceptions.

Key Words

HOV lanes, travel times, transportation modelling

Related Work

Surveys of travelers in the vicinity of HOV lanes often include a question concerning perceived travel time savings. Where these data and actual travel time measurements exist, comparisons can be made. Much of the mode choice research deals with perceived versus actual characteristics of modes.

Urgency/Priority

Longer-term need. Without knowledge of this subject, assessments of potential HOV usage will be difficult to produce.

Costs

$100,000

User Community

State and local traffic engineers, consultants, transportation researchers.

Implementation

Synthesis results would be widely disseminated for integration into research and planning efforts.

Effectiveness

The results of this synthesis will help to more efficiently develop priorities for, and to implement HOV facilities.

RESEARCH PROBLEM NUMBER 4

Analysis of Factors Impacting the Effectiveness of HOV and TDM Strategies

In response to escalating urban-area traffic congestion, increasing attention is being given to high-occupancy vehicle (HOV) facilities and travel-demand management (TDM) strategies as means of addressing these problems. It is postulated that the effectiveness of these

strategies can be significantly impacted by the trip types, trip purposes, previous modes and routes of potential HOV lane users. In addition, there are many conflicts which can arise when applying HOV and TDM strategies simultaneously within the same travel corridor. To date, very little research has been completed that addresses all of these issues.

Objective

Perform a comprehensive review of HOV and TDM applications (emphasizing instances involving simultaneous application for which HOV user trip types and purposes are known) and examine the characteristics associated with the clearly successful and unsuccessful implementation of these strategies.

Key Words

HOV Facilities, TDM Applications, Urban Congestion

Related Work

A recently completed study involving an assessment of strategies for alleviating urban congestion would be used as a source for background information. In this recent study, issues such as individual versus combined application of strategies were examined. This research would also draw upon previous research related to identifying the previous mode and/or route of HOV lane users.

Urgency/Priority

Mid-Term-Need. As the planning/implementation of HOV and TDM applications increases, it is becoming more important to examine the impacts these strategies can have when applied simultaneously within the same travel corridor, as well as understanding the influence of certain factors (e.g., trip types and purposes) on the effectiveness of these strategies.

Costs

$200,000

User Community

State and Local Traffic Engineers, Consultants

Implementation

Copies of the study would be provided to state and local officials in urban areas.

Effectiveness

Providing insight relative to when and where HOV and TDM strategies should be applied (individually and/or simultaneously) will promote the efficient expenditure of limited funds on combating urban traffic congestion problems.

RESEARCH PROBLEM NUMBER 5

Developing HOV Systems To Improve Efficiency

HOV lanes, when applied in conjunction with a variety of complementary treatments, such as queue-jump treatments at ramps, park-and-ride lots and transit centers, have been found to collectively promote more use and effectiveness than lane treatments alone. A network of HOV lanes providing efficient transitions between corridors could be expected to further enhance the usefulness of individual HOV lanes and corridor treatments. The trade-offs between maximizing lane-miles of HOV facilities on independent corridors and providing freeway-to-freeway HOV connections between corridors needs to be examined. Furthermore, the approaches to integrating transit services, park-and-ride lots, rideshare park-and-pool sites, TDM strategies, and marketing with the planning, implementation and operation of HOV facilities need to be developed to optimize a "systems" approach to HOV facility planning and development. The impacts of these on use has not been explored. Queue jump lanes, in particular, offer point-specific treatments for HOVs which may be as effective as line-haul dedicated lanes, but no comparative research has been performed. The profession needs some cost/benefit analysis procedures specifically applicable to components of HOV system planning, which can offer local transportation planners tools in making multimodal choices when comparing a variety of urban transit alternatives. These same tools are also needed for arterial HOV systems and arterial linkages to freeway systems including ramps.

Objective

To evaluate strategies, policies and program adopted by various agencies in developing a variety of HOV facilities and networks, and develop approaches to

integrating all aspects of the highway-based transportation system, including bus transit and bus-to-rail connections, with HOV lane networks.

Key Words

HOV connectors, HOV lanes, HOV system, park-and-ride, TDM.

Related Work

Various HOV planning and design manuals and guideline treatises have been developed by the U.S. DOT, TRB, ITE, AASHTO, state DOTs such as CALTRANS, and other agencies such as Parsons Brinckerhoff Quade & Douglas, Inc., which generally address HOV system components, needs and issues.

Urgency/Priority

Mid-Term Need. Various HOV facilities are under study and design, and strategies for implementation are being developed.

Costs

$400,000

User Community

State Departments of Transportation, metropolitan transportation authorities, transit agencies, Metropolitan Planning Organizations (MPOs), and other transportation planning, programming and implementing agencies.

Implementation

Copies of guidelines would be provided to state and local agencies.

Effectiveness

The development of approaches to evaluating HOV lane networks and integrating the overall transportation system with the HOV network will provide planners and programmers with valuable information in determining short- and long-term capital improvement strategies.

RESEARCH PROBLEM NUMBER 6

HOV Marketing Plans

It has been perceived, but not documented, that in order to facilitate use of HOV systems, as well as secure acceptance of those facilities by non-users, marketing of HOV facilities must begin early. At the HOV facility planning stages, this marketing has historically manifested itself in a wide variety, both in breadth and depth, of education and constituency building activities. As the specific HOV project moves into the design stage, a variety of marketing activities have been undertaken from basic information distribution to linking the specific goals, objectives and impacts of that facility with a broad range of target markets — elected officials, employers, commuters, jurisdiction officials, and communities. As construction begins, marketing activities have varied as well, from distributing information about construction activities to working to paint a "visual picture" of the benefits of the facility to the target markets previously mentioned. Promotion and advertising activities are more traditionally implemented during the final stages leading up to the opening of the new HOV facility. Sometimes these activities continue, along with on-going education actions, until acceptable usage of the facility is established, other times they are concluded immediately following facility opening. Rarely is an evaluation of marketing actions conducted following facility opening.

Objective

To evaluate marketing actions associated with the design, development, implementation and change of use (2+ to 3+, 3+ to 2+, 24-hours to peak hour only, lane conversion) of HOV facilities. To evaluate the role of marketing as a tool in the development and operation of successful HOV projects. To assess the impacts of HOV marketing activities on the short- and long-term attitudes and opinions of constituency groups including commuters both users and non-users of HOV facilities, elected officials, employers, jurisdiction officials, communities, and environmental groups.

Key Words

Marketing, Promotion, Advertising, Education, Constituency Building, Public Affairs, Public Relations, Media, Newspaper, Television, Radio, Market Research, Attitude and Opinion Research.

Related Work

A number of Attitude and Opinion surveys regarding HOV facilities have been recently completed in order to establish the baseline data necessary for the development of marketing activities. FHWA is also pursuing the development of a handbook to aid marketing professions in designing HOV marketing activities.

Urgency/Priority

Mid-Term Need. ISTEA mandates the public become more involved in the development of HOV facilities. The success or the Clean Air Act and more localized transportation demand and commute trip reduction legislation is dependent upon the success and broad-based support of HOV facilities.

Costs

$210,000

- $10,000 to establish overall research criteria, methodology, etc.
- $160,000 to evaluate the marketing activities of 8 separate HOV facilities (evaluation of eight marketing campaigns at a cost of $20,000 each. An effort should be made to select at least two facilities in the same region which are in close proximity to one another to allow for analysis of two different facilities but comprise at least a portion of that region's HOV system).
- $40,000 to compare and contrast findings from eight individual evaluations.

User Community

State and local public affairs officers; public affairs, public relations and advertising consultants; transportation project managers.

Implementation

Copies of report would be distributed to state and local officials in urban areas.

Effectiveness

Evaluation of HOV marketing activities not only guards against costly future mistakes, it helps to maintain the reputation of existing HOV facilities locally and nationwide. Compelling and persuasive arguments to fund future HOV facilities are directly tied to broad-based constituency support as well as specific success indicators for existing facilities. This support can be significantly increased through thoughtful and strategic marketing actions.

RESEARCH PROBLEM NUMBER 7

The following research problem statement is drafted to include an inventory of current policies, evaluation of policy effectiveness based on examples and experience to date, and subsequent development of guidelines. It is possible to accelerate meaningful work on this subject by proposing that an inventory of current policies and identification of issues based on prevailing policies be undertaken as a white paper topic. This option should be considered in reviewing the following problem statement and need for timely information.

Effectiveness of State and Regional HOV Policies

While many states that have implemented HOV priority treatments since the late 1960s have no specific policies addressing HOV systems, an increasing number of locations are currently adopting policies. Some of these are in response to the Clean Air Act amendments for areas in noncompliance with respect to the mandated air quality standards. Other policies are being drafted in response to ISTEA funding provisions and draft regulations. The number of areas that will draft HOV system policies will continue to increase in response to these federal acts and an increasing local interest in this approach to ensure mobility in congested corridors. However, there is not current inventory of policies that have been enacted, no evaluation of their effectiveness, and no tools available from which to guide state and local agencies in measuring the effectiveness of adopted HOV policies. In an era of increasing multimodal planning focus, these tools are needed.

Objective

Provide documentation and guidance in the development and implementation of effective HOV policies in urban and suburban settings.

Key Words

HOV policy, HOV lanes, HOV planning, project programming, funding, institutional arrangements.

Related Work

HOV policies have been enacted by the states of California, Florida, Washington, and Missouri. Draft policies are pending in New Jersey and the Province of Ontario. The FHWA has issued various policy memorandums at the Washington, Region, and Division levels which address HOV planning and policy considerations.

Urgency/Priority

Longer-Term Need. As a result of federal funding regulation, air quality compliance, and increased interest in providing urban mobility, an increasing number of locations area currently considering, drafting and enacting HOV policies. Experience and guidance is needed to support these actions.

Costs

$150,000

User Community

FHWA, FTA, EPA, State Department of Transportation, and local and regional transportation, transit and air quality agencies.

Implementation

Guidelines would be provided to policy makers and the user community.

Effectiveness

A compilation of experience and development of guidelines will assist makers, planners, developers, and related regulators in such disciplines as air quality and environmental issues in establishing and monitoring the effectiveness of policies supporting HOV systems.

RESEARCH PROBLEM NUMBER 8

Guidelines for Determining the Feasibility of Lane Conversion Projects

Experience to date suggests conversion of existing general purpose lanes to HOV restricted use is a prescription for failure which can adversely affect the implementing agency's credibility and public attitudes toward IVHS in general. Air quality measures, however, are encouraging various urbanized areas, such as Seattle, that are in non-attainment with respect to the 1990 Clean Air Act Amendments to consider this approach. Therefore there is a need for guidelines that can contribute to the success or failure of this approach. Even though arterial lane conversion has not been highly controversial, it is not clear to what extent these experiences can be transferred to freeway applications. Consequently, it is generally accepted that one or more freeway general lane conversion projects need to be implemented to provide the opportunity for meaningful research in this area. Research designed to analyze the traffic impacts and the public attitudes leading to the development of needed conversion guidelines.

Objective

Document, evaluate and review one or more demonstration projects as may materialize in the U.S. in which freeway lane conversion is the selected and implemented projectwide strategy. Currently, no projects are committed from which to base this research, although several sites are considering this approach in Seattle, Atlanta, and Los Angeles. The Seattle area I-90 HOV lane conversion project is being implemented.

Key Words

HOV Lane Conversion, HOV Design, HOV Marketing, Empty Lane Syndrome

Related Work

Several State DOT policies address lane conversion, as do a variety of HOV treatises from AASHTO, TRB (NCHRP Synthesis 185), Caltrans (Santa Monica diamond lanes), and Parsons Brinckerhoff Quade & Douglas, Inc. An issue paper prepared by the TRB HOV Systems Committee has also been recently prepared to address needs for a white paper on this topic.

Urgency/Priority

Long-Term Need. New federal regulations have placed increase emphasis on HOV measures for air quality control and congestion mitigation in urban areas. In many developed areas, taking an existing lane may be

the only means of implementing HOV strategies. In others, it may be the only fiscally feasible alternative. In either case, if there is not a reasonable assurance that lane conversion will succeed, implementing agencies run a very high risk of losing time, public support, and most importantly, program credibility.

Costs

$400,000

User Community

FHWA, FTA, State Departments of Transportation, and regional and local transportation planning and implementation agencies.

Implementation

Evaluations of successful lane conversion would provide the basis for planning and implementation guidelines for the user community.

Effectiveness

These experiences, coupled with a compilation of experiences from prior failures and arterial treatments, will assist planners and developers in determining whether or not lane conversion is a viable approach worth considering in a given situation.

RESEARCH PROBLEM NUMBER 9

Improved Training and Documentation for HOV Planners

The renewed interest in HOV facilities caused by recent federal and state legislation (namely CAAA of 1990, ISTEA of 1991) has created a need for more highly trained HOV planners. HOV projects are now more frequently being challenged by the environmental community concerning air quality impacts. In addition, HOV forecasting methodology as well as the forecasts themselves are being called into question. Previous HOV training courses, the planned FHWA/NHI course, and other HOV workshops cover a broad range of HOV topics and do not deal in depth with any one subject. There is need to develop a detailed "hands on" training course for HOV planning, similar to the earlier FHWA-sponsored courses on urban transportation planning. The training course would provide HOV planners with a better understanding and a more comprehensive knowledge of the total HOV planning process, allowing them to better integrate HOV projects into the transportation planning process.

Objective

Develop a framework for HOV training that would include varying level and length training courses for HOV practitioners and then develop a course and materials that deal solely with the HOV planning process.

Key Words

HOV, HOV planning, HOV marketing, public involvement, training.

Related Work

FHWA Training Course son High Occupancy Vehicle Facility Development, Operation and Enforcement, JHK & Associates, May 1981; High Occupancy Vehicle Facilities, Current Planning, Operation and Design Practices, Parsons, Brinckerhoff, Quade & Douglas, October 1990; White Paper at 1991 HOV Symposium.

Urgency/Priority

Longer-Term Need. Increased interest in HOV facilities requires more knowledgeable planning capability than currently exists.

Costs

$250,000 which includes two pilots and ten course presentations.

User Community

FHWA, FTA, state, local transportation and transit agency planners, and consultants.

Implementation

Courses would be offered through State DOT agencies and would include a User's manual and other documentation.

Effectiveness

This course would result in increased numbers of highly trained and competent HOV transportation planners, resulting in more and better HOV projects. Those who are trained could also train others in their agency.

RESEARCH PROBLEM NUMBER 10

Developing Guidelines for Improved HOV Facility Access, Egress, and On-Line Station Design

The design of access and egress points associated with high-occupancy vehicle (HOV) lanes plays a significant role in the effectiveness of these facilities. The increased use of HOV lanes by buses and an initiative to develop multimodal links in urban transportation systems are also creating the need for on-line HOV station design(s) for mixed-vehicle use. A variety of access, egress, and on-line station design applications for HOV facilities are currently in operation throughout North America. Guidelines for such designs have not, however, been developed. Many questions regarding the most safe and effective design applications still, therefore, remain unanswered.

Objective

Perform a comprehensive evaluation of existing access, egress, and on-line station design applications and develop design and implementation guidelines that will improve the overall effectiveness of HOV facilities.

Key Words

HOV Design, HOV Implementation, HOV Operations

Related Work

A recently completed study describing HOV facilities in North America would serve as one of the many sources available for performing the evaluation of existing design applications. The guidelines developed in this research would also draw upon AASHTO design guidelines and the Manual on Planning, Operation, and Design of HOV Facilities (Fuhs, 1990).

Urgency/Priority

Longer-Term Need. Due to recent changes in legislation, HOV facilities and multimodal planning and implementation is increasing significantly.

Costs

$500,000

User Community

State and Local Traffic Engineers, Consultants.

Implementation

Developed guidelines would be provided to state and local transportation officials in urban areas.

Effectiveness

Developing guidelines for HOV facility access, egress, and on-line station design would improve the operating efficiency and utilization of HOV facilities. In the case of barrier-separated HOV facilities constructed within freeway rights-of-way, better HOV access/egress design would likely result in improved operations on the adjacent general-purpose lanes as well.

RESEARCH PROBLEM NUMBER 11

Guidelines for Improved Design of HOV Facilities To Accommodate Mixed Vehicle Use, Especially to Access Points

Case I

HOV lanes often serve a variety of vehicle types carpools, vanpools, buses, and motorcycles. Locations where exclusive busways can be justified in a freeway HOV network are often limited, but the additions of transit buses to HOV lanes greatly increases their effectiveness. In the U.S., FHWA regulations also require that motorcycles be permitted on HOV lanes unless safety can be shown to be a problem. The presence of mixed vehicles poses design and operations problems, especially with respect to access and egress. If public transit buses must leave the HOV facility to stop for passenger pick-up and drop-off, it greatly slows their effective operating speed. However, if on-line stations are provided, safe provision must be made for other buses and HOV vehicles to bypass. Further, the design of all access points to HOV lanes for all vehicles buses, vanpools, carpools, and motorcycles is widely at variance in North American applications, and many questions exist, including: (1) Location and frequency of HOV access points; (2) Whether such points should be grade-separated; and (3) the impact of their design on mixed vehicle operations.

Design of HOV lanes for mixed-use operations has implications for grades, widths, number of lanes and provisions for breakdowns.

Case II

In other situations such as in Pittsburgh and Ottawa, busways have been built as successful rapid transit alternatives to rail. In both cases, the initial peak hour ridership was sufficient to justify their initial designation as exclusive bus facilities. This will not be the case in all future busway applications where interim HOV use may be necessary to justify the early construction of the facility. In this case, the design guidelines must show how to adapt an exclusive busway with on-line stations to temporary HOV use.

Objective

Perform a comprehensive evaluation of the impact of existing HOV facility, ramp and station designs on mixed vehicle operations; and develop some key design guidelines to provide for improvements.

Key Words

HOV Design; HOV Ramp Design; HOV Access; HOV Vehicle Mix; Safety; HOV Operations; Busways, On-line Stations.

Related Work

A recently completed study describing HOV facilities in North America; design standards used on the Ottawa and Pittsburgh busways, Houston HOV lanes and Seattle freeway-flyer stops; NCHRP Reports 143 and 155; AASHTO Guide for Bus Transfer Facilities, 1983; Chuck Fuhs Manual on Planning, Operation and Design of HOV Facilities, 1990; Virginia DOT Study of safety of motorcycle use on HOV lanes.

Urgency/Priority

Longer-Term Need. Important to get guidelines in place to improve effectiveness of many HOV facilities now being planned and designed.

Costs

$250,000

User Community

State and Local Traffic Engineers and HOV Design Engineers; State and Local Transit Planners and Engineers; Rideshare Organizations; Consultants.

Implementation

Design guidelines would be widely distributed to state and local officials in urban areas.

Effectiveness

High potential to significantly improve HOV lane usage, effectiveness and operating efficiency.

PROGRAM SUMMARY FOR OPERATIONS AND ENFORCEMENT OF HOV SYSTEMS

SCOPE

This section addresses research opportunities in HOV lane operations and enforcement. The topic of HOV system operations encompasses a number of issues, including vehicle/user eligibility, demand/capacity relationships, operating hours, system surveillance, lane utilization, incident management, air quality impacts, and traffic safety.

Enforcement issues include strategies for detecting and apprehending violators, penalty assessment, public education, officer deployment and safety, and interagency coordination. Four research project statements (numbered 8 through 11) have been developed to address key issues in HOV lane operations and enforcement.

RESEARCH ISSUES

Operations

Decisions made in the design stage concerning occupancy requirements, vehicle mix, and operating hours have a pronounced impact on HOV lane operations. As HOV lanes mature, it may be necessary to reassess these definitions, particularly those governing occupancy requirements. Underutilized lanes might benefit from relaxed occupancy restrictions, while congested HOV lanes might flow more freely if occupancy requirements are tightened. Occupancy requirements can also be varied by time of day to reflect changing traffic conditions. Research is needed to document the operational steps required to change occupancy definitions on an existing HOV project and explore responses to the changed requirements.

Although most HOV operating agencies regularly count the number of vehicles using the lane during peak commute periods, few have attempted to document the source of new carpools and identify which HOV lane users have always carpooled on the altered route, which are carpoolers diverted from parallel routes; which are new carpoolers who got together to take advantage of improved travel times, and which are casual carpoolers who just happen to have the required number of occupants to use the lane for a single day. The additional driving (if any) needed to collect carpool passengers is not well documented, and the disposition and use of vehicles left at home by regular carpoolers is not well understood. The driving patterns of carpoolers before they get together in a single vehicle will have an impact on any air quality improvements which might be traced to an HOV lane, as will the impact of the HOV lane itself on congestion in adjacent mixed-flow lanes. The impact of HOV lanes on transit use in adjacent corridors is another topic worthy of research. Because these impacts are not well understood, transit proponents often oppose HOV lanes for fear they will result in decreased transit ridership.

Safety has been a long-standing concern of HOV lane operators. Although accident rates have increased with the installation of some concurrent-flow, non-separated HOV facilities, they have declined on others. The relationships between buffer design and accident rates are not well understood, although barrier-separated designs are generally accompanied by an overall decline in accident rates.

Enforcement

HOV lanes cannot succeed without effective enforcement. The growing number and wide variety of HOV lane designs present an increasingly wide range of enforcement options and problems. At the same time, police agencies are facing funding cutbacks which limit the personnel available for assignment to HOV enforcement. To get the most out of available personnel, more efficient and effective enforcement approaches must be developed, evaluated and implemented.

Potential areas for enforcement research include the design and placement of enforcement areas; automated enforcement techniques; the impact of design features on violation rates; the deterrent effect of fines; officer deployment levels; enforcement strategies; public attitudes; and public participation programs. Research is needed to identify those deployment levels, enforcement approaches, and design features that produce cost-effective compliance with HOV regulations.

RESEARCH PROBLEM NUMBER 12

Safety Aspects of Various HOV Lane Configurations

HOV lanes throughout the U.S. are characterized by various geometric designs. In some cases, barriers separate high-occupancy vehicles from mixed-flow lanes, while in other instances lane striping or a painted buffer

affords the only separation between fast moving HOV traffic and stop-and-go conditions in contiguous mixed flow lanes.

Different degrees of separation can be expected to affect the safety of HOV lane operations, as can the presence or absence of median shoulders adjacent to HOV lanes, and access lane design. Before/after and control freeway comparisons are needed to document the impact of different design choices (which are often imposed by limited right-of-way) on freeway accidents. While HOV lanes can provide excellent service for ridesharing vehicles, research is needed to determine whether the resulting congestion and accident problem in mixed use lanes offsets the overall system benefits.

Objective

Document the impact of different barrier types, separation widths, median shoulders, and access designs on freeway accidents in and adjacent to HOV lanes.

Key Words

Buffer; HOV lanes; safety; accidents; median; shoulder; congestion.

Related Work

Before/after accident studies on various freeways (i.e. U.C. Irvine study of I-55 in Orange County and SYSTAN's study of the Santa Monica Diamond Lanes). "High Occupancy Vehicle Lane Safety," 1992 CALTRANS study performed by Cal Poly of San Luis Obispo; "Safety Evaluation of Priority Techniques for High Occupancy Vehicles," 1979 FHWA Study by Beiswenger, Hoch and Associates.

Urgency/Priority

Immediate Need. The safety of HOV lane operations is of paramount importance. Designers should be aware of the safest available alternatives, and should be able to weigh the accident cost of proposed designs against the overall benefits of HOV lane installation.

Costs

$250,000

User Community

State and local planners and designers; elected officials; researchers; consultants.

Implementation

Findings should be made available to state and local officials and planners in urban areas.

Effectiveness

Documentation of the safety implications of different HOV designs will ensure the safe and efficient operation of HOV lanes and minimize opposition to the implementation of well-designed lanes.

RESEARCH PROBLEM NUMBER 13

Experience with HOV Eligibility and Operational Definitions

A number of operational definitions must be established in planning, implementing, and operating HOV lanes. These include:

- Vehicle occupancy requirements (i.e., 2+ or 3+ occupants?);
- Hours of operation (i.e., peak periods or 24-hour operation?);
- Vehicle mix (i.e. allow carpools and/or motorcycles?)

Each of these decisions can lead to different operating characteristics and different perceptions of HOV lane operations.

As HOV lanes mature, it can be necessary to reassess occupancy requirements. Underutilized lanes might benefit from relaxed occupancy restrictions, while congested HOV lanes might flow more freely if occupancy requirements are tightened. Occupancy requirements can also be varied by time of day to reflect changing traffic conditions. Alternatively, different occupancy requirements may exist in different portions of a regional network. What if a 3+ definition is underutilized but 2+ is congested? Research is needed to document the operational steps required to change occupancy definitions on an existing HOV project and explore responses to the changed requirements. Research should also document what has been done,

and what operators feel might have been done differently.

Objective

Consolidate HOV lane operations and safety experience with different occupancy requirements, vehicle mixes, and operating hours. Assemble before/after data from projects which have changed occupancy requirements with the aim of developing guidelines for managers and operators faced with the problem of HOV lanes which are either too full or too empty.

Key Words

HOV lanes; carpool definitions; motorcycles; level of service; vehicle mix; operating hours; occupancy requirements; operational efficiency.

Related Work

Seattle I-5 2+ occupancy requirement demonstration; TTI report on Katy Freeway experience in Houston; Results of post-earthquake changes in HOV occupancy requirements in San Francisco Bay Area. ITE Publication #IR-050, The Effectiveness of HOV Facilities (1988), Studies in New York on the Long Island Expressway (1992), Orange County HOV Hours of Operation, OCTA (1991).

Urgency/Priority

Mid-Term Need. As more HOV lanes are implemented, more and more planners must define operating hours and consider changing occupancy requirements as lanes with loose restrictions fill up, eliminating any carpool advantage, and lanes with too-tight restrictions appear empty. Guidelines are needed to acquaint planners with the available options for changing carpooling criteria and to document experience with different options.

Costs

$200,000.

User Community

HOV managers and operators, state and local transportation planners, consultants, elected officials and transportation air quality and environmental professionals.

Implementation

Copies of options and consolidated experience would be provided to HOV lane operators and state and local transportation planners.

Effectiveness

Experience-based guidelines for setting operating hours, defining vehicle mix, and establishing or changing vehicle occupancy requirements will enable planners to learn from the experience of other jurisdictions and avoid costly duplication of effort.

RESEARCH PROBLEM NUMBER 14

Documenting Mode Choice on Existing HOV Facilities

Several studies have documented the increase in HOV usage on affected freeways immediately following lane implementation. However, few researchers have attempted to separate new carpools formed in response to the HOV lane opening from existing (and/or casual) carpools that change their routes to take advantage of the time savings offered by preferential lanes. Fewer still have tracked the growth of new carpools over time as the HOV lane matures or documented the impact of HOV facilities on parallel transit lines. Jurisdictions planning HOV lanes need to be able to assess the short- and long-term impact of HOV lanes on carpooling and transit ridership, and demand modelers need to have better data for developing and calibrating mode choice equations.

Objective

Assemble existing data on the growth of carpooling in HOV lanes over time, isolate the impact of the lanes on mode choice alternatives, and survey users of a sampling of existing lanes regarding their modal choices.

Key Words

Modal share; HOV lanes; mobility; person-movement; auto occupancy; transit use; carpooling incentives; carpool formation.

Related Work

Concept paper "HOV Facilities in a Multi-Modal Transportation System," presented at 1992 TRB Conference; numerous mode split models; HOV lane user surveys in the San Francisco Bay Area, Orange County, and elsewhere.

Urgency/Priority

Immediate Need. The development of accurate demand models requires reliable modal share data from existing HOV systems. Effects of HOV lanes on transit use are not well understood and often ignored in mode split models, which make an auto/transit split before estimating auto occupancy. Because of the lack of knowledge, transit proponents often oppose HOV lane installation for fear it will result in decreased transit usage.

Costs

$200,000.

User Community

State and local transportation planners, traffic modelers, researchers, consultants, elected officials and transit professionals.

Implementation

Better data will improve mode split models. In addition, better insight into the joint impacts of HOV lanes on transit use and short-and long-term mobility would assist state and local officials in multi-modal transportation decisions and possibly reduce friction between proponents of different modes.

Effectiveness

Better data will provide a clearer picture of HOV lane effectiveness over time and supply planners with an objective basis for making decisions regarding lane implementation. An understanding of HOV-transit tradeoffs will improve the effectiveness of investment in all modes of transportation and help to mitigate opposition from advocates of single systems.

RESEARCH PROBLEM NUMBER 15

Effective HOV Enforcement Procedures

Effective enforcement is necessary if HOV lanes are to fulfill their objectives. The growing number and wide variety of HOV lane designs present an increasingly wide range of enforcement options and problems. At the same time, police agencies are facing funding cutbacks which limit the personnel available for assignment to HOV enforcement. To get the most out of available personnel, more efficient and effective enforcement approaches must be developed, evaluated, and implemented. Issues to be addressed include:

- The design and placement of enforcement areas acceptable to police agencies;
- The exploration of automated enforcement techniques;
- The impacts of design features on violation rates and enforcement requirements;
- The deterrent effects of publicized penalties; and
- The role and effectiveness of "hero" programs.

Objective

Identify deployment levels, enforcement techniques, and design features that maximize compliance with HOV regulations and develop HOV enforcement guidelines for police agencies.

Key Words

HOV lanes; occupancy monitoring; citations; occupancy violations; police deployment; traffic law enforcement; ramp meter bypass lanes; enforcement areas; fines; "hero" programs; mail-out citations; automated enforcement.

Related Work

SYSTAN-TSM Project Violation Rates (1981); SYSTAN-HOV Lane Violation Study (1989); SYSTAN-Use of Video Tape in HOV Lane Enforcement (1990); HOV Guidelines for Planning, Design and Operations, CALTRANS (1991), HERO system evaluation.

Urgency/Priority

Longer-Term Need. Each new HOV project must decide how to build enforcement into its project

development. To go back after a project is operating and construct enforcement area is often impossible or at least very expensive. Each facility constructed without the best possible enforcement facilities results in increased cost of enforcement resources, for the life of the HOV project.

Costs

$300,000.

User Community

State and local law enforcement agencies, traffic planners and engineers, researchers, consultants.

Implementation

Guidelines developed on the methods and facilities to provide maximum compliance would be provided to state and local officials, planners, and enforcement agencies in urban areas.

Effectiveness

Development of guidelines for enforcement will improve compliance, ensure the safe and efficient operation of HOV lanes, minimize the disruptive effect of enforcement activity, and increase the safety of enforcement personnel.

PROGRAM SUMMARY FOR HOV SYSTEMS ON ARTERIALS

SCOPE

A considerable amount of attention has been given to freeway HOV treatments and the research needed to support freeway HOV systems. Freeway HOV systems have been implemented throughout North America. With this widespread acceptance and support of freeway HOV systems, it is appropriate to apply the same philosophy to the arterial system. HOV treatments on surface streets and arterials traditionally consist of bus only lanes, mostly in downtown areas, and bus preemption systems for signalized intersections. However, very little research has been directed to the most appropriate HOV treatments in the non-limited access or signalized intersection environment.

The successes of the freeway system have taught us valuable lessons. However, the arterial system is distinct from the freeway system in several key ways which require a different perspective than approaches to freeway applications. In an arterial setting, congestion emanates from signalized intersections. Buses have difficulty reentering the traffic stream from a bus stop. In an arterial setting there are numerous driveways, on-street parking, and frequent intersections which require a much higher level of interplay with general purpose traffic than in a freeway setting. Pedestrian activity adds a challenge. These issues have not been successfully addressed on a systematic basis.

In a freeway environment, there are typically limited options for providing HOV incentives -- HOV lanes, HOV bypasses, and HOV-only ramps. Many more options are possible in an arterial street setting, including HOV lanes, HOV turning lanes, restricted movements at intersections, HOV only movements, HOV signal priority, and HOV emphasis corridors. These options and their effectiveness under various conditions must be better understood in order to make decisions on the most appropriate HOV treatments to implement on an arterial system.

RESEARCH ISSUES

Many of the issues that have been topics for research in the freeway environment are worthy of research in the arterial environment. These include appropriate design of HOV lanes, access and egress provisions, signing, enforcement requirements and methods, vehicle occupancy requirements, and hours of operation. However, most of these issues will be difficult to research or difficult to integrate into a broader knowledge of arterial HOV treatments until more understanding is gained on the conditions appropriate for implementing various arterial treatments and a methodology is developed to evaluate the effectiveness of these treatments. The following two research statements address these research issues. The first project, "Arterial Street High-Occupancy Vehicle Treatments," will lead to a menu of arterial HOV options appropriate for various conditions. After successfully completing this project, additional research issues will be identified.

The second project will then provide a methodology for evaluating the success of implementing the treatments identified in the first project.

SUMMARY

Arterial environments differ significantly from freeway environments. These differences lead to a host of different problems for providing HOV incentives. These differences also provide for many more options for HOV treatments. There is not the operational experience nor the research knowledge in HOV treatments in the arterial setting that there is in the freeway setting. Research is needed to specifically address arterial HOV issues. Many issues that have been the subject of freeway related HOV research cannot yet be researched because of the lack of experience with arterial HOV treatments and a lack of understanding of the unique issues associated with those treatments. The research recommended here will consolidate the knowledge that exists on arterial HOV treatments, identify those issues unique to providing HOV incentives in the arterial environment, determine appropriate options to address those issues, and develop methods to evaluate the effectiveness of arterial HOV treatments. This research will identify additional areas for arterial HOV research. A truly comprehensive research program for arterial HOV treatments could then be developed for further consideration.

RESEARCH PROBLEM NUMBER 16

Arterial Street High-Occupancy Vehicle Treatments

A good deal of recent research has focused on HOV lanes on freeways and on separate rights-of-way. Little of this research, however, has specifically addressed HOV priority treatments on arterial streets. It is known that most current arterial HOV facilities are oriented only to buses yet such treatments could also greatly enhance carpool and vanpool operating conditions.

Research is needed to identify the myriad of issues associated with providing priority for buses, carpools, and vanpools on arterial streets. Priority treatments that need investigation range from signal priority methods to continuous HOV lanes. A better understanding is needed on what is the current state of the practice in arterial HOV treatments, what treatments have been successful and why, and what role technology can play to enhance HOV operation on arterial streets.

Objective

The objectives of this research are to:

1. Identify the state of the practice for arterial HOV treatments;
2. Identify unique issues associated with HOV treatments on arterial streets;
3. Identify and analyze techniques to accommodate these issues; and
4. Develop guidelines for planning, designing, and operating arterial HOV treatments.

Key Words

High Occupancy Vehicles, Arterial Traffic Control, Traffic Signal Preemption, Traffic Signal Priority.

Related Work

Several projects have reported on freeway HOV facilities in recent years. However, very little work has been focused on arterial HOV treatments. There are projects in progress around the country planning or assessing arterial treatments for specific areas or facilities, but very little has been published.

Urgency/Priority

Immediate Need. Increasing traffic congestion and air quality considerations are influencing the demand for more extensive use of HOV treatments. Great interest has been expressed through a number of forums by transit agencies, state and local highway agencies, FTA and FHWA for the wider application of HOV lanes on arterial streets.

Costs

$350,000

User Community

State and Local Traffic Engineers, Transit Agencies, Consultants.

Implementation

Copies of the report would be provided to State and local officials in urban areas to raise their awareness and understanding of arterial HOV treatment options and help guide them in planning and selecting arterial HOV treatments.

Effectiveness

Information on and assessment of arterial HOV treatments will provide practitioners valuable guidance as an increasing number of jurisdictions are planning to implement HOV treatments on arterials.

RESEARCH PROBLEM NUMBER 17

Development of Evaluation Procedures and Data-Collection Techniques for Arterial Street HOV Treatments

A number or metropolitan areas in North America are developing and implementing a variety of priority treatments for high-occupancy vehicles (HOVs) on arterial streets. Further, many more areas are considering arterial street HOV treatments. The types of HOV facilities being pursued include bus-only lanes, HOV lanes, signal priority treatments, and other techniques. To date, little analysis has been conducted on the impact of these facilities. One of the reasons for this is the lack of agreed upon evaluation procedures and data collection techniques for arterial street HOV treatments.

The research proposed in this study would fill this void. Building on the suggested procedures for evaluating freeway HOV facilities developed previously, this research project. would identify the appropriate objectives, measures of effectiveness, and data collection techniques for use in monitoring and evaluating arterial street HOV projects.

Objectives

The objectives of this research project are to:

1. Review before-and-after studies, evaluation programs, and data collection techniques with the different types of existing arterial street HOV facilities.

2. Develop suggested objectives. measures of effectiveness, and data collection techniques for use with the different priority measures for HOVs on arterials.

Key Words

High-occupancy Vehicles, HOVs, arterial streets, traffic signal priorities

Related Work

The *Assessment of HOV Projects in North America* sponsored by the Federal Transit Administration and conducted by the Texas Transportation Institute, developed a set of suggested procedures, measures of effectiveness, and data collection techniques for use with conducting before-and-after evaluations of freeway HOV projects. Corresponding work relating to HOV priority treatments on arterial streets has not been conducted.

Urgency/Priority

Mid-term need. It is important that arterial street HOV projects are developed and implemented to maximize benefits to HOVs, while minimizing poten tial negative impacts on general traffic. The development and use of evaluation measures is critical to advancing the state-of-the-practice and the level of understanding of the impacts and benefits of arterial street HOV applications.

Costs

$200,000

User Community

State and local transportation professionals, engineers, planners, transit agencies and consultants.

Implementation

Copies of the reports would be widely distributed to jurisdictions and individuals at the federal, state, and local levels. The results could also be incorporated into the training and education activities associated with different HOV conferences and programs.

Effectiveness

The development of suggested evaluation procedures and data collection techniques for arterial street HOV facilities will provide an immediate tool for transportation professionals and others to use in determining the impact and effectiveness of arterial street HOV projects.

RESEARCH PROBLEM NUMBER 18

Development of Periodic Updated HOV Systems Manual

Currently there are local guidelines available for selected aspects of HOV systems based on previous experience and research. There is a need to integrate these guidelines nation-wide and extend them into a comprehensive and detailed manual as new research is completed.

Objective

Develop initial HOV Systems Manual in 1995 and periodic update of manual in the years 1997, 1999, and 2001.

Key Words

HOV systems, manual, planning, design, operations, enforcement, marketing.

Related Work

NCHRP Synthesis Report 185 "Preferential Lane Treatments for High-Occupancy Vehicles" published in 1993.

Urgency/Priority

Immediate and continuous need.

Costs

$400,000

User Community

HOV system planners, designers, operators, enforcers, and marketers from local, consultant, state, and federal agencies.

Implementation

The initial version of the HOV Systems Manual is expected to be distributed in draft form for review purposes by mid-1995, published by the end of 1995, and widely distributed. The Manual would be updated in 1997, 1999, and in the year 2001.

Effectiveness

A comprehensive and detailed manual to guide professionals in planning, designing, operating, enforcing, and marketing of HOV systems will insure more consistent and effective applications in the future which will provide greater mobility, higher level of service, and at the same time reduce energy consumption and vehicle emissions