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Use of NASS Data for Evaluation of AVCS Devices

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1. Introduction - The Evaluation Method

An examination has been made of the 1986 National Accident Sampling System (NASS) raw data files, as currently available, in order to determine if they provide sufficient information relating to events (including mental events) preceding an accident which would enable an evaluation of an IVHS (Intelligent Vehicle/Highway System) device by the method devised by the author (Hitchcock, 1987, 1988; Fontaine, 1989). In this method, an in-depth accident data base is scanned and the researcher forms a judgment (coupled with a judgment as to certainty) about whether an IVHS device of pre-defined operational specification, present in any of the vehicles, could have affected the course of an accident. By relating the number of hits and misses to data describing the extent to which the database is representative of the population of accidents, it is possible to deduce an upper bound to the effectiveness of the device. A subsequent paper (Hitchcock, 1991) proposes a method by which the estimation can be made more precise by quantifying the movements of the vehicles in a computer shell, and adding assumptions about driver responses and reaction times.

NASS raw data have some of the characteristics of the in-depth sets used by Hitchcock, Fontaine, and others who have reported results by the method described above. NASS concentrates on events during the crash, effects on the vehicle, and their relation to injuries. It is not immediately apparent if NASS data can be used to determine IVHS effectiveness. However, it is a very large database of consistent quality with a national coverage in the United States, and using this database to evaluate some or all IVHS devices, even with some reduction of certainty, would save much time and money. For this study, a sample of NASS raw data files was examined to determine their applicability. A positive finding in this study would mean that it could be determined whether an accident could have been affected by the IVHS device. It does not mean that the device would have been effective in preventing the accident. The objective here is to evaluate the database, not the device.

The NASS files in the form available to researchers have been edited. Parts of the evidence originally available have been deleted in order to avoid identification of particular individuals or accidents. This process has been carried out in a rather drastic fashion, and both the Police Accident Record, and the words used by the drivers in describing the accident are deleted. A further judgment has therefore been made about whether the results obtained would have been altered, had the interview data been present. The judgment here accepts that if the subject refused interview, no extra data would have been obtained, but assumes that, had there been an interview, some insight into the driver's intentions and perceptions would have been available. Thus, it would, for example, have been possible to distinguish between "did not look" and "looked, but failed to perceive." Clearly, some devices can cope with one of these human errors but not the other. While there is no evidence that the actual edited reports of NASS interviews would, if available, produce data about intention, it would be possible to make it an objective to have them do so.

2. Evaluation of Data Set

Seven Advanced Vehicle Control Systems (AVCS) devices were selected and, using strict protocols defined in advance, judgments were made about whether the data available was sufficient to judge whether a particular device, mounted on any of the vehicles in the accident, could have affected the course of the accident.

All of the devices selected were of an advisory nature. Judgments were made about whether the data were sufficient to determine if the device would have operated, whether it would have been noticed, and, if so, whether corrective action would have been effective. In the evaluation method used, only the last of these is important. However, the judgment that these devices would or would not have operated or been noticed is significant in the evaluation of other devices and in attempts to generalize the results about the value of the data set. This is discussed later.

From the 1986 NASS files, 103 cases (174 vehicles) of accidents not on urban freeways and 87 cases (151 vehicles) of accidents on urban freeways and arterials were selected by a random process in which each accident in its category had an equal chance of selection. The seven devices tested were:

- Forward night vision;
- A forward object detection device;
- A "blind spot" warning;
- A red light warning;
- A vehicle status indicator;
- A driver status indicator;
- A rollover threshold warning.

The operation of each device is more fully specified in the Appendix. It is believed that these are practical specifications with realistic limitations. Some of the devices are of an "early development" character, so that more sophisticated versions can be conceived, while others are more advanced concepts. It is desirable that it be possible to assess both and it seemed good practice to consider examples of each. In fact, no difference was found.

All these devices give warnings. In most cases it is possible to conceive of a controlling version which will, for example, put on the brakes if the warning is not heeded after a brief interval. For these automated versions, it is not necessary to consider whether the warning would have been noticed and the interval for reaction may be shorter. Consequently it may be possible to form a judgment about the effect of the controlling version in any case where it can be determined that it operated (which is one reason why data on operation are recorded here).

Equally, if one is prepared to make assumptions about the speed and manner in which drivers respond to warnings, it is again only necessary to determine if the device operated. Further, in some cases, notably the forward object detector, it is possible to form further judgments about effectiveness if there is good evidence about vehicle speed, and stopping distances. However, the ability to judge whether or not the device would have operated is important for another reason. There are cases where the device is relevant, but it is not possible to judge whether it would have operated. The fraction that these make of the whole introduces a corresponding uncertainty into an evaluation of the effectiveness of the device. This is made more important by the likely correlation between its actual effectiveness and the ability to judge whether it would have operated.

The ability to judge whether the device operated is therefore recorded and discussed in what follows, as well as the main result, the ability to judge whether the device would have affected the course of the accident. In the case of the forward object detector, the presence or absence of calculated relative speeds is also recorded.

3. Results

In forming the judgment about whether a device of the kind considered was relevant to the accident (e.g., a red light warning is relevant at signalized intersections only), it was possible to be precise--yes or no. Thus the data set is fully adequate here. A determination can be made in all cases. Uncertainty here was rare. But in the other cases, the scale “yes--probably--possibly--no” was used. In the numbers in the tables below, “yes” is given weight 1, “probably," weight **2/3,** “possibly, " weight **1/3,** and the numbers are summed before a percentage of relevant cases is taken. (Presumably in future uses it will be possible to use the computer index to select relevant cases only.) Results are given in the tables.

Table 1. Urban “Freeway” Cases (N = 151)

Device	Relevant		Percentage of Relevant Cases Without Interviews			Percentage of Relevant Cases With Interviews		
	Number	Percentage	operated	Noticed	Effective	Operated	Noticed	Effective
Night Vision	53	35	92	0	0	93	9	50
Forward Object	53	35	78	0	0	80	10	11
Blind Spot	29	19	80	0	0	90	31	35
Red Light	5	3						
Vehicle status	7	5						
Driver Status’	29	19	44	0	0	50	25	25
Rollover	7	5						

In 41% of relevant cases there was good information on relative speed.

Notes

‘Relevant if police report presence of alcohol or there is positive evidence of fatigue or illness.

Operated, Noticed, and *Effective* refer to the percentage of cases where the device is relevant in which a judgment can be made that the device would have operated, been noticed, or been effective.

A dash indicates that the numbers are too small for a percentage to be meaningful.

Table 2. Non-Urban "Freeway" Cases (N = 174)

Device	Relevant		Percentage of Relevant Cases Without Interviews			Percentage of Relevant Cases With Interviews		
	'Number	Percentage	Operated	Noticed	Effective	Operated	Noticed	Effective
Night Vision	61	35	69	1	5	69	31	33
Forward Object	64	37	62	2	6	68	36	38
Blind Spot	13	8						
Red Light	9	5						
Vehicle status	2	1						
Driver Status*	41	24	34	0	0	51	32	35
Rollover	2	1						

In 34% of relevant cases there was good information on relative speed.

Notes

'Relevant if police report presence of alcohol or there is positive evidence of fatigue or illness.

Operated, Noticed, and ***Effective*** refer to the percentage of cases where the device is relevant in which a judgment can be made that the device would have operated, been noticed, or been effective.

A dash indicates that the numbers are too small for a percentage to be meaningful.

The main purpose of this paper is achieved by looking at the columns headed "effective" only. These give the fraction of the cases where the device is relevant to the accident in which it is possible to judge whether the device would have affected the outcome of the accident. As explained in the previous section, the fraction of cases in which it is possible to judge whether or not the device would have operated is also significant. It affects both the magnitude of the uncertainty in the main result, and is relevant to the assessment of a fully automatic device. The fraction of cases in which it is possible to judge in which the warning would have been noticed is an intermediate measure of rather less importance, but it does become important, if one chooses to consider variations on the accident, to allow for uncertainty in e.g., speeds; or if some model of human reactions is being used.

4. Discussion

As is to be expected in the examination of warning devices, direct evidence about the drivers' thoughts or bold assumptions are needed if one is to reach any conclusion about the probability that warnings will be heeded. For automated devices, the entries in the tables which refer to the number of cases where one can infer operation of the device are sufficient. Evidence from other forms of human factor studies may provide information about reaction to warnings on the basis of which assumptions can be made. Clearly, the NASS data would be much more useful if police reports and interview summaries were accessible, and probably even more valuable for this purpose if the interviews were conducted with the intention of finding out and recording something about drivers' thoughts and intentions at the time of the accident. However, under the present circumstances, it is possible to draw some conclusions about the use of NASS data in evaluating each type of device considered.

A. Night Vision Aid. Without good interview data, NASS provides minimum evaluative information about this device. It is necessary to know the nature of any perceptual error before assuming that providing an aid to vision would cure it. Further, cases were said to be relevant if it was dark and there were relevant sights to be seen in front of the vehicle. In fact, many of the night accidents occurred on lighted roads, and no vision aid may have been necessary. There is no automated version of this device.

B. Forward Object Detection. NASS data would be useful here, even in an edited form, though good interview data would improve the quality of the conclusions. The maps, which are found only in the raw data, are particularly useful. The automated version of this device is a forward object avoidance device. The fraction of cases in NASS which include data on speed is large enough to make it possible to assess such a device.

C. Blind S-pot Warning. NASS data would be valuable in assessing the practicality of BSW, especially if the index were used to pick out relevant cases. Assessment is aided by the maps and good interview data would help the quality of the results.

D. Red Light Warning. A proper assessment would require a more selective choice of cases. In most cases that were examined, it was extremely easy to determine if the device would have operated. It may tentatively be concluded that NASS data would be useful. The small number of cases makes this conclusion uncertain.

E. Vehicle Status Indication. The NASS files do not contain very much data about vehicle condition which is relevant to crash avoidance; the condition of the steering and brakes is not reported. Some tire conditions are reported but these are not the ones which the vehicle status indicator considered could measure. Those reported could not be measured in motion. NASS does not seem likely to be useful here.

F. Driver Status Indication. The assumptions made in this report are dubious and may be optimistic. The fraction of relevant cases in which NASS data are sufficient to judge if the device would have operated is low. This means that an evaluation would be very uncertain. The indicator is supposed to detect incapacity by monitoring lane keeping. It is assumed that this will detect all cases of alcohol involvement, fatigue, and illness. It is not known if this is the case. Nor is it known if someone who has chosen to drink and drive will be influenced by an in-car warning. Thus the estimates probably overstate the case. The raw NASS data added nothing to what is already in the computer index and in a great many other data banks. NASS is not useful here.

G. Rollover Threshold Warning. Very few relevant cases were found. This was not because rollover is rare but because it is nearly always initiated, according to NASS, by an event which occurs after the driver has lost control. Thus the use of the device may be limited. Based on the current evidence, the value of this device for cars is limited.

5. Conclusions

In general, the NASS raw data is useful for evaluation of AVCS whenever the drivers' choices are limited to keeping a straight course at an appropriate speed. The usefulness declines when stop-go conditions are encountered. Under such conditions, different errors in perception and judgment can have similar outcomes. It has little value for evaluating vehicle status indicators and adds nothing to more conventional data sets on driver status indicators. Nothing can be said about the effectiveness of a rollover threshold warning. There are very few accidents where it is relevant, so that its impact will be small. It is possible that it would be more cost-effective if confined to trucks.

In the cases where the data has value, the maps are particularly useful, and will become more so if the basic evaluation is developed along the lines envisaged by the author (1991).

6. Acknowledgment

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APPENDIX

Operational Specification of Test Devices

Night Vision Aid

This device enables a driver to see, in a screen adjacent to the windshield, objects in the road and on the shoulder at night or in fog at a distance not exceeding 500 ft. Nothing is enlarged or emphasized, color is not detectable, and objects well to the sides of the road, (e.g., vehicles on a cross road) are not visible.

Forward Object Detection

This device gives an audible warning of an object in front of the vehicle:

- The object may be made of any material.
- It must be more than 3.5 ft high and 1 ft wide.
- It must remain on a constant bearing (i.e., be on a collision course) for more than 0.1 sec.
- The closing speed must be over 10 mph.
- The object must be in the road.
- It will also warn if the vehicle is leaving the road at an angle exceeding 10 degrees.

Thus the device will not react to:

- children or small animals;
- a human body lying in the road;
- anything on the sidewalk or otherwise off the road;
- anything on a crossing road;
- shadows, mist, or smoke.

Note: This is a sophisticated device, which may require passive beacons at the roadside. Even so, it is not known if it is so specified as to avoid an excessive number of false positives.

Blind Snot Warning

This device will detect the presence of a metallic object of cross-section perpendicular to the line of sight of at least 1 sq ft. The object must be in one of the two quadrants of radius 10 ft centered on the rear doors of the vehicle. A warning will sound if the vehicle, while going forward, starts to turn to the side in which an object is detected.

Red Light Warning

This device gives a visible warning (an amber light on the dash) 1 **sec** before the vehicle, if it started braking at **0.15g** (i.e., hard, but not emergency), would run an amber light. A red light shows, and an audible warning is sounded if it would, under the same circumstances, run a red light.

This device can cope with the complexities of vehicle-actuated signals, but not with lights forced to change by the presence of a special vehicle.

Vehicle Status

This device warns the driver continuously of any of the following defects:

- shortage of fuel;
- excessive play in the steering;
- worn brakes or loss of pressure in the brake hydraulics;
- over- or under-inflation of any tire;
- maldistribution of load on the suspension.

Driver Status

This device gives a visible warning if the steering of the vehicle measured by lateral wander from the curb or lane marking, is greater than the driver normally displays. It is ineffective if the vehicle is not familiar with the driver (it uses a stored pattern of behavior) or if there is no curb or lane marking.

Rollover Threshold Warning

This device gives an audible warning if the wheels on one side of the vehicle are bearing six times as much weight as the other (as measured by deflection of the suspension).

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