EFFICACY OF JURISDICTION-WIDE TRAFFIC CONTROL DEVICE UPGRADINGS

FINAL REPORT

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ABSTRACT

An evaluation of several jurisdiction-wide traffic control device upgradings in Michigan was undertaken. A "before-after with control" experiment design was employed in the examination of general accident distribtuions and a more detailed distribution of vehicle-vehicle accidents. Results in regard to assessing the overall effectiveness of TCD upgradings on a jurisdiction-wide basis were mixed at best. The general variability of accident statistics and the fact that most sites in a jurisdiction have only minor, if any, problems tend to overwhelm potential positive results at sites where there may be significant improvements. It is suggested that "safety-effectivness" studies are more appropriate at lower levels of aggregation.

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INTRODUCTION

Over the years Michigan has spent considerable amounts of federal funds to undertake sign inventories/analyses and then to upgrade traffic signs as a direct results of these inventories. This has been done in order to meet compliance with both state and federal uniform manuals. Over the past few years federal funds for upgrading signs have diminished. However, the Michigan Office of Highway Safety Planning (OHSP) has continued to support the funding of sign inventories. Since the OHSP recognized that Section "402" Federal Funds utilized to do so are of themselves quite limited, it was decided to undertake an evaluation which would look at whether such efforts actually resulted in reduced traffic accidents or, more importantly, casualties resulting from such accidents.

Thus, the study described herein was undertaken by Michigan State University with the objective of quantifying the safety-related impacts of comprehensive sign upgradings in several jurisdictions of varying size in Michigan. The study was sponsored by the OHSP of the Michigan kDepartment of Sate Police in cooperation with the Federal Highway Administration.

Federally-supported programs for inventorying and subsequently upgrading traffic control devices (TCDs) within specific local jurisdictions have long been thought of as effective investments in highway safety. The purpose of such an upgrading is to bring all TCDs and and their placement into compliance with the *Manual on Uniform Traffic Control Devices.* Although there are numerous studies on the effectiveness of specific devices at specific locations, there are few which have been explicitly concerned with the evaluation (in terms of safety measures) of jurisdiction-wide programs.

Michigan is well-suited for the undertaking of a study on the effectiveness of TCD upgradings (or other safety programs) because of its reasonably extensive and reliable machine-accessible accident file. Regardless of the jurisdiction, a common accident report form (UD-10) must be filed with the Michigan State Police (MSP), coded, and entered in a central system maintained by MSP. The report contains information about the physical description of the accident, the involved vehicles, the accident site, the drivers and passengers, as well as other descriptive information (e.g., geo-coding, dates). For the analysis that was undertaken, approximately twelve years of data were used (1972 through 1983).

There are two more-or-less fundamental approaches to undertaking such an evaluation: a simple "before and after" comparison and analysis of safety statistics; or a comparison of jursidictions that had TCD upgradings with "control" jurisdictions which did not have such upgradings (i.e., a comparison of "treated" vs. "untreated" jurisdictions). The approach that was chosen in this study would best be described as a "before and after study with limited control" - that is, a combination of the two general approaches.

The measures of effectiveness adopted concerned the distribution of accidents by general type (e.g., vehicle-vehicle collisions, vehicle with fixed object), the distribution of multi-vehicle accidents by type of collision (e.g., rear-end, angle, turning), the absolute number of accidents, and the severity of accidents. That is, did the TCD upgradings have any apparent impact on these safety (accident) measures.

The experiment design, the analysis, and the results are all discussed in more detail in the following sections.

METHODOLOGY

The basic approach to the study was to select several jurisdictions which had undertaken TCD upgradings and identify the safety-related impacts, if any, of those upgradings. There are several aspects of the general methodology that should be mentioned.

ALTERNATIVE EXPERIMENT DESIGNS

As indicated in the introduction, for a study where the jurisdiction itself is the basic analysis unit, there are two basic approaches for the experiment design: a before and after study of the "treated" jurisdictions; and a comparison of treated vs. untreated (control) jurisdictions. Each approach has certain advantages and disadvantages - the attempt was to develop a design which would capitalize on the best attributes of each approach while being responsive to their weaknesses or constraints. The before-after design has the advantage of reasonable consistency of, for example, socio-economic and other potentially confounding factors (e.g., the "users" of the system are reasonably consistent) while the treated-control design has the advantage of providing an explicit basis for adjusting for general background trends. Disadvantages of the treated-control comparison include difficulty in identifying a control jurisdiction that precisely "matches" a treated jursidiction, and more data are required for the analysis.

SELECTED EXPERIMENT DESIGN

Given the foregoing, a design was selected which capitalized on the advantages of each of the two approaches: the study was based on a "before and after with modified control" design. The modified control consisted of comparing treated and untreated streets in each jurisdiction - the latter being state trunklines (i.e., numbered state routes) ineligible for TCD upgrading project funds. Thus, a control is provided which has the advantage of being "internal." A potential problem not addressed is that there may be differences between the kinds of accidents that occur on state trunklines and the local city street system. This point notwithstanding, the impacts of many other confounding factors are avoided by using streets which have the same variations in weather conditions and other external factors over the analysis period. In addition, the control is provided without data being required from another jurisdiction. For each jurisdiction in the analysis, one or more before periods and an after period (all of equal duration) were identified.

MEASURES OF EFFECTIVENESS

The next step was to identify the measures of effectiveness and collect the appropriate data. The measures of effectiveness (MOEs) were based on the distribution and numbers of accidents in each jurisdiction. More specifically, the MOEs included the following:

1. <u>The distribution of accidents by general type</u>. For example, is there a shift between vehicle-vehicle collisions and vehicle-fixed object collisions? Examination of the before-after statistics for the control streets (state trunklines) would generally

establish whether there were shifts among general accident categories. Having established this baseline, the shifts on the treated streets (the local system which actually had the benefit of a TCD upgrading program) could be examined - with some caveats. If there was a shift for this group of streets (and none for the control), it could be reasonably concluded that the shift was due to the upgrading project.

2. The distribution of vehicle-vehicle collisions. For example, is there a shift between multi-vehicle rear-end and angle collision accident types? Again, the comparison proceeds from a consideration of what happened on control streets to what happened on treated streets.

Evidence of the above shifts for treated and control streets within jurisdictions is useful information in itself, but there are at least two other aspects of the shift which are also important.

3. The total number of accidents. Given that equal duration before and after periods were defined for each jurisdiction, absolute comparisons of the total number of accidents and the number of accidents in various categories can also be made. Comparisons between control and treated streets provide the basis for allocating the decreases (increases) in accidents per se or accident types to background variation or the TCD upgrading.

4. The severity of accidents. The above information is supplemented by a consideration of accident severity. For example, it is useful to know whether there was an increase in the severity of accidents as a result of the TCD upgrading - for example, there could be more, but less severe, occurrences in certain accident categories resulting from new TCDs.

APPROACH TO DATA ANALYSIS

The approach to data analysis was straightforward and consisted of three basic stages. The first was to identify all jurisdictions to be studied and select one as a "test case" - the latter to be examined in detail prior to undertaking the analysis on all jurisdictions. The latter selection was undertaken primarily as a cost consideration. Albion was chosen for this purpose based on the average number of accidents occurring in a year and the fact that 100% of the local system had been treated during an upgrading project.

The second level of analysis was concerned with the examination of the distributions of different characteristics of the accidents occurring in Albion - e.g., what age groups were involved, were there any contradictions among data that were purported to report the same information. This analysis provided a list of criteria for eliminating accidents which could confound the results from further consideration. In addition, this level of analysis was also directed to identifying any basic differences between accidents on trunklines (the control group) and those on the local street system (the treated group). For example, were the age distributions of accident-involved drivers the same for accidents occurring on local streets and trunklines. This analysis provided, in part, the basis for defining different groups of motorists/accidents on which the effects of TCDs might be apparent - for example, one group of accidents consisted of those occurring during the day in good weather where the driver of vehicle #1 was unimpaired, another group consisted of those where an impaired driver was involved in an accident at night in bad weather.

The third level of analysis was the actual comparison of the before group(s) with the after group for the treated streets and the comparison between control and treated groups as outlined above. Specific statistical tests and the results of the analysis are discussed in a later section.

SELECTION OF JURISDICTIONS

The selection of which jurisdictions would be analyzed was based on several criteria: the percentage of local streets (i.e., other than state trunklines) in the jurisdiction treated as part of the upgrading project; whether the project completion date allowed an adequate "after" period for analysis; and did the set of jurisdictions provide for a reasonable mix of population and geographical representation. There were also implicit economic considerations. There were several other "checks" of a somewhat more qualitative nature that were made on each jurisdiction - for example, did experience indicate that accident reports filed by the jurisdiction were typically dependable?

There were several problems with identifying the jurisdictions. One of the more serious was identifying exactly when the TCD upgrading project actually began and ended. For example, some of the projects were shown in records as having extremely short durations while others had official close-out dates that were clearly long after the work had actually been completed. Most of these vagaries were explainable but introduced some doubt as to precise specification of when projects actually started and ended. In the end, only those jurisdictions where the project's start and end dates could be specified with reasonable accuracy were included in the analysis.

Thirteen jurisdictions were chosen, and they are shown in table 1 along with some of the pertinent information about each.

TABLE 1 Jurisdictions Used in Analysis

Jurisdiction	Approximate Population	% of Streets Treated*1	Total # Accidents*2	Approx. Average Annual # Accidents
Kaleva	450	100	120	11
Martin	450	100	100	9
Freeport	480	100	105	10
Leonard	420	100	33	3
Vandalia	450	100	114	10
Mackinaw City	820	100	695	63
Dundee	2600	100	948	86
East Tawas	2600	100	1145	104
Hudsonville	4800	100	1034	94
Albion	11000	100	3657	332
Muskegon Heights	14600	70	6971	634
Mt. Pleasant	23750	84	7828	712
Pontiac	76700	86	64954	5412

NOTES

*1 The percentage reported is based on the approximate total local street system mileage (not counting trunklines).

*2 Total accidents = all accidents in file, not all used in analysis.

COLLECTION OF DATA

Several kinds of data were collected for each jurisdiction such as accident records as well as project start and end dates, jurisdiction population, and so forth. Other than the accident records the data were primarily used in the selection of the sample of jurisdictions to be analyzed. Once the jurisdictions had been identified, *all* of the accident records for each jurisdiction over the entire time period 1972 to 1983 were obtained from files maintained by the Michigan Department of Transportation (MDOT). (These files contain a somewhat shorter version of the complete accident record that is coded and maintained by MSP. Generally, the data that are eliminated from the longer record concern the "other" vehicles in a collision.

There were several problems encountered with the data - some which relate specifically to the data that were available and others which would likely be encountered in any study. The former were primarily concerned with the coding of the accident data and internal descrepancies. These problems are discussed in more detail in appendix I. The latter problems include: differentiating the effects of the TCD upgrading from general background accident trends across the state; isolating accidents that could realistically be expected to be affected by TCD upgradings from the general set of all accidents in a jurisdiction; identifying an appropriate "control" for each jurisidiction; and accounting for general occurrences like seasonal variation in accidents and user volumes, weather conditions, and so forth.

The resolutions of these problems as well as the results of the analysis are discussed in the sections that immediately follow.

DATA ANALYSIS AND RESULTS - TEST CITY

The data analysis was done in two fundamental phases - the first was an exploration of the data for Albion, the test city; and the second was concerned with applying the knowledge gained from the Albion investigation to the twelve other cities. The discussion in this section is broken into two parts: general description of the data; and presentation and discussion of the analysis results for Albion. The presentation and discussion of the results for the rest of the cities is left to the next section.

GENERAL DESCRIPTION OF THE DATA

As indicated above, the first phase of the analysis was concerned with Albion as a "test" city. The general examination of the data started with a review of the frequency distribution of the several variables available in the accident files. The rationale for this review was to make a basic determination of which "confounding" variables were of concern - in order to either a) eliminate some accidents from the analysis (e.g., accidents occurring in a construction zone) or b) provide the basis for data stratification (i.e., identification of specific groups such as separating [alcohol] impaired and non-impaired drivers).

Once the basic data were obtained from MDOT, the distributions of variables were examined for general reasonableness and the elimination of certain accidents. Table 2 shows the set of criteria that each accident had to meet in order

TABLE 2 Criteria for Eliminating Accidents from Analysis

Variable Name*1	Variable Definition	Accidents that Are Eliminated
MSPAT	MSP accident type	involving animals; other or unknown
D1A	Age of driver of vehicle #1	where driver <16 years old
VO1	Visual obstruction of driver of vehicle #1	where obstruction is in or on vehicle #1 (e.g., blocking vision through windshield)
CO1	Condition of vehicle #1	where condition of vehicle was contributing factor to accident (e.g., tire blowout)
TAG	Special tag	"special" circumstance accidents (e.g., occurred in a construction zone)
VT1	Vehicle type	where vehicle #1 is non-standard such as farm vehicle
RD	Road defect	where road defect is contributing factor (does not eliminate weather-related accidents)
C1	Condition of driver of vehicle #1	where "defect" is really vehicle related - e.g., load shift

NOTE

*1 Acronym used in analysis programs and report.

to be considered in the analysis. This initial analysis was largely qualitative in nature - e.g., examination of the frequencies of the occurences of different types of accidents. Selected cross-tabulations of the data were also reviewed in order to be reasonably certain that the data were dependable - e.g., did wet/icy pavement conditions occur during bad weather periods; were there snow days in July. Another principal purpose was to differentiate those accidents which could realistically be expected to be affected by the presence or absence of appropriate TCDs - for example, there were several accidents in each jurisdiction where the driver of vehicle #1 (the "at fault" vehicle) was not of age to be a licensed driver, in some instances accidents involved emergency vehicles (e.g., police cars giving chase). The idea being that in neither of these instances would it be likely that TCDs would have any impact on the accident occurrence.

Table 3 shows a few selected characteristics of Albion accidents. Care should be taken in interpreting these results - they are based on an early version of the Albion data (in the original file 1972-1982 data were available, while in a later file 1972-1983 data were available) and later information may vary slightly. For illustrative purposes however, these earlier data are acceptable. The table shows the distribution of all accidents after basic deletions were made in accordance with the goal of only considering those accidents where the TCDs could reasonably be expected to have an efffect.

In addition to eliminating certain accidents, the accidents were also stratified by assigning group designations. These were

TABLE 3 Selected Characteristics of Albion Accidents

Variable	% of Cases After Selection*1	Variable	% of Cases After Selection
Light condition		**Weather condition**	
Daylight	70	Clear/cloudy	76
Dawn/dusk	5	Fog	<1
Dark-lights	14	Rain	12
Dark-no lts.	12	Snow	12
Unknown	<1*2		
Driver 1 circumstance*3		**Driver 1 drinking?**	
DUIL or drugs	2	Yes	13
Reckless	2	No	87
Ill, fatigued	2	Unknown	<1
Lic. restrict	<1		
Obscured vision	3	**Vehicle 1 type**	
Load shift	<1	Passenger car	85
None	9	Truck	14
Skidding	8	Motorcycle	1
Other/unknown	74	Bus	<1
MSP accident type (MSPAT)		**Highway accident type (HWYAT)**	
Overturned	<1	Head-on	2
w/train	<1	SS-same dir	2
w/parked veh	20	SS-opp dir	1
w/another veh	36	Angle	25
w/pedestrian	1	Left turn	9
w/fixed obj	11	Right turn	4
w/bike	2	Rear end	18
w/other obj	<1	Back into	3
		Parking	3

NOTES

*1 some accidents were eliminated because they could not be affected by TCD improvements and/or because they occurred during the project implementation period

*2 percentages may add up to slightly more or less than 100% because of rounding

*3 "Driver 1 circumstance" and "driver 1 drinking" are complementary descriptors - with the exception of the drinking driver the first provides more detail; the distinction between DUIL and "drinking" is that DUIL represents a related citation and "drinking" does not.

not necessarily mutually exclusive (i.e., an accident could be classified into more than one group). The purpose of the group designation was not to eliminate accidents but to stratify them according to certain common characteristics of interest (and which might also confound the analysis) - for example, the drunk or otherwise drug-impaired drivers were separated from the non-impaired drivers for potential separate analysis. The reason being that the reaction of drunk driver to TCDs may be different than the reaction of the non-impaired driver. Indeed, failure to separate the drunk drivers may confound the effects of the TCDs. The group specifications are shown in table 4. The sample size for each group is shown for Albion for illustrative purposes. It should be noted that in many instances, the groups have too few members to allow meaningful analysis. For larger cities, such as Pontiac, some of the smaller groups may have more significance.

The third step prior to beginning the final analysis was the identification of before and after periods for each of the test cities. First, using records maintained by MDOT, the project duration was identified for each city. As the study evolved, several different definitions for the periods were used. The initial definition (for Albion only) of before and after periods was based solely on whether an accident was before or after the project per se. Hence, the before period was typically of substantially longer duration. A subsequent definition (again, only for Albion) was based on the length of time from the close-out date of the project to the date of the most recent data (the after period) that were available (initially 1982). Once the "after" period was identified, one (or more) before periods of

TABLE 4 Characteristics of Accident/Driver Groups*1

Group Number	Differentiating Characteristics (n = number in group for Albion as example)
1	Good weather, day, dry pavement, straight*2, unimpaired drivers, cars only (n=920)
2	As 1 except trucks only (n=199)
3	As 1 except motorcycles only (n=19)
4	As 1 except night*3 (n=180)
5	As 4 except street lights are present (n=96)
6	As 4 except no street lights are present (note that groups 5 and 6 are mutually exclusive subsets of group 4) (n=84)
7	As 1 except impaired drivers only (n=46)
8	Bad weather, day, wet/icy pavement, straight, unimpaired drivers, cars only (n=362)
9	As 8 except night (n=119)
10	Bad weather, night, wet/icy pavement, straight, impaired drivers, cars only (n=56)
11	As 1 except all vehicles (n=1138)
12	As 11 except night (n=199)
13	Bad weather, night, wet/icy pavement, straight, unimpaired drivers, all vehicles (n=136)
14	As 1 except curves only (n=10)
15	Combines 1 and 14 (n=930)
16	Impaired drivers only (no other modifiers) (n=388)

NOTES

*1 Groups are not necessarily mutually exclusive - i.e., an accident can belong to more than one group

*2 Straight is a descriptor of the road alignment (i.e., vs. curve)

*3 Night includes accidents that occurred either in the presence or absence of street lights equal duration was (were) defined. This approach led to periods of different length for each project. Later, the criterion for defining the length of the periods was changed to a common three years. While the three year periods are equal in length they do not contain data for the same precise time periods (due to different projects occurring during different years). The advantage of the equal before and after periods is that both relative and absolute comparisons of the number of accidents can be made. Analysis was done for Albion using both types of definitions for the before and after periods while for the other cities only the three-year definitions were used.

DISCUSSION OF THE ANALYSIS FOR ALBION

As indicated earlier, Albion was chosen for the preliminary analysis because all of the local street system was treated under the TCD project; it had a reasonably large number of accidents per year, but not so large as to incur high analysis costs; and there were no known problems with the accident data. As it turned out later, the general accident reduction trend for Albion was somewhat atypical although that does not invalidate any of the analysis that was done.

Basic Analytical Approach

The fundamental analytical approach taken was to compare accident statistics before and after the project was undertaken. The statistical technique was chi-square testing to evaluate whether the before and after distributions of, say, accidents (MSP accident type [MSPAT] - see table 3) or other variables were the same. This was augmented with other testing as appropriate. There was also a before-after comparison for the "control" (untreated) streets. In general, the analysis proceeded as follows: for a specific variable (say MSPAT) a before-after comparison was made for the control streets (which were the state trunklines and ineligible for treatment); and then the same comparison was made for the treated streets. If the data were "well-behaved" and the TCD upgrading was effective, the following results could be expected (for MSPAT): for the state trunklines (the control) a net decrease in accidents in all categories might be observed although the before-after distribution would be proportionately the same; and, for the city streets (the treated group) there would be larger decreases accompanied by shifting among the categories.

The initial before-after analysis used a definition that grouped all accidents as either before, after, or during the actual project period. Hence, the before period was a much longer time period since the project was relatively recent. Table 5 illustrates two of the numerous comparisons that were undertaken to ensure that there were not radical problems with the data.

The first variable illustrated is weather condition. One would expect that there would be few differences in the distributions of accidents by weather category regardless of making before-after or treated-control comparisons. Both qualitative and statistical comparisons of the data in table 5 show that this is indeed the case. Qualitatively, this is illustrated by reviewing the percentages (in parentheses) of the accidents occurring when the weather was clear/cloudy - the percentage hovers around 77% regardless of whether one examines accidents on local streets or trunklines, or before or after the project.

Statistically, a chi-square comparison based on the frequency counts was conducted. Ignoring the "fog" category as being inconsequential, the chi-square values are shown immediately below the distributions in the table. The small chi-square value shows that there is not much difference between the distributions taken in a pair-wise fashion (except (1) vs. (3) where a marginal difference is noted). From this sort of analysis one could come to the conclusion that any variations in accident statistics that may be found later are probably not due to variation in weather conditions.

Other variables which reflect environmental, accident, driver, and vehicle characteristics were examined in a similar manner to determine which variables should be used to exclude certain accidents from analysis; should form the basis for defining group stratifications; or could legitimately be ignored as a potentially confounding variable in the analysis. This type of analysis led to the specification of accidents to be eliminated (table 2) and groups (table 3).

In general, it was found that weather conditions, driver age characteristics, and the other variables listed in table 2 were reasonably similar between the treated and untreated portions of the system.

The second variable shown in table 5 is MSPAT which is of considerable interest as it is one of the fundamental variables that can be used to evaluate safety impacts of the TCD upgradings.

The "testing" is basically the same as just described for weather condition. In this instance, however, if the TCD projects had some identifiable impact, "positive" results would be variations in the percentages of accidents in different categories and higher values of the chi-square statistic.

The results for MSPAT are, unfortunately, not as "good" as those for weather condition. Indeed, on a qualitative basis (examining the percentages) there does not seem to be much variation in the before-after comparisons for either the treated or control groups. This is a positive result insofar as the control group is concerned, but a negative result for the treated group. It can further be seen that the distributions for treated (local streets) and control (state trunklines) groups are different in both the before and after period - a not unexpected result.

Other Albion Results - General Distribution of Accidents (MSPAT)

As noted, there were several different definitions for the before and after periods used at various stages of the analysis. Table 5 incorporated the initial, very broad definition - all before accidents vs. all after accidents - which allowed for unequal durations of the two periods. A more refined definition (used for most of the initial analysis of the Albion data) was based on the duration of the after period as a common time length which was, in turn, used to define several before periods. This allowed for additional testing of variations in the accident distributions and so forth.

Table 6 shows the results for Albion for group 1 (representing the "best" conditions and drivers - see table 4) for the variable MSPAT. There are four sections in the table, one for each of four pairwise time period comparisons (e.g., immediately

TABLE 5 Sample Before-After-Control Comparisons for Albion

Variable = Weather Conditions

Category	Local Streets (Treated) Before (1)	Local Streets (Treated) After (2)	State Trunklines (Untreated-Control) Before (3)	State Trunklines (Untreated-Control) After (4)
Clear/cloudy	1209 (76.6)	175 (78.8)	841 (75.4)	116 (77.9)
Fog	4 (0.3)	0 (0.0)	1 (0.0)	1 (0.7)
Rain	178 (11.3)	20 (9.0)	146 (13.1)	17 (11.4)
Snow	188 (11.9)	27 (12.2)	127 (11.4)	15 (10.1)

Chi-square information (note that tests were on 3X2 tables):

(1) vs. (2): Statistic = 1.044; p = .593
(3) vs. (4): Statistic = 0.594; p = .743
(1) vs. (3): Statistic = 2.061; p = .357
(2) vs. (4): Statistic = 0.231; p = .891

Variable = MSP Accident Type (MSPAT)

Category	Local Streets (Treated) Before (1)	Local Streets (Treated) After (2)	State Trunklines (Untreated-Control) Before (3)	State Trunklines (Untreated-Control) After (4)
Overturned	8 (0.5)	0 (0.0)	3 (0.3)	2 (1.3)
w/train	5 (0.3)	0 (0.0)	0 (0.0)	1 (0.7)
w/parked veh	426 (27.0)	61 (27.5)	126 (11.3)	10 (6.7)
w/other veh	875 (55.4)	131 (59.0)	862 (77.3)	118 (79.2)
w/pedestrian	18 (1.1)	0 (0.0)	22 (2.0)	4 (2.7)
w/fixed obj	203 (12.9)	26 (11.7)	83 (7.4)	11 (7.4)
w/other obj	3 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)
w/bike	41 (2.6)	4 (1.8)	19 (1.7)	3 (2.0)

Chi-square information (note that tests were on 4X2 tables):

(1) vs. (2): Statistic = 5.740; p = .125
(3) vs. (4): Statistic = 4.986; p = .173
(1) vs. (3): Statistic = 155.550; p = <10 (-6)
(2) vs. (4): Statistic = 32.874; p = <10 (-6)

before the project with immediately after the project - B1-A; the immediately before period with the preceeding before period - B2-B1). This allows examination of not only the before-after time periods which should be of most interest, but also whether there were other variations over time (i.e., well before the project) which allows a judgement to be made as to whether the variation between the before and after periods was similar to past variations. (For example, was a decrease in accidents between the before and after periods significant or merely an extension of a trend starting earlier?)

While there are more MSPAT categories (see table 3) than shown in table 6, the two illustrated are of most interest (accounting for over 80% of the accidents - see table 5). Examination of the first line of data shows that accidents with parked vehicles on (untreated) trunklines (STL) decreased both in actual frequency (6 to 1) and as a percentage of the total number of accidents (5 to 1). On the other hand, on the (treated) local street system (LOC) such accidents represented an increased percentage (22 to 28) while there was a decrease in actual number (24 to 19). Further, vehicle-vehicle collisions (neither vehicle parked) decreased on the STL system in frequency but increased as a percentage of the total. The results for such accidents on the LOC system was similar. The percentage decrease in vehicle-vehicle accidents on the STL system was 24%, while it was 35% on LOC. These results would lend tentative support to the notion that the TCD upgrading may have had some positive effect, at least in an absolute sense.

Examination of the chi-square statistics indicates that the

TABLE 6 Summary of Selected Albion Results for MSPAT, Group 1

Street System	Comparison Time Period	Comparison Accident Type	% Shift Within Category*1	No. of Accs in Cat	% incr (decr)	Total Accs
STL	B1-A	w/pkd veh	5-1	6-1	-83	111
LOC	B1-A	w/pkd veh	22-28	24-19	-21	174
STL	B1-A	veh-veh	82-87	53-40	-24	111
LOC	B1-A	veh-veh	64-66	68-44	-35	174
		STL: chi-square = 5.291; p = .38*2				
		LOC: chi-square = 3.059; p = .22*3				
STL	B2-B1	w/pkd veh	16-6	15-9	-40	171
LOC	B2-B1	w/pkd veh	29-22	36-24	-35	233
STL	B2-B1	veh-veh	76-82	80-53	-34	171
LOC	B2-B1	veh-veh	62-64	78-68	-15	233
		STL: chi-square = 1.269; p = .53				
		LOC: chi-square = 2.644; p = .45				
STL	B3-B2	w/pkd veh	11-15	10-16	+60	200
LOC	B3-B2	w/pkd veh	22-29	22-36	+67	228
STL	B3-B2	veh-veh	83-76	80-78	- 3	200
LOC	B3-B2	veh-veh	68-62	69-78	+13	228
		STL: chi-square = 1.140; p = .57				
		LOC: chi-square = 1.464; p = .48				

continued

TABLE 6 Continued

Street System	Comparison Time Period	Comparison Accident Type	% Shift Within Category	No. of Accs in Cat	% incr (decr)	Total Accs
STL	B4-B3	w/pkd veh	8-11	7-10	+43	187
LOC	B4-B3	w/pkd veh	24-22	27-22	-19	216
STL	B4-B3	veh-veh	87-83	81-78	- 4	187
LOC	B4-B3	veh-veh	65-68	74-69	- 7	216

STL: chi-square = .672; p = .72

LOC: chi-square = .186; p = .91

NOTES

For group definitions, see table 4; STL are state trunklines and LOC is local street system; A refers to after period, B1 is immediately before project, B2 is before B1, etc.; accident type is according to MSPAT, see table 3; total accidents include other accidents in remaining MSPAT categories.

See narrative for discussion of results.

*1 % Shift = the shift in percentage of all accidents in a specific category between the two time periods in question

*2 Chi-square statistics calculated using all cells

*3 Chi-square statistics calculated using only cells with >5 observations; all statistics without *2 calculated in this way also; using all cells results in somewhat lower chi-square statistics and higher p-values distribution of accidents in the MSPAT categories for both LOC and STL systems varied between the before and after periods - a result that indicates that the observed decrease on the LOC system may well have been more attributable to overall decreases and background variations than to the TCD upgrading (i.e., since the decrease occurred on both systems).

Further, examination of the comparisons of the earlier time periods (e.g., B2 with B1) shows that there had been some reduction in vehicle-vehicle crashes before the TCD upgrading. For example, comparing the two (before) time periods prior to the upgrading (B2 and B1) shows that on the STL system there was a 34% reduction and 15% on the LOC system. Results from still earlier comparisons show mixed results - accident increases for B3-B2, increases and decreases for the earliest comparison. The chi-square statistics indicate that there was some shifting among the MSPAT categories on both systems in all except the earliest comparison (B4-B3) where the distributions were similar especially for the LOC system.

Based on these results it is quite difficult to say whether the TCD upgrading had any substantial impact on accident statistics.

The somewhat erratic behavior noted above prompted the redefinition of the before and after time periods for the final analysis such that all periods were measured in three-year increments. This is consistent with generally accepted "rules" for studying accident frequency at individual sites - the idea being that some of the year-to-year variation will be dampened by using the longer period. This redefinition notwithstanding, additional (initial) results are presented immediately below for Albion with the same definition of before and after periods. (In later analyses, Albion was re-examined using the three-year definition.)

Table 7 illustrates some of the (MSPAT) results for other groups for Albion. The analysis was based on all relevant MSPAT categories although only the vehicle-vehicle crashes are explicitly shown. The statistics are based on the comparison of the entire distribution (often in truncated form for the purposes of calculating the chi-square statistic). Group 2 is composed of trucks only, group 4 consists of cars only at night, group 8 consists of day and bad weather/road conditions, and group 16 consists of impaired drivers (see table 4).

Although the sample sizes are small for group 2, it can be seen that for the before-after (B1-A) comparison both the percentages and absolute numbers of accidents decrease although somewhat more precipitously for the LOC system. The statistical measures also indicate that the overall MSPAT before-after distributions were somewhat more different for the LOC system than for STL. Comparing the two most recent before groups (B2-B1), it is seen that a similar, but less pronounced, absolute trend is apparent for the LOC system, but that statistically the distributions are somewhat more similar. This is a positive finding in regard to potential TCD effects.

Examination of the other time comparisons for group 2 indicates that, in general, the MSPAT distributions for the STL system were diverging over time while the opposite was true for the LOC system although the trend is not entirely consistent.

TABLE 7 Summary of Selected Albion Results for MSPAT (Other Groups)

Group	Street System	Comparison: Time Period	Comparison: Accident Type	Percentage Shift	Number of Accidents in Category	Total Accidents
2	STL	B1-A	veh-veh	69-50	11-7	30
		chi-square = 3.92; p = .56*[1]				
2	LOC	B1-A	veh-veh	46-18	12-2	37
		chi-square = 3.93; p = .27*[1]				
2	STL	B2-B1	veh-veh	61-69	11-11	34
		chi-square = 2.29; p = .51*[1]				
2	LOC	B2-B1	veh-veh	46-46	17-12	63
		chi-square = .93; p = .63*[2]				
2	STL	B3-B2	veh-veh	63-61	12-11	37
		chi-square = .44; p = .80				
2	LOC	B3-B2	veh-veh	55-46	11-17	57
		chi-square = .64; p = .73				
2	STL	B4-B3	veh-veh	68-63	13-12	38
		chi-square = .15; p = .99*[1]				
2	LOC	B4-B3	veh-veh	63-55	12-11	39
		chi-square = 3.10; p = .54*[1]				
4	STL	B1-A	veh-veh	89-91	8-10	20
		chi-square = 2.04; p = .36*[1]				
4	LOC	B1-A	veh-veh	25-25	6-2	32
		chi-square = 1.23; p = .94*[1]				
4	STL	B2-B1	veh-veh	65-89	11-8	26
		chi-square = 3.33; p = .34*[1]				
4	LOC	B2-B1	veh-veh	31-25	5-6	40
		chi-square = 4.49; p = .61*[1]				

continued

TABLE 7 Continued

Group	Street System	Comparison: Time Period	Comparison: Accident Type	Percentage Shift	Number of Accidents in Category	Total Accidents
8	STL	B1-A	veh-veh	83-90	19-18	43
		chi-square = 3.84; p = .28*1				
8	LOC	B1-A	veh-veh	78-72	31-13	58
		chi-square = 1.09; p = .58*1				
8	STL	B2-B1	veh-veh	79-83	30-19	61
		chi-square = .65; p = .88*1				
8	LOC	B2-B1	veh-veh	69-78	40-31	98
		chi-square = 1.89; p = .60*1				
16	STL	B1-A	veh-veh	53-56	17-9	48
		chi-square = 1.88; p = .39				
16	LOC	B1-A	veh-veh	30-29	16-7	77
		chi-square = 0.31; p = .86				
16	STL	B2-B1	veh-veh	48-53	14-17	61
		chi-square = 5.43; p = .14*1				
16	LOC	B2-B1	veh-veh	32-30	21-16	118
		chi-square = 0.09; p = .95				

NOTES

For group definitions, see table 4; STL are state trunklines and LOC is local street system; A refers to after period, B1 is immediately before project, B2 is before B1, etc.; accident type is according to MSPAT, see table 3; total accidents include other accidents in remaining MSPAT categories.

See narrative for discussion of results.

*1 Chi-square statistics calculated using all cells

*2 Chi-square statistics calculated using only cells with >5 observations; all statistics without *2 calculated in this way also; using all cells results in somewhat lower chi-square statistics and higher p-values

For group 4 (night), the trend on the LOC system is opposite that just reported - with the before-after comparisons indicating that the MSPAT distributions are similar. The distributions for the STL system are, however, different with vehicle-vehicle accidents increasing as a percentage. There is no particularly satisfying explanation (in regard to TCD upgrading) for why the STL distribution should be changing, nor any implicit reason why the TCD upgrading should cause the distribution to be the same for the LOC system. These unexplained reversals tend to pose problems in interpreting the results with respect to the impact of the TCD upgrading. It should, however, be noted that the sample sizes are even smaller for group 4 which no doubt contributes to the instability of the results.

Group 8 (bad weather/road conditions) shows that there was some increase in vehicle-vehicle collisions and a general change in the distributions (before and after) on the STL system - the reverse of the results on the LOC system. Compared to the earlier time period comparison, the results are somewhat similar for the STL system but the opposite for the LOC system.

For impaired drivers (group 16), there appears to be little difference in the MSPAT distributions for the LOC system although there is an absolute decrease in vehicle-vehicle and all other accidents. This is opposite to the results on the STL system where the distributions shifted and there were increases in vehicle-vehicle collisions in spite of an overall accident reduction.

In general then, the results in regard to MSPAT are varied - in some instances there appears to be potential support for the assertion that the TCD upgrading had a positive result, while in others there is no support. Given that the most important changes in accident statistics would likely be found in the distribution of vehicle-vehicle accidents, additional preliminary work was done on the variable HWYAT (see table 3 for categories).

Other Albion Results - Vehicle-Vehicle Accidents (HWYAT)

The results in table 8 are for HWYAT. Considering the before-after comparisons, on the LOC system there were more angle accidents, fewer left turn accidents, fewer rear end accidents, fewer parking accidents, and fewer accidents in all other remaining multi-car categories - all are consistent in terms of both percentages and absolute numbers. The results for the STL system differ primarily in rear end accidents where the accidents increased proportionately and absolutely.

The chi-square statistics indicate that the accident distributions on both the LOC and STL systems varied significantly between the before and after periods.

Again, the variation on both systems makes the interpretation of the results for the LOC system problematic at this point in the analysis - i.e., one would expect the STL distribution to remain the same with variation for the LOC system.

For the comparisons of the earlier before periods, the trends are somewhat different. For the more recent periods (B2-B1), the LOC and STL system shifts are similar with decreases in angle accidents (different from above), increases in left turn accidents (different from above), decreases in rear end accidents (different from above for STL), decreases in parking accidents (as above), and increases in "all other" categories (different from

TABLE 8 Summary of Selected Albion Results for HWYAT, Group 1

Street System	Comparison Time Period	Comparison Accident Type	% Shift Within Category	No. of Accs in Cat	% Incr (Decr)	Total Accs
STL	B1-A	angle	15-31	8-12	+50	92
LOC	B1-A	angle	31-67	21-29	+38	110
STL	B1-A	lt turn	26-13	13-5	-62	92
LOC	B1-A	lt turn	15-2	10-1	-90	110
STL	B1-A	rear end	15-26	8-10	+25	92
LOC	B1-A	rear end	10-9	7-4	-43	110
STL	B1-A	parking	13-13	7-5	-29	92
LOC	B1-A	parking	2-0	1-0	-100	110
STL	B1-A	all other	32-18	17-7	-59	92
LOC	B1-A	all other	42-21	28-9	-68	110
		STL: chi-square = 7.396; p = .193				
		LOC: chi-square = 13.791; p = .001				
STL	B2-B1	angle	25-15	18-8	-56	125
LOC	B2-B1	angle	32-31	22-21	- 5	136
STL	B2-B1	lt turn	13-25	9-13	+44	125
LOC	B2-B1	lt turn	12-15	8-10	+25	136
STL	B2-B1	rear end	32-15	23-8	-65	125
LOC	B2-B1	rear end	15-10	10-7	-30	136
STL	B2-B1	parking	10-13	7-7	-	125
LOC	B2-B1	parking	3-2	2-1	-50	136
STL	B2-B1	all other	21-32	15-17	+13	125
LOC	B2-B1	all other	39-42	27-28	+ 4	136
		STL: chi-square = 9.382; p = .095				
		LOC: chi-square = 1.450; p = .835				

continued

TABLE 8 Continued

Street System	Comparison: Time Period	Comparison: Accident Type	% Shift Within Category	No. of Accs in Cat	% Incr (Decr)	Total Accs
STL	B3-B2	angle	21-25	17-18	+ 6	152
LOC	B3-B2	angle	32-32	23-22	- 4	141
STL	B3-B2	lt turn	10-13	8-9	+13	152
LOC	B3-B2	lt turn	4-12	3-8	+167	141
STL	B3-B2	rear end	24-32	19-23	+17	152
LOC	B3-B2	rear end	17-15	12-10	-17	141
STL	B3-B2	parking	13-10	10-7	-30	152
LOC	B3-B2	parking	3-3	2-2	-	141
STL	B3-B2	<u>all</u> other	33-16	26-15	-42	152
LOC	B3-B2	<u>all</u> other	44-39	32-27	-16	141

STL: chi-square = 6.896; p = .440

LOC: chi-square = 3.979; p = .913

NOTES

For group definitions, see table 4; STL are state trunklines and LOC is local street system; A refers to after period, B1 is immediately before project, B2 is before B1, etc.; accident type is according to HWYAT, see table 3; total accidents include other accidents in remaining HWYAT categories.

See narrative for discussion of results.

above). Taken alone, the results for the LOC system could be interpreted as a TCD effect but the results for the STL system belie this.

The chi-square results indicate that there was substantial change in the accident distributions for the STL system, but much less for the LOC system - the latter being opposite the result reported above. The before-after comparison for rear end accidents would perhaps suggest that a TCD effect was a decrease in such accidents on the LOC system - however, examination of the shifts in the earlier before periods indicates that similar decreases had taken place earlier, discounting the TCD explanation.

Examination of the comparison of the earliest two time periods (B3 and B2), further confuses the interpretation - the patterns are different for both systems and somewhat inconsistent with those reported above.

Summary Comments - Albion Results

The interpretation of the Albion results is not straightforward - there appears to be considerable variation in the distributions of accidents on both the LOC and STL systems that is unrelated to the TCD upgrading. Trends that appear in one instance to be "favorable" (i.e., a "positive" TCD upgrading effect) are reversed in the next portion of the analysis or are seen to be possible extensions of earlier trends. Clearly, at this point no conclusion can be drawn with respect to the impact of the TCD upgrading - either in a positive or negative sense.

DATA ANALYSIS AND RESULTS - ALL CITIES

A review of the annual accident trends for several of the test cities shows that Albion was somewhat atypical with a sharper decreasing trend - see figures 1 and 2. As a result of the difficulties in interpreting the data from Albion, the before-after periods were defined for all cities with an uniform duration of three years to dampen the potential yearly fluctuations. In addition, a consideration of accident severity was also pursued. For the analysis of all cities, the same data selection criteria and group definitions were used. Numerous problems were encountered with the "all cities" file - the very small cities have inadequate data and were virtually eliminated and Muskegon Heights was eliminated because of problems with an unrealistically low number of accidents on the STL system - these issues are discussed at somewhat more length in appendix 2. Of the remaining cities, several had very few accidents and are given only cursory attention. The basic approach to the analysis was, however, basically as defined for Albion.

GENERAL ANALYSIS - ALL CITIES COMBINED

The first step was to examine all of the cities collectively for the trends in MSPAT and HWYAT. (The exception was Pontiac which was examined separately because of the number of observations and cost of combining it with all the other cities.) The overall analysis provides the broadest possible view of the potential TCD impact. The one shortcoming is that although all time periods have a common time length, the overall "before" data,

FIGURE 1 All Accidents - Selected Cities

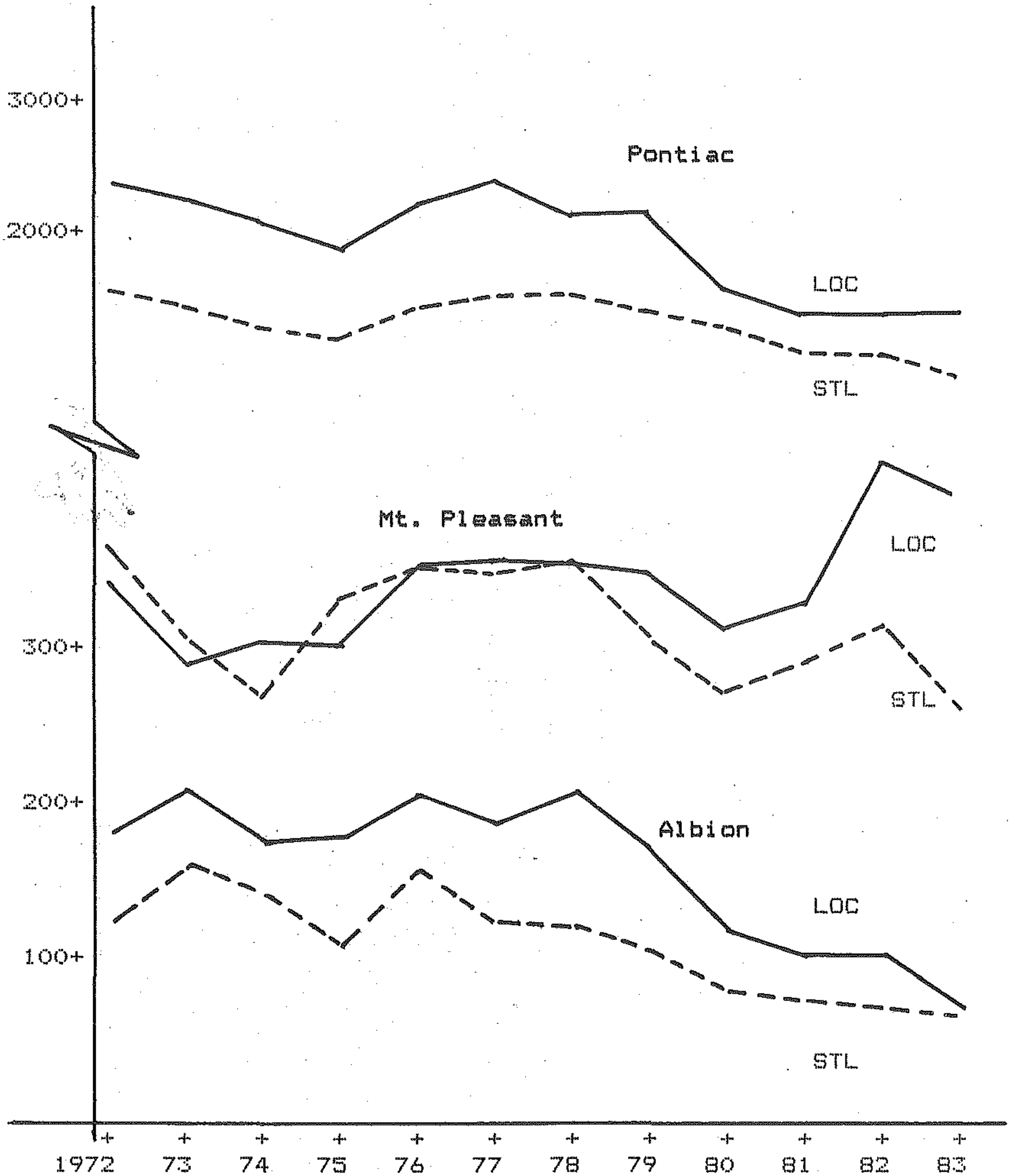
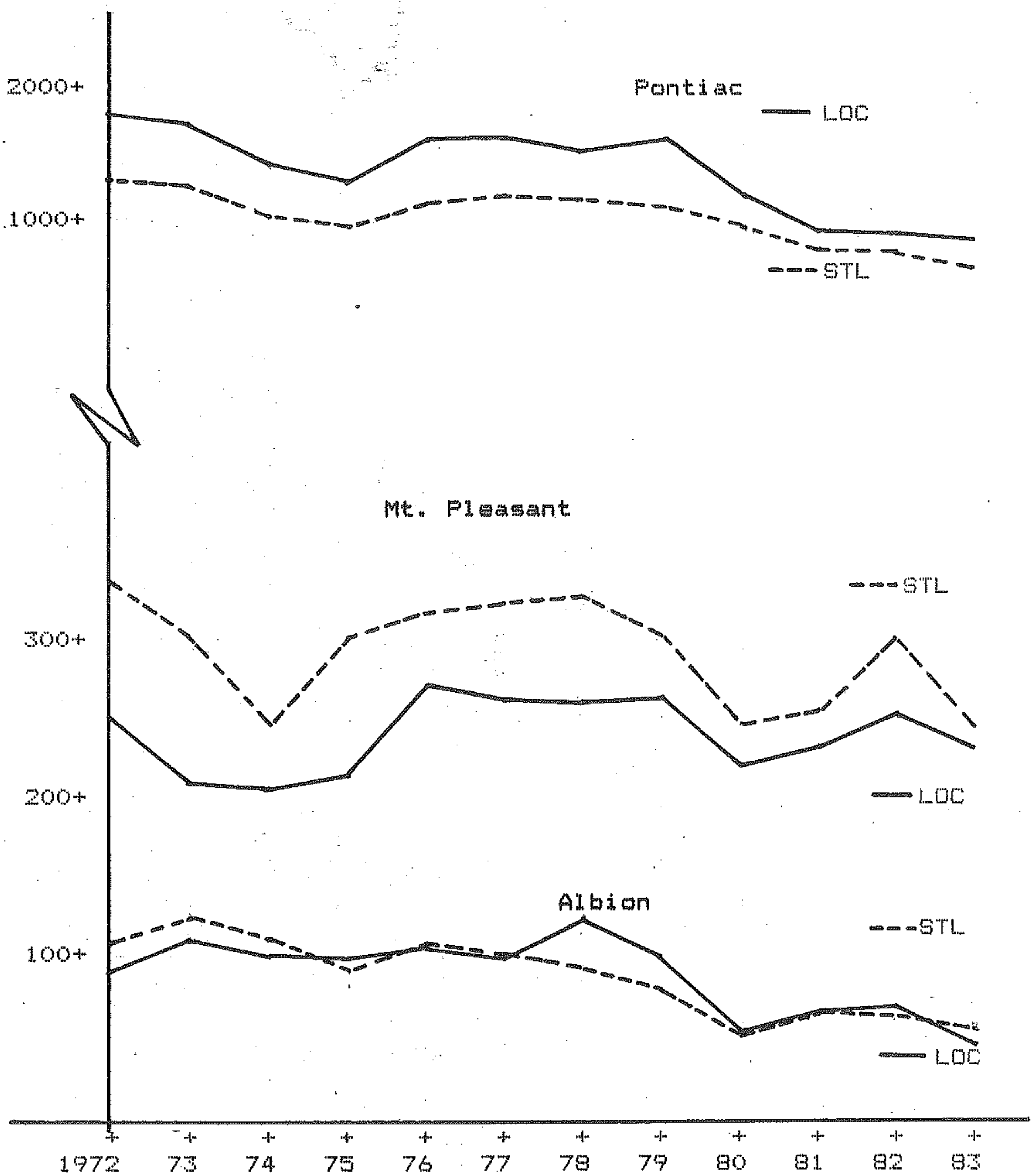


FIGURE 2 Vehicle-Vehicle Accidents - Selected Cities



for example, will contain data from different "real time" periods (due to different project start and end dates). No group stratifications are reported here.

Table 9 shows the overall results for MSPAT. Qualitatively, there appears to be little difference in the percentages of the different types of accidents (shown in parentheses). However, the chi-square statistics indicate that the MSPAT distributions are different on both systems (LOC and STL) which is counter to the result that would lead to a straightforward interpretation of the TCD upgrading effect. Indeed, based on the relative p-values, the before-after distributions are more similar for the LOC system than for the STL system - the opposite result from one indicating that the TCD upgrading had any effect. It should be noted that the changes in the total number of accidents are somewhat less pronounced than was seen for Albion alone - indicative of the earlier observation that the decreases in the number of accidents witnessed in Albion was atypical.

The next variable examined was HWYAT which is a subset of MSPAT (the vehicle-vehicle collision category). It is on this category of accidents that the TCD upgradings could be expected to be most likely to have a positive effect.

Table 10 shows a before-after comparison for all cities (except Pontiac) for HWYAT. Again, a qualitative examination shows that for the STL system the major shifts in vehicle-vehicle accident types are: a decrease in same direction side-swipes, a relatively sizable increase in angle accidents, and a relatively small decrease in left turn accidents. This is within the context of an overall decrease in vehicle-vehicle accidents - 1528 to

TABLE 9 Before-After Comparison for MSPAT
All Cities Combined*1

Categories	STL System		LOC System	
	Before	After	Before	After
overturned	10*2 (0.6)	10 (0.6)	26 (0.7)	14 (0.4)
w/train	(combined with others)		11 (0.3)	14 (0.4)
w/parked vehicle	65 (3.7)	43 (2.7)	612 (16.5)	568 (16.1)
w/another vehicle	1528 (87.2)	1412 (88.6)	2638 (71.0)	2529 (71.8)
w/pedestrian	18 (1.0)	14 (0.9)	72 (1.9)	59 (1.7)
w/fixed object	112 (6.4)	91 (5.7)	287 (7.7)	272 (7.7)
w/bike	17 (1.0)	18 (1.1)	69 (1.9)	65 (1.8)
other categories (combined)	3 (<1.0)	5 (<1.0)	3 (<1.0)	2 (<1.0)
TOTAL	1753	1593	3718	3523

Chi-square comparisons of before and after periods

STL: chi-square (6X2) = 3.906; p = .563
chi-square (7X2) = 4.619; p = .594

LOC: chi-square (8X2) = 4.664; p = .701

NOTES

*1 Except Pontiac

*2 Key for entries in table: absolute number of accidents
(percentage of total in category)

TABLE 10 Before-After Comparison for HWYAT
All Cities Combined*1

Categories	STL System		LOC System	
	Before	After	Before	After
other	277 (18.1)	243 (17.2)	435 (16.5)	417 (16.5)
head-on	27 (1.8)	20 (1.4)	63 (2.4)	62 (2.5)
side-swipe (same direction)	60 (3.9)	25 (1.8)	61 (2.3)	38 (1.5)
side-swipe (opposite direction)	10 (0.7)	11 (0.8)	24 (0.9)	19 (0.8)
angle	348 (22.8)	409 (29.0)	1106 (41.9)	1147 (45.4)
left turn	254 (16.6)	223 (15.8)	243 (9.2)	248 (9.8)
right turn	46 (3.0)	33 (2.3)	96 (3.6)	66 (2.6)
rear end	442 (28.9)	413 (29.2)	456 (17.3)	392 (15.5)
back into	37 (2.4)	16 (1.1)	82 (3.1)	105 (4.2)
parking	27 (1.8)	19 (1.3)	72 (2.7)	35 (1.4)
TOTAL	1528	1412	2638	2529

Chi-square comparisons of before and after periods

STL: chi-square (10X2) = 32.965; p = .0001

LOC: chi-square (10X2) = 30.800; p = .0003

NOTES

*1 Except Pontiac

*2 Key to entries in table: absolute number of accidents
(percentage of total in category)

1412. On the local system the qualitative review of the percentage changes shows: a small decrease in same direction side-swipes (similar to the STL results); a moderate increase in angle accidents (again, similar to STL results); a small increase in left turn accidents (opposite of and somewhat less than the STL results); a decrease in rear end accidents (STL had increased very slightly); and an increase in "backing" accidents. This with an overall decrease of vehicle-vehicle accidents - 2638 to 2529. The chi-square comparison of the before-after distributions showed that they were different for both the LOC and STL systems.

The overall results then, are not particularly enlightening in terms of the effects of the TCD upgrading. While there were changes on the LOC system, there were also changes on the STL system. Moreover, the shifts that took place between categories on the two systems were of similar magnitudes - again making it difficult to isolate TCD effects. A further confounding note is that the data used for the comparisons just discussed apparently contained a problem for one of the cities. Muskegon Heights had relatively few observations for the STL system in comparison to the LOC system. This over-representation in the combined LOC data may well make the above interpretation even more problematic.

The problem just cited was avoided in the next set of analyses which was a general examination of individual cities.

ANALYSIS OF INDIVIDUAL CITIES

Before-After Comparison of General Accident Types (MSPAT)

Several of the cities were examined on an individual basis. Table 11 shows the results from the first variable that was investigated, MSPAT, for Albion, Dundee, East Tawas, Hudsonville,

TABLE 11 Summary of Before-After Comparisons - MSPAT Individual Cities

City	STL*1 Stats	STL*1 Absolute	LOC Stats	LOC Absolute
Albion	4.870 (.182)	256-171 (-33)	5.232 (.156)	304-161 (-47)
Dundee	3.983 (.263)	109-88 (-19)	0.970 (.809)	44-41 (-7)
East Tawas	- *2 -	79-58 (-27)	0.697 (.874)	115-83 (-28)
Hudsonville	- -	74-67 (-9)	- -	122-108 (-11)
Mackinaw City	- -	44-27 (-39)	1.845 (.605)	69-64 (-7)
Mt. Pleasant	4.601 (.331)	876-913 (+4)	14.685 (.012)	727-747 (+3)
Pontiac	17.189 (0.16)	3106-3104 (<1)	18.862 (.009)	4483-4019 (-10)

NOTES

*1 Key to entries:

Stats	Absolute
chi-square statistic (p-value)	change in veh-veh accidents (% change)

Chi-square is calculated on all possible cells of MSPAT distribution; one cell is a combination.

*2 Inadequate number of cells with high enough frequency for chi-square calculation

Mackinaw City, Mt. Pleasant, and Pontiac. Several other, very small cities were not explicitly considered because of the extremely low number of accidents. (That is, chi-square tests were impossible due to low frequencies in a number of categories.) Muskegon Heights, a larger city, was eliminated as just noted. Albion is included again because these results used the "final" definition for the before and after periods - i.e., of three-year duration. A comparison of the earlier Albion results with those here will provide some insight to the viability of "smoothing" the yearly variations in accident statistics.

Looking first at Albion, it can be seen that the results displayed in table 11 indicate that the MSPAT distributions vary for both the LOC and STL systems although the vehicle-vehicle collisions on both decreased between the periods. On a percentage basis the LOC system experienced a somewhat larger decrease. The earlier examination of Albion (results in tables 5 and 6) indicated similar trends when the earlier definitions had been used both in terms of the values of the statistics and percentage decreases. The absolute values would not be comparable.

Dundee, which is somewhat smaller than Albion, showed somewhat different results. While there was a difference in the before-after distribution for the STL system, it was markedly less for the LOC system. Indeed, the absolute and percentage decreases in vehicle-vehicle accidents reflected this - being more pronounced for the STL system. Most of the statistics were not calculated for East Tawas, Hudsonville, and Mackinaw City but the absolute and percentage decreases can be examined. All three towns showed decreases for both systems - for East Tawas and

Hudsonville, the percentage decrease on the LOC system was approximately the same as for the STL system but less (LOC vs. STL) for Mackinaw City.

Mt. Pleasant is substantially larger than Albion and, more importantly, exhibited different results. While the results for the chi-square were similar (distributional differences for both systems), vehicle-vehicle accidents increased.

Pontiac, the largest city in the study, showed results which were similar to Albion and Mt. Pleasant as far as the statistical comparison was concerned but somewhat more "favorable" in terms of the changes in accidents - approximately the same number of vehicle-vehicle accidents occurred on the STL system while there was a decrease on the LOC system.

Based on the examination of the MSPAT distributions for the several cities, there is little consistent evidence that the TCD upgradings had either a positive or a negative effect.

Before-After Comparison of Vehicle-Vehicle Accidents (HWYAT)

HWYAT is a more important variable which allows a more detailed evaluation of vehicle-vehicle accidents. Table 12 provides a summary of the before-after comparisons for the several cities for HWYAT. Examining the chi-square information, it appears that there is a shift in the before-after distributions for the STL systems for Hudsonville, Mackinaw City, Mt. Pleasant, and Pontiac. Whereas for Albion, Dundee, and East Tawas there is not. With the exception of Dundee (and to a lesser extent, Mackinaw City), the cities generally show changes in the HWYAT accident distributions for the LOC system.

The results for Albion here are somewhat different than were

TABLE 12 Summary of Before-After Comparisons - HWYAT Individual Cities

City	STL	LOC	Comments
Albion	0.522 (.991)	8.803 (.117)	STL: accidents decreased 256-171 LOC: accidents decreased 304-161 higher % angle lower % left turn
Dundee	0.366 (.985)	0.027 (.871)	generally low frequencies STL: accidents decreased 109-88 LOC: accidents decreased 44-41
East Tawas	0.809 (.847)	1.283 (.257)	STL: accidents decreased 79-58 higher % left turn LOC: accidents decreased 115-83 higher % angle lower % left turn lower % rear end
Hudsonville	6.561 (.087)	7.341 (.290)	STL: accidents decreased 74-67 lower % left turn higher % rear end LOC: accidents decreased 112-108 higher % "other" lower % angle
Mackinaw City	2.628 (.105)	3.625 (.459)	STL: accidents decreased 44-27 fewer rear end and "other" %s not meaningful LOC: accidents decreased 69-64 higher % angle lower % left turn higher % backed into
Mt. Pleasant	17.982 (.021)	16.000 (.067)	STL: accidents increase 876-913 higher % angle LOC: accidents increase 727-747 higher % angle

continued

TABLE 12 Continued

City	STL	LOC	Comments
Pontiac	23.340 (.005)	38.348 (.000)	STL: accidents "decreased" 3106-3104 on a percentage basis, distributions very similar
			LOC: accidents decreased 4483-4019 on a percentage basis, distributions very similar

NOTES

Key to entries: chi-square statistic
(p-value)

Chi-squares calculated on distributions of values in HWYAT categories, before and after project.

In comments, only shifts on the order of 5% or more are noted.

noted earlier when there were significant shifts on both systems (as opposed to only the LOC system now) - apparently a result of the smoothing of the year-to-year fluctuations. It is important to note between which categories the "shifts" in accidents actually occurred - in Albion, for example, there was a higher percentage of angle accidents and a lower percentage of left turn accidents on the LOC system between the before and after periods.

One of the interesting results is that for several of the cities higher percentages of angle accidents are noted on the LOC system (the exception being Hudsonville where the percentage was lower). In two of the smaller cities and Albion, this was accompanied by a lower percentage of left turn accidents. This is a potential result of the TCD project.

Based on the finding just cited, a review of the shifts in the accident categories was undertaken using a slightly different technique. If the TCD upgradings have a consistent effect (regardless of whether it is favorable or unfavorable) in terms of "preventing" some types of accidents (and possibly encouraging others), a pattern of categorical shifts should emerge from a review of the different cities. Table 13 represents a summary of HWYAT accident type shifts for the five cities that were studied in some depth. The table is divided into four separate sections. The first is a summary for the LOC system where the table entries are either plus (+), minus (-), or zero (0). A plus indicates that the percentage of accidents in the category increased by 1.5% or more between the before and after periods; a minus indicates that there was a decrease of 1.5% or more; and a zero indicates that the before-after shift was between -1.5% and + 1.5%. Note

TABLE 13 Summary of Proportional Shifts in HWYAT Categories

HWYAT Category*[1]	Pontiac	Albion	E. Tawas	Hudson-ville	Mt. Pleasant
LOC system (criterion = change > 1.5%)					
Other	0	0	-	+	-
Head-on	0	0	0	-	0
SS-same dir	0	-	-	+	0
SS-opp dir	0	0	0	0	0
Angle	+	+	+	-	+
Lt turn	0	-	-	+	0
Rt turn	0	0	0	0	0
Rear end	+	-	-	+	-
Back into	0	+	+	0	0
Parking	0	-	+	0	0
STL system (criterion = change > 1.5%)					
Other	0	+	-	0	-
Head-on	0	0	0	0	0
SS-same dir	-	-	-	-	-
SS-opp dir	0	0	0	+	0
Angle	0	+	+	+	+
Lt turn	0	0	+	-	0
Rt turn	0	0	0	-	0
Rear end	0	0	-	+	0
Back into	0	-	0	0	0
Parking	0	0	-	0	0

continued

TABLE 13 Continued

HWYAT Category	Pontiac	Albion	E. Tawas	Hudson-ville	Mt. Pleasant
LOC system (criterion = any change)					
Other	+	+	−	+	−
Head-on	+	+	−	−	+
SS-same dir	−	−	−	+	+
SS-opp dir	−	+	−	+	−
Angle	+	+	+	−	+
Lt turn	−	−	−	+	−
Rt turn	−	−	−	−	−
Rear end	+	−	−	+	−
Back into	−	+	+	−	−
Parking	−	−	+	+	−
STL system (criterion = any change)					
Other	−	+	−	−	−
Head-on	O	−	+	O	O
SS-same dir	−	−	−	O	−
SS-opp dir	+	+	−	+	+
Angle	+	+	+	+	+
Lt turn	+	−	+	−	−
Rt turn	+	−	−	−	−
Rear end	+	−	−	+	+
Back into	−	−	+	−	−
Parking	−	−	−	O	−

NOTES

Key to entries given stated criterion: if % increases +
if % decrease −
if "no change" O

that these percentages are relative and have no implications in regard to the absolute number of accidents in any category. "Angle" accidents can then be seen to have increased in four of the five cities analyzed. The only other categories to show such consistent results were "side-swipe-opposite direction" and "right turns" which experienced very little proportional change - all the entries were zeroes. This finding taken alone would indicate that a TCD effect was the increase of angle accidents.

The second part of the table is the same sort of comparison for the STL system. Again, it is seen that angle accidents increased in four of the five cities (although the city without the increase is different). Other consistent trends for the STL system include a decrease for all cities in the "side-swipe-same direction" category and little change in head-ons, side-swipe-opposite direction, right turns, backing, and parking.

The increase in the angle category for the STL system as well as for the LOC system indicates that the change was not attributable to the TCD upgrading (or anything else that is characteristic of the LOC system).

The last two parts of table 13 are addressed to the same sort of comparison with the exception that the "criterion" is now any change at all - i.e., if there was any proportional increase or decrease in a category, it is noted.

Review of the last two parts of the table reveals no consistent trends on one system that are not present on the other. Further, in most instances the results vary from city to city for any given accident category. In short, the systems are consistent only in their inconsistency in terms of shifts among accident categories.

Before-After Comparison of Accident Severity

The last phase of the analysis is the examination of the severity of accidents occurring on the systems in the various cities. Regardless of whether the shifts in accident types could be tracked and/or attributed to the TCD upgradings, changes in the severity of accidents might be attributable to them. There are confounding factors that must be considered as well - motorists becoming more safety conscious, vehicles becoming safer, and so forth. However, the comparisons between trends on the STL and the LOC systems will negate these problems.

A comment about the coding of accidents by severity is appropriate. An accident can result in a serious injury, property damage, and a fatality, and different numbers of each - however it was necessary to give each accident one code for straightforward analysis. Further, an accident can result in several injuries which is not, for purposes here, really a measure of the likely severity of the crash per se. Hence, using information in the accident record, each accident was assigned to a category according to its most serious outcome. The resultant coding (table 14) was as follows: PDO - only property damage was incurred; C - the most serious outcome was a possible injury; B - the most serious outcome was a non-incapacitating injury; A - the most serious outcome was an incapacitating injury; and F - the most serious outcome was a fatality.

Given the above, table 14 provides a summary of all vehicle-vehicle accidents (subjected to the "screening" criteria as before) in all cities other than Pontiac. The overall

TABLE 14 Summary of Severity of Vehicle-Vehicle Accidents Combined Cities

Acc Sevr	STL Before		STL After		LOC Before		LOC After	
All Vehicle-Vehicle Accidents								
PDO	1147	(75)	1017	(72)	2062	(78)	1999	(79)
C	246	(16)	244	(17)	358	(14)	350	(14)
B	80	(5)	107	(8)	144	(5)	128	(5)
A	54	(4)	42	(3)	73	(3)	51	(2)
F	1	–	2	–	1	–	1	–

STL: Chi-square = 8.569; p = .036
LOC: Chi-square = 3.613; p = .306

Acc Sevr	STL Before		STL After		LOC Before		LOC After	
Angle Accidents								
PDO	236	(68)	267	(65)	777	(71)	865	(75)
C	63	(18)	79	(19)	183	(17)	176	(15)
B	26	(7)	46	(11)	96	(9)	73	(6)
A	22	(6)	16	(4)	45	(4)	32	(3)
F	1	–	1	–	1	–	1	–

STL: Chi-square = 5.323; p = .150
LOC: Chi-square = 8.891; p = .031

Acc Sevr	STL Before		STL After		LOC Before		LOC After	
Left Turn Accidents								
PDO	183	(72)	147	(66)	188	(77)	187	(75)
C	42	(17)	44	(20)	29	(12)	37	(15)
B	21	(8)	23	(10)	18	(7)	17	(7)
A	8	(3)	9	(4)	8	(3)	7	(3)
F	0	–	0	–	0	–	0	–

STL: Chi-square = 2.118; p = .548
LOC: Chi-square = 1.017; p = .797

NOTES

Acc Sevr: accident severity classification where

PDO = property damage only
C = possible injury
B = non-incapacitating injury
A = incapcitating injury
F = fatal

Key to entries: absolute number (column percentage)

Chi-square calculations did not include the fatal cell statistics indicate that, in general, the before-after severity distributions tend to be marginally different on the STL system - most explicitly when all vehicle-vehicle collisions are considered and somewhat less so when angle or left turn accidents are considered; and they also tend to differ statistically (although qualitatively they appear similar) for the LOC system - although they are reasonably similar when only left turn accidents are considered.

More qualitatively, the percentages of accidents in each category can examined. For example, for all accidents on the STL system it is seen that there are, proportionately, fewer PDO accidents, slightly more C accidents, more B accidents, and slightly fewer A accidents - that is, while the number of accidents decreased they became somewhat more serious between the before and after periods on the STL system. For all accidents on the LOC system, it is seen that there are, proportionately, slightly more PDO accidents and slightly fewer B accidents - that is, not only did the number of accidents decrease they became slightly less serious.

Consideration of all angle accidents shows that on the STL system the number of accidents increased and there was some shifting from the extremes (PDOs and As) to the middle (Bs and Cs). On the LOC system, there was an increase in accidents in the category but, in general, the shift was to less serious accidents - the PDO category was the only one with a proportionate increase.

Considering left turn accidents, there were fewer on the STL system but they were somewhat more serious; and there were somewhat more on the LOC system and they became slightly more serious (the shift, such as it is, was between PDO and C categories).

The same sort of comparison is made on an individual basis for three cities (Albion, Mt. Pleasant, and Pontiac) in table 15. In each instance all vehicle-vehicle accidents are examined and then angle and left turn accidents. For the Albion STL system it is seen that within the context of an overall decrease in the number of vehicle-vehicle accidents (between the before and after periods) there is a shift to somewhat more severe accidents (PDOs decrease proportionately [4%] while B and C accidents increase). On the LOC system there is a more pronounced shift to more severe accidents within an overall context of a decreasing number of accidents. The trend is similar, but somewhat more pronounced when only the angle accidents are concerned. For left turn accidents there is a decrease in number on both systems with the STL accidents becoming somewhat more serious and the LOC accidents becoming less serious. It should be noted that sample sizes are quite small for the angle and left turn categories and the percentages vary greatly with only a few accidents.

The results in Mt. Pleasant are somewhat different. For all vehicle-vehicle accidents, the numbers of accidents on both the STL and LOC systems remained nearly constant between the before and after periods while on the STL system they became somewhat more serious and on the LOC system then became somewhat less serious (although the latter shift was between the two least serious categories).

The Mt. Pleasant angle accidents increased on both systems, becoming less serious on the STL system and more serious on the

TABLE 15 Summary of Severity of Vehicle-Vehicle Accidents Selected Cities

Acc	STL		LOC	
Sevr	Before	After	Before	After
Albion: All Vehicle-Vehicle Accidents				
PDO	215 (84)	136 (80)	258 (85)	126 (78)
C	27 (11)	22 (13)	23 (8)	19 (12)
B	11 (4)	11 (6)	16 (5)	11 (7)
A	3 (1)	2 (1)	7 (2)	5 (3)

STL: Chi-square = 1.635; p = .441
LOC: Chi-square = 3.356; p = .340

Acc Sevr	STL Before	STL After	LOC Before	LOC After
Albion: Angle Accidents				
PDO	40 (80)	27 (71)	95 (81)	55 (71)
C	8 (16)	8 (21)	10 (8)	11 (14)
B	2 (4)	3 (8)	9 (8)	7 (9)
A	0 –	0 –	4 (3)	4 (5)

Statistics not calculated, small cell frequencies

Acc Sevr	STL Before	STL After	LOC Before	LOC After
Albion: Left Turn Accidents				
PDO	26 (79)	15 (71)	19 (70)	5 (83)
C	4 (12)	2 (10)	2 (7)	0 –
B	2 (6)	3 (14)	5 (19)	1 (17)
A	1 (3)	1 (5)	1 (4)	0 –

Statistics not calculated, small cell frequencies

Acc Sevr	STL Before	STL After	LOC Before	LOC After
Mt. Pleasant: All Vehicle-Vehicle Accidents				
PDO	219 (75)	211 (73)	193 (76)	200 (81)
C	53 (18)	44 (15)	39 (15)	28 (11)
B	14 (5)	25 (9)	14 (6)	16 (6)
A	6 (2)	9 (3)	7 (3)	4 (2)

STL: Chi-square = 4.671; p = .198
LOC: Chi-square = 2.056; p = .357

Acc Sevr	STL Before	STL After	LOC Before	LOC After
Mt. Pleasant: Angle Accidents				
PDO	35 (61)	60 (67)	80 (67)	92 (54)
C	12 (21)	12 (13)	26 (22)	19 (15)
B	7 (12)	12 (13)	9 (8)	11 (9)
A	3 (5)	5 (6)	4 (3)	3 (2)

STL: Chi-square = 1.441; p = .486
LOC: Chi-square = 1.921; p = .383

continue

TABLE 15 Continued

Acc Sevr	STL Before	STL After	LOC Before	LOC After
Mt. Pleasant: Left Turn Accidents				
PDO	50 (81)	41 (73)	29 (78)	31 (84)
C	9 (15)	12 (21)	5 (14)	3 (8)
B	3 (5)	3 (5)	1 (3)	3 (8)
A	0 -	0 -	2 (5)	0 -

Statistics not calculated, small cell frequencies

Acc Sevr	STL Before	STL After	LOC Before	LOC After
Pontiac: All Vehicle-Vehicle Accidents				
PDO	2230 (72)	2080 (67)	3201 (71)	2767 (69)
C	577 (19)	633 (20)	802 (18)	762 (19)
B	202 (7)	265 (9)	314 (7)	332 (8)
A	92 (3)	123 (4)	155 (3)	153 (4)
F	5 -	3 -	11 -	5 -

STL: Chi-square = 20.781; p = .000
LOC: Chi-square = 8.404; p = .038

Acc Sevr	STL Before	STL After	LOC Before	LOC After
Pontiac: Angle Accidents				
PDO	433 (62)	379 (53)	731 (68)	669 (65)
C	134 (19)	179 (25)	201 (19)	208 (20)
B	87 (13)	96 (14)	105 (10)	102 (10)
A	38 (5)	52 (7)	40 (4)	56 (5)
F	2 -	3 -	5 -	2 -

STL: Chi-square = 16.569; p = .001
LOC: Chi-square = 4.742; p = .192

Acc Sevr	STL Before	STL After	LOC Before	LOC After
Pontiac: Left Turn Accidents				
PDO	347 (65)	376 (70)	330 (61)	284 (59)
C	115 (22)	88 (16)	115 (21)	110 (23)
B	47 (9)	51 (10)	64 (12)	51 (11)
A	23 (4)	21 (4)	33 (6)	32 (7)
F	1 -	0 -	1 -	2 -

STL: Chi-square = 4.994; p = .172
LOC: Chi-square = 0.900; p = .825

NOTES

Key to entries: absolute number (column percentages)
Accident classifications: PDO = property damage only
C = possible injury
B = non-incapacitating injury
A = incapcitating injury
F = fatal
Chi-square calculations did not include the fatal cell

LOC system (again the major shift was between PDO and C categories in both instances). STL left turn accidents decreased while LOC left turn accidents stayed the same. However, there was a "positive" shift on the LOC system in terms of severity and a "negative" one on the STL system. Again most shifting was between the less severe categories and sample sizes were small.

The review of the situation in Pontiac is somewhat more definitive in the sense that all of the sample sizes are greater. For total vehicle-vehicle accidents there was a shift toward more severe accidents on both systems in the context of an overall decrease in accidents on the LOC system. For angle and left turn accidents, on the LOC system the shift is not great but clearly toward more severe accidents within an overall decrease in the numbers of both types of accidents. The shifts on the STL system were toward more severe accidents for the angle category and less severe in the left turn category with little change in the numbers of accidents in the categories. For Pontiac the chi-square statistic and p-value indicate that the shifts for the LOC system are: highly significant for all vehicle-vehicle accidents, moderately significant for angle accidents, and insignificant for left turn accidents.

SUMMARY AND DISCUSSION

The first analysis of Albion and then of several other cities in Michigan in regard to the efficacy of jurisdiction-wide traffic control device upgradings yielded inconsistent results. In short, there is no substantive evidence that TCD upgradings have a consistent, measurable (positive or negative) impact on safety on a jurisdiction-wide basis as measured by a variety of safety (accident) measures. However, it is important to note that this is not to say that such upgradings should not be undertaken.

Table 16 is a summary of the results for each of the several parts of the analysis that was undertaken. A review of this information indicates that the most striking result is the overall lack of consistency in the results whenever detailed analysis was attempted - this is especially important in view of a general similarity in broad background characteristics.

Does the lack of results (either positive or negative) mean that TCD upgradings should not be undertaken? The answer is, at least, twofold. First, from the point of view of a jurisdiction's liability for damage suits and so forth, TCD upgradings are quite important. The relative success or failure to identify and quantify system-wide effects does not mitigate against the efficacy of improved TCDs at specific sites.

The "failure" to arrive at definitive quantitative results is due to general variability in accidents and a host of confounding variables for which no control was possible. Looking

TABLE 16 Summary of Results

Trends in Background and Descriptive Statistics

Accident distribution (by type of crash) were somewhat different for the STL and LOC systems with the biggest difference being in the proportion of the vehicle-vehicle crashes in the angle category.

In general, background information was similar for LOC and STL systems - e.g., demographic characteristics of the drivers, weather conditions.

General Trends in Accident Frequencies

There was some city-city variation in the trends in the numbers of accidents occurring on the LOC and STL systems. For example, in Albion there was a general decreasing trend on both systems while in Pontiac the trend was increasing and then decreasing.

Trends in Changes in General and Specific Accident Types (MSPAT and HWYAT)

Changes occurred on both systems - that is, between the before and after periods on *both* systems there were changes in the MSPAT and HWYAT distributions. This result was expected on the LOC system but unexpected on the STL system. This points to the general variability of the accident statistics over time which make isolation of the effects of specific changes on either system (i.e., the TCD upgrading) problematic.

Absolute and Proportional Changes in the Number and Type of Vehicle-Vehicle Accidents

Neither absolute nor proportional changes in the overall number of accidents, vehicle-vehicle accidents, or specific categories of vehicle-vehicle accidents yielded any consistent results for either the STL or LOC systems. Indeed, one qualitative comparison of trends in the specific accident categories showed that the trends were the same on both systems.

Trends in Accident Severity

Overall the trends in severity showed that there were minimal changes among the different accident types, and there was some contradictory information - e.g, a trend toward more severity for one type of accident and less severity for another for the LOC system with some STL trends being the same and some opposed, in addition to city to city differences.

at a jurisidiction as an analysis unit has inherent drawbacks - while the TCD upgrading is indeed jursidiction-wide, many intersections, for example, would probably experience no change in either the placement or type of TCD present. Additional intersection-related changes might be concerned with relatively minor placement modifications. These are modest changes unlikely to be picked up in a general analysis. What is left then is a relatively few changes in a jursidiction that might be termed changes of substance. The changes in accident frequency, for example, at these relatively few intersections are then lost within (confounded by) the overall lack of change at the other sites.

An additional factor is that many of the TCD changes may be concerned with "non-critical" signs such as no parking and so forth. Add to this that, in spite of reasonable consistency in the user groups in most cities (over the short term), there would be some demographic changes, new developments, and so forth within the city with resultant changes in the numbers of accidents.

In summary, it would appear that safety analyses would be better directed toward the consideration of key "problem sites" in a jurisdiction. Procedures for this type (level) of analysis are well-defined and accepted within traffic engineering. While the idea of being able to make a sweeping generalization about the efficacy of TCD upgradings for different jurisdictions is appealing, and would indeed be helpful from an agency viewpoint (in terms of resource allocation for example), the overall variability of the data appears to overwhelm detectable changes at the jursidiction level.

APPENDIX 1

INTERSECTION CODING PROBLEMS

An internal inconsistency with the coding of accidents occurring in proximity to intersections was discovered. The dimensions of this problem are described in the following pages which are notes which formed the basis for discusssions between MSP, OHSP, MDOT, and MSU staff in September, 1984.

In the data analysis for the project which followed these meetings, the intersection-related problems were basically avoided by not making the intersection/non-intersection differentiation. (Given the results that were obtained, such differentiations were not required.)

Notes provided for MSP/OHSP/MSU meeting on 13 Sept 84

SUMMARY INFORMATION

INTRODUCTION

For the project it was desired to be able to examine the impacts of TCD upgrading on the number, rate, and type of accidents occurring in a jurisdiction. For example, if an intersection (or group of intersections) had been uncontrolled before the project and a stop or yield sign was installed as part of the project, it would be expected that the type(s) of accident(s) occurring at such intersections would change between the before (the porject) and after periods - e.g., there might be fewer angle accidents and more rear-end accidents. Therefore it was useful to attempt to isolate different types of accidents - e.g., intersection vs. non-intersection. Note that the basic data used to develop all of the following was provided by MDOT in their "252" format.

I. TOTAL ACCIDENTS

In the Albion file there is a total of 2327 "good" accidents over the 11 year period (1972-1982) in question. Note that for this exercise some accidents were deleted - that is, there are more than 2327 accidents in the original Albion file.

Based on HAT, the breakdown is as follows:

HAT = 1 (interchange accidents)	3
HAT = 2 (intersection accidents)	1471
HAT = 3 (not 1 or 2 above)	853

II. TOTAL INTERSECTION ACCIDENTS

For the 1471 intersection accidents (based on HAT), the breakdown is as follows:

accidents within the confines	393
accidents within the "vicinity"	426
accidents near(?) driveways	33
accidents otherwise coded or blank	619

III. TOTAL TRUNKLINE VS. LOCAL SYSTEM ACCIDENTS

For the total of 2327 accidents, the split between trunkline and non-trunkline systems was:

accidents on the trunklines	1039
accidents on the "local" system	1288

The differentiation between the local and trunkline system within a specific jurisdiction was made based on the "highway class" variable which was recoded as "RC" where RC=1 if highway class was any of the following: interstate route, US route, M route, interstate loop or spur, US business route, connectors, or service drive; and RC=2 if highway class was "9" - county road, city street, or not known.

IV. INTERSECTION ACCIDENTS VS. SYSTEM

Of the 1039 trunkline accidents, 905 were intersection-related with the following breakdown:

accidents within the confines	282
accidents within the vicinity	271
accidents near driveways	33
accidents otherwise coded or blank	319

Of the 1288 non-trunkline accidents, 566 were intersection-related with the following breakdown:

accidents within the confines	111
accidents within the vicinity	155
accidents near driveways	0
accidents otherwise coded or blank	300

V. DISTRIBUTION OF INTERSECTION ACCIDENTS BY TRUNKLINE AND NON-TRUNKLINE SYSTEMS BY YEAR

Table 1 provides a more detailed summary of the distribution of accidents by the two systems and by year. Table 1 is based on the coding for the variable "highway area code" which is, in turn, based on the specification of highway area type. That is, if, for example, highway area type is coded as a 2 (i.e., HAT=2; an intersection), then highway area code (HAC) is coded to give more specific information about the accident - e.g., was the accident within the confines of the intersection or was it within 150 north of the intersection.

It should be noted that the codes for HAC have changed over the years. The code for an accident within the confines of the intersection ("00") has, however, remained constant over the eleven year period of interest according to the manuals - all other codes changed.

In order to facilitate tables 1 and 2, HAC was recoded as HACK with the following rules:

1. If HAC ="00," then HACK = "00"

2. If HAC greater than or equal to "1" and less than or equal to "55," then HACK = "1"

   the range 1 to 55 basically defines (regardless of year) an accident that occurred relatively close to the intersection - varying between 50 and 250 feet depending on the year

3. If HAC greater than or equal to "56" and less than or

equal to "61," then HACK = "2"

this range is basically driveways

4. If HAC in the range from "62" to "97", then HACK = "3"

   this is a miscellaneous group and turns out to be unimportant

5. HACK = "4" - mis-specified but also turns out to be unimportant

6. If HAC = "99," HACK = "5"

   This is a leftover group - misc. coded (i.e., did not fit elsewhere) accidents ended up here as did uncoded accidents

TABLE 1. Distribution of accidents - by year for <u>trunkline</u> system

	VALUES OF "HACK"								
YEAR	0	1	2	3	4	5	N1	N2	NOTES
1972	54	9	11	0	0	19	93	116	
1973	70	17	7	0	0	29	123	138	
1974	41	15	8	0	0	43	107	116	
1975	26	9	7	0	0	33	75	88	
1976	41	72	0	0	0	5	118	130	coding change
1977	2	90	0	0	0	0	92	113	
1978	1	11	0	0	0	73	85	100	coding change
1979	2	22	0	0	0	47	71	83	
1980	3	8	0	0	0	19	30	37	project yr.
1981	19	9	0	0	0	27	55	58	
1982	23	9	0	0	0	24	56	60	
TOTAL	282	271	33	0	0	319	905	1039	

N1 = total accidents coded HAT=2 (intersection)

N2 = total accidents for year regardless of HAT code

1980 was the project year - some accidents discarded

TABLE 2. Distribution of accidents - by year for <u>non-trunkline</u> system

VALUES OF "HACK"

YEAR	0	1	2	3	4	5	N1	N2	NOTES
1972	0	0	0	0	0	2	2	133	few HAT=2 coded
1973	0	0	0	0	0	0	0	150	no HAT=2 coded
1974	0	0	0	0	0	0	0	123	"
1975	0	0	0	0	0	0	0	130	"
1976	32	68	0	0	0	1	101	141	coding change
1977	11	87	0	0	0	0	98	131	
1978	2	0	0	0	0	112	114	162	coding change
1979	1	0	0	0	0	83	84	114	
1980	8	0	0	0	0	39	47	61	project yr.
1981	24	0	0	0	0	34	58	73	
1982	33	0	0	0	0	29	62	70	
TOTAL	111	155	0	0	0	300	566	1288	
GRAND TOTAL	393	426	33	0	0	619	1471	2327	

N1 = total accidents coded HAT=2 (intersection)

N2 = total accidents for year regardless of HAT code

GRAND TOTAL = total for both systems and over all years (from tables 1 and 2)

1980 was project year - some accidents discarded.

VI. THE PROBLEMS

The problems concern the inconsistency <u>within a single accident record</u> of several variables - specifically those dealing with where the accident actually occurred. The points below summarize how the problem was identified.

1. One of the cross-tabulations that was done was HAT vs. MSPAT (highway accident type). MSPAT is important because it is used as the basis for the "where and how" analysis that is of use in examining the types of accidents - e.g., a 2-car angle collision in an intersection. Inconsis- tencies between HAT and MSPAT are not necessarily obvious.

2. Based on the value of MSPAT, the "where" code is assigned. For example, if MSPAT = 4 (motor vehicle with another motor vehicle), then the WHERE can take seven different values - e.g., 1 indicates that the crash involved two vehicles going in the same direction at an intersection; 2 indicates that again the crash involved two vehicles going in the same direction, but not at the intersection.

   New variables were created in the analysis that separated the "where" codes from one another - for example, WH4 was created such that it took values only when MSPAT = 4 and then it took the appropriate "where" values.

   An x-tab between HAT and the new WHn variables, indicated that, for example, when HAT was equal to 2, there were numerous instances where WH4 indicated that the accident occurred away from the intersection.

3. The above was initially attributed to changing definitions (for coders) as to what constituted the intersection. In order to explore this more fully, the HAC code was examined.

   HAC provides a more explicit indication of where the accident occurred - the explanation of HAC is dependent on what value HAT takes. HACK (a new variable) is merely an abbreviated version of HAC. Tables 1 and 2 show that there appears to be some problem with the HAC codes - for example, although the HAC coding changed over the years, the "00" code remained constant and indicated an accident that occurred within the confines of the intersection (that is, within the curblines).

   For the <u>trunkline</u> system (T1) the number of accidents occurring within the confines of the intersection seems to vary considerably more than one would expect - accounting for more than one-half of the accidents in the early years, dropping off to almost none in the mid-70s, and then increasing again in the more recent years. Further, the variations are not explained by known changes in the coding manual.

For the non-trunkline system (T2) the situation is worse (and of more concern to the project) as there were no accidents coded "00" in the first four years being con- sidered or even any coded as even being intersection (HAT=2) accidents. For 1976 and after, there are numerous "intersection" accidents, but little consistency in the number of incidents coded as "00."

The questions that arise from the above findings and discussion are as follows:

1. Is there some fundamental error that we are making in recoding the data or in interpreting them?

2. Is there some way to explain the variation so that consistent data can be developed? Or are the inconsistencies with the original coding?

3. Is there any way to construct a new variable that accurately and consistently provides the type of information that is desired?

4. What are the long and short term impacts of the identified problems if the inconsistencies cannot be resolved? What actions are necessary?

In an effort to begin to look for some sort of recoding solution, complete records were "dumped" in order to see what data were available and whether availability varied over time. The following comments pertain to those data:

1. Positions 01 and 02 (highway district) were coded as "07" prior to 1978, then there were two "13s" and the rest were "12s."

2. Positions 03 through 07 (control section number) were coded as "13999" prior to 1978, then the numbers vary.

3. Positions 08 through 12 (control section milepoint) were coded as "99990" prior to 1978, then the numbers vary.

4. Positions 57 through 60 (distance from crossroad) were coded as "0000" prior to 1978, then the numbers vary.

5. Positions 61 and 62 (direction to/from the crossroad) and 63 through 82 (intersecting street name) were not coded until 1978.

The general thrust of the above is that it would seem to be impossible to create a new intersection variable (e.g., based on the distance to the intersection) for data coded prior to 1978 given the information in the 252-format. It may be possible to create such a variable if the original MSP "long form" data are used, if the requisite distance data are in that form. For post-1978 data, such a reconstruction may work, although for TCD analysis purposes there would only be a few cities with adequate length before and after periods.

APPENDIX 2

CONCERNS WITH MUSKEGON HEIGHTS DATA

A problem was encountered with the data from Muskegon Heights which caused this jurisdiction to be eliminated from further analysis. As indicated in the text (page 35) once the data from Albion had been subjected to the initial analysis, data from several other jurisdictions were analyzed. The first step in that phase of the analysis was directed to aggregate data from all cities, except Pontiac. These results are presented and discussed (e.g., table 9) in the text. The next step was to look at several of the cities individually. When the data were broken down by city there was a problem with Muskegon Heights.

As indicated in the text, accidents were identified as having either occurred on the STL or LOC system - in most instances the accidents were split (very) roughly on the order of 50-50. Examination of Muskegon Heights data showed a much different distribution -

year	STL accidents	LOC accidents
72	13	462
73	14	587
74	24	510
75	31	504
76	28	603
77	29	566
78	29	609
79	29	613
80	20	417
81	14	435
82	17	438
83	18	405

Given this atypical split between the data reported for the two systems, Muskegon Heights was eliminated from futher analysis. No attempt was made to discern why this split was so different from all of the other jurisdictions. While the split may be correct for reasons that are specfic to Muskegon Heights, it would seem more likely that there may be some problem with accident reporting for this city.

This problem will provide some skew to all aggregate statistics in this report (i.e., for "All Cities Combined"). Moreover, these data will also provide some slight skew to all statewide statistics done by any agency - the problem (whatever it actually is) may also be present for other cities that were not covered in the analysis here.