Signal Modernization

A. F. MALO
Director
Department of Streets and Traffic
City of Detroit

It is generally recognized that traffic signals have a profound influence on traffic flow. They automatically assign right-of-way to the various movements necessary at intersections, and thereby affect every individual in the traffic stream, including pedestrians. In the age when signals were first put into use, their design was simple and uncomplicated. but they adequately handled the comparatively light and slow-moving traffic of the times. The normal installation was a single four-way solid head on a span wire or pedestal in the center of the intersection, or corner-mounted signals either on two diagonal corners or on all four corners of the intersection.

Traffic in most cities has reached volumes at or approaching the capacity of the normal intersection. The traffic stream is made up of all types of vehicles including many passenger automobiles, large trucks, and buses, representing different sizes and operating characteristics. Streets and intersections must operate at peak efficiency in order to move such traffic. Controls must be modern and efficient, and signal visibility must be perfect. The efficient and safe movement of traffic through the intersection, therefore, generally requires signal indications in the driver's line of vision, unobstructed by large vehicles, and undisturbed by a background of advertising signs. Special turn indications or lane control might be required, and at wide or boulevarded streets, advance greens and lagging ambers and reds might be indicated. For safe intersection clearance, an all-red period in addition to normal amber may be required.

In urban areas, pedestrians are an important part of the traffic problem and must be considered in the signalization of intersections. Pedestrian signals, therefore, frequently constitute a part of modern traffic signal installation.

Signal modernization at individual intersections has been accomplished at varying scales in numerous cities. Modernization projects at individual intersections have included both controller and visibility improvements. Improvements in visibility might include the installation of additional heads, the relocation of heads, or the placing of the units on mast arms or span wires over the traffic lanes to replace or supplement curb-mounted signals. The location of heads over the lanes of travel place the indications in the line of sight of the driver. They eliminate to a great extent the possibility of large trucks and buses obscuring from view the low-mounted corner signal. On business streets, the visibility of corner signals is often reduced by a background of numerous brightly lighted advertising signs.

Modernization of controls may include the replacement of an obsolete controller with a modern fixed-time or actuated controller with detectors in the intersection. Arrows controlling individual movements such as right and left turns have been effectively employed. Special timing sequences and the use of all red periods to clear wide intersections have reduced accidents.

Most controller or visibility modernizations tailored to the needs of the intersection have generally proved safer and more efficient. Before-and-after studies provide evidence to back this statement. Although many improvements have been made without measuring the results, some studies are available which prove the benefit of modern traffic signal installations. Examples in this paper are the results of studies comparing conditions before and after the installation of modern signals and controls.

The signal visibility modernization program for the City of Detroit included primarily the installation of over-the-road indications, generally installed on mast arms mounted diagonally from the near right and far left corners and with the faces in line with the

TABLE 1

ACCIDENTS BEFORE AND AFTER MODERNIZATION, DETROIT, MICH.

Location	Date of Modernization	Before (1955)					After (1960)				
		Angle	Ped.	Rear End	Other	Total	Angle	Ped.	Rear End	Other	Total
Boston-Dexter	Dec. 1958	18	–	4	1	23	1	–	1	1	3
Calvert-Linwood	July 1958	4	–	2	2	8	2	–	2	2	6
Chalmers-Charlevoix	Jan. 1958	13	1	3	2	19	2	–	3	2	7
Charlevoix-Grand Blvd.	Feb. 1958	4	–	10	3	17	1	–	6	1	8
Charlevoix-Van Dyke	Feb. 1958	8	1	–	2	11	3	–	2	5	10
Chene-Ferry	April 1958	14	–	12	4	30	1	1	4	2	8
Chicago-Fourteenth	May 1958	10	–	4	1	15	3	–	2	2	7
Clairmount-Twelfth	May 1958	6	1	9	9	25	3	1	12	6	22
Conner-Kercheval	Jan. 1958	5	–	5	2	12	1	–	1	2	4
Conner-Vernor	Feb. 1958	7	1	5	2	13	3	–	7	3	13
Elmhurst-Fourteenth	May 1958	2	–	4	3	9	–	1	1	2	4
Elmhurst-Linwood	June 1958	12	2	10	6	30	–	2	7	2	11
Ferry-Russell	April 1958	4	1	13	19	37	–	–	3	5	8
Grand Blvd. -Kercheval	Feb. 1958	12	–	6	6	24	3	–	4	4	11
Grand Blvd. -Mt. Elliott	March 1958	12	1	11	9	33	3	–	17	10	30
Grand Blvd. -E. Vernor	June 1958	11	1	13	2	27	6	–	3	3	12
Kercheval-McClellan	Jan. 1958	10	–	7	4	21	2	1	3	1	7
Kercheval-St. Jean	Feb. 1958	4	3	4	2	13	3	–	5	2	10
Kercheval-Van Dyke	Feb. 1958	8	1	2	3	14	4	1	8	4	17
Twelfth-Webb	Aug. 1958	5	–	3	11	19	2	–	6	2	10
Total		169	13	127	91	400	43	7	97	61	208
Percent change							-75	-46	-24	-33	-47

approach to the signal controls. Such intersections might have, in addition, corner installations of standard heads or "Walk—Don't Walk" signals, or a combination of the two. Each location is tailored to the needs of the intersection. On December 31, 1961, there were 1,334 signalized intersections in Detroit, 1,152 operated by the city and 182 operated by the county. All of these were modernized. Pedestrian "Walk—Don't Walk" signals are provided at 300 locations operated by the city, and at 36 locations operated by the county. Twenty representative locations were chosen for a before-and-after study of accidents at these modernized intersections. Before modernization, none of these locations were equipped with over-the-roadway signal indications. After modernization, the approaches on the major streets were equipped with two overhead indications and each approach on minor streets with at least one overhead indication. The analysis is given in Table 1. From the data, the following accident reductions were calculated:

Right-angle - 75 percent
Rear-end - 24 percent
Pedestrian - 46 percent
Other types - 33 percent
Overall - 47 percent

TABLE 2

PEDESTRIAN ACCIDENTS AT TEN LOCATIONS IN THE CBD BEFORE AND AFTER INSTALLATION OF WALK-DON'T WALK SIGNALS, DETROIT, MICH.

Location	Date of Installation	1958		1960	
		Pedestrian Accidents	Violators	Pedestrian Accidents	Violators
Woodward-Montcalm	Jan. 1959	–	–	2	1
Woodward-Columbia	Jan. 1959	3	1	1	1
Woodward-Elizabeth	Jan. 1959	–	–	–	–
Woodward-Adams	Jan. 1959	4	2	2	–
Woodward-Park-Witherell	June 1959	–	–	1	1
Woodward-Clifford-John R	July 1959	3	2	1	1
Woodward-Grand River	July 1959	2	1	–	–
Woodward-Gratiot-State	June 1959	3	2	2	–
Washington Blvd. -Grand River	Oct. 1959	1	1	–	–
Washington Blvd. -Clifford	Sept. 1959	–	–	–	–
Total		16	9	9	4
Percent change				-44	-56

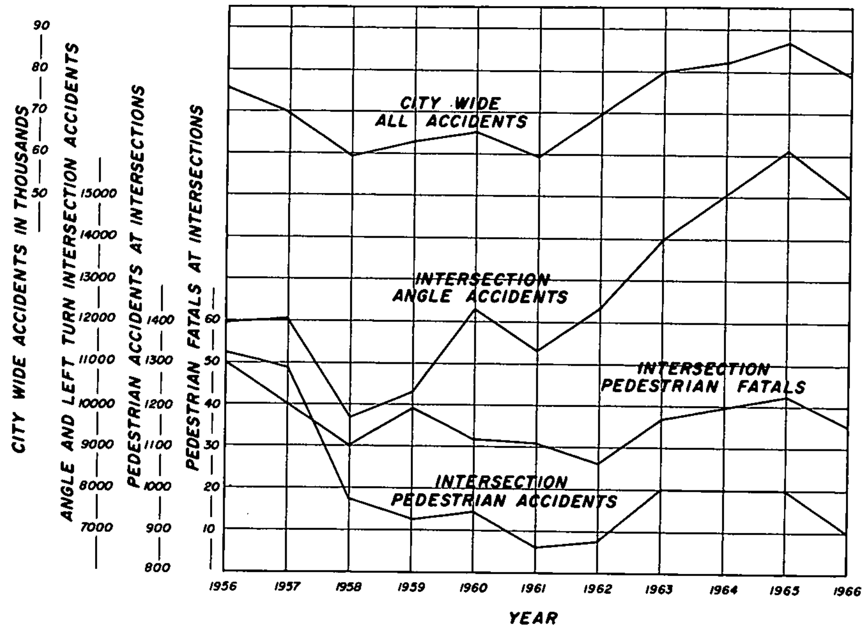


Figure 1.

Probably the most significant figure in this analysis is the reduction in the most serious type of accident—the right-angle. The reduction in right-angle accidents accounts for 65 percent of the total reduction at these locations. The analysis indicates that the modernization of traffic signals has achieved the desired results from the safety standpoint; not reflected in this study is the greater convenience and comfort for the driver.

The modernization of signals in the CBD included the equipping of the majority of the locations with Walk—Don't Walk pedestrian signals. To measure the results of this program, ten of the locations with the highest pedestrian volume were selected, and pedestrian accidents before the installation of the signals were compared with the number of accidents after the installation. Also studied was the number of pedestrian accidents occurring while a pedestrian was walking against a red or Don't Walk signal. Table 2 indicates a reduction from 16 pedestrian accidents before to nine pedestrian accidents after, or a reduction of 44 percent. Better observance of the Don't Walk signal as compared to the normal red indication was indicated by the reduction from nine accidents occurring before to four pedestrian accidents after installation, or a reduction of 56 percent. The results of this study indicate, at least on a sample basis, the results achieved with pedestrian signals. A subsequent study of 60 locations before and after the installation of Walk—Don't Walk signals included all of the CBD installations (40 locations), plus 20 at other locations. There was a similar result with 57 before and 29 after or a 49 percent reduction in total accidents, and of those involving violations, a reduction from 22 to 8, or 72 percent. These results substantiated the findings of the previous study.

On January 1, 1951, there were 70 intersections equipped with pedestrian signals, most of which were at school crossing locations. Between January 1, 1951, and December 31, 1965, 280 additional intersections were equipped, including most intersections within the CBD, intersections of wide streets and high pedestrian volumes, some school crossing locations, and newly signalized intersections with street widths in excess of 40 ft.

During the 10-yr period 1956 through 1965, the city-wide total accident picture showed a generally upward trend (accidents were down in all categories in 1966). There were 16 percent more accidents occurring in 1965 than in 1956. During the same period, the trend of intersection right-angle and left-turn accidents was definitely upward. The 1965 total was 47 percent higher than the 1956 total for these categories. The intersection pedestrian accident picture, however, showed a definite downward trend with the 1965 total being 25 percent less than the 1956 total (Fig. 1). It is felt that a definite relationship exists between the reduction of pedestrian accidents and the more extensive use of pedestrian signals. This may be contrasted with the increase in total accidents, right-angle and left-turn accidents at intersections. Discretion used in determining locations for pedestrian signal installation, judicious enforcement of the punitive pedestrian signal ordinance, and adequate public information on the subject have apparently improved pedestrian safety.

The Wayne County Road Commission installs and operates signals at 706 locations in Wayne County, 192 of which are in the City of Detroit. At isolated locations in the built-up suburban areas, the county installed single, four-faced signals on span wires in the center of the intersection. As traffic increased, the single indication was insufficient and many locations were modernized by adding additional indications or by other means. At the intersection of Allen Road and Eureka Road in Wyandotte (Figs. 2 and 3), the installation of a second set of signal faces for each direction reduced accidents from a total of 12 in the year before to seven in the year after installation, or approximately 41 percent reduction. Two of the after accidents were side-swipes on which signal control would ordinarily have no effect. The greatest reduction was in rear-ends, which reduced from four to none, indicating better visibility approaching the intersection.

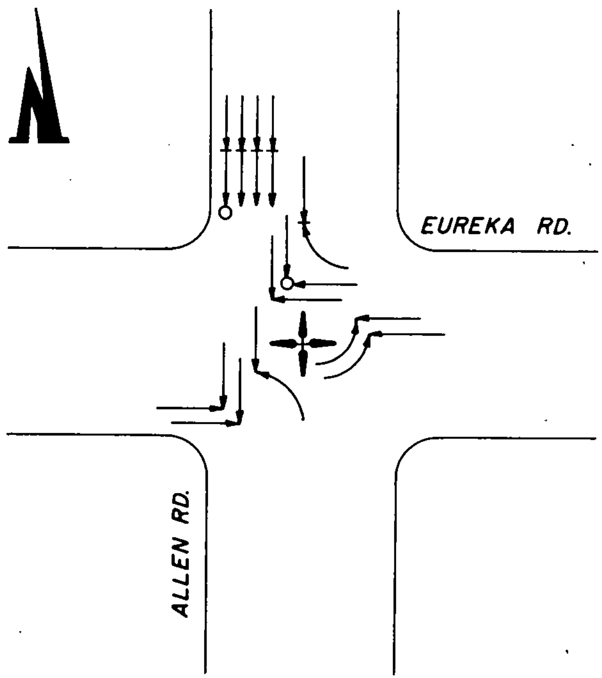
A similar improvement at the intersection of Farmington Road and Five Mile Road (Figs. 4 and 5), in the center of Livonia showed a reduction in total accidents from 7 to 4, or 43 percent. In this case, the right-angles which reduced from 2 to none showed the greatest reduction.

A third location, similarly modernized, at Allen Road and Sibley Road (Figs. 6 and 7) near the City of Riverview, showed a reduction in accidents from 8 to 5, or 38 percent. Right-angles in this case were reduced from 5 to 3.

At the intersection of East Outer Drive, a boulevarded street with a wide divider and three moving lanes in each direction, and Conant Avenue, a four-lane undivided street in Detroit (Figs. 8 and 9), signals were modernized to provide two indications for each approach including double indications on Conant on each side of the center island. This improvement resulted in a reduction in total accidents from 36 to 29, but right-angle accidents which were a problem in two quadrants before reduced from 15 to 2, or 86 percent. The right-angle accidents were all far-side-of-the-island accidents before modernization. The installation of far-side island indications were the major factor in reducing right-angle accidents.

At the intersection of Inkster Road and Joy Road (Figs. 10 and 11), bordering Dearborn Heights and Livonia, accidents increased to a total of 35 for a 1-yr period. This intersection is equipped with two complete four-face installations on span wires over the intersection. Volumes are heavy on all approaches, all turns are allowed, and turning movements are comparatively heavy. This intersection was modernized by the introduction of a 1-sec, all-red interval after each phase. The results were surprising. Total accidents reduced from 35 to 11, or approximately 70 percent. Turning accidents reduced from 12 to 7, rear-end from 11 to 3, and right-angle from 9 to 1. The additional second evidently has provided the additional time required to clear through and turning traffic from the intersection.

The City of Detroit has also had favorable results with the use of all-red periods. A typical example is the intersection of Larned and Mt. Elliott (Figs. 12 and 13). Larned is a one-way street originating in the CBD, dead-ending about three miles east at Mt. Elliott. At this point, drivers use Mt. Elliott to reach other major arteries continuing east into the residential areas. Right-angle accidents were reduced by the use of an all-red period. During the base with a 60-sec cycle, the all red is 1.2 sec. During the peak with a 70-sec cycle, this is extended to 1.4 sec (2 percent of the total cycle).

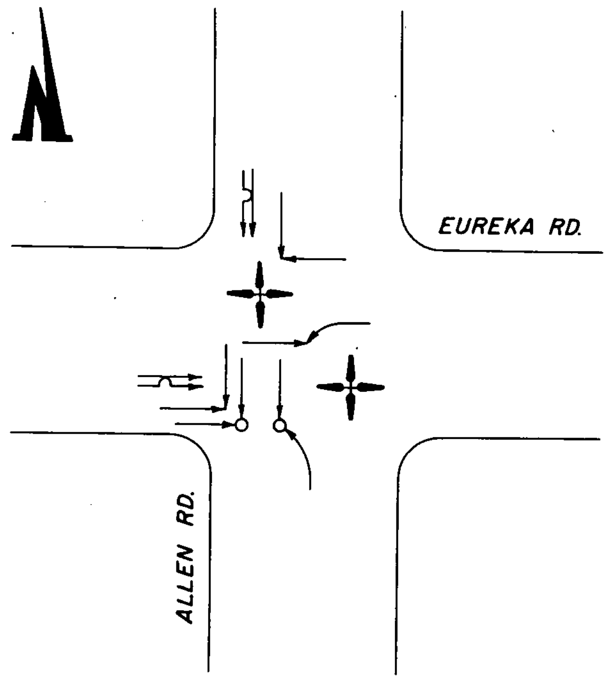


BEFORE MODERNIZATION

12/58-12/59	Number of Accidents	12
12/58-12/59	Ave. Daily Traffic into Intersection	14,850
	Accident rate per Million Vehicles	2.34

Wayne County, Michigan

Figure 2.

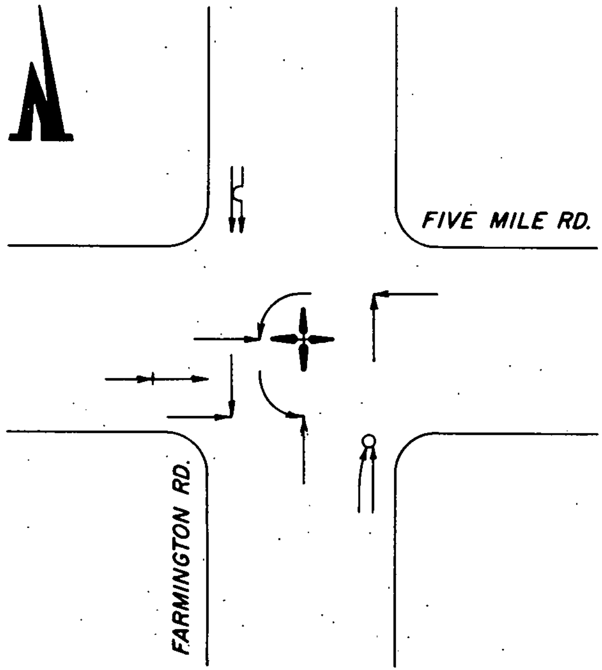


AFTER MODERNIZATION

12/59-12/60	Number of Accidents	7
	Ave. Daily Traffic into Intersection	15,300
	Accident rate per Million Vehicles	1.33
	Reduction in Accident rate	43.2 %

Wayne County, Michigan

Figure 3.

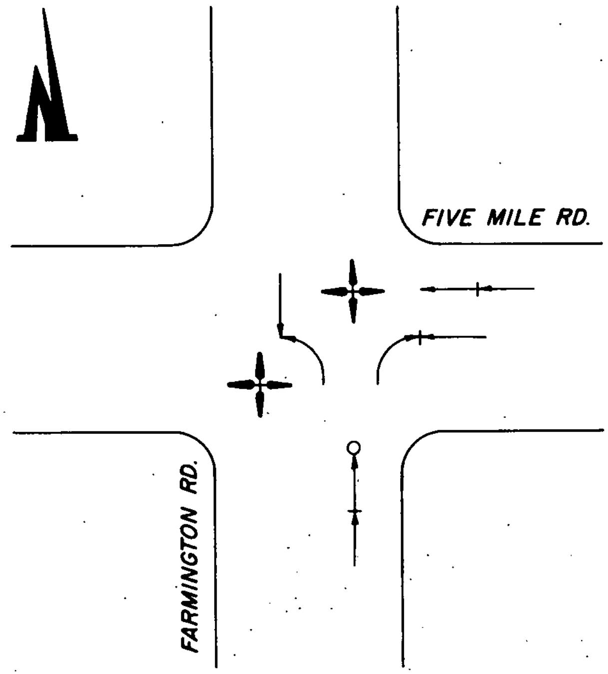


BEFORE MODERNIZATION

9/58-9/59	Number of Accidents	7
9/58-9/59	Ave. Daily Traffic into Intersection	27,200
	Accident rate per Million Vehicles	0.74

Wayne County, Michigan

Figure 4.

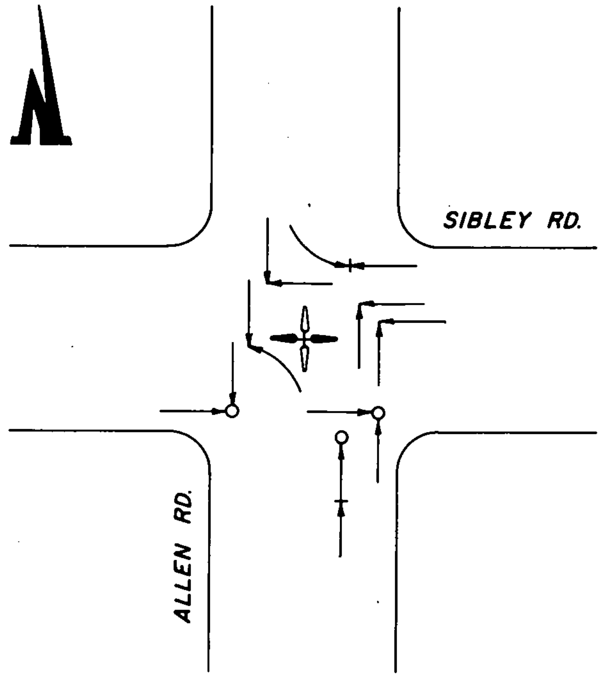


AFTER MODERNIZATION

9/59-9/60	Number of Accidents	4
	Ave. Daily Traffic into Intersection	28,000
	Accident rate per Million Vehicles	0.41
	Reduction in Accident Rate	44.6 %

Wayne County, Michigan

Figure 5.

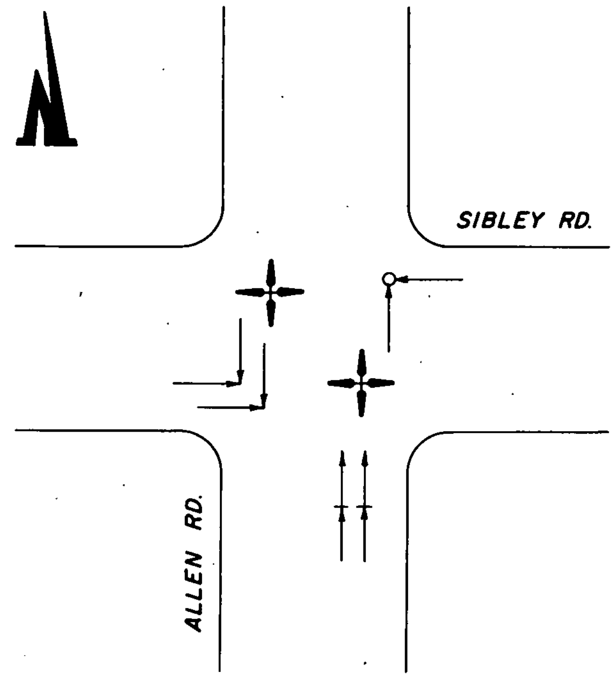


BEFORE SIGNALIZATION

2/64-2/65 Number of Accidents ______ 8
2/64-2/65 Ave. Daily Traffic into Intersection ______ 7,750
Accident rate per Million Vehicles ______ 2.99

Wayne County, Michigan

Figure 6.

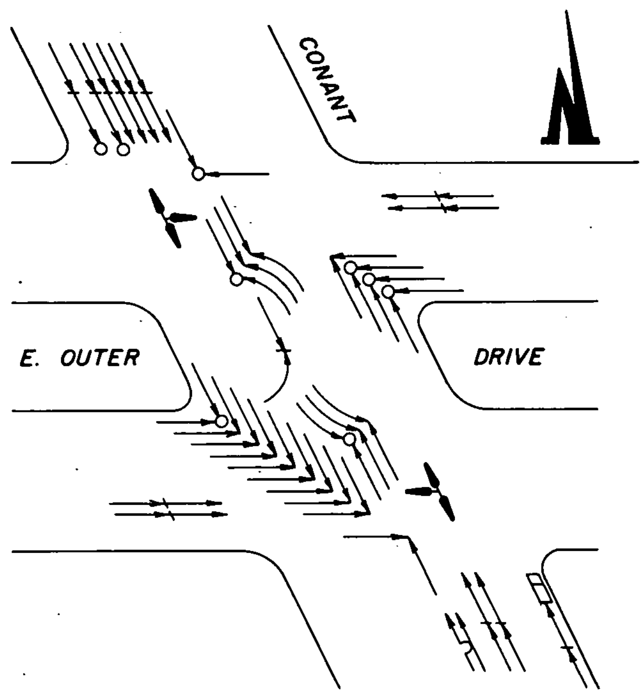


AFTER SIGNALIZATION

2/65-2/66 Number of Accidents ______ 5
Ave. Daily Traffic into Intersection ______ 7,900
Accident rate per Million Vehicles ______ 1.84
Reduction in Accident rate ______ 38.5%

Wayne County, Michigan

Figure 7.

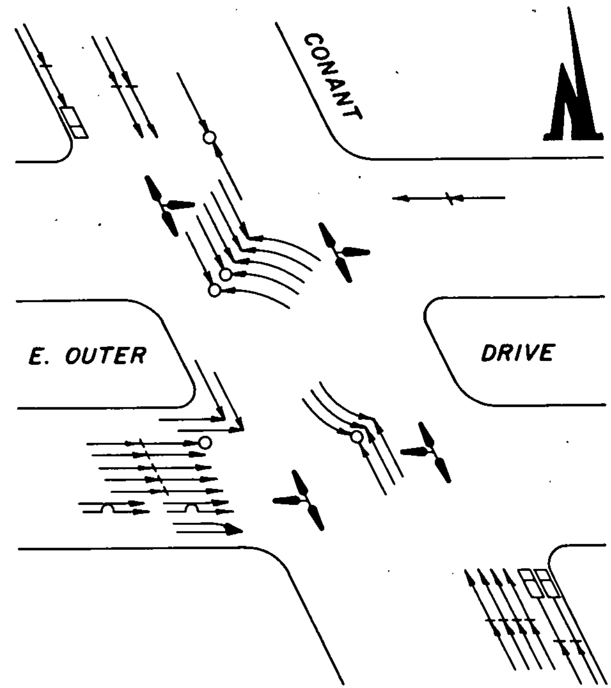


BEFORE MODERNIZATION

4/59-4/60	Number of Accidents	36
4/59-4/60	Ave. Daily Traffic into Intersection	46,500
	Accident rate per Million Vehicles	2.27

City of Detroit, Michigan

Figure 8.

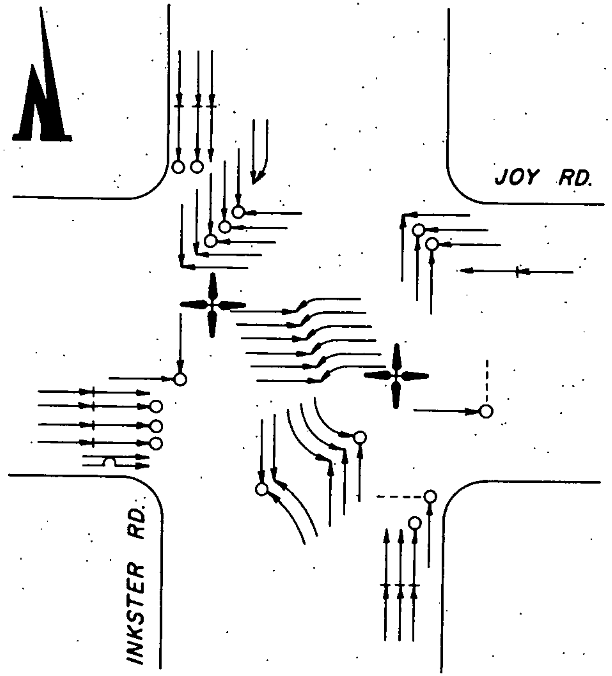


AFTER MODERNIZATION

4/60-4/61 Number of Accidents	29
Ave. Daily Traffic into Intersection	47,900
Accident rate per Million Vehicles	1.78
Reduction in Accident rate	21.6%

City of Detroit, Michigan

Figure 9.

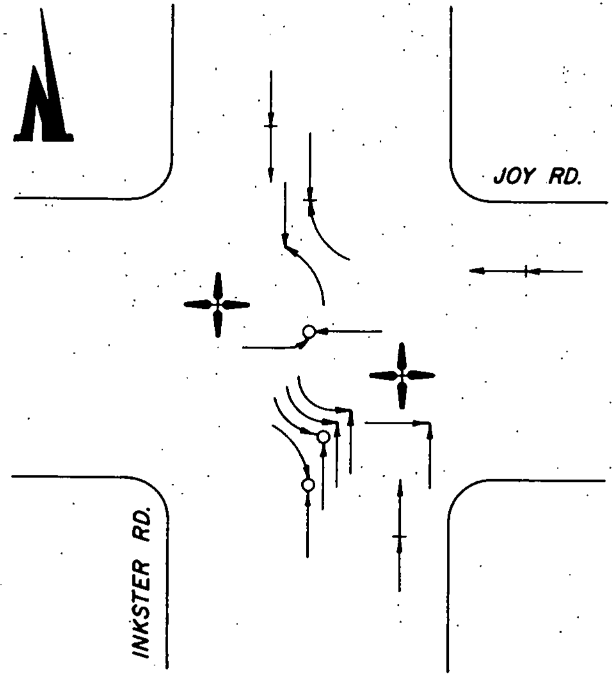


BEFORE INSTALLATION OF ALL RED SIGNAL PHASE

2/64 - 2/65 Number of Accidents ______ 35
2/64 - 2/65 Ave. Daily Traffic into Intersection ______ 33,300
Accident rate per Million Vehicles ______ 3.04

Wayne County, Michigan

Figure 10.

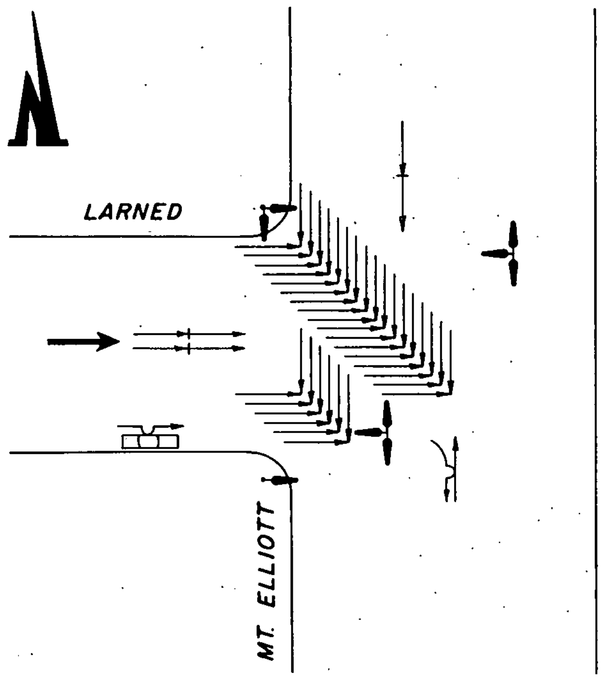


AFTER INSTALLATION OF ALL RED SIGNAL PHASE

2/65-2/66 Number of Accidents ______ 11
Ave. Daily Traffic into intersection ______ 33,900
Accident rate per Million Vehicles ______ 0.94
Reduction in Accident rate ______ 69.0 %

Wayne County, Michigan

Figure 11.

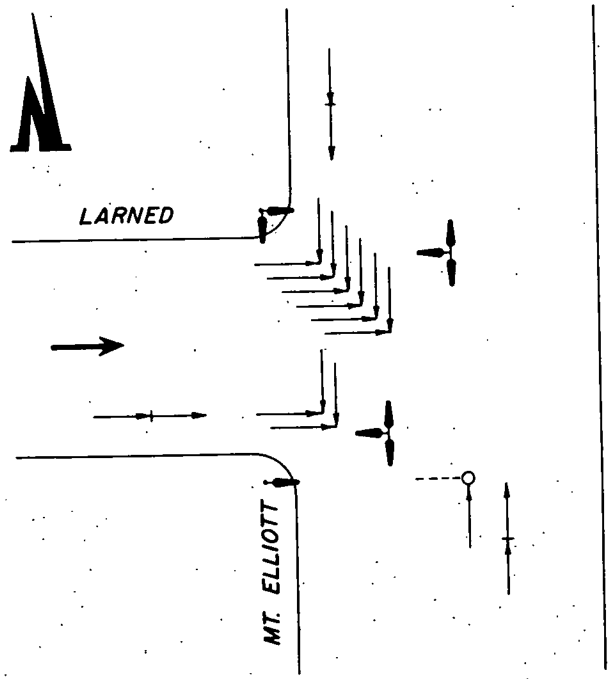


BEFORE INSTALLATION OF ALL RED SIGNAL PHASE

1959 Number of Accidents	28
1959 Ave. Daily Traffic into Intersection	11,800
Accident rate per Million Vehicles	6.98

City of Detroit, Michigan

Figure 12.

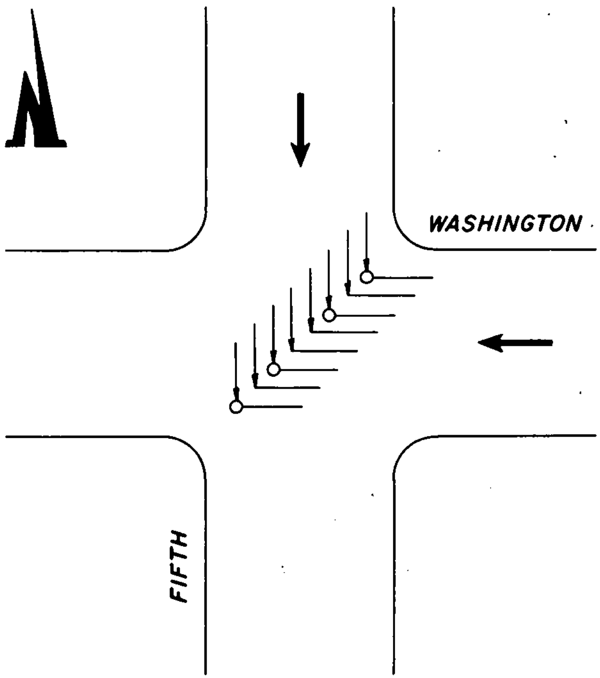


AFTER INSTALLATION OF ALL RED SIGNAL PHASE

1962 Number of Accidents	12
1962 Ave. Daily Traffic into Intersection	12,150
Accident rate per Million Vehicles	2.90
Reduction in Accident rate	58.4 %

City of Detroit, Michigan

Figure 13.

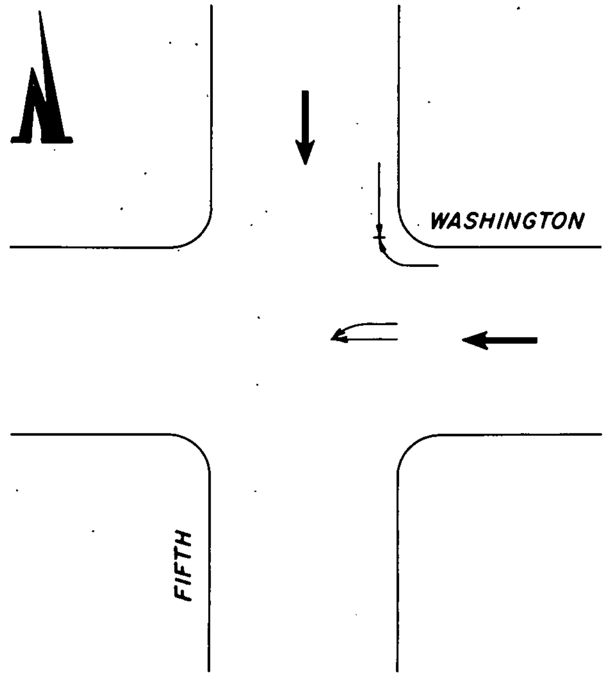


BEFORE - NO MAST ARM SIGNALS

1/1/65 - 12/30/65 Number of Accidents ________ 8

City of Phoenix, Arizona

Figure 14.



AFTER - WITH MAST ARM SIGNALS

1/1/66 - 12/30/66 Number of Accidents ________ 2

City of Phoenix, Arizona

Figure 15.

Total accidents reduced from 28 to 12 with right-angles reducing from 23 to 8, or 35 percent. Some of the difficulty at this intersection results from the fact that southbound traffic on Mt. Elliott can see not only the signal at Larned, but also the one at Jefferson not more than 300 ft beyond Larned. A possible change in timing is being studied in an effort to further reduce the number of right-angle accidents.

The Division of Traffic Engineering of the City of Phoenix experienced a reduction in accidents at an intersection after the installation of mast arms to supplement far side corner indications. The traffic engineer describes the improvement somewhat as follows:

> Traffic signals in the downtown area of Phoenix are double indication, far right and far left. Both Washington and Jefferson Streets are 68 ft wide with a 52-ft width on all crossing streets. Because of the width of these one-way streets and the volumes of traffic, we have felt that mast arms were highly desirable for these east-west streets. Subsequently, at the intersection of 5th Avenue and Washington, 20-ft mast arms with 8-in. indications were installed which provide a total of 4 indications. The accident diagrams (Figs. 14 and 15) are for 1965 prior to the mast arms, and the accident diagram for 1966 is the after period. The number of accidents decreased 8 to 2 and right-angle accidents were entirely eliminated in the after year. We subsequently made accident analyses of all intersections that are signalized on Washington and Jefferson between 5th Avenue and 4th Street. Throughout this distance, the speed limit is 25 mph. The number of accidents for the year 1966 is given in Table 3. About 52 percent of the accidents are susceptible to correction by improvement of the signal indications. Using these data, we were able to procure funds for the coming year to install mast arm indications facing all Washington and Jefferson traffic throughout the area. In about 18 months, we should be ready to make a one-year after study.

The results recorded by Phoenix parallel those resulting from the same type of modernization in Detroit which experienced a 75 percent reduction of right-angle accidents for 20 representative locations. It is apparent that the installation of overhead indications providing improved signal visibility reduced significantly those accidents susceptible to correction with modern traffic signal control.

The Department of Traffic in the City of Los Angeles has reported on the results of various types of signal modernization. At seven isolated intersections where existing signals were up-dated to provide greater visibility and better control, a before-and-after study indicates a reduction in total accidents from 103 to 52, or almost 50 percent. Right-angles show a 75 percent reduction. Details for each intersection are shown in Table 4.

The Bureau of Traffic Research of the Department of Traffic has furnished a staff report on accident frequency comparison at three high-accident locations. The summary report is quoted vertabim as follows:

> Introduction
>
> In 1960 a list of high accident frequency locations was prepared from data recorded during the 18 month period January 1, 1959, to June 30, 1960. A detailed study in 1960 of the top 50 locations resulted in traffic signal and control modifications.
>
> This report summarizes the effect of these changes on accidents at three locations in the Hollywood Area of Los Angeles.
>
> The intersections (including approaches) selected for "before" and "after" accident studies were:
>
> 1. Sunset Boulevard and Highland Avenue (location "A")
> 2. Sunset Boulevard and LaBrea Avenue (location "B")
> 3. Hollywood Boulevard and Gower Street (location "C")
>
> Data for the "after" study was recorded during the 18 month period January 1, 1964, to June 30, 1965.

TABLE 3

WASHINGTON-JEFFERSON ACCIDENT STUDY IN DOWNTOWN PHOENIX, ARIZ.
(January 1, 1966 to December 31, 1966)

Street	Type of Accident	Total	Accident of Correctable Type (%)
(a) Intersecting Washington Street			
4th Street	12 Angle 1 Rear-end (6 Injury)	13	92
3rd Street	1 Turning 4 Angle (1 Injury)	5	80
2nd Street	1 Turning 1 Pedestrian 1 Rear-end (2 Injury)	3	0
1st Street	2 Pedestrian 1 Turning (2 Injury)	3	66
Central Avenue	7 Angle 2 Rear-end (2 Injury)	9	80
1st Avenue	3 Angle 5 Turning 1 Pedestrian (3 Injury)	8	50
2nd Avenue	2 Turning 1 Pedestrian (1 Injury)	3	0
3rd Avenue	4 Turning	4	0
Total	4 Rear-end 26 Angle 14 Turning 4 Pedestrian (17 Injury)	49	53
(b) Intersecting Jefferson Street			
5th Avenue	6 Angle 2 Turning (3 Injury)	8	75
3rd Avenue	3 Turning 7 Angle (4 Injury)	10	70
2nd Avenue	None		
1st Avenue	2 Angle 1 Turning (1 Injury)	3	66
Central Avenue	5 Angle 3 Rear-end (3 Injury)	8	62
1st Street	2 Angle 4 Turning 1 Pedestrian (4 Injury)	7	28
2nd Street	2 Turning	2	0
3rd Street	3 Turning 1 Rear-end 1 Pedestrian 3 Angle (2 Injury)	8	37
4th Street	3 Turning 2 Angle 1 Pedestrian (3 Injury)	6	33
Total	27 Angle 3 Pedestrian 18 Turning 4 Rear-end (20 Injury)	52	52
(c) Totals of Washington and Jefferson Streets			
	32 Turning 53 Angle 8 Pedestrian 8 Rear-end (37 Injury)	101	52.5

TABLE 4

EFFECTS OF TRAFFIC SIGNAL MODERNIZATIONS ON ACCIDENT REDUCTION, LOS ANGELES, CALIF.

Location	Before Modernization					After Modernization				
	RA	LT	RE	Other	Total	RA	LT	RE	Other	Total
1st St. and Mission Rd.	5	4	5	9	23	4	1	1	2	8
1st St. and Virgil Ave.	7	2	0	0	9	3	4	1	1	9
6th St. and Central Ave.	3	0	2	1	6	1	1	1	3	6
15th St. and Alameda St.	6	0	3	2	11	0	0	1	2	3
67th St. and Western Ave.	11	0	1	3	15	0	1	2	1	4
Century Blvd. and Vermont St.	7	0	13	2	22	1	4	4	4	13
LaBrea Ave. and Wilshire Blvd.	10	1	6	0	17	3	1	4	1	9
Grand totals	49	7	30	17	103	12	12	14	14	52

Purpose

The purpose of this study was to determine to what extent modifications in traffic signals and controls influence accident frequency. It was also intended to show if specific changes reflect reductions or increases in certain types of accidents.

Conclusions

In general, the traffic signal and control modifications made in 1960 appear to have reduced accident frequency within intersections. Accidents on the approaches to the three intersections have increased.

On the approaches where mast arm indications were installed or had been in place, rear end collisions increased much more rapidly than on those which do not have mast arm indications.

However, right-angle accidents showed a much greater reduction at the two intersections where mast arm indications were installed on all approaches than at the intersection which has mast arm indications on the major street only.

A considerable reduction in left turn accidents occurred at those locations where special left turn signal phases were installed.

Pedestrian accident data for the two locations where pedestrian signals were installed showed one accident "before" and two "after" for both locations. This was considered to be an insufficient number to draw conclusions concerning the effect of pedestrian signals on the frequency of accidents involving pedestrians.

Since improved street lighting was installed in conjunction with traffic signal modifications, no relation between accident frequency and street lighting alone could be determined.

As the traffic signal modifications varied for each location the extent of the modification and the accident reductions or increase by type and total follows:

Before and after traffic volume data are also included.

The details for each intersection are given in Tables 5, 6, and 7. Right-angle accidents show a significant reduction where mast arm indications were installed on all approaches. The report shows a considerable reduction in left-turn accidents occurring at those locations where special left-turn signal phases were installed.

A more complicated modernization accompanied by rechannelization is contained in a report obtained from the Montana Highway Commission. The location is the intersection of Helena, Montana and Lyndale Avenues in the City of Helena. A plan of the intersection before and after is shown in Figures 16 and 17. The description of the intersection and the completed modernization project is as follows:

The before installation by the City of Helena consisted of near-right and far-left signal indications post-mounted 8 ft high. Signal controller equipment was fixed time with railroad preemption. Cycle length was 50 sec split

TABLE 5

TRAFFIC CONTROL CONDITIONS, LOS ANGELES, CALIF.

Before January 1, 1959, to June 30, 1960	After January 1, 1964, to June 30, 1965
(a) Sunset Blvd. and Highland Ave. [a]	
1. Two-phase fixed-time signal.	1. Actuated left turns for Sunset Blvd.
2. No left turns from Highland Ave. (3:00 p. m. -6:00 p. m.).	2. No left turns from Highland Ave. (7:00 a. m. -7:00 p. m.).
3. Highland Ave. off-centering during a. m. and p. m. peak hours.	3. Highland Ave. off-centering during a. m. and p. m. peak hours.
	4. Four-way mast arm indications.
	5. Pedestrian signals.
	6. Mercury luminaires installed in conjunction with mast arm signals.
(b) Sunset Blvd. and LaBrea Ave. [b]	
1. Two-phase, fixed-time signal.	1. Two-phase, fixed-time signal.
2. Mast arms for Sunset Blvd. only.	2. Mast arms for Sunset Blvd. only.
3. No pedestrian signals.	3. No pedestrian signals.
	4. Three-second all-red interval following LaBrea Ave. green.
(c) Hollywood Blvd. and Gower St. [c]	
1. Two-phase, fixed-time signal.	1. Two-phase, fixed-time signal.
	2. Four-way mast arm indications.
	3. Pedestrian signals.
	4. Mercury luminaires installed in conjunction with mast arm signals.

[a] 24-hr volume entering intersection: before, 80,870; after, 74,870; change, -7.44 percent.
[b] 24-hr volume entering intersection: before, 65,760; after, 67,760; change, +3.04 percent.
[c] 24-hr volume entering intersection: before, 36,500; after, 41,670; change, +14.16 percent.

TABLE 6

SUMMARY OF INTERSECTION AND APPROACH ACCIDENTS BY TYPE AND SEVERITY, LOS ANGELES, CALIF.

Type	Prop. Damage		Injury		Fatal		Total		Change in Total (%)
	Before	After	Before	After	Before	After	Before	After	
(a) Sunset Blvd. and Highland Ave.									
Left-turn	10	2	9	6	0	0	19	8	-58
Right-angle	8	0	8	2	0	0	16	2	-88
Rear-end	9	11	8	11	0	0	17	22	+29
Side-swipe	6	3	2	1	0	0	8	4	-50
Pedestrian	0	0	1	1	0	0	1	1	0
Other	1	3	2	0	0	0	3	3	0
Total	34	19	30	21	0	0	64	40	-38
(b) Sunset Blvd. and LaBrea Ave.									
Left-turn	3	4	6	2	0	0	9	6	-33
Right-angle	6	1	3	4	0	0	9	5	-44
Rear-end	4	10	5	8	0	0	9	18	+100
Side-swipe	2	5	0	1	0	0	2	6	+200
Pedestrian	0	0	3	1	0	0	3	1	-67
Other	4	3	0	5	0	0	4	8	+100
Total	19	23	17	21	0	0	36	44	+22
(c) Hollywood Blvd. and Gower St.									
Left-turn	3	3	3	5	0	0	6	8	+33
Right-angle	5	2	6	5	0	0	11	7	-31
Rear-end	2	4	4	3	0	0	6	7	+17
Side-swipe	3	1	0	0	0	0	3	1	-67
Pedestrian	0	0	0	1	0	0	0	1	—
Other	4	2	0	0	0	0	4	2	-50
Total	17	12	13	14	0	0	30	26	-13

TABLE 7

ACCIDENT FREQUENCY BY TYPE AND LOCATION, LOS ANGELES, CALIF.

Type of Accident	Intersection			Approach		
	Before	After	Change	Before	After	Change
(a) Sunset Blvd. and Highland Ave.						
Left-turn	19	8	-11	0	0	0
Right-angle	14	2	-12	2	0	-2
Rear-end	2	2	0	15	20	+5
Side-swipe	1	1	0	7	3	-4
Pedestrian	1	0	-1	0	1	+1
Other	1	0	-1	2	3	+1
Total	38	13	-25	26	27	+1
(b) Sunset Blvd. and LaBrea Ave.						
Left-turn	6	6	0	3	0	-3
Right-angle	6	5	-1	3	0	-3
Rear-end	2	2	0	7	16	+9
Side-swipe	0	1	+1	2	5	+3
Pedestrian	2	1	-1	1	0	-1
Other	0	0	0	4	8	+4
Total	16	15	-1	20	29	+9
(c) Hollywood Blvd. and Gower St.						
Left-turn	6	8	+2	0	0	—
Right-angle	10	7	-3	1	0	-1
Rear-end	2	1	-1	4	6	+2
Side-swipe	1	0	-1	2	1	-1
Pedestrian	0	1	+1	0	0	—
Other	0	1	+1	4	1	-3
Total	19	18	-1	11	8	-3

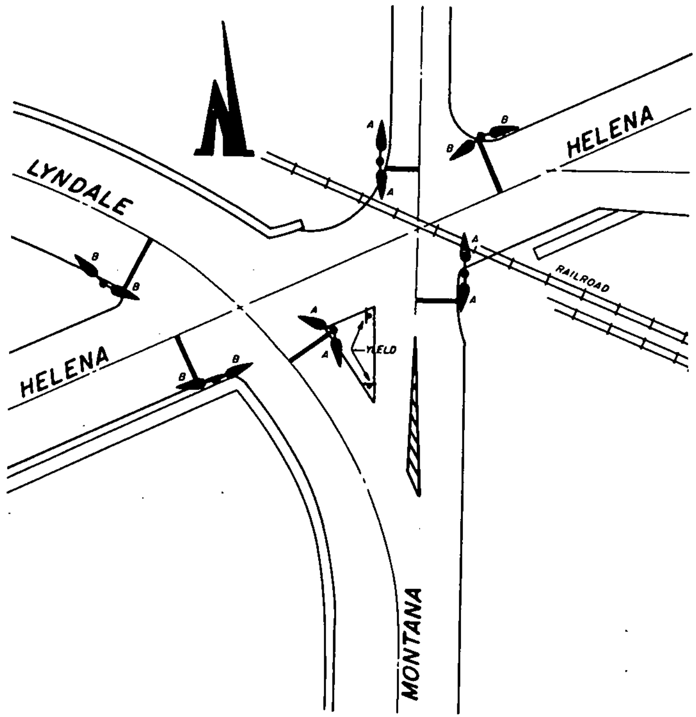
50-50. Montana Ave. traffic proceeding south had only a YIELD sign to guide it in crossing the Montana-Lyndale traffic, as did the traffic turning left from Lyndale Ave. onto Helena Ave. to cross Montana Ave. This resulted in considerable congestion at the intersection with accompanying hazard due to restriction of sight distance.

The intersection improvement consisted of rechannelization and installation of new traffic signals. Three strain poles support signals on span-wires. This leaves the islands clear of signal poles which might be a physical and sight-restricting hazard. Double indication was used for each approach except that additional pole-mounted signals provide sight distance for the Montana-Lyndale Ave. approaches which are on a curve. The signals on the northeast corner of the intersection are mast-arm mounted. Actuated pedestrian signals provide indications for pedestrians crossing the street.

The signal controller is three-phase traffic actuated with loop detectors on each approach. Signal timing includes a 3-sec yellow and 3-sec all red following each green interval. Montana-Lyndale is the major movement and is left on recall. There is a railroad preemption which, after appropriate yellow intervals, locks the controller onto the Montana-Lyndale green indication and illuminates a NO LEFT TURN sign for Lyndale Ave. traffic approaching the traffic from the west.

The before and after improvements show a reduction in accident rate of 48.3 percent for 1966, the first full year of operation.

It is sometimes impossible to properly signalize a complicated intersection without proper channelization to guide traffic through the intersection. The intersection described in the foregoing was improved by the combination of both signalization and channelization. The after study shows a substantial decrease in accidents and there is little doubt that the intersection operates more efficiently than before.

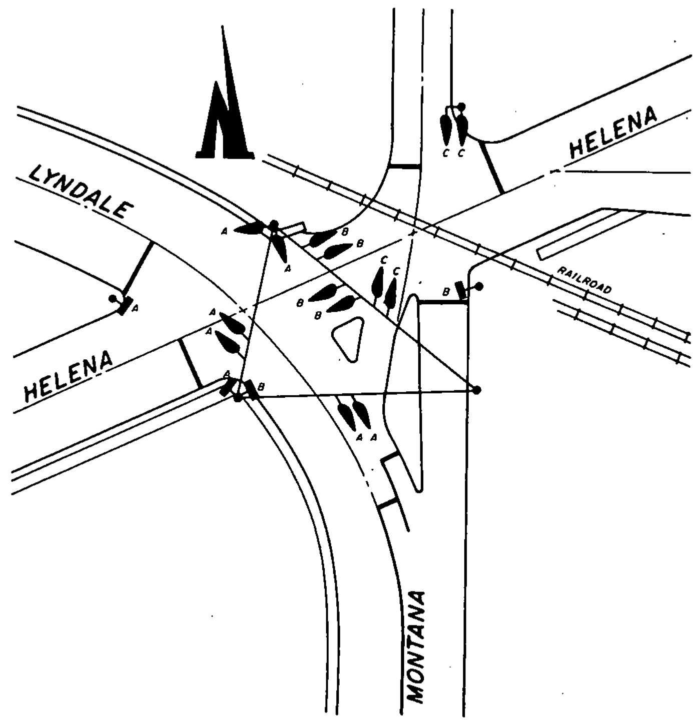


BEFORE IMPROVEMENTS

1962-1964 Number of Accidents	31
1962-1964 Ave. Number of Accidents	10.3
1965 Ave. Daily Traffic into Intersection	11,580
Accident rate per Million Vehicles	2.45

City of Helena, Montana

Figure 16.



AFTER IMPROVEMENTS

1966 Number of Accidents	7
1966 Ave. Daily Traffic into Intersection	15,054
Accident rate per Million Vehicles	1.27
Reduction in Accident rate	48.3 %

City of Helena, Montana

Figure 17.

CONCLUSIONS

The examples of traffic-signal modernization described in the foregoing indicate that modern signal controls tailored to the needs of traffic can improve the efficiency of intersections and reduce accidents. It is obvious that improved visibility is a major factor in accident reduction. The introduction of mast arm or overhead signals in every case resulted in reduced accidents. Observations have shown that the use of all red periods by Wayne County and the City of Detroit has been successful. Unfortunately, the examples cited are the only ones available with before-and-after experience. There should also be more studies indicating the value of special left-turn signal phases. The one cited by Los Angeles indicated a considerable reduction in left-turn accidents as a result of such an installation.

Detroit is committed to a pedestrian signal program using the incandescent Walk—Don't Walk indication. Each year, major streets are being equipped with such signals at intersections warranting such protection. It is felt that the use of the words Walk—Don't Walk has had an effect on observance by the pedestrian of all type signals throughout the city.

Pedestrian signals properly observed, especially on wide streets, not only benefit the pedestrian, but also expedite the movement of vehicular traffic. Detroit uses the flashing Don't Walk which is the clearance period timed to normal walking speed. Properly observed, this eliminates pedestrians from the crosswalk when the green appears for the intersecting street. This eliminates considerable delay but unfortunately before-and-after studies have not been made to measure this effect accurately.

Addenda

PHOENIX, ARIZ.

A study of accident records demonstrated a need for mast arms. These were installed at a cost of $2, 000. The before and after collision diagrams (Figs. 18 and 19) present the remarkable reduction in accidents which this action achieved. Washington Street is one-way and carries approximately 15, 000 cars a day at this location.

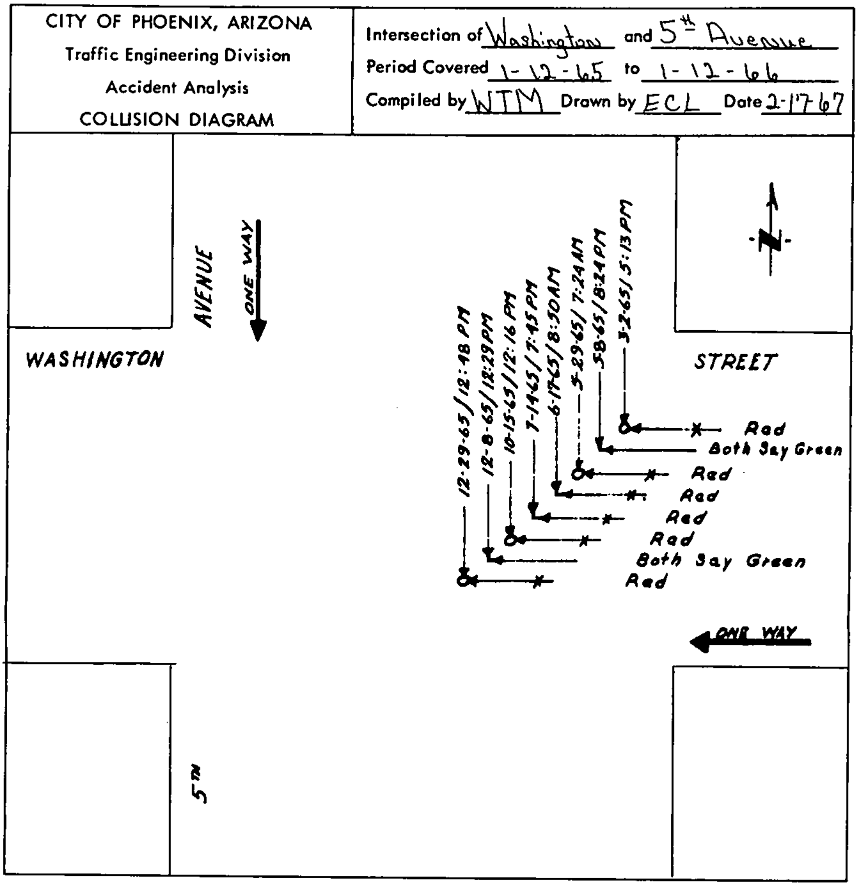


Figure 18. Before mast arms.

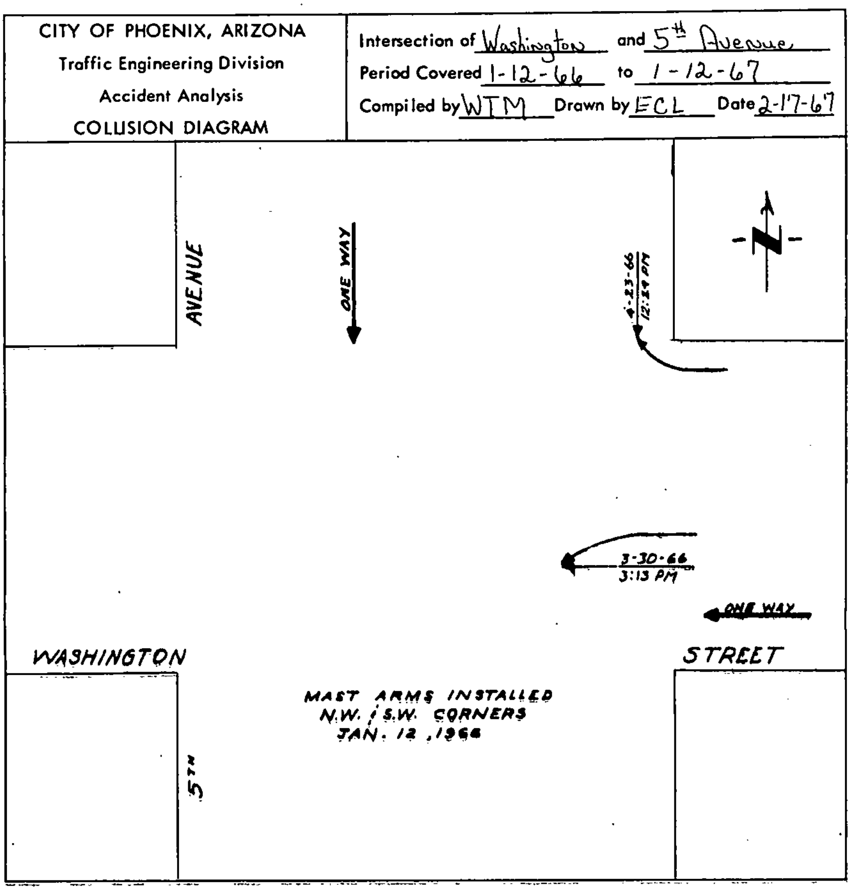


Figure 19. After mast arms.

WASHINGTON, D. C.

The system originally developed in Washington provided that whenever a Walk message appeared it represented an exclusive walk interval for pedestrians. When it was decided to convert some of these pedestrian signals to semi-exclusive or share the green intervals, the following system was used: (a) the green ball vehicular indication appeared for both cars and pedestrians when it was legal to walk, (b) the pedestrian signal indication was dark until it was time to provide a clearance interval, at which time the Don't Walk was lighted, (c) the Don't Walk stayed on during the balance of the green vehicular indication, yellow clearance and red interval, and (d) the Don't Walk was blanked out at the beginning of the next green.

Several of these signals were formerly in operation near the Matomic Building on H Street, N. W. The following news release spells out the changeover and gives a description of the flashing Walk operation currently used at locations where a semi-exclusive interval is in use.

* * *

The District of Columbia, a pioneer city in the protection of pedestrians, has been the installation of new flashing Walk signals at numerous intersections in the downtown area. Where traffic volumes do not warrant a complete separation of pedestrians and vehicles, the flashing Walk signal will be used to advise pedestrians when to cross. The new devices will flash a white Walk signal to pedestrians while vehicular traffic signals will permit motorists to turn providing they yield to pedestrians in the crosswalk.

Deputy Director for Traffic Engineering and Operations of the D. C. Department of Highways and Traffic, Daniel J. Hanson, feels that the distinctive white Walk and portland orange Don't Walk indications are an important step in providing pedestrians with their own color combination. Red pedestrian signal faces now in use will be phased out of service over several years as a part of this new pedestrian safety program.

The Don't Walk pedestrian signal indication tells a pedestrian when not to step off the curb. H Street, N. W., between 14th and 18th, was the site chosen for installing the new devices. Intersections along I, L and M Streets are also scheduled for similar installations.

When the program is complete there will be two standard pedestrian signal indications in the District of Columbia. A steady Walk indication will signify a vehicle-free pedestrian crossing. A flashing Walk light will be used only at intersections where traffic is permitted to turn providing motorists yield to pedestrians.

ST. LOUIS, MO.

The City of St. Louis has a unique situation related to walk signals. The walk signal as used in St. Louis, with the designation WALK, has always meant that the pedestrian had exclusive use of the crosswalk—there would be no interference from vehicles. Therefore, when upgrading signals, particularly on one-way streets, using pedestrian indications, and in order not to conflict with the WALK policy, the "Walking Man" symbol was used. At the present time, there are approximately 40 intersections with this type control.

There are other locations where St. Louis would like to use this indication; however, the city has been somewhat hesitant because it is not in the Uniform Manual.