

# Analysis of Insurance Claims to Determine Effects of 1980 Bumpers on Crash Damage

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The effectiveness of the crash-protecting automobile bumpers required by the 1980 version of the Federal Motor Vehicle Safety Standard, Part 581—Exterior Protection, Passenger Cars, was evaluated through an analysis of insurance claims filed with the State Farm Insurance Company. Data for the 1980 model year are compared with both 1972 and 1979 data to determine whether vehicles conforming to the 1980 version of the standard exhibit any significant changes in claim proportions or average claim cost for bumper-related incidents. The relationship of bumper type and bumper design to the two measures of effectiveness is also examined. Pairwise statistical comparisons were performed for the three model years by using hypothesis tests for differences in claim proportions and differences between mean costs stratified by market class and impact point. Findings indicate that the 1980 data continue current trends in which the actual proportion of bumper-involved claims has been decreasing, whereas average claim costs adjusted for inflation have been increasing.

In 1971, NHTSA issued Federal Motor Vehicle Safety Standard 215 (FMVSS-215), Exterior Protection, Passenger Cars, for the performance of automobile bumpers. The standards required bumpers to meet requirements for the protection of safety-related parts in low-speed collisions starting with model year 1973 passenger cars. Over the years, various versions of the standards have been implemented with the intent to offer increased protection to the automobile and cost savings to consumers. Effective with 1979 model year passenger cars, Part 581 incorporated FMVSS-215 and added requirements for bumper protection of nonsafety items.

Research (1) is described that extends the results of two previous studies (2,3) that compared insurance-claim data on proportions and average cost of bumper-involved claims for automobile model year periods corresponding to various versions of FMVSS-215. In those studies, prestandard period, 1972 model year vehicles were compared with 1973, 1974-1978, and 1979 model year vehicles to assess the impact of the crash-protecting bumper standard. The latter model year periods corresponded to potentially significant changes in the standard. The general requirements of each successive version of the bumper standards are listed below:

<u>Standard</u>	<u>Model Year</u>	<u>Requirement</u>
FMVSS-215	1973	5-mph front and 2.5-mph rear impact with barrier Limited damage to lamps and reflectors; hood, trunk, and doors; fuel, cooling, and exhaust systems
FMVSS-215	1974-1978	5-mph front and rear impacts with barrier and pendulum; 3-mph corner impact with pendulum Limited damage to same items as earlier test and propulsion, suspension, steering, and braking systems; pendulum test established bumper height between 16 and 20 in
Part 581, incorporating FMVSS-215	1979	All of above Exterior surfaces shall not be damaged or have permanent deviations except for damage to bumper face bar and components and fasteners that attach bar to chassis frame

<u>Standard</u>	<u>Model Year</u>	<u>Requirement</u>
As above	1980	All of 1973-1978 requirements and exterior surfaces shall not be damaged or have permanent deviations except for face bars, which can have no permanent deviation greater than 3/4 in from its original contour relative to vehicle frame and no permanent surface deviation greater than 3/8 in from original contour on areas of contact with test devices

In this study, 1980 model year data were compared with 1972 and 1979 data to determine whether the 1980 period exhibits any significant changes in claim proportions or average cost of these claims for bumper-related incidents. The primary emphasis of this work was on the changes observed between the 1979 and 1980 model year data.

The study also examined the relationship of bumper type and bumper design as reflected by the data of different manufacturers on the two measures of effectiveness. This was done to detect any differences in the proportion of bumper claims and their average cost that may exist between bumpers of different materials and designs. This analysis could thereby identify preferred bumper materials and design from a cost-effectiveness point of view. As with the previous studies, State Farm insurance-claim data obtained from their claim service centers constituted the data base for this study.

## EXPERIMENTAL DESIGN

The analysis of 1972, 1979, and 1980 bumper claim data obtained from the State Farm Insurance Company was organized into two experiments. In experiment 1, all claims involving one-year-old vehicles, where bumpers were either repaired or replaced, were stratified by market class and by impact point. The proportion of property-damage claims involving the bumper and the average repair cost of these claims were the measures of effectiveness used to compare three model-year periods statistically. The pairwise comparisons were 1972 versus 1979 model year, 1972 versus 1980 model year, and 1979 versus 1980 model year. They were made by using the hypothesis tests for the difference between proportions and for the difference between means. Each comparison was stratified into four vehicle classes--compact, subcompact, intermediate, and full-size vehicles--and two impact points--front and rear. The vehicle classes were defined by the following criteria:

<u>Market Class</u>	<u>Wheelbase (WB) (in)</u>
Subcompact	WB < 101
Compact	101 < WB < 111
Intermediate	111 < WB < 120
Full size	WB > 120

Results of these comparisons were summarized to identify the existence of significant trends that may be attributable to the influence of the bumper

**Table 1. Analysis of bumper-related insurance claims for one-year-old vehicles by model year.**

Market Class	Model Year	Percentage of All Claims by Impact Point			Avg Repair Costs at 10 Percent Inflation Rate by Impact Point (\$1980)		
		Front	Rear	Total Bumper Related	Front	Rear	Avg, All Bumper Related
Subcompact	1972	37	23	60	771	556	689
	1979	26 <sup>a</sup>	15 <sup>a</sup>	41 <sup>a</sup>	925 <sup>b</sup>	620	812 <sup>b</sup>
	1980	21 <sup>c</sup>	12 <sup>c</sup>	33 <sup>c</sup>	1141 <sup>d</sup>	730 <sup>b</sup>	996 <sup>d</sup>
Compact	1972	35	21	56	894	599	782
	1979	23 <sup>a</sup>	14 <sup>a</sup>	37 <sup>a</sup>	1145 <sup>b</sup>	785 <sup>b</sup>	1008 <sup>b</sup>
	1980	21 <sup>a</sup>	15 <sup>a</sup>	36 <sup>a</sup>	1128 <sup>b</sup>	706	957 <sup>b</sup>
Intermediate	1972	33	20	53	819	620	744
	1979	22	21	42 <sup>a</sup>	907	689	800
	1980	26 <sup>a</sup>	14 <sup>c</sup>	40 <sup>a</sup>	1078 <sup>b</sup>	758	962 <sup>d</sup>
Full size	1972	31	21	53	840	652	764
	1979	25	21	45 <sup>a</sup>	1010	686	862
	1980	23 <sup>a</sup>	22	45	1638	1038	1348 <sup>d</sup>
All sizes	1972	34	21	55	830	611	746
	1979	24 <sup>a</sup>	16 <sup>a</sup>	40 <sup>a</sup>	1001 <sup>b</sup>	690	877 <sup>b</sup>
	1980	22 <sup>c</sup>	13 <sup>c</sup>	35 <sup>c</sup>	1146 <sup>b</sup>	741	994 <sup>d</sup>

<sup>a</sup>Reduction in claims relative to 1972 is significant at 5 percent level.

<sup>b</sup>Cost increase relative to 1972 is significant at 5 percent level.

<sup>c</sup>Further reduction between 1979 and 1980 is significant at 5 percent level.

<sup>d</sup>Further increase between 1979 and 1980 is significant at 5 percent level.

**Table 2. Sample sizes for analysis in Table 1.**

Year	Total No. of Claims in State Farm Data Base	Claims by Market Class							
		Subcompact		Compact		Intermediate		Full Size	
		Bumper	Total	Bumper	Total	Bumper	Total	Bumper	Total
1972	8275	1039	1722	967	1734	1171	2218	1375	2601
1979	3368	615	1492	433	1165	226	532	81	179
1980	4631	893	2730	486	1341	169	423	62	137

standards in 1979 and 1980. The main thrust of the analysis was to determine whether there were significant differences in observed claim experience between the 1979 and 1980 data.

Experiment 2 consisted of two parts. In the first, the proportion of property-damage claims and average cost of these claims were analyzed by bumper type. Three types--steel, aluminum, and hybrid--were compared. The pairwise model year comparisons were made only for compact and subcompact market classes due to the lack of data for intermediate or full-size market classes.

In the second part of the experiment, an analysis by bumper manufacturer (General Motors, Ford, Chrysler) was made. Both proportion and cost data were evaluated.

The two parts of experiment 2 were intended to ascertain whether differences in bumper design or material affect the proportion or average cost of bumper-involved claims. Summaries of these results are presented and interpreted.

#### Experiment 1

Experiment 1 examined all claims involving one-year-old vehicles where bumpers were repaired or replaced to determine whether there were significant differences in the proportion of property-damage claims and average cost of these claims between model years.

#### Methodology

For the proportion analysis, the number of front and rear bumper claims was aggregated for each market size class and for each model year period. The proportion of these claims relative to the total of all property-damage claims for that market class was

computed for each model year. No totaled vehicles were in the State Farm data, although both collision and liability claims were included. For each of the time-period comparisons--1972 versus 1979, 1972 versus 1980, and 1979 versus 1980--the hypothesis test for differences in proportions was computed for each combination of market class and impact point. These comparisons are shown in Table 1.

Table 1 also displays the cost analysis, in which the average cost of the claims in each combination of market class and impact point was computed for each of the three model year periods. For each model year comparison, the differences between these average costs were statistically tested by using the hypothesis test for the difference between means at the 5 percent level of significance.

The sample sizes available for this experiment are given in Table 2.

#### Proportion-Analysis Summary

As can be seen in Table 1, the 1979 model year period exhibits significant reductions in the proportion of bumper-involved claims for each market class when compared with 1972. These reductions are largely due to reductions in the proportion of front-impact claims. The market-class differences in proportions range from about 8 percent for full-size vehicles to 19 percent for subcompacts. For the overall mix of vehicles, the 1979 model year proportion of bumper claims is 40 percent as compared with 55 percent for the 1972 period--a difference of 15 percent. In the 1979-1980 comparison, few proportions are significantly reduced within each market class, subcompact cars excepted; however, the proportion of all bumper claims was reduced from 40 to 35 percent. This decrease of 5

percent is statistically significant. Thus, in the 1979 to 1980 model years, a further decrease in the proportion of bumper-involved claims occurred for the total vehicle mix, primarily due to further significant decreases for subcompact vehicles.

#### Cost-Analysis Summary

Cost comparisons can be summarized from Table 1 by noting that from 1972 to 1979, average claim costs for bumper claims increased for all vehicle classes and impact points; statistically significant increases occurred particularly in the case of subcompacts and compacts. Between 1979 and 1980, all market classes with the exception of compact vehicles showed statistically significant increases. Average repair costs for compacts appear to decrease between 1979 and 1980. However, this reduction is not statistically significant.

It should be noted that the total sample sizes for 1979 and 1980 are about one-half of the 1972 sample. However, with the possible exception of full-size vehicles, these sample sizes are adequate for inferential purposes for this experiment.

#### Experiment 2

Experiment 2 was divided into two parts:

1. Analysis of bumper types--steel, aluminum, hybrid; and
2. Analysis by bumper manufacturer--General Motors, Chrysler, Ford.

Although both proportion and average cost comparisons were made in each analysis, the available data created special restrictions and limitations in each case. The specific constraints and conditions for each study will be treated separately.

#### Part 1: Analysis of Bumper Types

The bumper types compared were steel, aluminum, and hybrid. Since no data were available for intermediate or full-size market classes, the analysis was restricted to subcompact (Table 3) and compact (Table 4) market classes. Furthermore, there were no aluminum or hybrid bumpers for the 1972 model year data. The three model year comparisons--1972 versus 1979, 1972 versus 1980, and 1979 versus 1980--are presented for each of the two market classes. However, comparisons with 1972 involve only steel bumpers. The following sample sizes were available for the bumper-type analysis:

Model Year	Claims by Bumper Type					
	Steel		Aluminum		Hybrid	
	Bumper	Total	Bumper	Total	Bumper	Total
1972	2027	3506	-	-	-	-
1979	844	1986	82	210	87	390
1980	1176	3286	86	229	118	561

The analysis was intended to determine whether either of the measures of effectiveness is a function of bumper type. Hypothesis tests for the differences between proportions and means were applied as in experiment 1.

Table 3. Analysis of bumper-related insurance claims for one-year-old subcompacts by bumper type.

Bumper Type	Model Year	Percentage of All Claims by Impact Point			Avg Repair Costs at 10 Percent Inflation Rate by Impact Point (\$1980)		
		Front	Rear	Total Bumper Related	Front	Rear	Avg, All Bumper Related
Steel	1972	37	23	60	772	557	690
	1979	26 <sup>a</sup>	16 <sup>a</sup>	42 <sup>a</sup>	931 <sup>b</sup>	636	818 <sup>b</sup>
	1980	22 <sup>c</sup>	12 <sup>c</sup>	34 <sup>c</sup>	1149 <sup>d</sup>	755 <sup>b</sup>	1025 <sup>d</sup>
Aluminum	1972	NA	NA	NA	NA	NA	NA
	1979	31	10	41	818	530	747
	1980	15 <sup>a</sup>	17	32	884	624	748
Hybrid	1972	NA	NA	NA	NA	NA	NA
	1979	13	7	21	1189	423	914
	1980	12	10	22	1273	633	989

Note: NA = no data available.

<sup>a</sup>Reduction in claims proportion relative to 1972 is significant at 5 percent level.

<sup>b</sup>Cost increase relative to 1972 is significant at 5 percent level.

<sup>c</sup>Further reduction between 1979 and 1980 is significant at 5 percent level.

<sup>d</sup>Further increase between 1979 and 1980 is significant at 5 percent level.

Table 4. Analysis of bumper-related insurance claims for one-year-old compacts by bumper type.

Bumper Type	Model Year	Percentage of All Claims by Impact Point			Avg Repair Costs at 10 Percent Inflation Rate by Impact Point (\$1980)		
		Front	Rear	Total Bumper Related	Front	Rear	Avg, All Bumper Related
Steel	1972	34	21	55	896	596	782
	1979	27 <sup>a</sup>	15 <sup>a</sup>	42 <sup>a</sup>	1142 <sup>b</sup>	832 <sup>b</sup>	1029 <sup>b</sup>
	1980	25 <sup>a</sup>	15 <sup>a</sup>	40 <sup>a</sup>	1121 <sup>b</sup>	740	975 <sup>b</sup>
Aluminum	1972	NA	NA	NA	NA	NA	NA
	1979	19	17	36	1123	685	913
	1980	22	25	47	1020	595	797
Hybrid	1972	NA	NA	NA	NA	NA	NA
	1979	14	9	23	1106	656	924
	1980	11	9	20	1154	606	897

Note: NA = no data available.

<sup>a</sup>Reduction in claims proportion relative to 1972 is significant at 5 percent level.

<sup>b</sup>Cost increase relative to 1972 is significant at 5 percent level.



### Proportion-Analysis Summary for Bumper Types

Due primarily to inadequate data on aluminum and hybrid bumpers even for the 1979-1980 comparison, no significant findings relative to these types emerged. The overwhelming presence of steel bumpers leads to the conclusion that the observed reduction in the proportion of bumper claims for subcompact and compact vehicles from 1972 to 1979 and from 1972 to 1980 is due to reductions in claims involving steel bumpers. Similarly, the reduction in claims for subcompact vehicles from 1979 to 1980 is due to reductions in such claims.

### Cost-Analysis Summary for Bumper Types

As in the proportion analysis, only data for steel bumpers were available for model year 1972. Results observed here are similar to those seen in experiment 1. Between 1972 and 1979, the average repair costs for bumpers (adjusted for inflation) increased significantly for both subcompact and compact vehicles. Between 1979 and 1980, further significant cost increases were observed for subcompact vehicles with steel bumpers, whereas costs for aluminum and hybrid systems remained relatively unchanged.

Again, compact vehicles appeared to experience a reduction in average repair costs between 1979 and 1980, although this reduction is not significant. As seen in Table 4, this experiment indicates that the cost reduction from 1979 to 1980 is noticeable for each of the three bumper types.

In the comparison of bumper types, aluminum systems on average appear to involve the lowest average repair costs regardless of the model year and applicable version of the standard. Hybrid systems are second lowest, and steel systems are consistently the most expensive to repair. When specific impact points are examined, these rankings do fluctuate.

### Part 2: Analysis by Bumper Manufacturer

General Motors (GM), Ford, and Chrysler were the three manufacturers analyzed to determine whether any significantly different experiences in bumper claim proportions or average costs exist as a function of the manufacturer. This was intended to serve as a surrogate measure for bumper design and therefore as a means for isolating a design that may exhibit enhanced performance relative to the stated measures of effectiveness.

Within each pairwise model year comparison, for both proportions and average cost, each manufacturer was analyzed separately. The number of claims by manufacturer available for this analysis was as follows:

Claims by Manufacturer

Year	GM		Ford		Chrysler	
	Bumper	Total	Bumper	Total	Bumper	Total
1972	1878	3398	1464	2652	551	1155
1979	629	1545	226	617	191	565
1980	678	1841	199	622	107	324

The model-year comparisons are shown in Tables 5-7. These tables summarize the comparisons within manufacturer for GM, Ford, and Chrysler, respectively. Very few comparisons are statistically significant; however, in the hope of identifying design-related effects, some potentially interesting results are noted.

### Proportion-Analysis Summary by Bumper Manufacturer

Between 1972 and 1979, each manufacturer's overall fleet of vehicles exhibited statistically significant

reductions in bumper claim proportions. During this period, both GM and Ford showed statistically significant reductions in their subcompact and compact classes. The two manufacturers differed in the performance of the larger classes. GM demonstrated a significant reduction in the proportion of bumper-involved claims for its intermediate vehicles, whereas its full-size vehicles showed a slight increase. On the other hand, Ford showed significant reductions for its full-size vehicles but a slight (not significant) decrease for its intermediate vehicles. Chrysler sample sizes were too small to make any inferences on the basis of market class.

From 1979 to 1980, both GM and Ford subcompacts exhibited further significant reductions in the proportions of bumper-involved claims. In addition, claims for rear collisions of GM intermediate vehicles were also significantly reduced, which led to an overall reduction for the total GM fleet. Counter to this trend was the performance of the front bumpers of GM intermediate vehicles, which exhibited a significant increase between 1979 and 1980. Chrysler showed no change between 1979 and 1980.

The results of these comparisons should be considered as recommendations for further investigation, since the 1979 sample sizes need to be enlarged to permit definitive conclusions. However, one observation obtained from the 1979-1980 comparison is that of the three manufacturers, only GM exhibited statistically significant reductions in bumper-claim proportions. This may reflect that the corresponding bumper designs are responsible for the observed differences.

### Cost-Analysis Summary by Bumper Manufacturer

Between 1972 and 1979, average repair costs for both the GM and the Ford fleets adjusted for inflation increased \$120 to the same figure of about \$875. Undoubtedly, due to the sample sizes, the GM increase was noted as significant, whereas Ford's was not. Although these increases were apparent in all market classes, increases for compacts were statistically significant for both these two manufacturers. During the same period, Chrysler showed overall increases of only \$21.

From 1979 to 1980, all manufacturers showed continued increases in average repair costs of \$21, \$63, and \$115 for Ford, GM, and Chrysler, respectively. However, none of these increases was found to be significant. In the case of Chrysler, this is likely to be due to the small sample size. The most notable increases over this period were for GM intermediate and full-size vehicles.

### STUDY RESULTS

Experiment 1 analyzed the variations in bumper claim proportions and average costs for the model years 1972, 1979, and 1980. The analysis sought to determine whether any significant changes have occurred in these two measures of effectiveness, particularly for the 1979-1980 time period, and thus to assess the effectiveness and impact of the current version of the bumper standard. The major conclusions were as follows:

1. The proportion of bumper-involved claims for 1979 for each market class has decreased significantly when compared with that for 1972.
2. The reduction in proportion noted from 1972 to 1979 is largely due to reduction in the proportion of front-impact claims.
3. From 1979 to 1980, a further decrease in the proportion of bumper-involved claims occurred for

**Table 5. Analysis of bumper-related insurance claims for one-year-old GM vehicles.**

Market Class	Model Year	Percentage of All Claims by Impact Point			Avg Repair Costs at 10 Percent Inflation Rate by Impact Point (\$1980)		
		Front	Rear	Total Bumper Related	Front	Rear	Avg, All Bumper Related
Subcompact	1972	38	24	62	771	681	737
	1979	28 <sup>a</sup>	16 <sup>a</sup>	45 <sup>a</sup>	864	675	795
	1980	24 <sup>a</sup>	13 <sup>a</sup>	36 <sup>b</sup>	933	703	853 <sup>c</sup>
Compact	1972	35	25	60	891	625	782
	1979	24 <sup>a</sup>	14 <sup>a</sup>	38 <sup>a</sup>	1016	789	937 <sup>c</sup>
	1980	21 <sup>a</sup>	15 <sup>a</sup>	35 <sup>a</sup>	1065	643	890 <sup>c</sup>
Intermediate	1972	37	21	57	817	669	764
	1979	20 <sup>a</sup>	22	42 <sup>a</sup>	868	749	805
	1980	28 <sup>d</sup>	13 <sup>b</sup>	41 <sup>a</sup>	1101 <sup>c</sup>	719	980 <sup>e</sup>
Full size	1972	27	23	50	858	626	749
	1979	29	23	52	931	649	804
	1980	19	26	45	1993	1357 <sup>c</sup>	1629 <sup>e</sup>
All sizes	1972	33	23	55	838	645	759
	1979	24 <sup>a</sup>	17 <sup>a</sup>	41 <sup>a</sup>	954	749	874 <sup>c</sup>
	1980	23 <sup>a</sup>	14 <sup>b</sup>	37 <sup>b</sup>	1071	724	937 <sup>c</sup>

<sup>a</sup>Reduction in claims proportion relative to 1972 is significant at 5 percent level.<sup>b</sup>Further reduction between 1979 and 1980 is significant at 5 percent level.<sup>c</sup>Cost increase relative to 1972 is significant at 5 percent level.<sup>d</sup>Increase in claim proportion between 1979 and 1980 is significant at 5 percent level.<sup>e</sup>Further increase between 1979 and 1980 is significant at 5 percent level.**Table 6. Analysis of bumper-related insurance claims for one-year-old Ford vehicles.**

Market Class	Model Year	Percentage of All Claims by Impact Point			Avg Repair Costs at 10 Percent Inflation Rate by Impact Point (\$1980)		
		Front	Rear	Total Bumper Related	Front	Rear	Avg, All Bumper Related
Subcompact	1972	35	23	58	773	537	679
	1979	20 <sup>a</sup>	11 <sup>a</sup>	31 <sup>a</sup>	844	520	730
	1980	13 <sup>b</sup>	11 <sup>a</sup>	24 <sup>a</sup>	1217	601	944
Compact	1972	34	21	55	874	630	779
	1979	23 <sup>a</sup>	15	38 <sup>a</sup>	1260 <sup>c</sup>	773	1068 <sup>c</sup>
	1980	22 <sup>a</sup>	16	38 <sup>a</sup>	997	611	835
Intermediate	1972	28	21	50	832	594	730
	1979	28	18	46	NA	NA	NA
	1980	NA	NA	NA	NA	NA	NA
Full size	1972	38	19	57	819	719	786
	1979	22 <sup>a</sup>	18	39 <sup>a</sup>	1091	753	929
	1980	29	17	46	1325	401	983
All sizes	1972	34	21	55	827	639	756
	1979	22 <sup>a</sup>	14 <sup>a</sup>	37 <sup>a</sup>	1031	639	876
	1980	18 <sup>a</sup>	14 <sup>a</sup>	32 <sup>a</sup>	1104	619	897

Note: NA = insufficient data available.

<sup>a</sup>Reduction in claim proportion relative to 1972 is significant at 5 percent level.<sup>b</sup>Further reduction between 1979 and 1980 is significant at 5 percent level.<sup>c</sup>Cost increase relative to 1972 is significant at 5 percent level.**Table 7. Analysis of bumper-related insurance claims for one-year-old Chrysler vehicles.**

Market Class	Model Year	Percentage of All Claims by Impact Point			Avg Repair Costs at 10 Percent Inflation Rate by Impact Point (\$1980)		
		Front	Rear	Total Bumper Related	Front	Rear	Avg, All Bumper Related
Subcompact	1972	NA	NA	NA	NA	NA	NA
	1979	22	7	29	NA	NA	NA
	1980	17	14	31	NA	NA	NA
Compact	1972	NA	NA	NA	914	537	792
	1979	19	17	36	1231	470	868
	1980	27	12	39	1172	915	1094
Intermediate	1972	28	16	44	823	499	707
	1979	21 <sup>a</sup>	19	39	887	582	741
	1980	17	21	38	1097	741	897
Full size	1972	NA	NA	NA	NA	NA	NA
	1979	NA	NA	NA	NA	NA	NA
	1980	NA	NA	NA	NA	NA	NA
All sizes	1972	31	17	48	871	525	749
	1979	21 <sup>a</sup>	12 <sup>a</sup>	34 <sup>a</sup>	879	581	770
	1980	19	14	33	1006	725	885

Note: NA = insufficient data available.

<sup>a</sup>Reduction in claim proportion relative to 1972 is significant at 5 percent level.

the total mix of vehicle market classes, primarily due to further significant decreases for subcompact vehicles.

4. Average claim costs, adjusted for inflation, for bumper claims increased for all vehicle classes and all impact points from 1972 to 1979; the significant increases occurred particularly for subcompacts and compacts.

5. From 1979 to 1980, significant increases in average costs occurred for all market classes except compact vehicles, which showed a slight reduction in average repair costs.

Thus, the proportion of bumper claims has decreased from 1979 to 1980; however, average costs increased for the total vehicle mix. This is a continuation of the pattern found in the earlier years of the standard. However, the decrease in costs for compacts is a departure from the earlier pattern.

In the first part of experiment 2, bumper types were compared to determine whether steel, aluminum, or hybrid bumpers exhibit different performance characteristics as measured by the proportions and average cost of bumper claims. The major results were the following:

1. No significant differences in proportion of bumper claims emerged for aluminum and hybrid types;
2. Most of the reductions in the proportion of bumper claims involved steel bumpers, due to their predominance in the sample;
3. On average, claims involving aluminum bumpers appear to involve lower average costs than do the other types; and
4. Bumper type does not appear to be as significant as vehicle class in its relation to average cost.

The second part of experiment 2 compared the bumper manufacturers—GM, Ford, and Chrysler. Major results are listed below:

1. Between 1979 and 1980, GM was the only one of the three manufacturers studied to indicate an overall significant decrease in claim proportions; and
2. Between 1979 and 1980, none of the manufacturers showed any significant overall change in average repair costs.

#### CONCLUSIONS

It is intended that this analysis be used to interpret the effectiveness of the 1980 bumper standards. The two surrogate measures of effectiveness used in this evaluation, namely, claim proportion and average repair costs, yielded conflicting results. Although it was demonstrated that the actual proportion of bumper-involved claims was decreasing, average claim costs adjusted for inflation were steadily increasing. This raises several additional questions to illuminate the picture fully:

1. What factors contributed to the increases in repair costs?
2. Were any of these factors directly related to the bumper standards themselves and, if so, how?
3. If it is found that factors outside the standards themselves were at work to increase costs, would average repair costs be even higher if the bumper standards were not in effect?
4. Why do compacts run counter to the trend and show a decrease in average claim costs between 1979 and 1980?
5. Although claim proportions were more directly influenced by the bumper standards than were average claim costs, is it possible that the reductions in-

dicated were part of some general trend independent of the bumper standard and evident in non-bumper-related accidents?

There are several possible explanations, which are recommended as avenues for further investigation:

1. Significant automotive design changes have occurred since 1978, which include unitized bumpers and many other changes unrelated to bumpers, such as rectangular headlamps, front-drive McPherson-type suspensions, and the wider applications of plastics. These changes may influence repair costs significantly.
2. In general, deductibles are not increased to match inflation; therefore, it is possible that the proportion of collision claims made with higher deductible amounts has increased. This, or a change in the mix of policy claim type (liability and collision), would increase the cost of the average claim without an actual increase in bumper repair costs.
3. Since it was beyond the scope of this study to investigate non-bumper-related claims, it remains unknown whether the decrease in claim proportions attributed to the bumper standard is also evident in non-bumper-related claims. Because of the conflicting results of this evaluation, this is an important area for further investigation. It is necessary to ascertain the extent to which claim-proportion reductions are attributable to the standards themselves, independent of other factors. It is recommended that the analysis procedure used in this study for claim proportions and costs be applied also to non-bumper-related claims. It would then be possible to compare results for both types of claims to provide the perspective needed to evaluate the influence of the bumper standards. Using non-bumper-related claims as an additional control group would be useful in understanding both the proportion and the average cost results.

The State Farm Insurance Company suggested that the following conditions be understood in drawing conclusions from their data base:

1. Damage estimates in the data base were taken in service centers that provided a disproportionately metropolitan sample.
2. A bumper-involved crash is defined by State Farm as one in which there is repair or replacement of the bumper face bar. Where a soft face is damaged, without repair or replacement of the bumper face bar, this definition may or may not be appropriate, depending on the inference one is trying to draw. Changing designs since 1972, including the emergence of soft-face technology, greatly complicate the problem of defining bumper involvement.
3. Observed insurance claim frequencies vary from year to year and are affected by many other factors besides the bumper standard. These other factors include the weather, the economy, price and availability of gasoline, condition of roads and highways, and changes in traffic laws and the quality of enforcement. For this reason, and also because it is impossible to define the group of cars that produced the claims in this data base, conclusions about overall effect on insurance costs would have to rely on estimated changes in claim frequency determined inferentially from changes in the distribution of bumper-involved and non-bumper-involved claims. This is made more difficult by the change in designs, as explained above.
4. To the extent that improved bumpers perform their function of eliminating relatively low-cost



claims, the remaining claims are, on the average, larger. This basic point is necessary to an understanding of these data.

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## Acceleration Characteristics of Late-Model Automobiles

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In response to federal mandates and consumer demand for more fuel-efficient automobiles, the American automobile industry is currently producing markedly smaller and lighter automobiles than it was 10 years ago. As fuel prices rise, one can only anticipate that this trend will continue. Many of the changes made in the newer automobiles to promote fuel economy adversely affect acceleration capability. Therefore, this study was conducted to examine acceleration characteristics and determine the extent to which the acceleration capability of passenger vehicles has deteriorated over the past decade. Data were collected from automotive reports in popular magazines for two acceleration maneuvers. The first maneuver, the time required to accelerate from 45 to 65 mph, increased an average of 18 percent between 1971 and 1979. The second maneuver, the acceleration time required for a speed change from 0 to 60 mph, increased an average of 22 percent between 1971 and 1979. The results of the acceleration-data analysis were used to investigate design criteria involving vehicular acceleration rates. In all cases the current automobiles were found to accelerate more quickly than those used when the original acceleration tests were performed in the 1930s. Although there has been some deterioration in acceleration capability over the past decade, it has not occurred to the point where the design criteria exceed the current capability and thus pose a safety hazard.

Over the past decade the average American automobile has changed significantly in response to oil embargoes and the rising cost of gasoline. In 1970 a typical standard-sized car weighed 4000 lb and was probably powered by a V-8 engine with a displacement of at least 350 in<sup>3</sup>. In 1980 the average American car weighed some 3300 lb and was probably equipped with a six-cylinder engine that had less than 250 in<sup>3</sup> of displacement. Hence, a marked trend has evolved in which new automobiles have become smaller and lighter from year to year.

The predominant reasons for the current automotive trend are the federal mandates and consumer demand for improved fuel economy. One step taken in achieving these aims has been to use more fuel-efficient components in the drive train of the automobile, such as smaller-displacement engines and higher rear-axle ratios. Although such components are superior for fuel economy, they are generally not better in terms of vehicle acceleration and performance. Other considerations, such as reducing weight and improving aerodynamics, can be said to enhance both fuel economy and performance. Therefore, there is considerable question whether the

acceleration capabilities of cars manufactured today are on a par with those of a decade ago.

The tests conducted to determine the acceleration capabilities of passenger vehicles were performed in the 1930s and 1940s. Design criteria derived from these tests appear in A Policy on Geometric Design of Rural Highways (1), hereafter referred to as the AASHO Blue Book. Naturally, many improvements in automotive technology followed during the postwar period, such as the automatic transmission and the high-compression V-8 engine. The design criteria derived from the early tests remained applicable during the 1950s and 1960s, with an added safety factor. However, in light of recent changes that are detrimental to automotive performance, it seems appropriate to also investigate applicable design criteria and assess their relevance to present-day automobile performance.

#### PURPOSE AND OBJECTIVES

The primary purpose of this study was to examine vehicle acceleration characteristics and determine whether there has been a significant change in the acceleration capabilities of passenger vehicles over the past decade. Factors that affect the acceleration rates will also be discussed. The objectives of this study were to analyze design criteria involving vehicular acceleration rates recommended in the AASHO Blue Book and evaluate their relevance to current passenger-car performance trends.

#### METHOD OF STUDY

The test data for this study were obtained from popular magazines that regularly report automotive test data. Data extracted from these magazines include acceleration times from 0 to 60 mph and from 45 to 65 mph, rated engine horsepower, and curb weight.

The data obtained are used to analyze trends in automobile acceleration characteristics over the past decade. One measure of performance is the ability of a vehicle to perform a certain passing maneuver that was initially described in the liter-