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PHASE I IMPLEMENTATION ACCIDENT LOCATION AND ANALYSIS SYSTEM

PREPARED FOR

IOWA STATE HIGHWAY COMMISSION
AMES, IOWA

IN COOPERATION WITH

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

BY

Wilbur Smith and Associates

1974

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March 10, 1974

Mr. Harold C. Schiel
Traffic and Safety Engineer
The Iowa State Highway Commission
Highway Commission Building
Ames, Iowa 50010

Dear Mr. Schiel:

We are pleased to submit this final report, Accident Location and Analysis System, in accordance with our agreement of October 25, 1972.

This report presents an overview of the Phase I implementation program of a statewide accident information system. It describes the computer system developed as part of this work program and discusses considerations for future system implementation.

Detailed information concerning the computer system is presented in two companion manuals. Accident Location and Analysis System User's Manual contains information on system capabilities and instructions to the user for obtaining specific accident information. Accident Location and Analysis System Data Processing Systems Manual contains necessary documentation of the computer system for data processing personnel.

We wish to acknowledge the valuable assistance and cooperation of your staff and those of the Data Processing Department with our program manager, M. E. Goolsby, and Don Comalander, computer systems director, during this study; and appreciate the opportunity to participate in this important work program.

Respectfully submitted,

WILBUR SMITH AND ASSOCIATES

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Chapter 1

Introduction

Traffic accident records are a basic element in any safety program to reduce the incidence and/or severity of highway collisions. Without a readily accessible information base containing accident history, trends, and relationships, the defining of problems and decisions for improving safety at specific locations are necessarily difficult and often subjective.

A traffic accident information system, easily accessible and accurately keyed to locations, therefore is an important tool for use by highway, traffic, and safety engineers.

The program described in this report is part of a broader program being conducted by the Iowa State Highway Commission, directed toward providing a computerized accident information and analysis system for all traffic accidents occurring in Iowa.

Program Developmental Phase

An accident locational basis and a conceptual design for a computerized accident analysis system for the state of Iowa were presented in a study report prepared in 1972.[(1)]

In addition, the 1972 report outlined a multi-phase program for implementation of the recommended system. The work program covered in this present study report represents Phase I of the recommended system implementation activity.

Program Objectives

The Phase I implementation program has two objectives:

1. To assign and map a system of node numbers covering the complete rural network of state highways and county roads, and the complete urban and rural freeway system in the State of Iowa, to facilitate coding of locations of reported accidents.

2. To develop the basic components of an automated data processing system for accident information, generate reports of accidents by specific locations, and identify locations experiencing high accident frequency.

Program Reports

This report presents an overview of the Accident Location and Analysis System (ALAS) as developed in Phase I of the implementation program. It is written for highway and

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(1) Accident Location and Accident Analysis Systems, Development Phase, prepared for Iowa State Highway Commission by Wilbur Smith and Associates, 1972.

safety engineers, and avoids use of computer terminology and details of the computer system itself.

In addition to this overview report, two other reports have been developed as part of the Phase I implementation program. They are:

1. ALAS User's Manual, which is oriented to individuals who will be requesting and using information from ALAS. This manual contains procedures for updating certain elements of the data system, as well as giving detailed instructions for requesting information from the system.
2. ALAS Data Processing Systems Manual, which is oriented to use by data processing personnel who will operate the system. This manual gives documentation of the computer system developed.

Review of System Capabilities

ALAS system capabilities are discussed in Chapter 2 of this overview report. Typical examples of accident data requests are presented to illustrate the flexibility of ALAS in supplying specific types of accident information.

A general explanation of ALAS and its subsystems is contained in Chapter 3. This brief discussion is intended to provide an overall understanding of the logic-flow of ALAS. More detailed information and flowcharts describing the system are contained in the Data Processing Systems Manual.

Future Development Potentials

Considerations involved in future development of ALAS are discussed in Chapter 4. This discussion includes statistical techniques which might be applied to accident analysis, as well as a review of the need for a common base of reference, or compatability method, for relating ALAS to other existing files currently maintained by the Iowa State Highway Commission.

Chapter 2

System Capabilities

The system discussed in this report is the initial phase upon which a more comprehensive traffic accident location and analysis system ultimately will be developed.

The first phase of ALAS development included provision of capability to identify locations where accidents occur, their characteristics and frequencies. In addition, the system is highly flexible in its ability to respond to information needs of the user, with numerous user-specified options available.

ALAS Limitations

As developed in Phase I, the system will not be linked to traffic volumes or roadway lengths. Therefore, in this phase, it will not be capable of providing analyses based on computation of accident rates: i.e., accidents on a vehicle-mile basis on roadway links, or accidents per million entering vehicles at intersections.

These additional capabilities, as well as linkage to other information systems utilized by the Iowa State Highway Commission, will permit more sophisticated statistical analyses to be performed in subsequent phases of ALAS development.

Accident Location Basis

A "link node" system was selected for identifying locations on the primary road, secondary road, and municipal street systems of the State of Iowa. The node assignment method possesses some characteristics of a coordinate system, using the township-range system as a basis.

A unique node number is assigned to each intersection or other prominent feature of the roadway, such as railroad grade crossings and bridges. On this basis, 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 nodes in each direction, with a distance measurement from one of the nodes.

By use of node numbers and distance measurements, locations of accidents can be defined accurately and in a form suitable for summarizing and analyzing accidents by automated data processing techniques.

Location Coding - Translation of the traffic accident location from the police accident report to the link-node identification basis will be accomplished by trained coders of the Iowa Department of Public Safety during routine processing of accident reports. This will be done by use of specially prepared maps containing node designations.

During the Phase I work program, node maps were prepared for all 99 counties of the State of Iowa. Node assignments were made for all roads and highways outside of urban boundaries and corporate limits.

In addition, freeway strip maps were developed and node coding accomplished for all freeways, both rural and urban, in the state. The remaining node coding necessary to complete node assignments for the entire state are those in urban areas or within incorporated cities. This work is presently underway under a separate work program.

TRACIS

The State of Iowa presently is in the development phase of a comprehensive Traffic Records and Criminal Justice Information System (TRACIS).

When completed, TRACIS will provide a statewide data processing system having capabilities for storage and rapid retrieval of detailed information relating to traffic and criminal information.

All accident data for ALAS will come from TRACIS, which is the state's official repository for traffic accident data. By agreement with the Iowa State Highway Commission, TRACIS will provide periodically an accident transaction file to the Commission, encompassing detailed traffic accident records for the interval subsequent to the previous transaction file.

These transaction files will be used to update the ALAS data system. They will be structured to correspond to the ALAS master file, for simplicity in merging new data with that already on file.

System Capability

As presently designed, ALAS provides important new capability for identifying accident locations and permits special analysis to be made by the Highway Commission and other users of the system.

ALAS is able to develop high-accident rankings for road and street locations, on a statewide basis or for individual counties and cities, in terms of any one of three definitions of ranking significance, as specified by the particular user requesting such information. The three ranking bases are:

1. By aggregate number of traffic accidents;
2. By accident severity; and
3. By total cost of accidents.

Accident rankings can be obtained for (a) intersections, (b) nodes, or (c) links. This permits the Highway Commission or other users of the ALAS system to identify locations which require special study, analysis, and on-site observation, with the objective of selecting design or control measures for reducing accident frequency and/or severity. An example of the output format for high accident ranking is illustrated in Figure 1.

ALAS also has the capability for rapid retrieval of accident histories for specific locations. This capability includes assembling accident data for specific nodes, intersections, links, or node strings (sections of roadway).

The system user can simply specify the locational identification and the time interval of interest, and obtain from the system a listing of accidents and their characteristics which took place at the specified locations. An example of output for accident history of an intersection is shown in Figure 2.

Use of this system capability can be a natural extension of the identification of high-accident locations, through the ranking capability described above. Thus, once high-accident locations are identified, more detailed accident information can be obtained for study and analysis.

DATE - 01/31/74 PAGE 1
PROGRAM - P141-310

** HIGH ACCIDENT LOCATION LISTINGS **

HIGH ACCIDENT NODES — TOTAL PRIMARY SYSTEM — RANKED BY - NUMBER OF ACCIDENTS
COUNTY - DECATUR

TIME PERIOD -70/01 THRU 73/12

MINIMUM NUMBER OF ACCIDENTS AT EACH LOCATION
1 FATAL ACCIDENTS OR
1 PERSONAL INJURY ACCIDENTS OR
1 TOTAL ACCIDENTS

SEVERITY INDEX
12 FATAL ACCIDENT
3 PERSONAL INJURY ACCIDENT
1 PROPERTY DAMAGE ACCIDENT

VALUE LOSS INDEX
FATALITY = $ 52000
INJURY = $ 3100
PROP DAM ACC = ACTUAL OR $ 440

LOCATION	LITERAL DESCRIPTION	RNK	NO ACC	FAT ACC	INJ ACC	PDO ACC	NO KLD	NO INJ	TOTAL VALUE LOSS $	AVG VALUE LOSS $	TOT SEV	AVG ACC SEV	DAILY ENT VEH	ACC RATE PER MEV
27-112865	US-69 AT EX LOOP FROM I-35 SB	1	5	5	0	0	5	0	260350	52070	60	12.00		
27-128114	US-69 AT I-35 NB RAMPS	2	2	2	0	0	2	0	104140	52070	24	12.00		
27-128415	GRADE SEP I-35 & US-69	2	2	2	0	0	2	0	104140	52070	24	12.00		
27-220125	GRADE SEP I-35 & CO J-52	2	2	0	0	2	0	0	80	40	2	1.00		
27-000000	GRADE SEP I-35 & IA-2	3	1	1	0	0	1	0	52070	52070	12	12.00		
27-127710	I-35 NB AT EX RAMP TO US-69	3	1	1	0	0	1	0	52070	52070	12	12.00		
27-320148	GRADE SEP I-35 & CO R30	3	1	1	0	0	1	0	52000	52000	12	12.00		
27-323756	********************************	3	1	1	0	0	1	0	52000	52000	12	12.00		
27-329362	I-35 NB AT EX RAMP TO CO J-20	3	1	1	0	0	1	0	52000	52000	12	12.00		
27-420565	I-35 NB AT ENT RAMP FROM CO J-20	3	1	1	0	0	1	0	52000	52000	12	12.00		

SAMPLE HIGH ACCIDENT RANKING REPORT

ACCIDENT LOCATION AND ANALYSIS SYSTEM

STATE OF IOWA

```
REQUEST NO: 0011                                COUNTY: DECATUR                                     DATE: 01/31/74, PAGE   1
                                                                                                     PROGRAM: P141-344

  ACCIDENT HISTORY FOR INTERSECTION:
  27-112866

  TIME PERIOD-70/01 THRU 73/12                                  : V:  V T  :D T:  V A  :P I:  S C  : D D D :      DRIVER/VEHICLE       :
                                                                : E:  E Y  :I R:  E C  :T M:  U O  : R R R :         RELATED           :
                                                                : H   H P  :R A:  C T  : P:   R N  :       :       CONTRIBUTING        :
                                                                : :     E  : V:     I  :O A:  F D  : A S R :       CIRCUMSTANCES       :
: DATE-DAY  :TIME:ACC NO:KLD:INJ: $ DAM :LOC:ROUTE:DIST:LIGHT : N:         :O E:    O  :F C:       : G E E :
: ACC TYPE : ACC ANAL : RD CHAR :RD GEOM:RD/ENV REL CONTR CIRC: O:         :F L:    N  : T:        : E X S :
---------------------------------------------------------------------------------------------------------------------------------

  AT NODE: 27-112865 - US-69 AT EX LOOP FROM I-35 SB

:08-05-71/TH:0014:000131:K01:I00:$ 00070: 4 :0235 :+9.99:LGHTD:01:  CAR   : S :STRAIGH:RFR:DRY/DRY:20/M/77:EX SPEED LIM/ NO CONTROL :
:ON -FIX OB:BRDG/OVPAS: MIN RD  :INT/LEV: NONE APP              :

:08-05-71/TH:0014:000135:K01:I00:$ 00070: 4 :0235 :+9.99:LGHTD:01:  CAR   : S :STRAIGH:RFR:DRY/DRY:20/M/77:EX SPEED LIM/ NO CONTROL :
:ON -FIX OB:BRDG/OVPAS: MAJ RD  :CRV/HLC:FOG /CLOU              :

:08-05-71/TH:0014:000132:K01:I00:$ 00070: 4 :0235 :+9.99:LGHTD:01:  CAR   : S :STRAIGH:RFR:DRY/DRY:20/M/77:EX SPEED LIM/ NO CONTROL :
:ON -FIX OB:BRDG/OVPAS: ENT/MAJ :INT/LEV:NO RD DEF              :

:08-05-71/TH:0014:000133:K01:I00:$ 00070: 4 :0235 :+9.99:LGHTD:01:  CAR   : S :STRAIGH:RFR:DRY/DRY:20/M/77:EX SPEED LIM/ NO CONTROL :
:ON -FIX OB:BRDG/OVPAS: ENT/MAJ :INT/LEV:NO RD DEF              :

  BETWEEN: 27-112866 -                                  AND  113169

:05-20-70/SU:2025:000185:K00:I01:$ 00250: 5 :0035 :+ .08:DUSK :01:PICKUP :NW :R TURN :LCE:DRY/DRY:34/M/77: SPEED/COND /  DRNK-IMP  :
:ON -MTRCYC:           :   RAMP  :CRV/GRD: NONE APP              :

:05-20-70/SA:2025:000186:K00:I01:$ 00250: 5 :0035 :+ .08:DUSK :01:PICKUP :NW :R TURN :LCE:DRY/DRY:34/M/77: SPEED/COND /  DRNK-IMP  :
:ON -MTRCYC:           :   RAMP  :CRV/GRD:J UNKWCLER             :

:05-20-70/WE:2025:000184:K00:I01:$ 00050: 5 :0035 :+ .08:DUSK :01:PICKUP :NW :R TURN :LCE:DRY/DRY:34/M/77: SPEED/COND /  DRNK-IMP  :
:ON -NONCOL:OVERTURNED:    RAMP  :CRV/GRD: NONE APP              :

  AT NODE: 27-112866 -

:09-24-71/FR:1630:000181:K01:I03:$ 00460: 3 :0P30 :+9.99: DAY :01:  CAR   : N :STRAIGH:RCE:DRY/DRY:71/M/25:ROW-UNC INT /VO-TRES/CRPS:
:ON -MV-MV :ANG-BRSIDE:  AT INT :INT/LEV: NONE APP             :02:SCH BUS: W :STRAIGH:FR :DRY/DRY:45/M/39:VO-TRES/CRPS/ UNKNOWN    :

:10-02-70/FR:1634:000182:K00:I01:$ 00025: 3 :0995 :+9.99: DAY :01:MTRCYCL: N :STRAIGH:FR :DRY/DRY:20/M/52:  NONE APP  / UNKNOWN    :
:ON -MTRCYC:ANG-L TURN:  AT INT :INT/LEV: NONE APP             :02:  CAR   : S :L TURN :RFR:DRY/DRY:26/F/48:ROW-LFT TURN/ UNKNOWN    :

:07-17-70/FR:1220:000183:K00:I00:$ 00090: 3 :0995 :+9.99: DAY :01:  CAR   : W :SGN/SIG:LFR:DRY/DRY:36/F/65:  NONE APP  / UNKNOWN    :
:ON -MV-MV :ANG-BRSIDE:  AT INT :INT/LEV: NONE APP             :02:  CAR   : N :STRAIGH:FR :DRY/DRY:36/F/37:  NONE APP  / UNKNOWN    :
                                                               :03:  CAR   : E :L TURN :RCE:DRY/DRY:  / / :             /            :
```

SAMPLE ACCIDENT HISTORY REPORT

ACCIDENT LOCATION AND ANALYSIS SYSTEM

STATE OF IOWA

One of the most flexible capabilities of the system is its ability to process requests of a "generalized" nature, based on specific user needs. Thus, through use of the options provided, the user can request selection of accidents possessing particular attributes or combinations of attributes.

In addition to time-range and locational identification, up to three generic characteristics (or data attributes) of accidents can be specified for selection. An illustrative generalized request report is shown in Figure 3.

The wide range of accident information available to the system user through multiple options provided by the system is best illustrated symbolically in Table 1. All requests for accident data involve use of a series of codes for input into the system, to indicate the options selected. Following is an explanation of the meaning of symbols used in Table 1:

1. Two different types of data requests can be made. One request is for generalized data, the other a high-accident summary. Under either type of request, the range of dates to be covered in the accident records search must be specified.

2. Options contained within brackets [ ] represent alternatives that may be included or omitted, depending on requirements of the user.

```
REQUEST NO: 0008                                   COUNTY: DECATUR                                          DATE: 01/31/74, PAGE   1
                                                                                                             PROGRAM: P141-344

  DR1      19,20                          DRIVE AGE = 19 AND/OR 20.

 ACCIDENT HISTORY FOR NODE STRING
 27-0002   I-35  MP11 TO MP19

 TIME PERIOD-70/01 THRU 73/12                                      : V:  V T  :D T:  V A  :P I:  S C  : D D D :     DRIVER/VEHICLE     :
                                                                   : E:  E Y  :I R:  E C  :T M:  U O  : R R R :        RELATED         :
                                                                   : H   H P  :R A:  C T  :  P:  R N  :       :      CONTRIBUTING      :
                                                                   :  :    E  :  V:    I  :O A:  F D  : A S R :      CIRCUMSTANCES     :
: DATE-DAY  :TIME:ACC NO:KLD:INJ: $ DAM :LOC:ROUTE:DIST:LIGHT : N:            :O E:    O  :F C:       : G E E :
: ACC TYPE : ACC ANAL : RD CHAR :RD GEOM:RD/ENV REL CONTR CIRC: O:            :F L:    N  :  T:       : E X S :
-------------------------------------------------------------------------------------------------------------------------------------

 AT NODE: 27-320148 - GRADE SEP I-35 & CO R30

:07-31-72/MO:1625:000166:K01:I00:$ 00000: 1 :0035 :+9.99: DAY :01:ST-TRK : N :R TURN :UNK:DRY/DRY:19/M/40: INAT/DIST  / NO CONTROL :
:OFF-NONCOL:OVERTURNED:0 NON-INT:STR/LEV: NONE APP

 AT INTERSECTION: 27-321749 - GRADE SEP I-35 & IA-2

 AT NODE: 27-000000 -      NON-IDENTIFIABLE NODE

:08-05-71/TH:0014:000168:K01:I00:$ 00070: 4 :0235 :+9.99:LGHTD:01:  CAR  : S :STRAIGH:RFR:DRY/DRY:20/M/77:EX SPEED LIM/ NO CONTROL :
:ON -FIX OB:BRDG/OVPAS: MIN RD  :INT/LEV: NONE APP                   :
 --------------------

 AT NODE: 27-329362 - I-35 NB AT EX RAMP TO CO J-20

:07-15-72/MO:1625:000163:K01:I00:$ 00000: 1 :0035 :+9.99: DAY :01:ST-TRK : N :R TURN :UNK:WET/ICE:19/M/40:  NONE APP  / RAN SIGNAL :
:OFF-NONCOL:OVERTURNED:FARM/RES :STR/LEV: NONE APP /CLOU/FOG  :

 AT NODE: 27-420565 - I-35 NB AT ENT RAMP FROM CO J-

:07-15-72/MO:1625:000164:K01:I00:$ 00000: 1 :0035 :+9.99: DAY :01:ST-TRK : N :R TURN :UNK:WET/ICE:19/M/40:  NONE APP  / RAN SIGNAL :
:OFF-NONCOL:OVERTURNED:0 NON-INT:STR/LEV: NONE APP /CLOU/FOG  :
```

SUMMARY DATA:

# ACC	FAT ACC	INJ ACC	PDO ACC	# KLD	# INJ	TOTAL VALUE LOSS $	AVG VALUE LOSS $	TOTAL SEVER	AVG ACC SEVER	TRAFFIC VOL (DEV)	ACC RATE PER MEV
4	4	0	0	4	0	208,070	52,018	48	12.00		

VALUE LOSS INDEX: FATALITY - $52000, INJURY - $3100, PROPERTY DAMAGE - ACTUAL DAMAGE OR IF UNKNOWN - $440
SEVERITY INDEX: FATAL ACCIDENT - 12, PERSONAL INJURY ACCIDENT - 3, PROPERTY DAMAGE ONLY ACCIDENT - 1

SAMPLE GENERALIZED REPORT

ACCIDENT LOCATION AND ANALYSIS SYSTEM

STATE OF IOWA

Table 1

SYSTEM CAPABILITIES OF ALAS

Generalized Request:

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

High Accident Summary:

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

Data File Maintenance:

Node String Definitions	Create
Location Literal Descriptions	Delete
	Insert
	Change

3. Options contained within braces {} represent another choice of alternatives, only <u>one of which must be</u> chosen per request run.

4. Brackets within braces {[ ]} denote that <u>one or more</u> of the indicated options <u>must</u> be chosen, depending upon the programming requirements.

5. Braces within brackets [{}] denote that the entire step <u>may</u> be omitted if desired.

The Data File Maintenance items refer to a requirement that two ALAS files must be maintained and regularly updated--the Node String Definitions, and the Location Literal Descriptions. It is assumed that the Traffic and Safety Department of the Iowa State Highway Commission would bear this responsibility.

<u>Sample Request Types</u>

To illustrate the flexibility of ALAS in providing accident information, several hypothetical user requests in narrative form are shown. It is through these example requests that systems capabilities can best be demonstrated. It should be pointed out that the examples used are illustrative in nature and not intended to be exhaustive of all possible requests which the system is capable of processing. In the absence of real accident data, computer output for the following examples are not presented. For more detail on request procedures, the reader is referred to ALAS User's Manual.

Request for Statewide High Accident Ranking - It is desired to develop a high accident ranking for intersections on the Primary roadway system for the entire state, based on the aggregate number of accidents at each intersection for the last five years. The output format for this type request would be similar to that shown in Figure 1.

Request for Citywide High Accident Ranking - The City of Ames requests a high accident ranking for links on all streets within the city based on total value loss based on accident experience in 1973. The output format for this type request is again similar to that shown in Figure 1.

Request for Node String Accident History - It is desired to obtain the 1973 accident history on Interstate 35 and its interchanges in Story County. The output format for this request would be similar to that shown in Figure 2.

Request for Accident History at an Intersection - The user wishes to have detailed information on all accidents occurring during the last five years at the intersection of Fluer Drive and Army Post Road in Des Moines. The output format for this request is similar to that shown in Figure 2.

Request for Node String by Accident Type - It is desired to obtain accident experience for 1973 for accidents in which surface condition was a contributing cause on State Highway 92 in Pottawattamie County, between the cities of Treynor and Carson. The output format for this request is similar to that shown in Figure 3.

Request for Statewide Accidents with Specific Attributes - It is desired to list all head-on collisions in the state during 1973, which occurred at night and involved a drunken driver. The output format for this request is similar to that in Figure 3.

Chapter 3

ALAS And Its Subsystems

ALAS is a unique computer system designed to identify high accident locations, accident history by location, perform file maintenance, and generate special request summaries.

ANS COBOL has been used as the programming language for all ALAS routines. This language is almost self-documenting in nature and possesses versatility in input/output operations.

Sophisticated and scientific analysis programs as envisaged in subsequent development of ALAS (Chapter 4) can be written in other high-level language--such as PL/I or FORTRAN with Assembly Language, where random retrieval of data is involved. ALAS is designed to be compatible with any IBM computer operating under OS.

ALAS consists of 32 programs and three permanent tape files. These three permanent or master files are: Accident, Node String, and Location Literal.

The TRACIS transaction file is used as an input to ALAS on a periodic basis. In addition, various tape or disk files are generated temporarily to support different phases of ALAS runs.

ALAS makes use of the ISHC cataloged "County Name" and "City Name" files to produce literal rather than coded output.

ALAS Subsystems

ALAS is divided in three subsystems: Accident Data Subsystem (ADS), Location Literal Subsystem (LLS), and Node String Subsystem (NSS).

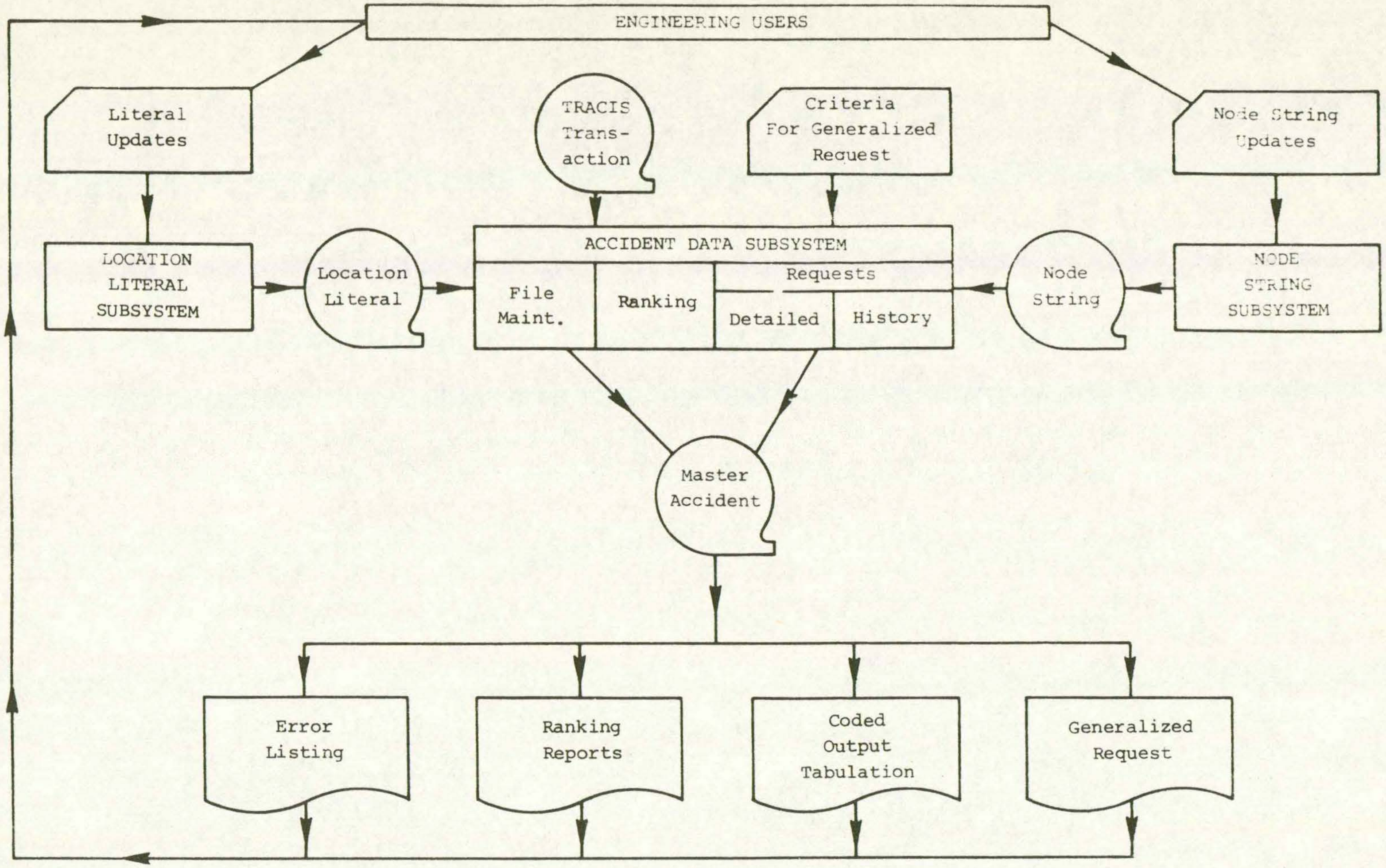
An overview of ALAS and its subsystem is shown in Figure 4. More detailed information on system logic and programming features is contained in the companion report, ALAS Data Processing Systems Manual. Each of these subsystems is discussed briefly in the remainder of this chapter.

Accident Data Subsystem

ADS is made up of 24 individual programs as indicated in Figure 5, and is the core of ALAS. It has report-generating as well as file maintenance capabilities.

ADS interfaces with Location Literal Subsystem and Node String Subsystem in the production of accident ranking, history, and coded accident reports. There are three components in ADS:

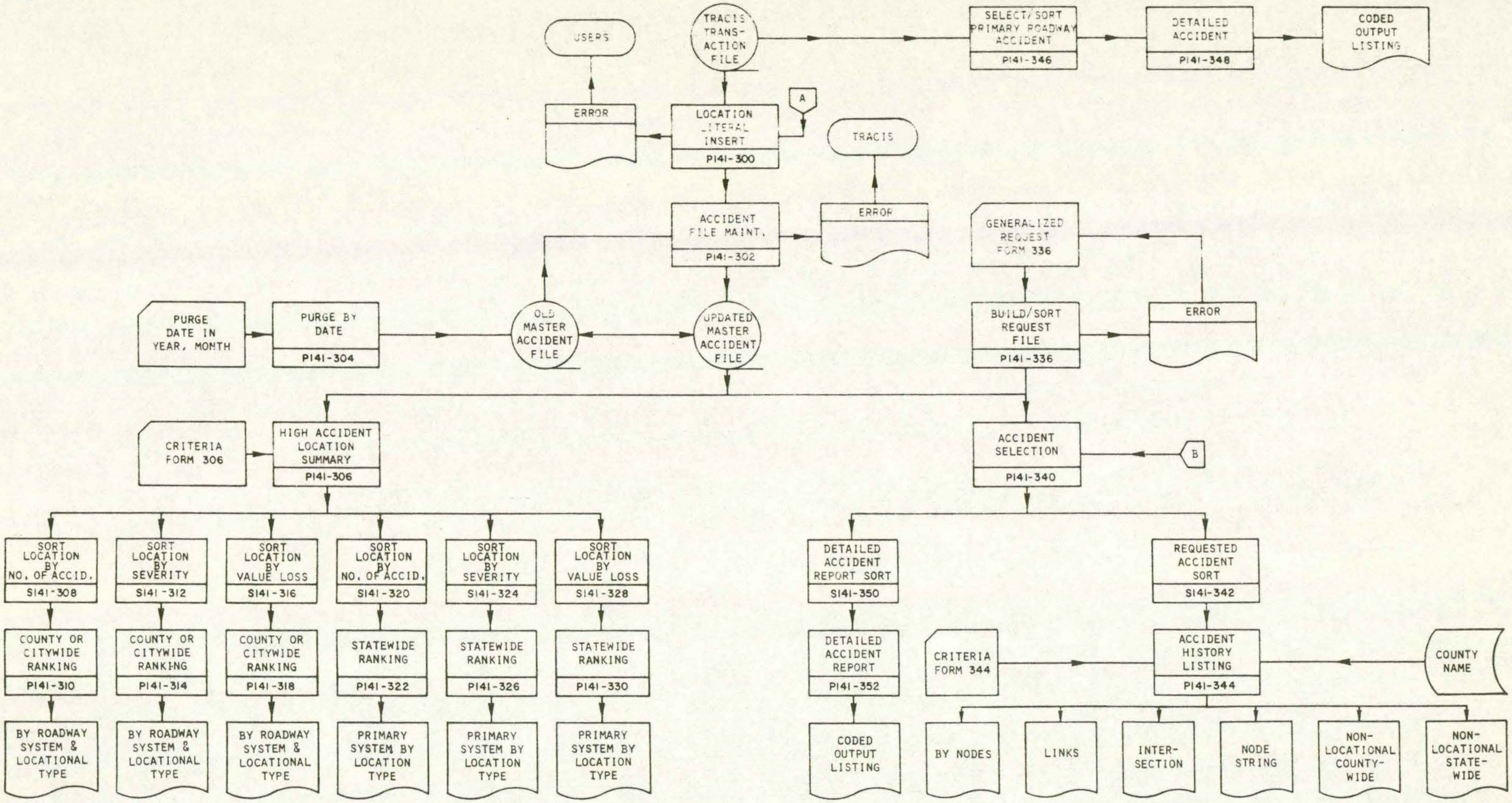
1. File maintenance, through which the location literals and TRACIS transaction file are inserted into the Master Accident File;



OVERVIEW OF ALAS

ACCIDENT LOCATION AND ANALYSIS SYSTEM

STATE OF IOWA



ACCIDENT DATA SUBSYSTEM FLOWCHART

ACCIDENT LOCATION AND ANALYSIS SYSTEM

STATE OF IOWA

2. High accident location, through which countywide, citywide, or statewide ranking by number of accidents, value loss, and severity may be compiled; and

3. Generalized request, in which an extensive repertoire of data retrieval processes are used in compiling accident history reports.

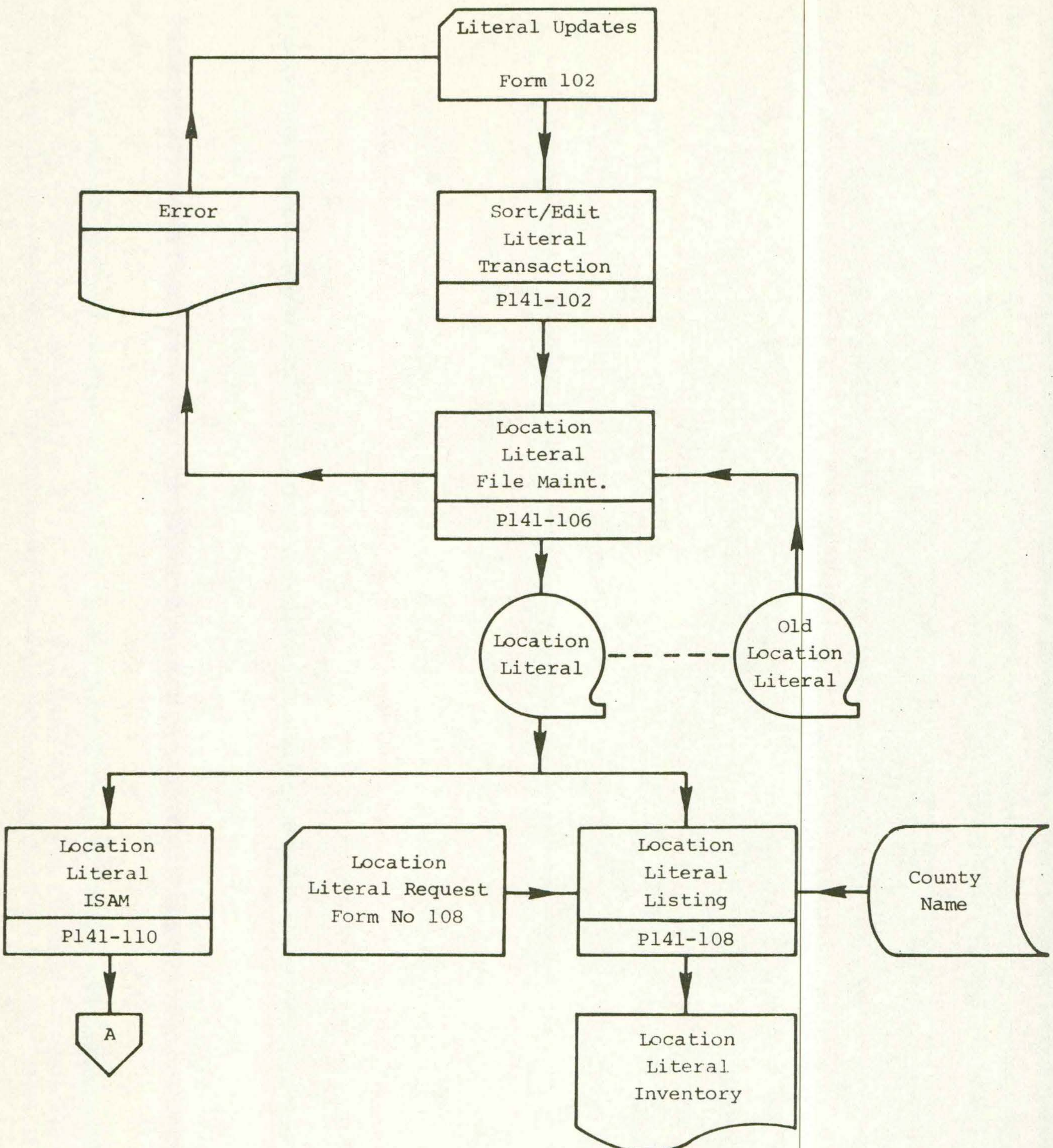
ADS is completely open-ended. Other special-purpose programs may be appended to enhance its analysis capabilities. In other words, programs can be added on to ADS without altering its basic structure.

Location Literal Subsystem

LLS is made up of four individual programs (Figure 6). LLS is responsible for storing locational descriptions, consisting of familiar highway designations and street names for easy identification for use in producing output reports.

Records (node description) may be deleted, added to, or changed in the file. Contingency checks on data are provided by LLS.

Controlled statistics on updated activities, such as number of records read, deleted, or changed, are printed out



LOCATION LITERAL SUBSYSTEM FLOWCHART

ACCIDENT LOCATION AND ANALYSIS SYSTEM

STATE OF IOWA

for record-keeping purposes. Random listing of the Location Literal File content for verification purposes is available.

LLS interfaces with ADS through file maintenance as shown in Figure 5, by inserting updated location literals to the Master Accident File.

Node String Subsystem

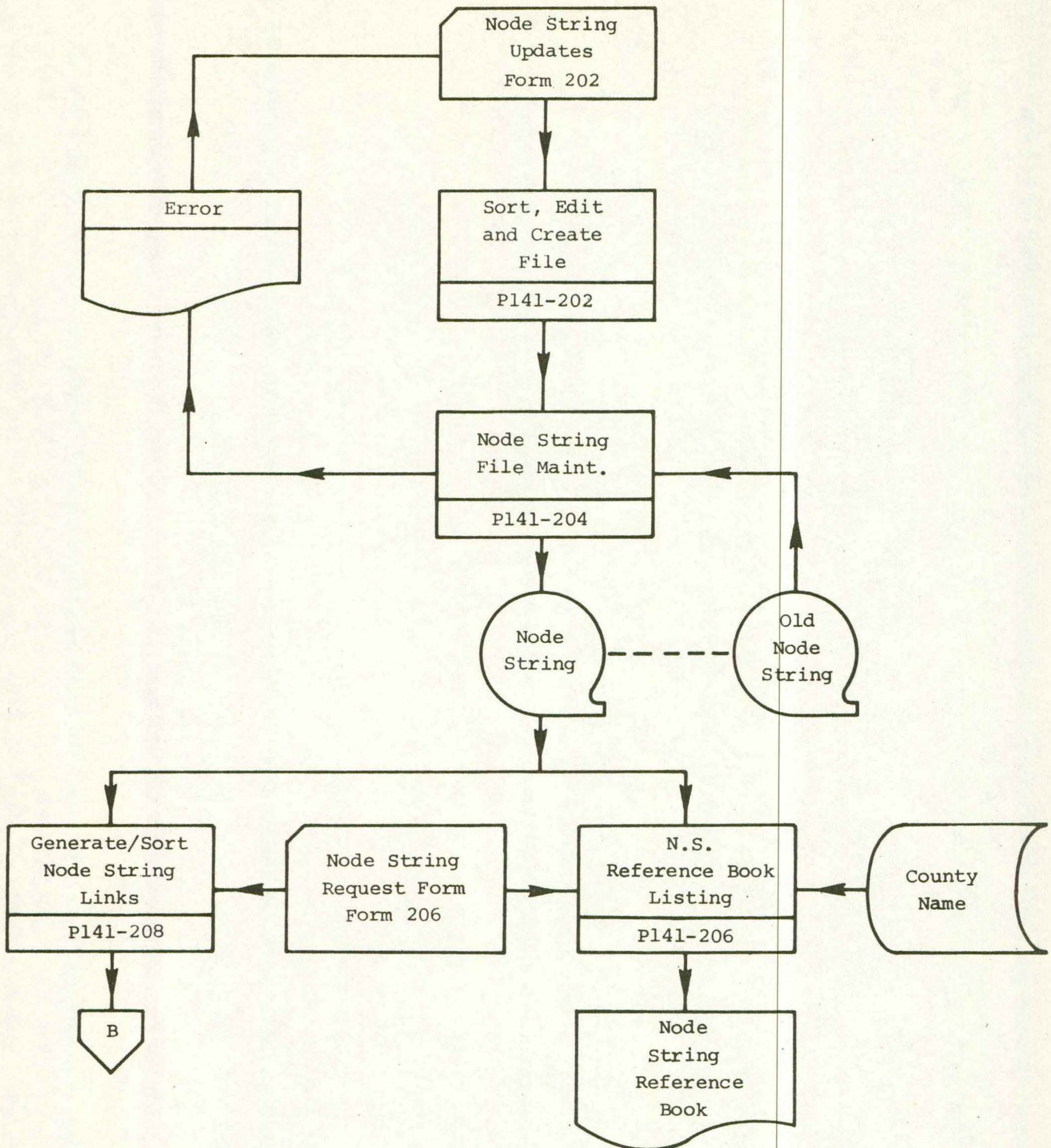
NSS is made up of four individual programs as shown in Figure 7. It contains programs having capabilities of:

1. Adding, modifying or deleting individual node strings;
2. Preparing a node string reference book; and
3. Selectively making available to ADS the links of any node string for analysis.

Contingency check and controlled statistics on updated records, similar to those of LLS, are offered. NSS interfaces with ADS through the latter's generalized request component as shown in Figure 5.

Systems Design and Configuration

ALAS as a computer package is relatively compact, yet powerful enough to satisfy a wide range of user needs as well as perform file maintenance.



NODE STRING SUBSYSTEM FLOWCHART

ACCIDENT LOCATION AND ANALYSIS SYSTEM

STATE OF IOWA

In recognition of future expansion of ALAS, a modular concept in programming has been adopted in the development of the ranking programs in ALAS. For example, the ranking variables can easily be changed to other variables such as accident rates, at a later date, without affecting the programming logic or the output format.

Execution of ALAS programs can be run under as small as 64K environment in terms of core size. A minimum machine configuration of one disk drive and three tape drives are required for operating ALAS.

Chapter 4

Future Development

The system developed in this work program is the first phase, or fundamental development, of a more comprehensive system, as reported in the developmental study.(1) The general system development concepts and a staged implementation program are contained in that report and are not repeated in detail here.

Considerations for continued development of ALAS fall into two general areas: statistical techniques in accident data analysis, and systems considerations for effective data management.

Statistical Considerations

In considering statistical analysis techniques to be employed in subsequent system expansion, it is of primary importance to keep in mind that ALAS is an engineering-oriented system. As such its objectives are to:

1. Determine those locations where traffic accidents are a critical problem.
2. Develop information and analyses which provide the engineer with an indication of accident causative factors.

(1) Accident Location and Accident Analysis Systems, Development Phase, op. cit.

3. Correlate accident experience to design elements and accident characteristics.

4. Provide engineers with a means for identifying preventive and corrective action to reduce accidents.

5. Provide a means for evaluating corrective measures.

Accident Rate Analysis - Accident rates are the most significant measure of accident experience, since they relate accident frequency with traffic exposure.

Accident rates normally are expressed in terms of accidents per million vehicle-miles on roadway sections, and accidents per million entering vehicles for intersections.

Use of accident rates provides a common denominator for comparison of accident experience between different locations, or against a critical rate, in identifying locations with abnormal accident experience. Therefore, an important objective in further system development is provision of capability to calculate accident rates.

To achieve this objective, a means must be provided for supplying lengths of roadway sections and traffic volumes--the two additional elements necessary in accident rate calculation. Acquisition of these data items are discussed under "Systems Considerations."

Control Limits - A quality control statistical technique for identifying high-accident locations was discussed in detail in the developmental report cited earlier. This technique permits examination of each location to determine whether accident experience is significantly different than that for all other similar locations.

Control limits are statistically established to define an abnormally high or low accident rate. The critical accident rate is determined by the following equation:

$$R_c = R_a + k\sqrt{\frac{R_a}{M}} - \frac{1}{2M}$$

Where: R_c = critical accident rate at a given location;

R_a = average accident rate for the corresponding roadway locational family;

M = exposure at the given location over the surveillance period; and

k = constant which corresponds to the desired level of confidence.

This control-limit method for identifying hazardous roadway locations conforms to the Policy and Procedure Memorandum (PPM) 21-16 of the Federal Highway Administration.(2)

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(2) Highway Safety Improvement Projects, Policy and Procedure Memorandum 21-16, Federal Highway Administration, U.S. Department of Transportation, March 7, 1969.

Before-and-After Studies - The control limit method also can be used in assessing the effectiveness of remedial actions in before-and-after studies. The accident rate following an improvement can be compared with prior accident experience to determine if a significant reduction has resulted.

This is expressed as follows:

$$R_s = R_b - k\sqrt{\frac{R_b}{M}} + \frac{1}{2M}$$

Where: R_s = accident rate which would indicate a significant accident rate reduction; and

R_b = accident rate before improvement

Other statistical methods may be applicable for evaluating before-and-after accident experience. One applicable model is the Poisson distribution, which is an approximation of the binomial density function when the probability of an event is low and the population in which it occurs is large.

A "liberal test" has been developed, using the "before" time period accident frequency or rate as the expected value of the Poisson distribution. The percentage reduction in accidents that is statistically significant can be calculated.

Another technique for before-and-after studies is the Chi-square test, or "conservative test." This test is preferable is a useful tool for the safety engineer in relating accident cause to safety control devices and such design elements as highway geometrics, with the hope of improving design and operational practices to minimize accident occurrences. This consideration should be an objective of subsequent ALAS development steps.

Systems Considerations

While statistical analysis techniques are important in subsequent development of ALAS, it is equally important that consideration be given to the interface and data management related to ISHC data files not directly a part of ALAS. Without information from these files, many of the proposed statistical analyses cannot be readily performed by data processing means.

Use of existing data files in accident analysis will be a part of further development of ALAS, to expand and enhance its accident analysis capability--particularly as related to development of accident rate analysis and correlation of accident experience with roadway features.

The following discussion outlines some of the considerations in developing inter-file linkage or a coordinated file management, to provide the needed data accessibility considered desirable for further development of ALAS.

Compatibility File - One means of attaining inter-file linkage is by development of a compatibility file. This file would be essentially a "go-between" of the Master Accident File and the ISHC Base Record File.

Complete development of this compatibility file for the three roadway systems in Iowa will be tedious and costly and require maintenance to reflect locational changes in the two files.

The concept of the compatibility file has been discussed in the developmental study report. In building the file, a technician must establish the continuity between accident location references and the roadway inventory sections; subdivide the accident link or roadway section if they do not correspond directly; ascertain the length of the roadway segment; and transfer the reference information pertaining to the addressing schemes, along with the section length, to a data coding sheet. The data then must be keypunched and verified.

Size of File Required. It has been estimated that about 250,000 accident analysis links will correspond to the 130,000 Iowa statewide roadway nodes. Additional links attributable to structure and railroad nodes will increase the total to approximately 300,000.

It may be assumed that each accident link must be subdivided once, on average, to establish compatibility with the section breaks of the roadway inventory. There are about 325,000 roadway inventory sections. Obviously, many will correspond directly, and others will have to be subdivided into several segments. It is estimated that 520,000 compatibility records will be needed to describe 520,000 roadway segments.

Base Record File - The premise upon which the compatibility file concept was derived is that the Base Record File was an established file and not subject to basic change.

During the Phase I program, the ISHC has indicated plans for making an intensive review of the Base Record File, which may open the possibility for using other means of obtaining compatibility between the Master Accident File and the Base Record File.

The following discussion explores some areas for consideration by the ISHC in making its review of the Base Record File.

Common Base of Reference - For interfacing of data files, a common base of reference is a highly desirable feature of all files which must be related.

With a common referencing system, interfacing of files becomes a straightforward operation. Without a common base of reference, or natural inter-file compatibility, interfacing becomes more involved, having to rely upon such techniques as development of compatibility files, or other manually developed indexing methods.

Roadway inventory files, commonly called the ISHC Base Records, are the primary files which would be utilized by ALAS.

The Base Record File is actually a set of inventory files containing roadway inventory information for primary, secondary and municipal road systems; structures for the three road systems; and a city/place file.

Coordinated File System. Along a highway, the points, or breaks, at which data characteristics change are recorded relative to one another. In data processing, information for each of these essentially homogeneous roadway sections is a record, and a collection of records is a file.

In a coordinated file system, all files are equal in rank or order and represent various classes of highway data such as roadway inventory, sufficiency rating, traffic accident, bridge, and maintenance, etc. The existing Iowa State Highway Commission roadway inventory is essentially a master file consisting of most of these data.

For inter-referral purposes, i.e., for one file to access one or more other files, it is necessary to tie the separate files together. This can be done by relating all data records to a common base of reference.

This base is known as a key, and is a related series of selected identifiers that uniquely define a record (hence, a location). Commonly used identifiers by many state highway departments are: control section, milepost, county number and highway number.

A record contains all the data associated with a particular key. In a direct-access file, each record is identified by a key and the file is resident in a direct access storage device, such as a disk pack.

ISHC has excellent direct access storage facility, with two IBM 3330 disk drives. For direct access using a disk pack, each record has a discrete location and a unique address. Records are stored in such a way that any record can be accessed directly or indexed sequentially, instead of sequentially starting from the beginning, as in files on magnetic tapes. This concept of storing and retrieving data is very adaptable to a coordinated information retrieval system.

Desirable Features of a Key. In development of a data retrieval system, it is logical that a "best" record control key be sought. The attributes of such a key are that it:

1. Is absolutely unique for each section, or a point on the highway;
2. Is simple to use both in field and in office;
3. Is based on some logical progression or sequence;
4. Is a relatively short symbol (code);
5. Is a meaningful symbol without extensive reference documents (control section maps, etc.);
6. Is readily compensating for route changes; and
7. Involves minimum conversion from existing reference systems.

In a national survey of state highway department data banks,(3) the following combinations of identifiers were found to be in common use:

1. Control section, milepost.
2. County, route sequence.
3. Project number.
4. Federal aid system, route number, milepost.

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(3) Yu, F.C.F., "Design of a Computer-based Information Retrieval System for Highway Planning," M.Sc. Thesis, Montana State University, 1970.

5. County, route number, section, log mile.

6. Distance and direction from a given reference point.

7. System, district, highway number, agreement number, mileage.

8. Road number, section, coordinates.

<u>File Organization</u>. In order that information can be randomly sorted and retrieved, a record has to be keyed internally. In an indexed sequential access method (ISAM) the records in a file are organized on the basis of a collating sequence determined by the keys resident on each record.

Currently ISHC's IBM 370/145 supports ISAM. An ISAM file exists in space allocated in a direct-access storage device as the prime area, the index area, and the overflow area.

In the prime area, records are written when the file is created or organized, and the keys are imbedded in the records. The index gives the location of a record, and the index area is created and written by the operating system (OS) of the computer when the file is created or reorganized.

The overflow area provides additional storage for use when the prime area becomes full. The latter feature is particularly useful when there is extensive updating activity.

The three roadway inventory systems (primary, secondary, and municipal) currently used by the Iowa State Highway Commission have several identifiers in common. These identifiers are:

1. County
2. Highway System Designation
3. Route or Street Number
4. Township (Tier)
5. Range
6. Section

If a method could be developed to utilize these identifiers common to all three systems to interface with the ALAS locational basis, then a common base of reference would virtually exist.

The coordinate aspects of the public land survey method for subdivision of the State of Iowa (e.g. township, range, section) and quasi-coordinate nature of node assignments could possibly be used in developing a base of reference. It may be possible to develop an algorithm which correlates information from the Base Record File and the Master Accident File on a common base of reference.

For example, a direct correlation exists between the township, range, section identification and the node assignment in ALAS. The six-digit node assignment system is basically coordinate in nature, with the township designation (first and second digits) and relative location in the township (third through sixth digits) of the node number corresponding approximately to X and Y offsets of a coordinate system. Roadway section lengths (Z) could be approximated using the relationship $Z = \sqrt{(X_1 - X_2)^2 + (Y_1 - Y_2)^2}$

Obviously, this is a matter which would require additional study and in-depth review of locational elements of the Base Record File and level of accuracy required. Such an approach would be more problematic in incorporated areas where there is more intensity of development of roads and streets, and facility identification is more difficult.

Separate Information File - One means of providing the capability for ALAS to calculate accident rates is by creation of a new "stand-alone" file which would contain link lengths (distance between nodes) and traffic volumes (ADT). These two parameters coupled with accident frequency, are required in calculating accident rate.

Such a file would be created by coding node identifications, link lengths, and traffic volumes. As a stand-alone file, it would require periodic updating independent of other data file updating which the ISHC routinely conducts for the Base Record File.

Use of such a stand-alone file would have limited value in terms of the long-range objectives of ALAS. Although providing the capability to express accident experience in terms of accident rates, it would not provide inter-file linkage with the Base Record File for access of ALAS to roadway inventory information.

Future Implementation

An implementation program for ALAS was presented in the Developmental Phase report. It was pointed out that implementation of the total Accident Location and Analysis System rests with two agencies of the State of Iowa: TRACIS and the Iowa State Highway Commission. The responsibilities of these two agencies are discussed with reference to ALAS future development.

TRACIS Responsibility - TRACIS is to be responsible for the processing of accident reports, coding of locational data as well as accident data elements, entering accident reports into the Accident Case File, aggregating all reports for each accident, checking and resolving information conflicts, and entering the records into the Traffic Accident File. Finally, TRACIS would supply periodically, an Accident Transaction File to the ISHC for updating of the ALAS Master Accident File.

ISHC Responsibility - Further development of ALAS is the responsibility of the ISHC. The Phase I program has developed a basic accident analysis system which has powerful capabilities in determining high accident locations, furnishing accident data for specific locations, or with specific data attributes.

ALAS, as now configured, is the foundation upon which a more comprehensive and powerful system can be developed. Future implementation will build upon the system as developed in the Phase I program.

Implementation Objectives - There are two basic objectives for subsequent implementation of ALAS. The first objective is to develop the interface mechanism between ALAS and the ISHC Base Record File to permit access to data needed for expansion of ALAS capability.

The second objective is aimed at further development of the analysis capabilities of ALAS particularly as related to incorporation of information from the Base Record File. One of the most important capabilities to be gained will be the ability to compute accident rates. Statistical analysis techniques, as previously discussed, would be incorporated into ALAS.

Recommendations

Future development of ALAS is seen as an ongoing process. Initial effort should be focused upon developing the inter-file linkage between ALAS and the ISHC Base Record. It is highly desirable to have an analysis package using statistical techniques to complement ALAS. Ideally, this statistical package should be available to analyze accident data as soon as accident data are available in sufficient quantity for such analyses. In accordance with considerations for future development as discussed in this chapter, it is recommended that:

1. An in-depth feasibility study be conducted to investigate the inter-face mechanism between ALAS and ISHC Base Record File of the following;
   a. Compatibility file, and
   b. Common base of reference.
2. The findings of the feasibility study be implemented by appropriate system design and programming.
3. Development of statistical programs for ALAS analysis package be implemented simultaneously.

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