All-Way Stops: A New Policy

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This project was undertaken to develop a new all-way stop policy that would, with success and credibility, select intersections best suited to all-way stop controls. A variety of categories is considered by the new policy: accidents, unusual conditions, traffic volumes, and pedestrian volumes. Each category contributes points to a total that may, in sum, justify all-way stops for the intersection. Conversely, the circumstances within one category may be sufficiently extreme as to justify all-way stops based on that category alone. Existing all-way stop policies were determined to not be sufficiently flexible. The new policy combines the best features from national policies and the old City of San Diego policy. Also, the provisions within the new policy are derived from research and experience with all-way stops, not simply modifications of traffic signal warrants. The policy was tested by comparing accidents and field performance in a before-and-after study of existing all-way stop intersections. Some of these intersections met the all-way stop criteria in the new policy, whereas others did not. The study showed convincingly that the intersections that met the new policy's criteria had fewer accidents and stop sign violations than the intersections that did not.

San Diego, like many cities, has struggled with the issue of all-way stops for many years. The city receives many requests for all-way stops, which can be an emotional issue for some citizens. To many elected officials, a group of citizens requesting an all-way stop may themselves provide sufficient warrant to install an all-way stop, regardless of whether traffic engineering warrants have been met. Traffic engineers, however, want to be able to differentiate good all-way stop candidate intersections from bad ones through analysis of operational and safety factors. Part of the problem is that many engineers, in San Diego and elsewhere, are not comfortable with the *Manual on Uniform Traffic Control Devices* (MUTCD) (*1*) warrants.

A better all-way stop policy that is accepted and respected by both professionals and nonprofessionals will make it more likely for a confident engineering staff to successfully limit all-way stop installations to only those locations where the safety and operation of the intersection will improve with all-way stops.

Traffic Engineering Principles

The function of all-way stops is to control the right-of-way assignment at intersections. With all-way stops, vehicles on the intersecting streets alternate having the right-of-way. Therefore, all-way stops function best when the traffic volume at the intersection is high enough that vehicle conflicts are common and when the traffic volume is evenly split between the intersecting streets. All-way stops may also be effective at locations where there have been numerous correctable right-angle type accidents or where numerous unusual conditions exist.

It is neither wise nor practical to install all-way stops indiscriminately. On streets with frequent stops, motorists tend to drive at higher speeds to make up for the "lost time." Some motorists may even be tempted to disregard stop signs when there is no apparent "need" to stop because of cross traffic, pedestrians, or limited visibility. When motorists fail to obey stop signs, they are jeopardizing safety for themselves, other drivers, and pedestrians. Furthermore, the installation of unwarranted stop signs on major streets can create excessive queuing, delay, exhaust emission, fuel use, and noise.

PROBLEMS WITH EXISTING ALL-WAY STOP POLICIES

The MUTCD policy has three warrants. For an all-way stop to be justified, only one warrant must be met, but the warrant must be met in its entirety.

The MUTCD warrants the following (*1*):

1. Where traffic signals are warranted and urgently needed, the multiway stop as an interim measure that can be installed quickly to control traffic while arrangements are being made for the signal installation.
2. An accident problem, as indicated by five or more reported accidents in a 12-month period of a type susceptible to correction by a multiway stop installation. Such accidents include right- and left-turn collisions, as well as right-angle collisions.
3. Minimum traffic volumes:
   - The total vehicular volume entering the intersection from all approaches must average at least 500 vehicles per hour for any 8 hours of an average day; and
   - The combined vehicular and pedestrian volume from the minor street or highway must average at least 200 units per hour for the same 8 hours, with an average delay to minor street vehicular traffic of at least 30 seconds per vehicle during the maximum hour; but
   - When the 85th percentile approach speed of the major street traffic exceeds 40 mph, the minimum vehicular volume warrant is 70 percent of the above requirements.

There are numerous reasons to question the MUTCD policy. First, the MUTCD all-way stop policy is dependent on signals. Warrant 1 states that all-way stops may be used as interim measures before signal installation. Warrant 2 is a variation of Signal Warrant 6, and Warrant 3 is nearly identical to Signal Warrant 1.

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It is questionable to rely on an all-way stop policy derived from signals, not stop signs. The policy does not consider accidents or volumes when the numbers are below the specified thresholds. The MUTCD policy does not consider other factors that should be examined in an all-way stop evaluation, such as visibility, schools, or pedestrians. Furthermore, the "mixed" situation (moderate volumes, a few accidents, some pedestrians) is not addressed.

CITY OF SAN DIEGO'S EXPERIENCE

As an alternative to the national policy, the City of San Diego developed an all-way stop policy based on a point system in 1962. The system was based on several warrants, each worth a few points. All-way stops were justified at candidate intersections that were assigned a majority of the total available points. This policy was an improvement over the MUTCD policy because it was not dependent on signals, and it addressed the areas that the MUTCD policy overlooked. Another strength was the introduction of the Traffic Volume Difference Warrant, which awarded points to intersections based on the closeness of the traffic volumes on the intersecting streets.

The policy also had several weaknesses. For instance, no single warrant could in itself justify all-way stops. Each warrant simply contributed points to a total. In some circumstances, a candidate intersection may have received maximum points from one or more warrants but still did not qualify for all-way stops because a majority of the total points had not been accumulated. Another weakness was that the policy did not contain the MUTCD provision for using all-way stops as interim measures before installing traffic signals.

City staff encountered situations in which engineering judgment indicated that all-way stops would be appropriate at a particular location, yet neither the MUTCD warrants nor the city's own policy could justify the installation. Consequently, the City began in 1986 to research all-way stops and develop a revised all-way stop policy. The goals of the new policy were as follows:

1. Consistency. The policy should be in conformance with traffic engineering principles of safety and operation for all-way stop intersections.
2. Accountability. The policy should be based on all-way stops, not signals.
3. Flexibility. The policy should equally consider intersections that have extreme circumstances in one category that may justify all-way stops, as well as intersections that have a combination of factors, none of which individually would justify all-way stops.
4. Selectivity. The policy should be effective at distinguishing the candidate intersection that will benefit from the installation of all-way stops.

THE NEW POLICY

The new policy consists of five warrants and a total of 50 points. All-way stops may be justified at intersections that are assigned 25 or more points. The 25-point requirement may be waived, and all-way stops justified, under any one of the following special provisions:

1. Five or more accidents susceptible to correction by all-way stops have occurred in a 12-month period.
2. Traffic signals are warranted and not yet installed.
3. The intersection has an extreme combination of unusual conditions, and engineering judgment determines that the location would be best served by all-way stops. Examples of unusual conditions are a school, fire station, playground, bus route, steep hill, and visibility limitation. A school in itself is not considered to be sufficient justification for all-way stops.

Provisions 1 and 2 are adopted from the MUTCD warrants. Provision 3 should be used sparingly, usually after less severe controls have been attempted.

The following includes an explanation of each warrant:

1. Accident experience—maximum 15 points. Three points are assigned for each correctable accident that occurred in the preceding 12-month period.
2. Unusual conditions—maximum 5 points. Points are assigned for unusual conditions based on engineering judgment. The point value assigned to each condition should be correlated to the improvement to the situation that all-way stops would provide. When awarding points in this warrant, it is important to consider only the actual benefits that all-way stops provide, not the perceived benefits attributed to all-way stops by many nonprofessionals. Speed control should never be a basis for awarding points.
3. Traffic volumes—maximum 15 points. Two tables, one for the minor street and one for the major street, are used to assign points based on volume. The major street is defined as the traffic approaches that are not controlled by stop or yield signs at the time of the evaluation. The minor street is defined as the approaches that are controlled. For the minor street, the number of points awarded increases as the volume increases up to a maximum of ten points. For the major street, the maximum of five points is assigned to a range of volumes at which all-way stops function best. Above or below this optimum volume range, fewer points are awarded. To determine the optimum range for all-way stop volumes in the new policy, the 1985 *Highway Capacity Manual* (*2*) was consulted. The following is the method used for deriving "ideal" volume:

The 1985 *Highway Capacity Manual* was consulted for determining the point assignment tables for traffic volume. The level-of-service (LOS) C service volumes for four all-way stop intersections are as follows:

	LOS C Service Volume (vph) by Lane Configuration		
Demand Split	*2 by 2*	*2 by 4*	*4 by 4*
50/50	**1,200**	1,800	2,200
55/45	1,140	1,720	2,070
65/40	1,080	1,660	1,970
65/35	1,010	1,630	1,880
70/30	960	1,610	1,820

The tabulation is sorted into demand splits ranging from 50/50 to 70/30 and lane configurations (2 by 2, 2 by 4, and 4 by 4). It was determined that the traffic volume point assignment table should be derived from the case of a 50/50 demand split at a two-lane by two-lane intersection. The LOS C service volume for this situation is 1,200 vehicles per hour (vph) entering the intersection.

Since the City of San Diego uses 4-hour counts for traffic studies, the 1,200 vph translated into 4,800 vehicles in 4 hours. Therefore, with an ideal 50/50 split, each street should have a 4-hour approach volume of 2,400 vehicles. Consequently, the figure of 2,400 vehicles is within the maximum point range for both the major street and the minor street point assignment tables. For the major street, the optimum range is between 2,201 and 2,600 vehicles in 4 hours. For the minor street, all volumes above 2,201 are considered optimum and are assigned maximum points. The point assignment tables are shown in Table 1.

4. Traffic volume difference—maximum 10 points. This warrant differs from the "traffic volumes" warrant in that it considers only the difference between the 4-hour volumes of the two streets. All-way stops function best when the difference between the volumes is small. Accordingly, a small traffic volume difference is assigned maximum points. The point assignment table for this warrant is shown in Table 2.

5. Pedestrian volumes—maximum 5 points. The volume of pedestrians crossing the major street is of concern when evaluating for all-way stops. One point is assigned for each set of 50 pedestrians in 4 hours, as shown in Table 3.

An evaluation sheet is shown in Figure 1.

TABLE 1 POINT ASSIGNMENT FOR TRAFFIC VOLUME

Major Street		Minor Street	
4-hour Volume	Points	4-hour Volume	Points
0–1,000	0	0–400	0
1,001–1,300	1	401–600	1
1,301–1,600	2	601–800	2
1,601–1,900	3	801–1,000	3
1,901–2,200	4	1,001–1,200	4
2,201–2,600	5	1,201–1,400	5
2,601–2,900	4	1,401–1,600	6
2,901–3,200	3	1,601–1,800	7
3,201–3,500	2	1,801–2,000	8
3,501–3,800	1	2,001–2,200	9
3,801–over	0	2,201–over	10

TABLE 2 POINT ASSIGNMENT FOR TRAFFIC VOLUME DIFFERENCE

Volume Difference (4-hour count)	Points
0–150	10
151–300	9
301–450	8
451–600	7
601–750	6
751–900	5
901–1,050	4
1,051–1,200	3
1,201–1,350	2
1,351–1,500	1
1,501–over	0

TABLE 3 POINT ASSIGNMENT FOR PEDESTRIAN VOLUME

No. of Pedestrians Crossing Major Street in 4 hours	Points
0	0
1–50	1
51–100	2
101–150	3
151–200	4
201–over	5

TESTING THE NEW POLICY

Once it had been developed, there was interest in how the new policy compared to the city's previous policy. A total of 23 intersections in the City of San Diego were used to test the ability of the new policy to select intersections that benefit from and function well with all-way stops. The intersections chosen for the study all had all-way stops that had been installed (either by engineering judgment or City Council directive) despite having failed to meet the city's previous policy. The intersections were then reevaluated, by using the new policy with data from the original evaluation.

Fourteen of the intersections met the criteria of the new policy. That is, if the new policy had been in effect at the time that the intersections were originally evaluated for all-way stops, then 14 of the 23 would have qualified. The 14 were placed in Group A for comparison purposes. The remaining nine intersections, those that failed to meet all-way stop warrants under either the old or new policy, were placed in Group B.

The study consisted of analyses of accidents and field performance. The accident analysis involved 19 intersections, 12 from Group A and 7 from Group B. The field analysis used 15 intersections, 8 from Group A and 7 from Group B. All 23 of the intersections were included in at least one of the analyses.

The first analysis, a comparison of the number of accidents 12 months before and after the all-way stops were installed, showed that the intersections in Group A experienced a significant reduction. In contrast, the intersections in Group B did not experience a significant change in accidents; in fact, the number of accidents rose slightly. Figures 2 and 3 show the results of the before-and-after accident comparison. For Group A, the reduction in accidents that occurred at the intersections was found to be statistically significant at the 99 percent confidence level. For all accidents at or near the intersections (midblock accidents are assigned to the nearest intersection), the decrease was also significant at the 99 percent confidence level.

The field analysis also gave interesting results. Group A had an average volume ratio of major street to minor street of 1.8, whereas the ratio for Group B was 4.0, as shown in Figure 4. These data support the idea that all-way stops function best when the cross-street volumes are nearly equal. A key finding was that Group B had a higher frequency of major street motorists failing to stop, as shown in Figure 5. In Group A, 6.8 percent of the motorists on the major street failed to stop, whereas in Group B, 13.0 percent failed to stop. The difference between the two groups was found to be statistically

Intersection ____________ (MAJOR) ____________ (MINOR)

File ________
Date ________
Investigator ________

Qualifies for All-Way Stop based on 25 or more points:
Yes ___ No ___ Points ___

Qualifies for All-Way Stop based on other criteria: Yes ___ No ___
If yes, explain:

____

Sketch of intersection with visibility data
On back ___ Attached ___

	Points	Possible
1. Accident Experience		
From ___/___/___ to ___/___/___		
Accidents/year correctable by Stops x 3 points/accident	______	15
2. Unusual Conditions		
______________________________	______	5
______________________________		
______________________________		
3. Traffic Volumes (Peak 4 Hours)		
Major approaches ______	______	5
Minor approaches ______	______	10
4. Traffic Volume Difference ______	______	10
5. Pedestrian Volume		
Pedestrians ______ crossing the major street during 4 hour count	______	5
TOTAL	______	50
Points Required	25	

FIGURE 1 All-way stop evaluation worksheet.

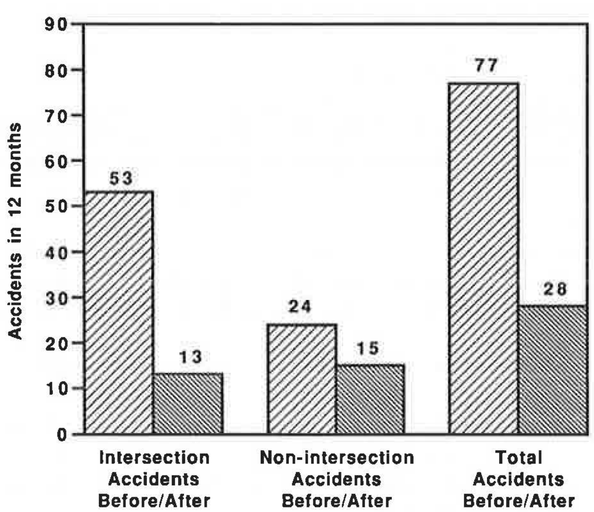

FIGURE 2 Before-and-after accident comparison (Group A).

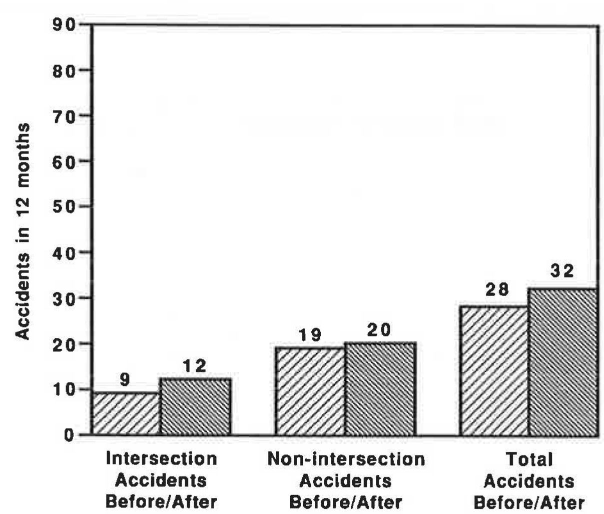

FIGURE 3 Before-and-after accident comparison (Group B).

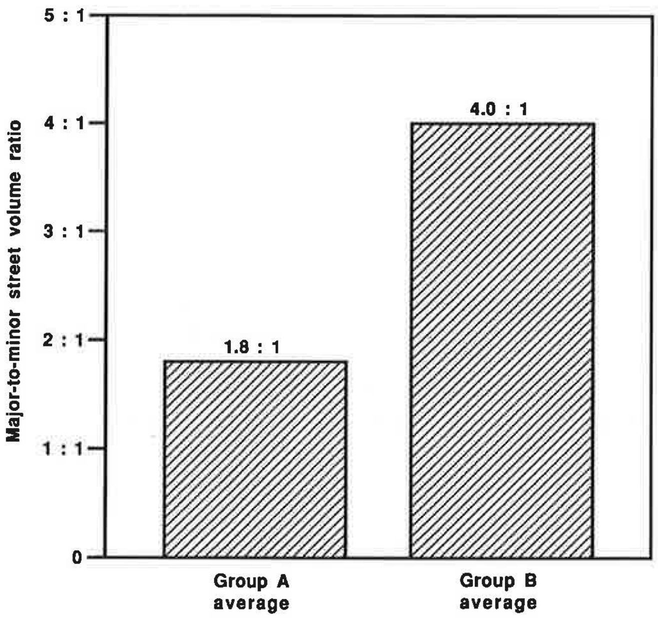

FIGURE 4 Volume ratio comparison (Group A versus Group B).

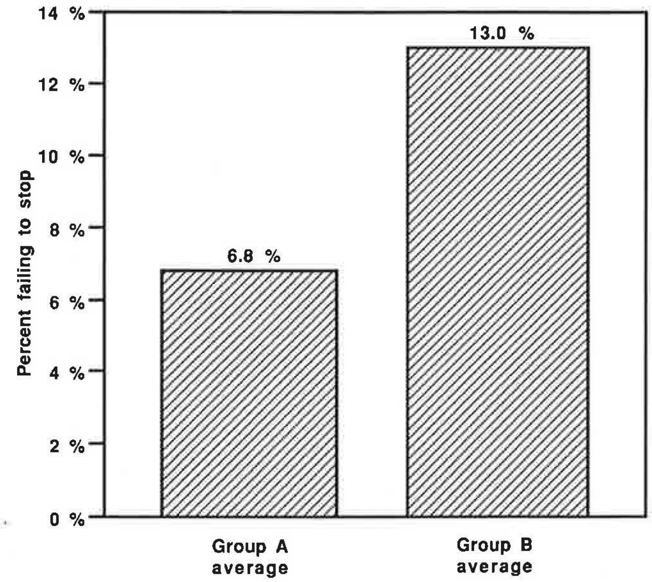

FIGURE 5 Failure-to-stop comparison (Group A versus Group B).

significant at the 95 percent confidence level. These figures indicate that the new policy is successful at selecting intersections where all-way stop controls will earn motorists' respect and have a better rate of stop sign compliance.

The results of the statistical analyses are shown below:

Note: Only those tests that showed statistical significance are shown.

1. Accidents at intersection: 53 in 12 months before all-way stop was installed; 13 in 12 months after.
   - Calculated t = 3.028, d.f. = 22;
   - Tabulated t (at 99 percent confidence) = 2.819;
   - Therefore the difference is significant at the 99 percent confidence level.

2. Total of accidents at and near intersection: 77 in 12 months before all-way stop was installed, 28 in 12 months after.
   - Calculated t = 2.865, d.f. = 22;
   - Tabulated t (at 99 percent confidence) = 2.819;
   - Therefore the difference is significant at the 99 percent level.

3. Percent of vehicles on major street failing to stop: Group A—6.8 percent, Group B—13.0 percent.
   - Calculated z = 2.334, d.f. = 13;
   - Tabulated z (at 99 percent confidence) = 3.012;
   - Tabulated z (at 95 percent confidence) = 2.160;
   - Therefore the difference is significant at the 95 percent confidence level.

CONCLUSION

The new policy meets all of the goals for a model all-way stop policy. The policy is consistent with traffic engineering principles, is not dependent on traffic signal warrants, is flexible for use in differing conditions, and is successful at selecting intersections that benefit from the installation of all-way stops. It will give traffic engineers confidence in the all-way stop warrants when discussing the issue with citizens' groups and elected officials. The policy will assist traffic engineers in their mission of educating the public about traffic safety and providing the public with safe streets and efficient traffic flow.

ACKNOWLEDGMENTS

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REFERENCES

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DISCUSSION

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The paper by Celniker is a welcome departure from the MUTCD multiway stop warrants, which have been criticized elsewhere (*1,2*) for their lack of scientific validity.

This comment deals with Celniker's statement that safety is jeopardized when drivers disobey a stop sign. When a sign imposes a needless stop, it fails to meet two basic requirements for a traffic control device to be effective: it does not fulfill a need and it does not command respect. In Dyar's study, (*3*) 88 percent of all motorists disregarded stop signs in light traffic and treated them as yield signs when there was no one to stop for—clear evidence of an overly restrictive control (*4*).

The compulsory stop regardless of traffic conditions should not only be justified by evidence showing that the failure to stop per se (rather than the failure to yield) contributes to collisions, but also that the cost of these collisions outweighs the cost of the additional delay, fuel consumption, and air pollution. Without such proof, the unconditional stop is not warranted (*5*).

To first maintain that needless stops should be avoided in the interest of safety, efficiency, and respect for traffic controls, and then claim that the failure to come to a peremptory but needless stop jeopardizes safety, is a contradiction the traffic engineering profession has yet to explain. The logical way out of this contradiction is the all-way yield, a technique capable of competing with traffic signal control in terms of costs to the road user and highway agency (*6*).

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AUTHOR'S CLOSURE

The purpose of the new all-way stop policy is to balance the public's request for all-way stops with traffic engineering principles of safety and operations. The new policy is positive for the following reasons:

- The all-way stop is an existing, familiar traffic control device.
- The new policy is flexible to a variety of factors, yet it allows only all-way stops to be installed at intersections where they will function well.
- The concept of avoiding unnecessary stop signs is consistent with, not contradictory to, the statement that a failure to stop jeopardizes safety. The policy's goal is to install all-way stops only where they will have a high rate of compliance.

The "all-way yield" proposal is a deeply flawed alternative. Traditionally, a yield sign says to motorists "yield the right-of-way to cross traffic by either stopping or slowing down; then, when there are no vehicle conflicts go ahead." This message is very useful and successful in cases of low-volume intersections or channelized right-turn lanes. The yield signs face only the direction of traffic that yields.

The proposed "all-way yield" changes the message of the yield sign to "slow down, a complete stop is not necessary; yield the right-of-way to cross traffic as you would at an all-way stop or an uncontrolled intersection, then go ahead."

The all-way yield is a basic contradiction in terms, potentially dangerous, and unnecessary. Motorists will be confused about the new use of a familiar sign, and such confusion may lead to accidents. Also, the successful, traditional use of the yield sign will be lost if yield signs take on a new meaning.

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