Authors' Closure

We thank both Glennon and Mulinazzi for reading our paper and for their highly relevant and well-chosen comments.

We share Glennon's estimate of the importance of the finding that the severity of fixed-object accidents is much greater on highway curves than on tangents. If nothing followed from this research other than the direction of particular attention to objects located on curves, we would feel that our efforts have been more than worthwhile. It appears that the profession is now at a stage to use the Glennon modified microscopic model for a wide range of applications.

There was some concern with the variables that we used to capture the obviously important roadway alignment effect. In the model-building effort, attention was necessarily paid to variables that could be directly retrieved by our highway agency. In our opinion, the variables we selected meet this criterion for Michigan. Extensive efforts were made to select the best alignment variables from among those available (Table 2). Mulinazzi suggests the need for a quantitative measure that represents longitudinal changes in roadway alignment. Such a measure would also serve as a guideline for consistent roadway geometric design. We agree and would like to have developed such a measure.

The investigators would like to have had much more detailed information on roadway and traffic characteristics available in machine-retrievable form. Unfortunately, the state of practice and economics have not permitted the development of data systems in which obviously better variables are available. On the other hand, it is believed that the variables that we have used provide significant guidance with respect to the type of data file that would be valuable in future data systems.

Concern was also expressed about obtaining data on the length of exposure to objects at various distances from the edge of the road. In the study, these variables were developed by recording the dimensions and offset of the object from the roadway from the photolog screen and then converting them into equivalent exposure length at the edge of the roadway by using Glennon's relation (2). Although this process is time consuming, use of the photolog system eliminates expensive field trips, and developing this measure for the entire roadway system is, for Michigan, not a difficult task.

Concerning the predictive performance of the model, Glennon points out that our models predict the number of accidents on a section within a 50 percent error only one-third of the time. However, attention must be paid to the stochastic nature of accident occurrence, particularly on the low-ADT highways on which the validation studies were conducted. The percentage of predictions within a given percentage of error does not apply as an appropriate criterion to judge model performance. We suggest using an evaluation that involves the total number of accidents predicted on several sections versus those that actually occur and also paying attention to the extreme values. For the <750-ADT group, the total number of observed accidents in the 14 sections used in the validation study was 20 whereas the predicted total was 13.3—a 67 percent error. However, if we eliminate the (to us) obvious outlier, these figures become 14 observed versus 12.6 predicted, clearly a reasonable and unimportant difference. In similar fashion, an even better fit was found for the model for the higher ADT class.

Significant progress has been made during this decade in the identification of locations where off-road accidents are likely to occur as well as in the techniques of counteracting this serious highway safety problem. We are pleased to join our discussants in making some contribution to this effort.

Publication of this paper sponsored by Committee on Operational Effects of Geometrics.

Two-Way Left-Turn Lanes: State-of-the-Art Overview and Implementation Guide

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The results of a research project to synthesize existing information on continuous two-way left-turn median lanes and to conduct before-and-after studies to evaluate the effectiveness of such lanes as an access control measure are presented. Recommendations were prepared for the traffic engineer concerned with the evaluation of a situation in which a two-way left-turn median lane is a potential solution to existing capacity and safety problems. The research approach included studies in three distinct areas: a nationwide expert opinion survey, a literature review, and before-and-after field studies. Both the literature review and the survey indicated that two-way left-turn median lanes work well in spite of a wide variety of methods of signing and marking. There is uniform agreement that these lanes have excellent safety records; specifically, head-on collisions in the lanes are extremely rare. The before-and-after studies demonstrated that the effectiveness of the lanes and public reaction depend on proper engineering. A step-by-step decision-making strategy has been developed for the implementation of two-way left-turn median lanes.

To increase efficiency, conserve energy, and reduce air pollution, it is national transportation policy to make maximum use of the available transportation capacity in the existing transportation network. There is a continuing emphasis on transportation system management (TSM) plans designed to solve short-range urban transportation problems. Typical examples of TSM actions are innovative traffic engineering measures that improve both capacity and safety and require a minimal investment of manpower, material, or capital.

The two-way left-turn median lane (TWLTL) falls into this category. It serves to reduce the particular conflict observed on roadways that were originally intended predominantly to serve the through-movement function but are now being called on to satisfy an increasing demand for accessibility as well because of changes in adjacent land use. However, in spite of the increasing use of TWLTLs in recent years, spurred in part by the federal funding provided for such improvements under the TOPICS program and then more recently by other categories of federal-aid funds in urbanized areas, considerable skepticism remains regarding TWLTLs. One major concern is the potential hazard created by permitting two-way movement of traffic in a single median lane.

The objective of this study is to bring about a wider application of the TWLTL by lessening the prevailing uncertainties regarding the effectiveness as well as the proper application of this device. To achieve this objective, existing information on TWLTLs was synthesized, and a questionnaire survey, personal interviews, and a literature review were conducted.

SURVEY OF EXPERT OPINION

Questionnaire

The purpose of the questionnaire survey was to elicit pertinent facts and expert opinions from transportation engineers who had practical experience with TWLTLs. Primary areas of interest were (a) the effect of the TWLTL on traffic safety, (b) the effect of the TWLTL on traffic flow characteristics, and (c) conditions conducive to the installation of such a median lane. Secondary interests were signing and lane-marking practices, optimum lane width, proper use by drivers, police enforcement, public acceptance in general, and cost-effectiveness.

The questionnaire developed contained 16 questions. Of the 90 questionnaires mailed out, 70 were returned; they represented 36 states and one Canadian city. The more significant results are summarized below by subject matter.

Practical Experience

In terms of time, the experience of the 70 respondents was as follows:

Years of Experience	Number of Responses
1 or less	7
1-5	36
5-10	21
More than 10	2
Not reported	4

In terms of the number of TWLTLs, the breakdown of experience was as follows:

Number of TWLTLs	Number of Responses
1	11
2-10	42
10-30	6
More than 30	9
Not reported	2

Effect on Flow Characteristics

Respondents were asked if in their opinion TWLTLs were successful in reducing travel time and friction. The response was as follows:

Increase in Quality	Responses (%)
Significant	77
Little	20
None	3

Ten of the respondents stated that they had conducted studies to support their answers. Five responses were received to the question that asked what factors among the following contributed to the ineffectiveness of less successful TWLTLs: too many left turns, narrow lane, lane markings not maintained, adverse news media, or no enforcement.

Effect on Safety

Respondents were asked if TWLTLs improved the safety of roadways:

Effect on Safety	Responses (%)
Significant improvement	66
Slight improvement	27
No improvement	7
Decrease	0

As might be expected, those who did not perceive any improvement in safety belonged to the one-TWLTL category in terms of experience. Of the 22 respondents who had conducted studies to support their answer, 21 cited significant improvement and one slight improvement.

Public Reaction

The following responses regarding public reaction to TWLTLs were received:

Reaction	Responses (%)
Favorable	62
Mixed	25
Unfavorable	1
No reaction	12

About 10 respondents mentioned that the public found the signs confusing.

Proper Use

Of the 70 responses received, 56 noticed improper use, including 50 who judged the problem severe enough to warrant enforcement. In 30 cases, police enforcement resulted.

Signing, Pavement Markings, and Lane Width

The following responses were received on the use of various types of signs by respondents:

Type of Sign	Responses (%)
Overhead	50
Roadside	34
Pavement arrows	48

Eight percent of the respondents stated that they followed the lane markings recommended in the Manual on Uniform Traffic Control Devices (MUTCD) (18). Four percent used dashed yellow outside, solid yellow inside. Other deviations included white lines, solid yellow lines, or double dashed yellow lines. Lane width ranged from a 2.4-m (8-ft) minimum width to a 5.1-m (17-ft) maximum effective width. The distribution of answers is represented by the mean and mode values given below (1 m = 3.3 ft):

Width	Mean (m)	Mode (m)
Minimum allowable	3.1	3.0
Optimum	3.7	3.6
Maximum allowable	4.4	4.2

Conditions Conducive to TWLTLs

Respondents were asked to name the conditions under which TWLTLs would be most useful. The following factors were mentioned most frequently:

Condition	Number of Responses
High number of driveways per block	42
Commercial development	36
Substantial midblock left turns	18

Perceived Effectiveness Versus Signing

It was hypothesized that there might be a relation between the level of signing of a TWLTL and the effectiveness of the lane perceived by the traffic engineer. Responses received are given in Table 1. The table indicates (if only informally, since no statistical testing was done) that, as level of signing increased from no signs to a combination of all three signs, so did the perceived improvement achieved by the TWLTLs.

Personal Interviews

Selected state, county, and city traffic engineers were interviewed in California, Ohio, Texas, and Washington to discuss design and operational aspects of TWLTLs and to obtain unpublished reports, guidelines, and before-and-after data. Most of the material covered by the literature review was obtained through these personal contacts.

LITERATURE REVIEW

The literature was searched for three types of information: (a) general criteria for application, (b) design details, and (c) evaluation. The objective was to get a general consensus of opinion and an overview of the state of the art.

General Criteria for Application

Seven categories of factors that have been considered in connection with TWLTLs either as warranting factors or as constraints were identified.

Adjacent Land Use

Strip commercial development was identified throughout the literature as the adjacent land use most applicable to use of TWLTLs. Continuous high-density commercial land use of this type is most common in the traffic conditions for which TWLTLs are most effective. But successful applications were also documented in residential areas, commercial-residential areas, and even in industrially developed areas under the proper traffic flow conditions. The applicability of the TWLTL is thus a function of the particular traffic conditions that result from adjacent land use rather than a function of the land use itself. In partially developed areas, the TWLTL will generate more strip development. If this is undesirable, preference should be given to raised medians (2).

Access Conditions and Requirements

Existing access conditions are not easily classified or quantified since there are many ways in which access can be provided and a number of factors that determine the ease of access to fronting properties.

References to existing access as a general warrant are common in the literature (2, 3, 4), and, in most cases, its relevance is ascribed to the extent to which alternative means of access are provided (5, 6, 7). Access gained by negotiating a midblock left turn creates the specific traffic conflict and through-movement delay that TWLTLs are designed to treat; therefore, the availability of access through alternative means, such as parallel streets or alleys, service roads, off-street parking facilities, and U-turn or around-the-block movements, must be considered an important factor in weighing TWLTL proposals versus more restrictive left-turn control measures.

The total access requirement, expressed in terms of midblock left-turn demand, would be expected to present a prime factor for consideration in installing TWLTLs. The literature expresses the importance of this access demand as a general TWLTL warrant but only to the extent that a "high" demand contributes to the "general" traffic conditions that warrant consideration of TWLTLs.

Table 1. Perceived effectiveness of various types of signing.

Signing of TWLTL	Number of Respondents	Percentage Perceiving Service Improvement			Percentage Perceiving Safety Improvement		
		Significant	Slight	None	Significant	Slight	None
No signing	10	50	40	10	50	30	20
Overhead	14	86	14	0	57	29	14
Side mounted	5	80	20	0	80	20	0
Painted arrow	10	70	20	10	70	20	10
Composite, one device only	29	72	24	4	66	24	10
Arrows and side mounted	10	80	20	0	67	33	0
Overheads and side mounted	4	67	33	0	50	50	0
Arrows and overhead	8	100	0	0	87	13	0
Composite, two devices	22	86	14	0	71	29	0
All three signing devices	5	100	0	0	80	20	0

Little effort has been made to measure left-turn demand or to establish standard values or ranges of values that would specifically dictate conditions for installation of a TWLTL.

Traffic Volume

In the literature, successful TWLTL operations were described as widely ranging traffic volumes [8000 to 31 000 average daily traffic (ADT)], and traffic volume was not identified as a particularly critical factor except when it approached capacity. The references to roadways operating at or near maximum capacity (3) only predicted that the value of the TWLTL in reducing congestion under such conditions might become questionable because of the unavailability of gaps of sufficient size in the approaching traffic to allow the left-turn movement.

In such cases, however, if direct left-turn access must be provided but signalization cannot be used to alter gap size or distribution favorably so as to accommodate left-turning vehicles, then left-turn storage of some type becomes even more necessary. A policy directive of the Washington State Department of Highways (6) specifically states that the following minimum and maximum volumes should prevail: 5000 to 12 500 ADT on two-lane roadways and 10 000 to 25 000 ADT on multilane roadways.

Speed Limit

The existing speed limit on a highway facility does not appear to be a critical factor for consideration in TWLTL applications except in the general sense. The reports in the literature that refer to speed reinforce its consideration as a general warrant and refer to TWLTLs operating at speeds that range from 40.3 to 80.5 km/h (25 to 50 mph). Concern has been expressed about TWLTL operations at speeds higher than these (5, 6, 8) because of the increased accident potential and at speeds lower than these because of the possibility that impatient drivers may use the median lane to pass slower vehicles. Neither concern has been sufficiently supported by data to rule out TWLTL applicability at wider ranges of speed.

Spacing of Existing Intersections

The effects of intersection spacing on TWLTL application have not been thoroughly examined or documented in the literature. The studies that did comment on intersection spacing (2, 5) provided very general testimony about the adverse effects of closely spaced intersections without defining any specific minimum desirable limitation on spacing. Their concerns were based only on the problem of maintaining a sufficient block length to accommodate exclusive left-turn-only lanes at each intersection and also some minimum length for the TWLTL in midblock. Perhaps the major importance of intersection spacing lies in its contribution to the effect on local traffic circulation patterns and therefore on alternative access.

Economic Considerations

Only two reports that attempted a detailed economic analysis of TWLTLs were located (9, 10). These studies used a method to determine user benefits based on reductions in fatal, injury, and property-damage accidents. The first evaluation (9) determined that the TWLTL installation would pay for itself in less than 2 years; the accrued benefits for the four TWLTLs in the other study (10) were such as to surpass the improvement costs in 7 years. Significantly, all five installations involved some capital costs as a result of widening of the pavement.

Where sufficient pavement width is already available, the TWLTL installation primarily involves only restriping and signing so that in many instances the work can be accomplished by force account with maintenance personnel and equipment rather than by more costly contracting procedures.

Investigation of the economic impact of the TWLTL on adjacent properties has been minimal (3), but the value of this information in a typical traffic engineering study is limited.

Safety

The 15 reports that were reviewed for safety considerations represented accident experience at approximately 50 TWLTL installations. However, because of the great variation in the detail and the methods of the many TWLTL evaluation studies, no quantitative, composite figures for accident reduction could be derived that would be truly representative of all the TWLTLs investigated in the literature.

Only a few reports included data on fatal and personal-injury accidents or gave particular emphasis to investigating accident severity. This was a surprising omission, but the studies that did include such data offered conclusive evidence that TWLTLs significantly reduce accident severity (11). In their investigations, Sawhill and Neuzil (4) found that the TWLTL accident is somewhat less severe than the non-TWLTL accident, and the two studies by the Michigan Department of State Highways (9, 10), which represented experiences at five TWLTL installations, substantiated their findings.

The types of accidents that are acknowledged to be most commonly affected by the installation of the TWLTL, and therefore the types of accidents to which the improvement has subsequently been most directed—rear-end, sideswipe, and midblock left-turn collisions—were found either to decrease substantially in numbers or at least to have had their growth rates significantly retarded in the face of regional trends of increasing accident occurrence in nearly every case documented in the literature.

The head-on collision, which has been a major concern underlying every decision to install a TWLTL because of deadly past experience with the old median bidirectional passing lanes, has been proved in every study to be an uncommon occurrence and of negligible concern (12).

Design Details

Number of Lanes and Lane Width

The literature documents successful TWLTL operations on facilities that have one, two, or three through lanes in each direction. No data are available that favor any of the three basic configurations generally in use from an operational standpoint, but the five-lane section is the most common. In addition, there is nothing to prevent the TWLTL from being used in applications where there is unbalanced distribution of lanes, but this configuration has not been documented in the literature.

The only conclusive value of lane width discernible from the literature is the 3-m (10-ft) minimum width, which appears to be universally accepted. Until such time as optimum lane widths are defined and uniformity is obtained through strict adherence to the MUTCD, practical experience will dictate that the current 3- to 4.5-m (10- to 15-ft) range of lane width continue to be used.

Signing and Pavement Marking

The review of the literature points out that current signing and pavement-marking practices are still best characterized by a considerable lack of uniformity (13, 14, 15). One point worth noticing is that BEGIN TWO-WAY LEFT-TURN LANE signs in medial island areas were subject to repeated damage unless they were placed with proper clearance (13). Standards for signing and marking TWLTLs have been developed and included in the MUTCD (18).

Treatment at Intersections

The standard method of pavement marking in the MUTCD provides separate left-turn bays at major intersections while permitting the TWLTLs to be carried up to minor intersections (18). This solution seems logical, but the literature reviewed did not provide formal evidence either for or against this practice.

Evaluation

Accident Characteristics

The conflict study used in our field studies can provide immediate feedback after the installation of TWLTLs and thus would be more useful than the before-and-after accident studies reported in the literature. Accident patterns take a considerable amount of time to develop.

Proper Use of TWLTLs

Since TWLTLs are still unknown in many cities, a certain segment of the driving population is not familiar with them. Two-way traffic in a lane is foreign to normal driving instincts. The literature and our field studies indicated that improper use could be a problem, at least initially. Improper use can only be prevented by educating the public before installation of the lanes. Some extensive and equally effective approaches have been reported in the literature (9, 10). Deliberate violation of the rules, such as driving in the TWLTL for an excessive distance, can only be eliminated by enforcement.

FIELD STUDIES

Purpose

Before-and-after studies were completed at three sites in Ohio where the introduction of TWLTLs was not accompanied by other major improvements. The purpose was to measure the effect of TWLTLs on traffic flow conditions and on safety.

Data Collection

Data on travel time and delay were collected by using a vehicle equipped with a tachograph. Through volumes were counted by mechanical recorders, and turning volumes were tallied by visual observation. Data on traffic conflicts were collected by a team of specialists from the Ohio Department of Transportation.

Running speeds were computed by eliminating from the travel time those delays that were in no way related to midblock left turns. Average running speeds were computed from approximately 40 runs, usually made between 9:00 a.m. and 6:00 p.m. on two weekdays and on one Saturday, for each phase—before, immediately after, and 6 months after the installation of TWLTLs.

Only running speeds and conflicts are presented here. Details of the field studies are given elsewhere (1).

Site 1, Painesville, US-20

Characteristics

Site 1 had the following characteristics: length—1.5 km (0.95 mile), width (used as four-lane roadway although centerline only was marked)—10.9 m (36 ft), volume—16 320 ADT, speed limit—72.5 km/h (45 mph) posted, and adjacent land use—commercial strip development.

Reconstruction

This four-lane arterial was restriped as a three-lane roadway. The TWLTL was identified by overhead signs and pavement arrows.

Effect on Flow

Average running speeds and directional hourly traffic volumes are given below (1 km/h = 0.62 mph):

Direction	Period	Average Speed (km/h)	Hourly Volume
Eastbound	Before installation	55.47	405
	After installation	49.71	401
Westbound	Before installation	53.45	508
	After installation	45.81	574

The elimination of one through lane in each direction offsets the beneficial effects of the TWLTL.

Effect on Safety

Brake applications were reduced 22 percent, from 614 to 480, but weavings increased 78 percent, from 105 to 187. The increase in weavings prompted us to investigate driver behavior further. A time-lapse film recorded 548 left turns, with the following results:

1. Eighteen (or 3 percent) did not use the TWLTL at all.
2. Thirty-two (or 6 percent) turned into the TWLTL at an angle, and part of the vehicles protruded into the through lanes.
3. Seventy-eight (or 14 percent) moved into the TWLTL only partially, and the two right-hand wheels remained in the through lanes. This type of improper use might have been caused by the old centerline, which was not properly removed. (A similar problem was observed at site 2, and proper removal of the line eliminated the problem.)

Results

The conversion of two through lanes into a TWLTL improved the access function of the roadway at the expense of the movement function. During the short peak periods, the impact was much worse than the above-average speeds would indicate. The traffic backup in the area prompted some impatient drivers to use the TWLTL as a passing lane. The obvious solution would be to operate the median lane as a TWLTL during off-peak periods and use it as a reversible flow lane during peak periods. Several such installations are now in operation in some cities.

Site 2, Cincinnati, OH-264

Characteristics

Site 2 had the following characteristics: length—1.48 km

(0.92 mile), width (four lanes with different types of medians on some parts)—17.9 m (59 ft), volume—17 610 ADT, and adjacent land use—commercial strip development.

Reconstruction

This four-lane roadway was restriped as a five-lane roadway. Overhead signs and pavement arrows were used to identify the TWLTL.

Effect on Flow

Running speeds were obtained before, after, and 6 months after installation of the TWLTL. Although speeds increased slightly, the increase is not statistically significant (1 km/h = 0.62 mph):

Direction	Period	Average Speed (km/h)	Hourly Volume
Eastbound	Before installation	51.97	762
	After installation	54.38	798
	6 months after installation	53.71	745
Westbound	Before installation	54.02	886
	After installation	56.32	887
	6 months after installation	55.39	727

Running speeds were quite satisfactory during the before period, and thus the possibilities for improvement were limited.

Effect on Safety

Brakings and weavings are given below:

Period	Number of Brakings	Number of Weavings
Before installation	575	589
After installation	685	530
6 months after installation	485	565

There was considerable variation in conflicts at different sections of the roadway. During the first data collection after installation of the lane, it was quite obvious that many drivers did not know how to use the TWLTL properly. Consequently, three samples of driver behavior—totaling 668 left turns—were observed:

1. Forty-seven (or 7 percent) did not use the TWLTL at all.
2. Seventy (or 10.5 percent) turned into the TWLTL at an angle, protruding into the path of through traffic.
3. One hundred and twenty-six (or 18.9 percent) weaved into the TWLTL only partially. This type of behavior was especially frequent in those areas where the old centerline had not been properly removed.

This high frequency of improper use caused conflicts in through lanes.

The centerline was eventually properly removed. A similar observation was scheduled for the study 6 months after installation to check for improvement after a learning period. By this time, however, improper left turns were so infrequent that data collection was discontinued.

Results

The results of the field studies do not indicate a drastic improvement in running speeds and conflicts. Traffic conditions were already quite satisfactory during the before period. The advantages of the TWLTL will become more obvious when traffic volumes increase in the area.

Site 3, Mansfield, US-42

Characteristics

Site 3 had the following characteristics: length—1.3 km (0.8 mile), width (two lanes)—9.4 m (31 ft), volume—14 070 ADT on northern half and 12 940 ADT on southern half, speed limit—56.4 km/h (35 mph) on northern half and 72.5 km/h (45 mph) on southern half, and adjacent land use—commercial (more intensive on northern half).

Reconstruction

By improving a narrow strip of the shoulder, this roadway was widened to 10.9 m (36 ft). The widening reduced the shoulder to less than 1 m (3.3 ft) on the northern half. The through lanes were reduced in width from 4.5 to 3.5 m (15 to 11.5 ft). The TWLTL is 3.9 m (13 ft) wide.

Effect on Flow

Running speeds and directional volumes are given below for the two sections separately (1 km/h = 0.62 mph):

Section	Period	Average Speed (km/h)	Hourly Volume
North			
Northbound	Before installation	56.68	490
	After installation	59.10	491
	6 months after installation	62.16	393
Southbound	Before installation	62.00	306
	After installation	64.09	295
	6 months after installation	64.00	330
South			
Northbound	Before installation	47.18	473
	After installation	48.31	527
	6 months after installation	52.53	NA
Southbound	Before installation	48.47	521
	After installation	49.11	416
	6 months after installation	52.88	568

In spite of the reduced lane width, there was a small, statistically significant increase in running speed.

Effect on Safety

Braking and weaving conflicts are summarized below:

Period	Number of Brakings	Number of Weavings
Before installation	1327	245
After installation	567	22
6 months after installation	833	48

The reduction in conflicts is dramatic. The difference between the after and 6-months-after time periods cannot be explained by the available data.

Results

The introduction of the TWLTL even at the expense of narrowing both through lanes resulted in a measurable improvement in traffic flow and safety.

IMPLEMENTATION GUIDELINES FOR TWLTLs

Implementation guidelines have been developed for traffic engineers who have had little or no experience with TWLTLs. A step-by-step decision-making process is outlined, but the traffic engineer must apply engineering judgment every step of the way.

The initial step involves the documentation of existing conditions so that the problem can be properly defined. By extending the principle of providing separate storage lanes for left-turning vehicles at intersections, TWLTLs are intended to shadow midblock left-turning vehicles from through traffic. Consequently, the objectives of the review of existing conditions are to establish that

1. A conflict between midblock left turns and through traffic exists and
2. The particular solution offered by the TWLTL is both potentially feasible and desirable.

To this effect, information is needed in three areas: existing physical conditions (both transportation and land use), existing traffic conditions, and accident histories. The following series of relevant items provides a checklist type of approach to the review of existing conditions.

Establish Conflict

Physical Conditions

1. Driveway spacing—Identify the spots where conflicts may occur.
2. Type and intensity of land use—Identify access needs, which determine the frequency and time distribution of conflicts.
3. Level of development—Establish the stability of current access needs.

Strip commercial developments and, to a lesser degree, multiple-unit residential areas generate traffic throughout the day. Industrial areas tend to generate morning and evening peak traffic.

Existing Traffic Conditions

1. Traffic volumes—The combination of through volumes and turning volumes gives a measure of the potential conflict on a given road section.
2. Flow characteristics—Directional distribution and peaking characteristics of both through and turning traffic give a more accurate indication of the conflict. Some measurement of congestion will indicate the level of the problem, which may have been caused (mostly or partially) by midblock turns.

Engineering judgment is needed to interpret and evaluate this information. Since the level of the conflict at any driveway is a complex function of opposing volumes, left-turning volumes, and through traffic and the level of the conflict on a roadway segment is a function of the conflicts at all the driveways, the establishment of quantitative guidelines was not attempted.

Accident History

Midblock sideswipe and rear-end accidents are typical results of conflict between delayed left-turning vehicles and through vehicles (weaving to avoid entrapment or braking to stop in the through lane behind a turning vehicle). The interpretation of these data will probably require a comparison of accident rates with accident experience on other arterials that carry similar volumes without midblock access conflicts.

Establish Appropriateness of TWLTL

Physical Conditions

1. Driveway spacing—Provide a basis for comparison of TWLTL with channelized left turns or other alternatives. Closely spaced driveways indicate a potential for TWLTLs.
2. Type and intensity of land use—Activities that generate left turns throughout the day will probably stimulate the development of remaining undeveloped lots. The provision of a raised median would have the opposite effect or attract only those establishments that do not generate much traffic.
3. Ease of alternative access—The conditions must be evaluated so that the relative attractiveness of TWLTLs can be evaluated in relation to alternative techniques of access control.
4. Distance between intersections—Since intersections often require channelized left-turn storage lanes, a very short block would not be appropriate for TWLTLs.
5. Section length—In urban areas, where TWLTLs are common, even extremely short TWLTLs work satisfactorily. Pioneering efforts, however, should concentrate on longer sections, probably several blocks long.
6. Number of lanes—Three- and five-lane applications are common. Some existing seven-lane installations have had accident records, and others have been reported to work well.
7. Pavement width—The TWLTL should be at least as wide as left-turn lanes. Lanes wider than 4.8 m (16 ft) might encourage two-lane use. If no excess pavement width is available, pavement widening will add to installation costs.
8. Right-of-way limits—Since TWLTLs improve access to adjacent properties, property owners may tend to cooperate when expansion of the right-of-way is needed for this purpose.
9. Curb parking—Eliminating curb parking is often the most convenient way to obtain the needed extra pavement width.
10. Sight distance—On higher speed roadways (especially in semirural areas), the provision of sufficient sight distance may require special attention.
11. Speed limit—Speed limits may need to be reevaluated (TWLTLs are reported to work in all speed ranges).

By reserving one traffic lane for left turns only, TWLTLs reduce the conflict between midblock left turns and through traffic. The source of this extra lane width requires careful consideration. Pavement widening increases the initial investment, elimination of curb parking reduces accessibility, and reduction or narrowing of through traffic lanes affects the through capacity of the roadway.

Physical conditions may require the reconsideration of the proper function of a given arterial and reduce through left-turn conflict by limiting either through or turning traffic. Signalization of major driveways, prohibition of some left turns, and provision of access from side streets are some examples of alternative approaches.

Existing Traffic Conditions

1. Traffic volumes—Existing through volumes and the capacity of major intersections should be investigated to determine the through capacity requirements of the midblock area. This must be a major factor when the source of the required pavement is considered.

2. Flow characteristics—Distribution of through and turning traffic volume during the day may be an important consideration.

The time-related distribution of turning traffic during the day is a function of the use of adjacent lanes. The center lane could be operated as a reversible-flow lane in conditions of peak-hour through traffic and as a TWLTL during off-peak hours. It would be advisable, however, to reserve this type of application for urban areas where TWLTLs have been accepted and extensively used.

Accident History

Since TWLTLs remove left-turning vehicles from through lanes, they are effective in reducing rear-end accidents. When TWLTLs are properly used, left-turning vehicles are completely shadowed from through traffic. In addition to protecting vehicles as they prepare to enter a driveway, a TWLTL provides a refuge for left turns made from driveways.

Future Development

Before the final selection of access-control needs, some attention must be paid to future conditions in terms of both access needs and volumes of through traffic.

1. Access needs—The selection of methods of access control will influence the future, especially on arterials where adjacent land development has not yet been stabilized. Increased accessibility stimulates land development. If, for example, the future land-use goals of a community include containment of strip commercial development, the TWLTL is not the best choice. A restrictive median that concentrates and controls access points might be a more logical choice.

2. Through traffic needs—The TWLTL has some potential for increasing the carrying capacity of arterials beyond the obvious improvement provided by the separation of midblock left-turning vehicles. Some examples of reversible lane operation during peak hours and even a reversible lane and separate bus lane combination have been reported in the literature (16, 17). The increasing acceptance of TWLTLs will eventually make it feasible to take advantage of bolder variations of this sound concept.

In addition, it must be remembered that TWLTLs provide such emergency service as a detour lane during construction, a detour lane during blocking of the through lane by vehicle breakdowns, and a path for emergency vehicles during congested periods.

ACKNOWLEDGMENTS

This project was sponsored by the Ohio Department of Transportation and the Federal Highway Administration, U.S. Department of Transportation. The contents do not necessarily reflect the official views or policies of the Ohio Department of Transportation or the Federal Highway Administration.

I wish to acknowledge the major contributions made by the following graduate research associates: Thomas Lunt (literature review), David Morena (questionnaire survey), and Nagui Rouphail and Fouad Bayomy (field studies). Richard D. Paddock of the Ohio Department of Transportation provided help in the conflict studies.

Special thanks are due to all transportation engineers in the country who cooperated with us in the opinion survey.

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Publication of this paper sponsored by Committee on Operational Effects of Geometrics.