One-Way Major Arterial Streets

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To be successful, all business districts and other traffic generation areas need traffic access, traffic circulation within, and parking or terminal facilities. In past years when traffic flows were lighter the conventional two-way arterial was adequate; but under today's heavier flow conditions, almost all cities are utilizing one-way arterial systems to improve access and circulation. These one-way arterials and one-way grid systems have a record of successful service. It is difficult to imagine the congestion many cities would have today without them. Furthermore, most communities are planning more one-way streets to improve the level of traffic service along their major transportation corridors and in their business districts.

Several reasons may exist for conversion to one-way operation. In general, one-way streets are used because they are more efficient and safer than two-way arterials; thus, they relieve traffic congestion and promote automobile and pedestrian safety.

Improved efficiency and level of traffic service is developed in several ways. One-way streets organize traffic better for improved operation and circulation, allow better progressive signal timing, solve the left-turn problem inherent in two-way arterials, allow better use of multi-turns, develop a more efficient use of street widths, and reduce vehicular and pedestrian conflicts. Through these factors, the capacity of a one-way system is usually considerably higher than a comparable set of two-way arterials; delays are minimized, and travel speeds are increased.

One-way streets are safer because conflicts in the flow pattern are reduced, the one-way direction of traffic eliminates the problem of head-on collisions, and pedestrians can cross one-way streets much easier. Nighttime safety is improved by the elimination of oncoming traffic headlight glare.

ONE-WAY STREETS

Operational Characteristics and Circulation

Unidirectional flow simplifies and organizes traffic better and results in greatly improved operational characteristics for a one-way system, allowing this system to collect and distribute traffic more efficiently. A street should accept traffic from other streets easily and should distribute that traffic to desired destinations including other streets, curb or off-street parking areas, and through curb cuts, to other auto-oriented uses such as drive-ins and service stations. In urban areas, even on crosstown one-way arterials, very little of the traffic is of the "through" type.

Two-way streets have difficulty in distributing traffic, primarily because much of the traffic desires to turn left in the face of the opposing flow which has the right-of-way. Also, parking spaces on the left of a two-way street cannot be reached, and on divided roadways, curb access points on the left are not accessible.

On the other hand, one-way streets distribute their traffic to the left or right with equal ease. Parking spaces and curb access on both sides are open to all motorists. Businessmen often resist one-way operation because they fear the effect of having only one-half of the traffic passing their doors. Yet, it is easy to demonstrate that if motorists are properly directed through public and private announcements, and when motorists have developed experience with a one-way arterial system, businessmen will receive the benefits of the better and safer mobility and access developed by a pair of one-way streets.

Signal Timing

In modern street operation a great deal of emphasis is placed on a smooth flow of traffic controlled by traffic signals. The most efficient, the most accident-free, and the most pleasurable to drive arterial system is the one which maintains a reasonably constant and uniform speed throughout. Stop-and-start driving destroys all three of these attributes.

Two-way streets can provide this desirable smooth flow, if proper spacing of traffic signals can be maintained. All too often, however, signals are required at spacings too close to permit timing that affords smooth flow in both directions. Compromises must be made in the delicate time-distance relationship which governs speed, and the result is a loss of the desired uniform travel speed.

To solve the left-turn circulation problems of two-way arterials, invariably many added left-turn signal phases are installed. These added phases further complicate signal-timing procedures and further restrict the traffic engineer's ability to provide smooth progressive signal timing and flow. Acute signal-timing problems brought about by adverse spacing and multi-phase operation can nearly ruin an otherwise well-designed two-way street.

On a one-way street system there is much less difficulty in obtaining uniform flow and better efficiency because the spacing of signals is no longer a major factor, and the adding of special phases is seldom required. A smooth progression can be provided even with traffic signals every block, such as along a business one-way street or through a grid.

Vehicular and Pedestrian Conflicts, Left-Turn Problems and Multi-Turns

One indication of the accident potential of an intersection is the number of vehicular conflicts. Comparing the intersection of two 4-lane two-way streets with two 4-lane one-way streets, the two-way streets generate 44 possible vehicular conflicts, whereas the one-way streets have only 18 conflict points. This reduction is a major advantage.

Because they cross opposing traffic lanes, left-turn movements on a two-way street cause many points of conflict; therefore, the left-turn movement requires expert motorist judgment unless a special signal phase is provided so that the turn can be made without opposing traffic. Difficulty with left turns from two-way streets is very apparent because of the great number of requests from motorists for left-turn signal phases and the many high-accident locations recorded where left turns are the basic cause.

Left turns from two-way arterials, unless provided with separate left-turn storage lanes, or prohibited entirely, also cause major delays to through lane traffic. Through-motorist irritation leads to unsafe driving practices, such as lane changing and speed limit violations involving motorists trying to catch up with the normal flow set by the signal timing.

One-way streets solve the left-turn problem inherent on two-way streets and even allow a multi-turn design which is difficult to install in two-way operation. Multi-turns in one-way flows must be carefully considered, however, as double turns from a one-way street are a problem if pedestrian volumes in the conflicting crosswalk are moderate to heavy and special WALK phases are not provided. Many cities, however, have utilized double-right and left turns along one-way systems successfully for many years.

Efficient Use of Street Widths

In two-way street design, many streets in areas where congestion occurs have relatively fixed roadway widths and their dimensions do not lend themselves to two equal and usable half-widths for opposing traffic flows. For example, assuming no parking, a street of 34 ft in roadway width with two-way operation is only suitable for two-lane design. In one-way operation, three lanes can be fitted to a 34-ft pavement with an increase in capacity. The same principle applies to other widths which provide an odd number of lanes. More efficient use of existing pavement widths can often be made by designing all lanes in one direction.

Capacity

It has been noted that one-way systems provide better capacity potential because of better operational characteristics, better signal timing, fewer vehicular and pedestrian conflicts, the elimination of the left-turn problem, provision of multi-turn possibilities, and more efficient use of certain street widths. Many references indicate that one-ways improve capacity under various conditions from 25 to 50 percent or more over comparable two-way arterials. This, of course, is a great boon to those responsible for traffic movement in a community. Capacity improvement leads to many one-way street developments as an alternative procedure to expensive two-way street widening projects.

At this point it should be emphasized that the 1965 Highway Capacity Manual (1, p. 325) cautions that the subject of relative efficiencies and capacities of one-way and two-way urban streets has solicited much discussion in recent years. Although early criteria showed substantial benefits in one-way over two-way operation, later interim intersection capacity criteria of the late 1950's showed somewhat contradictory relationships, largely because upgraded one-way systems were being compared with less efficient, unimproved two-way systems. However, the Highway Capacity Manual does concur that one-way traffic flow is more efficient and generally is highly desirable.

Accidents

There are no national statistics concerning the number of accidents on two-way streets versus one-way streets, but there are many indications from cities across the country that accident totals drop after conversion to one-way operation. Reports such as a 23 percent drop in total accidents, and a 62 percent drop in pedestrian accidents in Sacramento, Calif.; 51 percent in Hollywood, Fla.; 50 percent in Raleigh, N.C.; 28 percent in Modesto, Calif.; and 50 percent in Portland, Ore., support the conclusion that accident frequency will be reduced with a properly engineered one-way system (2).

One of the factors involved in a higher accident rate on two-way streets is undoubtedly headlight glare. National statistics show that the nighttime death rate is three times as high as the daytime death rate in urban areas (3). Thus, the use of one-way streets to eliminate nighttime headlight glare, head-on collisions, and left-turn collisions is a very positive step in the direction of reducing accident experience in urban areas.

From the pedestrian standpoint, the one-way street is also much safer. Pedestrians need only look in one direction for vehicular traffic. The platooning of traffic on a one-way street is usually very evident, thus making it quite easy for pedestrians to cross safely during well-defined gaps in flow. One-way street intersections have at least one and sometimes two protected crosswalks where no vehicular turns are made. From the signal-timing standpoint, pedestrians are also aided as excessively long cycles are usually avoided where one-way streets are used. Long cycles cause waiting periods beyond the tolerance of pedestrians, a condition which discourages voluntary observance of traffic controls by pedestrians.

In comparison, two-way arterials are much more difficult for pedestrians to cross because of the basic problems inherent in two-way traffic, e.g., pedestrians must continually look both ways for approaching traffic, adequate gaps in traffic are much less frequent, and the number of conflicts in intersection crosswalks is much greater.

Effect of One-Way Operation on Businesses

In the past, the great majority of businessmen have not favored one-way streets; many still do not. However, in cities today where one-way streets are frequently used as access arterials and CBD grids, disfavor is now at a minimum, as most businessmen realize that business activity is enhanced by the benefits of a properly designed one-way system.

A study conducted in Denver, Colo., in 1964 (4), summarized all available information on the economic effects of one-way streets on businesses. Included where a detailed study of 16th Street in Sacramento, Calif.; a survey by the U.S. Chamber of Commerce; and a survey by Fresno, Calif. Without excessive detail, it can be said that business on one-way 16th Street in Sacramento increased nearly 5 percent more than business on the other streets in the city. The Chamber of Commerce survey showed that businessmen in 103 out of 134 cities were in favor of one-way operation after a fair trial. The Fresno survey of merchants associations indicated that 90 percent of the businessmen felt that one-way streets were not harmful to business, and 85 percent would recommend them.

Certainly some types of businesses may be harmed, although probably only temporarily, by loss of traffic in a certain direction. These are primarily drive-in facilities which previously catered only to the direction of traffic which was eliminated. On the other hand, many other businesses will certainly increase their trade through the improved accessibility of one-way street systems.

Effect of One-Way Operation on a Residential Street

When a major arterial through a residential area needs traffic improvement, one-way system development is often the best answer. Transition construction at the end of a one-way system can usually be designed and landscaped to fit the neighborhood. The residential one-ways created for the arterial flow can usually carry the traffic demand without extensive widening, the use of parking prohibitions, and the loss of street trees.

However, if the added flow capacity must be developed under a two-way arterial plan, such a design almost always means widening, with the loss of street trees. The widening usually places moving traffic very close to residences and provides only a narrow attached sidewalk. This type of design leaves much to be desired and means less living comfort for those along the arterial.

Certainly, when a one-way couplet is suggested or developed in a residential district, those living along the heretofore little-used residential street will not be benefited by the added traffic. However, those living on the congested two-way arterial that is to be converted will benefit greatly, particularly in comparison to a two-way widening project.. The overall benefit to the neighborhood as a whole appears to be better, and the use of one-way street designs for major arterial streets in new subdivisions should be considered.

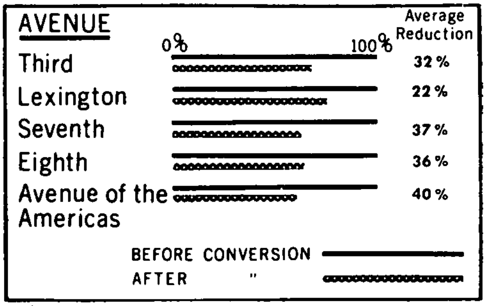
Other Considerations

There are a few minor disadvantages concerning one-way street flow. These can be summarized as follows: one-way streets may necessitate additional travel for some motorists; tourists may become confused with the system; one-way streets may require additional sign posting; emergency vehicles may have more difficulty moving on a one-way street than a comparable two-way arterial; transit riding habits may be adversely affected, especially if the distance between the one-way streets is great; added turns along a one-way system may increase pedestrian conflicts unless separate signal WALK phases are provided; and in a one-way grid or arterial system progressive signal timing may work to the disadvantage of circulating traffic as a block-circulating motorist generally will have to stop for a red signal at each successive intersection.

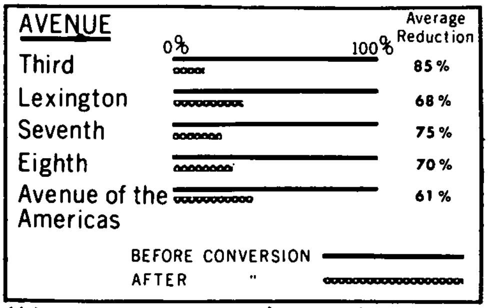
The disadvantages, however, are greatly offset by the benefits of one-way flow.

A New York City Department of Traffic publication, "Questions and Answers About One-Way Avenues," points out that one-way street operation reduces delays in bus movements caused by congestion, thus giving riders a more enjoyable trip in a smoother flow of traffic. Also, bus patrons have shorter waits for buses since buses are less subject to the "bunching up" which occurs in congestion.

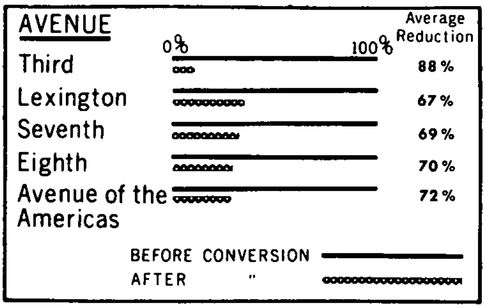
The New York report also notes that one-way street flows reduce air pollution from motor vehicles because of a reduction in stops and periods of acceleration and deceleration.



(a) *One-way avenues reduce trip time.*



(b) *One-way avenues reduce stop time.*



(c) *One-way avenues reduce the number of stops.*

Figure 1.

Future Planning

From the foregoing general discussion, it should be emphasized that the benefits of one-way flow must be considered when future traffic plans are being developed. New business districts, both downtown and along arterials, urban renewal areas, and new subdivisions can certainly use all of the advantages of one-way flows. The benefits can be combined in future planning to provide the most efficient, the safest, the most economic, and the easiest to drive arterial system possible.

ONE-WAY BEFORE AND AFTER STUDIES FROM SELECTED CITIES

New York, N. Y.

The information from New York City has been supplied by Henry A. Barnes, Commissioner, New York City Department of Traffic. The general information comes from a report by the Department entitled "Questions and Answers About One-Way Avenues." The second item is from data sheets concerning a specific study of 5th and Madison Avenues in New York.

General Information Concerning One-Way Avenues. Studies conducted before and after past major conversions have shown the following improvements and advantages gained through one-way operation. Figures shown are minimums. In a number of conversions, specific gains have substantially exceeded the minimums.

Pedestrian accidents reduced	20%
Total trip time reduced	22%
Stopped time reduced	60%
Number of stops reduced	65%
Crosstown delay reduced	40%
Crosstown capacity increased	20%
Bus running time reduced	17%

This information comes from study of 3rd Avenue, Lexington Avenue, 7th Avenue, 8th Avenue, and the Avenue of the Americas. These are major arterial streets carrying traffic through Manhattan. Figure 1 shows (a) the reduction in trip time, (b) the reduction in stop time, and (c) the reduction in the number of stops after conversion to one-way operation.

Before and After Studies of 5th and Madison Avenues. Tables 1 through 4 give the results of an examination of one-way traffic flow benefits achieved on 5th Avenue and Madison Avenue in New York City. Travel time, the number of stops, and the accident experience are studied in detail before and after conversion to one-way operation. Traffic volumes are included for comparison.

TABLE 1

5TH AVENUE—BEFORE AND AFTER CONVERSION (Conversion Date, Jan. 4, 1966)

Location	Month	Avg. Daily Volume	Avg. Trip Time-Min.	Average M. P. H.	Avg. No. of Stops
Washington Sq. to 23rd St., 0.8 mile	June 1966	18722	2.4	19.7	1
	Dec. 1965	15265	4.7	10.2	3
		+23%	-49%	+88%	-66%
23rd St. to 42nd St., 0.9 mile	June 1966	23591	2.9	18.6	1
	Dec. 1965	21725	7.3	7.4	5
		+9%	-60%	+151%	-80%
42nd St. to 57th St., 0.7 mile	June 1966	29965	4.4	9.4	3
	Dec. 1965	26130	7.4	5.7	5
		+15%	-39%	+65%	-40%
57th St. to 138th St., 4.1 miles	June 1966	14953	16.4	14.9	7
	Dec. 1965	11592	22.4	11.0	14.8
		+29%	-28%	+35%	-53%
Total (avg.), 6.5 miles	June 1966	19595	26.4	14.8	11
	Dec. 1965	16411	42.1	9.3	28
		+19%	-37%	+59%	-60%

TABLE 2

MADISON AVENUE—BEFORE AND AFTER CONVERSION
(Conversion Date, Jan. 4, 1966)

Location	Month	Avg. Daily Volume	Avg. Trip Time-Min.	Average M. P. H.	Avg. No. of Stops
23rd St. to 42nd St., 0.9 mile	June 1966	12057	5.9	9.2	4.3
	Dec. 1965	11224	7.0	7.7	4.5
		+7%	-16%	+19%	-7%
42nd St. to 57th St., 0.7 mile	June 1966	27277	5.3	7.9	4.5
	Dec. 1965	24136	5.9	7.1	5.3
		+13%	-10%	+11.3%	-17%
57th St. to 135th St., 4.1 miles	June 1966	20090	14.9	16.5	4.8
	Dec. 1965	16341	18.7	13.1	13.3
		+23%	-20%	+26%	-65%
Total (avg.), 5.7 miles	June 1966	19808	26.1	13.1	13.5
	Dec. 1965	17234	31.6	10.8	23.0
		+15%	-17%	+21%	-41%

TABLE 3

MADISON AVENUE ACCIDENT SUMMARY (5 Months)

Location	Time	Angle Collision	Rear Ends	Turns	Other	Pedestrian Accidents	Mid-Block Accidents[c]	Total Accidents	Total Injured	Total Killed
23rd St. to 42nd St.	Before[a]	4	6	11	11	11	2	43	19	0
	After[b]	4	6	8	13	11	1	42	20	0
43rd St. to 57th St.	Before	3	10	13	8	5	0	39	24	0
	After	1	4	3	11	5	0	24	17	0
58th St. to 109th St.	Before	8	22	18	32	9	15	89	43	0
	After	9	13	12	13	13	9	60	43	0
110th St. to 135th St.	Before	8	11	11	16	29	18	75	81	2
	After	9	11	1	8	3	8	32	21	0
Total	Before	23	49	53	67	54	35	246	167	2
	After	23	34	24	45	32	18	158	101	0
Change, %		0	-31	-49	-33	-41	-49	-36	-40	

[a]From Feb. 15, 1965 to July 15, 1965.
[b]From Feb. 15, 1966 to July 15, 1966.
[c]Mid-block accidents, those over 100 feet from an intersection, are also listed under their specific category.

TABLE 4

FIFTH AVENUE ACCIDENT SUMMARY (5 Months)

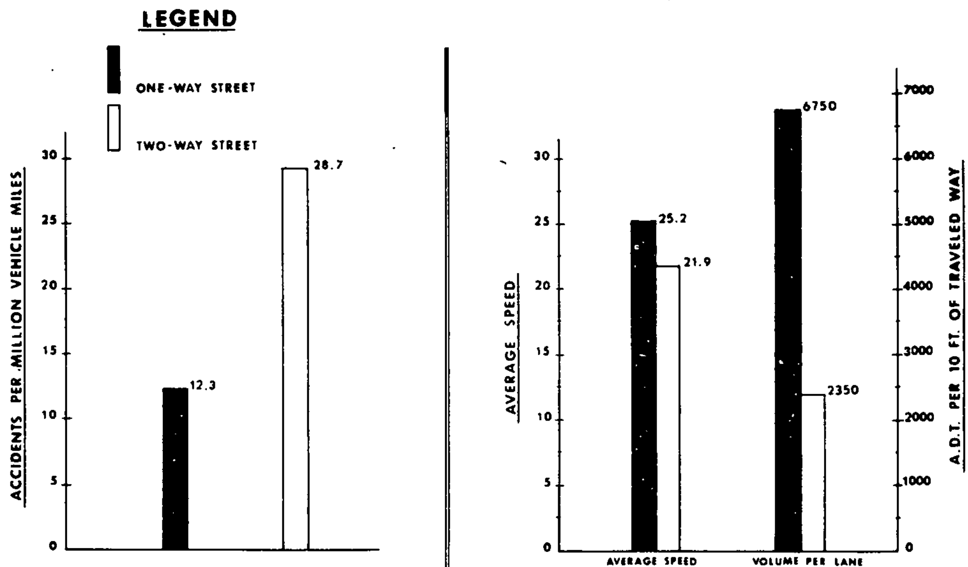
Location	Time	Angle Collision	Rear Ends	Turns	Other	Pedestrian Accidents	Mid-Block Accidents[c]	Total Accidents	Total Injured	Total Killed
Washington Sq. N. to 23rd St.	Before[a]	4	6	6	11	7	1	34	17	0
	After[b]	5	4	11	10	11	0	41	31	0
24th St. to 42nd St.	Before	6	8	15	19	18	4	66	45	0
	After	8	13	16	14	4	2	55	20	0
43rd St. to 57th St.	Before	11	31	14	18	16	6	90	58	0
	After	15	17	10	26	11	2	79	41	0
58th St. to 109th St.	Before	5	17	27	29	9	1	87	40	0
	After	3	14	5	9	11	0	42	29	0
110th St. to 138th St.	Before	14	3	6	7	13	4	43	30	0
	After	7	5	10	14	8	0	44	35	0
Total	Before	40	65	68	84	63	16	320	190	0
	After	38	53	52	73	45	4	261	156	0
Change, %		-1	-18	-23	-13	-29	-75	-18	-18	

[a]From Feb. 15, 1965 to July 15, 1965.
[b]From Feb. 15, 1966 to July 15, 1966.
[c]Mid-block accidents, those over 100 feet from an intersection, are also listed under their specific category.

San Francisco, Calif.

The following data are from "One-Way Traffic—Its Future in Traffic Operations" by William Marconi, Senior Traffic Engineer, Bureau of Engineering, San Francisco Department of Public Works.

One-Way Streets as Arterials. A very successful application of one-way street operation in San Francisco is to use these streets as arterial routes leading into the Central Business District. One pair of one-way streets feeding the CBD consists of



(a) ACCIDENT RATE (b) TRAFFIC FLOW

Figure 2. Two San Francisco arterial routes.

TABLE 5

BROADWAY-LINCOLN TRAFFIC VOLUME COMPARISON

Count Locations	Broadway			Lincoln			Combined			Increase (%)
	Two-Way 1963-65	One-Way 1965	One-Way 1966	Two-Way 1960-63	One-Way 1965	One-Way 1966	Two-Way 1960-65	One-Way 1965	One-Way 1966	
18th Ave.	12,300	9,200	10,600	5,500	7,900	9,200	17,800	17,100	19,800	11
Colfax	19,800	15,500	17,900	10,500	16,500	17,200	30,300	32,000	35,100	16
14th Ave.	25,700	20,600	28,700	8,800	14,700	17,600	34,500	35,300	46,300	34
8th Ave.	24,000	19,300	24,700	9,900	18,700	16,400	33,900	38,000	41,100	21
3rd Ave.	19,500		25,700			12,700	19,500		38,400	97
Alameda	25,000		22,600			12,200	25,000		34,800	39
Exposition	24,100		17,400			13,700	24,100		31,100	29
Average										33

two streets with 34-ft traveled ways (although an additional lane is added by a parking prohibition in the peak hours) carry almost 50,000 veh/day, and the unidirectional peak-hour flows are 3500 veh/hr. This flow is equivalent to what a four-lane bidirectional freeway would carry. Figure 2 compares the accident rate on two San Francisco arterial routes, a one-way couplet, and the two-way street. The accident rate (Fig. 2a) on the two-way street is 134 percent higher than on the one-way streets. The street cross sections and the neighborhoods they traverse are the same. Off-peak speeds and all-day traffic volume for these streets are also compared (Fig. 2b). Despite the fact that the per lane traffic volume on the one-way streets is 190 percent higher, the traffic movement is almost 4 mph faster. This differential in speed is also maintained in the peak hours of traffic flow.

Denver, Colo.

The information in this section is summarized from an unpublished report by Denver Assistant Traffic Engineers Richard C. Thomas and James L. Brown concerning Denver's Broadway-Lincoln Street one-way arterial system conversion in 1965.

Broadway in Denver has historically been the primary north-south arterial street in the central portion of the city and leads directly to the CBD. Its land use is entirely strip business over the 3.3 miles. Lincoln Street is roughly one-half in strip business use, and it was a secondary arterial street for that length. The other half of Lincoln Street was a residential local street carrying no through traffic.

Traffic Volumes. After conversion to one-way operation, the Broadway-Lincoln system as a whole showed an increase at seven count stations averaging 33 percent. As might be expected, Broadway, the heavier traffic carrier before conversion, shows losses in traffic volume at four of the seven stations, at least in the first year after conversion.

Lincoln Street, considerably the lesser of the two streets to begin with, shows substantial traffic volume increases in the section where it was formerly a secondary through street; and particularly, of course, in the local residential areas where it had no through traffic at all (Table 5).

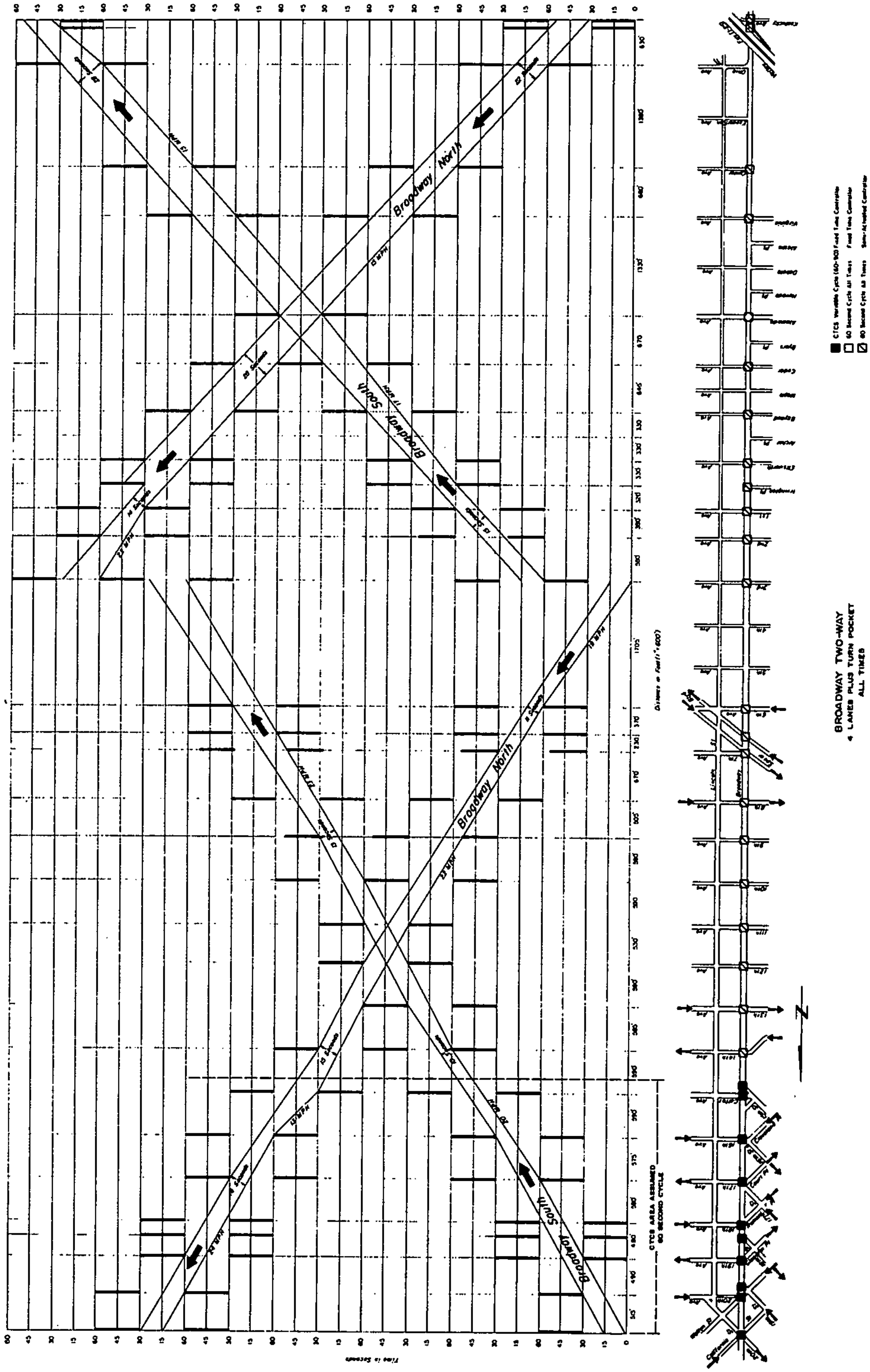
Accident Experience. A detailed examination of all accidents along Broadway

TABLE 6

BROADWAY-LINCOLN ACCIDENT EXPERIENCE[a]

Intersections	1962	1963	1964	1965	1966
Broadway—8th Ave.	38	42	43	41	53
Broadway—14th Ave.	33	25	44	44	33
Broadway—Colfax	61	55	61	37	28
Broadway—11th Ave.	—[b]	—[b]	31	36	27
Broadway—13th Ave.	54	31	46	28	27
Broadway—Speer Blvd.	54	66	70	63	18
Broadway—Alameda	28	30	27	45	18
Broadway—6th Ave.	39	33	20	26	23
Broadway—17th Ave.	32	—[b]	27	25	22
Broadway—1st Ave.	34	—[b]	31	21	21
Total	398	357	400	366	270
Avg.			380		270

[a]Decrease over 4-yr average—29%.
[b]Locations not reported as high-accident locations for the years shown. Since the low limit of accidents on the high accident list is usually 25, these intersections have been charged with 25 accidents even though the actual total may have been less.



BROADWAY TWO-WAY
4 LANES PLUS TURN POCKET
ALL TIMES

Figure 3.

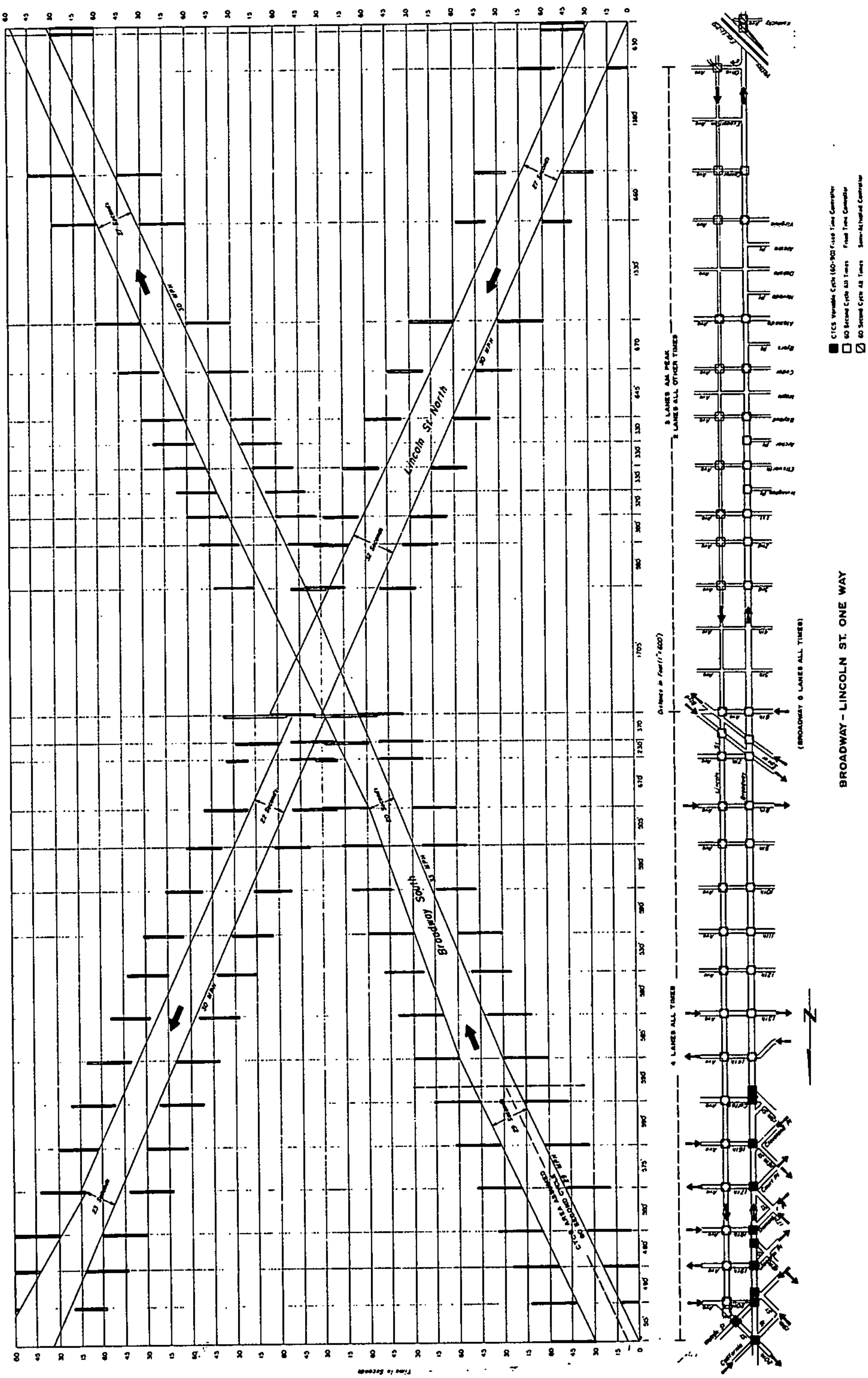

Lincoln St.-North
Broadway South
30 MPH
Time in Seconds
Distance in Feet (1"=600')
3 LANES A.M. PEAK
2 LANES ALL OTHER TIMES
4 LANES ALL TIMES
(BROADWAY 6 LANES ALL TIMES)
CTCS Variable Cycle (60-90) Fixed Time Controller
60 Second Cycle All Times Fixed Time Controller
60 Second Cycle All Times Semi-Actuated Controller
BROADWAY - LINCOLN ST. ONE WAY

Figure 4.

and Lincoln has not yet been achieved, but a study of the ten high-accident locations along Broadway appears to indicate a trend. It should be noted that the average of the seven traffic volume counts on Broadway is the same before and after conversion.

Table 6 illustrates that nine of the ten intersections had a reduction in traffic accidents, when comparing 1966 experience to the average of the preceding four years. The ten intersections together show a 29 percent decrease in accidents.

The one location which shows an increase in accidents has been examined in further detail, and it has been found that nearly half of the accidents reported are occurring between vehicles on the cross street, 8th Avenue.

It is believed that further motorist experience with the one-way system along Broadway and Lincoln Street will result in additional decreases in accidents in the future.

Traffic Signal Timing. Broadway and Lincoln Street before one-way conversion had all of the usual traffic signal problems of major arterial two-way streets. Left turns and left-turn phases presented problems of accidents, congestion, and signal timing as they do on all two-way streets.

Broadway, with four through lanes and continuous left-turn channelization, had traffic signals at such close spacing that the progressive signal speed was in the range of 22 to 25 mph on the northerly two-thirds of the portion later converted to one-way. The through band of signal time equaled only 50 percent of the full green time available to Broadway traffic (Fig. 3).

The southerly one-third of Broadway had different signal spacing and the progressive through band was able to utilize from 50 to 80 percent of the green time available to Broadway traffic. However, the progressive signal speed decreased to 15 to 18 mph.

After conversion to one-way operation (Fig. 4), the traffic signal timing situation showed considerable improvement. In the downtown area, the progressive signal speed is 29 mph, and outside of downtown it varies from 30 to 34 mph. Further, the through band of signal time is able to utilize about 80 percent of the green time available throughout the length of the project. The only exception along the 3.3 miles is at Lincoln Street, Speer Boulevard and 6th Avenue, where the green time available to Lincoln Street is only one-third of the signal cycle because of the required three-phase operation.

Economic Effects. An investigation of the possible effects of one-way operation on retail business is being conducted along Broadway. The facts gathered from a review of sales tax returns a year before and after one-way operation have not yet been fully analyzed; however, the basic conclusion seems apparent.

It has been determined that the more than 300 retail businesses examined along 3.2 miles of one-way Broadway show a sales increase of 12.2 percent comparing 1966 sales to 1964 sales. Over the same period, all businesses in Denver increased their sales by 9.2 percent. Thus, looking only at the street as a whole compared to the city as a whole, Broadway businesses definitely did better in sales.

Different types of businesses, and different sections of Broadway varied quite widely from this overall average. Further, there remains to be made an analysis of the businesses which disappeared during the two-year study. The investigation is continuing and will be reported at a future date.

CONCLUSIONS

The several reports available from cities that studied one-way operation clearly indicate that such operation is a significant method of improving the safety and efficiency of the urban street system. The disadvantages of one-way operation are minor in comparison to the important benefits which can be achieved.

In most one-way designs, capacity is improved, traffic flow is smoother, left-turn problems are solved, pedestrians find fewer vehicular conflicts, and accidents are significantly reduced. In view of these proved benefits, the use of one-way street operation should be considered wherever there is an opportunity for a street improvement project.

Greater attention should be given to the potential use of one-way streets for new developments. Although heretofore the primary application has been in the conversion of existing, parallel, two-way streets, the design of new subdivisions and the through streets serving them should properly include one-way street plans also. The present trend toward non-continuous street design in new subdivisions mitigates against future one-way conversion, thus if there is to be the possibility of utilizing the advantages of one-way operation in the future, they must be planned for in the beginning.

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Addendum

In Peoria, Ill., and in Florissant, Mo., the traffic engineer's office prepared rather grandiose plans for converting all the streets in the CBD to one-way operation. In both instances, these proposals were implemented at one time "in toto" over the objections of the traffic engineer. The results were chaotic even though considerable advance publicity was given to these elaborate one-way street changes.

In Florissant, all of the streets were narrow—in fact, less than 32 ft wide. Both the north-south and east-west streets did lend themselves to one-way coupling. However, when all fourteen streets were changed from two to one-way operation between Sunday evening and Monday morning, the resulting confusion forced a hasty retreat back to two-way operation on all but two streets. As a part of the post mortem it was apparent that a large degree of the opposition resulted from the overnight conversion of all the streets at once and a lack of opportunity for the motorist to become familiar with the proposed one-way system a little at a time.

In Peoria, the story was somewhat the same except the streets were considerably wider, averaging 60 ft. The bus company and some commercial groups in the downtown area were not fully "pre-sold" on the merits of the one-way plan. Consequently, when several of the major streets were converted all at once, these groups fought the change vigorously. The traffic engineer was forced to back off on several of the one-way pairs and had to do a very extensive "second" selling job over a number of years before these streets were again tried as one-way operation. Hindsight would plainly indicate that it would have been far more successful if one or two pairs at a time had been tried instead of disrupting the entire central business district.