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EVALUATION OF THE MICHIGAN TRIAL SUBSTITUTE VEHICLE INSPECTION PROGRAM

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First Year Interim Report

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16. Abstract

In a two-year study, a checklane vehicle inspection program is being evaluated as a substitute for a periodic motor vehicle inspection program. The first year's effort, reported here, measured the percent of defective vehicles in two sampled counties and provided a baseline against which to measure the second-year results. The overall failure rate was 47.6%, but this was found to increase markedly with the age of the vehicle. Detailed tables of results for several vehicle systems are presented.

As part of the study, a moving stopping test for braking capability was compared with a mechanic's inspection of the brakes. If failure by either type of inspection is considered to constitute deficient braking capability, then it is estimated that 6% of vehicles passed by the moving stopping test have deficient stopping capability, while 22% of vehicles passed by the wheel-pull brake inspection have deficient stopping capability.

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EVALUATION OF THE MICHIGAN TRIAL SUBSTITUTE VEHICLE INSPECTION PROGRAM: FIRST YEAR ACTIVITIES

1. SUMMARY

How effective is the checklane vehicle inspection conducted by the State of Michigan? How effective would a checklane inspection system be that inspected on the average 15% of the state's vehicles, coupled with an increased public awareness campaign? How would such a system compare with a periodic inspection? Which procedure, a moving stopping test or a wheel pull inspection is better for evaluating the braking system? These are some of the questions addressed by a current study conducted by HSRI jointly with the MSP and OHSP.

To qualify for federal highway funds under existing federal law, the 50 states must conduct vehicle inspection programs. Thirty-six states employ periodic motor vehicle inspection (PMVI), under which all vehicles are inspected and certified, usually annually. Michigan conducts a year-round randomized roadside inspection program. State Police teams set up temporary checklane sites at random times and locations, order approaching motorists into them, inspect and test the vehicle, and issue a citation to motorists whose vehicles are found with defects. The State Police have been inspecting about 300,000 vehicles each year, or about 6% of the passenger cars registered in Michigan.

The current study attempts to answer several questions relative to the Michigan checklane inspection program:

> What is the current proportion of defective vehicles in the driving population?

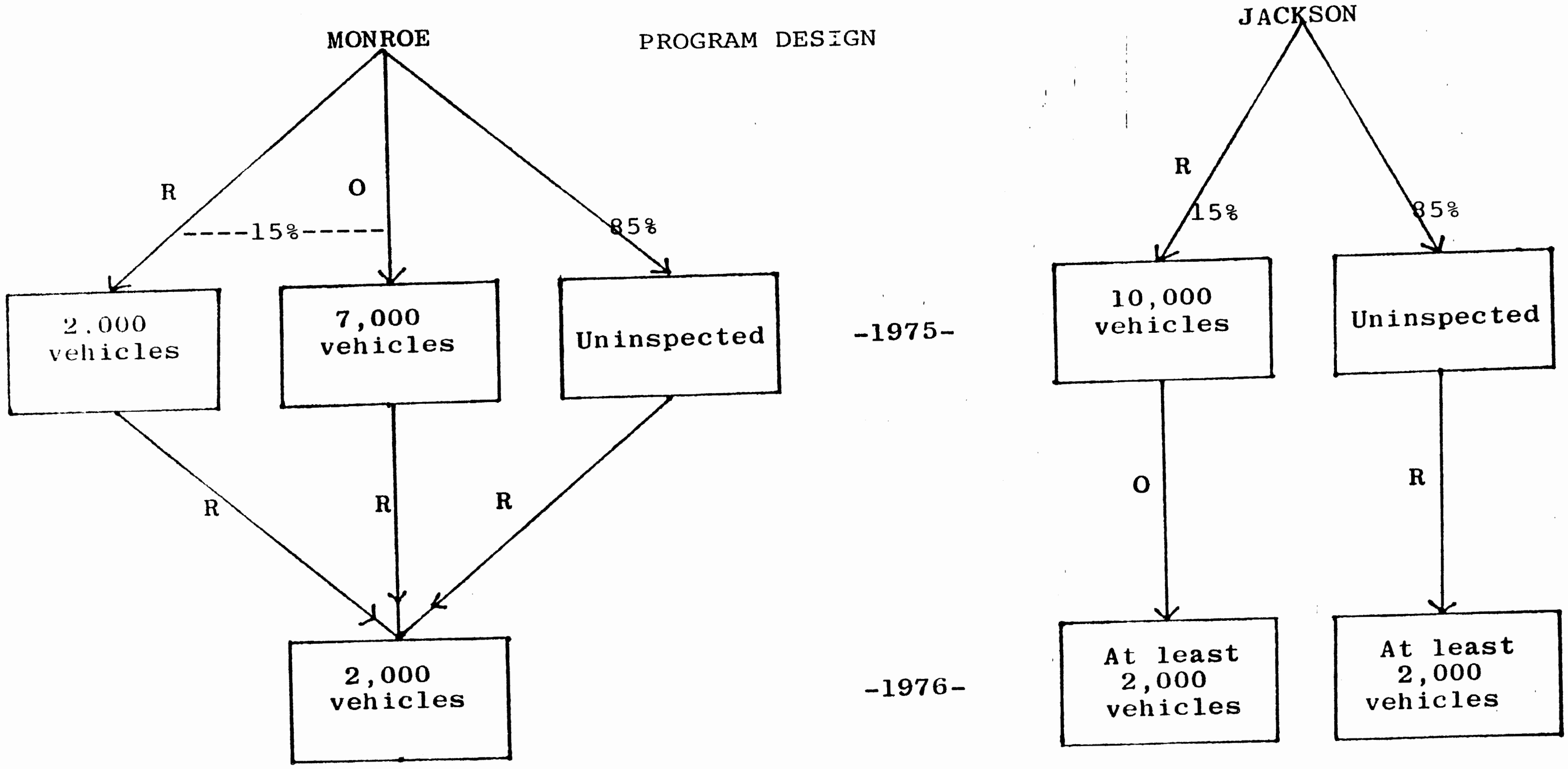
> Among the defective vehicles, what defects are most frequent?
>
> How do two different methods for testing the braking ability of vehicles compare?
>
> If the percent of inspected vehicles were raised to 15 percent and coupled with a public information campaign, how would the defect rate change?
>
> How would the defect rates under a 15% inspection program compare with those for a set of vehicles which had passed an inspection the previous year?

The project is currently beginning its second year. The last two questions posed can only be answered after the data from both years have been collected and analyzed, but information pertinent to the first three questions is available from the data collected during the first year's effort.

The general frame of the study is diagrammed in Figure 1.1. Two counties were selected for the trial program, Monroe and Jackson. The two counties have a similar number of registered vehicles, and each experienced approximately a 15 percent inspection rate during 1975. Two slightly different inspection methods were employed. The inspections denoted by "R" denote random inspections in which the sites were randomly visited and, on each site, a systematic sample of vehicles with a random start was inspected. The operational inspections, denoted by "O" in Figure 1-1, had a less rigid schedule for visiting the sites, and followed a somewhat judgmental system for selecting vehicles from the traffic flow for inspection. That is, a State Police officer would view each vehicle entering the inspection area and then order it into the inspection queue or allow it to proceed, depending on his initial impression. This results generally in a somewhat higher proportion of older vehicles actually being inspected, as well as vehicles with obvious defects, or defects suspected because of the vehicles exterior appearance. Only the results of the random inspections were recorded for analysis.

FIGURE 1-1

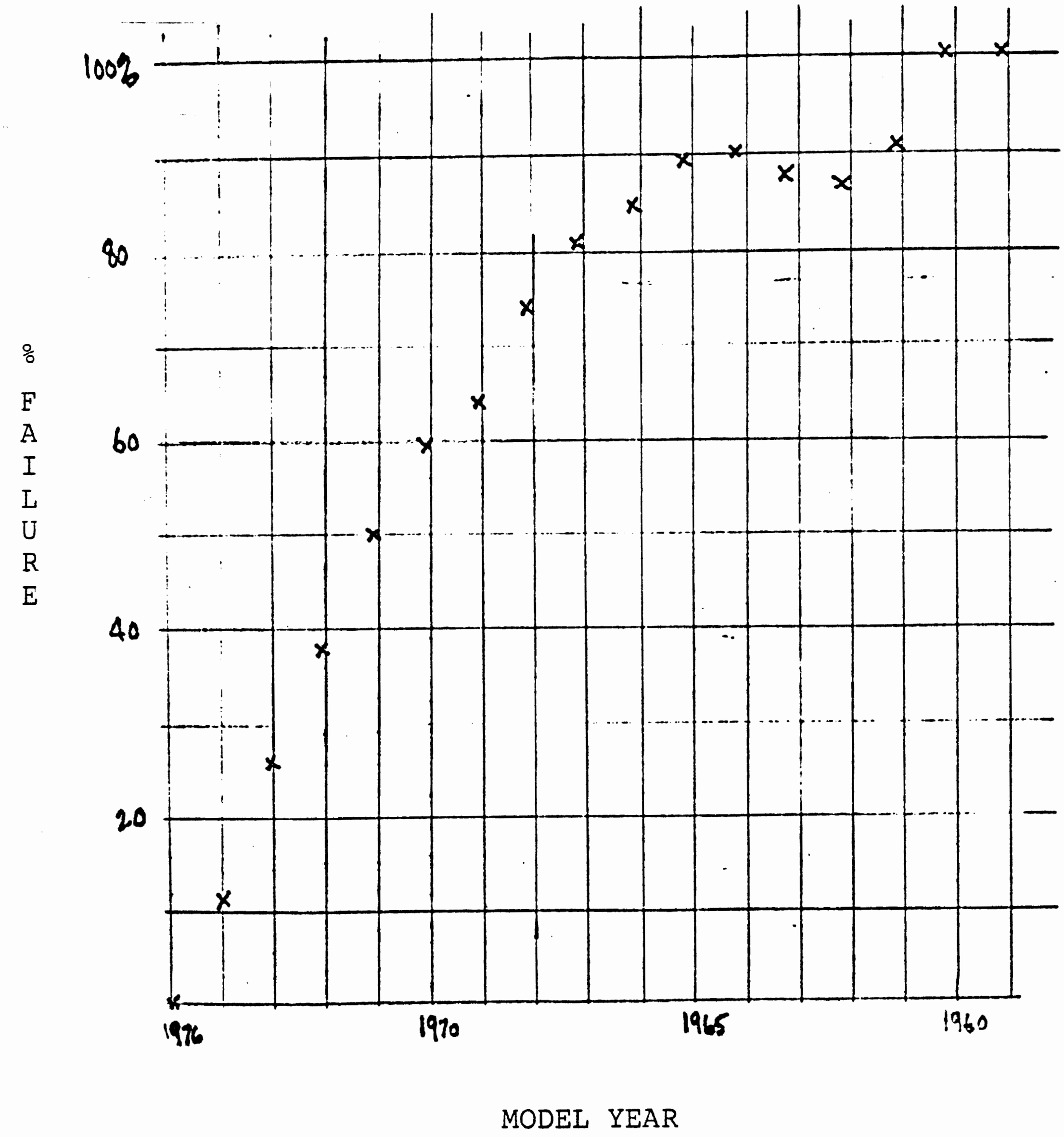
PROGRAM DESIGN



O = Operational type checklane
R = Random type checklane

FIGURE 1-2

PERCENT OF VEHICLES FAILING INSPECTION, BY MODEL YEARS



The numbers of inspected cars by model year were:

1976: 27
1975: 1,299
1974: 1,890
1973: 1,998
1972: 1,712
1971: 1,169

1970: 981
1969: 1,023
1968: 748
1967: 552
1966: 385
1964: 144

1963: 53
1962: 42
1961: 12
1960: 10

During the second year of the program, further random inspections will be conducted to investigate any changes in proportions of defective vehicles or patterns of defects. In addition, in Jackson County all--up to a maximum of 2,400 vehicles--of the vehicles which encounter the checklane sites and which were inspected in 1975 will be re-inspected. This group simulates a population of vehicles subjected to a PMVI, in that they will have been inspected (and presumably had defects corrected) the previous year. All drivers whose vehicles were inspected in the random checklane program in 1975 were given a windshield sticker and told that their vehicles were not subject to re-inspection for a year, but would be subject to re-inspection beginning in the summer (starting in May) of 1976. Although this group does not completely represent a population of vehicles subject to PMVI, it provides some comparisons of interest. If this group were found to have a substantially better defect rate than the general population (which was subject only to the operational checklane inspection), that might be taken as evidence that gains in reduced vehicle defect rates might be obtainable from PMVI in Michigan.

The overall rate of passing the inspection was 52.4% for both counties combined. Table 1-1 summarizes the overall passing experience for the two counties. This passing rate of 52.3% may be compared to passing rates reported from areas with annual PMVI which range from 45% to 75%.[1,2]

The overall passing rate was found to very considerably with the age of the vehicle; older vehicles failed much more frequently. Figure 1-2 plots the proportion of vehicles failing the inspection--at least one mechanical defect found--as a function of year of manufacture of the vehicle. The rise in the proportion failing is

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[1] "Report of an Evaluation of Motor Vehicle Inspection," Coverdane and Colpitts, Consulting Engineers, 100 Wall Street, N.Y., April 1967, p. 5-6.

[2] "The Influence of Periodic Motor Vehicle Inspection on Mechanical Condition," R.W. McCutcheon & H.W. Sherman, HSRI, The University of Michigan, July, 1968, p. 9.

evident. The data fit a quadratic curve or parabola quite well, particularly for the latest 13 model years. The years earlier than that are based on very few cases. One interesting observation from the figure is that the failure rate is consistently over 80% for cars at least six years old, and appears to stabilize at about 90% or so for cars ten years old or older. The relationship between failure rate and age of vehicle may indicate that inspections may more profitably be concentrated in the population of older vehicles.

TABLE 1-1

NUMBER OF DEFECTS FOUND

Number Defects	Monroe Co.		Jackson Co.		Total	
	Count	%	Count	%	Count	%
0 (Pass)	904	50.6	5206	52.8	6110	52.4
1	389	21.8	2000	20.3	2389	20.5
2	226	12.7	1211	12.3	1437	12.3
3 or more	266	14.9	1448	14.6	1714	14.8
Total	1786	100.0	9865	100.0	11651	100.0

When one looks at the failure rate on specific vehicle components, the results are somewhat mixed. Although most components show an increasing trend in the failure rate with the age of the vehicle, some components have quite low failure rates and show little if any increase with age. These include horn, steering, mirrors, and vision-impaired windshields. On the other hand, several components--brakes, windshield washers and wipers, tires, lights, and exhaust--show marked increasing trends with age. The implications of these differences are not clear. They may indicate that most owners maintain those components that they perceive as essential to safe operation of the vehicle, while being more lax about maintaining the others. If this is the case, additional education about the danger of defects of particular components might be useful.

Table 1-2 gives the percent of vehicles failing on each of several vehicle systems. Note that since some vehicles failed on several components, the individual failure rates do not add to the overall failure rates.

TABLE 1-2

VEHICLE FAILURE RATES BY VEHICLE SYSTEM

Vehicle System		Monroe Co.		Jackson Co.		Total	
		Count	%	Count	%	Count	%
Vision Defects	Pass	1361	76.2	7782	78.9	9143	78.5
	Fail	425	23.8	2083	21.1	2508	24.5
Total Lights	Pass	1230	68.9	6655	67.5	7885	67.7
	Fail	556	31.1	3210	32.5	3766	32.3
Tires	Pass	1566	87.7	8684	88.0	10250	88.0
	Fail	220	12.3	1181	12.0	1401	12.0
Exhaust	Pass	1605	89.9	8947	90.7	10552	90.6
	Fail	181	10.1	918	9.3	1099	9.4
Brakes	Pass	1340	75.0	8195	83.1	9535	81.8
	Fail	446	25.0	1670	16.9	2116	18.2
Total		1786		9865		11651	

One of the questions investigated by the random checklanes during 1975 was the relative performance of a moving-stopping test compared to an inspection of the brakes, including removal of a wheel for a mechanical inspection of the braking system. The moving-stopping test was conducted as follows. The vehicle was turned over to a regular state police trooper. The trooper accelerated the vehicle to twenty miles per hour, and attempted to stop in a lane twenty-five feet long and ten feet wide. A vehicle was judged to fail if it failed to stop, pulled to either side, if there was an unusual sound from the brakes, or if the pedal pressure required to stop was not within safe bounds.

A random subset of the vehicles in the random checklane were also given the "wheel-pull" brake inspection. In this inspection the right front wheel of the vehicle was removed to permit inspection of the condition of the brakes. A vehicle was judged to fail this inspection if any of the following conditions were found: lining on the brake shoe or pad less than 1/32 inch, cracked rotor or drum, defective or leaking wheel cylinder, low master cylinder fluid level. This inspection was conducted independently and without knowledge of the results of the stopping test.

A total of 2465 vehicles were given both types of brake inspections/stopping tests in the two counties combined. The results are shown in Table 1-3. The two testing procedures agreed on 75.0% of the vehicles. There were 617 cases of diaagreement as to pass or fail between the two methods. If the disagreements were symmetric--that is, if a vehicle was equally likely to pass the wheel pull and fail the stopping test as it was to pass the stopping test and fail the wheel pull--then approximately equal numbers of each type of disagreement would be expected. In fact, the numbers are quite unequal and the difference is statistically significant beyond the .001 level by McNemar's test.

TABLE 1-3

COMPARISON OF BRAKING TEST RESULTS

		Wheel Pull Inspection		
		Pass	Fail	Total
Moving Stopping Test	Pass	1773	114	1887
	Fail	503	75	578
	Total	2276	189	2465

The disagreements in the two methods of evaluating the braking system of the vehicle raise the policy question of which method should be preferred. The moving-stopping test requires less equipment and is cheaper and faster to conduct than the wheel-pull inspection. It also does not require the presence of one or more mechanics. On the other hand, the wheel-pull inspection provides a more definitive statement of the mechanical condition of the braking system--at least of the right front wheel. This might indicate vehicles which currently could stop, but which might need repairs to the brakes in the near future.

One useful comparison of the results of the two tests is to assume that vehicles which failed either test are deficient in braking capability. One can then estimate what proportion of the vehicles passed by either criterion would actually be defective. Formally this is the conditional probability that a vehicle which passes the moving-stopping test actually has defective brakes (as judged by the wheel pull). The similar quantity is the conditional probability that a vehicle which passes the wheel-pull inspection actually is deficient in stopping capability (as judged by the moving stopping test).

From Table 1-3 the estimate of the proportion of vehicles which would pass the moving stopping test but yet have defective brakes is found to be $\frac{114}{1887} = 0.060$. A 95% confidence interval for this proportion is from 0.043 to 0.077.

On the other hand, the estimate of the vehicles which would be deficient in stopping capability, given that they passed the wheel pull inspection, is $\frac{503}{2276} = 0.221$. A 95% confidence interval for this proportion is from 0.200 to 0.242.

The comparison of the two proportions in the preceding paragraphs may be viewed as comparing the expected proportions of vehicles with defective stopping capabilities which would not be detected if only one of the two brake inspection techniques were used. Thus, if only the wheel-pull inspection were used, one might expect over 20% of the vehicles which passed the inspection to be deficient in stopping capability. On the other hand, if only the moving stopping test were used, one would expect only about 6% of the vehicles which passed to actually have deficient braking capability. This comparison, coupled with the ease and economy of performing the moving-stopping test, would seem to argue that it is the superior test procedure.

Note that only one wheel was inspected in the wheel pull inspection. Presumably more vehicles with deficient braking systems would be detected if two or more wheels were to be inspected. However, this would markedly increase the difficulty and cost of performing the wheel-pull inspection. Also, the usual practice is to reline brakes on all four wheels at the same time, so the condition of one brake is generally regarded as a good indicator of the others. It seems doubtful that one wheel would be in much better condition than the others, though brakes are sometimes repaired in pairs (i.e., both front or both back wheels). Thus it seems unlikely that even if the wheel-pull inspection were to be extended to more wheels, a much better rate of detection of vehicles with deficient braking capability would be obtained.

Driver interviews were conducted for the subsample of vehicles selected for the wheel-pull inspection. This population of drivers were selected to represent local traffic rather than long trip and interstate traffic, so responses may not represent the population of drivers. Drivers in Jackson County demonstrated a greater knowledge of the vehicle inspection program in Michigan than did drivers in Monroe County. Jackson County drivers gave 32% more correct responses to questions dealing with knowledge of the checklane. This seems to have been due to the more intensive media campaign in Jackson County, since 75% of the drivers there learned of the program through the media as compared with only 52% in Monroe County.

In both counties over two-thirds of the drivers agreed that "seat belts save lives." However, officers observed only eleven percent of the drivers actually wearing them. Reported use of seat belts was higher in Jackson County than in Monroe County. Twenty-one percent of the drivers in Jackson County reported they "always" wore seat belts and twenty-seven percent that they "often" wore seat belts. The corresponding figures for Monroe County were 17 percent and 22 percent. Jackson County drivers reported less inconvenienced from seat belts (43% not inconvenienced) than did Monroe County drivers (34% not inconvenienced).

A large proportion of drivers (84% in Monroe, 91% in Jackson) agreed that the 55 mph speed limit reduced traffic fatalities. Slightly fewer (76% in Monroe; 74% in Jackson) agreed that higher limits should not be reinstated on all state highways. Over half of the drivers (58% and 60% in Monroe and Jackson) were also opposed to reinstating a higher speed limit only on interstates. A majority (56% in Monroe, 53% in Jackson) of the drivers interviewed felt that points should be given on a drivers license for speeding violations between 55 and 70 mph.

At the end of this year the data should provide a good estimate of the percent of vehicles in acceptable condition to be obtained by a 15% operational checklane inspection rate coupled with a public information campaign. Also, the comparison between the operational checklane inspection populations and the simulated PMVI population will provide additional evidence about the possible benefits of a PMVI in Michigan. This evidence can be coupled with estimates of the relative costs of the two inspection systems to aid administrators and the legislature in selecting the most cost-beneficial system for Michigan.

2. PROJECT DESIGN

This project has a twofold purpose: (1) to measure the effect on vehicle defect rates of a 15% operational checklane inspection program and (2) to compare this effect with that which can be achieved by a (simulated) periodic motor vehicle inspection program. A valuable side result is the description--from a random sample of vehicles--of the type, condition, and age of the vehicles, together with a description of the population of drivers. Some information on the knowledge and opinions of the drivers was also collected.

At least two years are needed for the project: the first year to implement the programs and the second year to measure the effects. It must be emphasized that this report discusses only the results of the first year's activities. That is, only baseline descriptions of the vehicle populations are presented. Comparisons of the programs and conclusions about the effects must wait until the second year's data have been collected and analyzed.

Two similar counties in Michigan, Monroe County and Jackson County, were selected as the study areas. Monroe County was subjected to the operational checklane vehicle inspection program conducted by the Michigan State Police during 1975. This program operated at an intensity designed to inspect 15% of the registered vehicles in the county. In addition to the operational checklanes a special checklane was operated to obtain a random sample of at least 2000 vehicles. (The differences between the random and operational checklanes are described later in this section).

The random sample taken from Monroe County during the first year had two purposes: (1) to determine the baseline state of vehicles in Monroe County so that any effect could be measured and (2) to provide a profile of the vehicle population in Monroe County for comparisons with Jackson County. Thus, at the end of the second year, a measure of the effect of the 15% checklane inspection program can be obtained by comparing the random sample taken during the first year (1975) with that taken in 1976 after the checklane had been in operation for one year.

Due to legislative requirements, it was not possible to have an actual periodic motor vehicle inspection program operate. Consequently, an attempt was made to simulate such a PMVI as closely as possible within the framework of the enabling legislation. In Jackson County, a random sample of 10,408 vehicles was inspected by the random checklane inspection teams. This comprised approximately 15% of the registered vehicles in the County. These vehicles had a sticker placed on their windshields so that they could be identified in the subsequent year. The owners were requested to correct any defects found and were told that they were not subject to the operational checklane inspections the remainder of the year, but that their vehicles could be re-inspected the following year. The group which is re-inspected would thus simulate a population of PMVI vehicles with one year's experience in 1976.

During 1976, a second random sample of at least 2000 vehicles will be taken from Monroe County to measure the effect of the 15% checklane inspection program. In Jackson County, a random sample of at least 2000 vehicles will be taken from the previously inspected vehicles to measure the effect of the simulated PMVI program. In addition, a random sample of at least 2000 will be obtained from the population of uninspected vehicles in Jackson County.

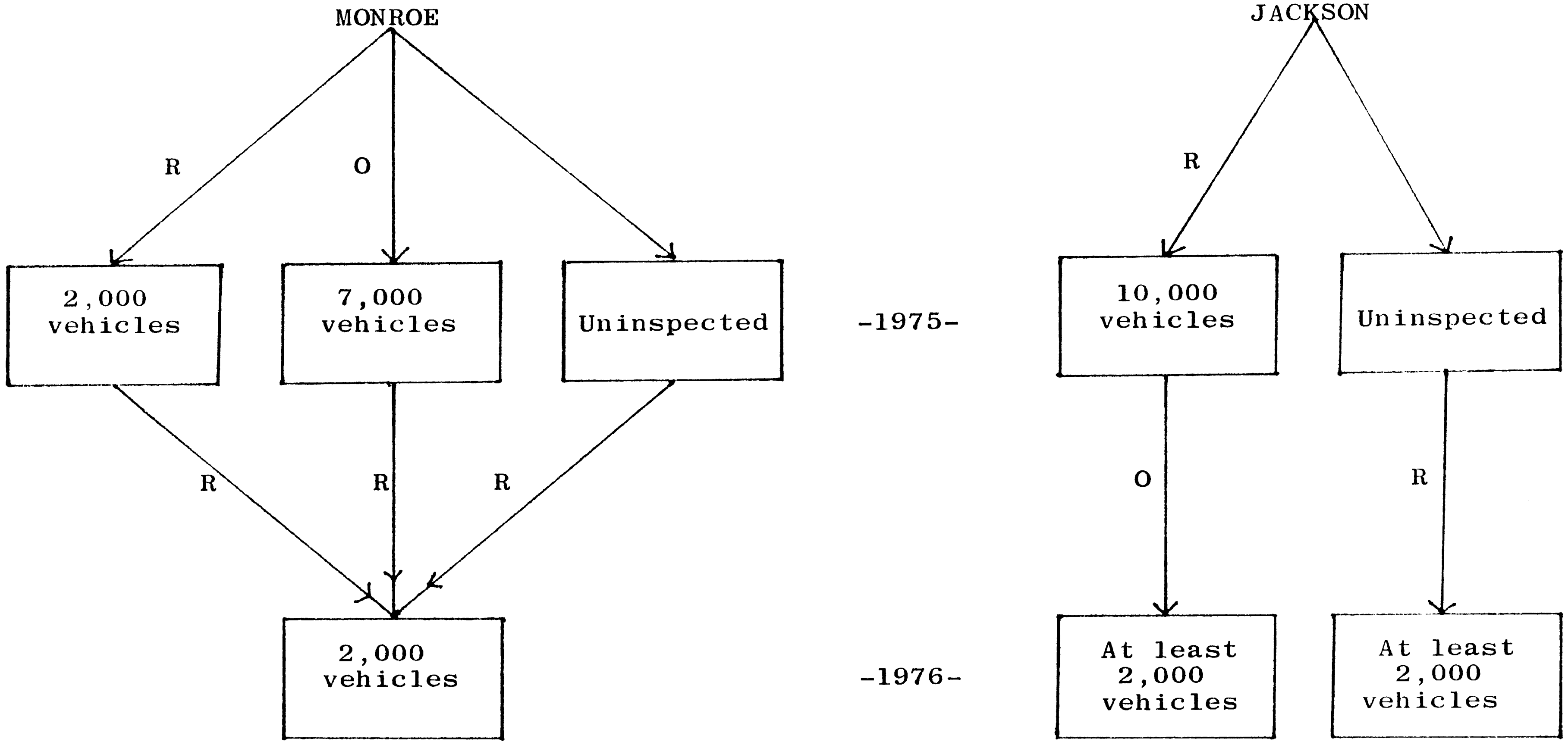
The random sample from the previously inspected vehicles in Jackson County will be used to measure the effect of the (simulated) PMVI by comparing its results to the original sample of vehicles from Jackson County. If the vehicle populations of the two counties are sufficiently similar, a direct comparison of the checklane program and the PMVI program can be made on the basis of the comparison of two random samples: that from the general vehicle population of Monroe County in 1976 and that from the previously inspected vehicles in Jackson County.

If important differences in the two counties are found which affect defect rates, and if these cannot be adjusted for, then an alternative comparison of the PMVI program with the checklane program is possible using only the 1976 samples from Jackson County. The sample from the previously inspected cars would represent a sample from a PMVI population, while the sample form previously uninspected population would represent a sample from a population which had been subject to a 15% checklane inspection, but which had not actually been inspected. This comparison is biased in favor of the PMVI group, since one of the benefits of the checklane is presumeably to effect repair of those vehicles stopped and found defective. However, this comparison would provide an upper bound on the benefits of the PMVI over the checklane. The bias could be removed by randomly selecting a subsample (of size equal to 15% of the sample size of the uninspected sample--about 300) and combining these with the uninspected sample to obtain a random sample of a population which was subjected to a 15% random inspection program, but which does not have the 15% of the vehicles which were previously inspected artificially removed.

Figure 2.1 summarizes the design of the study. In the figure, "R" denotes the random sample of vehicles inspected by the random checklane, while "O" denotes vehicles inspected by the operational checklane as usually operated by the Michigan State Police. There are some differences between the operational and the

FIGURE 2.1

PROGRAM DESIGN



O = Operational type checklane
R = Random type checklane

random checklanes. The operational checklanes were not restricted to a set pattern of sites. In addition, the officers could use their judgment in selecting vehicles for inspection from the traffic stream. Thus, they could tend to select older vehicles, vehicles with obvious defects, or vehicles suspected of defects because of the vehicle's exterior appearance, etc. The random checklane team adhered strictly to a random sampling protocol for visiting the inspection sites and for selecting the vehicles from the traffic stream for inspection. A vehicle with a flagrant defect would be stopped, however, but not included in the sample data unless it met the sampling protocol. Also, the random checklane inspection team conducted a moving stopping test and various interviews which were not part of the operational checklane procedure.

2.1 Field Operations

2.1.1 The Sample Checklane Procedures.

The sample checklane inspections were conducted in cooperation between the Michigan State Police and the HSRI researchers. The Michigan State Police performed most of the inspection, while the HSRI researchers were involved only in the driver interviews and the wheel pull inspections.

The checklane inspection takes place adjacent to a roadway. A diagram of a typical inspection lane is given in Figure 2.2. Vehicles are directed out of the traffic stream, are inspected for defects in major systems, are given a moving stopping test, and then released, given a postcard to return (for minor defects), or issued a summons (for major defects). A subsample is selected for driver interviews and for a brake inspection involving removal of one wheel to permit inspection of brake components.

The point man is responsible for selecting the vehicles from the traffic stream for the inspection. In the random checklane, he began each period with a random start, after which he selected every n-th eligible vehicle into the inspection lane. (Eligible vehicles were passenger cars and light trucks with Michigan license plates.)

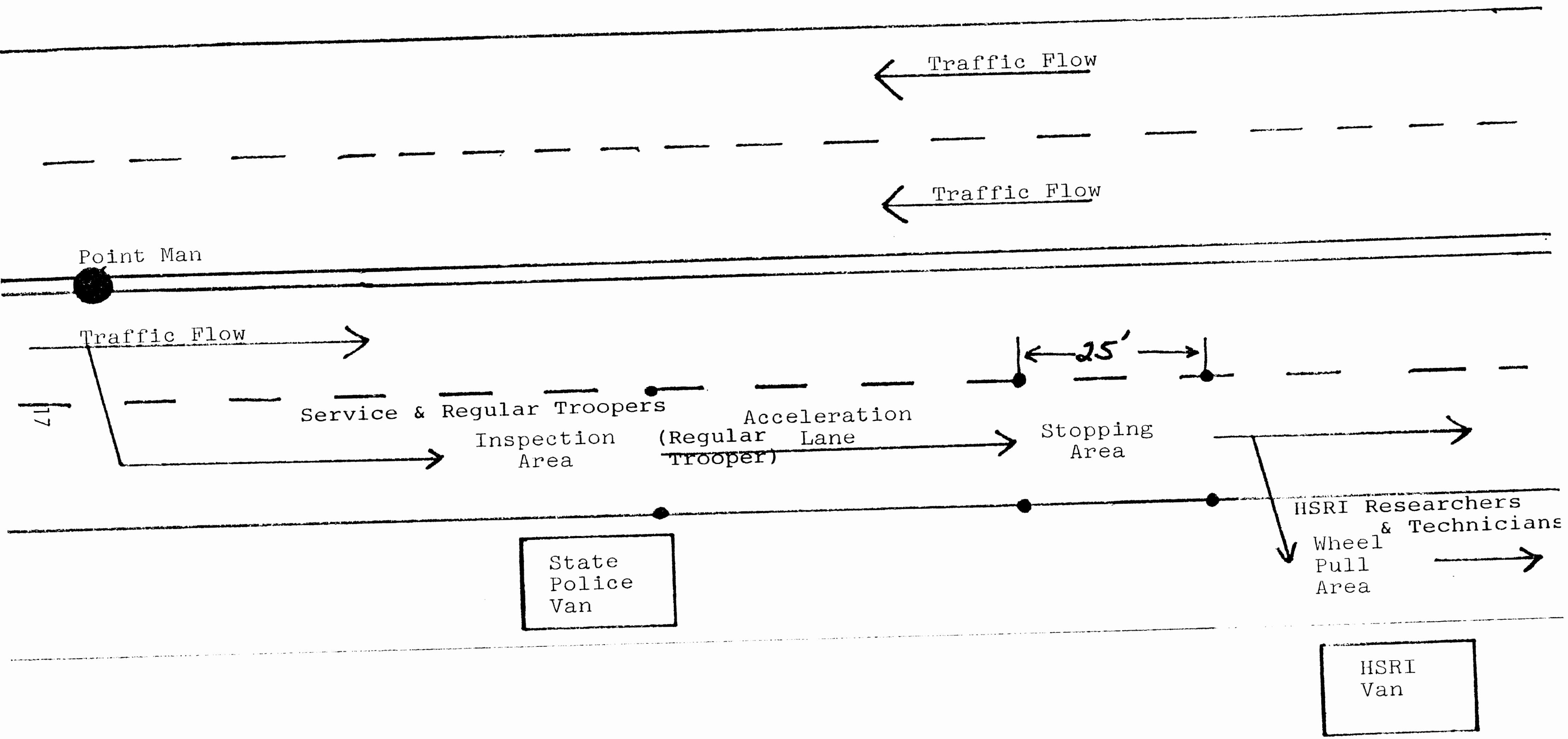


Figure 2.2

TYPICAL INSPECTION LANE

Thus, the random checklane used a systematic sample of vehicles with a random start. The interval, n, varied, depending upon the density of traffic flow at the site. Since higher sampling rates could be used at sites with low traffic volume, high density sites were visited more frequently to balance the density. Hence, over the course of the sample, approximately equal fractions were sampled from high density and low density sites.

Once the vehicle was selected for inspection, it was directed to the inspection area, where a regular trooper or a service trooper would inspect the vehicle systems. The results of the inspection were recorded on a computer mark-sense form, sample of which is given in Appendix A.1. The service troopers also checked the driver's license, vehicle registration, and vehicle insurance, and issued a postcard to the driver if any inoperative equipment was found on the vehicle. In Jackson County, a prenumbered sticker was placed on the lower left corner of the windshield. This sticker exempted the vehicle from further inspections during the year and provides the means of identification for the second year's sample.

After the visual inspection of the vehicle had been completed, it was turned over to a regular trooper who conducted the moving stopping test. The trooper entered the vehicle, accelerated to twenty miles per hour, and then attempted to stop in a lane twenty-five feet long and ten feet wide. The results of this test were recorded on unused lines at the end of the mark-sense form and were tabulated along with the other results.

After the moving stopping test was completed, the vehicle was directed to the wheel-pull area for a driver interview and a mechanical inspection of brake components by HSRI technicians if that area was free. If the wheel pull area was occupied, the vehicle was released if it had passed. If major sefety defects had been found, the vehicle was detained and a summons written. If minor defects were found the driver was instructed to repair these and return the postcard certifying that the defects had been repaired, after which the vehicle was released. A sample of the postcard form is given in Appendix A.2.

2.1.2 The Operational Checklane Procedures. The operational checklane procedure differed slightly from the random checklane. In the operational checklanes, no moving stopping tests or wheel-pull brake inspections were conducted, nor were any driver interviews taken. Also, no postcards were issued. Drivers were either issued a summons for major defects, or were verbally instructed to repair any minor defects found. The other major difference is in the selection of vehicles for inspection.

In the operational checklanes, sites were visited on a judgmental basis rather than according to a prescribed sampling schedule. Further, the selection of vehicles from the traffic stream for inspection is left to the judgment of the point man. He may select a higher proportion of older vehicles or those which appear to be likely to have defects from the general appearance. In consequence, operational checklanes may be more efficient at finding defective vehicles than random checklanes. However, the random selection process is necessary to accurately reflect the status of the vehicle population.

Because no moving stopping tests or wheel-pull inspections of brakes were conducted in the operational checklanes, the site requirements for an operational checklane are not as stringent as those for a sample checklane. Consequently a wider variety of roadways may be used with a correspondingly better coverage of the vehicle population.

2.1.3 Site Requirements. The procedure for conducting checklane inspections dictated certain requirements for the inspections sites. A prospective site had to have ample room for vehicles to wait without blocking traffic while undergoing the inspection and space for the police van to be parked out of the way.

The stopping test added the requirements of a large, dry, flat, paved area. There had to be room for the vehicle to be accelerated and stopped which implied a total of about two hundred feet for the stopping test. Care was also taken to provide for a safe run-over area past the stopping lane in the event of a brake failure during the stopping test. The final space requirement was dictated by the presence of the HSRI wheel-pull area. Room was needed for the vehicle to be parked alongside the HSRI van for the brake inspection. This area had to be sufficiently distant from the stopping lane so that the vehicle could be easily manuvered into position for a wheel-pull and still have a minimum of danger in the case of a run-over form the stopping lane. These space requirements restricted potential sites to those of roadsides with ample space, large parking lots, or "triangle" types of areas.

Sites also had to be chosen for the traffic flow and origin. For purposes of the sample checklane, the flow had to be of mostly local origin (within the particular county) in sufficient volume that about 200 vehicles could be randomly inspected daily. The above requirements limited the sites to those which were feeders into the cities and therefore eliminated some rural areas from the inspection procedures. The actual sites used were assigned randomly to the days in such a manner that the same site was not used on two consecutive days. Table 1 in Appendix A gives the sites used and Table 2 gives the inspection schedule for 1975.

The actual equipment state police needed for the sample checklane can be divided into that required for the inspection and that required for the wheel-pull. The state police needed roadside signs, traffic marker cones, an equipment van, and a chase car for the enforcement officer. The HSRI technicians required a jack, an air wrench, and assorted tools to complete their wheel-pull inspection of the brake. A supply of spare parts for the brakes was also carried. In addition, an air compressor was needed to power the air wrench, a trailer to carry the compressor and jack, and a van needed to store the extra tools and parts as well as to tow the trailer. Most of the HSRI equipment was leased over the course of the summer.

2.1.4 Publicity. An active publicity campaign was conducted in both counties as an attempt to explain the inspection situation to the uninspected population and encourage good maintenance of the uninspected vehicles. A more intense campaign was conducted in Jackson County, since the sample checklane operated with a higher intensity in that county. Both counties had good coverage of the checklane procedures by the media in the forms of radio, television, and newspaper. Jackson County also had an active billboard campaign combined with a pamphlet given to the drivers of all inspected vehicles to explain the sample checklane. The total publicity campaign was credited with giving an unexpectedly high degree of public cooperation with the state police vehicle inspections and the HSRI wheel-pulls.

2.2 Data Collection and Management

The basic inspection variables were recorded by the MSP on a computer mark-sensing form (Appendix A). The mark-sensing forms were collected by the MSP. The data were read from the mark-sense forms and a magnetic tape of the data was prepared by the MSP.

The data from the wheel-pull inspections (see Appendix A) were keypunched at HSRI and a computer file of these data was also prepared. To prepare the data for analysis, the data file from the from the MSP was merged with the data file from the HSRI wheel-pull inspections. The data from the driver interviews was tabulated and summarized by HSRI. No merging or matching with other inspection results was required.

Appendix B gives the list of variables in the HSRI computer file. Also included are the details of the data storage such as the column locations, variable names and numbers, and notes on recoding.

According to HSRI records, the sample checklane conducted 2,019 inspections in Monroe County and 10,408 inspections in Jackson

County in 1975. Of those 12, 427 estimated inspections, 11,651 inspection results were received by HSRI. An estimated 776 inspection results were lost during the processing of the inspection data from the inspection forms to magnetic tape. Due to a clerical error, approximately 200 of those 11,651 results had the form numbers changed. Thus, approximately 976 (about 7.8%) of the data that were collected are missing or miscoded.

Again, according to HSRI records, 2,536 wheel-pull brake inspections were conducted in 1975. Of those 2,536 estimated inspections, the form numbers of 2,317 inspection results about 91.4% matched the form numbers on the tape that we received from the Michigan State Police. Of the 219 unmatched brake results, 198 appear to be due to MSP missing or miscoded records, and 21 appear to be due to HSRI processing errors.

3. ANALYSIS AND RESULTS OF FIRST YEAR'S DATA

This section summarizes the state of repair of the vehicle populations in Monroe and Jackson Counties in 1975. Thus, these data represent the baseline against which the effect of the checklane inspection program will be measured. Comparisons of the vehicle populations sampled in the two counties are presented as well as defect rates.

3.1 Representativeness of the Samples. The sampling plan presented in Section 2 has certain limitations. It represents an attempt to obtain a random sample of vehicles operated locally. This population of vehicles is not necessarily the same as the population of registered vehicles. In particular, a comparison of the model years between the registered vehicles and the sampled vehicles reveals large differences. The distribution of model year for sampled and registered vehicles is given in Tables B-1 through B-3 in Appendix B. In general, fewer older vehicles were found in the sample than expected from the distribution of registered vehicles, and correspondingly, more newer vehicles than expected were observed.

There are a number of possible interpretations of this observation. One is that the sampling procedure selects vehicles with probability proportional to their current usage and hence is a sample of the population of vehicles actually being used. As such, the sample would accurately represent the appropriate target group, since the more a vehicle is used, the more important it is that it be in safe mechanical condition.

An alternative interpretation is that the population of vehicles which uses the roads suitable for checklane sites at the hours when the checklane operates is different from the general population of vehicles in use. This could be the case if particular ages of vehicles are used predominantly for long distance and freeway driving on predominantly rural, low volume roads. To the extent that this is the case, this represents a limitation of the checklane inspection program's ability to reach the intended population. It is conceivable, though unlikely, that the differences result from deliberate attempts to avoid the checklane. It is not possible with these data to determine why the sampled population differs from the registered vehicles. The assumption is made that it represents differences in use by different types of vehicles, and hence that the checklane sample is at least as representative of the population of vehicles in use as the reigstration list.

It should be noted, however, that even if the population observed by the sample chec klanes is not the same as the population of registered vehicles, this will not offset the primary comparisons of the project adversely. That is, the measured effect of the checklane will be observed in the sampled population. Similarly, the effect of the PMVI will be observed in the sampled population and comparisons between these will be based on similar populations. Thus, the estimates of effects are based consistently on the sampled populations.

3.1.1 Differences in the Sampled Counties. Since it is hoped to make cross-county comparisons, it is important to compare the sampled population of vehicles in Jackson and Monroe Counties. Several comparisons of the sampled vehicles were made and are reported in detail in Tables B-4 through B-7 of Appendix B.

No significant difference was found in the distribution of vehicle types. A slight difference in reported mileage was observed (p=.044), with vehicles in Jackson County having slightly greater mileages. In view of the large sample sizes and small difference in mileage, this is probably not of practical importance. A somewhat more significant difference in the distribution of model years was found (p=.013). This difference is rather small, but may be important since defect rates have been found to vary considerably by model year. A very large difference in the distribution of vehicle makes was found. The relevance of this to the defect rates is uncertain at this point but will be considered in making the comparisons.

The overall defect rate in the two counties are given in Table 3.1.

TABLE 3.1

Total Vehicle Defect Rates

	County		
	Monroe	Jackson	Total
Percent Passing	48.1	50.5	50.1
Total	1786	9865	11651

The difference was not significant at the 5% level (p=.062), however Jackson County did exhibit a slightly better passing rate. Since Jackson County also had slightly higher mileage and older vehicles, it appears that the effects of age were not very pronounced. That is, it may not be necessary to adjust for age between the two counties.

Overall, the two counties seem to be quite similar in the population of vehicles sampled by the checklanes. The largest difference lies in the make of the vehicles. This probably reflects differences in availability and dealer agressiveness in the two areas. It does not appear to be closely connected with condition of vehicles.

3.2 Defect Rates. The selective random checklane used by the Michigan State Police inspects about 300,000 vehicles annually for an overall intensity of about 5 to 10 percent. The population from which our sample was drawn thus represents an inspection system with no mandatory inspections and a low proportion of actually inspected vehicles. The data collected represents the pooled data over the course of the summer of 1975 for Jackson and Monroe Counties.

Vehicles were inspected on twenty three items (Table 3.2). The total sample size for this police inspection from June to October was 12,315 vehicles from vehicle model years 1960 to 1976. Rates of pass and fail were tabulated on these variables, as well as on seven derived variables. The derived variables were formed on each general defect category which had more than one sub-category (lights, exhaust, brakes, tires, glass, wipers and washers) such that a failure in any one of the sub-categories was counted as a failure in the derived variable. A final derived variable was added for the total vehicle such that a failure in any category gave a fail in the total vehicle.

An analysis by vehicle age for some of the above variables was performed. It was found that all the inspected vehicles passed on the safety glass and beam indicator so these variables as well as total glass were deleted. The test for foot brake was replaced by another part of the experiment and so was not included in the analysis. For this reason, the variable for total brake also was not included in this analysis.

TABLE 3.2

Police Inspected Items

Inspection Variables

- Glass
  - Safety
  - Vision Impaired
- Wipers and Washers
  - Wipers
  - Washers
- Horn
- Steering
- Brakes
  - Foot
  - Parking
- Tires
  - Bulges or Break
  - Tread
- Lights
  - Front Directional
  - High Beam
  - Low Beam
  - Aim of Headlight
  - Output
  - Tail
  - Stop
  - Rear Directional
  - Plate
  - Beam Indicator
- Exhaust
  - Noisy
  - Smoke
- Mirror

3.2.1 Total Vehicle Defects. We developed a descriptive model relating the total vehicle failure rate to the model year of the vehicle. The dependent variable is the projection of vehicles failing on at least one component. The independent variable is the model year (or equivalently, the age) of the vehicle. The age is computed as the difference between 1976 and the model year of the vehicle. For example, a car with model year 1970 is regarded as having an age of six years.

Table 3.3 gives the data. The proportion failing is plotted against age (model year) in Figure 3.1. An increasing trend of the proportion of vehicles failing inspection is apparent. Since the dependent variable is a proportion which changes considerably, and since the sample sizes are unequal, the variances are also unequal. This implies that the usual regression or least squares method of fitting a trend line is appropriate. Instead, weighted least squares has been used. The details of this statistical technique are summarized in Appendix C.

TABLE 3.3

Observed Results on Total Vehicle
Model Years 1960-1976

Year	Age	Pass	Fail	Total
1976	0	27	0	27
1975	1	1151	148	1299
1974	2	1406	484	1890
1973	3	1241	757	1998
1972	4	862	850	1712
1971	5	579	690	1169
1970	6	358	623	981
1969	7	270	753	1023
1968	8	149	599	748
1967	9	86	466	552
1966	10	44	341	385
1965	11	28	242	270
1964	12	18	126	144
1963	13	7	46	53
1962	14	4	38	42
1961	15	0	12	12
1960	16	0	10	10

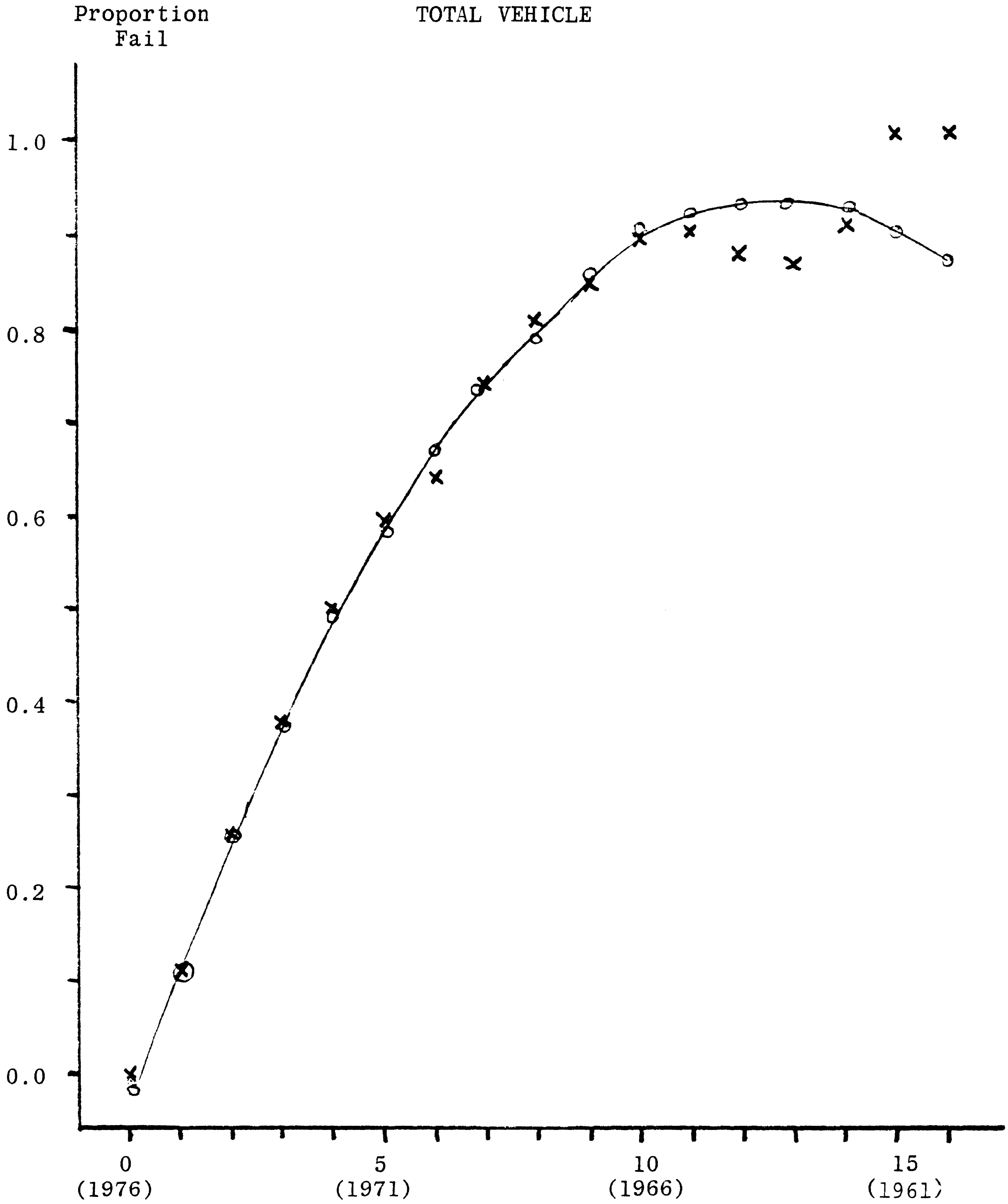


FIGURE 3-1
Observed Failure Rates for Total Vehicle,
Model Years 1960 - 1976

The results indicate that the relationship of proportion defective to age is best described by the model:

$$Y = -0.018 + 0.149\ X - 0.006X^2,$$

where X is the age in years and Y is the proportion defective. The linear model:

$$Y = 0.1185 + 0.077X$$

has nearly the same predicted power, but shows a significant lack of fit. Details of the model derivation may be found in Appendix C.

The main conclusion to be drawn from this regression model seems to be that there is a strong increase of defective vehicles with age. The exact form of the relationship may not be of primary interest. However the model provides a concise summary of what proportion of defective vehicles one should expect for a given age of vehicles.

Models of this sort also have potential utility in making policy decisions regarding vehicle inspections. For example, if it were determined that to be cost-effective an inspection should not be applied to a population of vehicles unless the defect rate were at least 25%, the model would indicate that only vehicles over two years old would be inspected.

3.2.2 Specific Components Defects. It might be that some specific component or some other combination of components would be considered an appropriate criterion for determining what set of vehicles should be the target of an inspection program. The percent defective for each model year are plotted for several specific defects in Figures B-1 through B-24 of Appendix B. Also in Table B-9 of Appendix B are detailed tables of the number and percent of vehicles with each specific defect for each county.

Most defect rates show an increase with the age of the vehicle. However a few, such as headlight output, steering, tire bulges or breaks, and exhaust smoke, are so rare that the tendency of the proportion to increase with age is hard to verify.

In Monroe County 10.2 percent of the drivers seen in the random checklane said that they had been previously inspected in a checklane. In Jackson County only 4.6 percent had had previous experience with a checklane inspection. Overall, 5.4 percent of the drivers had been through a checklane previously. This figure agrees with the statewide operational inspection rate of 5-6 percent.

3.2.2.1 Defects Relating to Vision. All of the vehicles seen in the random checklanes had approved safety glass in the windshield and windows. In both counties combined, 3.6 percent of the vehicles had vision impaired due to cracked or chipped windshields. Monroe County vehicles had a 2 percent rate while Jackson County vehicles had a 3.9 percent rate of defects. The incidence of this defect increases only moderately with the age of the vehicle remaining at about 3 percent until the vehicle is six years old or so. In the older vehicles the rate tends to be around eight percent, but was variable.

Windshield wipers were defective on 3.4 percent of the vehicles in Monroe County, and 3.6 percent of the vehicles in Jackson County, giving a combined rate of 3.6 percent. For windshield washers, the defect rates were 19.5 percent in Monroe, 15.3 percent in Jackson for a combined rate of 16.0 percent. Overall, 18.1 percent of the vehicles had either the windshield wipers or washers defective. Both wipers and washer defect rates show strong, nearly linear increases with age of the vehicles, however, the wiper rates were quite variable and were about a third of the washer rates.

About 2.4 percent of the vehicles observed had defective or insufficient mirrors. An increasing, nearly linear, trend with age was noted, rising from a rate of near zero for new cars to about six percent for vehicles ten years old.

Combining the vision defects, 78.5 percent of the vehicles had no vision related defects. Eighteen percent had one vision defect and 3.5 percent had two or more. The rates of all defective vehicles showed a marked tendency to increase with the age of the vehicle.

3.2.2.2 Lighting Defects. Only four of the 11,651 vehicles sampled had a non functional beam indicator light. Thus this component almost never fails. Headlight output was insufficient in only 1.3 percent of the vehicles. The output showed little relationship to age, being at most only about 4.0 percent in model years with sufficient sample size to give a reliable rate.

Headlight aim was faulty in 9.7 percent of the vehicles. This rate showed a linear trend increasing with age to about 7.0 percent for 10 year old vehicles. Low beams were out in only 2.4 percent of the vehicles, while high beams were out in 7.3 percent of the vehicles. The high beam outage rate showed a strongly increasing linear trend with age. On the other hand, the low beam outage rate was more variable and showed a smaller slope in its increase with age. In general the low beams were satisfactory in more cars than the high beams. This may reflect a much higher use of low beams than of high beams in this population. If so, then the indication is that drivers notice low beam headlight outages--and repair them--more readily than high beam outage. Overall 93.8 percent of the vehicles had satisfactory headlights.

Five percent of the vehicles had defective front directional lights and 6.9 percent had defective rear directional lights. The difference may be due to the relative ease of noticing bulb failures in the front directional lights. Both front and rear directional lights show a linear increase in defect rates with age. Front outages reach a high of about 11 percent for 10 year old vehicles, while rear outages range up to about 20 percent at 10 years.

Tail lights were defective in 6.2 percent of the vehicles, while stop lights were defective in 7.2 percent of the vehicles. Both of these defects showed linear trends, rising to about 12 percent defective in 10 year old vehicles. In vehicles older than 10 years, the rates were quite variable.

The license plate light had the highest rate of defects, 16.8 percent. This is probably due to a combination of factors. It is not readily noticed by an owner, and its repair is probably not regarded as urgent.

Only 67.7 percent of the vehicles had all lights functioning. However 79.8 percent had no major light defects. (Major light defects were directional lights, stop and tail lights, high and low beam headlights, or insufficient headlight output.)

3.2.2.3 Exhaust Defects. Of the vehicles inspected, 8.8 percent had excessive noise and 1.2 percent had excessive smoke. The noise rate exhibited a generally linear increase with age, rising to a rate of about twenty percent for 10 year old vehicles. The rate of excessive smoke was virtually zero for the first 5 or 6 years after which it varied widely among different ages. It ranged from zero to about 7 percent, averaging about 4 percent in cars over 6 years old.

3.2.2.4 Control Defects. Steering defects were recorded in 0.3 percent of the vehicles. The rate of steering defects is so low that no specific trend with age is rated, although the rates have been plotted by model year in Appendix B.

The foot brake was recorded as defective in one percent of the vehicles. A comparison of the moving stopping test with the wheel pull method of testing the braking capability of the vehicles is presented in Section 3.3. The determinations there are thought to be much more precise than this variable. There 18.2 percent of the vehicles were found to be defective, however, this was not determined separately for different model years. Ten percent of the vehicles were found to have defective parking brakes. This also showed an increasing trend with vehicle age.

Twelve percent of the vehicles had at least one tire with insufficient tread. Only 0.3 percent of the vehicles had tire bulges or cord breaks. The percentage of cars with insufficient tread (bald tires) showed an increasing trend with age, however the percent with tire bulges or breaks was too small to determine any tread with vehicle age. Tire pressures were also measured on the subsample of vehicles which had a wheel pull inspection. Distributions of the tire pressures are reported in Table B-10 of Appendix B. No satisfactory definition of what constituted incorrect tire pressures has been determined, so tire pressure was not recorded as a vehicle defect.

Overall, 87.2 percent of the vehicles had no control defects.

3.2.2.5 Miscellaneous Defects. Three percent of the vehicles were found to have defective horns. This variable also showed a linear increase with age, ranging from zero for new cars to about 9 percent for ten year old cars.

All but 1.5 percent of the drivers had valid operating licenses, and only 0.2 percent did not have proper vehicle registration. A total of six improper registrations were detected. A total of three failures to comply with insurance were found. However these results are not thought to be representative of the state, since the vehicles sampled do not come from any central city areas nor generally from completely rural areas. A citation was issued in 1.3 percent of the cases. Seat belts were observed in use by 11.4 percent of the occupants. However this is thought to be somewhat unreliable. It is probably an underestimate, since some drivers may have unbuckled them to get drivers licenses or registration papers before the officer reached the car.

3.2.3 Post Card Return Rates by Defect. Operators of vehicles with at least one defect were given a postcard to return certifying that the defect had been repaired. A total of 6,200 postcards were issued, of which 3,700 were returned. Thus 59.7% of the operators returned a postcard certifying that all defects noted had been repaired within 21 days.

The rate of return of post cards is not a totally satisfactory measure of the repair rate. A measure which was independent of the driver (owner) would be preferable, but was not available. (The sample results in 1976 from previously inspected cars will provide an independent estimate of the repair rate--which lasted a year). It may be that not all of the postcards returned actually had the repairs made. What seems more liekly, however, is that many repairs were made but the cards were not returned--perhaps because they were mislaid or forgotten until after the 21 day period.

An attempt was made to estimate the actual repair rates through a subsample. A random sample of 400 vehicles for which postcards were issued was drawn. Of these, 204 or 51% returned the postcards. There was no way to trace the other 196 for an interview. Of the 204 returns, 62 could not be matched with a name and address, 47 had no listed telephone, and 95 had telephone numbers. Of the 95, we were able to contact 30 (during regular working hours). Of the 30, the interviewer concluded that all had actually repaired the defects. However, the large non-response rate precludes much confidence in this result.

Table 3.4 tabulates the return rates by types of defect. These rates were estimated from the sample of 400 post card vehicles. Lights had the highest return rate, closely followed by mechanical. Vision and control variables had somewhat lower return rates. Looking at the return rates by number of defects found in the total inspection, one notes a decreasing rate of return with increasing numbers of defects. Thus there may be some indication that the cars with several defects are not required as well as a result of the inspection as are those with fewer defects.

It should be noted that vehicles which were issued citations were not issued postcards. Thus the 1.3 percent of the vehicles with the most serious defects--from the safety standpoint--were repaired or the owner faced a court appearance and fine.

TABLE 3.4

Rate of Post Card Return by Defect

Defect Type	% Return
Vision	44.9
Control	44.6
Light	56.2
Mechanical	55.4

Number of Mechanical Defects	% Return
1	55.3
2	56.4
3	47.1
4+	40.4

Number of Light Defects	% Return
1	60.4
2	49.1
3	57.1
4+	35.7

Total Inspection Defects	% Return
1	57.7
2	54.1
3	49.2
4+	41.4

3.3 Driver Interview Results

Druing operation of the sample checklane, a driver interview was conducted. The subsample of drivers whose vehicles were selected for the wheel pull brake inspections was used for this purpose.

The two-page interview as shown in Appendix A was given during the months of June and July, 1975. In August, a special second page replaced that shown for use by the Office of the Secretary of State and was not processed by HSRI. The final month and a half of the checklane had only the first page used (question 1-5) due to the absence of researchers at the checklane and as a time consideration. The absence of the second page for much of Jackson County explains the large numbers of missing values for questions 6 through 12. The questions deal with two topics: the sample checklane and opinions. Detailed results of this questionnaire are tabulated in Appendix B as Table B-11.

The results of the age and sex answers show similar patterns for the samples from each county. Both of the counties have the bulk of the drivers under 35 years old and male. The percentage male was more pronounced in Monroe County (60.2%) than in Jackson (56.3%), however.

Questions one and two dealt with driver knowledge of the Michigan Vehicle Inspection Program. The first question related to how the vehicle was to be inspected, with a correct response of "to allow the police to check it at any time." There was a marked increase in the correct responses from Monroe to Jackson Counties (51.0% to 63.6%) attributed to the more intense publicity campaign in Jackson County. Similarly, there was an increase in the correct responses for the second question on how often the vehicle must be inspected. The increase from 35.0% to 48.8% in Monroe and Jackson Counties, respectively, is explained in the same manner as above.

Questions three and four related to where and when the driver had heard about the Michigan inspection program. The press campaign was again evident in the proportions of the drivers who had not heard of the MVIP, as 7.5% in Monroe County had not compared to 1.9% in Jackson County. Other evidence is the proportion of the drivers who had heard about the checklane from the press (52.1% in Monroe County, 74.6% in Jackson County. Both counties had over 90% of the population who had heard of the checklane sometime before the day of the interview. Some inconsistencies occurred between the questions, because some drivers that heard of the inspection that day as they went through the inspection marked that they had heard of the checklane from the police in question 3 and "today" on question 4.

Question five was a check installed to ensure that the bulk of the traffic was of mostly local origin for the design purposes. The responses indicated that there was less than 20% non-county traffic for each county. This indicates that a sizeable number of inspected vehicles may be recovered in Jackson County.

Questions six through eight related to seat belt usage. There seemed to be a trend of less usage in Monroe County than in Jackson County. Fewer drivers in Monroe County reported they "always" or "often" wore seat belts (16.8% and 22.3%) than did drivers in Jackson County (21.1% and 26.7%). It is interesting to note that the troopers conducting the inspection observed only about 11 percent of the drivers to be wearing seat belts. Part of this difference may be due to the driver having removed the belt by the time the trooper reached the car, but it seems likely that there was a bias toward over-reporting of usage. At least the reported usage seems higher than the actual usage in the particular driving situation at the checklane site.

More drivers in Monroe County felt inconvenienced by seat belts (65.7% vs. 56.8%) than in Monroe County. Over two-thirds (67.3% and 69.3%) of the drivers in both counties agreed that seat belts save lives.

Questions nine through twelve referred to the 55 mph speed limit. Drivers in both counties strongly felt that the lower speed limit (55 mph) reduces highway fatalities (87.7%). There was a strong opinion that there should not be a higher speed limit on all state highways (75.0%) and a somewhat weaker feeling for the 55 mph speed limit on the interstate highways (59.0% in favor of maintaining the 55 mph limit). There was somewhat less support for instituting points on driver's license for speeding violations between 55 and 70 mph, with an average of only 54.6% of the drivers agreeing.

It should be recalled that the sampling techniques intended to concentrate on local traffic. Drivers who do most of their driving on interstates were excluded. Similarly most drivers on long trips were excluded. Consequently, these results cannot be generalized to the population of all drivers, but relate to the population of all drivers, but relate to those--in Monroe and Jackson Counties--who do mostly local, short trip driving. A survey taken on interstates might produce quite different results.

There may also be a bias of drivers to report the "officially acceptable" opinion. Although the interviews were not conducted by the MSP, the troopers were much in evidence and this may have influenced the results. The discrepancy between the percent of drivers observed to wear seat belts (11%) and the percent who reported that the "always" (19% or "often" (24%) wore seat belts may reflect this. In the future, randomized response techniques might be utilized to avoid this.

3.4 Brake Inspection Results

3.4.1 The Moving-Stopping Test. All vehicles (except for 1.9% who refused) were given a low speed moving-stopping test. A state trooper accelerated the vehicle to twenty miles per hour, and then attempted to stop it in a lane twenty-five feet long and ten feet wide. The results were recorded in three variables: pedal pressure, ability to stop, and stopping audible. The detailed results of this test are presented in Table B-12 of Appendix B.

It was believed that a fail on any of the three variables indicated a serious brake defect. Consequently a vehicle was judged to pass only if it passed all three. The percent of vehicles passing the moving stopping test was 75% in Monroe County and 83.1% in Jackson County. The most frequent causes of failure were stopping audible and pulling to one side in the moving test.

Table 3.5 gives the percent of vehicles in each county which failed the moving stopping test on each of the three variables. Also included are the overall passing rates and the percentage of vehicles failing on more than one defect.

TABLE 3.5

Moving Stopping Test Results

	Monroe County		Jackson County		Total	
	Count	% Fail	Count	% Fail	Count	% Fail
Pedal Pressure	122	6.9	371	3.7	499	4.1
Stopping Test	212	11.9	738	7.5	950	8.1
Stopping Audible	208	11.6	678	6.9	886	7.6
One Defect	358	20.0	1173	11.9	1531	13.1
Two Defects	68	3.8	217	2.2	285	2.4
Three Defects	16	0.9	60	0.6	76	0.7
Pass	1340	75.0	8195	83.1	9535	81.8

3.4.2 Wheel Pull Inspections. A random subsample of 2,465 vehicles were given a brake inspection by an automotive technician. This inspection was conducted separately and independently of the moving stopping test. It consisted of removing one wheel (the right front wheel) and inspecting the braking system's mechanical components. The detailed results are tabulated in Table B-13 of Appendix B. One interesting observation is that cars in Monroe County had a different distribution of brake types than did those in Jackson County. This may correspond to the differences in makes noted between the two counties.

Table 3.6 gives the number and percent of vehicles failing by each cause for the two counties.

TABLE 3.6

Wheel Pull Inspection Failures

	Monroe Co.		Jackson Co.		Total	
	Count	% Fail	Count	% Fail	Count	% Fail
Brake Fluid	12	4.1	74	3.7	86	3.8
Shoe/Pad	3	1.3	83	4.4	86	4.1
Rotor or Drum	10	4.2	158	8.5	168	8.0
Wheel Cylinders	8	3.4	7	0.4	15	0.7

3.4.3 Comparison of the Wheel Pull and Moving Stopping Test.

The main aim of the wheel pull inspections was to provide a comparison between the mechanical inspection and the moving stopping test as methods for determining the braking capability of the inspected vehicles. To do this is was necessary to define a pass-fail criterion for the wheel pull inspection. Three possible criteria for this pass/fail variable were considered:

HSRI 1 = Fail if shoe/pad fail, or cracked rotor/drum, or wheel cylinders fail
Pass otherwise

HSRI 2 = Fail if HSRI 1 fail, or low master cylinder fluid
Pass otherwise

HSRI 3 = Fail if HSRI 2 fail, or worn rotor/drum
Pass otherise

Due to their nested quality, a vehicle that fails HSRI 1 must also fail HSRI 2, and a vehicle that fails HSRI 2 must also fail HSRI 3. Conversely, a vehicle that passes HSRI 3 must also pass HSRI 2, and a vehicle that passes HSRI 2 must also pass HSRI 1. The results of the two tests jointly are presented in Table 3.7.

TABLE 3.7

Brake Inspection Results

HSRI 1

		Pass	Fail	Total
	Pass	1825	62	1887
Police	Fail	534	44	578
	Total	2359	106	2465

HSRI 2

		Pass	Fail	Total
	Pass	1773	114	1887
Police	Fail	503	75	578
	Total	2276	189	2465

HSRI 3

		Pass	Fail	Total
	Pass	1749	138	1887
Police	Fail	491	87	578
	Total	2240	225	2465

The policy issue that the analysis is meant to examine is whether the stopping test is an adequate brake inspection, or whether it is necessary to remove a wheel in order to perform an adequate brake inspection. Therefore, the objective is to provide estimates of the probability that a serious brake defect will be discovered by a wheel pull inspection for vehicles that had passed the stopping test.

An additional objective of the analysis is to examine whether a wheel pull inspection is adequate, or whether it is necessary to conduct a stopping test. Therefore, we also wish to estimate the probability that a serious brake defect will be discovered by a stopping test for vehicles that had passed the wheel pull inspection.

Note that the wheel pull is not a complete inspection of the brakes. Only one wheel is inspected. Inspection of all 4 wheels would give a complete description of the mechancial condition of the brakes, but might not detect a tendency of the car to pull to one side while stopping. However inspection of all four wheels would add a great deal of time and effort to the inspection.

From Table 3.7 it is simple to calculate the percent of vehicles which passed the moving stopping test, but failed the wheel pull inspection (by the HSRI 1, 2, or 3 criteria). This percent is an estimate of the unsafe vehicles which pass the moving stopping test. Table 3.8 gives these percents, together with their joint 95% confidence intervals. (Derivation of the confidence intervals is complex. It is presented in Appendix C.) Even using the most conservative criterion--the one that most favors the wheel pull--at most 9.1% of the vehicles which pass the moving stopping test would be unsafe. And the best estimate is that only 7.3% would be unsafe. We believe that the most reasonable pass/fail criterion is HSRI-2. This estimates that 6% of unsafe vehicles would fail the moving stopping test, and one is 95% confident that at most 7.7% of the vehicles passing would have unsafe brakes.

TABLE 3.8

Estimated Percent Vehicles Passing Moving Stopping Test which have Unsafe Brakes

	Percent	95% Confidence Intervals
Unsafe by HSRI-1	3.3	(2.0 to 4.6)
Unsafe by HSRI-2	6.0	(4.3 to 7.7)
Unsafe by HSRI-3	7.3	(5.4 to 9.1)

The other approach is to ask "if the wheel pull inspection were used, what proportion of vehicles passing the wheel pull inspection would have stopping defects?" That is, of those vehicles passing the wheel pull, what percent would fail the moving stopping test. Table 3.9 gives estimates of these percents for each of the 3 criteria together with the joint 95% confidence intervals.

Inspection of Table 3.9 reveals that if the wheel pull inspection were used, at least 19.8 percent of the vehicles passing the wheel pull would have stopping defects as judged by the moving stopping test.

If the HSRI-2 criterion for passing is used, an estimated 22.1% of the vehicles which passed could have stopping defects.

TABLE 3.9

Estimated Percent of Vehicles Passing the Wheel Pull which have Stopping Defects

	Percent	95% Confidence Interval
HSRI-1	22.6	20.5 to 24.7
HSRI-2	22.1	20.0 to 24.2
HSRI-3	21.9	19.8 to 24.0

Thus, if the criterion for the brake inspection is to avoid passing vehicles which have stopping difficulties, the moving stopping test is more efficient. Even if the criterion most favorable to the wheel pull is used, the proportion of defective vehicles that would be undetected by the moving stopping test is less than 9.1 percent, while the proportion of defective vehicles that would be undetected by the wheel pull is more than 19.8 percent. Since the moving stopping test is also easier and faster to conduct, it seems the preferred choice.

4. CONCLUSIONS AND RECOMMENDATIONS

The primary purposes of the study were to estimate the effect on the proportion of defective vehicles of a 15% checklane inspection program and to compare this with the estimated effect of a simulated PMVI inspection. Both of these require two years. Consequently no conclusions relative to the principle questions are possible at this time.

The average passing rates for the two study counties were 48.1% and 50.5% for Monroe and Jackson Counties, respectively. In this respect the vehicle populations of the two counties were quite similar. Large differences in the manufacturers of vehicles were found in the two counties, but this is not thought to be crucial to comparisons. Small differences in the age, mileage, and types of vehicles were observed. It appears currently that it will be possible to compare the results in the two counties directly--without adjustment. It is recommended that a sensitivity analysis of the possible effects of adjustments be tried to ensure that direct comparisons are valid.

Large differences between the population of vehicles sampled and the population of registered vehicles were observed in both counties. This was expected since sampling was done with probability proportional to usage on local feeder roads. As a result, the baseline failure rates are applicable only to the population sampled, not to the populations of registered vehicles as a whole. This restriction does not hinder the study's conclusions, since the same population will be sampled both years. It does indicate that checklane inspections do not reach all vehicles with equal probability. One interpretation of the differences between the population of registered vehicles and the population sampled is that the sampled population accurately represents those currently in use. If this is correct then the checklane method would be more closely connected with accident prevention than PMVI, because the checklane would concentrate on those vehicles most used.

Not surprisingly, defect rates were found to increase with the age of the vehicle. This adds credence to the contention that the operational checklane is highly efficient at detecting vehicles with safety defects.

Drivers with defective vehicles were issued a post card to return certifying that the repairs had been made within 21 days. A low rate of return--sixty percent--was observed. There was some indication that the return rate was lower for vehicles with several defects or with the more serious defects. Although the rate of return of the post cards may not completely reflect the rate of repair, it causes concern for the efficacy of this system for effecting repair of defective vehicles. We would recommend that efforts to strengthen the repair incidence be considered.

The comparison of the moving stopping test with the wheel pull brake inspection indicated that the moving stopping test more accurately determines the car's braking capability. It is also quicker and easier to perform. For these reasons we recommend that it be adopted as the inspection procedure for braking capability.

Inferences from the driver interviews are necessarily restricted to drivers in primarily local traffic. In particular, drivers on interstate roads and on long trips were excluded. Thus the results are not generalizable to the population of Michigan drivers.

Drivers generally thought that the 55 mph speed limit had reduced traffic fatalities and were opposed to raising the limit for all state highways. They were less opposed to increasing the speed limit on interstates and to instituting points for speeding violations in the 55 to 70 mph range.

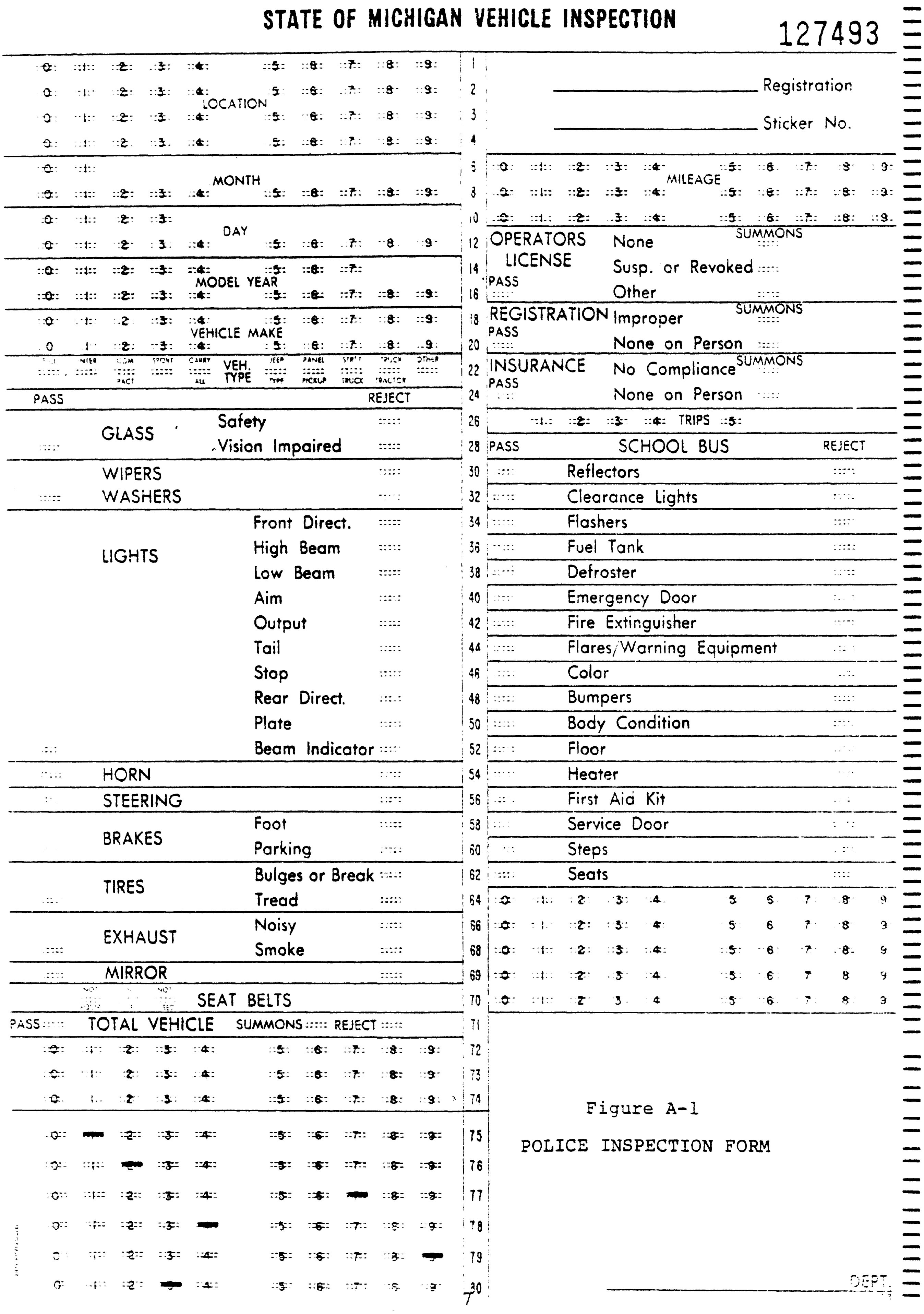
Drivers in Jackson County showed a greater knowledge and awareness of the checklane inspection program than did those in Monroe County. This coincides with a more intensive information campaign there. It is recommended that public information campaigns be continued.

Two thirds of the drivers believe that seat belts save lives. However only 43 percent reported that they often or always wore seat belts. Only eleven percent of the drivers were observed to be wearing belts by the inspecting officers. This indicates that there may be a bias in the interview results. In the future, it is recommended that randomized response techniques be considered to reduce this potential bias.

At the end of the study the data should provide reliable estimates of the effects of a 15% checklane inspection system. Comparisons between the operational checklane and the simulated PMVI should provide reliable estimates of the difference in effect on the proportion of defective vehicles obtained by the two methods. This, in turn, will give a solid basis for a recommendation of the preferred inspection system.

APPENDIX A

DATA COLLECTION INSTRUMENTS



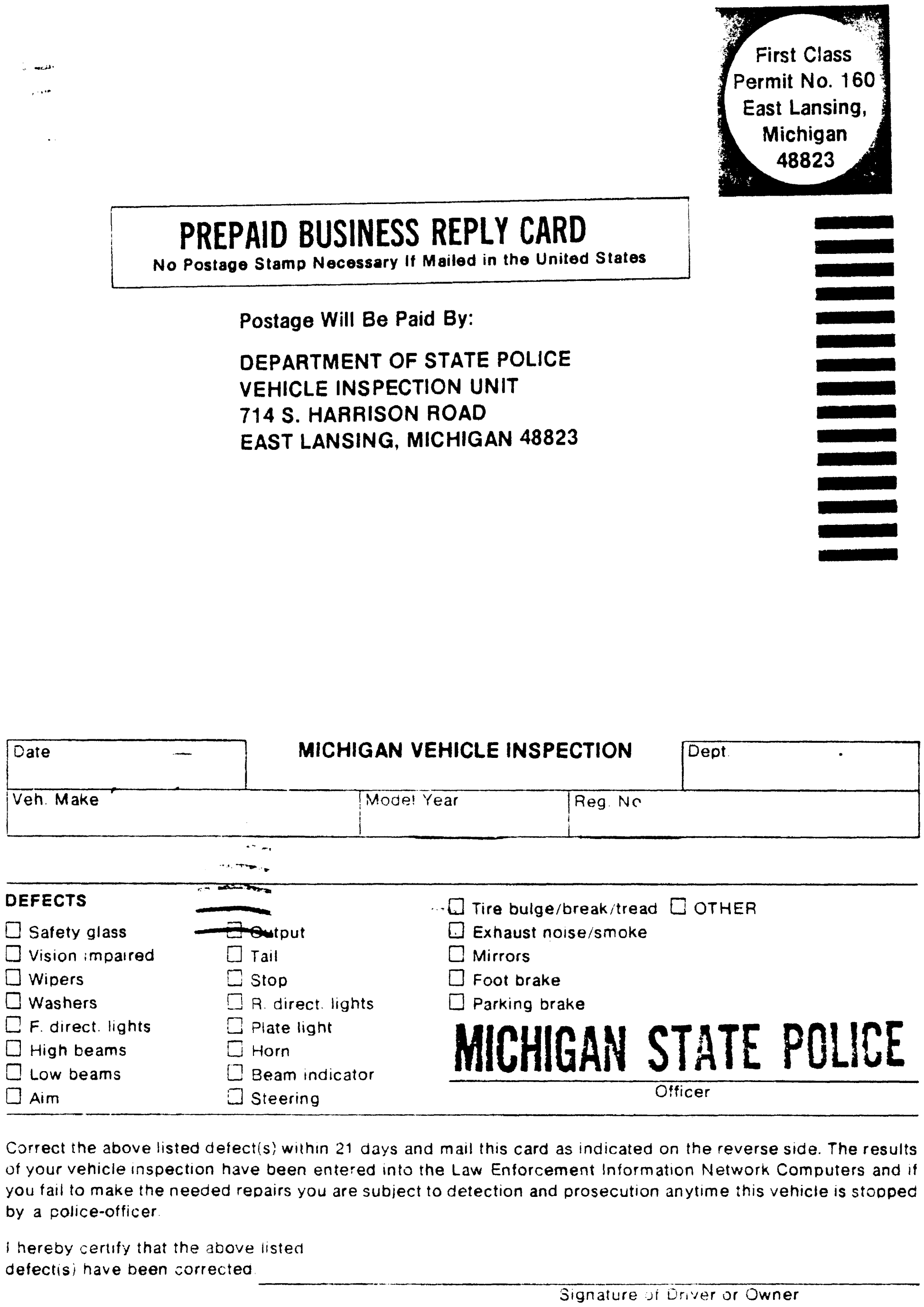
STATE OF MICHIGAN VEHICLE INSPECTION

127493

LOCATION 0 1 2 3 4 5 6 7 8 9	1	
0 1 2 3 4 5 6 7 8 9	2	________ Registration
0 1 2 3 4 5 6 7 8 9	3	________ Sticker No.
0 1 2 3 4 5 6 7 8 9	4	
MONTH 0 1	6	MILEAGE 0 1 2 3 4 5 6 7 8 9
0 1 2 3 4 5 6 7 8 9	8	0 1 2 3 4 5 6 7 8 9
DAY 0 1 2 3	10	0 1 2 3 4 5 6 7 8 9
0 1 2 3 4 5 6 7 8 9	12	OPERATORS LICENSE — None — SUMMONS ☐
MODEL YEAR 0 1 2 3 4 5 6 7	14	Susp. or Revoked ☐
0 1 2 3 4 5 6 7 8 9	16	PASS ☐ — Other ☐
VEHICLE MAKE 0 1 2 3 4 5 6 7 8 9	18	REGISTRATION — Improper — SUMMONS ☐
0 1 2 3 4 5 6 7 8 9	20	PASS ☐ — None on Person ☐
VEH. TYPE FULL ☐ INTER ☐ COMPACT ☐ SPORT ☐ CARRY ALL ☐ JEEP TYPE ☐ PANEL PICKUP ☐ STR'T TRUCK ☐ TRUCK TRACTOR ☐ OTHER ☐	22	INSURANCE — No Compliance — SUMMONS ☐
PASS — REJECT	24	PASS ☐ — None on Person ☐
GLASS — Safety ☐	26	TRIPS 1 2 3 4 5
☐ — Vision Impaired ☐	28	PASS — SCHOOL BUS — REJECT
WIPERS ☐	30	☐ Reflectors ☐
☐ WASHERS ☐	32	☐ Clearance Lights ☐
LIGHTS — Front Direct. ☐	34	☐ Flashers ☐
High Beam ☐	36	☐ Fuel Tank ☐
Low Beam ☐	38	☐ Defroster ☐
Aim ☐	40	☐ Emergency Door ☐
Output ☐	42	☐ Fire Extinguisher ☐
Tail ☐	44	☐ Flares/Warning Equipment ☐
Stop ☐	46	☐ Color ☐
Rear Direct. ☐	48	☐ Bumpers ☐
Plate ☐	50	☐ Body Condition ☐
☐ — Beam Indicator ☐	52	☐ Floor ☐
☐ HORN ☐	54	☐ Heater ☐
☐ STEERING ☐	56	☐ First Aid Kit ☐
BRAKES — Foot ☐	58	☐ Service Door ☐
Parking ☐	60	☐ Steps ☐
TIRES — Bulges or Break ☐	62	☐ Seats ☐
☐ — Tread ☐	64	0 1 2 3 4 5 6 7 8 9
EXHAUST — Noisy ☐	66	0 1 2 3 4 5 6 7 8 9
☐ — Smoke ☐	68	0 1 2 3 4 5 6 7 8 9
☐ MIRROR ☐	69	0 1 2 3 4 5 6 7 8 9
NOT EQUIP ☐ ☐ NOT USED ☐ — SEAT BELTS	70	0 1 2 3 4 5 6 7 8 9
PASS ☐ TOTAL VEHICLE SUMMONS ☐ REJECT ☐	71	
0 1 2 3 4 5 6 7 8 9	72	
0 1 2 3 4 5 6 7 8 9	73	
0 1 2 3 4 5 6 7 8 9	74	
0 ● 2 3 4 5 6 7 8 9	75	
0 1 ● 3 4 5 6 7 8 9	76	
0 1 2 3 4 5 6 ● 8 9	77	
0 1 2 3 ● 5 6 7 8 9	78	
0 1 2 3 4 5 6 7 8 ●	79	
0 1 2 ● 4 5 6 7 8 9	80	________ DEPT.

Figure A-1

POLICE INSPECTION FORM



First Class
Permit No. 160
East Lansing,
Michigan
48823

PREPAID BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By:

DEPARTMENT OF STATE POLICE
VEHICLE INSPECTION UNIT
714 S. HARRISON ROAD
EAST LANSING, MICHIGAN 48823

MICHIGAN VEHICLE INSPECTION

Date			Dept.
Veh. Make	Model Year	Reg. No	

DEFECTS

☐ Safety glass
☐ Vision impaired
☐ Wipers
☐ Washers
☐ F. direct. lights
☐ High beams
☐ Low beams
☐ Aim

☐ Output
☐ Tail
☐ Stop
☐ R. direct. lights
☐ Plate light
☐ Horn
☐ Beam indicator
☐ Steering

☐ Tire bulge/break/tread
☐ Exhaust noise/smoke
☐ Mirrors
☐ Foot brake
☐ Parking brake

☐ OTHER

MICHIGAN STATE POLICE
Officer

Correct the above listed defect(s) within 21 days and mail this card as indicated on the reverse side. The results of your vehicle inspection have been entered into the Law Enforcement Information Network Computers and if you fail to make the needed repairs you are subject to detection and prosecution anytime this vehicle is stopped by a police-officer.

I hereby certify that the above listed defect(s) have been corrected

Signature of Driver or Owner

Figure A-2

Reply Postcard

Figure A-3

Brake Inspection Checklist

Sticker No.__________ Inspector Initials__________

1. Brake type	( ) Disc ( ) Drum	( ) Power ( ) Non-power
2. Master cylinder fluid	( ) Full ( ) Half ( ) Low (slightly over the port)	
3. Brake Fluid Contamination	( ) Pass ( ) Fail due to__________	
4. Vacuum Hose	( ) Pass ( ) Fail	
5. Wheel Bearing Grease	( ) Pass ( ) Fail (seal leaking) ( ) Unable to inspect	
6. Wheel Pull	( ) Wheel pulled ( ) Unable to pull wheel (omit questions 7 through 10)	
7. Drum Shoe Condition or Disc Pad Condition	( ) 75-100% ( ) 50-75% ( ) 1/32" - 50% ( ) Fail (less than 1/32")	
8. Rotor or Drum	( ) Pass ( ) Cracked	( ) Worn (discolored) ( ) Grooves
9. Brake Hardware	( ) Pass ( ) Springs	( ) Retainers ( ) Self-adjuster
10. Wheel Cylinders	( ) Pass ( ) Fail (leaking)	
11. Actual Tire Pressure	LF__________ LR__________	RF__________ RR__________

12. Tire Size__________

13. Recommended Tire Pressure

LOADED__________

UNLOADED__________

14. Comments (use reverse side if necessary)

THIS QUESTIONNAIRE IS BEING USED TO FIND OUT WHAT PEOPLE THINK ABOUT DIFFERENT AREAS RELATED TO VEHICLES IN MICHIGAN. YOUR ANSWERS WILL NOT AFFECT THE INSPECTION OF YOUR VEHICLE. THANK YOU!

Age:__________ Sex:__________ Sticker number:__________

THE FOLLOWING QUESTIONS ARE DESIGNED TO TEST YOUR KNOWLEDGE OF THE MICHIGAN VEHICLE INSPECTION PROGRAM. PLEASE CIRCLE THE NUMBER OF THE ANSWER WHICH IS THE MOST CORRECT.

1. To have your car inspected in Michigan, you <u>must</u>
   1. Do it yourself
   2. Take it to an authorized inspection station
   3. Allow the police to check it at any time
   4. Don't know

2. How often <u>must</u> you have your car inspected in Michigan?
   1. Never
   2. Every 6 months
   3. Every year
   4. When requested by police
   5. Don't know

3. Where did you first hear of the Michigan Vehicle Inspection Program?
   1. Friends
   2. Newspapers, radio, television
   3. Service station or garage
   4. Police
   5. Don't remember
   6. Didn't hear of it

4. When did you first hear of the Michigan Vehicle Inspection Program?
   1. Today
   2. Sometime in the past

5. About how far are you away from home right now?
   1. Less than 1 mile
   2. One to 2 miles
   3. Two to 5 miles
   4. Five to 10 miles
   5. More than 10 miles and a resident of this county
   6. More than 10 miles but not a resident of this county

6. How often do you wear seatbelts when driving or riding in a car?
   1. Always
   2. Often
   3. Seldom
   4. Never

7. When wearing seatbelts, do you feel?
   1. Greatly inconvenienced
   2. Somewhat inconvenienced
   3. Not inconvenienced

THE FOLLOWING STATEMENTS REQUEST YOUR OPINION. PLEASE CIRCLE THAT OPINION WHICH BEST EXPRESSES YOUR OWN.

8. Seatbelts save lives.
   1. Agree
   2. Disagree
   3. No opinion

9. The 55 mph speed limit reduces highway fatalities.
   1. Agree
   2. Disagree
   3. No opinion

10. A higher speed limit should be reinstated on interstate highways.
    1. Agree
    2. Disagree
    3. No opinion

11. Higher speed limits should be reinstated on all state highways.
    1. Agree
    2. Disagree
    3. No opinion

12. Points should be given on a driver's license for speeding violations between 55 and 70 miles per hour.
    1. Agree
    2. Disagree
    3. No opinion

CP__________ IN__________

Figure A-4

Driver Interview

Table A-1

LOCATION CODES

Monroe County

4810	Stewart Road Church of God	Stewart Road between US-24 and M-125
4820	Route M-50	Near Raisinville Rd. west of Monroe
4830	First Baptist Church	Corner of Lewis Rd. and Erie Rd. North of Temperance
4840	Route US-24	On US-24 south of Mich. State Police post

Jackson County

4910	Springport Road	West of Campbell, Blackman Twp.
4915	Airport Lanes	Airport Rd. across from airport, Blackman Twp.
4920	Ann Arbor Road (BR 94)	East of Sutton, Leoni Twp.
4921	Wisener Street	Back of Shopping plaza, north of city of Jackson
4922	Monroe Street	Between Wisener St. and West St.
4930	Ramp from M-50 to US-127	From Westbound M-50 to Northbound US-127, Summitt twp.
4935	Moose Lodge	Lansing Ave. at the Moose Lodge, city of Jackson
4940	Route M-60	Between I-94 and McCain Rd., eastbound, Summitt twp.
4945	Route M-50	Southbound, city of Jackson
4950	Route M-106	At Bunkerhill Rd., Henrietta twp.
4955	US-127	East service drive of US-127 at Weatherby Rd., Columbia

Table A-1 Continued

4960	Parnall School Lansing Ave. north of Parnall St., Blackman twp.
4965	Lumen Christi High School Spring Arbor Rd. at L.C.H.S., Summitt twp.
4970	McDevitt Road West of US-127, Summitt twp.
4975	Parma Baptist Church Michigan Ave. east of Parma at church, Sandstone twp.
4980	Route M-50 North of McDevitt Rd., Summitt twp.
4985	Ferguson Road At the intersection of Ferguson, Horton, and Jackson Rds. Summitt twp.
4990	Elm Road North of I-94, Blackman twp.
4995	Jackson State Prison North of city of Jackson

Table A-2

Checklane Inspection Schedule 1975

Monroe County

DATE	LOC.	INSP.	TOTAL	WP	TOTAL
7-1-75	4810	177	177	0	0
7-2-75	4820	208	385	50	50
7-03-75	4830	185	570	0	50
7-07-75	4820	197	767	51	101
7-08-75	4830	177	944	41	142
7-09-75		000	944	00	142
7-10-75	4810	186	1130	49	191
7-11-75	4840	187	1317	19	210
7-14-75	4810	194	1511	41	251
7-15-75	4820	107	1618	23	274
7-16-75	4840	175	1793	29	303
7-17-75	4810	120	1913	30	333
7-18-75	4820	106	2019	0	333

Table A-2 Continued

Jackson County - 1975

DATE	LOC.	INSP.	TOTAL	WP	TOTAL
7-21-75	4910	197	197	22	22
7-22-75	4920	191	388	39	61
7-23-75	4930	215	603	43	104
7-24-75	4940	203	806	48	152
7-25-75	4950	120	926	38	190
7-28-75	4955	184	1110	48	238
7-29-75	4960	221	1331	54	292
7-30-75		000	1331	00	292
7-31-75	4910	203	1534	42	334
8-01-75	4920	150	1684	40	374
8-04-75	4930	210	1894	43	417
8-05-75	4940	83	1977	19	436
8-06-75	4965	202	2179	43	479
8-07-75	4955	185	2364	40	519
8-08-75	4960	92	2456	30	549
8-11-75	4965	221	2677	56	605
8-12-75	4975	222	2829	50	655
8-13-75	4920	100	2929	28	683
8-14-75	4930	160	3089	53	736
8-15-75		0	3089	0	736
8-18-75	4950	160	3249	40	776
8-19-75	4955	136	3385	40	816
8-20-75	4960	190	3575	45	861
8-21-75	4965	220	3795	52	913
8-22-75	4920	53	3848	16	929
8-25-75	4930	222	4070	51	980
8-26-75		0	4070	0	980
8-27-75	4955	213	4283	50	1030
8-28-75	4965	208	4491	49	1079
8-29-75	4970	116	4607	27	1106
9-01-75		0	4607	0	1106
9-02-75	4980	106	4713	18	1124
9-03-75	4985	200	4913	40	1164
9-04-75	4990	232	5145	42	1206
9-05-75	4920	28	5173	9	1215
9-08-75	4970	227	5400	45	1260
9-09-75	4975	211	5611	57	1317
9-10-75	4980	236	5847	44	1361
9-11-75	4985	213	6060	34	1395
9-12-75		0	6060	0	1395

Table A-2 Continued

Jackson County - 1975

DATE	LOC.	INSP.	TOTAL	WP	TOTAL
9-15-75	4930	226	6268	38	1433
9-16-75	4970	228	6514	41	1474
9-17-75	4975	190	6704	39	1513
9-18-75	4990	56	6760	13	1524
9-19-75	4985	49	6809	13	1537
9-22-75	4990	148	6957	33	1570
9-23-75	4940	176	7133	41	1611
9-24-75	4955	157	7290	40	1651
9-25-75	4965	108	7398	31	1682
9-26-75	4920	66	7464	18	1700
9-29-75	4950	238	7702	35	1735
9-30-75	4940	252	7954	45	1780
10-01-75	4985	188	8142	30	1810
10-02-75	4955	199	8341	32	1842
10-03-75	4965	141	8482	38	1880
10-06-75	4922	224	8706	37	1917
10-07-75	4945	228	8934	40	1957
10-08-75	4915	297	9231	47	2004
10-09-75	4921	201	9432	31	2035
10-10-75	4995	156	9588	29	2064
10-13-75	4940	241	9829	34	2098
10-14-75	4935	209	10038	35	2133
10-15-75	4955	150	10188	40	2173
10-16-75	4965	150	10338	30	2203
10-17-75	4985	0	10338	0	2203

Table A-3

Checklane Variable List

Variable Number	Variable Name	Original Location	New Location	Recode Notes
1	Sticker Number	16-21	1-6	
2	Location Code	1-5	7-11	
3	Month of Checklane	7-8	12-13	
4	Day of Checklane	9-10	14-15	
5	Year of Checklane	11-12	16-17	
6	Julian Date	----	18-22	
7	Vehicle Year	13-14	23-24	
8	Vehicle Type	15	25	note 1
9	Vehicle Make	22-23	26-27	note 2
10	Vehicle Mileage	24-26	28-30	
11	Number of Trips	30	31	
12	Safety Glass	31-32	32	note 3
13	Vision Impaired	33-34	33	note 3
14	Total Glass	35-36	34	note 3
15	Wipers	37-38	35	note 3
16	Washers	39-40	36	note 3
17	Total Wipers and Washers	41-42	37	note 3
18	Mirror	107-108	38	note 3
19	Vision Defects	-----	39	note 4
20	Front Directional Lights	43-44	40	note 3
21	High Beams	45-46	41	note 3
22	Low Beams	47-48	42	note 3
23	Headlight Aim	49-50	43	note 3
24	Headlight Output	51-52	44	note 3
25	Headlights Operation	-----	45	note 5
26	Tail-lights	53-54	46	note 3
27	Stop lights	55-56	47	note 3
28	Rear directional	57-58	48	note 3
29	Plate light	59-60	49	note 3
30	Beam indicator light	61-62	50	note 3

Table A-3 Continued

31	Total lights	63-64	51	note 3
32	Major light defects	-----	52	note 6
33	Total Light Defects	-----	53	note 7
34	Horn	65-66	54	note 3
35	Steering	67-68	55	note 3
36	Foot Brake	69-70	56	note 3
37	Parking Brake	71-72	57	note 3
38	Total Brake	73-74	58	note 3
39	Tire Bulges or Break	75-76	59	note 3
40	Tire Tread	77-78	60	note 3
41	Total Tires	79-80	61	note 3
42	Control Defects	-----	62	note 8
43	Exhaust Noise	81-82	63	note 3
44	Exhaust Smoke	83-84	64	note 3
45	Total Exhaust	85-86	65	note 3
46	Operators License	87-94	66	note 9
47	Vehicle Registration	95-100	67	note 10
48	Vehicle Insurance	101-106	68	note 11
49	Operator Defective	-----	69	note 12
50	Major Mechanical Defect	-----	70-71	note 13
51	Total Mechanical Defect	-----	72-73	note 14
52	Total Vehicle	109-110	74	note 3
53	Summons Issued	111-112	75-76	note 15
54	Seat Belts	113-114	77	note 3
55	Brake Light	115	78	note 16
56	Wheel Pull	116	79	note 17
57	Pedal Pressure Test	117	80	note 18
58	Stopping Test	118	81	note 19
59	Stopping Audible	119	82	note 20
60	Total Stopping Defects	-----	83	note 21
61	Total Inspection Defects	-----	84-85	note 22

Table A-3 Continued

62	Brake Key	----	86	note 23
63	Interview Key	----	87	note 23
64	Sticker Number	1-7	88-94	
65	Inspector Initials	8-9	95-96	note 24
66	Brake Type	10-11	97-98	note 25
67	Master Cylinder Fluid	12	99	note 26
68	Brake Fluid Quality	13	100	note 27
69	Vacuum Hose	14	101	note 27
70	Wheel Bearing Grease	15	102	note 28
71	Wheel Pull	16	103	note 29
72	Shoe-Pad Condition	17	104	note 30
73	Rotor or Drum	18	105	note 31
74	Brake Hardware	19	106	note 32
75	Wheel Cylinders	20	107	note 27
76	L-F Tire Pressure	21-22	108-109	
77	L-R Tire Pressure	23-24	110-111	
78	R-F Tire Pressure	25-26	112-113	
79	R-R Tire Pressure	27-28	114-115	
80	Tire Size	29-38	116-125	
81	Front Loaded Rec. Press.	39-40	126-127	
82	Rear Loaded Rec. Press.	41-42	128-129	
83	Front Unloaded Rec. Press.	43-44	130-131	
84	Rear Unloaded Rec. Press.	45-46	132-133	
85	Comments	47	134	note 33
86	Sticker Number	1-7	135-141	
87	Age of Driver	8-9	142-143	
88	Sex of Driver	10	144	note 34
89	Question 1	11	145	note 35
90	Question 2	12	146	note 35
91	Question 3	13	147	note 35
92	Question 4	14	148	note 35

Table A-3 Continued

93	Question 5	15	149	note 35
94	Question 6	16	150	note 35
95	Question 7	17	151	note 35
96	Question 8	18	152	note 35
97	Question 9	19	153	note 35
98	Question 10	20	154	note 35
99	Question 11	21	155	note 35
100	Question 12	22	156	note 35
101	Completion Problems	23	157	note 36
102	Interviewer Initials	24-25	158-159	note 24
103	Match Key		160	note 37
104	Sticker Number		161-166	
105	Location Code		167-171	
106	Month of Checklane		172-173	
107	Day of Checklane		174-175	
108	Year of Checklane		176-177	
109	Julian Date		178-182	
110	Vehicle Year		183-184	
111	Vehicle Type		185	note 1
112	Vehicle Make		186-187	note 2
113	Vehicle Mileage		188-190	
114	Number of Trips		191	
115	Safety Glass		192	note 3
116	Vision Impaired		193	note 3
117	Total Glass		194	note 3
118	Wipers		195	note 3
119	Washers		196	note 3
120	Total Wipers and Washers		197	note 3
121	Mirror		198	note 3
122	Vision Defects		199	note 4
123	Front Directional Lights		200	note 3
124	High Beams		201	note 3
125	Low Beams		202	note 3

Table A-3 Continued

126	Headlight Aim	203	note 3
127	Headlight Output	204	note 3
128	Headlight Operation	205	note 5
129	Tail Lights	206	note 3
130	Stop Lights	207	note 3
131	Rear Directional	208	note 3
132	Plate Light	209	note 3
133	Beam Indicator Light	210	note 3
134	Total Lights	211	note 3
135	Major Light Defects	212	note 6
136	Total Light Defects	213	note 7
137	Horn	214	note 3
138	Steering	215	note 3
139	Foot Brake	216	note 3
140	Parking Brake	217	note 3
141	Total Brake	218	note 3
142	Tire Bulges or Break	219	note 3
143	Tire Tread	220	note 3
144	Total Tires	221	note 3
145	Control Defects	222	note 8
146	Exhaust Noise	223	note 3
147	Exhaust Smoke	224	note 3
148	Total Exhaust	225	note 3
149	Operators License	226	note 9
150	Vehicle Registration	227	note 10
151	Vehicle Insurance	228	note 11
152	Operator Defective	229	note 12
153	Major Mechanical Defects	230-231	note 13
154	Total Mechanical Defects	232-233	note 14
155	Total Vehicle	234	note 3
156	Summons Issued	235-236	note 15
157	Seat Belts	237	note 3
158	Brake Light	238	note 16

Table A-3 Continued

159	Recheck	239	note 38
160	Pedal Pressure Test	240	note 18
161	Stopping Test	241	note 19
162	Stopping Audible	242	note 20
163	Total Stopping Defects	243	note 21
164	Total Inspection Defects	244-245	note 22

Table A-3 Continued

Checklane Recode Notes

1. V8 - Vehicle type

Orig. Value	Type	New Value
0	Full Size	9
1	Intermediate	1
2	Compact	2
3	Sports Car	3
4	Station Bus, Carryall	4
5	Jeep	5
6	Pickup or panel	6
7	Unit or straight tractor	7
8	Truck tractor (semi)	8
other	Unknown/missing	0

2. V9 = Vehicle Make

Orig. Value	New Value
01--14	01--14
18--31	18--31
39--47	39--47
00	50
other	00

3.

Orig. Value	Code	New Value
01	Fail	2
10	Pass	1
Other	Missing	0

4. V19= # visor defects plus 1

```
set to zero
scan (V12, V13, V15, V16, V18)
Count number of "2" and add 1
```

5. V25 = headlight operation

```
set to zero
scan (V21, V22, V24)
if all = "1"  V25 = 1
if any = "2"  V25 = 2
```

Table A-3 Continued

6. V32 = # major light defects plus 1

```
set to zero
scan (V20, V21, V22, V24, V26, V27, V28)
count number of "2" and add 1
```

7. V33 = # light defects plus 1

```
set to zero
scan (V23, 29, 30)
count number of "2"
Add V32
```

8. V42 = # control defects plus 1

```
set to zero
scan (V35, V36, V39, V40)
count number of "2" and add 1
```

9. V46 = operators license

```
set V46 and K1 to zero
if positions 93-94 equal "10" then V46=1 (pass)
If positions 87-88 equal "01" then V46=2 (no license
   and K1=K1 + 1
if positions 89-90 equal "01" then V46 = 3
   (suspended or revoked) and K1=V1+1
if positions 91-92 equal "01" then V46=4 (other)
   and K1=K1+1
if K1 is greater than 1 V46 = 5
```

10. V47 = vehicle registration

```
set to zero
if positions 99-100 equal "10" V47 = 1 (pass)
if positions 95-96 equal "01" V47 = 2 (improper)
if positions 97-98 equal "01" V47 = 3 (none on person)
```

11. V48 = vehicle insurance

```
set to zero
if positions 105-106 equal "10" V48 = 1 (pass)
if positions 101-102 equal "01" V48 = 2 (no compliance)
if positions 103-104 equal "01" V48 = 3 (none on person)
```

Table A-3 Continued

12. V49 = Operator defective

set to two
if V46, V47, V48 are all equal "1" then V49 = 1

13. V50 = major mechanical defects plus 1

add V19, V32, V42
subtract two
if V43 equals "2" then V50 = V50 + 1
if V44 equals "2" then V50 = V50 + 1

14. V51 = total mechanical defects plus 1

add V19, V33, V42
subtract two
if V43 = "2" then V51 = V51 + 1
if V44 = "2" then V51 = V51 + 1
if V34 = "2" then V51 = V51 + 1

15. V53 = # summons issued plus 1

add 1 to positions 111-112
if V53 is greater than 90 or less than 0, set V53 to 0

16. V55 = Brake light

set to zero

Old Value	Code	New Value
0	Pass	3
1	Fail	1
2	Not checked	2

17. V56 = Wheel pull

set to zero

Old Value	Code	New Value
0	Yes	2
1	No	1

Table A-3 Continued

18. V57 = Pedal Pressure Test

set to zero

Old Value	Code	New Value
0	Pass	7
1	Soft Pedal	1
2	Low Pedal	2
3	Pressure Loss	3
4	Complete Loss	4
5	Hard Pedal	5
6	Pulsating Pedal	6

19. V58 = Stopping Test

set to zero

Old Value	Code	New Value
0	Pass	4
1	Cannot Stop	1
2	Side to Side	2
3	Both 1 and 2	3

20. V59 = Stopping audible

Set to zero

Old Value	Code	New Value
0	Pass	2
1	Fail	1

21. V60 = total stopping defects plus 1

```
Set V60 to 1
if V57 not equal to "7" add 1 to V60
if V58 not equal to "4" add 1 to V60
if V59 not equal to "2" add 1 to V60
if V57=0 or V58=0 or V59=0 set V60 to 0
```

22. V61 = total inspection defects plus 1

```
if V60=0 set V61 = V51
if V60 not equal to zero, then V61=V60+V51-1
```

Table A-3 Continued

23. Code Values

0 = no data available
1 = data

24. Code values:

01 = R. Alexa
02 = R. Copp
03 = R. Corn
04 = R. Crombez
05 = D. Hindal
06 = M. Huber
07 = J.P. Monson
08 = M. Sackett
09 = M. Todd
00 = Other or missing

25. Code Values:

00 = missing
11 = power disc
12 = non-power disc
21 = power drum
22 = non-power drum

26. Code values:

0 = missing
1 = full
2 = half
3 = low

27. Code values:

0 = missing
1 = pass
2 = fail

28. Code values:

0 = missing
1 = pass
2 = fail
3 = unable to inspect

29. Code values:

0 = missing
1 = wheel pulled
2 = unable to pull

30. Code values:

0 = missing
1 = 75-100%
2 = 50-75%
3 = 1/32"=50%
4 = Fail

31. Code Values:

0 = missing
1 = pass
2 = cracked
3 = worn
4 = grooves

Table A-3 Continued

32. Code values:

0 = missing
1 = pass
2 = springs
3 = retainers
4 = self-adjuster

33. Code Values:

1 = no comment
2 = comment

34. Code values:

0 = missing
1 = male
2 = female

35. Refer to questionnaire for code values

0 = missing

36. Code values:

1 = none
2 = refused
3 = illiterate
4 = no reading glasses
5 = mentally-physically incapable
6 = other

37. Code Values:

0 = 1975 data only

1 = 1976 data only

2 = Both 1975 and 1976 data

38. Code Values:

20 = No

1 = Yes (stickered vehicle)

0 = Missing

APPENDIX B

DETAILED DATA TABULATIONS

Table B-1

Vehicle Year

Year	Monroe County	Monroe Sample	Expected	$(O-E)^2/E$
pre-1960	1101	5	28.3	19.2
1960	201	1	5.4	3.5
1961	232	2	5.9	2.6
1962	543	8	13.9	2.5
1963	928	14	23.9	4.1
1964	1544	20	39.8	9.8
1965	2767	37	71.2	16.4
1966	3436	50	88.5	16.7
1967	4000	78	103.0	6.1
1968	5290	101	136.2	9.1
1969	6019	154	155.0	0.0
1970	5734	159	147.7	0.9
1971	6479	168	166.8	0.0
1972	8379	232	215.8	1.2
1973	9608	292	247.4	8.0
1974	8468	315	218.0	43.2
1975	4626	150	119.1	8.0
Total	69355	1786		151.1

Chi-squared goodness of fit

χ^2=151.1 significance level = 0.0

Table B-2

Vehicle Year

Year	Jackson County	Jackson Sample	Expected	$(O-E)^2/E$
pre-1960	731	13	85.1	61.1
1960	221	8	25.7	12.2
1961	270	10	31.4	14.5
1962	605	32	70.4	20.9
1963	995	37	115.8	53.6
1964	1668	117	194.2	30.7
1965	3188	215	371.2	65.7
1966	4089	320	476.1	51.2
1967	5074	457	590.8	30.3
1968	6356	671	740.1	22.5
1969	7407	815	862.5	2.6
1970	7172	772	835.1	4.7
1971	7967	930	927.7	0.0
1972	10108	1388	1176.9	37.8
1973	12084	1598	1407.1	25.9
1974	10021	1450	1166.8	68.7
1975	6491	1060	755.8	122.4
	84447	9833		625.7

Chi-squared goodness of fit

$\chi^2=625.7$ significance level = 0.0

Table B-3

Vehicle Year

Year	Michigan	Sample	Expected	$(O-E)^2/E$
pre-1960	23861	18	63.6	32.7
1960	7165	9	19.1	5.3
1961	10043	12	26.8	8.1
1962	24787	40	66.0	10.2
1963	45801	51	122.0	41.3
1964	78133	137	208.2	24.3
1965	151632	252	404.1	57.2
1966	196794	370	524.4	45.5
1967	240481	535	640.8	17.5
1968	324817	712	865.6	27.2
1969	372177	969	991.8	0.5
1970	376082	931	1002.2	5.0
1971	430967	1098	1148.5	2.2
1972	529313	1620	1410.5	31.1
1973	614186	1890	1636.7	39.2
1974	540359	1765	1439.9	73.4
1975	393236	1210	1047.9	25.1
Total	4360052	11619		445.8

Chi-squared goodness of fit

χ^2=445.8 significance level = 0.0

Table B-4

Vehicle Type

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
Full Size	762	43.1	4309	44.6	5071	44.4
Intermediate	562	31.8	2962	30.7	3524	30.8
Compact	181	10.2	1014	10.5	1195	10.5
Sports Car	7	0.4	30	0.3	37	0.3
Station bus, carryall	9	0.5	21	0.2	30	0.3
Jeep	7	0.4	47	0.5	54	0.5
Pickup or Panel	239	13.5	1278	13.2	1517	13.3
Total	1767		9661		11428	
Missing	19		204		223	

Chi-square test of homogeneity

$\chi^2 = 7.034$ significance level = 0.3177

Table B-5

Vehicle Mileage
(thousands of miles)

Mileage	Monroe Count	Monroe %	Jackson Count	Jackson %	Total Count	Total %
0-10	169	9.5	903	9.2	1072	9.2
10-20	225	12.6	998	10.1	1223	10.5
20-30	224	12.5	1152	11.7	1376	11.8
30-40	208	11.6	1188	12.0	1396	12.0
40-50	223	12.5	1188	12.0	1411	12.1
50-60	179	10.0	1047	10.6	1226	10.5
60-70	168	9.4	951	9.6	1119	9.6
70-80	139	7.8	796	8.1	935	8.0
80-90	111	6.2	632	6.4	743	6.4
90-100	56	3.1	426	4.3	482	4.1
100-110	38	2.1	262	2.7	300	2.6
110-120	19	1.1	163	1.7	182	1.6
120-130	9	0.5	83	0.8	92	0.8
130-140	7	0.4	34	0.3	41	0.4
140-150	6	0.3	19	0.2	25	0.2
150-160	3	0.2	8	0.1	11	0.1
>160	2	0.1	15	0.2	17	0.1
Total	1786		9865		11651	

Mean	45.82
Std. Deviation	29.83

Chi-square test of homogeneity*

χ^2=21.456 significance level = 0.044

---

*Due to small numbers vehicles with over 120,000 miles were collapsed into one category.

Table B-6

Vehicle Year

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
Pre 1960	5	0.3	13	0.2	18	0.2
1960	1	0.1	8	0.1	9	0.1
1961	2	0.1	10	0.1	12	0.1
1962	8	0.4	32	0.3	40	0.3
1963	14	0.8	37	0.4	51	0.4
1964	20	1.1	117	1.2	137	1.2
1965	37	2.1	215	2.2	252	2.2
1966	50	2.8	320	3.2	370	3.2
1967	78	4.4	457	4.6	535	4.6
1968	101	5.7	611	6.2	712	6.1
1969	154	8.6	815	8.3	969	8.3
1970	159	8.9	772	7.8	931	8.0
1971	168	9.4	930	9.4	1098	9.4
1972	232	13.0	1388	14.1	1620	13.9
1973	292	16.3	1598	16.2	1890	16.2
1974	315	17.6	1450	14.7	1765	15.1
1975	150	8.4	1060	10.7	1210	10.4
1976	0	0.0	27	0.3	27	0.2
TOTAL	1786		9865		11651	

Chi-square test for homogeneity*

χ^2=31.036   significance level = 0.0133

* category 1976 deleted due to inspections in Monroe county before model year 1976.

Table B-7

Vehicle Make[*]

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
Passenger Cars						
Buick	81	4.7	791	8.3	872	7.8
Cadillac	27	1.6	108	1.1	135	1.2
Chevrolet	379	22.0	2242	23.6	2621	23.4
Chrysler	29	1.7	141	1.5	170	1.5
Dodge	85	4.9	420	4.4	505	4.5
Ford	338	19.6	1448	15.3	1786	15.9
Imperial	3	0.2	2	0.0	5	0.0
Jeep	9	0.5	11	0.1	20	0.2
Lincoln	13	0.8	27	0.3	40	0.4
Mercury	116	6.7	334	3.5	450	4.0
Oldsmobile	123	7.1	891	9.4	1014	9.0
Plymouth	111	6.4	488	5.1	599	5.3
Pontiac	91	5.3	877	9.2	968	8.6
Volkswagen	40	2.3	138	1.5	178	1.6
Other	30	1.7	263	2.7	293	2.6
Trucks						
Chevrolet	95	5.5	540	5.7	635	5.7
Dodge	24	1.4	131	1.4	155	1.4
Ford	114	6.6	487	5.1	601	5.4
GMC	10	0.6	95	1.0	105	0.9
International	2	0.1	17	0.2	19	0.2
Willys	6	0.3	33	0.3	39	0.3
Total	1726		9484		11210	

Chi-square test for homogeneity[**]

$\chi^2=149.79$ significance level = 0.00

[*] Due to some unexplained error, no American Motors vehicles were recognized in this table.

[**] Due to small expected values, Imperial and Jeep were included with other passenger cars and Willys and International were combined for trucks.

Table B-8

Total Vehicle

	Monroe		Jackson		Total	
	%	Count	%	Count	%	Count
Pass	48.1	859	50.5	4981	50.1	5840
Fail	51.9	927	49.5	4884	49.9	5811
Total		1786		9865		11651

Chi-square test of homogeneity

Table B-9

Tabulations of Variables Recorded by Service Troopers

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
NUMBER OF TRIPS						
Number						
1	1604	89.8	9416	95.4	11020	94.6
2	178	10.0	432	4.4	610	5.2
3	3	0.2	15	0.2	18	0.2
4	1	0.1	0	0.0	1	0.0
5	0	0.0	2	0.0	2	0.0
Total	1786		9865		11651	
SAFETY GLASS						
Category						
Pass	1786	100.0	9865	100.0	11651	100.0
Fail	0	0.0	0	0.0	0	0.0
Total	1786	100.0	9865	100.0	11651	100.0
VISION IMPAIRED						
Pass	1750	98.0	9485	96.1	11235	96.5
Fail	36	2.0	380	3.9	416	3.6
Total	1786		9865		11651	
GLASS DEFECTS						
Pass	1750	98.0	9485	96.1	11235	96.4
Fail	36	2.0	380	3.9	416	3.6
Total	1786		9865		11651	
WIPERS						
Pass	1725	96.6	9509	96.4	11234	96.4
Fail	61	3.4	356	3.6	417	3.6
Total	1786		9865		11651	
WASHERS						
Pass	1437	80.5	8355	84.7	9792	84.0
Fail	349	19.5	1510	15.3	1856	16.0
Total	1786		9865		11651	
WIPERS OR WASHERS						
Pass	1403	78.6	8138	82.5	9541	81.9
Fail	383	21.4	1727	17.5	2110	18.1
Total	1786		9865		11651	

Table B-9 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
MIRROR						
Pass	1745	97.7	9625	97.6	11370	97.6
Fail	41	2.3	240	2.4	281	2.4
Total	1786		9865		11651	
TOTAL VISION DEFECTS						
Number						
0	1361	76.2	7782	78.9	9143	78.5
1	367	20.5	1726	17.5	2093	18.0
2	54	3.0	314	3.2	368	3.2
3	4	0.2	40	0.4	44	0.3
4	0	0.0	3	0.0	3	0.0
Total	1786		9865		11651	
FRONT DIRECTIONAL LIGHTS						
Pass	1689	94.6	9382	95.1	11071	95.0
Fail	97	5.4	483	4.9	580	5.0
Total	1786		9865		11651	
HIGH BEAM						
Pass	1672	93.6	9128	92.5	10800	92.7
Fail	114	6.4	737	7.5	851	7.3
Total	1786		9865		11651	
LOW BEAM						
Pass	1750	98.0	9619	97.5	11369	97.6
Fail	36	2.0	246	2.5	282	2.4
Total	1786		9865		11651	
HEADLIGHT AIM						
Pass	1747	97.8	9593	97.2	11340	97.3
Fail	39	2.2	272	2.8	311	2.7
Total	1786		9865		11651	
HEADLIGHT OUTPUT						
Pass	1771	99.2	9733	98.7	11504	98.7
Fail	15	0.8	132	1.3	147	1.3
Total	1786		9865		11651	

Table B-9 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
TOTAL HEADLIGHT						
Pass	1656	92.7	8961	90.8	10617	93.8
Fail	130	7.3	904	9.2	1034	8.9
Total	1786		9865		11651	
TAIL LIGHTS						
Pass	1687	94.5	9237	93.6	10924	93.8
Fail	99	5.5	628	6.4	727	6.2
Total	1786		9865		11651	
STOP LIGHTS						
Pass	1672	93.6	9135	92.6	10807	92.8
Fail	114	6.4	730	7.4	844	7.2
Total	1786		9865		11651	
REAR DIRECTIONAL						
Pass	1658	92.8	9186	93.1	10844	93.1
Fail	128	7.2	679	6.9	807	6.9
Total	1786		9865		11651	
PLATE LIGHT						
Pass	1479	82.8	8211	83.2	9690	83.2
Fail	307	17.2	1654	16.8	1961	16.8
Total	1786		9865		11651	
BEAM INDICATOR						
Pass	1786	100.0	9861	100.0	11651	100.0
Fail	0	0.0	4	0.0	0	0.0
Total	1876		9865		11651	
TOTAL LIGHTS						
Pass	1230	68.9	6655	67.5	7885	67.7
Fail	556	31.1	3210	32.5	3766	32.3
Total	1786		9865		11651	
MAJOR LIGHT DEFECTS						
0	1461	81.8	7839	79.5	9300	79.8
1	162	9.1	1095	11.1	1257	10.8
2	84	4.7	444	4.5	528	4.5
3	52	2.9	344	3.5	396	3.4
4	20	1.1	107	1.1	127	1.1
>4	7	0.4	36	0.3	43	0.4
Total	1786		9865		11651	

Table B-9 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
TOTAL LIGHT DEFECTS						
Number						
0	1230	68.9	6655	67.5	7885	67.7
1	336	18.8	1929	19.6	2265	19.4
2	116	6.5	625	6.3	741	6.4
3	57	3.2	386	3.9	443	3.8
4	35	2.0	165	1.7	200	1.7
5	7	0.4	71	0.7	78	0.7
>5	4	0.2	32	0.3	36	0.3
Total	1785		9863		11648	
Missing	1		2		3	
HORN						
Pass	1725	96.6	9573	97.0	11298	97.0
Fail	61	3.4	292	3.0	353	3.0
Total	1786		9865		11651	
STEERING						
Pass	1785	99.9	9828	99.6	11613	99.7
Fail	1	0.1	37	0.4	38	0.3
Total	1786		9865		11651	
FOOT BRAKE						
Pass	1769	99.0	9768	99.0	11537	99.0
Fail	17	1.0	97	1.0	114	1.0
Total	1786		9865		11651	
PARKING BRAKE						
Pass	1568	87.8	8910	90.3	10473	89.9
Fail	218	12.2	955	9.7	1173	10.1
Total	1786		9865		11651	
FOOT AND PARKING BRAKE						
Pass	1560	87.3	8857	89.8	10417	89.4
Fail	226	12.7	1008	10.2	1234	10.6
Total	1786		9865		11651	
TIRE BULGES OR BREAK						
Pass	1784	99.9	9837	99.7	11621	99.7
Fail	2	0.1	28	0.3	30	0.3
Total	1786		9865		11651	

Table B-9 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
TIRE TREAD						
Pass	1567	87.7	8691	88.1	10258	88.0
Fail	219	12.3	1174	11.9	1393	12.0
Total	1786		9865		11651	
TIRES, OVERALL						
Pass	1566	87.7	8684	88.0	10250	88.0
Fail	220	12.3	1181	12.0	1401	12.0
Total	1786		9865		11651	
CONTROL DEFECTS						
number						
0	1553	87.0	8612	87.3	10165	87.2
1	227	12.7	1174	11.9	1401	12.0
2	6	0.3	75	0.8	81	0.7
3	0	0.0	4	0.0	4	0.1
Total	1786		9865		11651	
EXHAUST NOISE						
Pass	1621	90.8	9010	91.3	10631	91.2
Fail	165	9.2	855	8.7	1020	8.8
Total	1786		9865		11651	
EXHAUST SMOKE						
Pass	1759	98.5	9751	98.8	11510	98.8
Fail	27	1.5	114	1.2	141	1.2
Total	1786		9865		11651	
TOTAL EXHAUST						
Pass	1605	89.9	8947	90.7	10552	90.6
Fail	181	10.1	918	9.3	1099	9.4
Total	1786		9865		11651	
OPERATOR's LICENSE						
Pass	1765	98.8	9709	98.4	11474	98.5
No license	14	0.8	107	1.1	121	1.0
Suspended or Revoked	0	0.0	6	0.1	6	0.1
Other	7	0.4	40	0.4	47	0.4
More than 1 no pass	0	0.0	3	0.0	3	0.0
Total	1786		9865		11651	

Table B-9 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
VEHICLE REGISTRATION						
Pass	1783	99.8	9857	99.9	11640	99.8
Improper	0	0.0	5	0.1	5	0.1
None on person	3	0.2	3	0.0	6	0.1
Total	1786		9865		11651	
VEHICLE INSURANCE						
Pass	1785	99.9	9861	100.0	11646	100.0
No Compliance	0	0.0	3	0.0	3	0.0
None on Person	1	0.1	1	0.0	2	0.0
Total	1786		9865		11651	
TOTAL OPERATOR						
Pass	1762	98.7	9700	98.3	11462	98.4
Fail	24	1.3	165	1.7	189	1.6
Total	1786		9865		11651	
MAJOR MECHANICAL						
number						
0	1035	58.0	5836	59.2	6811	58.5
1	361	20.2	1961	19.9	2322	19.9
2	196	11.0	973	9.9	1169	10.0
3	91	5.3	477	4.8	538	4.9
4	51	2.9	303	3.1	354	3.0
5	24	1.3	150	1.5	174	1.5
6	18	1.0	80	0.8	90	0.8
7	3	0.2	51	0.5	54	0.5
8	3	0.2	19	0.2	22	0.2
9	1	0.1	13	0.1	14	0.1
10	0	0.0	2	0.0	2	0.0
Total	1786		9865		11651	
TOTAL MECHANICAL						
number						
0	904	50.6	5206	52.8	6110	52.4
1	389	21.8	2000	20.3	2389	20.5
2	226	12.7	1211	12.3	1437	12.3
3	127	7.1	619	6.3	746	6.4
4	67	3.8	356	3.6	423	3.6
5	32	1.8	207	2.1	239	2.1
6	23	1.3	113	1.1	136	1.2
7	11	0.6	71	0.7	82	0.7
8	3	0.2	34	0.3	37	0.3
9	2	0.1	29	0.3	31	0.3
10	1	0.1	10	0.1	11	0.1
11	1	0.1	6	0.1	7	0.1
12	0	0.0	3	0.0	3	0.0
Total	1786		9865		11651	

Table B-9 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
TOTAL VEHICLE						
Pass	859	48.1	4981	50.5	5840	50.1
Fail	927	51.9	4884	49.5	5811	49.9
Total	1786		9865		11651	
SUMMONS ISSUED						
number						
0	1731	96.9	9397	95.3	11128	95.5
1	21	1.2	134	1.4	155	1.3
2	1	0.1	3	0.0	4	0.0
Miscode	33	1.8	31	3.4	364	3.2
Total	1786		9865		11651	
SEAT BELTS						
Yes	199	11.2	1129	11.4	1328	11.4
No	1585	88.8	8732	88.6	10317	88.6
Total	1784		9861		11645	

Notes on TAble B-9

EXPLANATION OF CHECKLANE VARIABLES

Number of Trips - This is the number of times drivers said they had been inspected by a checklane, including the current inspection.

Safety Glass - This was a check to see whether windows and windshields were made of safety glass.

Vision Impaired - A vehicle failed if the glass was cracked or if the windshield had too many stickers on it, thus impairing vision.

Total Vision Defects - The number of vision items failed (safety glass, vision impaired, wipers, washers, and mirror).

Headlight Output - A vehicle failed if the headlights were not sufficiently bright.

Major Light Defects - The number of major light items that failed (front directional, high beams, low beams, tail lights, stop lights, and rear directional).

Total Light Defects - The number of major light defects plus the number of other light items that failed (headlight aim, and plate light).

Foot Brake - A vehicle failed this item if it was clear that the driver pressed the brake pedal to the floor.

Parking Brake - The driver was asked to set the parking brake and then slowly accelerate. If the parking brake did not seem to hold, the vehicle failed this item.

Control Defects - The number of control-related items that failed (steering, foot brake, tire bulges or brake, and tire tread).

Major Mechanical - The number of vision defects, major light defects and control defects, plus the number of exhaust defects (exhaust noise and exhaust smoke).

Notes on Table B-9 Continued

Total Mechanical - The number of vision defects, total light defects, and control defects, plus the number of exhaust defects and horn.

Summons Issued - The number of summonses issued by the enforcement officer.

Seat Belts - The service officers observed whether the passengers in the vehicle wore seat belts.

Table B-10

Tire Pressures

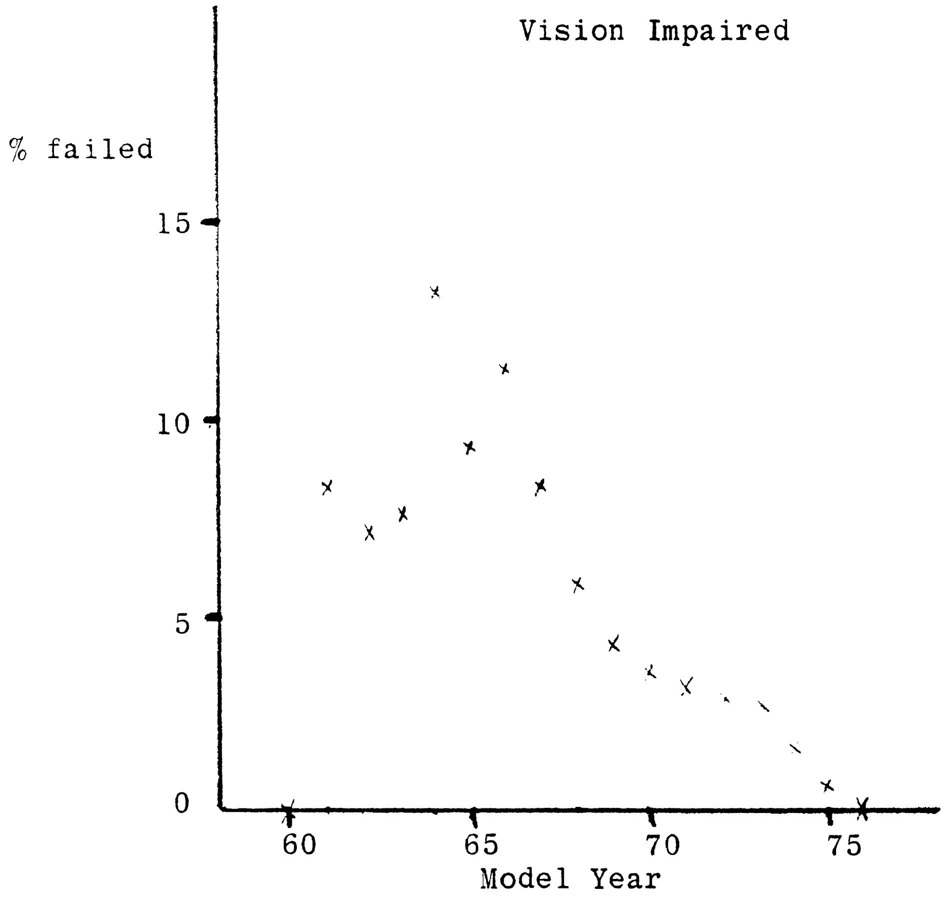
	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
LEFT-FRONT TIRE PRESSURE (PSI)						
<10	0	0.0	0	0.0	0	0.0
10-15	2	0.7	6	0.3	8	0.3
15-20	2	0.7	95	4.7	97	4.2
20-25	23	7.7	360	18.0	383	16.6
25-30	82	27.4	858	42.8	940	40.8
30-35	143	47.8	537	26.8	680	29.5
35-40	33	11.0	92	4.6	125	5.4
40-45	9	3.0	38	1.9	47	2.0
45-50	3	1.0	10	0.5	13	0.6
50-55	1	0.3	8	0.4	9	0.4
>55	1	0.3	1	0.0	2	0.1
Total	299		2005		2304	
Missing	0		13		13	
LEFT-REAR TIRE PRESSURE (PSI)						
<10	0	0.0	0	0.0	0	0.0
10-15	2	0.7	28	1.4	30	1.3
15-20	4	1.3	108	5.4	112	4.9
20-25	36	12.0	376	18.8	412	17.9
25-30	85	28.4	851	42.5	936	40.6
30-35	132	44.1	503	25.1	635	27.6
35-40	27	9.0	87	4.3	114	5.0
40-45	7	2.3	25	1.2	32	1.4
45-50	2	0.7	17	0.8	19	0.8
50-55	2	0.7	8	0.4	10	0.4
>55	2	0.7	1	0.0	3	0.1
Total	299		2004		2303	
Missing	0		14		14	
RIGHT-FRONT TIRE PRESSURE (PSI)						
<10	0	0.0	0	0.0	0	0.0
10-15	0	0.0	15	0.7	15	0.7
15-20	11	3.7	96	4.8	107	4.7
20-25	31	10.5	351	17.5	382	16.6
25-30	97	32.8	876	43.8	973	42.4
30-35	121	40.9	524	26.2	645	28.1
35-40	21	7.1	90	4.5	111	4.8
40-45	8	2.7	33	1.6	41	1.8
45-50	5	1.7	10	0.5	15	0.7
50-55	0	0.0	6	0.3	6	0.3
>55	2	0.7	0	0.0	2	0.1
Total	296		2001		2297	
Missing	3		17		20	

Table B-10 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
RIGHT-REAR TIRE PRESSURE (PSI)						
<10	0	0.0	3	0.1	3	0.1
10-15	1	0.3	29	1.4	30	1.3
15-20	4	1.3	131	6.5	135	5.9
20-25	36	12.0	384	19.2	420	18.3
25-30	96	32.1	841	42.0	937	40.7
30-35	122	40.8	466	23.3	588	25.6
35-40	29	9.7	101	35.0	130	5.6
40-45	5	1.7	31	1.5	36	1.6
45-50	2	0.7	13	0.6	15	0.7
50-55	3	1.0	2	0.1	5	0.2
>55	1	0.3	1	0.0	2	0.2
Total	299		2002		2301	
Missing	0		16		16	
FRONT LOADED RECOMMENDED TIRE PRESSURE (PSI)						
15-20	0	0.0	2	1.0	2	1.0
20-25	0	0.0	78	40.6	78	40.6
25-30	0	0.0	87	45.3	87	45.3
30-35	0	0.0	24	12.5	24	12.5
35-40	0	0.0	1	0.5	1	0.5
Total	0		192		192	
Missing	0		1826		1826	
REAR LOADED RECOMMENDED TIRE PRESSURE (PSI)						
20-25	0	0.0	19	9.9	19	9.9
25-30	0	0.0	101	52.6	101	52.6
30-35	0	0.0	67	34.9	67	34.9
35-40	0	0.0	5	2.6	5	2.6
Total	0		192		192	
Missing	0		1826		1826	
FRONT UNLOADED RECOMMENDED TIRE PRESSURE (PSI)						
15-20	0	0.0	3	0.9	3	0.9
20-25	0	0.0	183	57.7	183	57.7
25-30	0	0.0	123	38.8	123	38.8
30-35	0	0.0	8	2.5	8	2.5
Total	0		317		317	
Missing	0		1701		1701	

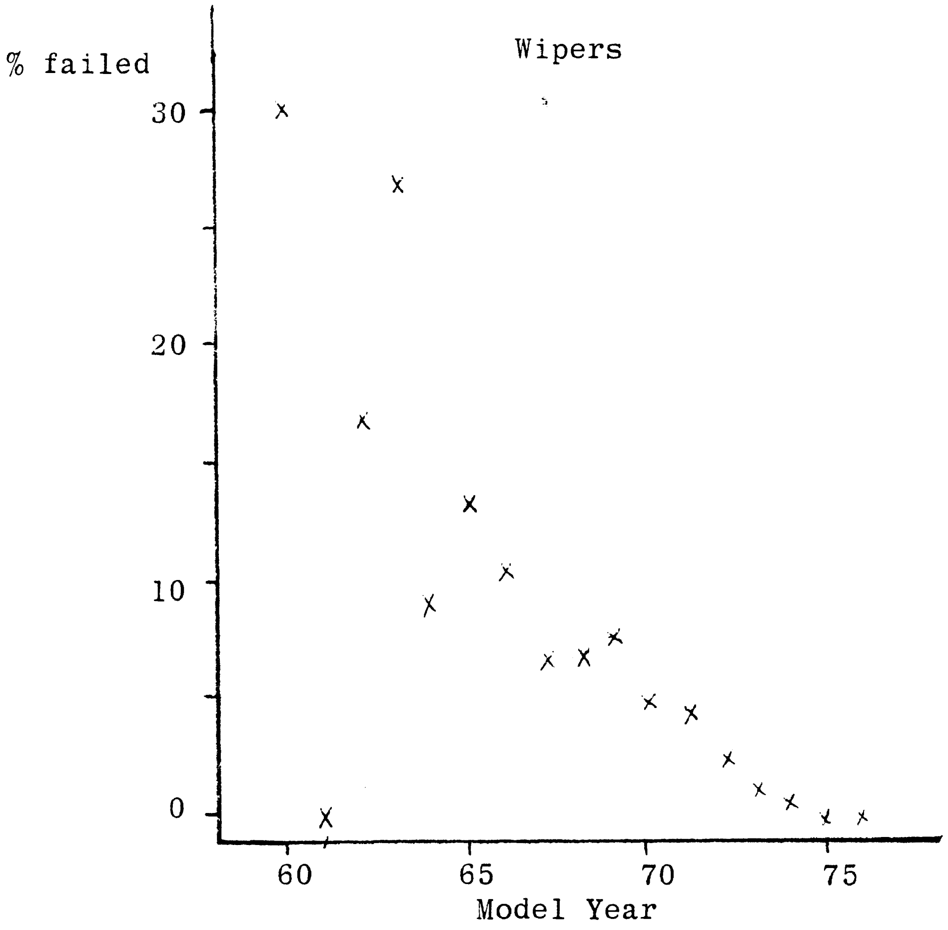
Table B-10 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
REAR UNLOADED RECOMMENDED TIRE PRESSURE (PSI)						
20-25	0	0.0	116	36.6	116	36.6
25-30	0	0.0	155	48.9	155	48.9
30-35	0	0.0	40	14.5	40	14.5
Total	0		311		311	
Missing	0		1701		1701	



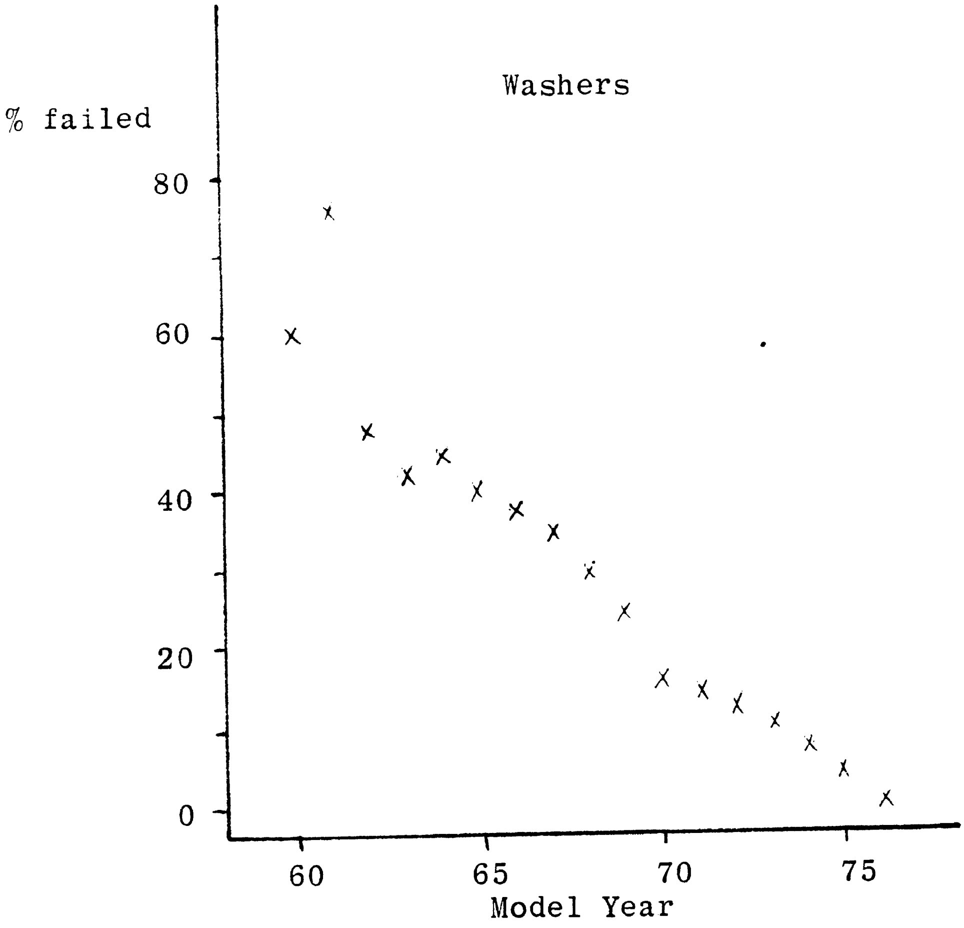
Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	1	8.3
1962	42	3	7.1
1963	53	4	7.5
1964	144	19	13.2
1965	270	25	9.3
1966	385	44	11.4
1967	552	45	8.2
1968	748	44	5.9
1969	1023	43	4.2
1970	981	33	3.4
1971	1169	36	3.1
1972	1712	49	2.9
1973	1998	54	2.7
1974	1890	31	1.6
1975	1299	8	0.6
1976	27	0	0.0
Total	12315	439	3.6

Figure B-1



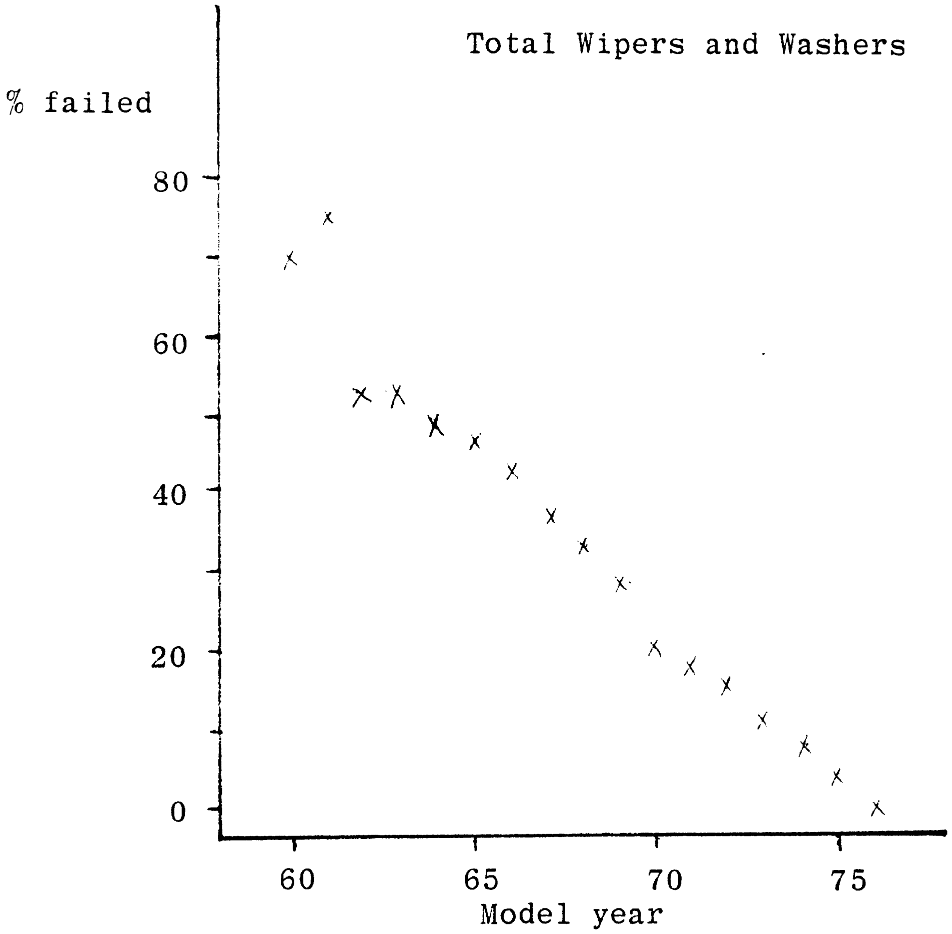
Year	Total	Failed	% Failing
1960	10	3	3.0
1961	12	0	0.0
1962	42	7	16.7
1963	53	14	26.4
1964	144	13	9.0
1965	270	35	13.0
1966	385	40	10.4
1967	552	35	6.3
1968	748	48	6.4
1969	1023	75	7.3
1970	981	47	4.8
1971	1169	52	4.4
1972	1712	39	2.3
1973	1998	19	1.0
1974	1890	10	0.5
1975	1299	0	0.0
1976	27	0	0.0
Total	12315	437	3.5

Figure B-2



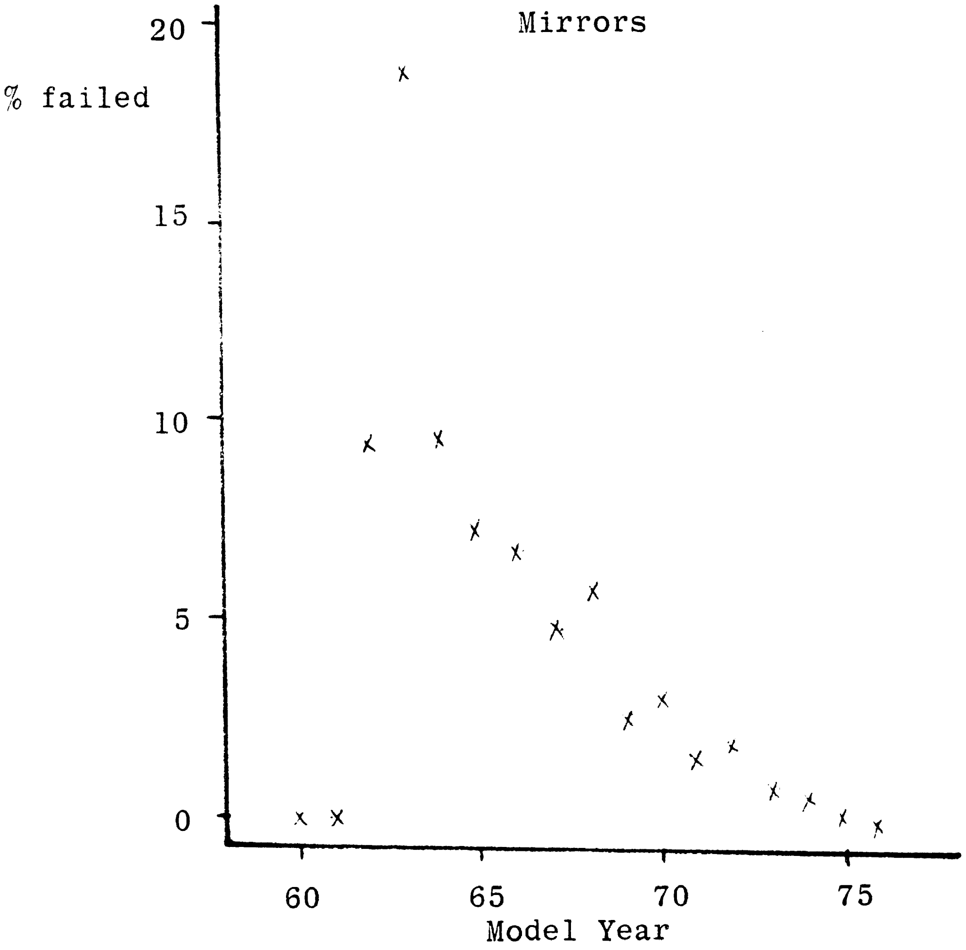
Year	Total	Failed	% Failing
1960	10	6	60.0
1961	12	9	75.0
1962	42	20	47.6
1963	53	22	41.5
1964	144	64	44.4
1965	270	106	39.3
1966	385	143	37.1
1967	552	191	34.6
1968	748	222	29.7
1969	1023	247	24.1
1970	981	156	15.9
1971	1169	167	14.3
1972	1712	231	13.5
1973	1998	206	10.3
1974	1890	148	7.8
1975	1299	52	4.0
1976	27	0	0.0
Total	12315	1990	16.2

Figure B-3



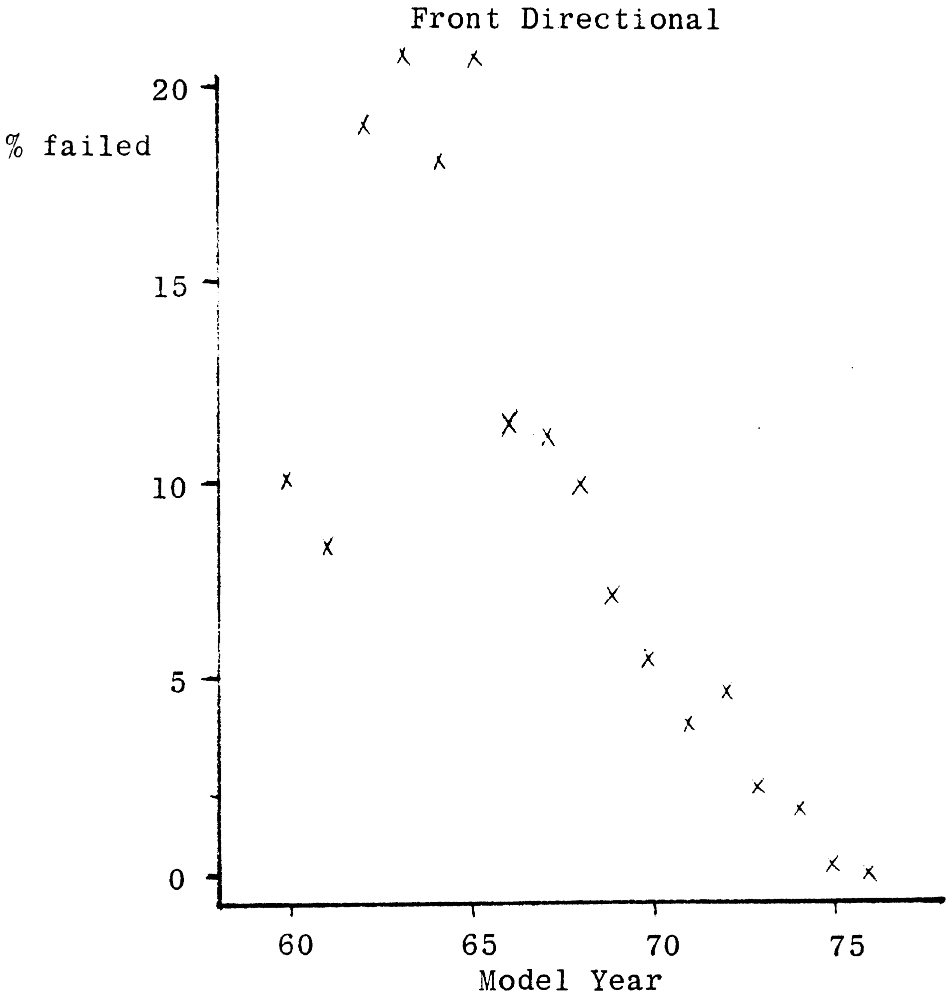
Year	Total	Failed	% Failing
1960	10	7	70.0
1961	12	9	75.0
1962	42	22	52.4
1963	53	28	52.8
1964	144	70	48.6
1965	270	126	46.7
1966	385	163	42.3
1967	552	206	37.3
1968	748	245	32.8
1969	1023	287	28.1
1970	981	193	19.7
1971	1169	205	17.5
1972	1712	262	15.3
1973	1998	220	11.0
1974	1890	154	8.1
1975	1299	52	4.0
1976	27	0	0.0
Total	12315	2249	18.3

Figure B-4



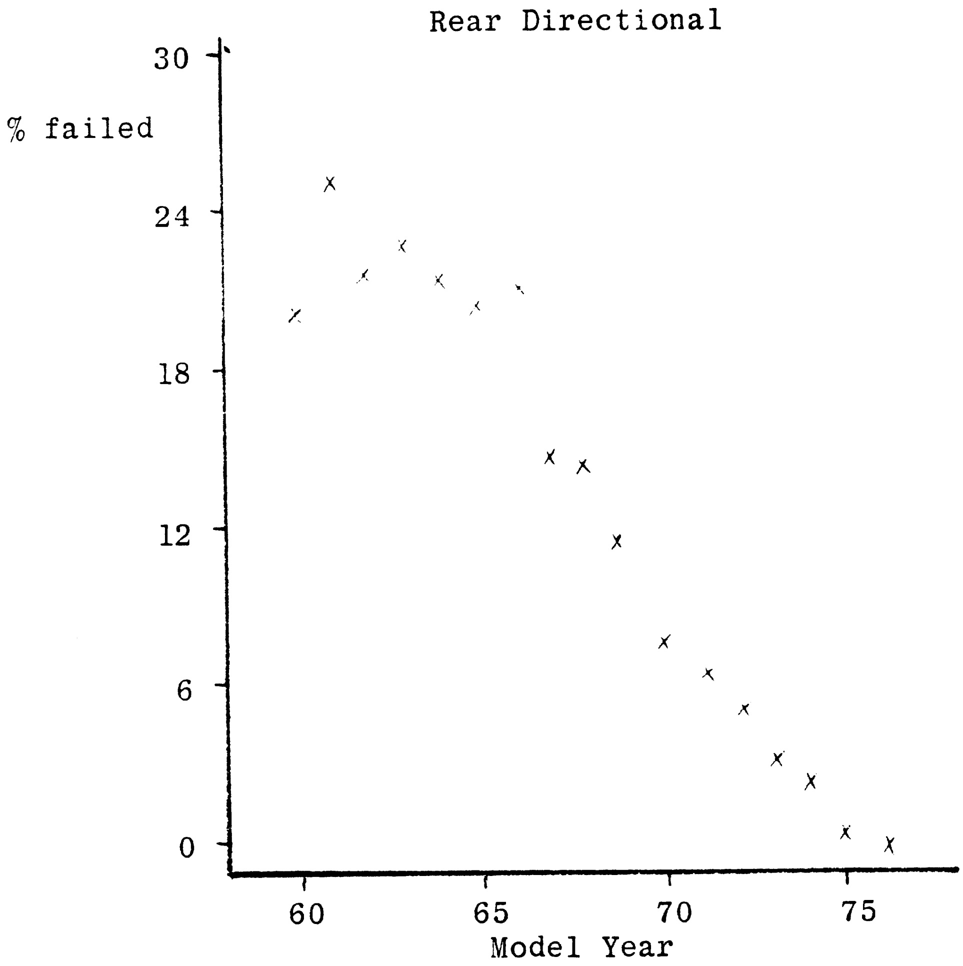
Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	0	0.0
1962	42	4	9.5
1963	53	10	18.9
1964	144	14	9.7
1965	270	20	7.4
1966	385	26	6.8
1967	552	27	4.9
1968	748	44	5.9
1969	1023	28	2.7
1970	981	30	7.9
1971	1169	20	1.7
1972	1712	35	2.0
1973	1998	20	1.0
1974	1890	14	0.7
1975	1299	4	0.3
1976	27	0	0.0
Total	12315	296	2.4

Figure B-5



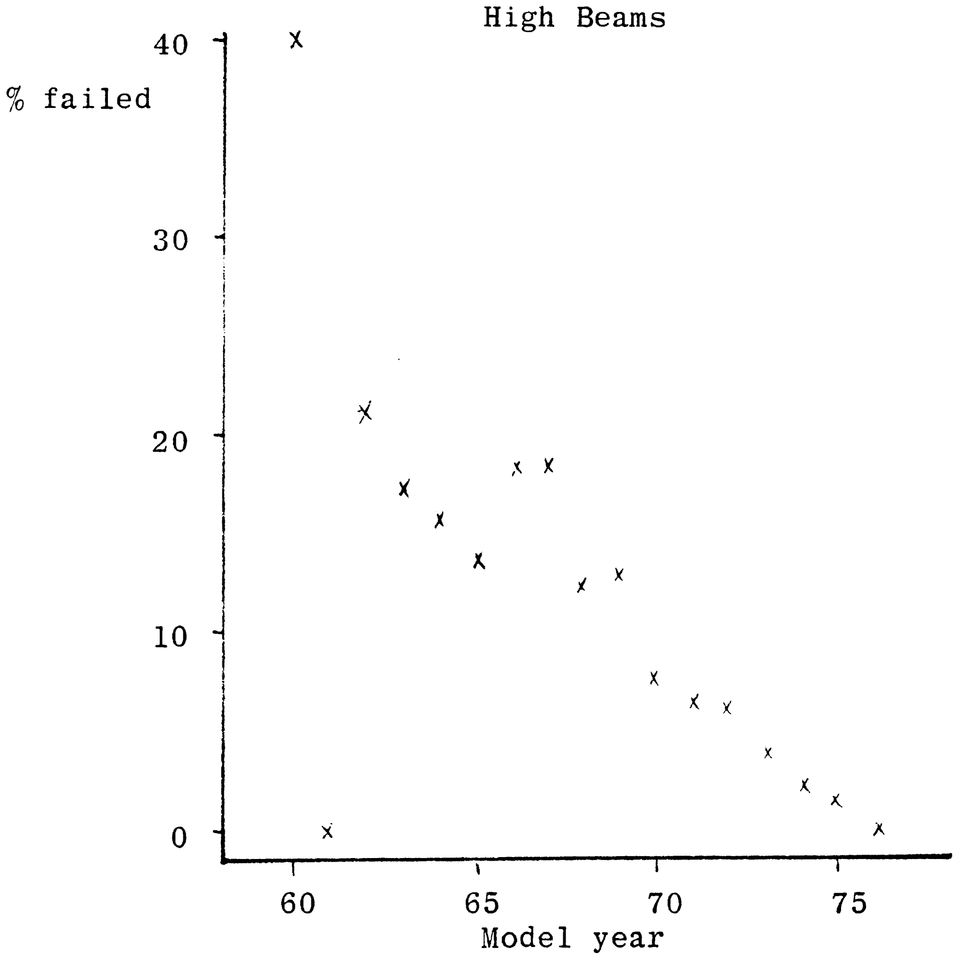
Year	Total	Failed	% Failing
1960	10	1	10.0
1961	12	1	8.3
1962	42	8	19.0
1963	53	11	20.8
1964	144	26	18.1
1965	270	56	20.7
1966	385	44	11.4
1967	552	62	11.2
1968	748	74	9.9
1969	1023	72	7.0
1970	981	54	5.5
1971	1169	45	3.8
1972	1712	78	4.6
1973	1998	43	2.2
1974	1890	31	1.6
1975	1299	2	0.2
1976	27	0	0.0
Total	12315	608	4.9

Figure B-6



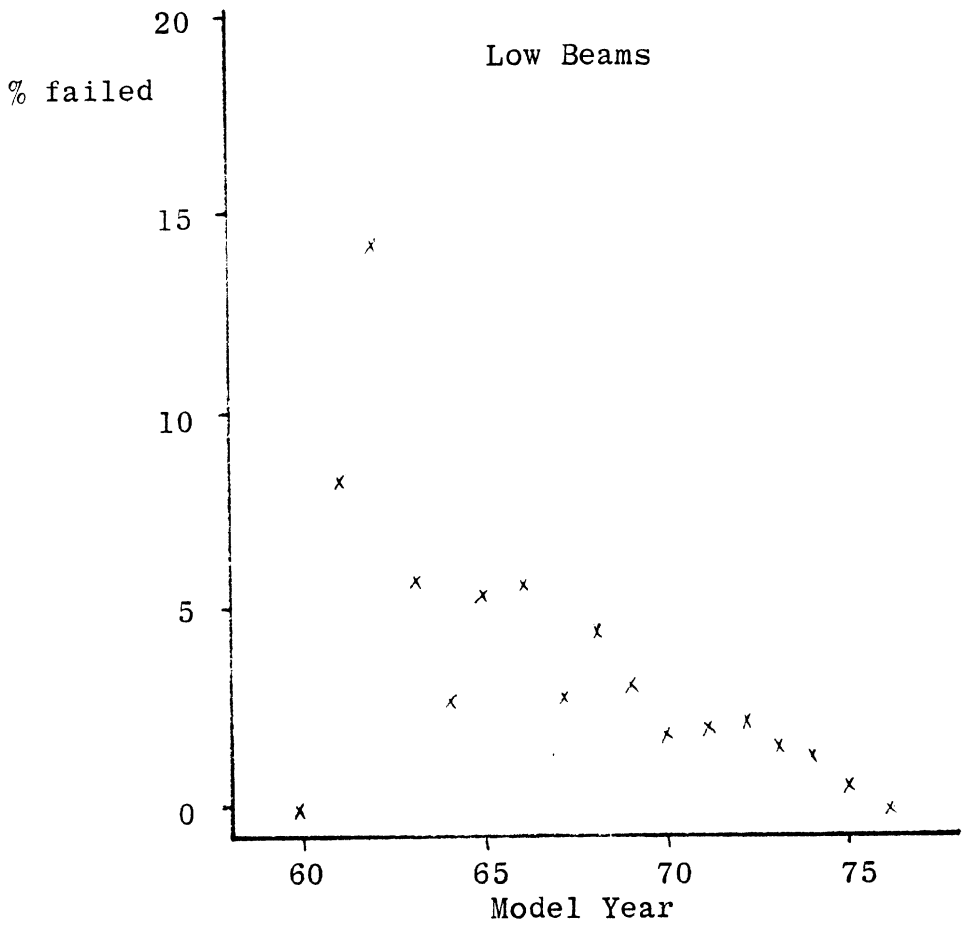
Year	Total	Failed	% Failing
1960	10	2	20.0
1961	12	3	25.0
1962	42	9	21.4
1963	53	12	22.6
1964	144	31	21.5
1965	270	54	20.0
1966	385	81	21.0
1967	552	81	14.7
1968	748	106	14.2
1969	1023	115	11.2
1970	981	75	7.6
1971	1169	73	6.2
1972	1712	87	5.1
1973	1998	62	3.1
1974	1890	47	2.5
1975	1299	6	0.5
1976	27	0	0.0
Total	12315	844	7.2

Figure B-7



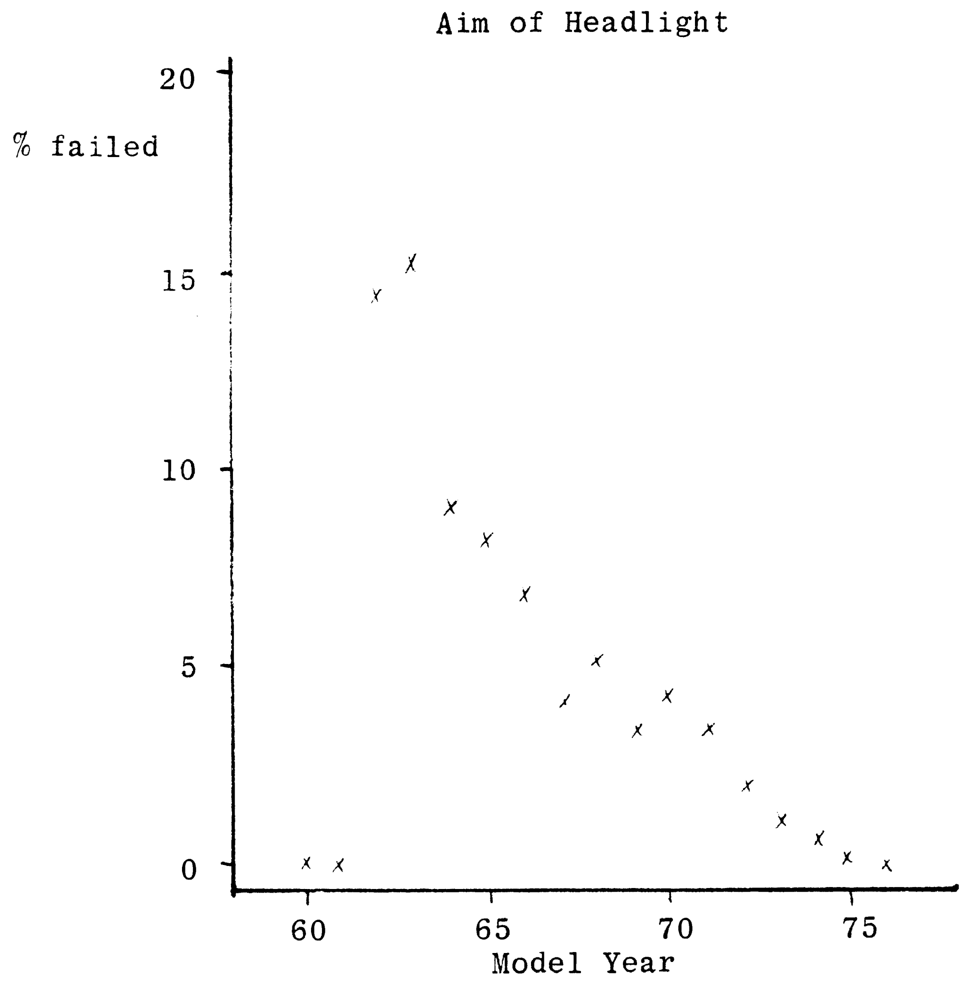
Year	Total	Failed	% Failing
1960	10	4	40.0
1961	12	0	0.0
1962	42	9	21.4
1963	53	9	17.0
1964	144	23	16.0
1965	270	37	13.7
1966	385	70	18.2
1967	552	101	18.3
1968	748	93	12.4
1969	1023	132	12.9
1970	981	77	7.8
1971	1169	76	6.5
1972	1712	106	6.2
1973	1998	81	4.1
1974	1890	46	2.4
1975	1299	20	1.5
1976	27	0	0.0
Total	12315	884	7.2

Figure B-8



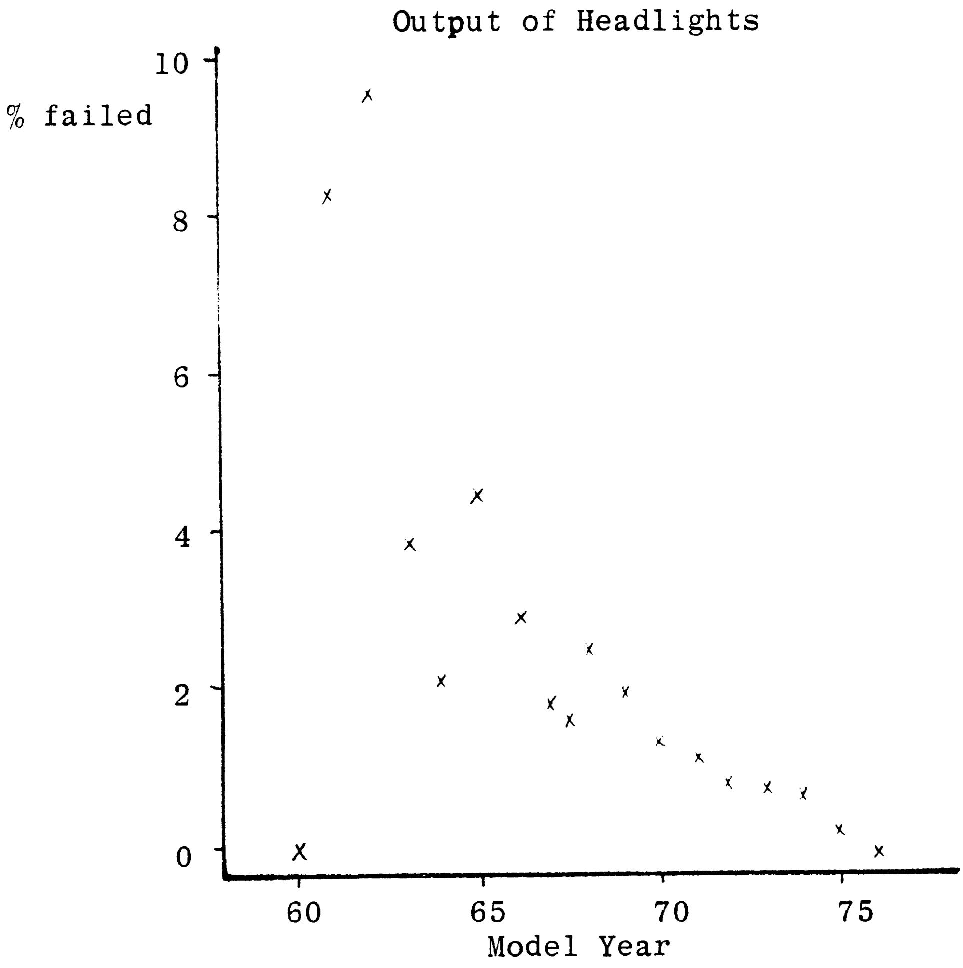
Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	1	8.3
1962	42	6	14.3
1963	53	3	5.7
1964	144	4	2.8
1965	270	15	5.6
1966	385	22	5.7
1967	552	16	2.9
1968	748	34	4.5
1969	1023	33	3.2
1970	981	28	2.9
1971	1169	24	2.1
1972	1712	37	2.2
1973	1998	34	1.7
1974	1890	28	1.5
1975	1299	8	0.6
1976	27	0	0.0
Total	12315	293	2.4

Figure B-9



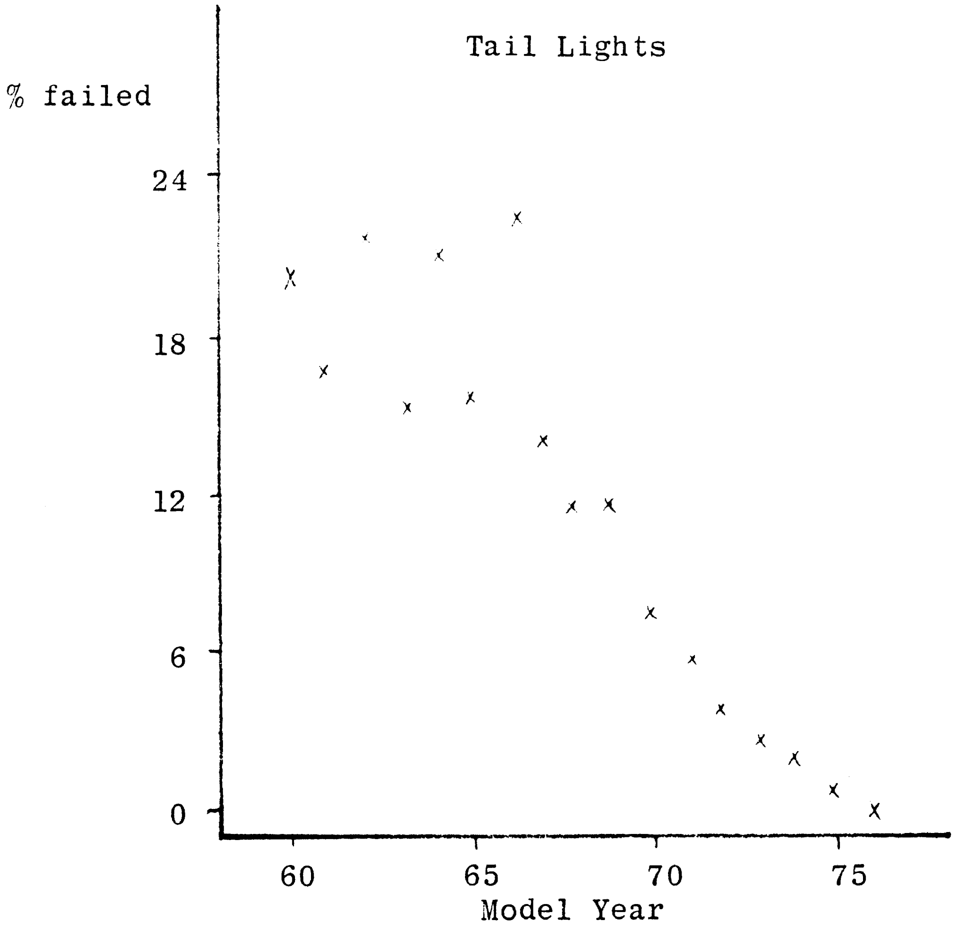
Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	0	0.0
1962	42	6	14.3
1963	53	8	15.1
1964	144	13	9.0
1965	270	22	8.1
1966	385	26	6.8
1967	552	23	4.2
1968	748	39	5.2
1969	1023	35	3.4
1970	981	41	4.2
1971	1169	39	3.3
1972	1712	34	2.0
1973	1998	22	1.1
1974	1890	12	0.6
1975	1299	2	0.2
1976	27	0	0.0
Total	12315	322	2.6

Figure B-10



Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	1	8.3
1962	42	4	9.5
1963	53	2	3.8
1964	144	3	2.1
1965	270	12	4.4
1966	385	11	2.9
1967	552	9	1.6
1968	748	19	2.5
1969	1023	19	1.9
1970	981	13	1.3
1971	1169	13	1.1
1972	1712	14	0.8
1973	1998	16	0.8
1974	1890	13	0.7
1975	1299	2	0.2
1976	27	0	0.0
Total	12315	151	1.2

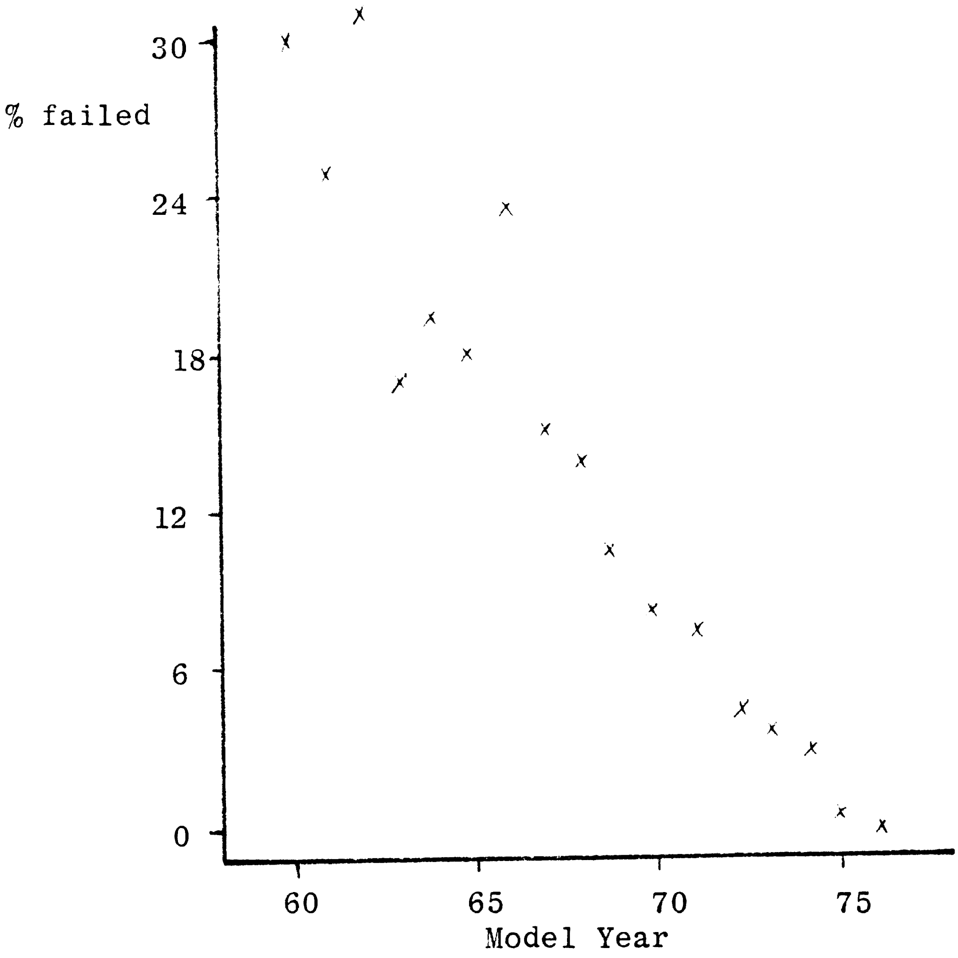
Figure B-11



Year	Total	Failed	% Failing
1960	10	2	20.0
1961	12	2	16.7
1962	42	9	21.4
1963	53	8	15.1
1964	144	30	20.8
1965	270	42	15.6
1966	385	87	22.6
1967	552	77	13.9
1968	748	83	11.1
1969	1023	115	11.2
1970	981	74	7.5
1971	1169	65	5.6
1972	1712	67	3.9
1973	1998	52	2.6
1974	1890	37	2.0
1975	1299	12	0.9
1976	27	0	0.0
Total	12315	762	6.2

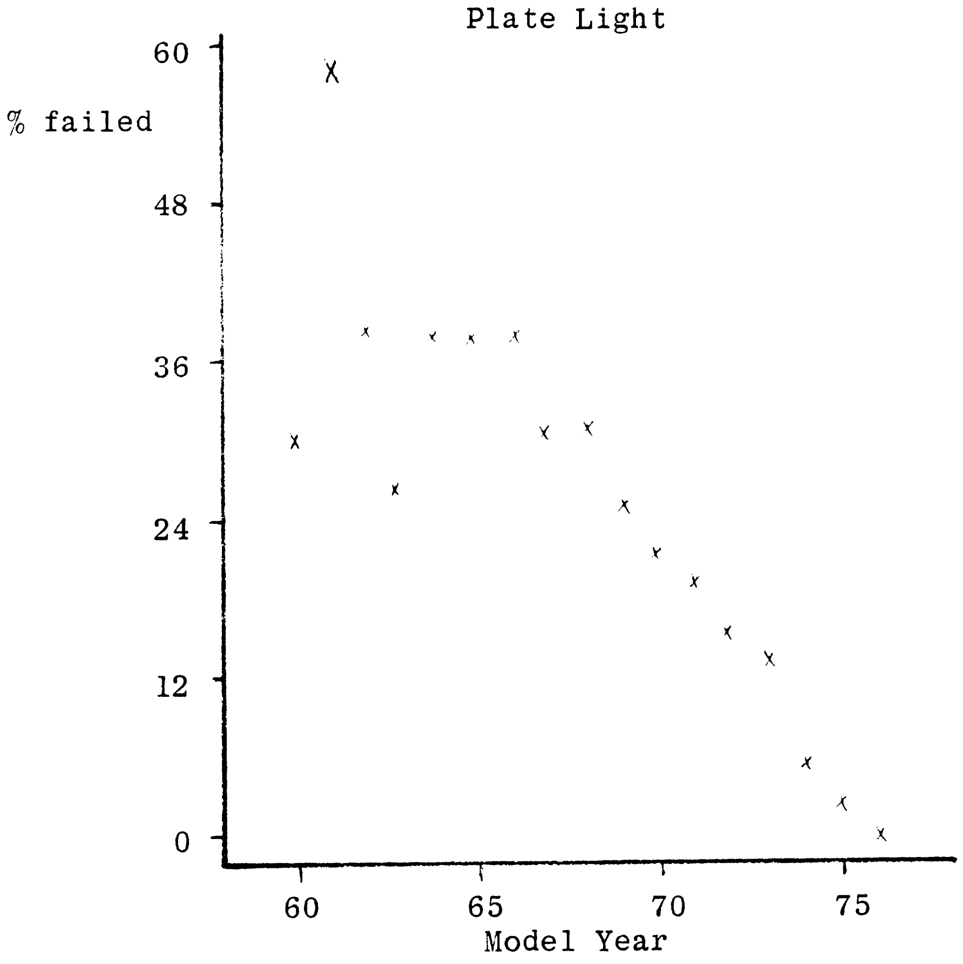
Figure B-12

Stop Lights



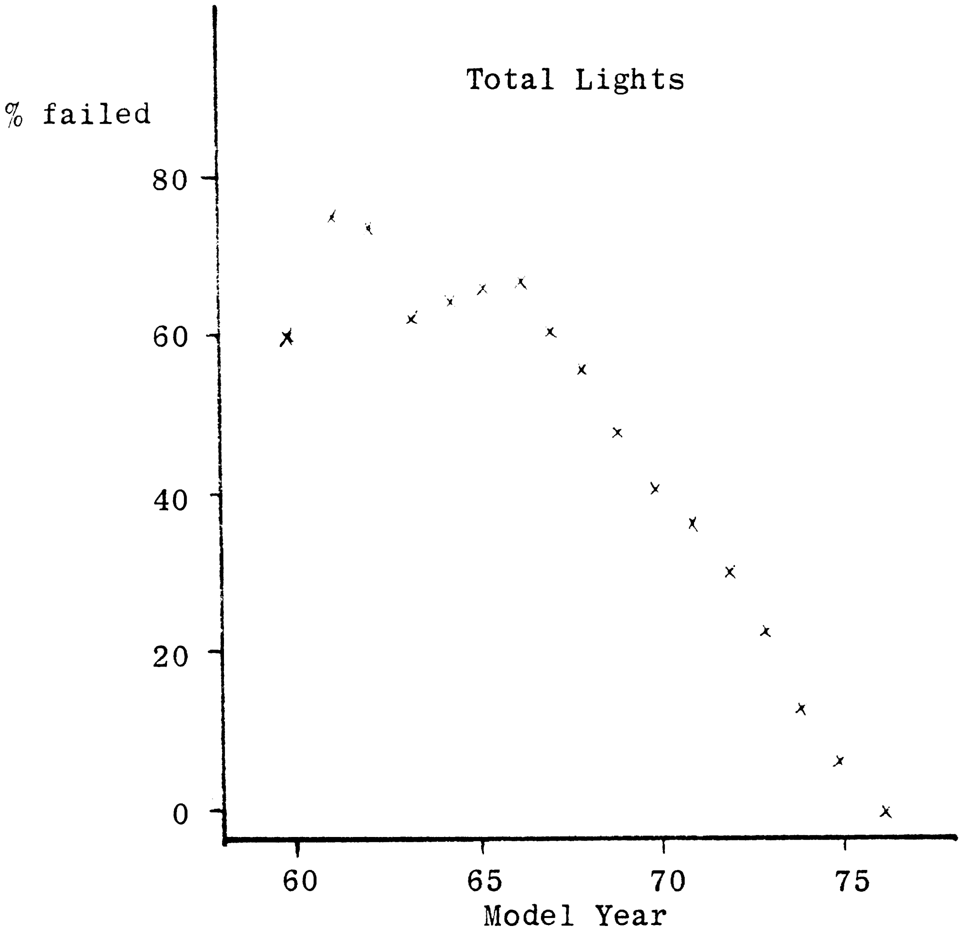
Year	Total	Failed	% Failing
1960	10	3	30.0
1961	12	3	25.0
1962	42	13	31.0
1963	53	9	17.0
1964	144	28	19.4
1965	270	49	18.1
1966	385	91	23.6
1967	552	84	15.2
1968	748	105	14.0
1969	1023	109	10.7
1970	981	80	8.2
1971	1169	86	7.4
1972	1712	80	4.7
1973	1998	73	3.7
1974	1890	57	3.0
1975	1299	7	0.5
1976	27	0	0.0
Total	12315	877	7.2

Figure B-13



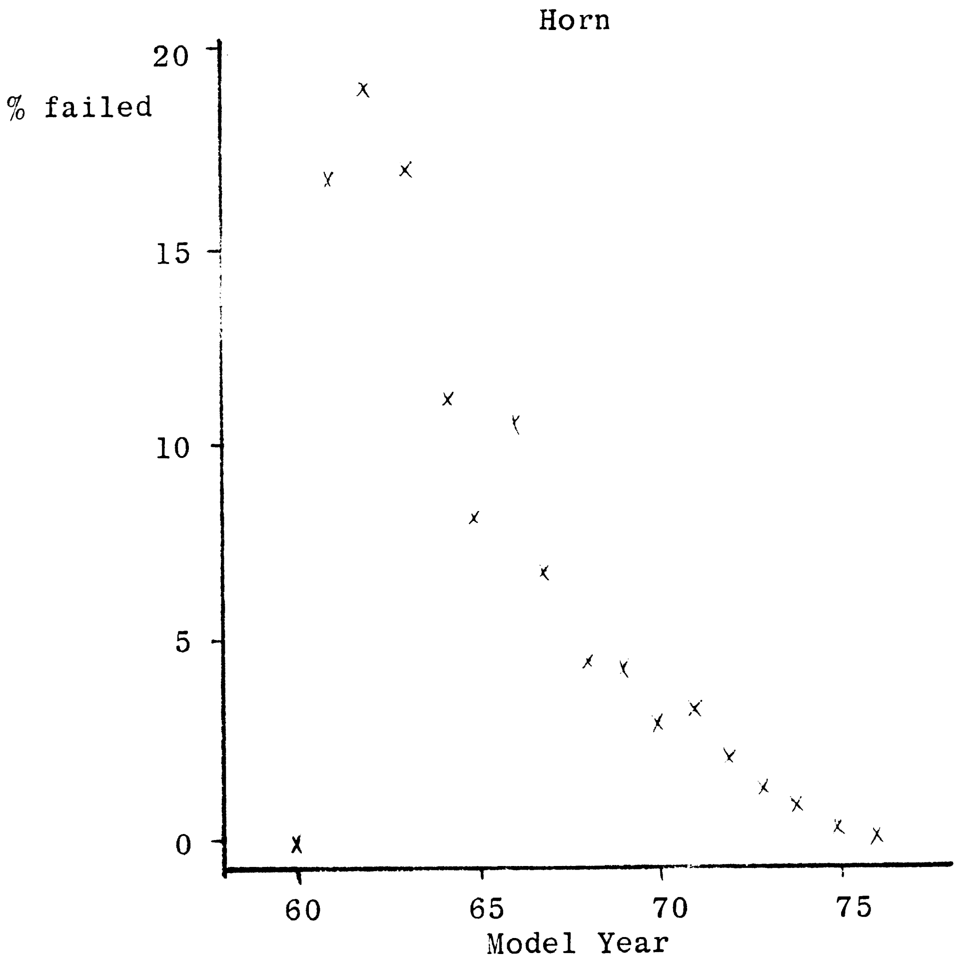
Year	Total	Failed	% Failing
1960	10	3	30.0
1961	12	7	58.3
1962	42	16	38.1
1963	53	14	26.4
1964	144	54	37.5
1965	270	101	37.4
1966	385	145	37.7
1967	552	167	30.3
1968	748	230	30.7
1969	1023	252	24.6
1970	981	210	21.4
1971	1169	223	19.1
1972	1712	264	15.4
1973	1998	262	13.1
1974	1890	97	5.1
1975	1299	35	2.7
1976	27	0	0.0
Total	12315	2080	16.9

Figure B-14



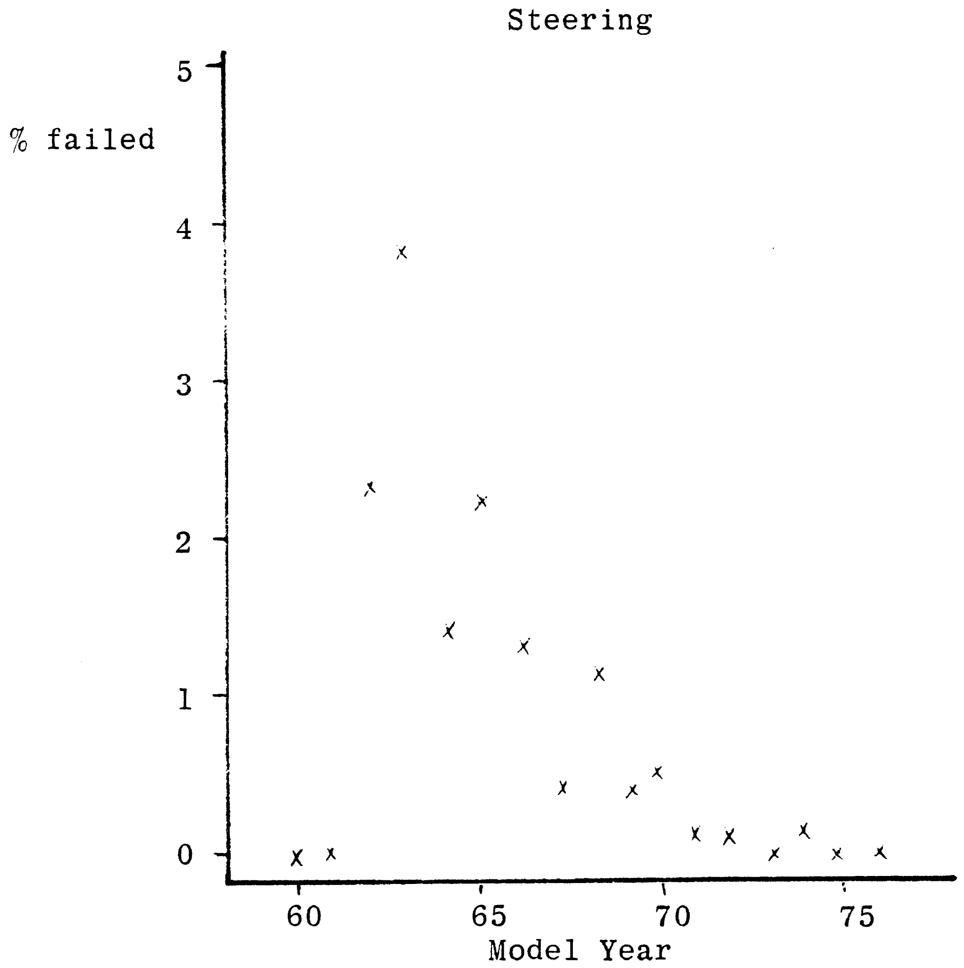
Year	Total	Failed	% Failing
1960	10	6	60.0
1961	12	9	75.0
1962	42	31	73.8
1963	53	33	62.3
1964	144	93	64.6
1965	270	176	65.2
1966	385	256	66.5
1967	552	337	61.1
1968	748	418	55.9
1969	1023	490	47.9
1970	981	398	40.6
1971	1169	429	36.7
1972	1712	513	30.0
1973	1998	454	22.7
1974	1890	248	13.1
1975	1299	74	5.7
1976	27	0	0.0
Total	12315	3965	32.2

Figure B-15



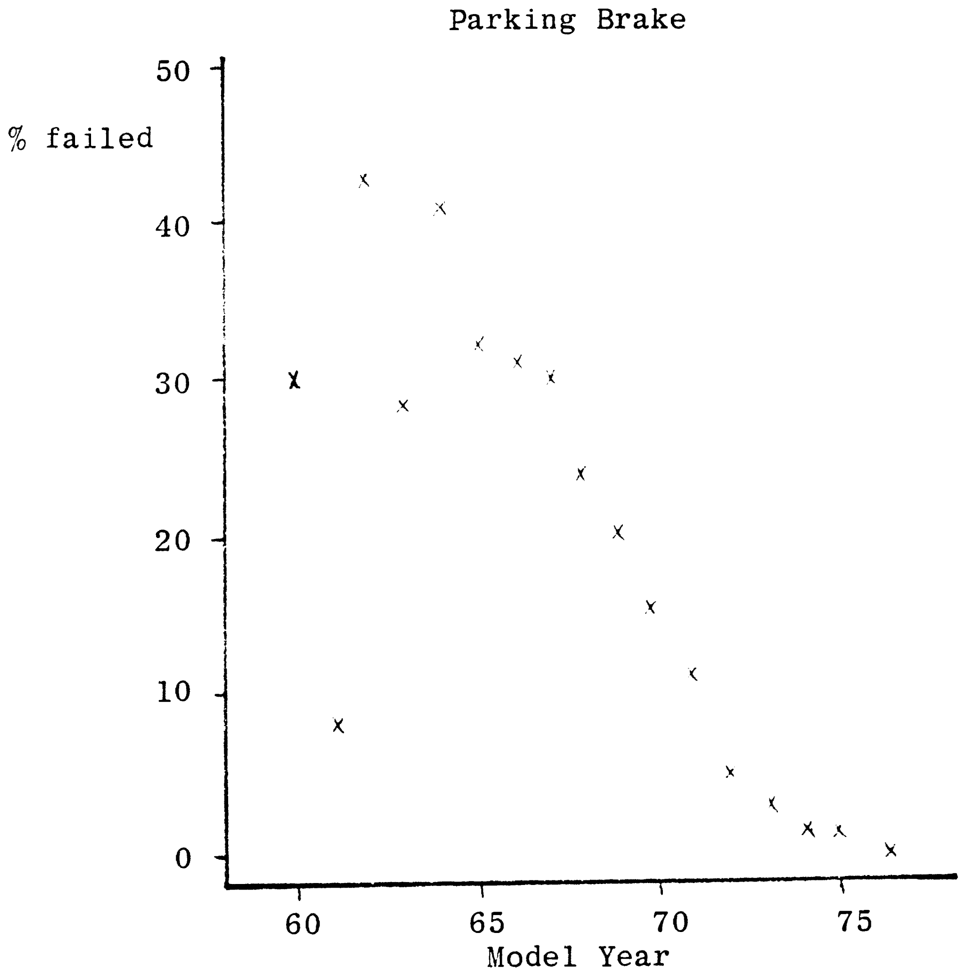
Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	2	16.7
1962	42	8	19.0
1963	53	9	17.0
1964	144	16	11.1
1965	270	22	8.1
1966	385	41	10.6
1967	552	38	6.9
1968	748	34	4.5
1969	1023	45	4.4
1970	981	29	3.0
1971	1169	39	3.3
1972	1712	36	2.1
1973	1998	26	1.3
1974	1890	19	1.0
1975	1299	2	0.2
1976	27	0	0.0
Total	12315	366	3.0

Figure B-16



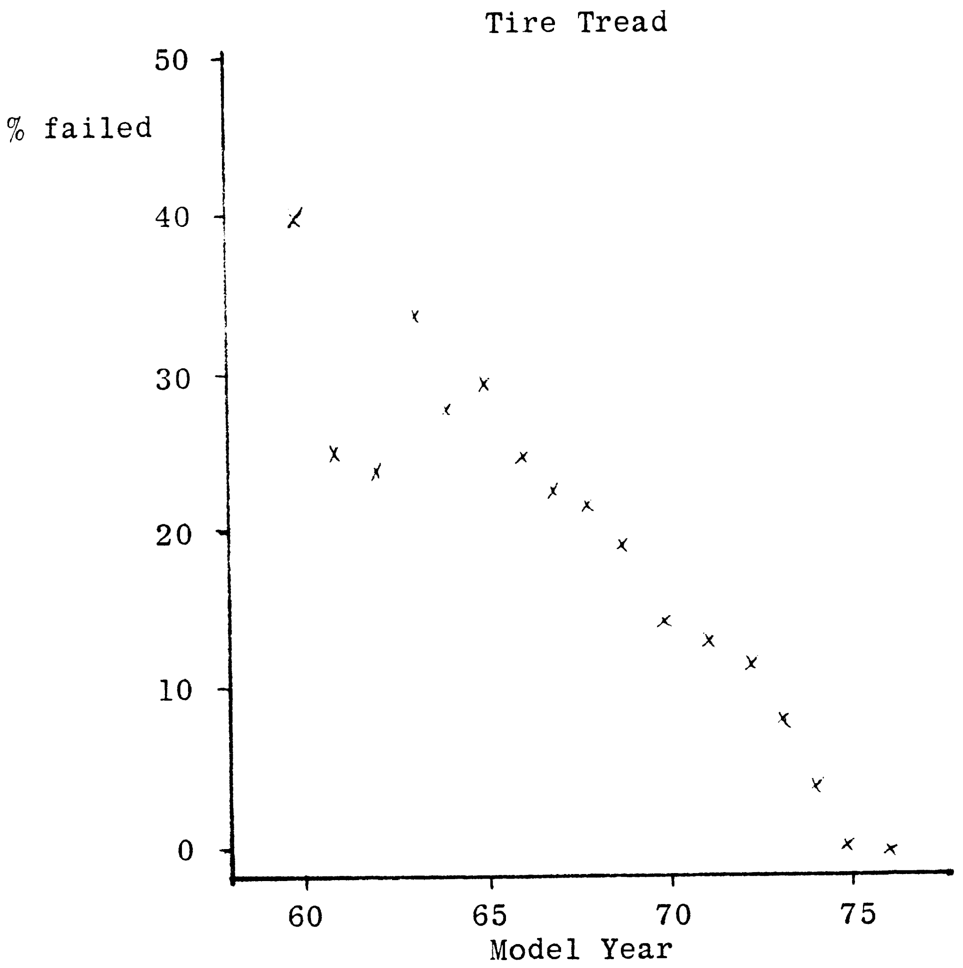
Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	0	0.0
1962	42	1	2.4
1963	53	2	3.8
1964	144	2	1.4
1965	270	6	2.2
1966	385	5	1.3
1967	552	2	0.4
1968	748	8	1.1
1969	1023	4	0.4
1970	981	5	0.5
1971	1169	1	0.1
1972	1712	1	0.1
1973	1998	0	0.0
1974	1890	1	0.1
1975	1299	0	0.0
1976	27	0	0.0
Total	12315	38	0.3

Figure B-17



Year	Total	Failed	% Failing
1960	10	3	30.0
1961	12	1	8.3
1962	42	18	42.9
1963	53	15	28.3
1964	144	55	38.2
1965	270	84	31.1
1966	385	114	29.6
1967	552	160	29.0
1968	748	171	22.9
1969	1023	193	18.9
1970	981	147	15.0
1971	1169	125	10.7
1972	1712	90	5.3
1973	1998	65	3.3
1974	1890	24	1.3
1975	1299	13	1.0
1976	27	0	0.0
Total	12315	1278	10.4

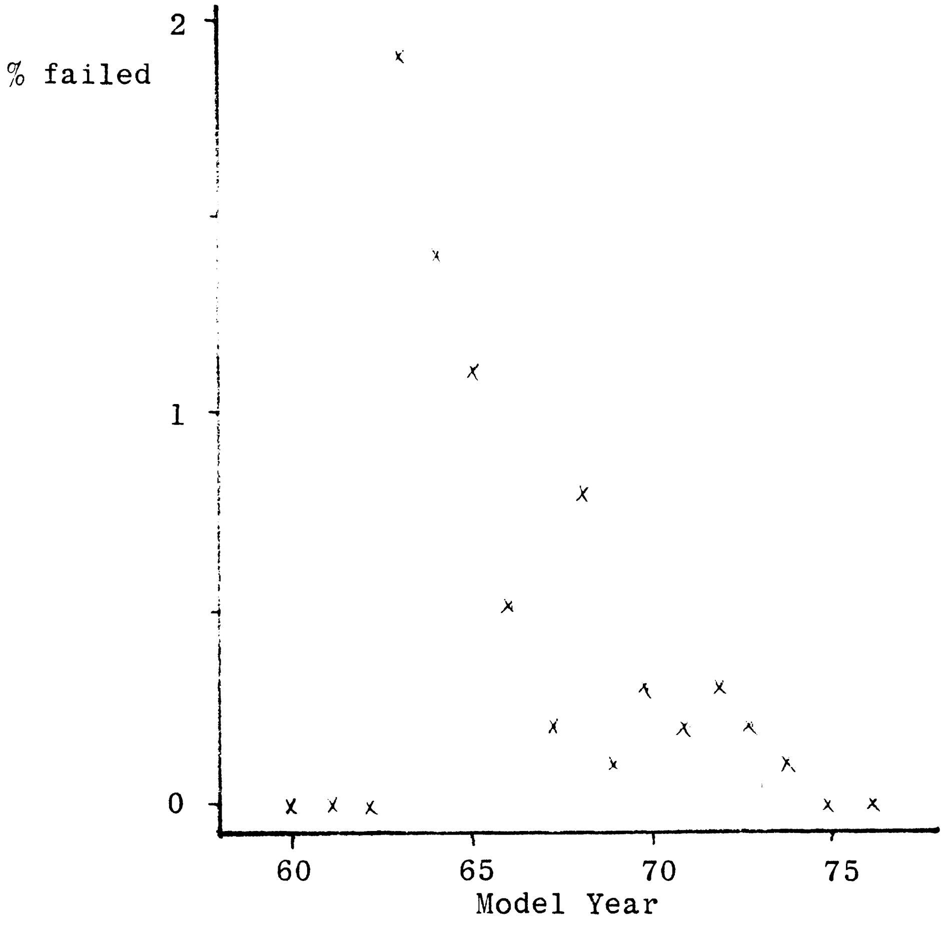
Figure B-18



Year	Total	Failed	% Failing
1960	10	4	40.0
1961	12	3	25.0
1962	42	10	23.8
1963	53	18	34.0
1964	144	40	27.8
1965	270	79	29.3
1966	385	96	24.9
1967	552	126	22.8
1968	748	177	23.7
1969	1023	195	19.1
1970	981	140	14.3
1971	1169	156	13.3
1972	1712	197	11.5
1973	1998	173	8.7
1974	1890	81	4.3
1975	1299	4	0.3
1976	27	0	0.0
Total	12315	1499	

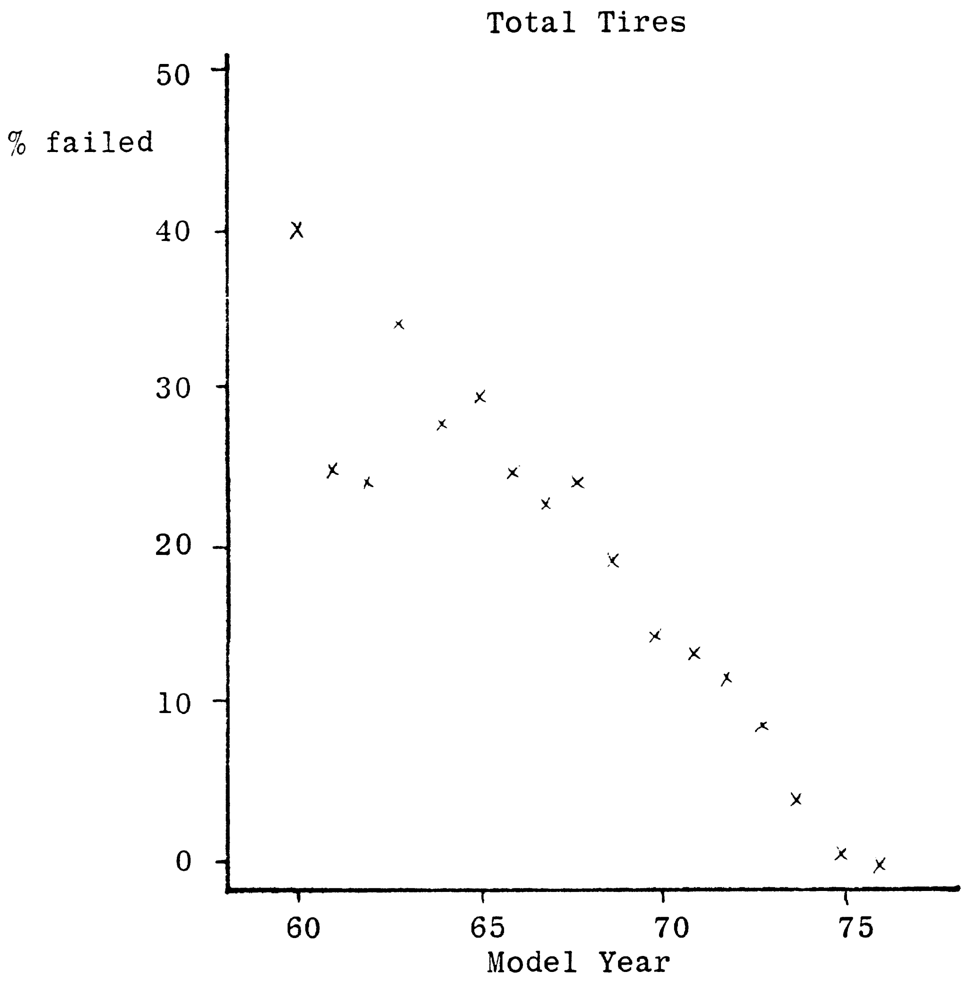
Figure B-19

Tire Bulges or Break



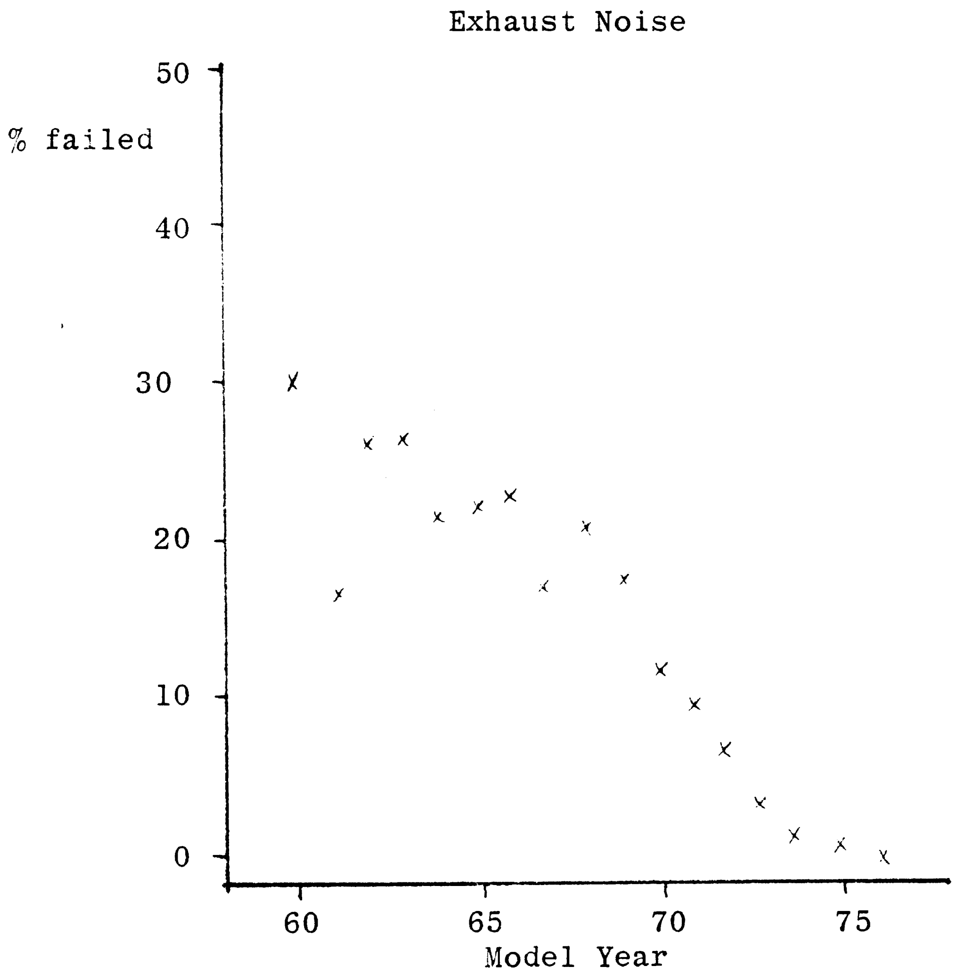
Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	0	0.0
1962	42	0	0.0
1963	53	1	1.9
1964	144	2	1.4
1965	270	3	1.1
1966	385	2	0.5
1967	552	1	0.2
1968	748	6	0.8
1969	1023	1	0.1
1970	981	3	0.3
1971	1169	2	0.2
1972	1712	5	0.3
1973	1998	4	0.2
1974	1890	1	0.1
1975	1299	0	0.0
1976	27	0	0.0
Total	12315	31	0.3

Figure B-20



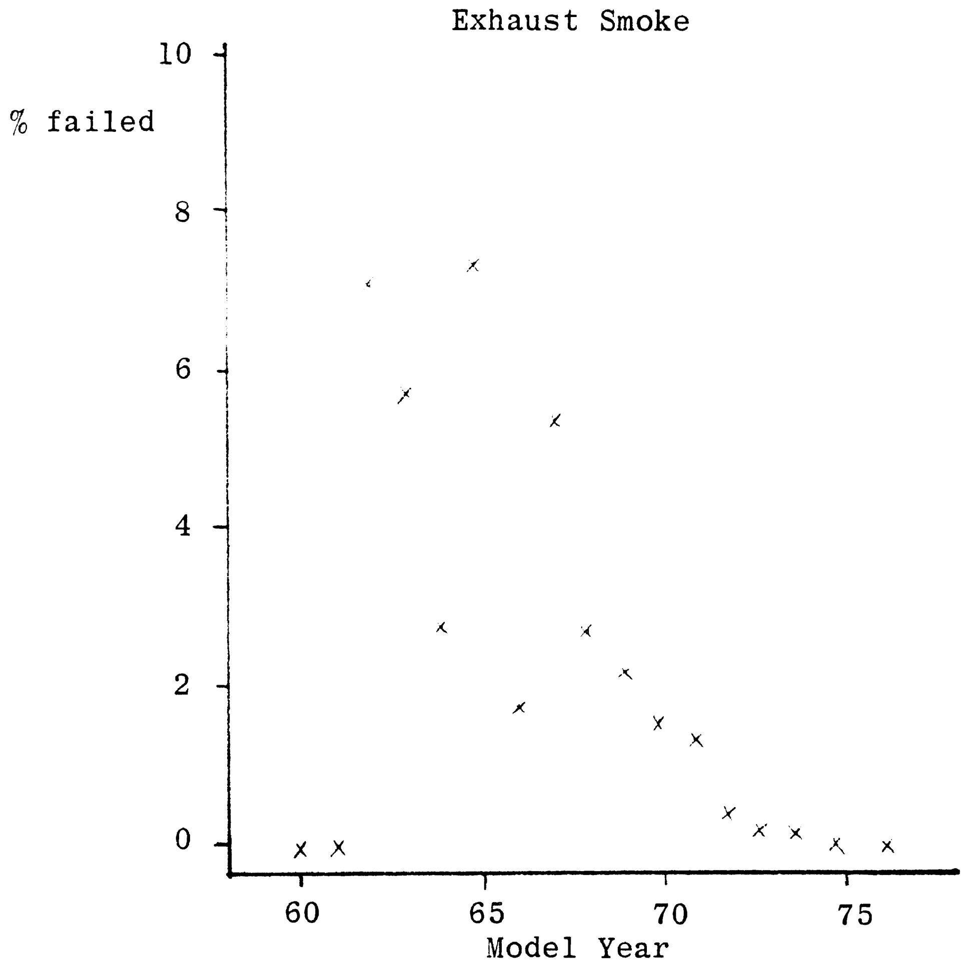
Year	Total	Failed	% Failing
1960	10	4	40.0
1961	12	3	25.0
1962	42	10	23.8
1963	53	18	34.0
1964	144	40	27.8
1965	270	79	29.3
1966	385	96	24.9
1967	552	126	22.8
1968	748	179	23.9
1969	1023	195	19.1
1970	981	141	14.4
1971	1169	157	13.4
1972	1712	200	11.7
1973	1998	175	8.8
1974	1890	81	4.3
1975	1299	4	0.3
1976	27	0	0.0
Total	12315	1508	12.2

Figure B-21



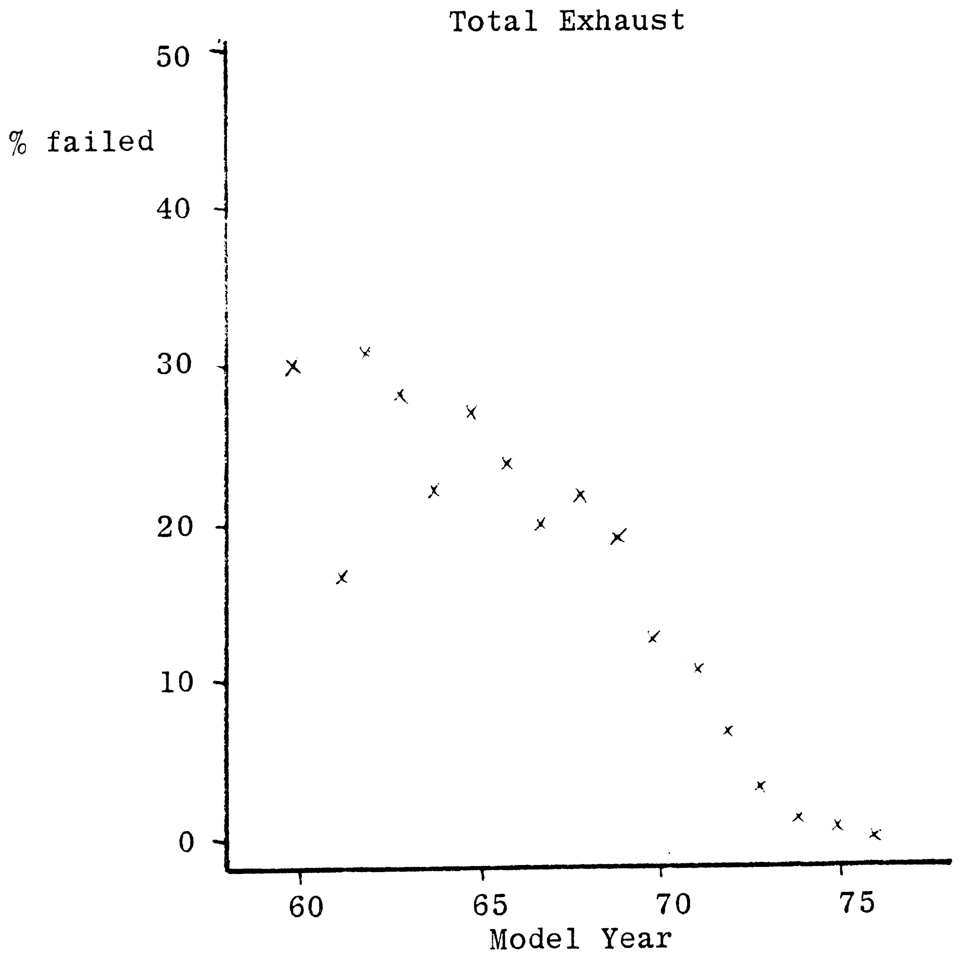
Year	Total	Failed	% Failing
1960	10	3	30.0
1961	12	2	16.7
1962	42	11	26.2
1963	53	14	26.4
1964	144	31	21.5
1965	270	60	22.2
1966	385	88	22.9
1967	552	94	17.0
1968	748	156	20.9
1969	1023	179	17.5
1970	981	115	11.7
1971	1169	112	6.7
1972	1712	114	3.3
1973	1998	65	1.2
1974	1890	22	0.6
1975	1299	8	0.0
1976	27	0	
Total	12315	1074	8.7

Figure B-22



Year	Total	Failed	% Failing
1960	10	0	0.0
1961	12	0	0.0
1962	42	3	7.1
1963	53	3	5.7
1964	144	4	2.8
1965	270	20	7.4
1966	385	7	1.8
1967	552	30	5.4
1968	748	20	2.7
1969	1023	23	2.2
1970	981	16	1.6
1971	1169	16	1.4
1972	1712	7	0.4
1973	1998	4	0.2
1974	1890	3	0.2
1975	1299	0	0.0
1976	27	0	0.0
Total	12315	156	1.3

Figure B-23



Year	Total	Failed	% Failing
1960	10	3	30.0
1961	12	2	16.7
1962	42	13	31.6
1963	53	15	28.3
1964	144	32	22.2
1965	270	73	27.0
1966	385	92	23.9
1967	552	110	19.9
1968	748	164	21.9
1969	1023	193	18.9
1970	981	127	12.9
1971	1169	124	10.6
1972	1712	118	6.9
1973	1998	67	3.4
1974	1890	24	1.3
1975	1299	8	0.6
1976	27	0	0.0
Total	12315	1165	9.5

Figure B-24

Table B-11

DRIVER INTERVIEW DATA

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
AGE OF DRIVER						
15-20	38	12.2	244	13.0	282	12.9
20-25	49	15.7	257	13.7	306	14.0
25-30	42	13.5	228	12.1	270	12.3
30-35	39	12.5	195	10.4	234	10.7
35-40	27	8.7	172	9.2	199	9.1
40-45	23	7.4	141	7.5	164	7.5
45-50	28	9.0	143	7.6	171	7.8
50-55	19	6.1	120	6.4	139	6.3
55-60	18	5.8	109	5.8	127	5.8
60-65	10	3.2	105	5.6	115	5.3
65-70	10	3.2	94	5.0	104	4.7
70-75	6	1.9	48	2.6	54	2.5
75	3	0.9	22	1.2	25	1.1
Total	312		1878		2190	
Missing	4		37		41	
SEX OF DRIVER						
Male	189	60.2	1071	56.3	1260	56.9
Female	125	39.8	831	43.7	956	43.1
Total	314		1902		2216	
Missing	2		13		15	
QUESTION #1						
Response						
1	22	7.1	68	3.7	90	4.2
2	107	34.5	485	26.2	592	27.4
3*	158	51.0	1179	63.6	1337	61.8
4	23	7.4	121	6.5	144	6.6
Total	310		1853		2163	
Missing	6		62		68	
QUESTION #2						
Response						
1	16	5.1	85	4.5	101	4.6
2	57	18.3	273	14.6	330	15.1
3	84	27.0	373	20.0	457	21.0
4*	109	35.0	913	48.8	1022	46.9
5	45	14.5	225	12.0	270	12.4
Total	311		1869		2180	
Missing	5		46		51	
QUESTION #3						
Response						
1	41	13.4	148	8.0	189	8.7
2	160	52.1	1383	74.6	1543	71.4
3	1	0.3	23	1.2	24	1.1
4	59	19.2	191	10.3	250	11.6
5	23	7.5	74	4.0	97	4.5
6	23	7.5	35	1.9	58	2.7
Total	307		1854		2161	
Missing	9		61		70	

* denotes correct response

Table B-11 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
QUESTION #4						
Response						
1	30	9.6	63	3.4	93	4.3
2	282	90.4	1811	96.6	2093	95.7
Total	312		1874		2186	
Missing	4		41		45	
QUESTION #5						
Response						
1	21	6.7	168	9.0	189	8.6
2	51	16.3	249	13.3	300	13.7
3	66	21.2	447	23.8	513	23.4
4	70	22.4	423	22.5	493	22.5
5	62	19.9	263	14.0	325	14.8
6	42	13.5	367	19.7	409	18.7
Total	312		1877		2189	
Missing	4		38		42	
QUESTION #6						
Response						
1	52	16.8	56	21.1	108	18.8
2	69	22.3	71	26.7	140	24.3
3	122	39.5	91	34.2	213	37.0
4	66	21.4	48	18.0	114	19.8
Total	309		266		575	
Missing	7		1649		1656	
QUESTION #7						
Response						
1	53	17.8	46	17.8	99	17.8
2	142	47.8	101	39.0	243	43.7
3	102	34.3	112	43.2	214	38.5
Total	297		259		556	
Missing	19		1656		1675	
QUESTION #8						
Response						
Agree	208	67.3	183	69.3	391	68.2
Disagree	28	9.1	20	7.6	48	8.4
No Opinion	73	23.6	61	23.1	134	23.4
Total	309		264		573	
Missing	7		1651		1658	

Table B-11 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
QUESTION #9						
Response						
Agree	262	84.5	242	91.3	504	87.7
Disagree	33	10.6	14	5.3	47	8.2
No Opinion	15	4.8	9	3.4	24	4.2
Total	310		265		575	
Missing	6		1650		1656	
QUESTION #10						
Response						
Agree	97	31.3	77	29.1	174	30.3
Disagree	181	58.4	158	59.6	339	59.0
No Opinion	32	10.3	30	11.3	62	10.7
Total	310		265		575	
Missing	6		1650		1656	
QUESTION #11						
Response						
Agree	41	13.2	45	16.9	86	14.9
Disagree	237	76.2	196	73.7	433	75.0
No Opinion	33	10.6	25	9.4	58	10.1
Total	311		266		577	
Missing	5		1649		1654	
QUESTION #12						
Agree	174	55.9	141	53.0	315	54.6
Disagree	96	30.9	90	33.8	186	32.2
No Opinion	41	13.2	35	13.2	76	13.2
Total	311		266		577	
Missing	5		1649		1654	
COMPLETION PROBLEMS						
None	306	96.8	1858	97.0	2164	97.0
Refused	1	0.3	1	0.1	2	0.1
Illiterate	5	1.6	10	0.5	15	0.7
No Reading Glasses	0	0.0	4	0.2	4	0.2
Mentally/Physically Incapable	1	0.3	9	0.5	10	0.4
Other	3	0.9	33	1.7	36	1.6
Total	316		1915		2231	

Table B-11 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
INTERVIEWER						
R. Copp	162	54.0	421	22.7	583	27.0
R. Corn	138	46.0	445	24.0	583	27.0
J.P. Monson	0	0.0	29	1.6	29	1.3
M. Sackett	0	0.0	1	0.1	1	0.1
M. Todd	0	0.0	961	51.8	961	44.6
Total	300		1857		2157	
Missing	16		58		74	

Table B-12

MOVING-STOPPING TEST VARIABLES

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
WHEEL PULL						
Yes	287	16.1	2004	20.3	2291	19.7
No	1499	83.9	7861	79.7	9360	80.3
Total	1786		9865		11651	
PEDAL PRESSURE						
Pass	1660	92.9	9275	94.0	10935	93.9
Soft Pedal	44	2.5	65	0.7	109	0.9
Low pedal	38	2.1	182	1.8	220	1.9
Pressure loss	0	0.0	3	0.0	3	0.0
Complete loss	1	0.1	14	0.1	15	0.1
Hard Pedal	21	1.2	50	0.5	71	0.6
Pulsating pedal	18	1.0	57	0.6	75	0.6
Refused	4	0.2	219	2.2	223	1.9
Total	1786		9865		11651	

Table B-12 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
STOPPING TEST						
Pass	1570	87.9	8908	90.3	10478	89.9
Cannot stop	13	0.7	92	0.9	105	0.9
Side to side	192	10.8	629	6.4	821	7.0
Both	7	0.4	17	0.2	24	0.2
Refused	4	0.2	220	2.2	224	1.9
Total	1786		9865		11651	
STOPPING AUDIBLE						
Pass	1574	88.1	8967	90.9	10541	90.5
Fail	208	11.6	678	6.9	886	7.6
Refused	4	0.2	220	2.2	224	1.9
Total	1786		9865		11651	
TOTAL STOPPING DEFECTS						
number						
o	1340	75.0	8195	83.1	9535	81.8
1	358	20.0	1173	11.9	1531	13.1
2	68	3.8	217	2.2	285	2.4
3	16	0.9	60	0.6	76	0.7
Refused	4	0.2	220	2.2	224	1.9
Total	1786		9865		11651	
TOTAL INSPECTION DEFECTS						
0	747	41.8	4728	47.9	5475	47.0
1	438	24.5	2126	21.6	2564	22.0
2	238	13.3	1252	12.7	1490	12.8
3	156	8.7	730	7.4	886	7.6
4	92	5.2	421	4.3	513	4.4
5	46	2.6	231	2.3	277	2.4
6	33	1.8	163	1.7	196	1.7
7	17	1.0	82	0.8	99	0.8
8	9	0.5	49	0.5	58	0.5
9	3	0.2	39	0.4	42	0.4
10	4	0.2	18	0.2	22	0.2
>10	3	0.2	26	0.3	29	0.2
Total	1786		9865		11651	

Table B-13

WHEEL PULL VARIABLES

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
BRAKE INSPECTION						
No	1487	83.3	7847	79.5	9334	80.1
Yes	299	16.7	2018	20.5	2317	19.9
Total	1786		9865		11651	
INTERVIEW						
Yes	316	17.7	1915	19.4	2231	19.1
No	1470	82.3	7950	80.6	9420	80.9
Total	1786		9865		11651	
BRAKE INSPECTOR						
M. Huber	17	5.7	0	0.0	17	0.7
J.P. Monson	173	57.9	105	5.2	275	11.9
M. Sackett	40	13.4	24	1.2	64	2.8
M. Todd	69	23.1	1888	93.6	1952	84.3
Total	299		201		2316	
Missing	1487		7848		9335	
BRAKE TYPE						
Power-disc	112	37.5	828	41.1	940	40.6
Non-power disc	35	11.7	142	7.0	177	7.6
Power-drum	43	14.4	404	20.0	447	19.3
Non-power drum	101	33.8	607	30.1	708	30.6
Incomplete code	8	2.7	35	1.8	43	1.9
Total	299		2016		2315	
Missing	0		2		2	
MASTER CYLINDER FLUID						
Full	228	78.6	1745	88.0	1973	86.8
Half	50	17.2	163	8.2	213	9.4
Low	12	4.1	74	3.7	86	3.8
Total	290		1982		2272	
Missing	9		36		45	
BRAKE FLUID QUALITY						
Pass	290	99.7	1963	99.0	2253	99.1
Fail	1	0.3	19	1.0	20	0.9
Total	291		1982		2273	
Missing	8		36		45	
VACUUM HOSE						
Pass	295	100.0	1978	100.0	2273	100.0
Fail	0	0.0	0	0.0	0	0.0
Total	295		1978		2273	
Missing	4		40		44	

Table B-13 Continued

	Monroe		Jackson		Total	
	Count	%	Count	%	Count	%
WHEEL BEARING GREASE						
Pass	266	89.9	1918	95.5	2184	94.7
Fail	3	1.0	2	0.1	5	0.2
Unable to inspect	27	9.1	88	4.4	115	5.0
Total	296		2008		2306	
Missing	3		10		13	
WHEEL PULL						
Yes	238	80.1	1865	93.3	2103	91.6
Unable to pull	59	19.9	134	6.7	193	8.4
Total	297		1999		2296	
Missing	2		19		21	
SHOE-PAD CONDITION						
75-100%	195	82.3	1490	79.7	1685	80.0
50-75%	29	12.2	182	9.7	211	10.0
1/32"-50%	10	4.2	114	6.1	124	5.9
Fail	3	1.3	83	4.4	86	4.1
Total	237		1869		2106	
Missing	62		149		211	
ROTOR OR DRUM						
Pass	215	91.1	1687	90.6	1902	90.7
Cracked	0	0.0	3	0.2	3	0.1
Worn	11	4.7	17	0.9	28	1.3
Grooves	10	4.2	155	8.3	165	7.9
Total	236		1862		2098	
Missing	63		156		219	
BRAKE HARDWARE						
Pass	237	100.0	1865	100.0	2102	100.0
Springs	0	0.0	0	0.0	0	0.0
Retainer	0	0.0	0	0.0	0	0.0
Self-adjuster	0	0.0	0	0.0	0	0.0
Total	237		1865		2102	
Missing	62		153		215	
WHEEL CYLINDERS						
Pass	227	96.6	1853	99.6	2080	99.3
Fail	8	3.4	7	0.4	15	0.7
Total	235		1860		2095	
Missing	64		158		222	

APPENDIX C
STATISTICAL METHODS

APPENDIX C

STATISTICAL METHODS

For testing whether the samples from the two counties had the same distribution on some variable, the chi-squared test was used. This was also the technique used to test whether a sample was representative of that county's registered vehicles. For example, consider the variable vehicle type. The data are given in Table A- . The null hypothesis is that the properties of vehicles in ofeach vehicle type is the same in the two counties. The test statistic is:

$$X^2 = \sum_i \sum_j \frac{(X_{ij} - E(X_{ij}))^2}{E(X_{ij})}$$

i = vehicle type indicator

j = county indicator

where $$E(X_{ij}) = \frac{(\sum_i X_{ij})\ (\sum_j X_{ij})}{\Sigma_i \Sigma_j X_{ij}}$$

This statistic was used to compare the distributions of vehicles in the two counties. It was also used to compare the sample to the population of registered vehicles in each county and to compare the combined sample to the state.

A more complex statistical procedure based on weighted least squares was used to estimate trend lines relating the proportion defective vehicles to the age of the vehicle. This approach was also used in the detailed analysis of the comparison of the wheel pull to the moving stopping test. It is described briefly below.

For purposes of analysis, the data can be regarded as independent binomial response variables representing the number of failures within each of the seventeen specified vehicle age categories. Since neither the failure rates nor the sample sizes are constant across the vehicle ages, the estimates of variance associated with these failure rates are unequal. As a result, the regression equation parameters can be estimated by a weighted least squares algorithm such as the computer program GENCAT discussed in Landis, et. al.[1] Within this framework, the probability vector $\underline{p}$ is the 34 x 1 vector of observed proportions associated with the frequencies in Table To avoid matrix singularities, cells with entries of zero were changed to 0.5. Then the function vector of interest is the 17 x 1 vector of failure rates.

$$\underset{\sim}{y} = \underset{\sim}{F}(\underset{\sim}{p}) = \underset{\sim}{A}\underset{\sim}{p}$$

where $\underset{\sim}{A} = (0\ 1) \otimes \underset{\sim}{I}_{17}$, $\otimes$ denotes Kronecker product of matrices and $\underset{\sim}{I}m$ is the m x m identity matrix.

We are now interested in using the vector of failure rates $\underset{\sim}{y}' = (p_1, p_2, \ldots, p_n)$ and its symmetric variance-covariance matrix $\underset{\sim}{V}$ to fit a regression model via weighted least squares. The elements of $\underset{\sim}{V}$ are computed as follows:

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[1] Landis, J. Richard, W.M. Stanish, and Gary G. Koch: A Computer Program for the Generalized Chi-Square Analysis of Categorical Data Using Weighted Least Squares to Compute Wald Statistics (GENCAT), Biostatistics Technical Report No. 8, Dept. of Biostatistics, Univ. of Michigan, Ann Arbor, Michigan February 1976.

$$v_{ij} \begin{cases} 1/n_i \; p_i(1-p_i) \quad , & \text{if } i = j \\ 0, & \text{if } i \neq j \end{cases}$$

for i,j = 1, 2, ..., 17. The regression model is of the form $E\{y\} = \underset{\sim}{X}\underset{\sim}{B}$ where $\underset{\sim}{B}$ is the t x 1 vector of coefficients and $\underset{\sim}{X}$ is the s x t design matrix. The value of t is the number of coefficients (or effects) to be estimated in the model. Accordingly, the vector of estimated coefficients can now be calculated by

$$\underset{\sim}{\hat{B}} = (\underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{X})^{-1} \; \underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{y}.$$

Moreover, the estimated variance-covariance matrix of these parameter estimates is given by

$$\underset{\sim}{V}_{\underset{\sim}{\hat{B}}} = \underset{\sim}{A}\underset{\sim}{V}^{-1} \; \underset{\sim}{A}' = (\underset{\sim}{X}'\underset{\sim}{V}^{-1} \; \underset{\sim}{X})^{-1}.$$

We can now generate the vector of fitted failure rates $\underset{\sim}{\hat{y}} = \underset{\sim}{X} \; \underset{\sim}{B}$ together with their estimated variance-covariance matrix

$$\underset{\sim}{V}_{\underset{\sim}{\hat{y}}} = \underset{\sim}{X}(\underset{\sim}{X}' \underset{\sim}{V}^{-1} \; \underset{\sim}{X})^{-1} \; \underset{\sim}{X}'.$$

A lack of fit statistic associated with this regression model can be obtained by computing

$$\begin{aligned} Q &= SSE = SSTO - SSR \\ &= \underset{\sim}{y}'\underset{\sim}{V}^{-1} \; \underset{\sim}{y} - \underset{\sim}{B}'\underset{\sim}{X}'\underset{\sim}{V}^{-1} \; \underset{\sim}{y} \end{aligned}$$

which has a Chi-square distribution with 17-t degrees of freedom under the assumption that the model is apt. If Q is non-significant (the model fits) then specific model effects can be tested. Otherwise, if Q is significant, the tests for specific effects are meaningless and another model should be tried.

Tests for the specific effects can be conducted using contrast matricies. The hypotheses for these tests take the form: $H_o: \underset{\sim}{C}\underset{\sim}{B} = \underset{\sim}{0}$, where $\underset{\sim}{C}$ is a c x t contrast matrix which selects the desired effects to be tested from $\underset{\sim}{B}$. The test statistic thus can be derived as

$$\underset{\sim}{Q_m} = (\underset{\sim}{C}\underset{\sim}{\hat{B}})'(\underset{\sim}{C}(\underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{X})^{-1}\underset{\sim}{C}')^{-1}\ (\underset{\sim}{C}\underset{\sim}{\hat{B}})$$

which tests the amount Q would be increased if the constraints implied by $\underset{\sim}{C}$ were not in the model. Finally an analogue to the multiple R^2 in standard regression analysis can be calculated as

$$R^2 = SSR\ /\ SSTO = Q_m /\ (Q + Q_m)$$

when the statistic Q_m tests for all effects to be simultaneously zero.

For our example, we wish to examine the fit of three different polynomial models to the data: linear, quadratic, and cubic. The models used and the coefficient matrices are as follows:

$$\begin{array}{ll}
Y = B_o + B_1X + e & \underset{\sim}{B}' = (B_o, B_1) \\
Y = B_o + B_1X + B_2X^2 & \underset{\sim}{B}' = (B_o, B_1, B_2) \\
Y = B_o + B_1X + B_2X^3 + e & \underset{\sim}{B}' = (B_o, B_1, B_2, B_3)
\end{array}$$

with t = 2,3,4 respectively. The design matrices used for the regression are all derived from the matrix used for the cubic regression:

$$\underset{\sim}{X}_c = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 \\ 1 & 2 & 4 & 8 \\ 1 & 3 & 9 & 27 \\ 1 & 4 & 16 & 64 \\ 1 & 5 & 25 & 125 \\ 1 & 6 & 36 & 198 \\ 1 & 7 & 49 & 343 \\ 1 & 8 & 64 & 512 \\ 1 & 9 & 81 & 729 \\ 1 & 10 & 100 & 1000 \\ 1 & 11 & 121 & 1331 \\ 1 & 12 & 144 & 1728 \\ 1 & 13 & 169 & 2179 \\ 1 & 14 & 196 & 2744 \\ 1 & 15 & 225 & 3375 \\ 1 & 16 & 256 & 4096 \end{bmatrix}$$

The design matrix for the linear model is the 17 x 2 matrix consisting of the first two columns of X_c and that of the quadratic the 17 x 3 matrix of the first three columns.

A test for the slope of zero in the model with only the linear term is done with a contrast matrix $\underset{\sim}{C}_1 = (0\ 1)$. The contrast matrix for the test that both the linear and quadratic effects are zero (SSR) is

$$\underset{\sim}{C}_2 = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

with specific effects tested by the two 1 x 3 matrices consisting of the individual rows of C_2. Finally, for the cubic model the test that the simultaneous effects are zero (SSR) is obtained by using the contrast matrix

$$\underset{\sim}{C}_3 = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

with specific effects tested by the individual rows of $\underset{\sim}{C}_3$.

The results of this analysis (Table C-1) indicate that although the cubic equation gives the best fit ($R^2 = 0.9975$), the individual cubic effect is non-significant so a quadratic model is more appropriate. The final model with estimated proportions and standard errors, observed proportions, and residuals is given in Table C-2.

It was also hypothesized that there might be a linear trend over a reduced range of the data, namely the ages 0 to 11 years. In a similar manner as before, the design matrix became the first twelve rows of the previous design matrix with the appropriate columns corresponding to the linear and quadratic effects. The results of this regression (Table C-2) again imply that the quadratic model is the most appropriate. The observed proportions, estimated proportions, and standard errors, and residuals are given in Table C-4.

Although point estimates of the three conditional probabilities that are of primary interest can be easily derived from the data, interval estimates were also desired. Thus the eight possible brake inspection outcomes and their frequencies were arranged as in Table two. The covariances of the means of the first four categories were derived from their multi-nomial structure. The means and their covariances were then combined to yield the three estimates of the probability that a serious brake defect will be discovered by a wheel pull inspection for vehicles that had passed the stopping test and their variances. The multivariate Hotelling's T statistic was then used to yield three simultaneous confidence intervals of the appropriate width.[1]

Point estimates of the three conditional probabilities that a serious brake defect will be discovered by a stopping test for vehicles that had passed the wheel pull inspection were derived in table three. The Bonferroni procedure was used to obtain three simultaneous confidence intervals of the appropriate width.[2]

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[1] Harris, Richard J. A Primer of Multivariate Statistics. New York: Academic Press, Inc. 1975, p. 73.

[2] Neter, John and Wasserman, William. Applied Linear Statistical Models. Homewood, Illinois: Richard D. Irwin, Inc. 1974 p. 147.

Table C-1

Fitted Models for the Total Vehicle, Complete Range

Model: $Y = B_0 + B_1X + e$

Parameters	Estimated Parameters	Standard Error
B_0	0.1185	0.006354
B_1	0.07697	0.001053

Source	d.f.	X^2	p	
Regression	1	5344.66	0.0000	
Error	15	441.56	0.0	$R^2 = 0.92369$

Model: $Y = B_0 + B_1X + B_2X^2 + e$

Parameters	Estimated Parameters	Standard Error
B_0	-0.01765	0.009167
B_1	0.14853	0.003629
B_2	-0.00588	0.000285

Source	d.f.	X^2	p	
Regression	2	5769.18	0.0	
Linear	1	1674.97	0.0	
Quadratic	1	424.53	0.0	
Error	14	17.04	0.254	$R^2 = 0.99706$

Model: $Y = B_o + B_1X + B_2X^2 + B_3X^3 + e$

Parameters	Estimated Parameters	Standard Error
B_0	-0.03117	0.012650
B_1	0.16015	0.008324
B_2	-0.00798	0.001382
B_3	0.00010	0.000065

Source	d.f.	X^2	p	
Regression	3	5771.59	0.0	
Linear	1	370.14	0.0	
Quadratic	1	33.32	0.0	
Cubic	1	2.41	0.1209	
Error	13	14.63	0.3309	$R^2 = 0.99747$

Table C-2

OBS & Fitted Values under Full Range Quadratic Model

Observed	Predicted	s.e.	Residual
0.18182	-0.017649	0.009167	0.035831
0.113930	0.12500	0.006506	-0.011067
0.25608	0.25589	0.004873	0.000194
0.37888	0.37502	0.004397	0.003858
0.49650	0.48239	0.004670	0.014104
0.59025	0.57800	0.005191	0.012247
0.63507	0.66185	0.005552	-0.026784
0.73607	0.73394	0.005706	0.002130
0.88080	0.79427	0.005743	0.006532
0.84420	0.84244	0.005903	0.001363
0.88571	0.87965	0.006547	0.006065
0.89630	0.90470	0.007983	-0.008402
0.87500	0.91799	0.000299	-0.042988
0.86792	0.91952	0.013433	-0.051593
0.90476	0.90929	0.017304	-0.004525
0.96000	0.88730	0.021852	0.072704
0.95238	0.85355	0.027039	0.098835

Table C-3

Fitted Models for the Reduced Range, Total Vehicle

Model: $Y = B_0 + B_1X + e$

Parameters	Estimated Parameters	Standard Error
B_0	0.088318	0.006653
B_1	0.085708	0.001199

Source	d.f.	X^2	p	
Regression	1	5107.29	0.0	
Error	10	206.16	0.0	$R^2 = 0.96120$

Model: $Y = B_0 + B_1X + B_2X^2 + e$

Parameters	Estimated Parameters	Standard Error
B_0	-0.02183	0.010287
B_1	0-15099	0.004802
B_2	-0.00609	0.000434

Source	d.f.	X^2	p	
Regression	2	5304.36	0.0	
Linear	1	988.51	0.0	
Quadratic	1	197.06	0.0	
Error	9	9.10	0.4281	$R^2 = 0.99829$

Table C-4

Observed and Fitted Values Under the Quadratic Model, Reduced Range

Observed	Predicted	s.e.	Residual
0.01818	-0.02182	0.010287	0.040010
0.11393	0.12307	0.006765	-0.009132
0.25608	0.25578	0.004885	0.000307
0.37888	0.37631	0.004764	0.002571
0.49650	0.48466	0.005417	0.011840
0.59025	0.58082	0.005951	0.009427
0.63507	0.66480	0.006084	-0.029738
0.73607	0.73661	0.005899	-0.000535
0.88080	0.79623	0.005823	0.004577
0.84420	0.84366	0.006637	0.000541
0.88571	0.87892	0.008910	0.006798
0.89630	0.90199	0.012595	0.005692

Table C-5
Brake Inspection Analysis

	Analysis Categories*								
Police	+	+	+	+	-	-	-	-	
HSRI 1	+	-	+	+	+	-	+	+	
HSRI 2	+	-	-	+	+	-	-	+	
HSRI 3	+	-	-	-	+	-	-	-	
Total	1749	62	52	24	491	44	31	12	= 2465
	1887				578				

From Table C-5,

$$\underline{\overline{X}} = \frac{1}{1887}\begin{pmatrix}1749\\62\\52\\24\end{pmatrix} = \begin{pmatrix}0.927\\0.033\\0.027\\0.013\end{pmatrix}.$$

Let $x_i = \begin{cases} 1 & \text{if } x \text{ falls in the ith classification} \\ 0 & \text{otherwise} \end{cases}$

then $\operatorname{var}(\overline{X}_i) = \dfrac{p(X_i=0)\ p(X_i=1)}{n}$, $\operatorname{cov}(\overline{X}_i, \overline{X}_j) = \dfrac{-p(X_i=1)\ p(X_j=1)}{n}$,

so

$$S_{\overline{X}} = \begin{pmatrix} 3.592 & -1.614 & -1.354 & -0.625 \\ -1.614 & 1.684 & -0.048 & -0.022 \\ -1.354 & -0.048 & 1.420 & -0.018 \\ -0.625 & -0.022 & -0.018 & 0.665 \end{pmatrix} \times 10^{-5}.$$

Now,

$$\underline{p} = A\underline{\overline{X}},$$

where

$$A = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 \end{pmatrix},$$

and $\underline{p}$ = vector of proportions of interest

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* + denotes pass

\- denotes fail

The results are

$P_1 = 0.033$, $\quad \text{var}(P_1) = (4.104 \times 10^{-3})^2$,

$P_2 = 0.060$, $\quad \text{var}(P_2) = (5.485 \times 10^{-3})^2$,

$P_3 = 0.073$, $\quad \text{var}(P_3) = (5.993 \times 10^{-3})^2$,

where $\text{var}(P_i) = \underline{a}_i \, S_{\bar{x}} \, \underline{a}_i'$.

The joint

95% confidence interval width = $T_{\text{critical}} \sqrt{\underline{a} \, S_{\bar{x}} \, \underline{a}'}$.

Using this one

$0.020 \leq P_1 \leq 0.046$

$0.043 \leq P_2 \leq 0.077$

$0.054 \leq P_3 \leq 0.091$

for the joint 95% confidence intervals.

Here,

$$T_{\text{critical}} = \sqrt{\frac{F(.95;P,N-P)\ P(N-1)}{N-P}}$$

$T_{\text{critical}} = 3.088$ $\quad$ $P = 4$

$N = 1887$

Table C-6

$H_1 = 0.226$ var $(H_1) = (8.61 \times 10^{-3})^2$

$H_2 = 0.221$ var $(H_2) = (8.69 \times 10^{-3})^2$

$H_3 = 0.219$ var $(H_3) = (8.74 \times 10^{-3})^2$

where $\text{var}\ (H_i) = \dfrac{p(H_i=0)\ p(H_i=1)}{n_i}$

95% confidence interval width = Z critical $\sqrt{\text{var}(H_i)}$

$0.205 \leq H_1 \leq 0.247$ $Z(0.9917) = 2.395$

$0.200 \leq H_2 \leq 0.242$

$0.198 \leq H_3 \leq 0.240$