USE OF A QUASI-COORDINATE LINK-NODE SYSTEM FOR LOCATING ACCIDENTS

Merrell E. Goolsby and Frank C. Yu, Wilbur Smith and Associates

The U.S. Public Land Survey method for land subdivision was used as the basis for development of a quasi-coordinate accident location system. The accident location and analysis system developed in Iowa is a link-node system that has been adapted to this quasi-coordinate method for recording accident location. This system is used to accurately identify accident locations for input to the computer system. This paper discusses the development of the system and the methodology for applying it to the complete network of urban and rural roadways in Iowa; sample maps developed for use by accident coders are included. The system is highly user oriented to provide a wide range of summaries and analyses for highway and traffic engineers and law enforcement agencies.

TRAFFIC ACCIDENT RECORDS are a basic element in any safety program to reduce the incidence or severity of highway collisions. Without a readily accessible information base containing accident history, trends, and relationships, the identification of deficiencies and decisions for improvement at specific locations are necessarily difficult and often subjective.

A usable traffic accident information system for accurately identifying the locations where accident losses have been significant would facilitate engineering or law enforcement countermeasures.

The U.S. Department of Transportation's Highway Safety Program Manual stipulates that "each state, in cooperation with county and other local governments, shall have a program for identifying accident locations and for maintaining surveillance of those locations having high accident rates or losses" (1).

This paper is based on a study conducted for the Iowa State Highway Commission to develop accident location and analysis concepts for a statewide computer-based accident records system that is responsive to local and state needs and conforms to the requirement of the U.S. Department of Transportation. The system developed has application to accidents occurring on all Iowa streets and highways. Iowa has one of the most intensely developed highway networks in the country: more than 112,000 miles (180 000 km) of streets and highways, of which 99,000 miles (159 000 km) are rural highways.

The objectives of the study were to develop a systematic procedure for accurately describing the location of accidents and to develop methods for analysis of interrelated accident, roadway, and traffic data to aid in determining appropriate remedial action.

This system will contain all accident reports for the entire state, including those on the state highway system, county road system, and local municipal streets. Because of the many accident reporting sources involved and the variety of methods used to report the locations of accidents, the coding of accident records for input to the state's computerized accident records system will be centralized.

It is axiomatic that any accident records system can be only as accurate as the information that comes from the field. Law enforcement agencies in Iowa will be

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requested to report accident locations to the desired degree of accuracy [generally 0.1 mile (0.16 km) in rural areas and 0.01 mile (0.016 km) in urban areas].

Although various methods of referencing accident locations in the field exist (2), all use a distance measurement from the point of incident to a known reference point and specify the direction of measurement. The characteristics of all data reduction from field recordings are essentially the same, whether the reduction is manual or computerized.

In order that accident information can be stored and retrieved systematically by location, accidents must be keyed internally in the computer.

A link-node concept was developed, based on a quasi-coordinate location system, that is applicable to the entire state of Iowa. Appropriate locational information is coded at the central processing facility for the state. This locational method and basic aspects of the function of the computer system are discussed later.

QUASI-COORDINATE NODAL SYSTEM FOR IOWA

In the link-node method, a unique node number is assigned to each intersection or other prominent feature of the roadway, such as railroad grade crossings and bridges. Thereby, a single node number identifies the location of a traffic accident occurring at that point. For an accident occurring between nodes, the link is identified by the nearest node in each direction and the distance from one of the nodes.

If node numbers are assigned arbitrarily without considering their spatial interrelationship, it may be difficult to assemble accident data on an areawide basis. It also is difficult to locate any given node on a map on the basis of its number alone. Even if nodes are initially numbered in a systematic manner, it may not be possible to relate new node numbers necessitated by land subdivision and new streets and highways to those numbers previously assigned. Therefore, a quasi-coordinate nodal system was developed (3). The system adopts the basic units of the U.S. Public Land Survey method and incorporates them in a nodal assignment system for identifying accident locations.

U.S. Public Land Survey Method

The public lands of many states, including Iowa, were originally subdivided into townships and sections under a rectangular system of land subdivision developed in 1785. These congressional townships are fixed land areas, each approximately 6 miles (9.6 km) square, bounded by meridional and latitudinal lines. (In contrast, civil townships are subdivisions established for purposes of political jurisdiction.) Congressional townships are divided into 36 secondary units called sections, each approximately 1 mile (1.6 km) square. A row of townships extending north and south is called a range, and a row extending east and west is called a tier (often referred to as township). The relationship of township, range, tier, and section is shown in Figure 1.

The Iowa State Highway Commission county and city maps contain no reference either to latitude and longitude lines or to any plane-coordinate system. Each map, however, does include a complete description of the system of congressional townships, ranges, and sections. County boundaries in Iowa include a number of complete congressional townships. This public land subdivision grid provided the basis on which the node-numbering scheme was developed. This readily available source of locational identification was a primary consideration in development of the quasi-coordinate system.

Selection of Nodes

The network of numbered nodes used in accident location coding includes all locations that an officer or motorist would ordinarily use as reference points to identify the

Figure 1. Relationship of township, range, tier, and section in the U.S. Public Land Survey method.

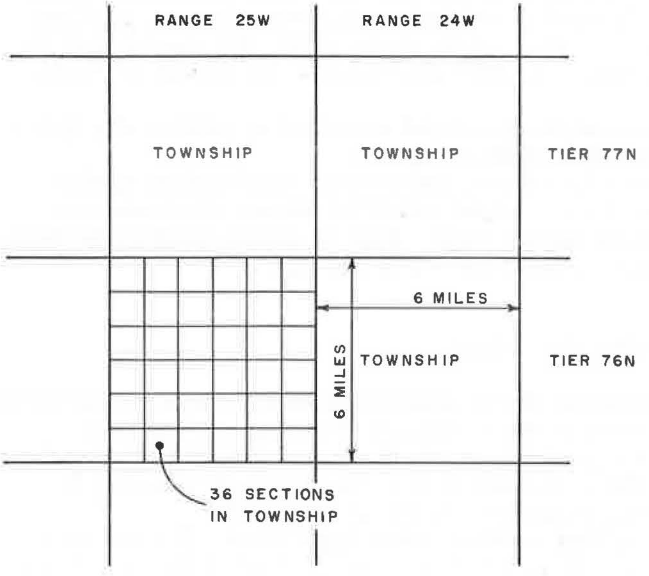
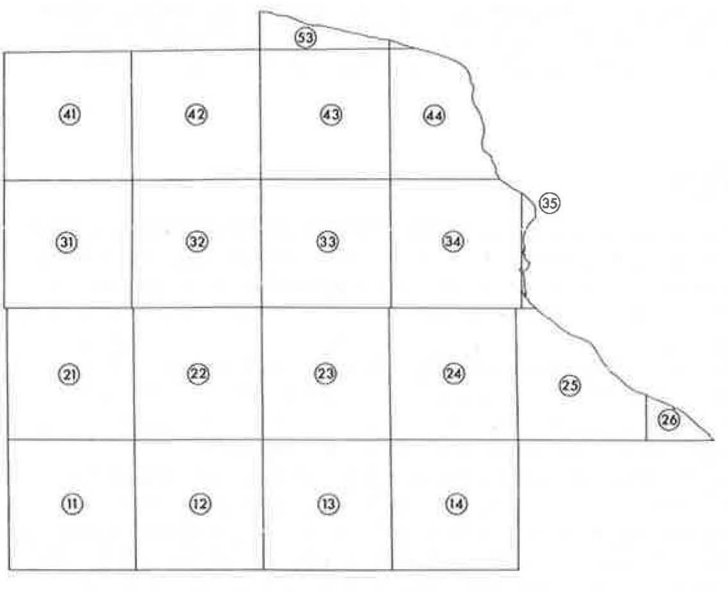


Figure 2. Example of township numbering scheme in a county.



location of an accident. Furthermore, to be usable in coding the accident location for the accident records system, all node locations must be identifiable on a county or city map.

Consequently, the following elements of the roadway network are assigned node numbers:

1. Intersections (except alleys),
2. Ramp terminals,
3. Railroad crossings,
4. Grade separation structures,
5. Bridges,
6. Road ends,
7. Ninety-deg turns, and
8. County boundaries.

The corporate limits of cities and towns are subject to change from year to year; therefore, they are not treated as nodes.

Numbering System

A special set of maps was developed for coverage of the complete state for use by office coders. County maps are used for indicating node numbers on rural highways, whereas larger scale maps are used for indicating nodes in cities and urbanized areas. These node maps were prepared by using specially developed scales to determine the appropriate node identification.

A six-digit number is assigned to each node. The first two digits represent the township in which the node is located. The first digit indicates the tier within a county, numbered sequentially from south to north, and the second digit indicates the range, numbered from west to east (Figure 2). This marking system gives county-level uniqueness only. For statewide uniqueness, a two-digit county number, which also appears in accident coding, is linked to this six-digit node number.

Each congressional township then is divided into 96 units in both the south-north and west-east directions. The third and fourth digits, therefore, indicate the south-north coordinate position, and the fifth and sixth digits indicate the west-east position within the township. A node is identified by the coordinate position that is closest to the scaled location of the node. The average spacing between available node numbers is approximately 330 ft (100 m) in each direction.

Some nodes, of course, are closer than the average spacing, whereas others are farther apart. It therefore is necessary to deviate somewhat from rigid coordinate positions in some instances in order to accommodate all nodes requiring numbers. Thus the system is not a true coordinate system; it is called a quasi-coordinate system because assignment of node numbers is based on approximate location in the grid. Generally nodes along a route are numbered in ascending order from south to north, or from west to east, within a county. For example, an intersection located in the second township at the center of the south edge of section 2 would be assigned the node number 2 1 81 73.

Dual node numbers are assigned to nodes on county borders (one for each county) on individual county maps, so that (a) both nodes on a single link that ends at the county boundary are assigned to the same county and (b) an accident occurring on the boundary may be assigned by county to the correct investigating agency (which varies from county to county).

Accidents at highway interchanges are assigned a node number to each ramp terminus. An example of interchange node numbering is shown in Figure 3. Sample node numbering on rural and urban maps is shown in Figures 4 and 5 respectively.

Figure 3. Example of freeway node coding.

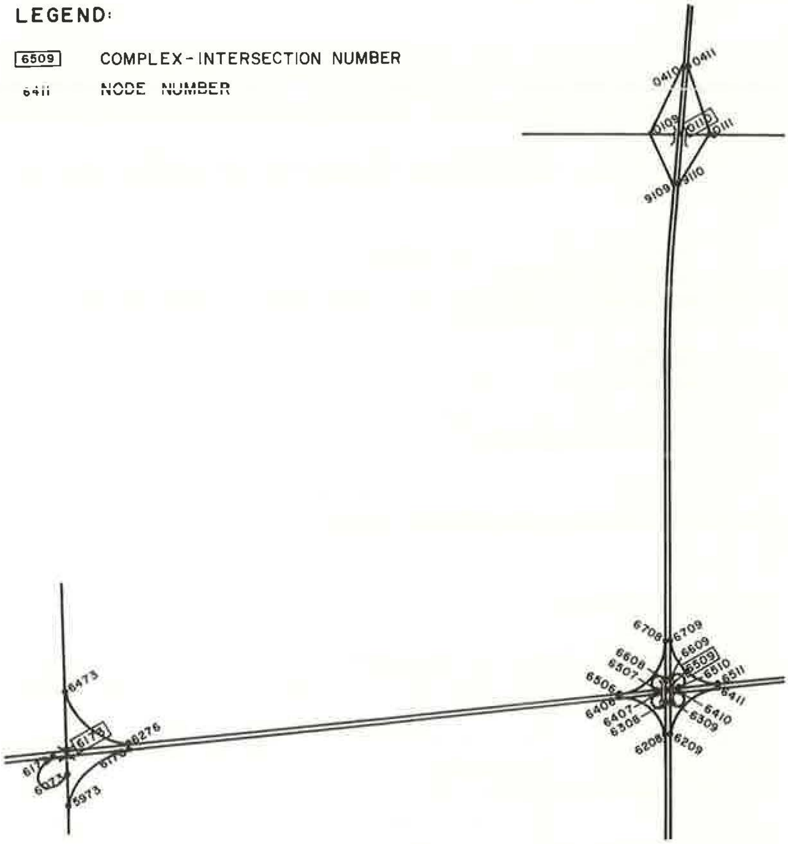


Figure 4. Example of rural node coding.

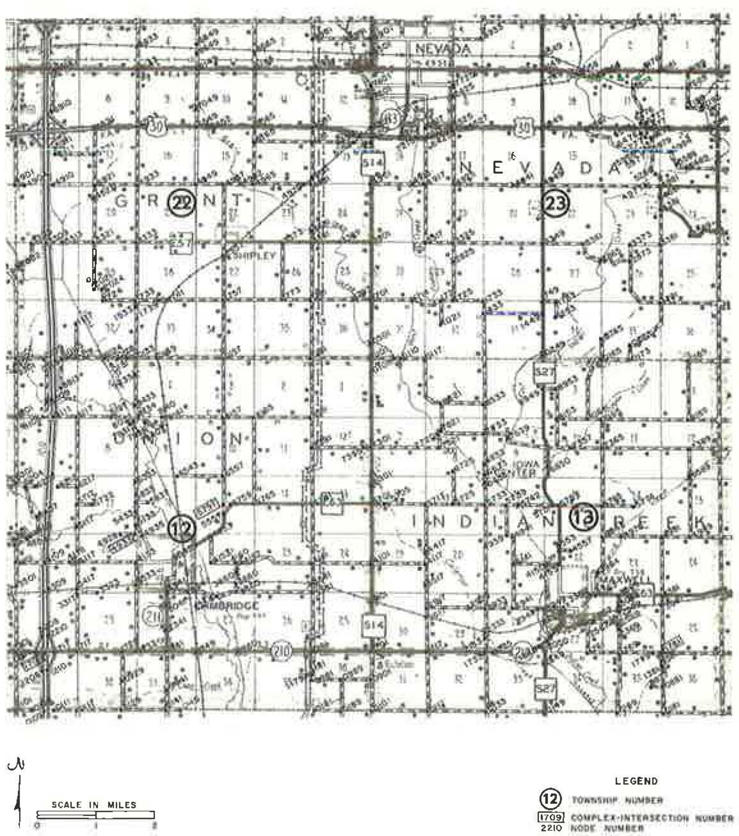
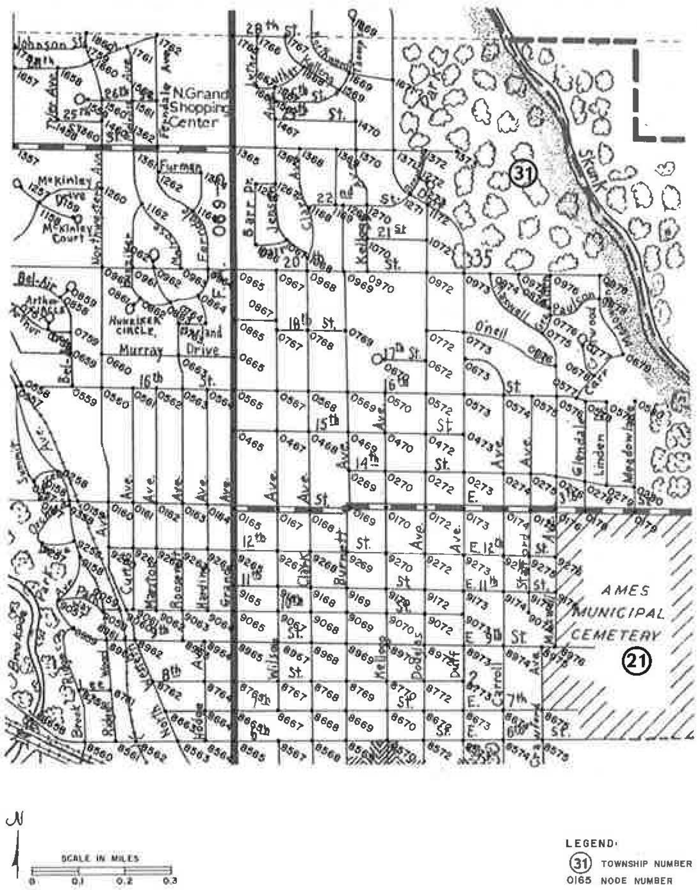


Figure 5. Example of urban street node coding.



Accident Location Coding

In the central office coding of accident reports, accidents occurring at intersections or other nodes are given a single-number location descriptor. Accidents occurring between nodes are coded by indicating (a) one of the two nodes defining the link on which the accident occurred, usually the nearer, (b) the distance from the first node in the direction of the second node, and (c) the second node.

For example, if an accident occurs 0.02 mile (0.03 km) west of an intersection bearing the node number 2 1 81 73, its location is coded as 218173/002/218172. No convention for deciding on the node to be referenced need be established. If the accident is 0.04 mile (0.06 km) west of node 218173, the location could also be coded as 218172/004/218173. The equivalency of these two location descriptions would be established by the computer accident system, which is interfaced with the roadway inventory system for roadway segment lengths.

Incomplete Locational Data

If an accident location cannot be determined from the information given on the accident report, zeros are coded in place of the unknown portions. For example, if the township alone is known, the location would be coded as 210000 (or 210000/0000/210000 for link accidents). Similarly, if the node numbers for a link accident are known but not the distance, the location of the accident would be coded as 281873/000/218172. By this method, accident information can be used to the extent possible in developing accident summaries.

Many location measurements on incoming accident reports are given in feet, particularly in urban areas. Coding personnel use conversion tables to convert from feet to miles.

Complex Intersections

A complex intersection or interchange containing several nodes, as shown in Figure 3, is identified by selecting one of the nodes as the intersection identifier and indicating it as such on the coding map. The intersection identifier is coded, in addition to the specific location identifiers discussed in the previous section. This field is left blank for all accidents not occurring within complex intersections.

Accident Location Accuracy

Investigating officers and drivers are required to cite reference points (nodes) on their respective reports only by their proper names, e.g., the intersection of two streets, a railroad grade crossing, and so on.

The location measurement given for an accident should be sufficiently accurate to pinpoint any roadway or environmental features that may have constituted a hazard. The Highway Safety Program Manual (1) recommends a minimum level of accuracy of 0.01 mile (0.016 km) for residential and commercial streets in urban areas, urban expressways and freeways, rural roads within the area of influence of an intersection, and all other locations where there is a convenient reference. In other cases, identification should be as accurate as possible under the circumstances.

Urban Areas

Accident locations in urban areas are generally referenced to the nearest intersection (node). If an accident does not occur at a node, a distance measurement is made by using tape or measuring wheel or possibly by visual estimation. An accuracy of 0.01 mile (0.016 km) is desired in all cases.

Rural Primary System

Accidents occurring on rural primary routes close to nodes may be referenced to the node by manual measurement, whereas other accidents generally are referenced to a milepost (which are placed only on the rural primary system) or highway feature by use of a standard automobile odometer. In this case, the accuracy obtainable would be approximately 0.1 mile (0.16 km).

Rural Secondary Roads

Many of the secondary roads in Iowa have not been assigned names or numbers. Thus description of these locations is often impossible. It was decided that the existing practice in Iowa of using reduced-scale county maps to pinpoint accident locations on these roads would be appropriate. These maps are supplied free of charge to all highway patrol districts, county sheriffs, and automobile insurance agencies.

Reports of accidents on the rural secondary system should be accompanied by a map with the accident location marked. Instructions to this effect are included in the accident report form. These maps are to be used by accident coders to associate an accident with the proper node or link. Marking a map will not replace an accurate distance measurement from the referenced node (for link accidents); this distance measurement should also be indicated on the report form.

ACCIDENT INFORMATION SYSTEM

A computerized accident location and analysis system (ALAS) that uses the location methods described previously was designed for the Iowa State Highway Commission. The first phase of development of this system became operational in early 1975 (4). ALAS has the capability of identifying locations of accidents and their characteristics and frequencies. The system has the flexibility to respond to information needs of the user and has numerous user-oriented options available. ALAS is being developed on a staged implementation basis and ultimately will be interfaced with the roadway inventory file as well as other data files to facilitate more detailed causative analyses and correlation.

The initial development of ALAS provides important new capabilities for identifying accident locations and permits special analyses to be made by the highway commission and other users of the system. ALAS can rank accident locations for the entire state or for individual counties and cities by any one of the following definitions of rank significance as specified by the user: total number of accidents, accident severity, and total value loss. Accident rankings can be obtained for intersections, nodes, or links. This permits the users of ALAS to identify locations that require special study, analysis, or on-site observation, with the objective of selecting design or control measures for reducing accident frequency or severity.

ALAS also can rapidly retrieve accident histories for specific locations or with particular attributes and can compile accident data for specific nodes, intersections, links, or node strings (sections of roadway). The system user can simply specify the location identification or attributes and the time interval of interest and obtain from the system a listing of accidents, and their characteristics, that took place at the specified location.

The capabilities of the initial development of ALAS are shown symbolically in Figure 6. Two types of data requests can be made: one for generalized accident information at specific locations or for particular attributes and the other for a high-accident summary. With either type of request, the range of dates to be covered in the accident records search must be specified. Following is an explanation of the symbols used in the figure:

1. Brackets represent alternatives that may be included or omitted, depending on requirements of the user;
2. Braces represent another choice of alternatives, one (and only one) of which must be chosen per request run;
3. Brackets within braces denote that one or more of the indicated options must be chosen, depending on the programming requirements; and
4. Braces within brackets denote that the information may be omitted if desired.

SUMMARY

The quasi-coordinate link-node system adopted in Iowa is based on the U.S. Public Land Survey method for land subdivision. This method of land subdivision is used by 30 states. The quasi-coordinate link-node system can be easily implemented for accident location when the township-range-section identifications are included on existing maps. It provides a permanent grid on which node numbers can be assigned, and additional node numbers can be added as new intersections (or other nodes) are created through realignment or as subdivision of land occurs. The coordinate properties of the node numbers offer some potential for schematic plotting, which would

Figure 6. Capabilities of ALAS.

Generalized Request:

Date Range	Juris-diction	Location		Data
Date Range	County State	Node String Node Intersection Link	Mainline Overall	General Vehicle Driver Injury Pedestrian

High Accident Summary:

	Roadway System	Juris-diction	Location	Criteria
Date Range	Rural Primary Primary Total Secondary Municipal	County City State	Node Link Inter-section	Value Loss Severity Critical Accident Frequency

Data File Maintenance:

Node String Definitions Location Literal Descriptions	Create Delete Insert Change

be useful for accident analysis.

An accident information system using the quasi-coordinate link-node locational method was developed for Iowa. ALAS provides the capability to identify locations that have experienced a high accident record and to obtain accident records for selected locations or accidents possessing particular attributes.

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