TRAFFIC OPERATIONS STRATEGIES

- ✓ Background
- ✓ Current Status
- ✓ Opportunities for Implementation

April 2000

Executive Summary

In appropriating State Highway Account funds for Fiscal Year 1999-2000 Caltrans Operations (Item 2660-001-0042), the Legislature included supplemental budget language that required the Department of Transportation to submit a report on Traffic Operations Strategies (TOPS). This report responds to the Legislative requirement by describing the motivation for TOPS, the current status of TOPS, and opportunities for implementing TOPS projects. Some aspects of the legislative request, including the use of movable barriers and the interrelationship between transportation planning and rapid urban development on congested corridors, will be addressed in future submittals.

The goals of TOPS are to reduce congestion, increase trip reliability, and enhance safety

INTRODUCTION

We currently face a major transportation challenge in California. Congestion has grown significantly on our highways despite efforts to expand our infrastructure to meet increasing demand. Looking ahead, California's population is forecasted to grow over 30 percent in the next 20 years. Our recent experience tells us that congestion will increase even faster than population: since 1990, our overall congestion has increased more than 50 percent while our population has grown by a little more than ten percent.[1]

This rapid increase in congestion can be explained by complicated traffic flow interactions. In general terms, as demand (i.e., number of vehicles) exceeds capacity (i.e., maximum number of vehicles that a given highway can serve), traffic choke points are created and our customers experience congestion. As congestion worsens, the traffic flow rate on our highways is reduced. At speeds of 45 miles per hour or more, each lane on a typical urban highway can carry around 2,000 vehicles per hour. When congestion occurs and speeds fall below 35 miles per hour, the flow rate per lane can drop considerably. Under congested conditions, a flow rate of only 1,500 vehicles per hour is typical.[2]

We refer to congestion that results from demand regularly exceeding capacity as *recurrent congestion*. Urban commuters face this problem almost every weekday on our busiest highways.

An equally important type of congestion, sometimes even more frustrating to our customers, results from accidents, special events, weather conditions, and other unusual circumstances. We refer to this as *non-recurrent congestion*. These unusual circumstances often lead to choke points (e.g., at an accident location), which in turn reduce the traffic volume (or flow rate) carried by our system.

Any comprehensive strategy to address congestion must address both types of congestion. Moreover, the strategy must aim to reduce overall demand to the extent feasible and practical, and then manage the transportation system in a manner that restores under-utilized capacity.

This strategy has been emerging since the realization in the 70s that fiscal and environmental constraints would restrict the 50s-60s era "build-build-build" option as a solution to transportation problems. Originally known as transportation system management, the strategy embodies the philosophy of planning, programming, developing, and operating the system, be it the overall transportation system or a significant component such as the highway system, so that the efficiency and effectiveness of the system is maximized. This is clearly stated in Caltrans' strategic goals as "Optimize the System." The TOPS version of system management will be an aggressive effort to utilize efficiently the existing infrastructure that lies at the heart of system management. A two-pronged TOPS approach of influencing demand and tapping all available capacity, is quintessential system management. The proposed TOPS projects' operational and performance focus acts as a bridge between major system

1 *1998 California Department of Transportation Congestion Monitoring Report (HICOMP)*

2 *Transportation Research Board, Highway Capacity Manual, Special Report 209, Third Edition, 1998*

management, transportation demand management and system expansion efforts.

WHAT IS TOPS?

TOPS is a strategy for addressing congestion problems through better system management. The goals of TOPS are to reduce congestion, increase trip predictability, and enhance safety, especially on our most congested corridors. Initially, the focus of TOPS will be on the state highway system for which we plan to:

- Leverage today's enhanced communication technology to equip our state freeways fully with intelligence that provides real-time information, which in turn will help us partner with the public and with the private sector to better manage our transportation system, and
- Adjust our current infrastructure to maximize traffic flows and restore under-utilized capacity corridor- and system-wide.

TOPS must ultimately address all modes, incorporate local streets and arterials, and address the demand side of transportation in a comprehensive manner.

In essence, TOPS offers an "Operations First" approach to corridor and system management. By evaluating the demands and constraints for each transportation corridor and understanding the inter-relationships among corridors, we can better manage capacity and reduce congestion.

However, TOPS should not be viewed as a replacement for system expansion. For certain corridors, system expansion is and will remain the only reasonable solution. TOPS investments and system expansion should be viewed as complementary.

TOPS implementation can be divided into four elements as follows:

- Complete the "intelligence" component of our existing infrastructure to improve traffic flow management
- Address infrastructure limitations with physical operational improvements at the corridor and system levels to alleviate choke points, increase overall traffic flows and restore all under-utilized capacities
- Fill all operational gaps in the high occupancy vehicle (HOV) network to eliminate traffic disruptions that result when HOVs merge with other vehicles
- Modify selected freeway-to-freeway interchanges to minimize traffic flow disruptions and resulting congestion.

CURRENT STATUS

Over the last ten years, we have made significant progress in the development and deployment of tools to manage and operate the transportation system better. Since the full deployment of these tools has relied on emerging technologies, they could not be part of a comprehensive strategy until now. Such a strategy is possible due to the rapid advancement of communications technology and Caltrans-sponsored research initiatives. However, to implement TOPS, we need more funding, coordination with regional and local agencies, and integration with other modes. The status of the four highway-related TOPS elements can be summarized as follows:

- **Intelligent Infrastructure –** We estimate that approximately 20 percent of the intelligent infrastructure planned under TOPS has been implemented under previous efforts. Caltrans has programmed an additional 15 percent of the necessary intelligent infrastructure.

- **Physical Operational Improvements –** These improvements address bottlenecks or choke points created by demand exceeding capacity, primarily at on- and off-ramps.

- **HOV Network Gaps –** California operates approximately 925 miles of HOV lanes. Nearly 127 additional HOV lane-miles are under construction, and 792 more HOV lane-miles are proposed.

- **Freeway Interchange Modifications –** We have identified a number of freeway interchanges where modifications will improve flow significantly.

WHERE DO WE GO FROM HERE?

Caltrans has already begun to develop comprehensive plans to implement TOPS. Every Caltrans district has submitted preliminary project lists, which will be refined over the next few months to produce a detailed 10-Year TOPS Plan. The 10-Year Plan will be completed over the coming year and presented to the Legislature no later than January, 2001.

However, even as these plans are finalized, we anticipate implementing significant portions of the Intelligent Infrastructure and Physical Operational Improvements TOPS elements. Implementation will include corridor-wide demonstration projects for each district.

TOPS implementation will require institutional coordination in planning, operations, and funding. Regional planning is currently accomplished through the local regional transportation planning process and the Regional Transportation Improvement Program (RTIP). Caltrans districts are and will continue to work with local and regional planning agencies to ensure that projects identified in the 10-Year TOPS Plan are embedded in the regional planning process and at least partly financed through RTIPs. The Department will also work with these agencies to coordinate highway-related activities with other modal priorities, and to develop comprehensive regional system management plans in the coming year.

TOPS FUNDING OPPORTUNITIES

Caltrans anticipates that initial (first-level) projects will focus on intelligent infrastructure and physical operational improvements. Other investments will focus on other aspects of TOPS.

Representative TOPS Projects

LEVEL 1		LEVEL 2	LEVEL 3
Intelligent Infrastructure	**Physical Operational Improvements**	**HOV Network Gaps**	**Freeway Interchange Modifications**
• Changeable Message Signs • Closed-Circuit Televisions • Communication Links • Fiber Optics • Highway Advisory Radios • Metering and Metering Control • Roadway Weather Information System • Signal Upgrades • Traffic Monitoring Stations • Transportation Management Center Upgrades	• Alignment Upgrades • Auxiliary Lanes • Intersection Upgrades • Lane/Shoulder Widening • Passing Lanes • Ramp Modifications • Other	• HOV Connectors • HOV Drop Ramps • HOV/Managed Lanes • Other	• Freeway Connectors • Freeway Connector Metering

Some TOPS investments may be funded through the State Highway Operation and Protection Program (SHOPP).

This year may present a unique, although short-lived, funding opportunity for TOPS. The California Transportation Commission (CTC) identified a potential lapse in federal funding due to project delivery, primarily in the Local Assistance Program. The CTC created a "Contingency Fund" to prevent such a lapse and directed that this fund emphasize TOPS as part of the SHOPP.

Not all contingency funds may be available for TOPS. SHOPP funding plus Congestion Mitigation and Air Quality Improvement (CMAQ) Contingency Funds can support a portion of the first-level TOPS investments required over the next ten years. Regional Share of Surface Transportation Program (RSTP) Contingency Funds increase available funding.

However, Caltrans cannot count on the availability of the Contingency Fund. Funding for the needs identified as first-level TOPS investments must come from a variety of sources, such as local funding commitments and future years of the State Transportation Improvement Program (STIP), SHOPP, or resource sharing by the private sector. Several regions have expressed interest and in some cases committed funding to these projects through the Regional Transportation Improvement Program (RTIP). Caltrans will continue to work closely with the regions and the private sector to obtain complete funding for TOPS.

HOW EFFECTIVE WILL TOPS BE?

Initial estimates demonstrate that TOPS projects are cost-effective investments that provide greater returns than do typical system expansion projects. The average system expansion project in the 1998 Inter-Regional Transportation Improvement Plan (ITIP) produced a benefit-cost ratio of only 2.4 to 1.

The benefits of TOPS include the reductions of: delay, user costs, accidents, and air pollution. These categories of benefits are conservatively estimated and summarized in the exhibit below for first-level TOPS investments.

The total benefit/cost ratio for the first level of TOPS investments is more than triple that of the average roadway expansion project. Moreover, this ratio does not reflect the additional benefits that will accrue from increased productivity, synergies among types of projects, or the further stimulation of the communication industry in California. In all, Caltrans strongly believes in the merits of TOPS and will work closely with its partners to implement it.

Summary of TOPS Benefits

Category	Benefit-Cost Ratio
Level 1: Intelligent Infrastructure	10.1 to 1
Level 1: Physical Operational Improvements	8.3 to 1
Level 1: TOTAL	8.9 to 1
Level 2: HOV Network Gaps	TBD
Level 3: Freeway Interchange Modifications	TBD

1. Background

In appropriating State Highway Account funds for Fiscal Year 1999-2000 Caltrans Operations (Item 2660-001-0042), the Legislature included supplemental budget language that required the Department of Transportation to submit a report on Traffic Operations Strategies (TOPS). This report responds to the Legislative requirement by describing the motivation for TOPS, the current status of TOPS, and opportunities for implementing TOPS projects. Some aspects of the legislative request, including the use of movable barriers and the interrelationship between transportation planning and rapid urban development on congested corridors, will be addressed in future submittals.

1.1 INTRODUCTION

We currently face a major transportation challenge in California. Congestion has grown significantly on California highways despite our efforts to meet increasing demand by building new highways and expanding existing ones as well as providing new and expanded transit services. Looking ahead, California's population is forecasted to grow by over 30 percent in the next 20 years. This population increase is the equivalent of adding another San Diego and San Francisco Bay Area to the state, and our recent experience tells us that congestion will increase even faster than population.

Consider the following historical trends:

- Between 1990 and 1998, California's population grew by a little more than ten percent. During that same time period, congestion, as reported in the 1998 HICOMP report, grew by more than 50 percent statewide. The growth in congestion outpaced population growth by a factor of five.
- Congestion in rapidly developing urban areas (e.g., Riverside, San Bernandino, Sacramento) grew even faster than the State average. Congestion in our Los Angeles-based District 7 grew slower during the same period. In total though, Los Angeles commuters still experience the most delay in the State.
- During that same period, the State has invested billions to expand the freeway system, develop new and expand existing rail systems, and develop the core of a high occupancy vehicle (HOV) sub-system in major metropolitan areas (e.g. Los Angeles, Orange County, and the San Francisco Bay Area).

It is very difficult to maintain financial and public support to add roads and lanes as fast as traffic volume grows

Clearly, our ability to expand our physical infrastructure cannot address the increasing demand for transportation. California is not alone in facing a problem with congestion. The Texas Transportation Institute's 1998 Annual Urban Mobility Study indicates that mobility has worsened for travelers in most of the 68 cities studied nationally, no matter how mobility is measured. Road construction has historically played a major role in helping us hold the line against increasing congestion. As the Texas Transportation Institute acknowledges in its study, "it is very difficult to maintain the financial and public support to add roads and lanes as fast as traffic volume grows." A new approach is necessary for tackling highway congestion.

Over the last 10 years, Caltrans and its regional partners have recognized that capacity increases can no longer be considered the only solution to congestion. This realization, combined with the maintenance and management responsibilities imposed by an increasingly complex transportation system, have necessitated a change in Caltrans' role to emphasize system management.

1.2 THE NATURE OF CONGESTION

This rapid increase in congestion can be explained by complicated traffic flow interactions. In general terms, as demand (i.e., number of vehicles) exceeds capacity (i.e., maximum number of vehicles that a given highway can serve), traffic choke points are created and our customers experience congestion. As congestion worsens, the traffic flow rate on our highways is reduced. At speeds of 45 miles per hour or more, each lane on a typical urban highway can carry around

2,000 vehicles per hour. When congestion occurs and speeds fall below 35 miles per hour, the flow rate per lane can drop considerably. A flow rate of only 1,500 vehicles per hour is typical at speeds between 20 and 30 miles per hour.[3]

We refer to this type of congestion, where demand exceeds capacity on a regular basis as *recurrent congestion*. Urban commuters face this problem almost every weekday on our busiest highways.

An equally important type of congestion, sometimes even more frustrating to our customers, results from accidents, special events, weather conditions, and other unusual circumstances. We refer to this as *non-recurrent congestion*. These unusual circumstances often lead to choke points (e.g., at an accident location), which in turn reduce the traffic volume (or flow rate) carried by our system. Caltrans conducted an analysis in Southern California and estimated that non-recurrent and recurrent congestion cause roughly equal delays for our customers. Non-recurrent congestion is also the primary factor for travel time "unpredictability," since customers cannot plan for it.

Any comprehensive strategy to address congestion must improve mobility (i.e., reduce delay), improve predictability (i.e., minimize the impacts of incidents and other unusual conditions), and enhance the safety of our customers. To achieve these goals, such a strategy must address both recurrent and non-recurrent congestion. It can do so by addressing both the demand for travel and the capacity of our transportation system. It must balance the total demand among modes (e.g., highway, transit, and HOV) and it must take advantage of the under-utilized capacity of our highway system.

Today, the need to "manage" the State's transportation system is as critical as the need to expand and maintain it. Fiscal and environmental limits on highway expansion have highlighted the need for comprehensive system management. In recent years, Caltrans districts have added components such as ramp metering, High Occupancy Vehicle (HOV) lanes and transportation management centers to traditional lane and roadway expansion projects. These components have been implemented primarily to address specific problem areas. However, they also provide the necessary foundation for larger-scale system management.

Today, the need to "manage" the State's transportation system is as critical as the need to expand and maintain it

We believe that TOPS leverages this foundation, offering comprehensive system management that initially addresses the highway system. However, to truly optimize our entire transportation system, the highway strategies must be fully integrated with other modes and must incorporate local streets and arterials. As such, successful coordination with regional and local transportation agencies will be a critical success factor for reaping the full benefits of our strategy.

1.3 REPORT FORMAT

The remainder of this report is organized as follows:

- Section 2 defines TOPS, identifies its primary categories, and discusses the reasoning behind this emerging transportation strategy.
- Section 3 summarizes the current status of TOPS and preliminary plans for implementing TOPS throughout California.
- Section 4 discusses funding opportunities for implementing projects under the TOPS framework.
- Section 5 summarizes the benefits of representative investments from TOPS and how these benefits address corridor and system congestion.
- Section 6 presents our conclusions related to TOPS and the need to commit to its implementation.

[3] *Transportation Research Board, Highway Capacity Manual, Special Report 209, Third Edition, 1998*

2. What is TOPS?

TOPS is a comprehensive strategy to reduce congestion through improved system management. The goals of TOPS are to reduce congestion, especially on our most congested corridors, improve the predictability of travel time, and enhance the safety of our transportation system. Initially, the focus of TOPS is on the state highway system for which we plan to:

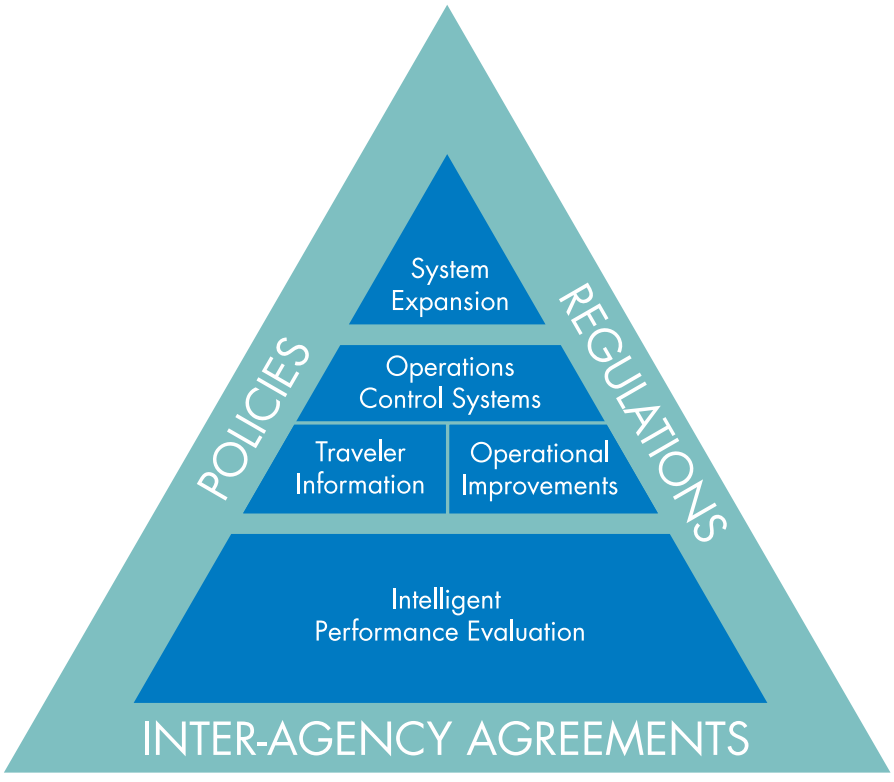
- Leverage today's enhanced communication technology to equip our state highway system fully with intelligence that provides real time information, allowing us to partner with the public to manage our transportation system better, and

- Adjust our current infrastructure to maximize traffic flows and restore under-utilized capacity.

However, TOPS must ultimately address all modes, incorporate local streets and arterials, and work hand-in-hand with infrastructure expansion strategies. As such, it requires coordination with regional and local agencies, and partnerships with the customer to address the demand side of transportation. Pricing policies, land use coordination and modal connectivity all must be addressed through a coordination effort illustrated in Exhibit 2-1 below.

When fully implemented and deployed, TOPS investments may provide congestion relief equivalent to adding as much as one lane to many congested freeway segments in California's urban areas. Since the cost of implementing TOPS is a fraction of the cost of the equivalent infrastructure expansion, TOPS is a more cost-effective investment.

Exhibit 2-1: TOPS Coordination



The overall benefit-cost ratio of TOPS is expected to be about nine-to-one (9:1) compared to less than three-to-one (3:1) for the typical system expansion project.

TOPS shifts our focus to corridor and system management, but TOPS should not be viewed as a replacement for infrastructure expansion. Adding roads and lanes has proven useful in addressing mobility needs in the past and cannot be ignored for the future. For certain corridors in California, system expansion is and will remain the only reasonable solution. TOPS investments and system expansion should work in concert, ultimately managing the total transportation system.

TOPS offers an "Operations First" approach to corridor and system planning. By evaluating the demands and constraints for each transportation corridor, we can manage capacity without focusing entirely on traditional system expansion. TOPS is designed to increase mobility and improve system performance.

By emphasizing statewide congestion management, TOPS provides a platform for inter-district planning and minimizes gaps or inconsistencies in regional and statewide system management efforts. Coordination between districts will ensure that issues affecting contiguous districts are not "dropped" at the district boundary, ultimately providing motorists with seamless traffic congestion measures and integrated sources of timely, accurate traffic information. District TOPS plans will be integrated and coordinated at the State level, with particular attention to neighboring districts in congested urban areas.

2.1 ELEMENTS OF TOPS

TOPS focuses our planning, implementation, and operations on system management. This approach complements current and projected infrastructure expansion investments and focuses future efforts in four primary areas:

- **Completing the "intelligence" component of our existing infrastructure.** New communications technology, better monitoring tools, and new control equipment can create an "intelligent infrastructure" that allows optimal routing of travelers to their desired destinations. Sample investments include system-wide adaptive ramp metering, changeable message signs, traffic management centers, incident response systems, advanced traveler information systems, and real-time performance measurement. These improvements provide the capacity for accurate, focused performance measurement, resulting in the real-time feedback necessary to maximize the performance of the existing system.
- **Correcting infrastructure limitations at the corridor and system levels with physical improvements to alleviate bottlenecks and increase overall traffic flow.** Potential investments include the construction of freeway auxiliary lanes (merge lanes provided before and after on-ramps), the modification of ramp/city street access, and the addition of short passing lanes and truck climbing lanes. As a result of a corridor approach to planning, projects in this category will allow motorists to take advantage of previously underutilized capacity. Since these projects are smaller in scale, they can typically be implemented faster than larger infrastructure expansion projects.
- **Filling gaps in the high occupancy vehicle (HOV) network to eliminate traffic disruptions that result when HOVs merge with other vehicles.** Merging causes traffic delays that can be experienced miles away. Potential investments to address this problem include the construction of drop ramps and freeway-to-freeway HOV connectors, as well as closing HOV gaps that exist within corridors. Because these investments improve travel times for HOVs corridor-wide, they can be expected to encourage an overall increase in carpooling. In addition, HOV network improvements facilitate the implementation of rapid bus systems.
- **Modifying selected freeway-to-freeway interchanges to minimize traffic flow disruptions and resulting congestion.** These modifications generally include the re-routing of merging traffic beyond the intersection point and through extended auxiliary lanes. Although generally more expensive, projects in this category can be extremely effective for improving traffic flows at major urban freeway interchanges. Freeway-to-freeway interchanges with design deficiencies can create significant choke points because they require traffic to merge or weave. Improvements at these interchanges will reduce recurrent delays.

Caltrans has developed TOPS implementation plans that combined projects in each of these categories on a corridor and system basis. The current status of TOPS and a summary of these plans are described in the next section.

3. Current Status of TOPS

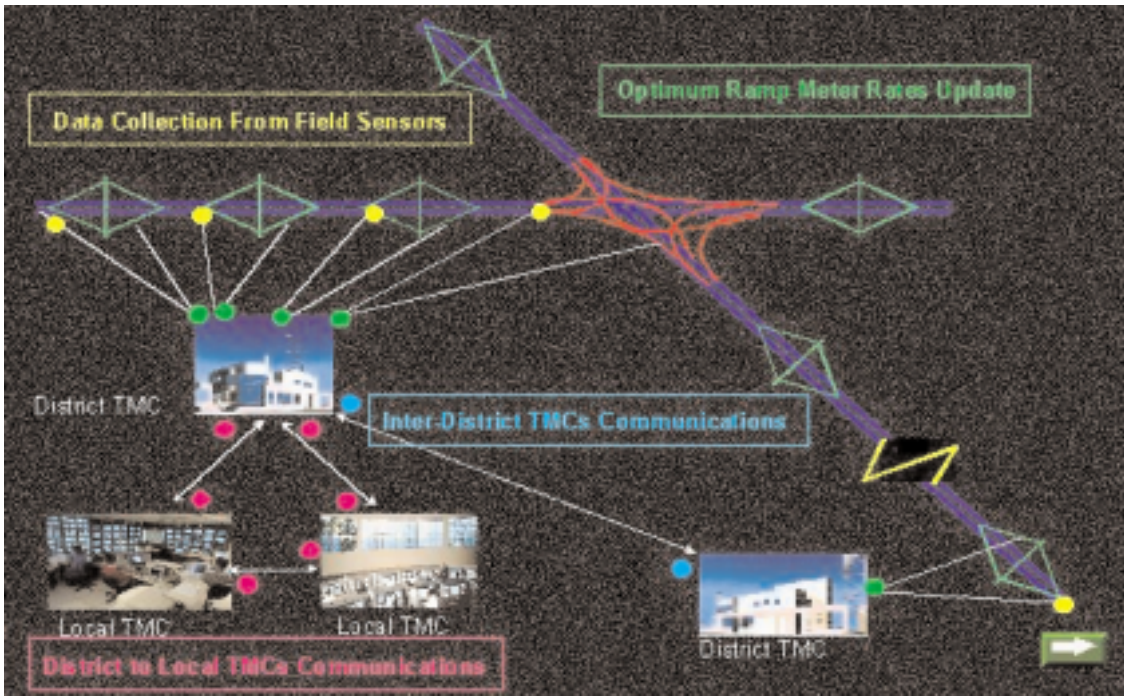
California has made an enormous investment in its state highway system, which is estimated at $300 billion (in today's dollars) over the last century. Within the last two decades, the State has recognized the growing need to manage and operate the system better. Some progress has been made in the development and deployment of components, such as ramp meters, that give us the tools to help manage and operate the transportation system.

Since these tools have relied on emerging technologies, they could not be part of a comprehensive strategy until now. Moreover, research sponsored by Caltrans has provided us with critical tools for planning and analysis. Even though many of these tools have been funded with limited budgets to address site-specific problems, TOPS can build on the foundation created by our existing infrastructure by incorporating four main components. The status of each component is summarized as follows:

- **Intelligent Infrastructure –** Caltrans has deployed intelligent infrastructure elements over the last two decades. TOPS requires additional investment in these components. In addition, recent innovations enable us to plan and implement a more fully integrated intelligent infrastructure linked by new telecommunications technologies. Exhibit 3-1 provides an example of how telecommunications can link field sensors, ramp meters, and transportation management centers.

We estimate that approximately 20 percent of the intelligent infrastructure planned under TOPS has been implemented under previous efforts. In addition, we estimate that an additional 15 percent has been programmed. Table 3-1 summarizes the status of this category by sub-element.

Exhibit 3-1: Example of Integrated Intelligent Infrastructure



Linked field sensors, ramp meters and TMCs facilitate better system management.

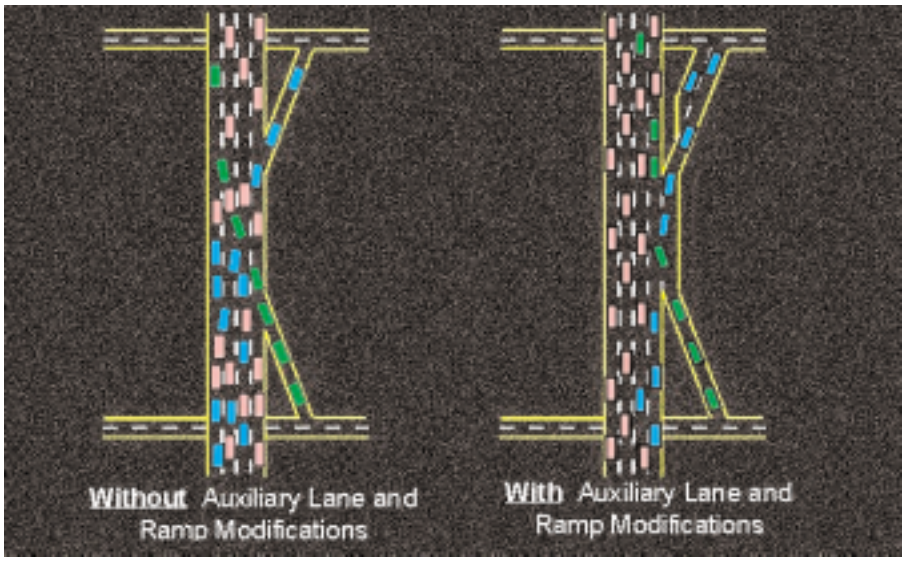
Table 3-1: Intelligent Infrastructure Buildout

ELEMENTS	EXISTING UNITS	PROGRAMMED UNITS	UNFUNDED UNITS	TOTAL UNITS
Transportation Management Centers (TMCs)	8*	4**	5***	11
Closed Circuit Televisions	570	623	920	2113
Fixed Changeable Message Signs	357	125	460	942
Fixed Highway Advisory Radio	72	46	135	253
Metering and Metering Control	1786	234	1512	3532
Traffic Monitoring Stations	2997	874	3475	7076
Roadway Weather Information Systems	27	16	198	126
Fiber Optics Communications (Miles)	152.5	553.9	1317	2023

** Existing TMCs in Districts 3, 4, 6, 7, 8, 10, 11, and 12*
*** Interim or final TMCs in Districts 3, 7, and 12, and upgrade to TMC in District 6*
**** New TMCs in Districts 6 and 8, improvements to TMC in Districts 7 and 11, and final TMC in District 8*

- **Physical Operational Improvements –** These improvements address bottlenecks or choke points that are created by existing capacity limitations. Caltrans has historically addressed these limitations on a project-by-project basis in a fiscally constrained environment as part of the SHOPP program. Caltrans districts have identified the projects necessary to address these deficiencies on a statewide basis. Specific needs are described further in Section 4 of this report. Exhibit 3-2 illustrates a typical physical operational improvement project.

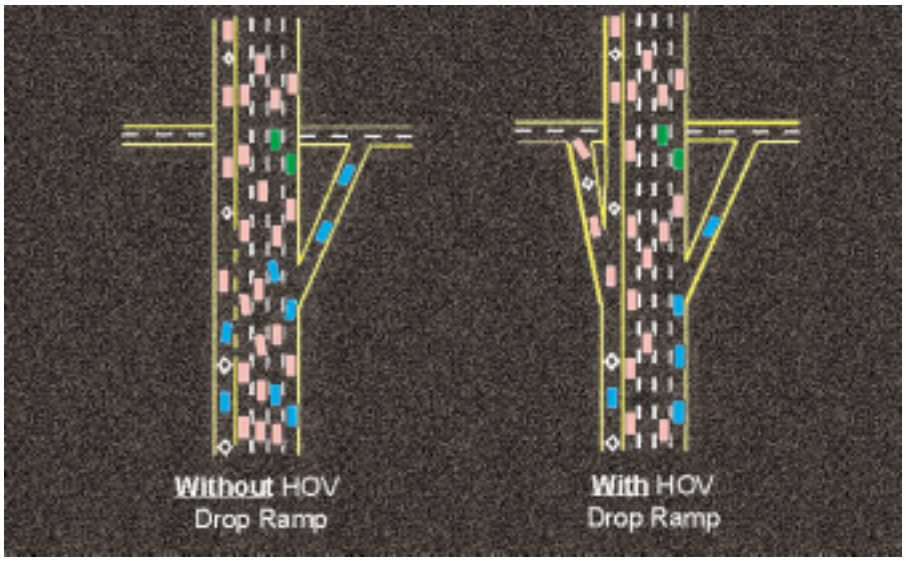
Exhibit 3-2: Auxiliary Lane and Ramp Modifications



Disruptions due to merging traffic are reduced

- **HOV Gap Closures –** Over the last 10 years, Caltrans and its regional partners have taken the first steps towards constructing a full HOV network by implementing HOV lane additions on a corridor basis. Today, California operates approximately 925 miles of HOV lanes. Nearly 127 additional HOV lane-miles are under construction, and 792 more HOV lane-miles are proposed. TOPS plans aim to link existing and future HOV lanes, filling any gaps to create a fully connected HOV network. These projects will include drop ramps and other strategies to alleviate the need for HOVs to cross other lanes of traffic. In addition, these projects will benefit future bus rapid transit systems. Exhibits 3-3 and 3-4 provide illustrations of HOV drop ramp and connector projects.

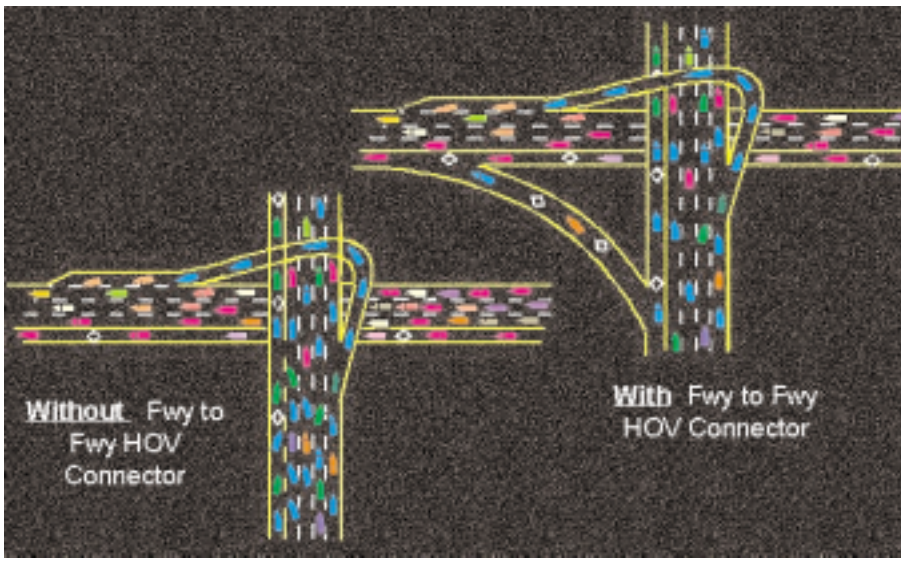
Exhibit 3-3: HOV Drop Ramp



Disruptions due to exiting HOVs are reduced.

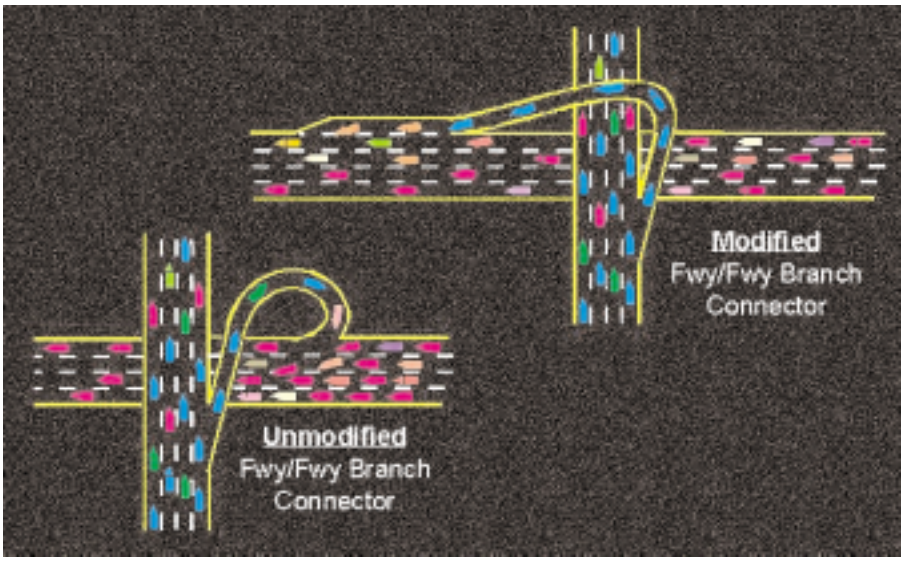
Exhibit 3-4: HOV Connector

HOVs can switch freeways without cutting across lanes.



- **Freeway Interchange Modifications –** Increasing demand has put significant pressure on major urban freeway interchanges. In some cases, the original design for these interchanges has become an impediment to traffic flows. We have identified a number of freeway interchanges where modifications will improve flow significantly. Exhibit 3-5 provides an illustrative example of a freeway interchange modification.

Exhibit 3-5: Freeway Interchange Modification

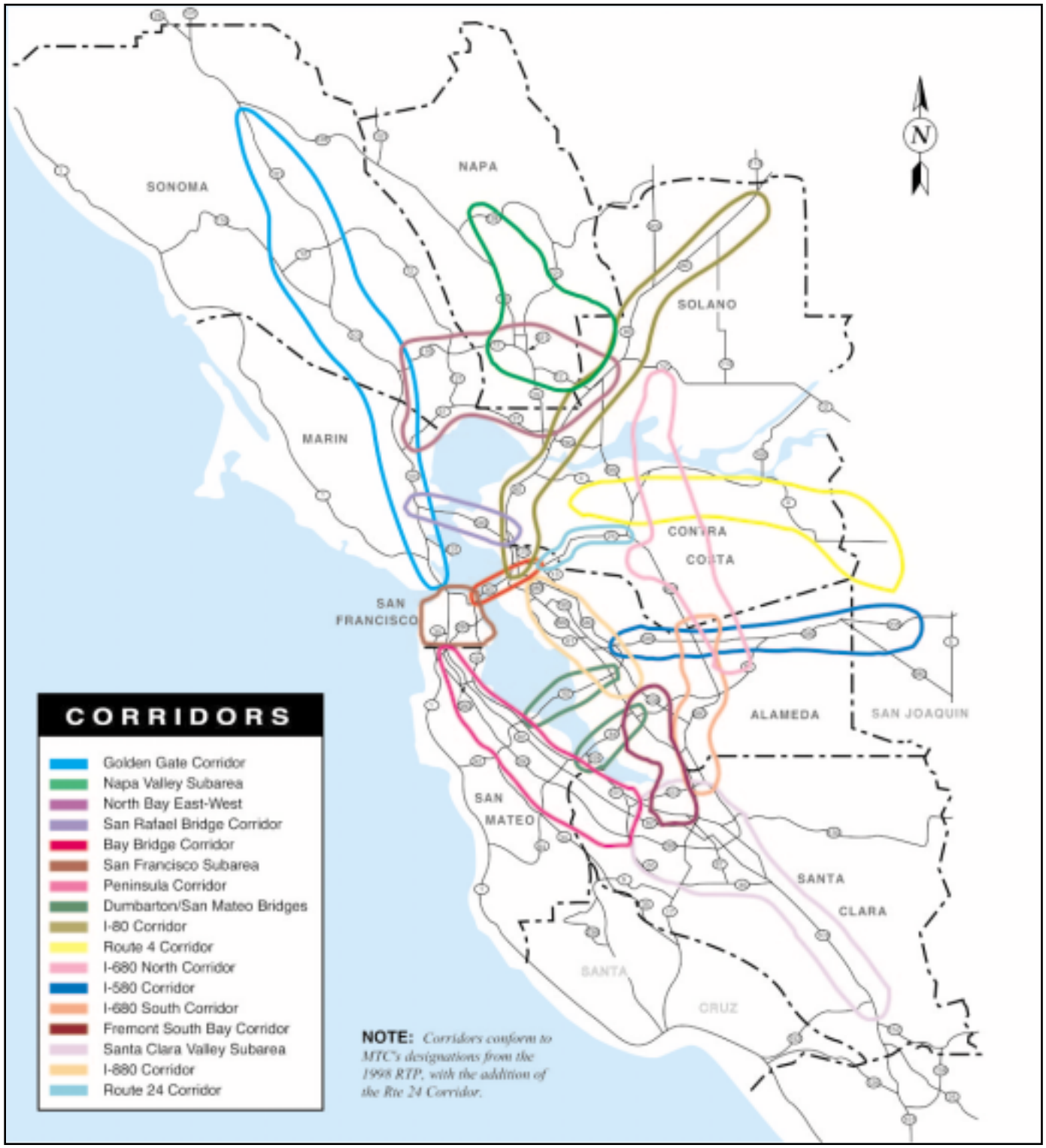


Modified connectors provide more room for traffic to merge safely.

Our approach to integrating these components and implementing TOPS focuses on corridor and system-wide mobility problems. Exhibit 3-6 illustrates how a regional transportation system can be divided into corridors in the San Francisco Bay Area. These designations build on the ones used by the Metropolitan Transportation Commission (MTC) in its 1998 Regional Transportation Plan. The same type of designation has been or will be made shortly for every district in California. Once the corridors are defined,

we overlay the known choke points for each corridor and analyze each separately and in conjunction with other corridors in the region.This analysis has already started in many districts and will continue for some time leading to corridor-wide implementation strategies.These projects can be staged as described in the sections that follow.

Exhibit 3-6: San Francisco Bay Area Transportation Corridors



3.1 WHERE DO WE GO FROM HERE?

We already have a tremendous foundation for implementing TOPS. In today's dollars, the State has invested about $300 billion in the existing state highway system. It has served us remarkably well given that over 75 percent was built more than twenty years ago. In addition, the State has incrementally added components of the intelligent infrastructure envisioned under TOPS. A significant portion of the required intelligent infrastructure is either installed or programmed.

The State now has an opportunity to take advantage of its previous investments to implement TOPS rapidly as a cost-effective strategy for addressing California's congestion. Full implementation requires progress in two primary areas:

- Developing state and regionally focused TOPS implementation plans
- Assuring appropriate TOPS funding.

In the short term, each district will select one of its corridors for demonstration deployment. Investments required for the demonstrations will be given higher funding priority. Other corridors will continue to be analyzed and prioritized for subsequent deployment.

3.2 TOPS IMPLEMENTATION PLANS

Caltrans has already begun to develop comprehensive plans for implementing TOPS. Every Caltrans district has submitted preliminary project lists, which will be refined over the next few months to produce a detailed 10-Year TOPS Plan. The 10-Year Plan will be completed over the coming year and presented to the Legislature no later than this time next year.

Highway congestion is not confined to urban areas, therefore projects are proposed for every district in the state. As illustrated in Table 3-2, TOPS projects can be broken into three potential investment levels:

Table 3-2: Representative TOPS Projects

LEVEL 1		LEVEL 2	LEVEL 3
Intelligent Infrastructure	**Physical Operational Improvements**	**HOV Network Gaps**	**Freeway Interchange Modifications**
• Changeable Message Signs • Closed-Circuit Televisions • Communication Links • Fiber Optics • Highway Advisory Radios • Metering and Metering Control • Roadway Weather Information System • Signal Upgrades • Traffic Monitoring Stations • Transportation Management Center Upgrades	• Alignment Upgrades • Auxiliary Lanes • Intersection Upgrades • Lane/Shoulder Widening • Passing Lanes • Ramp Modifications • Other	• HOV Connectors • HOV Drop Ramps • HOV/Managed Lanes • Other	• Freeway Connectors • Freeway Connector Metering

- **Level 1** focuses on congestion at choke points through minor operational improvements, such as auxiliary lanes and intersection modifications, and the addition/coordination of intelligent infrastructure. This level can be further separated into operational improvements and investments in intelligent infrastructure.
- **Level 2** adds HOV capacity and operational improvements. Representative projects include HOV gap closures, moveable barrier projects, HOV drop ramps, and HOV ramp meter bypasses.
- **Level 3** includes major operational improvements, such as freeway-to-freeway connectors.

Caltrans anticipates that initial investments will be focused on the first level. By addressing choke points along specific corridors and completing the intelligent infrastructure required to produce congestion-reducing benefits beyond what the physical infrastructure alone can produce, the first level of TOPS investment adds significantly to the state's ability to manage traffic congestion. As Exhibit 3-7 illustrates, combined operational improvements and infrastructure investments for the first level represent over 45 percent of TOPS projects.

3.3 REGIONAL COORDINATION

TOPS represents a system operation-centered approach that requires institutional coordination at the planning, operations and funding levels. Full implementation of these strategies will require significant regional coordination.

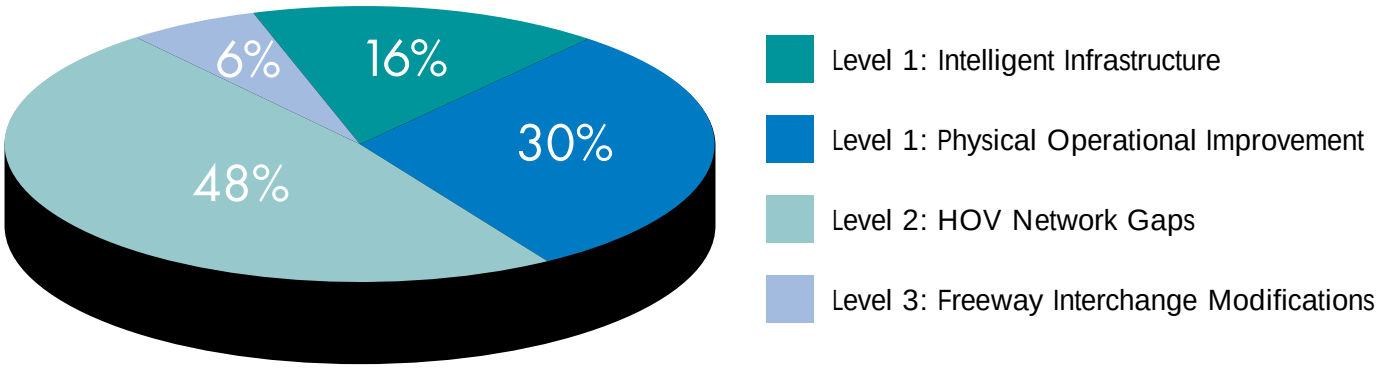
TOPS represents an operation-centered approach that requires institutional coordination at the planning, operations, and funding levels

Currently, regional planning is accomplished through the local regional transportation planning process and the development of the Regional Transportation Improvement Program (RTIP).

Caltrans districts are working and will continue to work with local and regional planning agencies to produce comprehensive TOPS plans. These plans will ensure that the projects identified in the 10-Year TOPS Plan are embedded in the regional plans and the regional planning process and are at least partly financed through RTIPs.

Conversely, Caltrans will coordinate with regional agencies in developing the State SHOPP plan to demonstrate the commitment to overall system management and develop effective partnerships to combat congestion.

Exhibit 3-7: Potential Split of TOPS Projects by Level



4. TOPS Funding Opportunities

Some TOPS investments are likely to be funded through the State Highway Operation and Protection Program (SHOPP). *The Ten-Year State Highway System Rehabilitation Plan* is the guiding document that sets SHOPP strategies and objectives, describes system deficiencies, and recommends funding. SHOPP funding extends to four elements: traffic safety, roadway rehabilitation, roadside rehabilitation, and operations.

This year may present a unique, although short-lived, funding opportunity for TOPS. At its August 1999 meeting, the California Transportation Commission (CTC) adopted the four-year 2000 State Transportation Improvement Program (STIP) Fund Estimate. During deliberations, the CTC identified a potential lapse in federal funding in the Local Assistance Program. The CTC created a "Contingency Fund" to prevent such a lapse. The CTC directed that this fund would emphasize TOPS and that the Department would manage the fund with the SHOPP.

Three federal programs were identified for the Contingency Fund:

- Congestion Mitigation and Air Quality Improvement (CMAQ)
- Regional Share of Surface Transportation Program (RSTP)
- Regional Share of Bridge Program (BR).

However, not all contingency funds may be available for TOPS. The federal programs identified have conditions limiting the types of projects, geographic areas, and timing for fund usage.

The Ten-Year SHOPP Plan targets CMAQ funding for TOPS projects. RSTP funds may be appropriate for TOPS. The 10-Year SHOPP Plan currently directs these funds toward expediting safety projects, pavement rehabilitation projects, and protective betterments.

Caltrans cannot count on the Contingency Fund being available in this or any future years. The unfunded needs identified for first-level TOPS projects may need to come from other sources, such as local funding commitments and future years of the STIP. Getting local funding commitments requires coordination with local and regional entities. The investments proposed in TOPS are consistent with needs identified by the California Alliance for Advanced Transportation Systems (CAATS) ITS Deployment Initiatives Strategic Plan, which has been developed with significant local and regional involvement.

5. Summary of TOPS Benefits

TOPS focuses on system management and therefore yields system-wide impacts. It achieves larger benefits than can be achieved by individual projects such as the placement of a Changeable Message Sign (CMS) or the construction of an auxiliary lane. For example, communications systems, ramp meters, and ramp widening constructed at a key bottleneck, such as Interstate 210 near Mountain Street in Los Angeles, and coordinated in operation with other TOPS improvements are likely to produce greater benefits due to network effects than any of these investments made individually.

Additional benefits result when investments to address congestion along specific corridors and at particular bottlenecks are coordinated so that the entire network of highways is placed in balance. This coordination extends beyond project placement to include construction and operations issues. TOPS' emphasis on corridor and system-wide impacts will include a consideration of the timing of construction projects in order to minimize delay and will provide an intelligent infrastructure that supports synchronized operations.

We estimate that the first level of TOPS will produce a benefit-cost ratio of 8.9 to 1, far higher than the typical STIP project

5.1 HOW EFFECTIVE WILL TOPS BE?

Caltrans estimates that TOPS will produce significant benefits for relatively small costs compared to typical STIP projects. To estimate these benefits, Caltrans worked with researchers at the University of California at Berkeley and Irvine.[4] The types of benefits we expect from the full implementation of TOPS include:

- **Mobility –** We expect a total reduction in delay due to congestion as we balance demand across our systems and recapture under-utilized capacities on the state highway system. We also expect delay reduction due to improved incident detection and management activities. Although not included in our benefit calculations, the aggregate delay reductions will have a positive impact on productivity, which in turn helps the economy.
- **Safety –** We expect improvements in all aspects of incident management. As a result, we anticipate an overall reduction in secondary accidents that occur at incident locations. As we reduce congestion, we will also reduce the total number of accidents.
- **Reliability/Predictability –** As we reduce the total number of accidents and the time it takes to respond to and clear accidents, we expect trip time predictability to improve significantly.
- **Environment –** Vehicles emit higher rates of pollution during stop and go traffic than at higher speeds. We have estimated the benefits that result from air pollution emission reductions. This benefit is especially relevant in non-attainment regions such as Los Angeles.
- **Vehicle Operating Costs –** As stop and go traffic is reduced, vehicle operating costs are also reduced due to lower fuel consumption and decreased vehicle wear.

We added all the benefits, with the exception of safety and reliability, which are difficult to quantify or predict, and divided the sum by the cost to derive the aggregate benefit/cost ratio. As a result, we estimate that the first level of TOPS will produce a benefit-cost ratio of 8.9 to 1, far higher than the typical STIP project.

For comparison purposes, consider the returns of recent transportation projects in California. The Department initially analyzed 145 projects for consideration in the Inter-Regional Transportation Improvement Plan (ITIP) portion of the 1998 State

[4] *The University of California at Irvine (UCI) modeled the effect of intelligent infrastructure investments on non-recurrent congestion and the benefits of physical operational improvements for representative sections of Orange County. The University of California at Berkeley (UCB) tested the effect of intelligent infrastructure investments on recurrent congestion for a sample network using the FHWA ITS Deployment Analysis System (IDAS).*

Table 5-1: Summary of TOPS Benefits

Category	Benefit-Cost Ratio
Level 1: Intelligent Infrastructure	10.1 to 1
Level 1: Physical Operational Improvements	8.3 to 1
Level 1: TOTAL	8.9 to 1
Level 2: HOV Network Gaps	TBD
Level 3: Freeway Interchange Modifications	TBD

Transportation Improvement Plan (STIP). These projects accounted for a total statewide investment of $5.1 billion with an average benefit-cost ratio of 2.7 to 1. System expansion projects, such as lane additions, freeway conversions and bypasses, produced benefit-cost ratios of only 2.4 to 1.

Based on the modeling conducted by UCI and UCB, Table 5-1 shows the potential benefits of TOPS, if we assume that similar benefit-cost ratios resulted statewide.

The benefits associated with implementing Level 1 TOPS are discussed in more detail below. Benefits can be broken down by whether they result from intelligent infrastructure or physical operational improvements. The intelligent infrastructure will help us address both recurrent and non-recurrent congestion and provide two sets of benefits. Physical improvements will target recurrent congestion only and provide a single set of benefits.

5.2 INTELLIGENT INFRASTRUCTURE AND RECURRENT CONGESTION

Recurrent congestion describes the regular, everyday rush-hour delays that occur when highway design capacities are exceeded, while non-recurrent congestion is caused by irregularly occurring events. These delays are a major problem on today's freeways. The last Highway Congestion Monitoring Program (HICOMP) report indicates that nearly 418,100 daily vehicle-hours of delay due to recurrent congestion occurred statewide in 1998. Since HICOMP monitors congestion only on urban freeway segments with a history of recurrent congestion and excludes congestion on other State highways and in rural areas, total recurrent congestion on all California highways is likely to be higher.

From the public's perspective, the most noticeable effect of recurrent congestion is increased delays and reduced mobility at major and minor bottlenecks, such as the I-580/I-880/I-80/SR24 interchange (frequently called "the Maze") in the San Francisco Bay Area. Intelligent infrastructure holds the potential for reducing recurrent congestion through metering and traffic monitoring. Metering programs, such as the timing lights at the San Francisco Bay Bridge toll plaza and ramp meters in Southern California, have been shown to reduce travel time delay significantly. To get a sense of the benefits of these metering programs, consider the traffic snarls that result on the rare days when the timing lights are not operational at the Bay Bridge toll plaza. Traffic monitoring allows metering to be coordinated and optimized across the highway system.

UCB examined the potential effects of coordinating a network of ramp meters using an intelligent centralized control system. Simulations using the federally-sponsored IDAS program showed that adding centralized control to metering systems reduces total travel time by an additional 13.1 percent compared to ramp meters alone. If a travel time reduction similar to that forecasted by UCB were to occur in Orange County, the intelligent infrastructure would produce a benefit-cost return of 5.7 to 1. Since these projects also have the potential to reduce non-recurrent congestion, they may produce even further benefits.

5.3 INTELLIGENT INFRASTRUCTURE AND NON-RECURRENT CONGESTION

Intelligent infrastructure, such as ramp metering control or advanced traveler information systems, also has the potential to reduce non-recurrent congestion. The most difficult problem associated with non-recurrent congestion is that it can be unpredictable, since it is caused by irregularly occurring events, such as accidents, weather, special events, maintenance, and construction. Research conducted by Caltrans indicates that total delays due to non-recurrent congestion are roughly equal to total recurrent delays. Since the location, duration, and magnitude of the congestion cannot be predicted, these delays cannot be "fixed" through physical improvements.

TOPS addresses non-recurrent congestion by applying advanced technologies in traveler information and operational controls. Monitoring systems, such as loop detectors and weather information systems, sense the occurrence of congestion-producing events. Traveler information systems, such as changeable message signs and highway advisory radios, warn travelers of congestion ahead and offer alternate routes. Operational controls, such as ramp and freeway meters, ensure that additional traffic does not contribute to the congestion. Emerging technologies, such as global positioning systems (GPS) and on-board computers, can provide additional tools for combating congestion. (These technologies also offer opportunities for public-private partnerships. TOPS initiatives will be coordinated with CAATS to ensure that these opportunities can be fully realized.)

To illustrate the benefits of TOPS on non-recurrent congestion, the University of California at Irvine (UCI) modeled the impact of centralized ramp meter control and coordinated traveler information systems in the area of the Orange County Y formed by Interstate 5, Interstate 405 and State Route 133.

UCI found that, across a variety of scenarios, combined advanced traveler information systems (ATIS) and advanced traffic management systems (ATMS) reduce non-recurrent delay by 33 percent. Assuming that our existing traffic management centers (TMCs) already achieve a quarter of these benefits and that similar benefits would occur throughout Orange County, this reduction in delay translates into benefit-cost ratio of 4.4 to 1. When added to the benefits associated with the reduction in recurrent delay, this intelligent infrastructure investment produces a total return of 10.1 to 1.

5.4 PHYSICAL OPERATIONAL IMPROVEMENTS

Level 1 TOPS projects coordinate intelligent infrastructure with projects to address bottlenecks or choke points that are created by unanticipated design deficiencies. To measure the impact of implementing projects that address design deficiencies, the University of California at Irvine (UCI) simulated the impact of implementing twelve projects that address choke points throughout Orange County.

Each project addresses a specific roadway bottleneck through a combination of improvements. For instance, I-405 between Talbert Avenue and Beach Boulevard experiences severe congestion and long delays due to weaving traffic and highway design deficiencies. The proposed solution to this problem is to extend auxiliary lanes and reconstruct the interchange at Brookhurst.

UCI found that the twelve projects reduced travel times in Orange County by 14 percent on average. This translates to an overall benefit-cost ratio of 8.3 to 1. Benefit-cost ratios for individual projects ranged from 4 to 1 to more than 60 to 1.

6. Conclusion

The research, analysis, and evaluation of TOPS projects clearly indicate that it is a strategy that must be implemented aggressively. This is especially true for level-one projects (i.e., intelligent infrastructure and physical operational improvements), for which we conducted in-depth testing and evaluation. The 9:1 benefit-cost ratio of these investments is almost three times as large as traditional highway expansion projects. Moreover, these same investments will increase the benefits associated with expansion projects by maximizing the utilization of any added physical capacity.

California is not alone in recognizing the need for and the benefits derived from operation-centric strategies. In Europe, the Netherlands implemented most of its intelligent infrastructure projects, including an automatic and operator controlled traffic management (MTM) system and reports that:

- Overall travel time decreased by 10 to 15 percent.
- Accident frequency declined by as much as 20 percent.
- The number of vehicles involved in accidents was reduced by 30 percent.[5]

Over the next few years, expect Caltrans to implement aggressively all the TOPS projects for which funding has been secured

Although our own estimates are more conservative, clearly we all want to achieve such benefits and more. As we move towards implementing TOPS, we must also stress the need to manage the demand side of transportation. TOPS will buy us some time and will optimize our highway system and ultimately help optimize our entire multi-modal, multi-jurisdictional system. However, even an optimized system can and will be overwhelmed when demand continues to exceed capacity by a large margin.

Over the next few years, expect Caltrans to implement aggressively all the TOPS projects for which funding has been secured. Also expect us to work with the private sector to exploit fully opportunities to integrate communication networks and encourage spin-off product development. In the end, full system management must involve the private sector as well as the individual traveler.

[5] *ITS Annual Review 1999, authored by Pernilla Hogman, Cap Gemini, Sweden*

Gray Davis
Governor

Maria Contreras-Sweet
Secretary, Business, Transport and Housing Agency

Jeff Morales
Director, California Department of Transportation

Kim Nystrom
Program Manager, Traffic Operations

For additional copies of this report,
please contact Stacy Watson at (916) 654-6097 or by email:
Stacy_Watson@dot.ca.gov.