9. Traffic conflicts and traffic conflict rates (especially severe conflicts) increase substantially from about 2:30 p.m. through about 5:00 p.m.

10. The training of persons in the TCT should rely heavily on supervised and/or critically reviewed field practice.

RESEARCH NEEDS

This research led naturally to ways and means of implementing the observation, recording, and analysis of traffic conflicts. Methodologies, definitions, etc., that are operationally feasible have been determined, and no further research along these lines is recommended.

Two needs that relate to the application of the TCT at intersections are apparent. One need is to determine the relationships between traffic conflicts of certain types and accidents of analogous types. Suggestions regarding such relationships are now available, but much more work is required. The other important need is to establish norms and warrants for various categories of traffic conflicts, dependent on site characteristics. Expected, as well as abnormal, conflict-rate guidelines should be established for individual types of intersections.

The present research was limited to intersection conflicts. However, the literature contains many examples of other areas of application, including midblock locations, freeway entrances and exits, weaving areas, construction zones, and pedestrian crossings. Further research is needed to clarify and standardize procedures to be used for these other applications.

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This paper summarizes the experimental findings obtained in NCHRP Project 17-3. We are indebted to many researchers and practitioners of traffic conflict techniques, both in the United States and abroad. We are particularly thankful for the contributions of our colleagues John C. Glennon, Michael C. Sharp, and Rosemary Moran. Finally, we express our appreciation to the 17 individuals who spent a summer collecting conflicts counts, so that we might, it is to be hoped, slightly advance the state of the art of traffic engineering.

REFERENCES

1. B. L. Allen and B. T. Shin. A New Look at the Conceptual and Empirical Aspects of the Traffic-Conflicts Technique. McMaster Univ., Hamilton, Ontario, Canada, Feb. 1977, 104 pp.
2. J. C. Glennon and others. Critique of the Traffic-Conflicts Technique. TRB, Transportation Research Record 630, 1977, pp. 32-38.
3. W. D. Glauz and D. J. Migletz. Application of Traffic-Conflict Analysis at Intersections. NCHRP Rept. 219, 1980, 109 pp.
4. S. R. Perkins and J. I. Harris. Traffic-Conflict Characteristics: Accident Potential at Intersections. HRB, Highway Research Record 225, 1968, pp. 35-43.
5. S. R. Perkins. GMR Traffic Conflicts Technique Procedures Manual. General Motors Research Laboratories, Warren, MI, Publication GMR-895, Aug. 11, 1969.
6. C. Hydén. A Traffic Conflicts Technique for Determining Risk. Univ. of Lund, Lund, Sweden, 1977, 48 pp.
7. Highway Capacity Manual: 1965. HRB Special Rept. 87, 1965, 411 pp.
8. Institute of Transportation Engineers. Transportation and Traffic Engineering Handbook. Prentice-Hall, Englewood Cliffs, NJ, 1976.

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Comparison of Three Loran Position-Determination Techniques in the Los Angeles Area

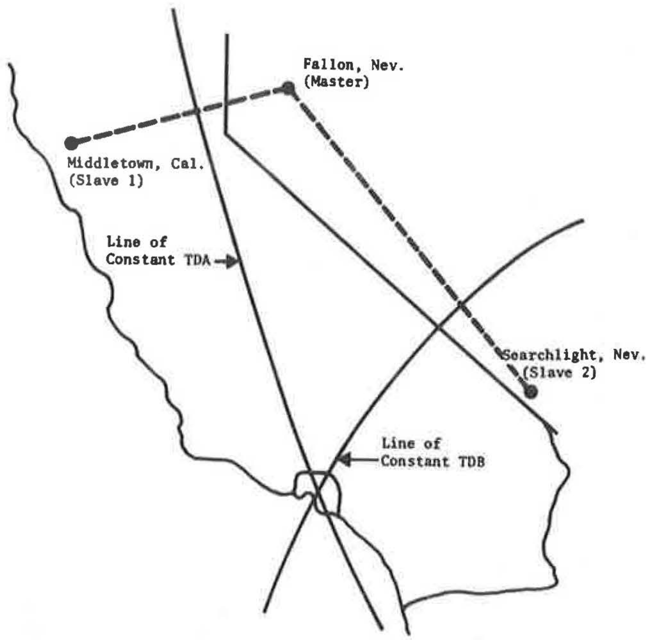
J. S. LUDWICK, JR.

A multiuser automatic vehicle monitoring system being developed for deployment in Los Angeles is discussed. In addition to the basic signpost technique to be used along transit routes and in the central business district, relatively inexpensive long-range navigation (loran) receivers will be used in a few vehicles to provide general location information over the entire 1000-km^2 (400-mile^2) Los Angeles Basin. Three techniques to convert loran time differences (TD) of arrival information to latitude and longitude were evaluated for accuracy, computation time, and memory requirements. The three methods are an empirical regression technique that uses best-fit equations to fit measured TDs to locations, a theoretical technique that uses a geometric earth model and a radio-wave-propagation model to determine location based on travel times from the known transmitters, and a combination technique that computes the position theoretically and then provides an empirical correction. All techniques gave approximately the same accuracy. It is possible that subdivision of the larger area into sectors could improve the overall accuracy to that of the central area, but not enough data were available to test this. It appears that TD grid warpages in the Los Angeles area are large enough and not sufficiently regular to be compensated for by standard techniques.

Automatic vehicle monitoring (AVM) systems provide the locations of members of a fleet of vehicles to a central control point. An AVM system will usually include radio communication links from the control center to the vehicles. The combination of location information and communications allows the efficiency of vehicle fleet use to be improved. For instance, police cars or taxis can be dispatched in an optimum manner, or transit bus drivers can be advised when they are exceeding permissible schedule deviations.

The Urban Mass Transportation Administration (UMTA) and the Transportation Systems Center are developing a multiuser AVM system to be deployed in a demonstration in Los Angeles (1). The basic fixed-route subsystem (for buses) uses low-power, high-frequency "signposts" at intervals along the routes covered. A portion of the central business district (CBD), including the high-rise area, will be furnished with signposts at a density high enough

Figure 1. Hyperbolic time-difference geometry in Los Angeles area.



to provide sufficient accuracy for random-route vehicles in this area. In addition, a number of vehicles will be instrumented with a hybrid location subsystem, which also includes a loran-C receiver and differential odometer, for operation over the entire 1000 km² (400 miles²) of the Los Angeles basin.

Although the characteristics of loran in seaborne application is well known, its use in land mobile applications, and especially in urban areas, is still in an exploratory stage. Loran-C was used during a test of candidate AVM technologies in Philadelphia; however, there were many parts of the city in which the signal was inadequate for accurate position determination, and signpost augmentation was required for system operation (2). The West Coast loran chain, which only recently became operational, gave promise of providing a high-quality signal in the Los Angeles demonstration area.

Three commonly used techniques for conversion of loran time-difference-of-arrival measurements to position estimates have been analyzed by using accuracy and processing requirements as criteria. The techniques varied in complexity; the comparison was designed to determine whether a particular technique appeared substantially better with respect to accuracy, performance, and costs than the others. Even if the more complex techniques could provide better accuracy (which has not been demonstrated), the incremental accuracy improvement might not justify the increased processing, which could only be performed at the central site.

The three basic types of algorithms tested were an empirical regression technique that uses best-fit equations to fit measured time differences (TDs) to locations, a theoretical technique that uses a geometric earth model and a radio-wave propagation model to determine location based on travel times from the known transmitters, and a combination technique that computes the position theoretically and then provides an empirical correction based on the relative position within a calibrated region. Data measured in the demonstration area in Los Angeles were used to determine the required coefficients, which were then used with a second set of data to evaluate the accuracy of each technique. A variety of graphical and statistical techniques was used to analyze the results. Processing time and core requirements were also measured for each method. A detailed description of the algorithms and the analysis techniques is presented by Ludwick (3).

All techniques gave approximately the same accuracy; mean and 95th-percentile errors over an 80-km² (30-mile²) central area were approximately 200 m (650 ft) and 500 m (1700 ft), respectively, and for the entire 1000-km² (400-mile²) area the figures were approximately 450 m (1500 ft) and 850 m (2800 ft), respectively. The results suggest that the wide-area accuracy could be improved significantly by subdividing it into sectors, each of which has its own set of coefficients. Insufficient data were available to test this; however, further subdividing the central area did not result in further improvements there. Comparative storage requirements were approximately the same for all methods; the regression technique was approximately five times as fast as the theoretical technique and approximately eight times as fast as the combination method.

Plots of the predicted position versus actual position showed the predictions of all three methods at most points to be relatively near each other. This seems to indicate that the large TD warpages (if they are not actually random) are not sufficiently regular to be compensated for by standard techniques. The plots, overlaid on U.S. Geological Survey maps, did reveal a number of large errors near railroad tracks, although other points seemingly similarly located did not show such errors.

LORAN THEORY AND OPERATION

The loran [long-range navigation] technique uses a network of transmitters at known locations that transmit accurately synchronized pulse trains. Based on the difference in time of arrival of signals from the "master" and a "slave" transmitter at a receiver site, a hyperbolic line of position is defined on the surface of the earth. A second set of TDs between the master and a second slave defines another hyperbolic line of position whose intersection with the first line determines the location of the receiver (Figure 1).

Loran-C has been in general use for 15 years; transmitter chains have generally been established to provide coverage of coastal confluence areas. (There is also loran-A, developed during World War II, which is less accurate and has a shorter range, and loran-D, a lower-power system intended for tactical military use.) Initially, the equipment required to locate vehicles by using loran was expensive, or large, or required time-consuming manual methods. Trade-offs could be made among these factors, depending on the space and response-time constraints, for shipborne or airborne use; in any case, cost was relatively small compared with the total cost of the vehicle. Use of such equipment for land vehicles would not have been feasible.

The advent of microcircuit technology has reduced the size and cost of receivers and has provided increasingly more-sophisticated processing internal to the unit. The size, cost, and ease of use of loran receivers now make their use feasible in mobile applications on land. However, there is no large body of data available to indicate the performance of such equipment in an urban environment. Closely controlled loran tests have been performed in Philadelphia, but the accuracy and coverage attained were inadequate for transit use. However, that environment has been described as a worst case by loran proponents.

It was originally anticipated that the Los Angeles area would enjoy good loran signal reception, since the farthest transmitter is only 650 km (400 miles) away. However, during the collection of calibration-point data, it was determined that the signal level of the master, which affects the computation of both TDs, was substantially lower than that of the two slaves. In addition, in many areas high noise, evidently caused by increasing use of silicon-controlled rectifier (SCR) controllers, was transmitted along power lines. Carrier-current signaling by utilities over transmission lines and some inductive-loop traffic detectors use frequencies within the loran receiver bandpass; such frequency overlap also resulted in severe interference in certain areas.

Obviously, the use of algorithms to determine coordinate location based on TDs cannot compensate for lack of signal. (Other techniques can be used to extrapolate a probability contour based on the last received point, direction and speed of travel, and route and schedule data.) However, some methods do attempt to account for the TD grid warpages encountered in an urban area.

LORAN POSITION-DETERMINATION TECHNIQUES

The techniques tested fall into three classes: a completely empirical curve fitting, or regression, technique; a theoretical, or interactive, geometrical technique; and a technique that combines the theoretical and regression methods. The regression technique tested was developed by Teledyne (4) and used by that company during the Philadelphia test; the theoretical technique used is described by Howard (5); and the combination technique is the method used in the AN/ARN-101 loran receiver (6).

Empirical

In the empirical approach, a functional relation between two sets of measured data is derived. In this application, the data are TDs and location. The locations can be expressed in nearly any coordinate system--longitude and latitude are used here--but relative position on a cathode-ray tube (CRT) is equally valid. It is assumed that some actual relationship exists between the data measured at the calibration points that can be approximated by a series of functions, the coefficients of which are determined from the measured data. Here the functions are powers of longitude and latitude (actually their difference from a reference position), and the technique is polynomial regression. Powers up to the fifth order can be handled by the program as it currently exists.

Standard least-square techniques are used to determine the best-fit coefficients. The program generating the coefficients is composed of 13 FORTRAN IV subroutines that consist of approximately 600 statements. If a functional relationship actually exists between the measured variables of the same form as that used in the regression, the fit should be very good. Since lines of constant TD are known to be hyperbolas, a second-order polynomial should fit well. However, since it is known that there are TD distortions in urban areas, higher-order polynomials may give better fits. Also, if it is assumed that there may be anomalies that affect all measurements in a given area, breaking the area up into a number of sectors, each of which has its own empirically determined set of coefficients, may improve overall accuracy. The regression technique is unequalled in speed of computation, since received TDs are just plugged into an equation, the output of which is the desired location. Coefficients for the equations have to be stored, however (up to 30 per sector for a fifth-order regression), and a certain amount of computer time is required to chose the proper sector. Also, since the coefficients were chosen to fit points within a certain area, TDs from points outside that area may result in large errors.

Theoretical

The second major technique is here called theoretical because it uses an earth model and a propagation model to actually compute signal travel times between the known transmitter sites and the assumed receiver site. The amount by which the computed TDs differ from the received TDs is used with a gradient equation that relates changes in TDs to changes in location in order to improve the estimate of the assumed receiver position. This process is repeated until successive position estimates are close enough, 3 m (10 ft) in the program tested, or until some iteration threshold (here, nine) is exceeded. Signal travel times are composed of a primary component (the time taken for light to travel in air between the transmitter and the assumed receiver position) and a secondary component (an additional delay caused by transmission over finitely conducting earth).

Three types of earth models were used in different tests of the theoretical technique: two forms of flat-earth models with corrections and a more complex precision earth model. The simplest earth model uses plane geometry to determine range and bearing between points and modifies the range by use of a flattening constant and a correction that acounts for the convergence of longitude lines as they approach the poles. The more complex flat-earth model includes higher powers of the flattening constant and an additional bearing correction. The precision earth model employed was taken from the combination method and uses much more complex functions of four spheroidal constants. Range and bearing accuracy is improved by an order of magnitude for each level of complexity, but loran position-determination accuracy is not necessarily improved, since the process of choosing the conductivity values compensates for these biases.

Since this technique is iterative, it is more time consuming than the use of regression equations. It does have the advantage of being relatively accurate over areas outside of where it was calibrated. (Changes in distance of the signal path are handled by the earth model, but large changes in the composition of the earth crossed by signals cannot be so handled.)

Combination

The third technique combines aspects of the theoretical and empirical techniques. The primary phase is computed as described for the theoretical method by using the precision earth model. The secondary-phase contribution, however, is calculated on the basis of coefficients previously computed from calibration-point data. Once the total signal-travel times are computed, the iterative process of determining location is the same as for the theoretical technique.

The program to determine the coefficients first forms an effective impedance map for each transmitter over the area of interest (i.e., a map of how much the signal is impeded at the calibration points) and then fits a set of functions to each impedance map by using least-squares techniques. The program, consisting of 35 subroutines and 3000 statements, was originally written in FORTRAN for Control Data Corporation equipment; I converted it to run on IBM computers.

This technique is more time consuming than either of the two previous ones, since it combines the iterative theoretical computation with a series of regression equations, look-up tables, and other computations more complex than the empirical technique. Like the theoretical technique, it is relatively accurate outside its calibration area.

It may be questioned whether any theoretical justification exists for believing that a given order of regression applied in the combination technique should provide any more accuracy than the same order of regression applied in the empirical technique. Intuitively, it does seem that, by fitting functions to each of the three transmitters and by using the results only to correct for differences from primary travel times separately computed, more flexibility is available than by using a direct TD to XY curve fit. However, only two independent pieces of information are available for use in either technique (the two TDs) and to use them in three equations instead of two is no guarantee of improved performance. Essentially the question is whether an impedance function (perturbed by the existing noise) provides better fit than the direct conversion of TDs (perturbed by the existing noise) to XY. At least when applied to the Los Angeles environment and the types of TD perturbations encountered there, the end results seem to indicate little difference between the two techniques.

ANALYSIS TECHNIQUES

The desired output from the analysis of the various loran position-determination algorithms is some measure of performance and cost. The performance relates to the accuracy of the technique, mainly represented here by the mean, standard deviation, and 95th-percentile accuracy. The cost relates to the processing time and storage requirements of a given technique, since a simple-enough technique could be performed on board a vehicle. In addition to relieving the central processor of a large amount of routine processing, an on-board processor could perform continuous smoothing and reasonability checks by using data that could not be available to the central computer.

The analysis technique was designed to simulate the manner in which the algorithms would be used. A data base of 800 points in an 80-km^2 (30-mile^2) area that includes the CBD (the central area) and 100 points over a 1000-km^2 (400-mile^2) area that includes most of the Los Angeles basin (the wide area) was collected in July 1978 by Teledyne during an earlier phase of the project. Figure 2 shows these areas. The raw data as received required a substantial amount of effort to be converted to a form suitable for analysis. Separate analyses were made of the central- and wide-area data. Every 10th data point was selected from the random-route area, and every other point was selected from the wide area to be used to generate the coefficients or conductivities required by the different techniques. A second sample, of the same size as the first and including completely different points, was then chosen to simulate the system use. The previously determined coefficients were used to predict the locations at these points, based on the received TDs, and the predicted and actual locations were compared.

The raw data were in the form of one data sheet for each measurement point, including three sets of TD pairs (TD-A and TD-B), the location of the point with respect to the nearest intersection, and comments (e.g., "near power line," "lost track"). After sample data points were selected, longitude and latitude were then determined by plotting the locations on 7.5' U.S. Geological Survey maps. The simplest flat-earth model was then used with the measured TDs to generate a set of predicted longitudes and latitudes, and a plotter program was used to create a map overlay by drawing a vector between the actual and predicted locations. A similar technique used the flat-earth model with the actual positions to compute TDs; the differences from TDs were measured at the point being plotted. Examination of the printout and plots for unusually large errors led to the discovery of some data-entry errors, some points incorrectly located on streets, and some points that obviously suffered "cycle slip" [caused when the wrong cycle of the loran signal is chosen to determine TDs, resulting in errors of multiples of approximately 3.2 km (2 miles)]. After all such points were corrected, the two sets of processed data points were used to evaluate the algorithms.

Figure 2. Los Angeles: wide area and central area.

After all explainable data-base errors had been corrected, there remained points with relatively large errors that would only be attributed to the types of TD perturbations that it was hoped the various curve fits could improve. Coefficients were generated both with and without those points in the data base and were tested against the second sample. In general, better results were obtained when they were included.

To evaluate the cost side of the analysis, relative processing time and storage required were examined. Special-purpose subroutines that allowed one to determine how much central processing unit (CPU) time has elapsed between calls were used to determine only the time required for the position computation, excluding program initialization, extraneous read-and-write instructions, and the accumulation and statistical analysis of data. Core storage requirements were determined by compiling only the instructions required for the algorithm's computation. No attempt was made at optimization of either CPU time or storage but, because the same general programming philosophy and techniques were used for all cases, the relative comparisons should be valid. The time-and-storage requirements for the programs used to generate the various coefficients were not evaluated, since they are off-line programs that would be seldom used after the initial application (for example, if sufficiently large seasonal variations made this desirable, or if experimentation with choice of sector boundaries were carried out).

RESULTS

Accuracy

Table 1 summarizes the results of the tests performed. These data result from using the first sample to determine the best-fit coefficients or conductivities and then using these constants with the second sample to simulate actual performance. In general, it can be seen that all methods gave approximately the same results: mean and 95th-percentile errors correspond to one and three blocks in the central area and to three and five blocks over the wide area.

From previous discussion, it is obvious that more tests were performed than are shown. However, in general, the others give no better results and so are not included. For example, regressions from first to fifth order were run, but the second order gave results as good as, or better than, the others. (As was previously discussed, a second-order regression would perfectly fit TDs that have no error--evidently the errors that do occur are not sufficiently regular to be better fit by a higher-order regression.) Also, three forms of earth models were used in the theoretical method, and all had approximately the same accuracy. However, the flat-earth model with extensive corrections required less computer time than the others, since it (and the precision earth model) required fewer iterations to converge than did the simplest flat-earth model and since the precision earth model required more processing time per iteration. Although the numbers are not exactly the same for the various techniques, it is obvious, based on the size of the standard deviation compared with the differences in means or 95th percentiles, that no significant difference in accuracy exists between the various methods.

It is also obvious that the accuracy obtainable over the wide area is substantially degraded from that in the smaller central area. This is not to suggest that larger grid warpages occur outside the random-route area but that the variations over the larger area may be sufficiently large and variable from area to area that one set of coefficients does not suffice. This seems to imply that subdividing the area into subareas, each of which has its own set of coefficients, should give better results. To test this hypothesis would require a density (not available) of data points over the wide area equivalent to that collected in the central area. It was found, however, that subdividing the points in the central area into geographically separated subareas, each of which had its own set of regression coefficients, gave results inferior to treating the area as a whole. These results seem to define an approximate range for the size of area for which it is reasonable to compute separate coefficients; i.e., 1000 km^2 (400 $miles^2$) is too large and 80 km (30 $miles^2$) is much better, but 40 km^2 (15 $miles^2$) is no better than 80 km^2.

Table 2 shows how well coefficients generated from the first sample fit the first sample and can be viewed as a best-case accuracy. When Table 2 is compared with Table 1, it can be seen that the empirical and theoretical methods behave similarly. Thus, the best-case results over the wide area are approximately 50 percent worse than those for the central area, e.g., 245 m (800 ft) mean error versus 170 m (555 ft) by using the empirical method. When the coefficients so generated are used to predict locations for the second sample, errors over the wide area are approximately 150 percent worse than those for the central area--540 m (1765 ft) versus 195 m (640 ft). This seems to reinforce the previous hypothesis: The variations over the larger area cannot be fit as well as those in the random-route area, and the effect of the greater variation is magnified when the second sample, which simulates actual use, is used.

It was previously noted that the radial-error statistics for the three methods are similar. In fact, map overlays show that all three techniques give similar predicted locations for the same data points. The predicted locations are closer to each other than they are to the actual point; the mean radial differences are approximately half the mean radial error and the 95th-percentile differences are one-half to one-third of the 95th-percentile radial area.

Computer Requirements

Core required by the computational parts of the FORTRAN program is approximately 30 kilobytes for each method, and the times required to compute the location for one data point are

Technique	Time (ms)
Empirical	15
Theoretical	
Flat-earth model and mid-latitude correction	85
Flat-earth model and extensive corrections	65
Precision earth model	105
Combination	125

Numbers shown are specific to operation on an IBM 370/148 computer using a FORTRAN IV, G1 compiler--it is the relative differences that are important. That is, the empirical regression method is four times as fast as the next method, the theoretical

Table 1. Algorithm accuracies.

Technique	Radial Error (m) Central Area Mean	SD	95th Percentile	Wide Area Mean	SD	95th Percentile
Empirical (second-order regression)	195	165	505	540	525	860
Theoretical (flat earth and corrections)	195	170	520	470	465	855
Combination	190	200	560	465	525	865

Table 2. Accuracy of fit to original sample.

	Radial Error (m)					
	Central Area			Wide Area		
Technique	Mean	SD	95th Percentile	Mean	SD	95th Percentile
Empirical	170	155	425	245	170	570
Theoretical	185	165	420	260	125	400
Combination	155	195	565	300	220	605

flat-earth model with extensive corrections. In turn, this is faster than the simplest flat-earth model, since fewer iterations are required for convergence. Further improvement in range and bearing accuracy provided by the precision earth model did not further decrease the number of iterations required and, since the precision earth model is also used in the combination method, there is no offsetting of the increased time required by their more complex calculations.

Other Analyses

Since all of the techniques, as used here, require that calibration points be chosen to determine the best set of coefficients to represent the given area, the question of how to select the best calibration points is of interest. One method that has been suggested is to choose points that exhibit small TD variability with repeated measurements; the theory is that a more stable measurement is also more accurate. Analysis showed that, although those points that have the largest errors do seem to follow a linear (or quadratic) relationship with TD variability, this does not help in choosing, a priori, which points to use in determining the best coefficients.

CONCLUSION

Based on the analysis, none of the techniques would be sufficiently accurate to meet the stringent random-route accuracy requirements of the AVM demonstration program. Consequently, loran alone would not be adequate to replace the signposts for this function. To improve on this accuracy, the hybrid technique currently being developed for the Los Angeles demonstration uses on-board loran processing, differential odometer data, and Kalman filtering. Further tests will determine the extent of the accuracy improvement.

The accuracy attainable by using only loran, however, may be adequate for many applications. Inasmuch as all of the algorithms gave approximately the same results, the second-order regression technique is the one to choose for use in an area of any reasonable size, e.g., on a metropolitan-area scale, since it is the simplest and fastest one to execute. It can be performed on board a vehicle by using a microprocessor and can even include coefficients for multiple sectors. For application in larger areas that require many sectors, e.g., on a statewide scale, the flat-earth method would probably give more-satisfactory results and could also be implemented aboard a vehicle.

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REFERENCES

1. D. Symes. U.S. Department of Transportation's Automatic Vehicle Monitoring Program. Presented at 29th Vehicular Technology Conference, Arlington Heights, IL, 79CH1378-9VT, March 1979.
2. B.E. Blood and B.W.A. Kliem. Experiments on Four Different Techniques for Automatically Locating Vehicles: A Summary of Results. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, UMTA-MA-06-0041-77-2, June 1977.
3. J.S. Ludwick, Jr. Loran Position Determination in an Urban Environment: A Comparison of Three Techniques. Mitre Corporation, McLean, VA, MTR 79W00356, Oct. 1979.
4. LAVM Location Subsystem Test Plan: Data Analysis Plan, Volume 1. Teledyne Systems Company, Northbridge, CA, 1976.
5. J. Howard. Loran Prediction and Coordinate Conversion. Mitre Corporation, Bedford, MA, WP-21504, Jan. 1978.
6. AN/ARN-101 Computer Program Development Specification RF-4C. Lear Siegler, Inc., Grand Rapids, MI, CB1001-004, 1976.

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