Indiana Traffic-Accident Record System (INTRACS)

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The Indiana Traffic-Accident Record System represents a major statewide effort and is being developed to geographically locate accidents on road segments anywhere in the state. When completed, the system will provide a procedure for analyzing accident rates and their relation to physical roadway conditions. The results will be used to identify critical accident locations and conditions that cause accidents. The system is founded on a geographic data base that allows automatic assignment of X-Y coordinates to all coded accidents. The process requires only simple information commonly coded on accident forms. Because of its unique design, it provides a comprehensive system capable of efficient and meaningful analysis of coded accident information. Roadway sections, intersections, corridors, and geographic areas can be examined over any specified period of time for a complete accident history. Accidents can be identified by type, precise location, or any other descriptive criteria included on accident-report forms. Accidents can also be correlated with roadway characteristics, jurisdiction, and federal-aid classification.

There were 195 672 traffic accidents involving 68 883 injuries and 1133 fatalities in Indiana in 1975. The state, through its Highway Commission, Department of Traffic Safety and Vehicle Inspection, and State Police is committed to a policy of improving highway safety in cooperation with federal and local agencies.

Highway safety can be improved by implementing countermeasures in the three general categories of the vehicle, the driver, and the roadway. Countermeasures to improve the safety of the vehicle include seat-belt requirements, collapsible steering columns, and vehicle inspections. Countermeasures among the human factors that affect highway safety include driver education, licensing, and alcohol safety. Countermeasures relating to the roadway include the installation of safety features, such as regulatory and warning signs, guardrails, breakaway signs and lighting supports, bridge and curve widenings, and various construction techniques.

This last category of accident countermeasures has been of recent concern in Indiana. The concern has been that a lack of systematic information that relates the locations of accidents to the physical roadway conditions has resulted in less than effective countermeasures. As a result of this concern, the Indiana Traffic-Accident Record System (INTRACS) has been designed and is being implemented throughout the state with the general goal of developing a capability for systematically determining hazardous roadway locations so that appropriate countermeasures can be implemented. The system has the following specific objectives:

1. To provide a uniform and systematic method of locating traffic accidents throughout the state,
2. To relate accident locations to roadway characteristics,
3. To produce standard graphical and tabular statistical summary reports on a periodic basis,
4. To produce special graphical and tabular locational summaries for routes or areas,
5. To produce special summaries of locations having high accident rates, and
6. To serve as a research tool for determining the cost-effectiveness of implemented countermeasures.

With these objectives, various resource information and data were identified for incorporation into the design of the system.

RESOURCE DATA

The basic resources for the design and implementation of INTRACS include roadway-inventory data and maps, the state plane-coordinate system and the U.S. Geological Survey (USGS) maps, aerial photography, and accident reports.

Roadway Inventory Data and Maps

The roadway system of Indiana consists of 150 000 km (93 000 miles) of variously classified urban and rural roads. About 37 000 km (23 000 miles) is on the federal-aid system.

A computerized inventory of the entire system is maintained and routinely updated by the state highway commission. Subsections along the inventory are designated for the purpose of recording physical characteristics. The inventory includes the following items: county code, district code, city code, record number, revision status, roadway jurisdictional code, state route number, roadway condition, number of lanes, directions of travel, surface type, surface width, roadbed width, right-of-way width, median type, median width, surface type, surface width, curbs, access control, section length, traffic volume, rural-urban size classification, functional classification, section number, federal-aid classification, urban-area classification, population-group code, and travel-over code. A series of maps describe the roadway system numbers throughout the state and relate it by numeric codes to the computerized inventory.

State Plane-Coordinate System and U.S. Geological Survey Maps

A plane-coordinate system has been established for the entire state and marked on the USGS maps. Thus, any point (accident location) or series of points (roadway locations) can be uniquely described relative to an established grid.

USGS maps at a scale of 1 cm = 240 m (1 in = 2000 ft) provide controlled cartography relative to the state plane-coordinate system. These maps were used as the basis for the process that determines the coordinates of points that describe the roadway system.

Aerial Photography

Aerial photographs taken by the state highway commission were used to update the USGS maps by the addition of recently constructed roadways and streets. This process is a way to verify that the road inventory file is complete and provides current maps of the entire roadway network.

Accident Reports

Reports are prepared for all accidents that result in fatalities, personal injury, or significant property damage. The reports are prepared by the State Police, the local police, or the individual drivers (when police are not called to the scene). These reports are standardized for computer processing and contain the information usually found in such reports.

SYSTEM CONCEPT

INTRACS is designed to automatically compute the X and Y plane coordinates of traffic-accident locations and to relate these specific locations to the roadway characteristics found in the highway inventory files. The system is designed to produce annual or periodic summaries of hazardous roadway locations in tabular form or in computer-plotted graphic form by using the coordinates that describe accident locations and those that describe the roadway system.

The system is designed to produce these summaries by the processing of six interrelated data files: These are (a) the roadway files (the road inventory, road number, road network, and road index files) and (b) the accident files (the accident-statistic and accident location master files). The roadway information is prepared or updated in batches by geographic matrix or political jurisdiction and entered into the appropriate files. The accident files are updated daily with new reports.

Road Inventory File

The road inventory file describes the roadway characteristics, such as pavement type and width and traffic volumes. The file is regularly updated by the state highway commission as roads are constructed or reconstructed. The roadway inventory assigns a unique road number to every roadway, and subsections along the inventory are designated for recording the physical characteristics. A change in any one characteristic requires that a new subsection be established. The beginning of each subsection is identified by its distance from the beginning of the roadway. Thus, the inventory system is linear (rather than two-dimensional) in that the roadways are described by distances along their lengths.

The roadway inventory file is used by INTRACS as a data resource for preparing the road number and road network files and as an analytical resource in conjunction with the accident-statistic and accident-location master files.

Road Number File

All the roads and streets are assigned a unique four-character road number by the road inventory file. The road number file is simply a directory that provides the equivalent road number for every road or street name. The road number file, shown in Figure 1, is used by the police to translate street and road names to unique road numbers.

Road Network File

The road network file is the framework of INTRACS. It contains descriptive information and the X-Y coordinates for all of the intersection and alignment points that collectively describe the street and roadway network.

The road network file is created for 2000 independent, but interlocking matrices or data cells for data processing and quality control. Each matrix is 6096 by 9144 m (20 000 by 30 000 ft) and further subdivided into six submatrices of 3048 m^2 (10 000 ft^2). The roadways in each matrix are traced from updated USGS maps onto stable mylar material to provide an accurate and permanent record of the system. Intersection points, roadway numbers, functional classifications, roadway distances and other descriptive information required to link INTRACS with the road inventory file are recorded on the matrix maps as shown in Figure 2. The data for each point are manually coded into the record forms by using the completed matrix maps as the resource. The X-Y coordinate for each of the points is determined quickly from the matrix maps by using the electronic digitizer shown in Figure 3. The digitizer operator aligns the cursor over each point in sequential order, and the coordinates are determined automatically by an electronic grid in the surface of the table. The coordinate output is then merged with the manually coded data into a record format as shown in Figure 4. Finally, these records are edited by a series of logic and computer plots to ensure that the matrix is accurately described by the file.

The resulting road network file is a two-dimensional computer-stored map of the road and street system that is linked to the road inventory file. Portions of the network can be plotted by the computer at specified scales to illustrate various roadway characteristics and to locate traffic accidents.

Road Index File

The road index file is created by the INTRACS programs and contains a record of every intersection as shown in Figure 5. The file is a directory that associates the road numbers of intersecting streets and highways with the unique intersection number. Thus, an accident referenced to the intersection of two roads can be determined to be at a specific intersection point number for which the road network file has a coordinate location and other information that leads to the roadway characteristics in the road inventory file.

Accident-Statistic Master File

The accident-statistic master file contains a record for each accident that has the accident number, driver, vehicle, injury, weather, and other data taken from the standard reports submitted by police agencies. This file is used to generate a variety of standard state summaries of accidents on an annual basis and by INTRACS as a resource from which specific records can be retrieved for special analysis.

Accident-Location Master File

The accident-location master file contains a record for each accident with its accident number (which links it to the statistical master file) and a variety of information that locates the accident as shown in Figure 6.

The first 51 characters of the record are coded manually from the accident reports, and the last 64 characters are computer-generated by the INTRACS programs.

The accident-location master file is created in the following manner:

1. Coders extract the following information from every accident report form—identification of the road on which the accident occurred (its name and the county and city), identification of a nearby road that intersects with the road on which the accident occurred (the intersection formed is referred to as the reference intersection), and the distance and direction of travel from the accident location to the reference intersection.
2. The coders then refer to the road number file, ex-

Figure 1. INTRACS road number file coding form.

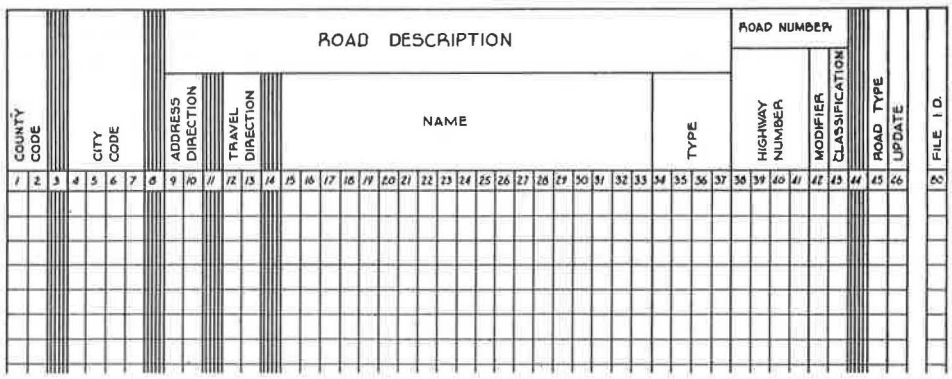
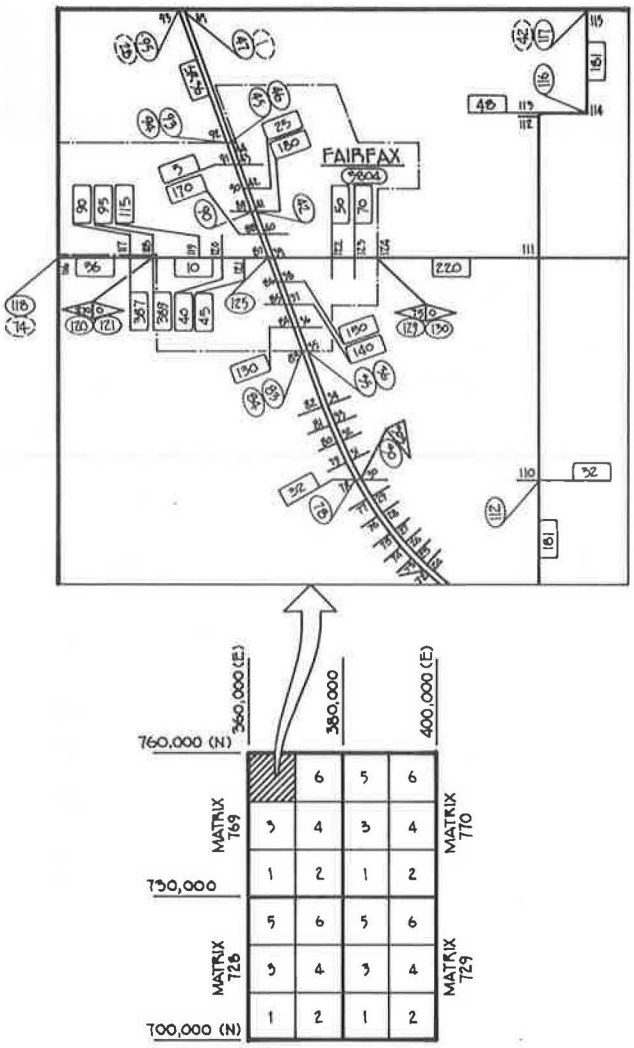


Figure 2. Sample matrix map.



tract the appropriate identification numbers for the road on which the accident occurred and the intersecting road, and code these numbers with the appropriate distance and travel direction information into a single record.

3. At the end of each day, all the coded accident-location records are processed through a series of programs that merge the new data into the existing location files and identify the reference intersection specified by the two roads coded for each accident. When the intersection is identified, its unique intersection number is automatically assigned to the accident-location record from the road index file, which identifies the reference intersection in the statewide frame of reference and specifies the appropriate entry point into the next level of accident-location processing.

4. Once a week, the new accident-location records that have been accumulated and partially processed are run through a final series of programs and data files for automatic computation of the X and Y coordinates for the accident-location records. Briefly, this process involves the use of the two-demensional road network file. The reference intersection number (automatically identified during daily processing) acts as a key and specifies the appropriate entry point into the statewide road network file. After locating the reference intersection, the INTRACS programs travel the appropriate direction and distance on the specified roadway through the road network file. Because the network includes points to describe the curves and other significant road characteristics, it is possible to simulate the true travel distance from the accident site to the reference intersection. Finally, the coordinate value for the accident location is automatically calculated from its relative position in the road network and entered onto the accident-location record.

ANNUAL (OR PERIODIC) ACCIDENT SUMMARIES

INTRACS is designed to process the accident-location master file with the road inventory file to determine three high-accident-location categories. These are

1. High-accident intersections,
2. High-accident sections, and
3. High-accident spots.

Once these locations are identified, all accidents occurring at one of them can be extracted from the accident-statistic master file and various detailed summaries of accidents can be prepared.

High-Accident Intersections

High-accident intersections can be determined on the basis of the number of accidents that occur or on the rate of accidents occurring when compared with the traffic volumes.

To determine the locations of intersections having high numbers of accidents, the system first computes the average number of accidents per intersection for a specified class of intersections (i.e., urban or rural). The number of accidents at each intersection is then compared to that of the average. Intersections at which the number of accidents exceeds the average number by

a specified value are listed in an output report.

To determine locations having high rates of accidents, the system first computes the accident rate at each intersection by dividing the number of accidents by its approach-traffic volume and then computes the average rate for all intersections in the designated class. The accident rate at each intersection is then compared with that of the average. Intersections at which the rate exceeds the average rate by a specified value are listed in an output report.

Figure 3. Electronic digitizer.

Digitizer Table

Standard Cursor

Figure 4. INTRACS road network file format.

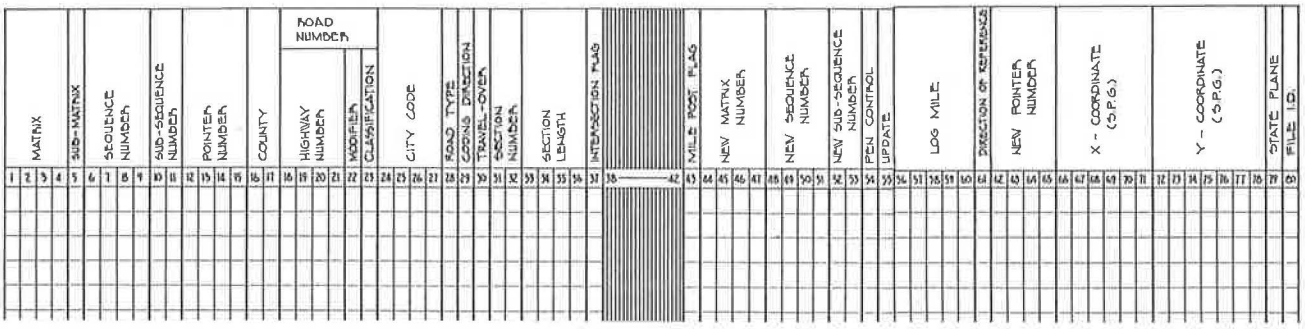


Figure 5. INTRACS road index file format.

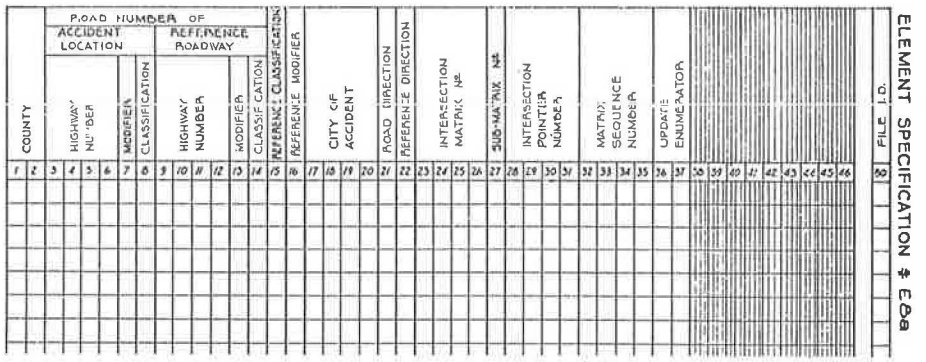
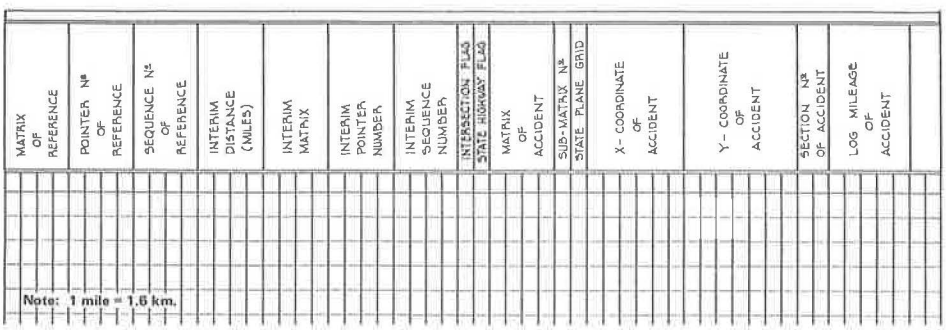


Figure 6. INTRACS accident-location master file.



High-Accident Sections

Sections are portions of continuous roadways between 4.8 and 12.8 km (3 to 8 miles) long. They may be stratified by five urban and five rural classifications. Continuous roadways are determined from the road network file, subdivided by the system into equal section lengths, and classified by the road inventory file.

High-accident sections may be determined on the basis of actual numbers of accidents or on the basis of the rate of accidents when compared to the vehicle kilometers of travel for each of the roadway classifications. As in the case of intersection locations, reports can be printed to describe the sections that exceed the average numbers or rates by specified amounts.

High-Accident Spots

Each accident appearing in the location file will be used in turn as the starting location for a road spot of specified length [such as 0.5 km (0.3 mile)]. By using the selected spot length, the statewide accident rate for the road classification under analysis, and the average daily traffic for the road section under analysis, the number of accidents occurring in each road spot is compared with the average or expected number. Those spots that have a significantly high-accident experience are reported in the order of the observed accident rate.

Summaries

After the high-accident intersections, sections, and spots are determined, all accidents occurring at each location can be extracted from the accident-statistic master file, and all roadway characteristics can be extracted from the roadway inventory file. A variety of summaries can relate the accident characteristics with the roadway, driver, vehicle, or environmental circumstances. Such summaries are useful for determining the most appropriate type of countermeasure that might be effective in reducing the frequency of accidents.

INTRACS techniques in the future may include the computer mapping of accident locations, roadway characteristics, traffic volumes, and street capacities for routes, corridors, or areas. All of these could be accomplished by using the six basic files.

SUMMARY

INTRACS represents a major statewide effort and is being developed to geographically locate accidents on road segments anywhere in the state. The system provides a procedure for analyzing accident rates and their relation to physical roadway conditions. The results will be used to identify critical accident locations and the conditions that cause accidents.

Because of its unique design, INTRACS provides a comprehensive system for efficient and meaningful analysis of coded accident information. Roadway sections, intersections, corridors, and geographic areas can be examined over any specified period of time for a complete accident history. Accidents can be identified by type, precise location or any of the other descriptive criteria included on individual accident report forms. Accident occurrence can also be correlated with roadway characteristics, jurisdiction, and federal-aid classification. INTRACS output can be in the form of printed summaries or computer-generated accident-spot maps.

A fundamental characteristic that sets the INTRACS system apart from other accident-record systems is the two-dimensional nature of its accident location and road files. Unique X and Y coordinates are assigned by electronic digitizer to every significant reference point along the federal-aid routes in the state. These coordinates specify the exact location of a given point within an established, statewide reference frame of interlocking matrices. The coordinates for accident locations are then determined by computer programs that use distances from the reference points.

The coordinates allow points having no common link other than their proximity to each other or to a specified location to be grouped for further analysis. For example, areas having excessively high-accident rates can be readily located by scanning the accident-location file for any instances of high-accident density. Accident rates can be automatically correlated with average daily traffic counts and other relevant roadway characteristics.

The coordinates for points that are coded into the INTRACS network are tied to a corresponding set of narrative files. These files contain key descriptive information for each particular point and connecting link, allowing a direct interface with existing statewide road inventory and accident-statistic files. The careful design of these files ensures maximum flexibility in accident analysis without needless duplication of the information already being maintained in separate file systems. Further, all files are designed to allow efficient updating, so that subsequent accident analyses can reflect the current status of a particular situation.

The INTRACS system can also be used by state and local governments for several other purposes. Additional information that can be coded to the same coordinate system and interrelated to the roadway locations established by the INTRACS project includes the following:

1. Vertical alignment of roads;
2. Utilities within the road right-of-way, e.g., water lines, sanitary sewers, electric lines, and telephone lines;
3. Right-of-way;
4. Adjacent land use;
5. Subsurface conditions determined from soil borings within the road right-of-way; and
6. Noise and air-quality data derived from field measurements or from theoretical computations by using roadway characteristics from data files.

The system is also flexible enough to incorporate geographic coding of the railroad network, major river systems, pipelines, and electrical transmission systems for the entire state.

An advantage of the program is the capability for local government agencies to define local data by using the same format. Identification of the locations of sanitary sewers, water courses, and storm drainage systems are among the data files that can be locally developed. The procedures are designed to permit local agency development of these kinds of data without the need for expensive electronic digitizing equipment. With this capability, local agencies can prepare their own data within the framework of the roadway system. As data files are developed, statewide summaries by county or other jurisdiction could be prepared as part of a normal state program of technical assistance to local governments.

Another capability of the system is the identification and coding of attributes and conditions of geographic areas (in contrast to the linear-system descriptions that characterize the initial development of the process). The matrix method of geographic coordination can be subdivided into smaller cell sizes, and cell attributes can be defined and coded for multiple purposes. Socioeconomic characteristics, bedrock and soil geology, ground cover, percolation, land use, climatology data, and other characteristics can be coded into matrix cells and the results

used for county, regional, or statewide land-use capability analysis.

The ability to geographically relate linear systems to area conditions can provide data for both research and applied planning of many functions that concern federal, state, and local governments.

ACKNOWLEDGMENTS

The accident reporting system described in this report was prepared for the Indiana Department of Traffic Safety and Vehicle Inspection, in cooperation with the Indiana State Highway Commission, the Indiana State Police, the Indiana Department of Administration, and the U.S. Department of Transportation. We wish to acknowledge the contributions of the many staff members of Vogt, Sage, and Pflum Consultants for their collective thinking that has resulted in the detailed design and programming of INTRACS and their persistence and diligence in coding, editing, and processing the data files that are the basis of INTRACS.

The INTRACS working committee, comprised of state personnel representing the four agencies that will maintain and use the system, has offered constructive reviews, comments, and suggestions that have contributed to a better system.

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Sampling Procedure Using Multistate Traffic Records to Select Accident and Exposure Data-Collection Sites

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This paper describes a sampling plan developed to select 80 field data-collection sites. At each of these locations, large-truck accident rates were to be measured and vehicle exposure was to be sampled simultaneously for 1 year. The problems to be addressed were (a) to stratify the sites in each state so that the accident experience developed would be representative of the state (to preclude selecting only high-accident locations) and (b) to devise a roadway typology whereby sites were consistent across states selected. Accidents are now being investigated at sites selected by this procedure in California, Maryland, Michigan, Nevada, Pennsylvania, and Texas.

This paper describes a sampling plan developed to obtain the accident rates (based on exposure) of large trucks. Truck exposure is the term used to describe the number of trucks currently in use and the annual number of kilometers these vehicles are driven. Fairly accurate information is available at the state and national levels as to the number of trucks registered through state licensing agencies each year. But, as one attempts to classify trucks into categories on the basis of such considerations as body type, number of axles, mass, and length, the available information becomes vague, especially in terms of truck combinations (where different trailer units can be combined with a particular tractor for different trips).

A great deal of information is available about truck accidents in general. The National Safety Council each year provides a broad estimate of trucks involved in motor-vehicle accidents in the United States and the distribution between single-unit and combination vehicles. Little or no information is available that identifies the relationship between truck accident frequency and truck size and mass.

Although exposure data are available, it is impossible to discuss accident rates by truck classifications, except in the most general terms. The data that are currently available do not indicate whether longer trucks or heavier trucks are over involved or under involved in accidents, based on their representation in the traffic population at the accident locations.

Although the methodology described here was developed to address truck accident rates (per million vehicle kilometers of exposure), the same technique could be used to obtain details about other types of vehicles such as automobiles, motorcycles, or buses.

A sampling technique has been developed for selecting 80 roadway segments at which large-truck accident and exposure data will be collected. These segments comprise approximately 1609 km (1000 miles) of highway throughout six participating states, e.g., California, Maryland, Michigan, Nevada, Pennsylvania, and Texas.

A typology was created to partition all roadways into six exclusive types. Two classification variables were used: road location (two levels, urban and rural) and roadway type (three levels, primary, secondary, and Interstate). Roadway type was nested within road location.

In each state, a multistage stratified random sampling of roadway segments was drawn within each roadway type. The distribution of large-truck accidents experienced was then plotted for those segments sampled. Potential data-collection sites were identified by using a two-way stratification method based on historic truck-accident distribution curves. The final sites were selected by a team of trained field crews after on-the-scene evaluation of the potential sites. These crews based their decisions on previously specified selection criteria (e.g., weight data and ability to collect exposure data). The logic of the site selection process is shown in Figure 1. Table 1 illustrates the final distribution of selected sites in the framework of the six states and two roadway classification variables.

SELECTION OF COOPERATING STATES

A literature review of the existing truck-related research and accident data was conducted at the beginning of the project (1). From this information, states in candidate areas of the country were selected on bases of annual