# Reevaluation of the Usefulness and Application of Decision Sight Distance

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**One of the most important elements of highway geometric design is sight distance. In *A Policy on Geometric Design of Highways and Streets*, the American Association of State Highway and Transportation Officials has adopted a new sight distance standard known as decision sight distance (DSD). These sight distances are considerably longer than stopping sight distance, giving motorists additional margin for error and sufficient length to maneuver their vehicles at the same or reduced speed rather than to just stop. Nevertheless, there has been some concern that states have not adopted and implemented this standard. To determine if this is true, a limited survey of 15 states was made. A questionnaire was used to determine if the state has adopted the standard—and if it has not, why. Comments were solicited on how the standard should be modified. This paper also critiques a proposed revised AASHTO standard for DSD and concludes with the author's recommendation for a change to the DSD standard.**

One of the most important elements for highway geometric design is sight distance. Providing maximum sight line within the vision capabilities of the driver is a desirable goal. If the driver can see what is unfolding far enough ahead, he can handle almost any situation.

Until the issuance of the current AASHTO geometric design manual, there were standards for stopping sight distance, intersection sight distance, passing sight distance, and railroad-highway grade crossing sight distance. Although these sight distance standards have brought about reasonably good design practice for a majority of our roadway system, it was felt that certain situations required longer sight distances. In particular, stopping sight distance, the design criterion that requires minimum sight distance at all points along the road, was thought to be inadequate for situations with high decision complexity, when the development of a potentially hazardous situation is difficult to perceive, and when severe braking is inappropriate. At locations where longer distances are needed, a review of human factors and traffic operations considerations shows that sight distance criteria should be based on the driver's ability to properly react to impending danger. With this concern in mind, the concept of decision sight distance (DSD) was formulated and eventually found its way into the 1984 AASHTO design manual—*A Policy on Geometric Design of Highways and Streets* (*1*)—known as the Green Book.

In that policy, DSD is defined as the distance required for a driver to detect an unexpected or otherwise difficult-to-perceive information source or hazard in a roadway environment that may be visually cluttered, recognize the hazard or its threat potential, select an appropriate speed and path, and initiate and complete the required maneuver safely and efficiently. This definition was developed by Alexander and Lunenfeld and was a key element of the concept of positive guidance (*2*).

At this point a little history of the development of DSD is in order. Although the term "decision sight distance" was first coined by Alexander and Lunenfeld (circa 1975), this longer sight distance concept has its roots with researchers such as the late Donald Gordon of the Federal Highway Administration and Richard Michaels, formerly with the then Bureau of Public Roads.

In his *Dynamic Design for Safety* (*3*), Leisch, drawing on the principles of perceptual anticipation discussed by Gordon (*4*), argues the need for what he labeled "anticipatory sight distance." This distance would provide sight distance at all points along the road adequate for the driver to anticipate changes in design features, intersections, entrances, exits, or trouble spots ahead in sufficient time to take the appropriate action and carry on normally. Using judgment and relationships to "focusing distance," Leisch suggested the following values for anticipatory sight distance:

| | *Design Speed (mph)* | | | | | |
|---|---|---|---|---|---|---|
| | *30* | *40* | *50* | *60* | *70* | *80* |
| Minimum anticipatory sight distance, ft | 600 | 800 | 1,100 | 1,500 | 2,000 | 3,000 |

These anticipatory sight distances were to be measured from the height of eye to road surface. Leisch further suggested that these distances be provided at points of decision or potential hazard, such as approaches to interchanges, at-grade intersections, toll plazas, tunnel portals, road narrowings, lane drops, design speed reduction zones, and the like.

In the article "New Safety and Service Guides for Sight Distance" (*5*), Pfefer discusses anticipatory sight distance, but he also includes "perception sight distance." This notion was based on the first perception of an object in the visual field at which the driver perceives movement (angular velocity). The values suggested were as follows:

| | *Design Speed (mph)* | | | | | |
|---|---|---|---|---|---|---|
| | *30* | *40* | *50* | *60* | *70* | *80* |
| Perception sight distance, ft | 675 | 775 | 875 | 950 | 1,025 | 1,100 |

These values, which are considerably lower than anticipatory sight distance at the higher speeds, were to be provided

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TABLE 1 DECISION SIGHT DISTANCE (*1*)

| Design Speed (mph) | Time(s): Premaneuver: Detection & Recognition | Time(s): Premaneuver: Decision & Response Initiation | Time(s): Maneuver (Lane Change) | Decision Sight Distance (ft): Summation | Decision Sight Distance (ft): Computed | Decision Sight Distance (ft): Rounded for Design |
|---|---|---|---|---|---|---|
| 30 | 1.5-3.0 | 4.2-6.5 | 4.5 | 10.2-14.0 | 449- 616 | 450- 625 |
| 40 | 1.5-3.0 | 4.2-6.5 | 4.5 | 10.2-14.0 | 598- 821 | 600- 825 |
| 50 | 1.5-3.0 | 4.2-6.5 | 4.5 | 10.2-14.0 | 748-1,027 | 750-1,025 |
| 60 | 2.0-3.0 | 4.7-7.0 | 4.5 | 11.2-14.5 | 986-1,276 | 1,000-1,275 |
| 70 | 2.0-3.0 | 4.7-7.0 | 4.0 | 10.7-14.0 | 1,098-1,437 | 1,100-1,450 |

continuously along the roadway and measured from the driver's eye to the pavement.

In 1978, analytical and field research was conducted that was documented in the report *Decision Sight Distance for Highway Design and Traffic Control Requirements* (*6*). The DSD values were analytically developed, based on a sequential hazard avoidance behavior model. It was assumed that each of the several steps target detection, perception, decisionmaking, reaction, and maneuver—was performed serially with no time-sharing. Values were established for each of the information processing elements and added to arrive at the total time for DSD. These values were then slightly modified based on results of limited field studies in which drivers were exposed to geometric changes such as lane drops and complicated intersections. The final recommended values were adopted and included in the 1984 AASHTO Green Book (*1*). Table III-3 in the Green Book is shown as Table 1.

## STATE SURVEY ON ACCEPTANCE OF DSD

In order to determine to what extent the states have adopted DSD as a design element and if they are using the recommended values as shown in Table 1, a limited survey of a few states was conducted in late 1988. Specifically, the questionnaire shown as Figure 1 was sent to 15 states; of those, 12 replied. The responses are discussed below.

### Has Your State Adopted DSD?

Of the 12 states that responded, half indicated that they have adopted DSD and the other half said that they had not. A 100 percent adoption would not be expected because the AASHTO policy manual was released in 1984, and all the states probably have not yet revised their design manuals to reflect any changes or additions in the AASHTO manual. Still, only a 50 percent acceptance of this design criterion indicates that there is no across-the-board acceptance of the values, if not the concept.

### *If Yes, Indicate How It Has Been Included*

Most of the states that have adopted the design criterion have merely referred to the AASHTO manual, or they have duplicated or paraphrased the relevant section dealing with DSD. The State of Maryland has a table for various sight distances, and for DSD requires the following:

| | Design Speed (mph): 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
|---|---|---|---|---|---|---|---|---|
| Decision sight distance, ft | 225 | 425 | 625 | 825 | 1,025 | 1,300 | 1,625 | 1,975 |

For each design speed Maryland has selected the higher values from AASHTO, and for design speeds of 60 mph and higher even longer distances than those in AASHTO have been recommended to allow for a stop maneuver.

### *If No, Which of the Reasons Apply?*

Two states indicated that they are considering adoption of DSD but have not yet formally adopted or rejected it. Three states responded that they have not adopted DSD because the costs of the longer distances required have not been justified. One state responded that new alignments are rare, and it is too costly to provide DSD for rehabilitation projects. Four states said that the guidelines for use of DSD were too vague.

### Are DSD Values Too Short, Too Long, or About Right?

The numerical responses to this question were too long, 4; too short, 2; and about right, 7. One state, commenting on its "too long" response, said, "It is difficult to obtain DSD values in urban areas especially in rolling terrain; it is more practical to use stopping sight distance for urban intersections."

### Comments

There were several comments that qualified the use or non-use of DSD:

- Although not applied yet, the concept is workable. What are other states doing?
- We don't use it as often as we should.
- DSD is good concept, but impractical given our budgets and backlog of work.
- DSD is used for placement of warning signs.

1. Has your State adopted Decision Sight Distance (as it appears in AASHTO's Policy on Geometric Design of Highway & Streets) as a design element in your design manual or standard? Yes _______ No _______

2. If YES, please indicate how it has been included or provided appropriate excerpts of your manual. ____________________________________________

____________________________________________

____________________________________________

____________________________________________

3. If NO, which of the reasons apply:

_______ Under consideration, but have not yet integrated into our manual.

_______ The longer distances required have not been cost justified.

_______ The guidelines for application of DSD are too vague.

_______ Other, ____________________________________________

____________________________________________

____________________________________________

4. Do you feel the decision sight distance values are:

1) Too long _______

2) Too Short _______

3) About Right _____

If, 1) or 2) please explain ____________________________________________

____________________________________________

____________________________________________

5. Do you have any comments concerning Decision Sight Distance and its applicability for highway design (e.g., when or where should it be applied)?

____________________________________________

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____________________________________________

____________________________________________

Please return to:
Dr. Hugh W. McGee, P.E.
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8330 Boone Blvd., #700
Vienna, VA 22180

Completed by: _______________
Address: _______________
_______________
_______________
Phone No. ( ) _______________

FIGURE 1 Questionnaire on decision sight distance sent to 15 states.

• DSD should be a routine consideration in all highway design.

• DSD should be applied only at very specific decision points such as at at-grade intersections and complex interchanges.

• Specific application areas of merging, lane drops, ramp exits, and approaches to intersections would be more applicable.

• There are too many variables and specific conditions that are site-specific to effectively utilize this set of criteria.

Several states commented on the object height, which is set at 6 in in the AASHTO standard. One state suggested a higher object height, specifically 4.25 ft, since most of the targets would be other vehicles. A higher object height would essentially result in the allowance of a much less restrictive vertical alignment, even though the distance values remain the same. Another state also said that another vehicle in the lane was the appropriate object to be seen but believed that the appropriate height should be 18 in, reflecting the taillight height.

## AASHTO REVISED DSD VALUES

Revisions to the current AASHTO Green Book are being formulated by appropriate committees, and changes to the DSD values is one of them. Table 2 shows the proposed revised DSD values. They have not yet been adopted as final.

As can be seen in Table 2, the recommended revised DSD values are based on the road type and maneuver. The road types are rural, urban, and suburban, and the maneuvers are either to stop or to change speed, path, or direction. A review of the values shows that DSD values are the longest for the urban road for all speeds. This results from the assumption that urban situations are more complex and, therefore, require more time for information processing. While this may be, it can also be argued that in urban situations drivers are more alert, which would result in lower detection time (drivers searching for potential hazards) and lower reaction time.

These values can also be criticized from a practical, cost-effectiveness basis. Adherence to these values requires the design agency to provide the longest sight distances in urban areas, where they are least likely to be realized because of limited right-of-way. Given the objections raised by some states from the survey, it is unlikely that the states would embrace these recommended values.

## RECOMMENDED REVISED DECISION SIGHT DISTANCE VALUES

I would like to offer for consideration yet another set of DSD values. These are shown in Table 3. In developing these values, several factors were considered:

• A consistent complaint from the states was that the application guidelines were too vague. Hence, the values are now established for specific situations—interchange exits (left and right); lane drops, lane closures, and merges (all essentially require a lane change); lane shift; and intersections.

• Because the lane shift situation is the least demanding, it requires the shortest sight distance. Sight distance should be measured to the beginning of the shift.

• For intersections, DSD is necessary to be able to see and respond to turn lanes. Therefore, DSD should consider the need for a lane change and be measured to the turn lane itself.

• Lane drops, lane closures, and merges all require a lane change. DSD should be measured to the taper area.

• DSD should be provided at all interchange exits. Longer distances are recommended for left-side exits because of the nonexpectancy factor and because drivers wanting to exit may be at least two lanes removed. Although it could be argued that there are some differences in the time for information detection, processing, and reaction, these differences are not deemed long enough to warrant DSD values for each area.

• Unlike the AASHTO revised values, there is no difference for the type of road or area, for example, rural versus suburban versus urban.

• Only one value is given for each design speed and situ-

TABLE 2 PROPOSED REVISED DECISION SIGHT DISTANCE

| DESIGN SPEED (MPH) | Decision Sight Distance Required For Maneuver (Feet) A | B | C | D | E |
|---|---|---|---|---|---|
| 30 | 220 | 500 | 450 | 550 | 625 |
| 40 | 345 | 725 | 600 | 725 | 825 |
| 50 | 500 | 975 | 750 | 900 | 1025 |
| 60 | 680 | 1300 | 1000 | 1150 | 1275 |
| 70 | 900 | 1525 | 1100 | 1300 | 1450 |

A: STOP REQUIRED ON RURAL ROAD
B: STOP REQUIRED ON URBAN ROAD
C: SPEED/PATH/DIRECTION CHANGE ON RURAL ROAD
D: SPEED/PATH/DIRECTION CHANGE ON SUBURBAN ROAD
E: SPEED/PATH/DIRECTION CHANGE ON URBAN ROAD

TABLE 3 RECOMMENDED DECISION SIGHT DISTANCE

| Design Speed (MPH) | SITUATIONS Interchange 1/ Right Exit | Interchange 1/ Left Exit | Lane Drop/ Closure/ Merge 2/ | Lane Shift 3/ | Inter-sections 4/ |
|---|---|---|---|---|---|
| 30 | N/A | N/A | 450 | 250 | 450 |
| 40 | 600 | 825 | 600 | 350 | 600 |
| 50 | 750 | 1025 | 750 | 425 | 750 |
| 60 | 1000 | 1275 | 1000 | 600 | 1000 |
| 70 | 1100 | 1450 | 1150 | 725 | 1150 |

1/ Sight Distance to Gore
2/ Sight Distance to Taper Area
3/ Sight Distance to Begin of Shift
4/ Sight Distance to Turn Lane

ation. These values should be considered minimums that could be exceeded within cost limitations. There is no reason to have a range as there is with the current design standard.

With regard to the object height, because the purpose of DSD is to provide the motorist with sufficient sight distance of the design feature, the appropriate height should be the pavement surface, that is, 0 ft. Nevertheless, because using the pavement surface as the object height would have the significant effect of increasing the radius of horizontal and vertical curves, using the 6-in object height may be more appropriate. If DSD is being used for design and placement of signs, then a much higher object height can be used.

These values were developed without the benefit of extensive analysis and evaluation and, therefore, are subject to justifiable criticism and review. Nonetheless, regardless of what values are finally selected for inclusion in the AASHTO geometric design policy, certain principles should prevail:

1. Sight distances longer than stopping sight distance are needed for certain situations. They should be identified and specific values should be provided as a standard.
2. DSD values should consider cost implications, especially in urban situations. They should not be unnecessarily long.

## REFERENCES

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