Prevention of
Wrong-Way Accidents
On Freeways

A Research Report
By the Division of Traffic Operations

California Department of Transportation
Business, Transportation and Housing Agency
Disclaimer

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Senate bill 233 (Davis 1987) required a current study on the wrong-way problem on freeways. This report discusses solutions developed over the years to prevent wrong-way driving by Caltrans, results of recent camera surveillance studies and the current annual wrong-way monitoring program. To determine if other states had developed any new solutions to the problem, traffic engineers from all the states were surveyed.

The recommendations to prevent wrong-way accidents are in the areas of sign maintenance, annual accident monitoring using a check-list process, ramp and intersection design, and reducing drunk drivers. It also recommends the purchase of new still camera, video, or movie camera and detector equipment, and continuing the pavement light experiment in San Diego.
Prevention of Wrong-Way Accidents on Freeways was prepared by the

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Conclusions and Recommendations

Conclusions

Methods of preventing wrong-way driving on freeways were thoroughly reviewed in the preparation of this report. It is important to realize that half of the wrong-way driving on freeways is from deliberate, illegal U-turns. Measures taken to improve ramp operation would not affect this half of the wrong-way problem. For the other half, none of the physical barriers tested to date appear appropriate. Methods other than physical barriers have proven helpful in decreasing the incidence of wrong-way driving.

Effective treatments include repainting or adding wrong-way pavement arrows; reorienting, moving, or adding wrong-way sign packages; modifying the trailblazing freeway entrance packages; placing edge lines and pavement markers; upgrading signs with high intensity reflective sheeting; and modifying lighting. Occasionally more extensive measures could be used to solve the problem at unique locations, such as airport-type pavement lights, modifying the design features of ramp terminals and adding ramps to incomplete interchanges.

It is important to note that three-quarters of the fatal wrong-way accidents are caused by drivers involved with alcohol or drugs. This presents a difficult challenge in terms of developing appropriate solutions.

Additional wrong-way pavement arrows may be beneficial. The use of larger DO NOT ENTER signs may be considered if an off-ramp still has a recurring problem. Larger, highly reflective signs may be helpful for confused or elderly drivers. Use of red pavement lights which are activated by wrong-way drivers may be considered at locations where traditional treatment is not effective. The condition of wrong-way signing packages at off-ramps and directional signs is important.

Fatal wrong-way accidents as a percentage of all fatal accidents on freeways have decreased substantially in the last 20 years. This reduction is believed to be related to the many actions taken by Caltrans over the years. Despite this reduction, additional improvement should be possible, as outlined on the next page.
Recommendations

The actions Caltrans can take which should further reduce wrong-way accidents were identified during this in-depth review.

1. **Continue the annual monitoring of wrong-way accidents.** An annual review is made in the field of off-ramps, which have been identified as entry points or are near concentrations of wrong-way accidents. This practice should be continued. The "Check List for Wrong-Way Entry Review" (Appendix A), developed as part of this project, should be helpful.

2. **Conduct periodic reviews of every ramp.** The systematic periodic review of the ramps for missing or worn signs or pavement arrows, and for a variety of changed conditions is very important. The review begun late last year should be expeditiously completed. Future reviews should be scheduled on about a three to five year cycle.

3. **Purchase new still camera, video, or movie camera and detector equipment.** The further systematic photographing of wrong-way vehicle entries at each ramp is not needed. However, each district should have access to reliable equipment for those few cases where photographs or videotapes would be helpful. This equipment should be purchased by Headquarters Traffic Operations.

4. **Continue the pavement light experiment in San Diego.** Definitive data on the effectiveness of the pavement lights to prevent vehicles from entering the freeway in the wrong direction is still needed. New movie or video cameras are needed for this experiment. The cameras should be operated as long as necessary to obtain statistically significant data.

5. **Conduct a training effort for designers.** Ramp and intersection design can have a significant effect on wrong-way entries. Training classes or instructional material should be developed for designers, especially the new ones.

6. **Consider edge lines or heavy bars across off-ramps.** The only technique identified which has not been previously tried or considered in California is to carry edge lines or wide painted bars across the off-ramps. This technique should be further investigated.

7. **Consider the option of using a second set of Wrong-Way and Do Not Enter signs and wrong-way arrows further along the off-ramp.** The option of using additional signs and markings on selected ramps may give a drivers a second chance to realize that they are headed the wrong-way before they enter the freeway.

8. **Contact the California Highway Patrol (CHP) regarding the wrong-way problem.** The CHP has been very helpful in the past. They should be contacted again to stress our continued interest in identifying problem ramps.

9. **Review the Traffic and Design Manuals.** Although not specifically discussed in this report, both the Traffic and Design Manuals should be reviewed to see that they reflect the latest thinking.
Introduction

This report is a current review on preventing the incidence of wrong-way driving on freeways. It also discusses solutions to decrease entering or leaving freeways via on-ramps and off-ramps in the wrong direction. This report discusses in more detail the report required by Senate Bill No. 233 (Davis, 1987) which was submitted to the California legislature in December 1988. This bill afforded Caltrans an opportunity to critically review the steps being taken to reduce wrong-way accidents, and to determine if any other states had developed any new solutions to this problem.

Because wrong-way accidents are tragic, they have been under intensive study by the California Department of Transportation (Caltrans) for nearly 30 years. Wrong-way fatal accidents account for about three percent of the fatal accidents on California freeways and about five percent of the fatalities. The actual number of wrong-way fatal accidents is the same today--about 35 per year--as in 1963 despite the fact that freeway travel has increased five-fold. Various actions taken by Caltrans over the years have been successful in preventing these accidents from increasing in proportion to the travel.

To review current practices in preventative methods, traffic engineers from the states were surveyed. The annual wrong-way monitoring program conducted by engineers in California's districts is discussed. Camera surveillance studies were conducted at seven off-ramps in southern California especially for this report. The renovated pavement lights projects in San Diego were reviewed. In addition, the California Highway Patrol's (CHP) programs against drunk drivers are summarized.

*See references starting on page 36.*
History of Wrong-Way Research

The problem of wrong-way driving on freeways has been studied intensively by Caltrans, formerly the California Division of Highways, since 1961. During this year, the California Highway Patrol, at the request of the Division of Highways, reported on 743 incidents of wrong-way driving.1,2 Immediate solutions were needed to the developing problem of wrong-way accidents as significant portions of new freeways were being opened to traffic.

By 1964, wrong-way signs and 24-foot white wrong-way pavement arrows had been developed by Caltrans and were being installed on California's freeways.4 The original signs included a black on white "DO NOT ENTER" sign mounted on the same post with a white on red "WRONG WAY" sign. White on green "FREEWAY ENTRANCE" signs at either side of on-ramp entrances were also posted to aid motorists in finding the correct way onto the freeway. Further studies on wrong-way sign colors indicated white on red was seen earlier than black on white.5 The "DO NOT ENTER" sign was later revised to white on red. These signs and pavement arrows were adopted as a national standard in 1967.

In the mid-1970s, the "Do Not Enter" packages were upgraded and other improvements were made in signing, delineation, lighting, and ramp design at the on- and off-ramps. Automatic cameras were used to record wrong-way entries. The cameras were in place for a minimum of 30 days at each of 4,000 off-ramps across the state.20 The "Do Not Enter" sign packages were relocated and lowered for better visibility to the headlights of vehicles entering the wrong-way. These various actions reduced the frequency of wrong-way moves from as high as 50 to 60 to 2 to 6 per month at problem ramps and completely eliminated them at the majority of ramps. The camera surveillance indicated that wrong-way entries were reduced to low levels of less than 2 per month at 90% of the ramps with previous entry problems.

In 1978, follow-up camera surveillance revealed that the most effective corrections for wrong-way movements were: the installation of "FREEWAY ENTRANCE" signs at on-ramps, and "DO NOT ENTER" and "WRONG WAY" signs at off-ramps; posting supplementary trailblazing signs and extra lighting at on-ramps; reducing the off-ramp throat opening and eliminating the free right turn from the off-ramp.20 These improvements have been incorporated into present standard procedures.

Locations where the sight distance was less than 1200 feet (366 m) on the mainline freeway lanes were the site of over one-half of the fatal and injury accidents.9 Design standards were changed to increase sight distances on new freeways. For over 25 years, data has been accumulated for wrong-way accidents and their corresponding off-ramp classifications. A few types of ramps and interchanges, such as the cul-de-sac, button hook, trumpet, and two quadrant cloverleaf were determined to have a greater number of wrong-way accidents than other types.4,7,8,13 Modifications to these interchanges are discussed later in this report. Also studies found that left-hand off-ramps appeared to be on-ramps to the wrong-way driver, and should be avoided.
During the late 1960s Caltrans installed red-backed reflective pavement markers on the lane lines on freeways. The Department of Motor Vehicles educated the public to the concept that a driver who sees red reflectors is going the wrong-way. The reflectors proved to be of limited value, especially with drunk drivers. Therefore, the red-backed markers are now installed only in the vicinity of off-ramps as a secondary treatment.

In 1965 parking lot spike barriers were tested to determine if they could be used at off-ramps to stop vehicles from entering the wrong way. Unfortunately, these devices were not found suitable. The spikes, even when modified with a fish-hook shape, would not cause tires to deflate quickly enough to prevent a vehicle from entering the freeway. Under high-volume traffic the spikes broke, leaving stubs that would damage the tires of right-way vehicles. It was believed that some right-way drivers, upon seeing the spike barriers, would hit their brakes and create a hazardous situation. Also, camera surveillance of off-ramps indicated that most drivers quickly realized they were starting a wrong-way entry and took corrective action. The spike barriers could prevent this corrective action from being taken.

California has designed moveable gates to bar traffic from high occupancy vehicle lanes. The gates are designed to stop even the heaviest vehicle. However, the gates take approximately 20 seconds to lower or raise, which is far too slow for a wrong-way vehicle entering a ramp. With the present state of the art, gates would not be appropriate for retaining a wrong-way vehicle.

The state of Georgia tested a pop-up device that presented a physical curb-like barrier to the wrong-way driver, but it was unsuitable for reasons similar to those of the spike barriers. A recent poll of the 50 states revealed that none has found a suitable physical barrier. No state is presently testing or considering to use barriers.

California tried adding horns and flashing red lights over the "WRONG WAY" signs in the 1970s, but these were found to be ineffective and drew complaints from neighbors.

One device that was tried did show promise. Red, airport-type pavement lights, embedded in the pavement across an off-ramp, activated by wrong-way vehicles, were shown by camera monitoring to reduce further wrong-way entries. From camera monitoring, about half of the wrong-way drivers at these ramps braked before reaching the wrong-way signs. Nearly half continued past the signs but braked before the pavement lights. However, some continued past the pavement lights and went out of view of the camera.
Reports on wrong-way driving have concluded that drinking drivers were responsible for three out of every four wrong-way accidents on California freeways. The typical wrong-way driver had received more traffic violations and more felony convictions and had been involved in considerably more accidents of all types than the average motorist. Another complicating characteristic of wrong-way drivers is that many make intentional U-turns on freeways; they do not enter via an off-ramp. Nearly half of the wrong-way accidents are caused by U-turns and half from wrong-way entries via off-ramps.

Since 1985, Caltrans has had a program to monitor wrong-way accidents. Ramps in the vicinity of wrong-way accident sites are investigated. Field reviews are conducted to make sure that signs and markings are in good repair, and that there are no conditions which could mislead drivers. A wide variety of improvements are made as are found appropriate.

In terms of technology development, rather than research, new materials have been developed for the wrong-way signs and markings in recent years. High intensity reflective sheeting for signs has recently been adopted for the wrong-way and freeway entrance sign replacements and upgrades. The use of larger signs also provides more visibility, especially for elderly drivers. Thermoplastic pavement wrong-way arrows are now being installed. The thermoplastic has a high reflectivity and greater durability.

With the results of present technology, new materials are being tested for wrong-way signs and markings. Synthetic materials are being developed for anti-theft signs in "high vandalism" urban areas (motivated by the aluminum resale value). An anti-graffiti coating is being developed. Innovations in reflective coatings are being made. The electronic system for the pavement lights is now more reliable under varying moisture conditions. Research is continuing on the effectiveness of these lights.

The research conducted to date has clearly led to a reduction in wrong-way accidents. This is illustrated in the next section. Other than continuing research into the accident reducing potential and reliability of the airport-type pavement lights, no research needs were identified.
Wrong-Way Accidents in California

The following charts and graphs highlight the wrong-way accident picture on California freeways. The number of fatal wrong-way accidents has averaged 35 per year over the last 20 years (Figure 1). The number of accidents has remained constant even as the miles of freeway and travel have increased substantially. Fatal wrong-way accident rates have decreased from about 1.5 per billion vehicle-miles of travel to under 0.4 (Figure 2). This is over a percent decrease.

Wrong-way accidents accounted for approximately 2.9% of the fatal, 0.3% of the injury and 0.1% of the property damage accidents on California freeways in 1987 (Figure 3). Wrong-way accidents tend to be more severe, and have a greater proportion resulting in death or injury than other types of accidents. In 1963, wrong-way accidents comprised of six percent of the freeway fatal accidents. By 1987, this figure had decreased to just under three percent. This is a reduction of over 50 percent.

Wrong-way accidents show distinct patterns by time of day (Figure 4). Caltrans is organized into 12 geographical districts. The freeways in districts 1,2,3,5,6,8,9,10 are predominantly in rural regions. The freeways in districts 4,7,11,12 are mostly in urban areas. Wrong-way accidents peak around 2 to 3 a.m. in every district, although this is more noticeable in the urban areas. The bars are required by law to close at 2 a.m. in California. The higher traffic volumes during the day in urban areas probably depress the wrong-way accidents during these hours. Urban areas have a much greater number of wrong-way accidents than rural areas.

The sobriety of drivers in wrong-way accidents on California freeways is shown next (Figure 5). During 1983 to 1987, the majority of the drivers either had been drinking or were driving under the influence of alcohol or drugs. Impaired drivers accounted for a staggering three-quarters of the wrong-way accidents. Drivers with drugs or alcohol in their systems are the number one cause of wrong-way accidents on California freeways.

Fatal wrong-way accidents as a percentage of all fatal accidents on freeways have decreased in the last 20 years. This reduction is believed to be substantially related to the many actions taken by Caltrans over the years.
The number of wrong-way fatal accidents is the same today as in 1963, approximately 35.

Source: Caltrans Traffic Accident Surveillance And Analysis System (TASAS)
Research into solving the problem of wrong-way drivers started in the early 1960s. As new solutions have been found, the number of fatal wrong-way accidents per billion vehicle-miles traveled has decreased.

Source: Caltrans Traffic Accident Surveillance And Analysis System (TASAS)
Wrong-Way Freeway Accidents

These charts show wrong-way accidents as compared to the total number of recorded accidents on California freeways during 1987. About 0.24 percent (approximately one out of 400) of the accidents were wrong-way. About 2.9 percent of all the fatal accidents were wrong-way. Although wrong-way accidents account for 0.24 percent of all accidents on California freeways, they are more severe and more likely to result in injury or death than other types of accidents.

The source of data is from the Caltrans Traffic Accident Surveillance And Analysis System (TASAS) and 1987 Accident Data on California State Highways (Road Miles, Travel, Accidents, Accident Rates)

PDO, Property Damage Only Accident; Inj, Injury Accident; Fatal, Fatal Accident
Urban areas have more wrong-way accidents than rural areas. The numbers of wrong-way accidents are higher in the evening than the daytime hours. Congestion in urban areas may prevent wrong-way drivers from entering or driving on the freeway during the daytime. The peaking of fatal wrong-way accidents occurs around 2 a.m. in all areas, although this is more evident in the urban areas, and is probably related to the closing time for bars in California.
The primary cause of wrong-way accidents, especially those which are fatal, is drivers who are under the influence of drugs or alcohol.

The source of data is from the Caltrans Traffic Accident Surveillance And Analysis System (TASAS).

Annual Monitoring of Wrong-Way Accidents

The purpose of the annual wrong-way accident monitoring system is to make sure everything possible is being done to prevent wrong-way accidents. This program was started in 1985. Listings of wrong-way accidents along with accident concentrations are provided annually to the traffic engineers in the twelve districts. Information on accident location, accident severity, time of day, direction of travel, and sobriety of the driver are noted. (Wrong-way accidents involving bicycles are eliminated from the listings. Most of these accidents happen when the drivers leaving the off-ramps and making right turns hit bicyclists going the wrong-way on the cross streets.) A running 5-year accident listing is maintained.

Field investigations are made upstream of wrong-way accident concentrations and at ramps of known or suspected wrong-way entries. Aerial photographs and accident reports are also reviewed. Most entry points are unknown because the wrong-way driver usually can not provide information due to his intoxicated condition, or because of his death in the accident. A new check list procedure has been developed as part of this current report which summarizes the experience and input of district field engineers. The check list, may be used as a training tool for new field investigators. (See Appendix A).

Reports are produced by the districts which cover the wrong-way concentrations, descriptions of deficiencies found, and changes or modifications made because of these investigations. These changes may include repainting or adding wrong-way pavement arrows; reorienting, moving, or adding wrong-way sign packages; modifying the trailblazing freeway entrance packages; placing edge lines and pavement markers; upgrading signs with high intensity reflective sheeting; and modifying lighting. Occasionally more extensive measures would be required to solve the problem at unique locations, such as installing pavement lights; adding ramps to incomplete interchanges; regrading ramps to improve sight distance; and other ramp redesigns. With the exception of pavement lights (now under testing) and minor redesigns at ramp terminals, modifications to interchanges and ramps are usually prohibitively expensive and have seldom been proposed.

This monitoring program appears to be effective in pin-pointing deficiencies in the field. It should lead to reduced accidents (although this has not been quantified yet), and the program should be continued as an annual effort. The check-list should be of significant use in the field reviews.
Special Review of Off-Ramps in Los Angeles and Ventura Counties

As a part of the effort requested by Senate Bill 233, (1987) Caltrans conducted a special review of seven ramps in Los Angeles and Ventura Counties. These ramps, based on previous studies, were thought to be the most susceptible to wrong-way moves. Automatic cameras were installed at each ramp for a minimum of 30 days. The seven ramps were:

**Los Angeles County**
- I-10, WB Off-Ramp to Hoover Street
- I-10, EB Off-Ramp to Ramona Road
- I-405, NB Off-Ramp to Palo Verde
- I-605, SB Off-Ramp to Rose Hills Road
- CA-101, NB Off-Ramp to Ventura Boulevard

**Ventura County**
- CA-1, NB Off-Ramp to Pleasant Valley Boulevard
- CA-1, SB Off-Ramp to Pleasant Valley Boulevard

No wrong-way moves were detected at 5 of the ramps. One wrong-way vehicle was photographed at Hoover Street. It is assumed that the driver realized his situation and turned around, since no accident was reported in the area. A field review showed that the wrong-way sign packages were in place and in good condition. The ramp configuration with the off- and on-ramps side by side may have contributed to this driver's error. No changes were recommended.

Five wrong-way moves were recorded at Rose Hills Road. It is assumed that the drivers realized their mistakes and made corrections, since no information with respect to wrong-way drivers on the freeway during the study period was received. The study concluded that city-owned directional signs to a local recreation area may have been the cause of driver confusion and wrong turns onto the freeway off-ramp.

The recommendations for improvement at Rose Hills Road were two-fold. First, the city was informed of the sign problem and requested that it be corrected. The city did remedy the problem with their signs. Second, Caltrans placed a second set of wrong-way signs closer to the ramp terminus, installed a no-turn sign facing westbound traffic on the city street, and installed a one-way sign on the easterly side of the off-ramp.
Based on previous experience, it was expected that these ramps would have 2 or more wrong-way moves per month each. The fact that they did not (with the exception of Rose Hills Road) was gratifying. The routine camera surveillance program had been continued for several years. As every ramp came to be photographed, as the equipment wore out, and as the belief grew that little was being achieved for a large expenditure of employee time, the camera effort mostly ceased by the mid-1980s. However, some cameras have remained in operation. The decision to stop the program in general appears warranted. In the course of preparing this report, it was disclosed that the remaining detectors and camera equipment are now in very poor condition.

It is therefore recommended that new equipment be purchased for those few cases where wrong-way entry problems continue and where cameras surveillance could help in deriving a solution.

The case of Rose Hills illustrates the importance of periodic reviews of every ramp. The systematic reviews of the ramps for missing signs, worn signs and pavement arrows, and changed conditions have been done several times in the past. Pavement arrows should now conform to the policy developed in 1985. The most recent review began in late 1988. It is recommended that this review be expeditiously completed and that future reviews be scheduled on about a 3 to 5 year cycle.
Pavement Lights Project in San Diego

In 1976, the freeway off-ramps in District 11 were studied to determine where wrong-way problems might occur. From the results of this study, seven off-ramps were selected for modification. Selection was based on an indication of operational problems, which meant a history of wrong-way entrances and/or misleading layouts of ramps. The modifications consisted of installing airport-type red pavement lights, induction loops in the pavement to detect the wrong-way vehicles and controllers, and adding extra wrong-way sign packages. These seven off-ramps were located as follows:

I-5, NB Off-Ramp to Sorrento Valley Road
I-5, SB Off-Ramp to Sea World Drive
I-8, WB Off-Ramp to Fletcher Parkway
I-8, EB Off-Ramp to Severin/Fuerte Drive
I-94, EB Off-Ramp to Broadway/College Avenue
I-163, NB Off-Ramp to Mesa College Drive
I-805, NB Off-Ramp to Mesa College Drive
(I-94, EB Off-Ramp to Home Avenue was installed at a different time.)

The pavement lights appeared to be effective in further reducing wrong-way entries. However, the equipment experienced severe and continuing maintenance problems. In the 1970s, the loops were replaced at the Off-Ramp to Fletcher Parkway. In 1985, an improved design was developed and the installations were rebuilt at five off-ramps:

I-5, SB Off-Ramp to Sea World Drive
I-94, EB Off-Ramp to Home Avenue
I-94, EB Off-Ramp to Broadway/College Avenue
I-163, NB Off-Ramp to Mesa College Drive
I-805, NB Off-Ramp to Mesa College Drive

The project was completed in 1986. The Sorrento Valley Road and Fletcher Parkway Off-Ramps did not require retrofits since they were working satisfactorily. Now, the system at Fletcher Parkway Off-Ramp is due for a minor retrofit. No retrofit was made at Severin/Fuerte Drive Off-Ramp since the bridge and ramps were soon to be removed and relocated during the construction of the Routes 5/125 interchange. The Off-Ramp to Home Avenue was reconstructed too.

In 1987, a study was initiated to determine whether there were still any operational problems at the remaining six locations.

I-5, NB Off-Ramp to Sorrento Valley Road
I-5, SB Off-Ramp to Sea World Drive
I-8, WB Off-Ramp to Fletcher Parkway
I-94, EB Off-Ramp to Broadway/College Avenue
I-163, NB Off-Ramp to Mesa College Drive
I-805, NB Off-Ramp to Mesa College Drive
Still cameras were installed at these six locations, which were monitored to
determine if the improvements had the desired effects. Problems arose at several
of these locations regarding false wrong-way readings. These false recordings
were attributed mainly to "rollbacks", which occur when a vehicle on an uphill
ramp rolls back across the detectors. At two locations, motorcycles traveling in
the correct direction produced most of the false readings. Equipment was
adjusted and detector placements were changed. The problems were alleviated,
but not completely eliminated.

In the wrong-way accidents documented in 1986 and 1987, none were
attributed to the six locations. At one location, however, several wrong-way
entries were experienced, although no accidents were recorded there. A few
motorists mistook the off-ramp for a city street. Modifications were made to the
wrong-way signs and to the pavement markings. These changes resulted in only
one detected wrong-way entry since the modifications.

Now that the design of the equipment appears to have been improved to
withstand problems such as short circuiting caused by ground water, the
pavement lights may be a feasible solution at locations where other treatments
have not been sufficiently effective.

The pavement light installations are relatively expensive (over $10,000 each)
and require constant maintenance. It is still not known for certain how effective
the lights really are in preventing entry onto the freeway lanes. The lights were
theorized to be effective since intoxicated persons experience poor divided attention
(for roadside signs) but relatively good concentrated attention (for the roadway
straight ahead).18 Prior research indicated that the lights were effective in
stopping most but probably not every driver.20 It was never possible to get good
data due to equipment problems. Now that a reliable design has apparently been
developed, it may be possible to obtain good data. To do this, new movie or video
cameras are needed. It is necessary to determine how many vehicles pass the
lights in the wrong direction and enter the freeway. Therefore, it is
recommended that still camera, video or movie camera equipment be purchased
and installed at these pavement light ramps. The cameras should be operated as
long as it takes to obtain statistically significant entry data.
Over twenty years ago, many of the wrong-way movements and accidents were caused by drivers who were honestly confused. Since then, guide and wrong-way signs and pavement markings provide better visual cues for the motorists. Many of the ramps which were determined to be confusing were modified with signs, pavement markings and sometimes minor reconstruction of ramp terminals. The number of wrong-way entries caused by confusion is now believed to be minor. Drivers under the influence of alcohol are the major cause of wrong-way accidents. However, improvements in interchanges and ramps to discourage wrong-way entries may still be desirable at some locations.

The following figures illustrate some of the factors which should be considered in new designs or in reconstruction to reduce wrong-way entries. Incomplete and partial interchanges, such as the half diamond, pose a particular problem. Sometimes motorists will risk using an off-ramp to enter a freeway if the on-ramp is miles away. A similar situation exists for motorists exiting the freeway using on-ramps. During construction or maintenance activities, closure of some ramps encourages wrong-way movements. When an off-ramp is closed (for example for maintenance), advance notice and detour guide signs should be considered on both the freeway and the surface streets; otherwise some drivers may exit the freeway and make an illegal U-turn across the median to the off-ramp on the other side of the freeway.

Interchanges with short sight distances at the decision points have a disproportionate number of wrong-way movements. These locations lack some of the visual cues, such as headlights of on-coming vehicles, which may alert the wrong-way driver. If possible, the sight distances at decision points should be as long as possible.

It is especially important that the wrong-way signs on both sides of the off-ramp and pavement arrows be visible from the decision points in the intersection. Guide signs should lead motorists to the correct on-ramp. When a local road is located opposite an off-ramp, special attention is required. The stop bar of the local road may be rotated toward the direction of travel to assist the driver in facing toward the on-ramp. The stop bar on the frontage road should not be perpendicular to the facing off-ramp, but rather slanted to direct drivers away from the facing off-ramp. Also helpful are pavement markings, such as directional turning arrows and lead lines with buttons or reflective markers, double yellow center lines and even curbed medians on the cross street.

Consistency and predictability are helpful in avoiding wrong-way movements. For example, if every interchange in a series of interchanges are of the cloverleaf type, the driver will consistently maneuver to the right lane to reach the freeway entrance ramp from a local street. Advance trail-blazing guide signs are particularly helpful for on-ramps requiring left lane entry from the city street.
Drivers can make only one decision at a time. Since motorists are used to a maximum of four legs at an intersection, five-legged intersections near off-ramps should be avoided. A tee intersection with the off-ramp perpendicular to the frontage road demands fewer decisions. Ramps should be located far enough apart for guide signs to provide precise on-ramp entrance information.

Many accidents occur when drivers collide with bicyclists at the ends of off-ramps. The drivers are looking to their left and the bicyclists are coming from the drivers' right, riding on the wrong side of the road. Markings for two direction bicycle flow on one side of a city street invites an unfavorable situation near off-ramps. Bicycling against traffic on the wrong side of the street is illegal in California.

Wrong-way entries due to confusion have largely been eliminated after years of research on the design of ramps, interchanges and their signing. Changes have been made to the Design and Traffic Manuals to reduce wrong-way accidents. The problem of how to deal with intoxicated drivers continues to present a difficult problem.

Changes in design policies have also been made as a result of wrong-way research. This information has been transmitted to designers in the past. However, new engineers are now entering the organization. The following figures could form the core of a training program or instructional bulletin for these new engineers. New interchanges are being built, and others are being modified as a result of property development.

It is important that the wrong-way problem be fully considered in these new designs. Therefore, it is recommended that training efforts be scheduled, especially for the new engineers.
Cloverleaf interchanges are the most desirable type of interchange to avoid wrong-way movements. Freeway access is provided in both directions with only right turns. Wrong-way movements are seldom a problem with this interchange, but the provision of a double yellow barrier stripe on the overcrossing bridge with reflective markers may help motorists stay on the proper side of the road. During the planning phase, developers sometimes try to apply pressure for a two quadrant cloverleaf (which is less desirable than the full cloverleaf interchange in terms of wrong-way entries) to create developed properties on the two opposite corners.

Figure 6

Cloverleaf Interchange
Wrong-way movements may be prevented in two-quadrant cloverleaf interchanges by:
1. separating the on- and off-ramps;
2. designing the orientation of the on-ramp for easy access;
3. constructing a larger, better lit opening for the on-ramp than the off-ramp;
4. reconstructing the curb nose between adjacent ramps;
5. grading the on-ramp entrance for better visibility than the off-ramp as viewed from the cross-road.
Occasionally, motorists will mistake an off-ramp of a diamond interchange for a frontage road located parallel to the ramp. If an attraction exists on the frontage road, signing is important in order that the motorists will not confuse the off-ramp with the frontage road. Signing to the attraction should be placed away from the off-ramp. The wrong-way signs and markings should be visible from the decision points in the intersection.

To prevent left turns on to an off-ramp, an island may be constructed to partially overlap the off-ramp. Thus, a motorist would have to make an unnatural turn to enter the off-ramp.

Proper guide signing and direction pavement arrows are important to direct motorists to the correct lane for the left turns onto the freeway. Lead pavement markers may also be installed to direct to the entrance of the on-ramp. If space permits, a left turning lane may be provided.
Access to the freeway from all directions is not provided for in half diamond interchanges. Therefore, good signing is extremely important. If the guide signing does not clearly indicate a safe route for the drivers to enter and exit the freeway, wrong-way movements may result. Also, as in partial interchanges, some may use U-turns to reach the freeway exit.

A full diamond interchange may function as a half-diamond at the time when ramps are closed for maintenance activities. Temporary signs are needed to give information on times of ramp closures and alternate routes available.
Wrong-way movements can be avoided in trumpet interchanges by installing curbed medians on the ramps or by using barrier stripes of double yellow lines and reflectors. As a last resort, a trumpet interchange may be modified by using a concrete median barrier.
Relatively few problems exist with slip ramps, except in locations where a two-way frontage road terminates at a slip ramp. An elephant's ear with a stop sign may be installed at the end of the road to assist the motorist in turning around. Slip ramps entering frontage roads at flat angles are more desirable than those oriented perpendicular to the frontage road, since they discourage turns onto the one-way ramp. (See buttonhook ramps on the following page.)
Buttonhook ramps can be very susceptible to wrong-way moves. With clear separation of the on- and off-ramps and signing, the wrong-way movements can be decreased. The nose may be reconstructed, and the on-ramp made wider and better lit than the off-ramp.

Figure 12

Buttonhook Ramp
Proper Direction of Travel
Wrong-Way Movements

Figure 13
Cul-De-Sac Intersection Near Off-Ramp

This type of off-ramp should be obsolete in new designs, although many still exist. Directional arrows and wrong-way pavement arrows, lead lines, reflective markers, and special attention to wrong-way signs are required so that the motorist avoids entering the freeway in the wrong direction from the cul-de-sac off-ramp.
This type of off-ramp is also obsolete and can be confusing for some drivers who head straight ahead onto the off-ramp instead of turning left. Directional and wrong-way pavement arrows, lead lines and reflective markers and special attention to wrong-way signs are also needed.
Left-hand off-ramps are obsolete and must be avoided in new construction. A driver naturally expects to enter the freeway using a right turn and may mistakenly make this turn and travel the wrong-way.
Work Done by Other States

A questionnaire was sent to the traffic engineers in the 50 states. Replies have been received from 40. (See appendix B for the questionnaire and state responses and appendix C for diagrams submitted by the other states.) The survey was designed to identify the actions taken by other states to reduce wrong-way accidents. Caltrans was particularly interested in knowing if anyone had developed special devices which would physically stop wrong-way drivers.

Most states have concluded that the most common cause of wrong-way accidents is alcohol. The Manual on Uniform Traffic Control Devices (MUTCD) is followed and considered adequate by most states for wrong-way signs and markings.

The traffic engineer's input into the planning and design process, the use of wrong-way pavement arrows, edge lines and painted channelization were mentioned as important in the effort to reduce wrong-way accidents.

One very important finding was that no state has developed special devices to physically prevent wrong-way entries. No traffic engineer responding to the survey endorsed the use of parking-lot spikes, barriers, raising curbs, etc. As mentioned previously, Caltrans has tested spikes and Georgia has tested raising curbs. Both states found the devices impractical.

In terms of the MUTCD, it is interesting that several states use more signs, better positioned than required by the MUTCD. Caltrans requires as a minimum more than twice as many signs (two wrong-way sign packages versus one in the MUTCD plus the freeway entrance totem pole which is optional in the MUTCD), better positioned (lower to be in the headlights or direct line of vision), and larger (36 inches versus 30 inches).

All of the techniques except one, mentioned by the states have been tried or considered in California. The one exception is the idea to carry edgelines on the crossing streets directly across the off-ramps to discourage right turns into the off-ramps. Another possible solution would be to place heavier stop bars at the off-ramp. It is recommended that these ideas be further investigated for possible implementation and incorporation into the Traffic Manual.
California Highway Patrol Contributions

The California Highway Patrol (CHP) makes a valuable contribution in combating wrong-way driving. The California Vehicle Code contains provisions in wrong-way accident-related areas such as sobriety, turning movements, and sign theft which are enforced by the CHP. Accident reports reveal that the typical wrong-way accident is caused by a driver who was either driving under the influence of alcohol or drugs, or had been drinking. The CHP has programs to remove these drivers from the road.

The CHP conducts two important programs: the Sobriety Checkpoint Program and the Sober Graduation Program. The aim of the Sobriety Checkpoint Program is to detect and remove drinking drivers from the road to reduce alcohol-caused accidents. Sites are chosen on the basis of high alcohol and drug related accident and arrest activity. For example, from May 1 to October 31, 1985, checkpoint teams screened over 16,000 vehicles, administered over 500 field sobriety tests and made over 200 arrests and citations in the Bakersfield and Sacramento Areas. Accidents caused by driving under the influence dropped 6% statewide, and 12% in the North Sacramento area. The cost, including salaries and equipment, was $51,887 for the 23 checkpoints.

The California Supreme Court ruled on October 29, 1987 that operation of the sobriety checkpoints was constitutional. The CHP resumed state wide checkpoints on November 27, 1987 in time for the holiday season. From the end of November 1987 to the end of September 1988, over 900 arrests were made after screening over 83,000 vehicles at 114 Sobriety Checkpoints.

The goal of the Sober Graduation Program, started in 1985, is to curb drinking and driving among young people. It is conducted during May and June, the two months of proms, grad nights, and end-of-school celebrations. The community-based effort involves 15 to 19-year-old drivers in accepting the 'don't drink and drive' message themselves and then delivering it to their peers.

The Sober Graduation Program is a catalyst that is unique to each area of the state. The CHP distributes basic materials like television and radio public service announcements, posters, bumper stickers, decals, key chains, and book covers. The CHP works with student groups, and local individuals and organizations. The Sober Graduation Program has a different creative emphasis in each community. Local involvement is the key to its success. The results of this program have been rewarding. In the 1985 May to June period alone, fatal accidents in this age group dropped 25%, and injury accidents decreased 19%.

Two examples of Sober Graduation Program radio announcements are:
1. "On grad night will you let your friends down? Of course not. That's why no one you know is gonna drive if they've been drinking. You won't let them, because you care about them. K_____ and the CHF care too. Have a Sober Graduation Class of '88 and make it to your future!"
2. "What's the best thing about graduation? Friends, family, fun, the future? K_____ and the CHF suggest that the best thing about graduation is being around tomorrow to start the rest of your life. Sober Graduation. Make it to your future!"
The Sobriety Checkpoint and Sober Graduation Programs appear to be very effective. Another way, however, in which the CHP can be of assistance is to make a special effort to report missing, damaged or worn wrong-way signs to Caltrans. Also the CHP can note on accident reports identified or suspected entry points in wrong-way accidents or in observed wrong-way travel. It is recommended that the CHP be contacted again, stressing our continued interest in wrong-way accidents. Renewing our request for information, such as outlined above, will help solve this problem.
References


Appendix A

Check List for Wrong-Way Entry Review
Check List for Wrong-Way Entry Review

1. Review pertinent accident reports. Using the aerial photographs, review ramps, cross roads, and median openings 3 miles upstream (less in urban, more in rural areas), from the accident location. Field investigation of ramps located within these 3 miles of the wrong-way accident site may reveal needed improvements in signing and striping. Bring figures 4-15 to 4-24, 6-16, 6-24, and 6-38 from the Traffic Manual with you.

2. Inspect off-ramps during both daylight and dark conditions, especially if the accident occurred at night. It is desirable to check the general visibility close to the same time of day and weather condition as when the accident occurred (sunrise, sunset, dark, fog, rain, etc.) Choose a safe observation location near entry points to the off-ramp where a wrong-way driver may have driven. Get out of your vehicle and view the scene from the wrong-way driver's perspective.

3. Check if Do Not Enter sign packages (R11 over R11A) are:
   - present in the minimum quantities (See Traffic Manual figures),
   - visible from the entry decision point; not too far back,
   - mounted at the recommended height (about 2' above the edge of the traveled way pavement but visible to headlights),
   - unfaded (3M company will replace faded signs 2 for 1),
   - not hidden by other objects or bushes,
   - oriented at the best possible viewing angle,
   - in good repair (riveted or bolted connections, etc.),
   - free from graffiti,
   - specify replacement and added signs made of high intensity sheeting.

4. Check if the 24' wrong-way pavement arrows (figure 6-23) are:
   - in the proper locations starting at about 20' from the limit line,
   - present in the minimum quantity (at least 2 per lane),
   - visible, with a reflective freshly painted look,
   - unfaded, not covered with grease, not chipped away,
   - not embedded between directional arrows in left/right only lanes.
   - Highly reflective thermoplastic material may be specified for replacement and added wrong-way arrows.
5. Check if other pavement directional arrows (figure 6-23) are:
   - visible,
   - unfaded, not covered with grease, not chipped away.

6. Check for the presence of other signs which discourage wrong-way movements:
   - One Way (R10, R10A) about 1 1/2' above the edge of traveled way pavement, but visible to headlights;
   - No Right/Left Turn (R16B, R17B);
   - No U-Turn (R34, R34A);
   - Keep Right (R7, R7A);
   - Divided Highway (R98, R98A, W25, W25A, W26, W26A);
   - Two Way Traffic (W44).

7. Off-ramp openings should discourage wrong-way entry from the cross street. The openings should:
   - be narrow, and
   - have an island or painted median dividing parallel, adjacent on and off-ramps,
   - have small radius corners on either side of the throat and be aligned towards local street travel.
   - Also, red-clear markers may be used on the freeway mainline approaching exit ramps (fig. 6-2, det. 14; fig. 6-9, det. 36-37; fig. 6-17).

8. Freeway entrances must be obvious and accessible.
   - Check that pathfinder-trailblazing signs are adequate for motorists to find the freeway entrances,
   - entrance packages are in place and in good condition,
   - one 18' entrance arrow per lane exists, in good repair (fig. 6-23),
   - freeway entrances are better lit than exits (fig. 9-15, 9-16),
   - interchanges are complete so motorists never have to enter a freeway using an off-ramp.

9. Where left turning movements may be confusing in an intersection adjacent to an off-ramp, recommend:
   - turning guide lines, either solid or broken,
   - pavement markers to aid the turning movement,
   - pavement markers on guide lines (good wear for high ADT),
   - directional pavement arrows.
10. Consider eliminating factors which contribute to wrong way moves on adjacent right of way by:

- recommending removal of guide signs or privately owned directional signs located close to the off-ramp which may encourage wrong way entry,
- locating guide signs for frontage roads paralleling off-ramps far from the off-ramp opening,
- removing bushes and structures which decrease visibility.
- During the planning process, discourage the location of business driveways next to off-ramps in original right-of-way agreements,
- deny permission for bar permits near freeway ramps.

11. Any recommendations which result from the field investigation should be approved by a supervisor with Traffic Engineering experience before filling out the HT-65 form. Recommendations shown on the HT-65 form must be accomplished in a timely manner to prevent tort liability. Do not editorialize. Never write suggestions on the HT-65 form which will not be accomplished. Recommendation for the installation of wrong way preventive treatments such as wrong-way packages and pavement arrows do not require a safety index > 200, but do require engineering judgment; Minor B funding is at the discretion of the District.

12. In locations where sign theft is a problem, try:

- replacing any missing signs with those made of synthetic material.
- coating the backs of existing signs with a thick layer of grease.

13. For recurring problems, try:

- reviewing through another pair of eyes,
- installing more Do Not Enter sign packages, larger Do Not Enter sign packages, illuminating the signs, or increasing the number of pavement arrows,
- monitoring with camera or video to isolate the sources and patterns of the problem,
- observing traffic flow during different times of day,
- increasing traffic flow on low ADT off-ramps (reroute),
- closing the ramp or a road to the intersection,
- regrading or realigning ramps with limited sight distances,
- regrading or realigning portions of freeways where sight distances are < 1200 feet,
- constructing wrong-way, vehicle activated red pavement lights,
- contact Headquarters Traffic Operations or other districts for new ideas.
CASE 1

LEGEND

Wrong Way Arrow
Lane Drop Arrow
Sign Location

NOTE:
1. See Figure 6-11 for additional information on lane reduction transition.
Figure 6-24
TYPICAL RURAL EXPRESSWAY INTERSECTION SIGNS AND MARKINGS

LEGEND
- Wrong Way Arrow
- Left Turn Arrow
- Sign Location

NOTES:
1. Distance between wrong way arrows is 100' ±.
2. See Figure 6-20 for location of intersection markings.
3. Use 8" white solid line for left turn lane.
4. The R98A sign may be placed as a separate installation in advance of stop sign.
Figure 6-38
TYPICAL OBJECT MARKERS
(See Section 6-05)

### TYPE K

- **Policy**: Type K marker is used:
  - In the far nose of median Island openings
  - Facing approaching traffic at the noses of Islands forming right-turn lanes.
  - In the nose of an Island where traffic may proceed to either side.
  - In the nose of exit ramps where there are curbs in the neutral area.

**Optional Installation in Urban Areas**

### TYPE N

- **Policy**: Type N marker may be used below and on the same post with the W56 or W57 arrow signs to warn of an abrupt turn. Orange Type N marker is used in construction zones.
- **Policy**: Red Type N marker is normally mounted below and on the same post with the W31 END sign to mark the end of a street or highway.

- **1. Yellow Reflective Background**
- **2. Red Reflective Background**
- **3. Orange Reflective Background**
- **4. Yellow Background with 9-3" Yellow Reflectors**
- **5. Red Background with 9-3" Red Reflectors**

### TYPE L

- **Policy**: Type L marker is used to mark obstructions adjacent to the roadbed (outside of paved shoulder).

### TYPE P

- **Policy**: Type P marker is used to mark an obstruction within the roadbed (between edges of paved shoulders). Type P marker with orange and white stripes is used in construction zones.

### TYPE R

- **Policy**: Type R marker is used to mark an obstruction within the roadbed where traffic may proceed on either side. It is mounted on the front of a crash cushion or guardrail protecting a fixed object. Except for crash cushions where traffic may pass to only one side of a fixed object, a Type P marker should be used instead of Type R. The bottom of the marker is normally mounted one foot above pavement.
Appendix B

Questionnaire Sent and Responses From Other States
Wrong-way traffic movements and their consequences are a major concern to all of us. The California Department of Transportation (Caltrans) is devoted to developing more effective signs, pavement markings, and devices to prevent the wrong-way entry of vehicles onto our freeways, and wrong-way U-turns on our freeways.

In addition, Caltrans is interested in standards and ideas developed by other states for preventing wrong-way movements. We are particularly interested in any positive barriers, such as spikes, raising curbs, etc., or other unique treatments you may have tried. Could you provide us information and diagrams of your standards for signs and markings other than the standard MUTCD (Manual of Uniform Traffic Control Devices) treatment, lights, devices, etc., used in your state to prevent wrong-way traffic movements? Please send your response to:

Mr. Charles D. Bartell  
Chief, Division of Traffic Engineering  
California Department of Transportation  
1120 N Street, Room 4212  
Sacramento, CA 95814

A summary of responses will be compiled by the end of this year. We would appreciate receiving this information by August 31, 1988. Please let us know in your response if you wish to obtain a copy of the final report on prevention of wrong-way traffic movements.

Sincerely,

C. D. BARTELL, Chief  
Division of Traffic Engineering
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<td>Harry O. Price, P.E., State Traffic Engineer</td>
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Summary of Responses to Questionnaire

Response on Causes

Driving Under the Influence, Elderly Drivers, Night-Time Conditions
The most common stated cause of wrong-way accidents was drivers who were under the influence of alcohol. These accidents tend to occur late at night. "Needless to say many drivers were impaired in one way or another."* "In discussing this matter with law enforcement officials, we find that the majority of wrong-way movements and wrong-way U-turns on the freeway system involve drivers under the influence of alcohol." Elderly drivers also accounted for a fraction of wrong-way drivers. "We had a recent rash of these wrong-way accidents in a one week period, all of which were either alcoholized or in one case an elderly person, and all happened late at night."

Response on Solutions

Solutions in preventing wrong-way accidents include using the signing and markings in the MUTCD (Manual on Traffic Control Devices), and obtaining the traffic engineers' input in the planning phase of ramp and interchange design. Particular attention is made to the sign location, mounting height and maintenance. Markings include wrong-way pavement arrows, pavement markers, and edge lines.

Traffic Engineer's Input in the Planning Phase
Since the sight distance and layout and types of off-ramps and interchanges have been shown to correlate with the frequency of wrong-way accidents, the traffic engineer's input in the planning phase of intersection, ramp, and interchange design is vital to public safety. "At the design phase for new construction, we include the traffic engineer's input in reference to ramp location and entrance control to discourage wrong-way maneuvers."

Complete, consistent interchanges lead to vehicles being channelized onto ramps in the correct direction. "We depend on geometric design, supplemented by standard signs and markings to discourage wrong-way movements." "To minimize the possibility of wrong-way traffic movements, we have utilized relatively few partial interchanges."

*Quotations from various respondents which give the flavor of the replies. Identification of individuals quoted would serve little purpose.
The majority of states adhere to the MUTCD standard which states:

"the 'DO NOT ENTER' sign should be conspicuously placed in the most appropriate position at the end of a one-way roadway or ramp. The sign should normally be mounted on the right-hand side of the roadway, facing traffic entering the roadway in the wrong direction. The 'WRONG WAY' sign may be used as a supplement to the 'DO NOT ENTER' sign...placed at a location along the exit ramp or the divided highway farther from the crossroad than the 'DO NOT ENTER' sign." The "DO NOT ENTER" sign is placed conspicuously on ramps, facing traffic entering the road in the wrong direction.

After research studies on visibility, California uses a Do Not Enter package, which is a "DO NOT ENTER" (R-11) sign with a "WRONG WAY" (R-11A) sign directly beneath it on a single post on both sides of the ramp. Other states responded that they also double up their signs. "Many times we have doubled up signs, especially 'Wrong Way' or 'Do Not Enter.'"

Legal Authority

Signs and markings are enforced by vehicle code sections regarding direction of travel, U-turns, and driving while intoxicated. One state provided an outline of their "legal authority to prohibit U-turns at median crossovers."

Sign Location

Many responding states provided diagrams of sign and pavement marking locations from their standards. These diagrams are included in the appendix of this report. Some of the states used more signs, above the standard shown in the MUTCD, either as their own standard, or as determined by engineering judgment.

Sign Mounting Height

States which had looked into sign height lowered their signs. "We do mount our 'Wrong-Way' ramp signs at a 4-foot height to the bottom of the sign. We believe that the sign at the lower elevation is more noticeable to a wrong-way driver than if it were mounted at the standard 7-foot height. Speeds are low at the ramp terminals so the low height should not present a hazardous situation."

One of the states increased the mounting height of the "ONE WAY" signs from 1-1/2 feet to 3 feet for better visibility. "There has been some concern about the 1 1/2 feet mounting height of the 'ONE WAY' signs...this mounting height should be adjusted, especially at locations where the 'ONE WAY' sign is mounted behind guard rail. Also there was concern about the signs being obscured by vegetation. Therefore in order to alleviate these concerns, it has been decided to increase the mounting height of the 'ONE WAY' sign to 3 feet."
From research studies in both responsiveness to headlights and avoidance of sight restrictions, California mounts the Freeway Entrance and Do Not Enter sign packages with the bottom of lower sign 2 feet higher than the edge of traveled way pavement, rather than the 7-foot height called for in the Manual. The Do Not Enter sign package consists of a "DO NOT ENTER" sign with a "WRONG WAY" sign directly beneath it on a single post. The Freeway Entrance package consists of a "FREEWAY ENTRANCE" sign, a route shield, cardinal direction, and arrow signs mounted on a single post. This places the signs directly in the view and in the headlights of vehicles turning into off-ramps.

**Sign Material**

Visibility is important. "We require that 'WRONG WAY' and 'DO NOT ENTER' signs be fabricated with high brightness encapsulated type reflective sheeting."

**Sign Size**

The MUTCD Manual sizes of the "DO NOT ENTER" and "WRONG WAY" signs were 30" x 30" and 36" x 24" respectively. California has sizes of 36" x 36", 48" x 48", and 72" x 72" for the "DO NOT ENTER" sign and 36" x 21" and 72" x 21" for the "DO NOT ENTER" sign.

**Sign Maintenance**

A sign maintenance and verification system ensures that the signs are in an acceptable condition and not missing. "We have also tried to keep the devices and markings in a good state of repair." "We recently made a special drive to insure that all our exit ramps were signed in accordance with the MUTCD."

In California, reviews are made by district traffic engineers of the wrong-way signing and delineation packages to remedy any deficiencies in missing signs, lost reflectivity of the signs, and worn wrong-way pavement arrows. As they are retrofitted and newly installed, the Do Not Enter sign packages in California have high intensity sheeting.

**Wrong-Way Pavement Arrow**

The wrong-way pavement arrow was designed to look like an arrow (not a "glob") when viewed from the pointed end of the arrow. Some states experimented with visibility of the arrow with raised pavement markers. "We also use the pavement arrow strategically thru interchange areas to guide motorists and to supplement the effectiveness of the arrow. We plan to experiment with outlining the arrow with raised pavement markers at locations where there is a high incident frequency." Also, reflective thermoplastic material is now being used as an alternative to reflective paint for wrong-way pavement arrows.
Pavement Markers and Edge Lines

Edge lines and pavement markers help to guide traffic, especially at intersections adjacent to ramps with left-turns. "We are strong advocates of using the turning path dots for guiding left-turning traffic in the par-clo's and folded diamond interchange types. But, once again, that is a standard marking consideration." "Where there are two ramps in the same quadrant, such as at a partial cloverleaf, we have dashed the left edge line from the crossroad to the ramp terminal to provide left-turning drivers with a defined path to follow the proper ramp."

Red/yellow and red/colorless reflective markings, which require extensive driver education programs are used by some states. "We use red/colorless, and red/yellow reflective pavement markers on ramps." "Two-way white/red reflectors have been used in raised pavement markers on lane lines at intersections and interchanges to provide the red indication for wrong-way movements."

Raised Medians

Raised curbs and medians are used to channelize traffic at ramps and to separate the entrance and exit ramps which lie parallel to each other. "We do use raised medians to channelize some intersections and ramp terminals. However, these are treatments which can be found in the AASHTO Manual on Geometric Design for Streets and Highways." Another state summarized the practice of using a "raised curb at one location where the entrance and exit ramps were somewhat parallel to each other. The purpose was to better define the entrance ramp from the exit ramp, and to control access." "Also, we make extensive use of curbed channelization in our interchange designs, with lateral separation between on and off ramps. Therefore, at most locations, overt action on the part of the motorist would be necessary to initiate a wrong-way movement."

Delineators

Delineators are being tried by two states on an experimental basis. In the first case, the delineators provide visible trail-blazing at on-ramp entrances. "At a few unlit entrance ramp locations, we have installed an experimental delineation treatment. Five reboundable delineator posts are placed on each side of the freeway entrance ramp. Standard signs and pavement markings accompany this." In the second case, "red reflectors will be placed on the backside (wrong-way side) of flexible delineator posts used on divided highways near intersections and on some freeway ramps and mainline."
Response on Treatments Not Used

Spikes

Every state in the nation was surveyed. Not one Traffic Engineer endorsed the use of spikes or barriers. In addition, past research has shown that a wrong-way vehicle may continue traveling onto the freeway after the tires are punctured. "We have considered the use of spikes to prevent wrong-way movements but we are concerned about legal liability associated with such a drastic device in case some motorist inadvertently backs up or enters the wrong-way and becomes disabled in a traffic lane." Spikes do not stop a vehicle from entering a freeway. A drunk driver may not notice that the tires have been punctured. The majority of the wrong-way drivers may not get into accidents since they do notice the signs, pavement arrows, or traffic flow, and get out of the way of traffic while still on the ramp, turn around, and head in the correct direction. "Barriers to wrong-way vehicles such as one-way spikes, sensor actuated lights etc. have been suggested but are not under consideration at this time." "Please be advised that ...DOT does not use any spikes, raising curbs, etc. to prevent wrong-way traffic movements."

Positive Barriers

There was also a consensus of the responding states in not using positive barriers. The problem of false signaling in pavement sensors because of motorcycles and backed-up traffic could result in harm to innocent victims. "We have not taken a positive approach to the problem and therefore have no experience with any such devices." "We have never installed any type of positive barriers, nor do we have any plans to do so in the future."

California has experimented with moving gates to change the direction of rush hour traffic flow and optimize high occupancy vehicle lanes. These positive barrier gates take 20 seconds to open or close. A gate designed to take the high impact loads of a wrong-way vehicle can not respond in time (up to 20 seconds) to stop a wrong-direction vehicle.
Appendix C

Diagrams Submitted by Other States
**NOTES:**
- Mount signs on existing lamp posts and back-to-back where feasible.
- Where roadway conditions do not permit the use of this sign, alternate treatment to be based on engineering judgment.
OFF - RAMP SIGNING

1. "Wrong Way" signing, see Traffic Guidelines.

2. "No Pedestrians" signing, normally one (1) sign per ramp. Use RS-10c for off-ramps and 31-0530 for on-ramps.

3. "Exit Speed" (off-ramp), ramp speed (turning roadway). First sign normally on parallel section.

4. Warning signs: Curve - Turn - U-Curve

Depending on geometry and safe speed, normally use "Curve" or "Turn" signing on loop ramps. These signs may be supplemented with "Arrow" signs.

"U-Curve" sign may be used only with existing geometry where there is an accident problem.

"Chevron" signs are used in accordance with our policies only when there is an accident problem.

"Stop Ahead", "Signal Ahead" and "Yield Ahead" are used only when there is a substandard sight line to the control.

5. Guide Signs:

Destination Signs (01-1) should be placed on off-ramps. The legends should be the same as the main line signing.

Advance turn route marker assemblies should be placed on off-ramps. These signs may be combined with destination signs when there is not more than three (3) destinations and one (1) route number.

6. Service Signs:

Service signs should normally be placed on the far side of the intersecting road. The signs may be placed on the off-ramp if space permits. The "Hospital" symbol sign with arrow should be installed on the off-ramp.

7. Commuter Parking Signs:

Install these signs only when you cannot see the commuter lot from the highway or ramp. Normally install these signs on the far side of the intersecting road. The signs may be placed on the off-ramp if space permits.

8. Special Destinations:

Auto Emission Test Centers, Historic locations not signed on the main line and other special signs are normally placed on the far side of the intersection.
SUBJECT: Pavement Marking Guide for Freeways and Ramps

ACTIVITY: Selection of appropriate pavement markings for use on freeway exit and entrance ramps, weave lanes, service road connections, and lane drops.

PURPOSE: To achieve statewide uniformity in freeway markings that are in compliance with national standards.

ORIGINATING UNIT: Reflective Systems

INFORMATION: Drawings (pages 3.1.2a, 3.1.2b, and 3.1.2c) are intended to provide guidelines for installing pavement markings on freeway exit and entrance ramps, weave lanes, service road connections, and lane drops.

ACTION REQUIRED: Those engaged in contract plan and work authorization preparation should follow the guidelines shown by the drawings.

This note updates and replaces the existing Traffic and Safety Division Note 3.1.2.

INFORMATION/COMPLETION: This note shall become effective upon date of signing.

11/23/84

By: M. Wittmeyer
Engineer of Traffic and Safety
FREeway, WENting LANE, & SERVICE ROAD CONNECTIONS

NOTES:
1. ALL "BROKEN LINES" ON SHEETS 1 AND 2 ARE 12.5" WIDE, 37.5" SPAC.
2. ALL "DOTTED LINES" ON SHEETS 1 AND 2 ARE 6" WIDE, 20" SPAC EXCEPT FOR LANE-DROP EXITS.
3. FOR LANE-SEPARATING LINES WHERE A "RIGHT LANE MUST EXIT" SIGN IS UNNECESSARY, PAINTED MARKING SUFFICIENT TO THE LANE-DROP EXIT TREATMENT SHOWN ON THIS SHEET.
4. FOR DETAIL OF PAINTED MARKING APPLICABLE AT EAG SWING INTO OR HAVING, SEE SHEET 3.

LANE-DROP EXIT

1/2 MILE

12' WHITE

1007

300

2' X 2' WHITE STRIPS WITH 12" GAPS

6' WHITE EDGE LINE

" WHITE SOLID LINE

6' WHITE SOLID LINE

6' WHITE SOLID LINE
NOTE: 1. LOCATE STOP LINE AS NEAR AS PRACTICAL TO EDGE OF ROADWAY.
2. AND THE LEGEND "ONLY" WITH EACH LANE USE ARROW AND INSTALL APPROPRIATE LANE USE CONTROL SIGNS WHEN A DUAL TURN IS RECOMMENDED.
3. DOUBLE-HEADED ARROWS MAY BE REQUIRED WHERE A SERVICE ROAD OR CITY STREET IS LOCATED OPPOSITE A RAMP TERMINAL.

SINGLE LANE EXIT RAMP TERMINAL

MULTIPLE EXIT RAMP TERMINAL
- 5 REBOUNDABLE DELINEATOR POSTS ARE PLACED ON EACH SIDE OF THE FREEWAY ENTRANCE RAMP.

- STANDARD SIGNS AND PAVEMENT MARKINGS ACCOMPANY THIS.

EXPERIMENTAL DELINEATION
USED @ UNLIT RURAL FREEWAY ENTRANCE RAMP

MICHIGAN DEPARTMENT OF TRANSPORTATION
8-11-88
The first sign shall be located 100 feet in advance of the point where the shoulder markings begin. Successive signs shall be spaced at intervals of 750 to 1,000 feet throughout the marked section. These signs shall be placed on the right hand side of the road, facing traffic. The mounting height and lateral position shall comply with the specifications contained herein.

![NO DRIVING ON MARKED SHOULDER](R-52)

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2J-6 Keep Off Median Sign (R-74)

On divided roadways having no physical barrier between the separated roadways, drivers often attempt to cross the median, particularly where such crossings offer an opportunity to correct an error in choice of direction at an intersection of interchange. A median also may be an inviting place to park. These practices can be dangerous and are prohibited by Section 4511.35 RC.

The Keep Off Median sign may be erected on the left of the roadway within the median wherever there is a tendency for drivers to enter or cross.

![KEEP OFF MEDIAN](R-74)

2J-7 Snowmobiles All Purpose Vehicles Sign (R-20)

This sign may be erected anywhere within the right-of-way, as needed, to inform operators of snowmobiles or all purpose vehicles that these vehicles shall not be operated on any limited access highway, freeway, interstate highway, or the right-of-way thereof in violation of Sec. 4519.40 RC.

![SNOWMOBILES ALL PURPOSE VEHICLES PROHIBITED](R-20)

2J-9 Other Exclusion Signs

In addition to the foregoing specific exclusion signs other legends may be required. Signs which clearly state the exclusion shall be designed in accordance with the principles stated in this manual.

Because of the variety of possible messages for these signs, it is not practicable to fix standard sizes for them as a class. In all cases the lettering should be large enough to give adequate legibility. They should be conspicuously placed at all entrances to the restricted roadway.

2J-10 Turn Prohibition Signs (R-22, 120, 121, 123)

These signs, except R-123, shall be used at intersections to indicate regulations prohibiting turning movements.
Turn Prohibition signs should be placed where they will be most easily seen by drivers intending to turn. The No Right Turn sign shall be placed at the near right-hand corner of the intersection. Where No Left Turn or No Turns signs are required, two should be used, one at the near right-hand corner and one at the far left-hand corner, facing traffic approaching the intersection.

These are minimum requirements, and additional signs should be placed as necessary at or in advance of the intersection. Overhead signs are sometimes desirable, particularly in congested areas. Signs may be mounted just above, below, or alongside traffic signal faces governing the traffic to which they apply. If advance signs are used, care should be taken that no alley or public driveway exists between them and the intersection where the turning movement is prohibited.

At an intersection with a one-way street, whether signalized or not, the One Way sign shall be used, and may be supplemented by the Turn Prohibition sign. (See Figure RS-7 and Section 21-36) A Turn Prohibition sign is not needed at a ramp entrance to an expressway or freeway where the design is such as to indicate clearly the one-way traffic movement on the ramp.

When the movement restriction applies during certain periods only, the use of Turn Prohibition signs calls for special treatment. The following alternatives are listed in order of preference:

(a) Internally illuminated signs or variable message signs that are lighted and made legible only during the restricted hours (particularly desirable at signalized intersections).

(b) Permanently mounted signs incorporating a supplementary legend showing the hours during which the prohibition is applicable.

(c) Moveable signs at each corner of the intersection where required, put in place under police supervision only when applicable and removed at other hours.

The "NO U TURN" sign may be used at or between intersections to indicate regulations prohibiting U turns at or on the specific intersections or roadways so posted. This sign may be used also on expressways and freeways where a crossover between roadways has been provided for emergency and authorized use only.
LANE USE SIGNS

23-15  Lane-Use Control Signs
       (R-24, R-25A thru R-30A, R-31, R-32)

Lane-Use Control signs are intended for use to control vehicle movements in specific lanes. These signs should be used where turning movements are required or where unconventional turning movements are permitted from specific lanes at an intersection. Overhead mandatory movement signs (R-26A, R-27A, R-30A) shall show a single arrow and the regulatory word message "ONLY". The overhead optional movement signs (R-28A, R-29A) shall show a straight and a curved arrow with the lower ends of their shafts superimposed, to indicate that either of the movements symbolized is permissible.

Lane-use controls permitting left or right turns from two or more lanes are normally warranted whenever the turning volume exceeds the capacity of one turning lane and when all movements can be accommodated in the lanes available to them. When multiple lane turns are to be permitted at signalized intersections, signal phasing should be used to allow the turning movements without interference from opposing or cross traffic, including pedestrians.

Side-mounted lane-use signs consist of combinations of arrows in the R-31 series of signs or the word messages of the R-24, R-25A, and the R-32 signs. The signs LEFT TURN ONLY (R-24) or RIGHT TURN ONLY (R-25A) should be used where all traffic must turn.

The optional movement signs R-28A and R-29A shall not be used alone to effect a turn prohibition.

Pavement markings may be used to supplement lane-use control signs and should be used with mandatory turn signs. See Section 3B-41 and Figures P-27, 28, 29.

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2J-32 Keep Right (Arrow) Sign (R-37 R & L)

The Keep Right (Arrow) sign should be used at median openings to guide traffic entering from the cross street into the proper roadway. This sign may also be used as an alternate to the R-38. See RS-6.

A Keep Left sign may be substituted where appropriate.

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2J-33 Keep Right (Left) Sign (OC-39R, L)

Information regarding the application of this Keep Right (Left) Sign in construction and maintenance work areas is presented in Part 7 of this manual. See Section 7E-13.
2J-36 One Way Signs (R-43) (R-44)

The ONE WAY sign shall be used when required to indicate streets or roadways upon which vehicular traffic is allowed to travel in one direction only. The sign shall be either (a) a white arrow on a black horizontal rectangle with the words ONE WAY centered in the ARROW (R-43); or (b) a vertical rectangle with black lettering and arrow on a white background (R-44). The vertical design has advantages where lateral space is limited. Both designs may be made in rights and lefts. A special size (72” x 24”) of the R-43 sign is provided for use on freeways and highways under special or unusual conditions which require a larger size to deter wrong-way movements.

One Way signs shall be placed on the near righthand and the far lefthand corners of the intersection so as to face traffic entering or crossing the one-way street. Where the intersection is signalized, the signs shall be placed near the appropriate signal faces. One Way signs shall also be placed parallel to the one-way street directly opposite the exits from alleys and other public ways. A One Way sign may be supplemented by a Turn Prohibition sign (Figure RS-7).

2J-37 Do Not Enter Sign (R-41B)

To prohibit traffic from entering a restricted road section the DO NOT ENTER sign should be conspicuously placed in the most appropriate position at the end of a one-way roadway or ramp.

The sign should normally be mounted on the right-hand side of the roadway, facing traffic entering the roadway or ramp in the wrong direction. However, a second sign on the left-hand side of the roadway may be justified, particularly where traffic may be approaching in a turn. Larger sizes are prescribed for use on major standard roadways or on expressways and freeways with one-way ramp or roadway connections.

When Do Not Enter and Stop signs are mounted back-to-back in an installation, the R-41B-30 shall not be used with a Stop sign smaller than the R-1-36, and only the R-1-48 shall be used with the R-41B-36.

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2J-38 Wrong Way Sign (R-41A)

The WRONG WAY sign may be used as a supplement to the DO NOT ENTER sign where an exit ramp intersects a crossroad or a crossroad intersects a divided highway, or at the end of a section of one-way roadway.

The sign should be placed at a location along the exit ramp, the divided roadway, or the one-way roadway, farther from the crossroad than the DO NOT ENTER sign.

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TYPICAL LOCATION OF SIGNS FOR MARKING ONE WAY STREETS

* OPTIONAL DUAL INSTALLATION OF "DO NOT ENTER" AND "WRONG WAY" SIGNS.

REF. SEC
2J-36

RS-7
Ohio
82
TYPICAL LOCATION OF ONE WAY AND WRONG WAY MOVEMENT SIGNS FOR EXPRESSWAY INTERSECTIONS

NOTES:
1. ONE WAY sign should be used to indicate single allowable direction of travel when median width exceeds 30'.
2. DO NOT ENTER sign should be used to prevent wrong-way movement on a one-way roadway when median width exceeds 16'.
3. WRONG WAY sign may be used to supplement DO NOT ENTER sign.

*Optional dual installation of DO NOT ENTER & WRONG WAY signs where median exceeds 30'.

REF. SEC. 2J-36
TYPICAL LOCATION OF ONE WAY AND WRONG WAY MOVEMENT SIGNS FOR FREEWAY RAMP INTERSECTION

Entrance Ramp

Exit Ramp

Do Not Enter

Stop

ONE WAY

Regulatory signing at exit ramp terminals to deter wrong way entry

REF. SEC.
21-36
24-37
21-38
21-39
21-40

RS-9
Ohio
84
2J-39 Wrong Way Traffic Control for Divided Highway Intersections

Efforts should be made to identify and make practical corrections at grade intersections on divided highways where wrong-way usage is being experienced or where a wide median, a rural unlighted environment or other contributing factors indicate the likelihood of wrong-way movement.

Where the roadways are separated by a median more than 8 feet wide, ONE-WAY (R-45) signs should be erected for each crossroad approach. For lesser median widths their use is optional. DO NOT ENTER (R-41-B) signs should be used to prevent wrong-way movement on a one-way roadway when the median width exceeds 15 feet. See Figure R5-8.

Where the median width exceeds 30 feet, both DO NOT ENTER (R-41-B) and WRONG WAY (R-41A) signs should be placed on a divided highway at a location to be directly in view of a driver making a wrong-way entry from the crossroad. Additional signs may be placed where the median width is 30 feet or more.

Standard directional arrow pavement markings may be placed in each approach lane of each roadway in advance of a grade intersection and at other selected locations to indicate the direction of traffic flow.

At locations which are determined to have a special need, other standard warning or prohibitive methods and devices may be used as a deterrent to the wrong-way movement.

On two-lane paved crossroads at interchanges double solid yellow lines should be used as a centerline for an adequate distance on both sides approaching the ramp intersections. Symbol arrow pavement markings may be placed on the crossroad at appropriate locations near the ramp junction to indicate that permissive direction of flow. See Figure R5-9.

At locations which are determined to have a special need, other standard warning or prohibitive methods and devices may be used as a deterrent to the wrong-way movement.

2J-41 Divided Highway Crossing Sign (R-107A, B)

The Divided Highway Crossing sign may be used as a supplemental sign on the approaching legs of a roadway that intersects with a divided highway.

The sign may be placed beneath a Stop sign or mounted separately. See Figure R3-6.

When the Divided Highway Crossing sign is used at a four-legged intersection, sign R-107A shall be used. When used at a “T” intersection, sign R-107B shall be used.

2J-40 Wrong Way Traffic Control For Ramp Intersections

To help prevent wrong-way usage, efforts shall be made to identify and correct wrong-way movements at highway ramp terminals.

For interchange exit ramps, ONE-WAY signs shall be placed where the exit ramp intersects the crossroad. Turn prohibition signs may be placed, especially on two lane rural crossroads, appropriately in advance of the ramp intersection to supplement the ONE-WAY sign. DO NOT ENTER signs shall be conspicuously placed near the end of the exit ramp in positions appropriate for full view of a driver starting to enter wrongly. At least one WRONG-WAY sign shall be placed on the exit ramp. Additional WRONG-WAY signs may be used where the ramp geometries justify their installations.

2K PARKING CONTROL SERIES

2K-1 General

Information regarding the classification, legal authority, and application of parking control signs is presented in PART 6 of this manual under the subject of Parking Control Zones.

2L MISCELLANEOUS SERIES

PEDESTRIAN SIGNS

2L-1 Walk on Left Sign (R-71)

The pedestrian sign WALK ON LEFT FACING...
NOTES:

1. DO NOT ENTER and WRONG WAY assembly shall be mounted with the bottom of the lower sign 2' above edge of pavement.
2. ONE WAY arrows shall be mounted 3' above edge of pavement.
3. Located 50' - 100' from stop bar.

Virginia
VIRGINIA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION

TRAFFIC AND SAFETY DIVISION

MEMORANDUM

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There has been some concern about the 1 1/2 feet mounting height of the ONE WAY signs as specified in T&ES memorandum No. 165 dated October 20, 1981, by District personnel and the Federal Highway Administration. They feel that this mounting height should be adjusted, especially at locations where the ONE WAY sign is mounted behind guardrail. Also, there was concern about the signs being obscured by vegetation.

Therefore, in order to alleviate these concerns, it has been decided to increase the mounting height of the ONE WAY sign to 3 feet. Drawing No. TA-1500 has been revised this date to reflect this change, as shown on the back of this memorandum.

cc: Mr. Leo E. Busser, III
    Mr. J. T. Warren
    Mr. J. M. Wray, Jr.
    Mr. O. K. Mahry
    Mr. W. L. Brittle, Jr.
    Mr. H. W. Worrall
    Division Heads
    Resident Engineers
    District Traffic Engineers

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Appendix D

Wrong-Way Related California Vehicle Codes
Wrong-Way Related California Vehicle Codes

California Highway Patrol officers can cite an individual for violating the California Vehicle Code if they witness the infraction. In the Los Angeles area, the wrong-way signs were vandalized with territorial gang symbols and stolen for their scrap metal value. Efforts were made in curbing vandalism and theft of traffic signs in the 26 citations for violation of the "Interference With Traffic Devices" Vehicle Code Section 21464. In addition, officers were instructed to "report any actual or potential highway condition that may affect the safe and efficient flow of traffic to the responsible highway authority." The majority of wrong-way accidents were caused by those driving under the influence. DUI arrests during the first three quarters of the 1988 year amounted to 725, in the sobriety checkpoint locations alone. The State of California Vehicle Code Sections which relate to wrong-way and U-turn related violations follow.

Designated Traffic Direction

21657. The traffic authorities in charge of any highway may designate any highway, roadway, part of a roadway, or specific lanes upon which vehicular traffic shall proceed in one direction at all times as shall be indicated by official traffic control devices. When a roadway has been so designated, a vehicle shall be driven only in the direction designated at all times or such times as shall be indicated by traffic control devices.

Interference With Traffic Devices

21464. (a) No person shall without lawful authority deface, injure, attach any material or substance to, knock down, or remove, nor shall any person shoot at, any official traffic control device, traffic guidepost, traffic signpost, or historical marker placed or erected as authorized or required by law, nor shall any person without such authority deface, injure, attach any material or substance to, or remove, nor shall any person shoot at, any inscription, shield, or insignia on any such device, guide, or marker.
(c) Any willful violation of subdivision (a) or (b) which results in injury to, or death of, a person shall be punished by imprisonment in the state prison, or imprisonment in a county jail for a period of not more than six months.

Willful or Negligent Damage

17300. (a) Any person who willfully or negligently damages any street or highway, or its appurtenances, including, but not limited to, guardrails, signs, traffic signals, and similar facilities, is liable for the reasonable cost of the repair or replacement thereof.
(d) The Department of Transportation and local authorities, with respect to highways under their respective jurisdictions, may present claims for liability under this section, bring actions for recovery thereon, and settle and compromise in their discretion claims arising under this section.
(e) If the Department of Transportation or a local authority provides services on a highway outside its jurisdiction, at the request of the department or the local authority which has jurisdiction over that highway, the department or the local authority may present a claim for liability for rendering this service under this section, bring actions for recovery thereon, and, in its discretion, settle and compromise the claim.
Damage by Illegal Operation of Vehicle

17301. (a) Any person driving any vehicle, object, or contrivance over a highway or bridge is liable for all damages which the highway or bridge may sustain as a result of any illegal operation, driving or moving of the vehicle, object, or contrivance, or as a result of operating, driving, or moving any vehicle, object, or contrivance weighing in excess of the maximum weight specified in this code which is operated under a special permit issued by the Department of Transportation.
(b) Whenever the driver is not the owner of the vehicle, object, or contrivance but is operating, driving, or moving the same with the express or implied permission of the owner, the owner and driver are jointly and severally liable for the damage.

Recovery of Damages

17303. Damages under Sections 17301 and 17302 may be recovered in a civil action brought by the authorities in control of the highway or bridge.

Blood Alcohol Information

1666 The department shall do all of the following:
(a) Include at least one question in each test of an applicant's knowledge and understanding of the provisions of this code, as administered pursuant to Section 12804 or 12814, to verify that the applicant has read and understands the table of blood alcohol concentration published in the Driver's Handbook made available pursuant to subdivision (b) of Section 1656. In order to minimize costs, the questions shall be initially included the earliest opportunity when the test is otherwise revised or reprinted.
(b) Include with each driver's license or certificate of renewal and each vehicle registration renewal mailed by the department, information which shows with reasonable certainty the amount of alcohol consumption necessary for a person to reach a 0.10 percent blood alcohol concentration by weight.

Arrest Without Warrant

40300.5 Notwithstanding any other provision of law, a peace officer may, without a warrant, arrest a person who is (1) involved in a traffic accident or (2) observed by the peace officer in or about a vehicle which is obstructing a roadway, when the officer has reasonable cause to believe that the person had been driving vehicle under the influence of an alcoholic beverage and any drug.

Place of Arrest: Driving Under the Influence

40300.6 Section 40300.5 shall be liberally interpreted to further safe roads and the control of driving while under the influence of an alcoholic beverage or any drug in order to permit arrests to be made pursuant to that section within a reasonable time and distance away from the scene of a traffic accident. The enactment of this section during the 1985-1986 Regular Session of the Legislature does not constitute a change in, but is declaratory of, the existing law.
Alcohol or Drugs: Driver

23152 (a) It is unlawful for any person who is under the influence of an alcoholic beverage or any drug, or under the combined influence of an alcoholic beverage and drug, to drive a vehicle.
(b) It is unlawful for any person who has 0.10 percent or more, by weight, of alcohol in his blood to drive a vehicle. For purposes of this subdivision, percent, by weight, of alcohol shall be based on grams of alcohol per 100 millimeters of blood. In any prosecution under this subdivision, it is a rebuttable presumption that the person had 0.10 percent or more, by weight, of alcohol in his or her blood at the time of driving the vehicle if the person had 0.10 percent or more, by weight, of alcohol in his or her blood at the time of the performance of a chemical test within three hours after the driving.
(c) It is unlawful for any person who is addicted to the use of any drug to drive a vehicle. This subdivision shall not apply to a person who is participating in a methadone maintenance treatment program approved pursuant to Article 3 (commencing with Section 43501 of Chapter 1 of Part 1 of Division 4 of the Welfare and Institutions Code.

Alcohol or Drugs Causing Injury: Driver

21353. (a) It is unlawful for any person, while under the influence of an alcoholic beverage or any drug, or under the combined influence of an alcoholic beverage and any drug, to drive a vehicle and, when so driving, do any act forbidden by law or neglect any duty imposed by law in the driving of the vehicle, which act or neglect proximately causes bodily injury to any person other than the driver.
(b) It is unlawful for any person, while having 0.10 percent or more, by weight, of alcohol in his blood to drive a vehicle and, when so driving, do any act forbidden by law or neglect any duty imposed by law in the driving of the vehicle, such act or neglect proximately causes bodily injury to any person other than the driver. For purposes of this subdivision, percent, by weight, of alcohol shall be based upon grams of alcohol per 100 milliliters of blood.
In any prosecution under this subdivision, it is a rebuttable presumption that the person had 0.10 percent or more, by weight, of alcohol in his or her blood at the time of driving the vehicle if the person had 0.10 percent or more, by weight, of alcohol in his or her blood at the time of the performance of a chemical test within three hours after the driving.
(c) In proving the person neglected any duty imposed by law in the driving of the vehicle, it is not necessary to prove that any specific section of this code was violated.

State Authority

21350. The Department of Transportation shall place and maintain, or cause to be placed and maintained, with respect to highways under its jurisdiction, appropriate signs, signals and other traffic control devices as required hereunder; and may place and maintain, or cause to be placed and maintained, such appropriate signs, signals or other traffic control devices as may be authorized hereunder, or as may be necessary properly to indicate and to carry out the provisions of this code, or to warn or guide traffic upon the highways. The Department of Transportation may, with the consent of the local authorities, also place and maintain, or cause to be placed and maintained, in or along city streets and county roads, appropriate signs, signals and other traffic control devices, or may perform, or cause to be performed, such other work on city streets and county roads, as may be necessary or desirable to control, or direct traffic, or to facilitate traffic flow to or from or on state highways.
Traffic and Pedestrian Regulation on State Highways

21352. The Department of Transportation may erect stop signs at any entrance to any state highway and whenever the department determines that it is necessary for the public safety and the orderly and efficient use of the highways by the public, the department may erect and maintain, or cause to be erected and maintained, on any state highway any traffic control signal or any official traffic control device regulating or prohibiting the turning of vehicles upon the highway, allocating or restricting the use of specified lanes or portions of the highway by moving vehicular traffic, establishing crosswalks at or between intersections, or restricting use of the right-of-way by the public for other than highway purposes.

Divided Highways

21651. (a) Whenever a highway has been divided into two or more roadways by means of intermittent barriers or by means of a dividing section of not less than two feet in width, either unpaved or delineated by curbs, double-parallel lines, or other markings on the roadway, it is unlawful to do either of the following:
(1) To drive any vehicle over, upon or across the dividing section.
(2) To make any left, semicircular, or U-turn with the vehicle on the divided highway, except through an opening in the barrier designated and intended by public authorities for the use of vehicles or through a plainly marked opening in the dividing section.
(b) It is unlawful to drive any vehicle upon a highway, except to the right of an intermittent barrier or a dividing section which separates two or more opposing lanes of traffic.
(c) A violation of subdivision (b) on a freeway is a misdemeanor.

On Ramp Exit

21664. It is unlawful for the driver of any vehicle to make an exit from or to leave any freeway which has full control of access and no crossings at grade upon any on-ramp providing entrance to such freeway.

U-Turn in Business District

22102 No person in a business district shall make a U-turn, except at an intersection, or on a divided highway where an opening has been provided in accordance with Section 21651. This turning movement shall be made as close as practicable to the extreme left-hand edge of the lanes moving in the driver's direction of travel immediately prior to the initiation of the turning movement, when more than one lane in the direction of travel is present.

Turning Near Fire Stations

22104. No person shall make a U-turn in front of the driveway entrance or approaches to a fire station. No person shall use the driveway entrance or approaches to a fire station for the purpose of turning a vehicle so as to proceed in the opposite direction.

Unobstructed View Necessary for U-turn

22105. No person shall make a U-turn upon any highway where the driver of such vehicle does not have an unobstructed view for 200 feet in both directions along the highway and of any traffic thereon.
U-Turn in Residence District

22103. No person in a residence district shall make a U-turn when any other vehicle is approaching from either direction within 200 feet, except at an intersection when the approaching vehicle is controlled by an official traffic control device.

Driving When Privilege Suspended or Revoked

14601. (a) No person shall drive a motor vehicle at any time when that person's driving privilege is suspended or revoked for reckless driving in violation of Section 23103 or 23104, and reason listed in ( ) subdivision (a) license, negligent or incompetent operation of a motor vehicle as prescribed in subdivision (e) of Section 12809, or negligent operation as prescribed in Section 12810, and when the person so driving has knowledge of the suspension or revocation. Knowledge shall be presumed if notice has been given by the department to the person. The presumption established by this subdivision is a presumption affecting the burden of proof.

Driving When Privilege Suspended or Revoked for Other Reasons

14601.1 (a) No person shall drive a motor vehicle when his or her driving privilege is suspended or revoked for any reason other than those listed in Section 14601 or 14601.2 and when the person so driving has knowledge of the suspension or revocation. Knowledge shall be presumed if notice has been given by the department to the person. The presumption established by this subdivision is a presumption affecting the burden of proof.

Driving When Privilege Suspended or Revoked for Driving Under the Influence, With Excessive Blood Alcohol, or When Addicted

14601.2 (a) No person shall drive a motor vehicle at any time when that person's driving privilege is suspended or revoked for a conviction of a violation of Section 23152 or 23153, and when the person so driving has knowledge of the suspension or revocation.

Habitual Traffic Offender

14601.3 (a) It is unlawful for a person whose driving privilege has been suspended or revoked to accumulate a driving record history which results from driving during the period of suspension or revocation. A person who violates this subdivision is designated a habitual traffic offender. For purposes of this section, a driving record history means any of the following, if the driving occurred during any period of suspension or revocation which resulted from a conviction of an offense or offenses of driving under the influence of alcohol or drugs, or both, or from negligent driving:

(1) Two or more convictions within a 12-month period of an offense given a violation point count of two pursuant to Section 12810.
(2) Three or more convictions within a 12-month period of an offense given a violation point count of one pursuant to Section 12810.
(3) Three or more accidents within a 12-month period that are subject to the reporting requirements of Section 16000.
(4) Any combination of convictions or accidents, as specified in paragraphs (1) to (3), inclusive, which results during any 12-month period in a violation point count of three or more pursuant to Section 12810.
Appendix E

Pavement Lights Retrofit Diagrams
NOTES (THIS SHEET)

1. FLASHING BEACON CONTROL ASSEMBLY, WHEN REQUIRED. 
   WIRING DIAGRAM- STANDARD PLAN ES-4C.

2. NEMA JR ENCLOSURE FOR TRANSFORMER, WHEN SHOWN 
   ON THE PLANS. (APPROX. DIMENSIONS: 12" H X 8" W X 8" D.)

3. INSTALL STATE-FURNISHED SIGN. 
   INSTALLATION DETAILS- STANDARD PLAN S44-7.

4. LOCATE SUCH THAT WIRES DO NOT INTERFERE 
   WITH CONTROL EQUIPMENT IN "O" CABINET.

5. EXISTING UPPER CASTING, WITH LENS.


7. LAMP AND REFLECTOR ASSEMBLY- SEPCO PART NO. 20449-1.

8. SOCKET AND LEAD ASSEMBLY- SEPCO PART NO. 19085-1.


11. EXISTING 3 INCH LB 30 BASE RECEPTACLE.