HR-1053

Review Of State Comprehensive Computerized Highway Information Systems

Research, Development, and Technology

Turner-Fairbank Highway Research Center
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U.S. Department of Transportation

Federal Highway Administration

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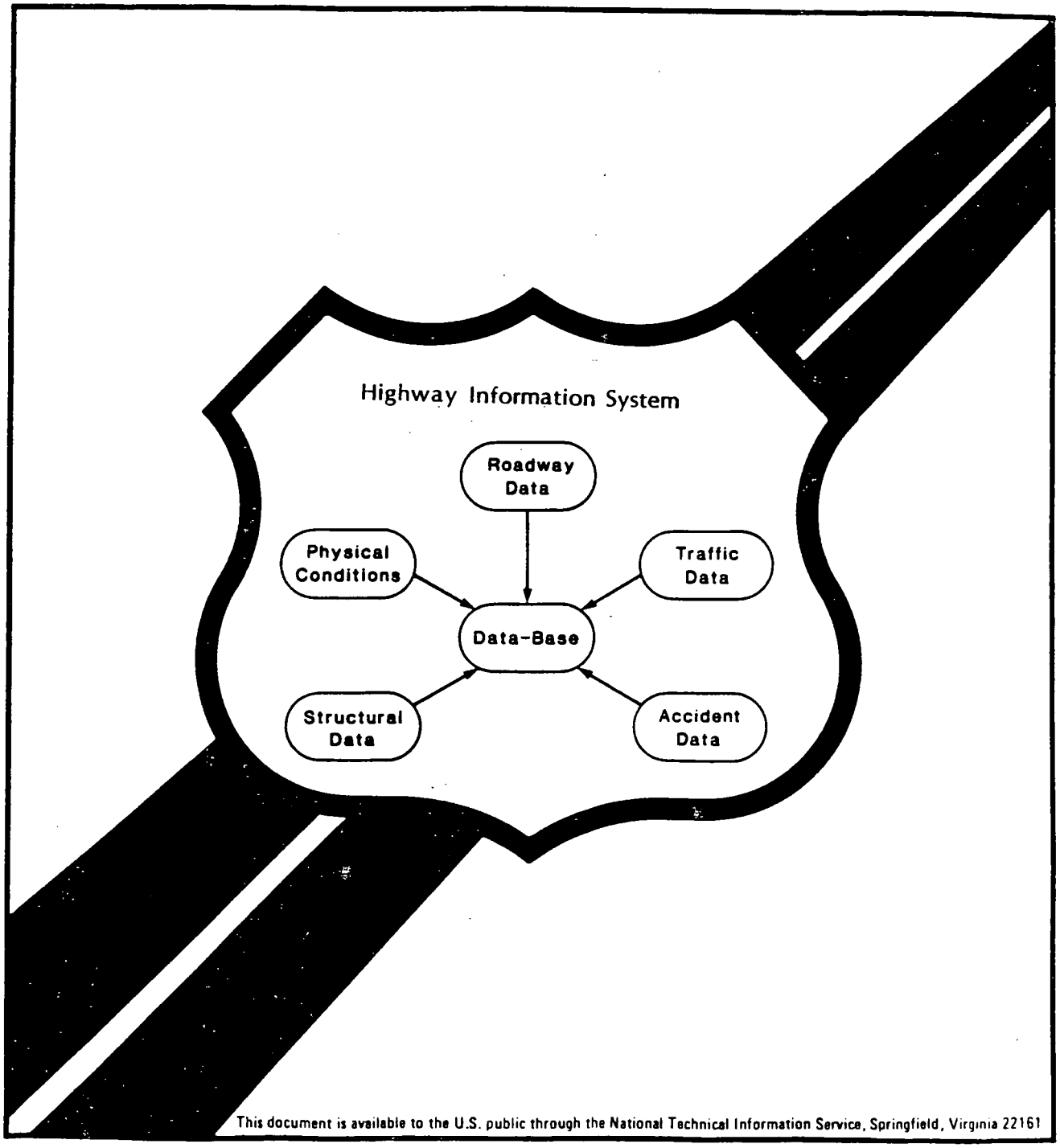


FOREWORD

This technology sharing report documents the implementation activity of computer based highway information systems by drawing upon the state of the practice from nine State highway agencies.

A computer based highway information system (i.e., file linkage) has the following three components.

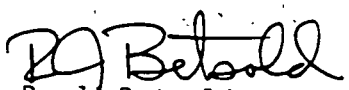
1. A reference system that allows data contained in each file of the system to be referenced to a common point.

2. A data collection system with all data files computerized and linked to the reference system.

3. A system with an ability to manipulate the data files within the system to develop desired analyses and appropriate reports.

Therefore, linked highway data files have a large potential benefit to State highway agencies. File linkage can be used to provide accident rates for various highway features, safety appurtenances, and roadway geometrics. Through computer linked files, decision makers are able to examine various roadway features and their accident relationships. Knowing these relationships, the decision makers can then determine the appropriate highway improvement.

Copies of the report are available from the National Technical Information Services, 5285 Port Royal Road, Springfield, Virginia (703) 487-4690.



R. J. Betsold
Director, Office of Implementation

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16. Abstract

This report presents an overview of where the computerized highway information system is now, and its status as a planning and programming tool for state highway agencies. A computerized highway information system is simply a computer linked system which can be used by many divisions of a transportation agency to obtain information to meet data reporting, analyses or other informational needs. The description of the highway information system includes: current use and status, applications, organization and system development, benefits and problems.

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METRIC (SI*) CONVERSION FACTORS

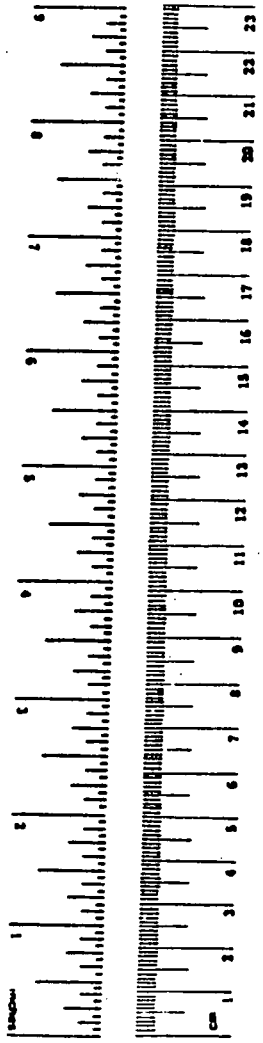
APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
AREA				
in²	square inches	645.2	millimetres squared	mm²
ft²	square feet	0.0929	metres squared	m²
yd²	square yards	0.836	metres squared	m²
mi²	square miles	2.59	kilometres squared	km²
ac	acres	0.395	hectares	ha
MASS (weight)				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
VOLUME				
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft³	cubic feet	0.0328	metres cubed	m³
yd³	cubic yards	0.0765	metres cubed	m³

NOTE: Volumes greater than 1000 L shall be shown in m³.

TEMPERATURE (exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
AREA				
mm²	millimetres squared	0.0016	square inches	in²
m²	metres squared	10.764	square feet	ft²
km²	kilometres squared	0.39	square miles	mi²
ha	hectores (10 000 m²)	2.53	acres	ac
MASS (weight)				
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T
VOLUME				
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m³	metres cubed	35.315	cubic feet	ft³
m³	metres cubed	1.308	cubic yards	yd³

TEMPERATURE (exact)

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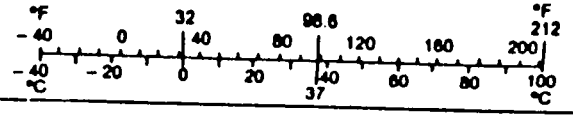

These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements

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Chapter 1
Program Definitions

This report describes a comprehensive computerized highway information system including;

- o current uses and status
- o applications
- o organization and system development
- o benefits and problems.

A computerized highway information sytem is simply a computer-linked system which can be used by many divisions of a transportation agency to obtain information to meet data reporting, analyses or other informational needs. Historically data has most often been kept in separate files by each division and organized for their individual needs, and was usually not readily available to other sections. In addition, data was unavailable to all but the most expert of computer analysts. This lack of integration and access has caused redundancy in data entry, excessive user efforts in extracting the information, limited flexibility of output, and produced highly cost-inefficient operations.

In the late 1970's and early 1980's, field equipment technology, planning techniques, engineering methods and maintenance management have evolved: more complex problems and solutions require more and different data and more sophisticated analyses. At the same time, limited funding and staff cutbacks have reduced the manpower available for data collection and analysis. As a result, the situation prompted State agencies to look to a computerized highway system as an answer to their data needs and analysis problems.

A computer linkage system allows ready access to many individual data files to create an efficient management system which interfaces all data files. This is made possible by merging all information data files into a common shared data-base, or unified data-base.

The two characteristics of such a comprehensive computerized highway information system are:

- o It is a completely automated computer system, thereby eliminating the need for prolonged hand calculations.
- o There is a common referencing system.

1.1 Completely Automated Computer Based System

All elements of the file linkage system should be automated. There must be provisions for automated access of files; that is, all files must be a part of computerized data base.

The significance of a computer based system is attributed to the ease of access and of linking the individual files, reducing duplication by having one set of information used by many, and an increased planning ability. Large amounts of information can be stored, easily retrieved and updated through use of the computer. Computer programs can be written to accomodate a large number of data files and to derive relationships between files.

The computer based information system must contain a mechanism for timely update or modification of the data files. This is often accomplished by including an edit capability, usually with a quality control procedure. This feature allows selective access to data files for edit purposes.

1.2 Common Reference System

The capability of the computer system to derive relationships between files can only be accomplished when the files have a common referencing system. When data files are maintained sepa-

rately by different departments, the data is usually referenced based on the needs of the data gatherer.

Thus, each division of a transportation agency may have its own structure for referencing information resulting in a mix of reference systems and incompatibility among the data. Simply put, one location may have five different identifications, based upon which referencing system is being used:

1. Milepoint - referencing by noting the value of the nearest milepost along a roadway. These delineators are usually spaced at a distance of one mile (1.6 km), but often at 1/10 or 1/20 of a mile (.16 or .8 km).

2. Reference Marker - referencing by noting the identification number of a post along the roadway. It is an artificial naming of points, not necessarily having any quantitative relationship to each other.

3. Link-Node - referencing of the distance (link) between two points (nodes). Nodes are similar to reference markers for they do not necessarily have any quantitative relationship to each other.

4. Coordinate - referencing through identification of X and Y values on artificial graph set atop a specific roadway.

5. Paper Reference - referencing through verbal identification of a point.

Since technical data is rarely unique to a single division in a transportation agency and therefore often obtained by several divisions, the data is often duplicated uselessly, or may be available but not recognized as such due to different referencing.

To attain a unified data-base usable by all divisions, the individual files in the system must be indexed by a common reference system. All records in every file must contain a field that can be directly related, or related through an equivalence file, to records in other files. By using the common reference system all elements in every file can be compared and related for analysis.

A number of states have found that the roadway milepoint and the link-mode reference systems best satisfy their data linking needs. For example, the Iowa Department of Transportation (DOT) found the milepoint code most feasible for their accident data system. This involved assigning milepoints to each node (point) along the route. Milepoints for structures and many intersections were scaled from maps.

On the other hand, Illinois found the link-node system best for their Comprehensive Computerized Safety Recordkeeping System (CCSRS). This referencing system was made standard throughout their Department of Transportation; all other necessary files would have to be interfaced with the link-node system.

1.3 Capabilities

This section presents the two most important capabilities of an integrated file linkage system:

- o File Linkage
- o Report Generation

File Linkage

Having integrated linked highway data allows a variety of analyses that make use of different combinations of data necessary for decision-making purposes. Figure 1 presents the typical data files which compose the highway database and are most frequently linked. This linking capability is best demonstrated by citing actual examples from those States' which have linked inter-

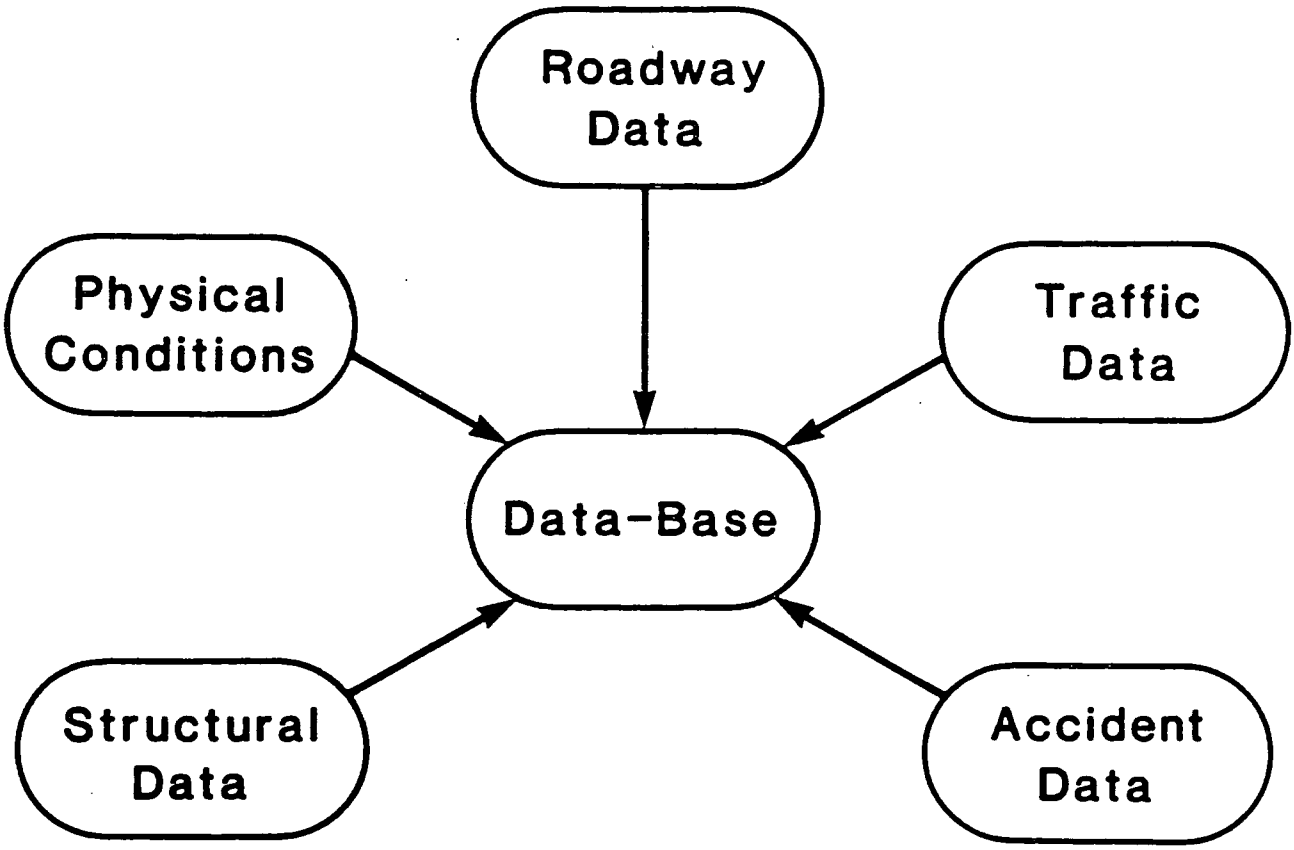


Figure 1
Typical Highway Data-Base Content.

related data from different sections and disciplines:

- Utah is currently linking Accident and Geographic files to produce reports for use in the analysis of accidents as a function of weather, pavement quality, and traffic volume.

- Iowa is linking their Accident Data File with Road/Structure files to generate reports on Accident Location.

- Colorado currently uses links to Accounting, Accident and Projects files to develop the Annual HPMS report.

- Kansas links Accident and Geometrics files in order to generate various Statistical Analyses Reports.

- Idaho merges data from Roadway, Accident and Geometric files in order to produce a Statewide Average Accident Report and Spot High Accident Location Report.

- Illinois links Accident and Roadway files in order to produce numerous descriptive and statistical reports concerning the location of accidi-dents and accident rates.

Report Generation

The information and analyses made possible through the integrated file linkage system are best utilized when presented in an organized manner. It is possible to program the system to produce both technical and management reports. In addition, many systems contain a special report generating function to enable creation of reports on very specific subjects.

Management Reports - The process of integrated decision-making is very essential for making optimum highway investment decisions. Regardless of whether the organization is centralized or decentralized, the creation of a unified data-base by file linkage will enable retrieval of needed information by users. Reports can be quickly and easily generated for needs of top level management for effective decision-making purposes. For example, reports ranking capital projects enable decision-makers to make wiser investments based on a priority basis.

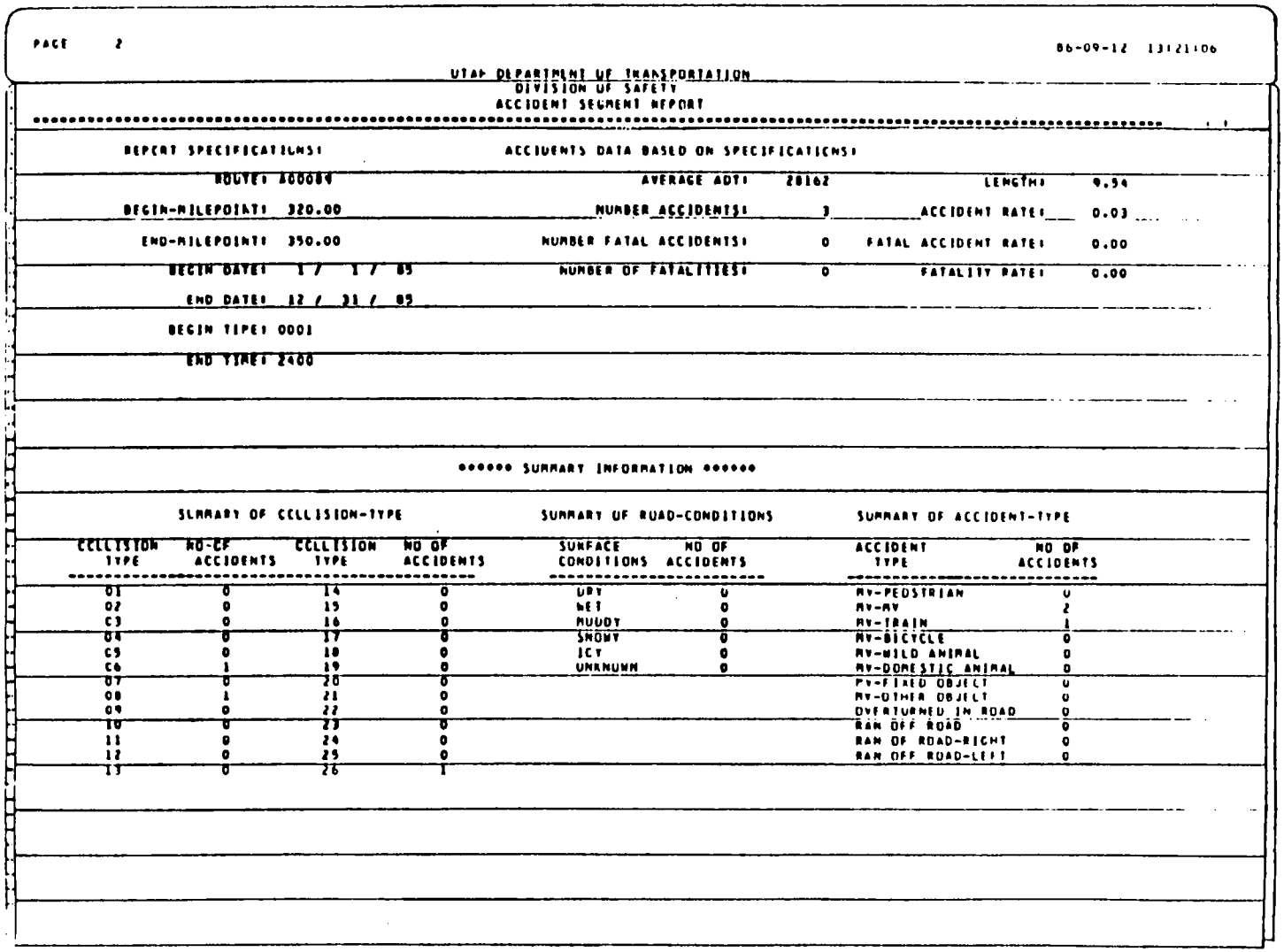
Technical Reports - All State transportation agencies are bound to report a variety of data and statistics either to other divisions within their agency or to other regional and federal agencies. There are three types of technical reports: data listing, data comparison and statistical evaluations.

Reporting individual combined data files is made easier through the integrated data-base by enabling the user to obtain desired files quickly for specific projects or for standard data reports.

The file linkage system also enables users to write programs to produce reports which interrelate data elements, and to acquire information through a pre-programmed data comparison function. This pre-programmed output eliminates the task of manual data integration required with independent files.

Statistical reports usually involve the testing of the gathered data for accuracy. An example of an FHWA Statistic report is the traffic and truck data reports from the Traffic Monitoring Guide.

Figure 2 presents an example of a road segment accident report. The accident data is listed for the specified roadway segment, including accident



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UTAH DEPARTMENT OF TRANSPORTATION
DIVISION OF SAFETY
ACCIDENT SEGMENT REPORT

REPORT SPECIFICATIONS: ACCIDENTS DATA BASED ON SPECIFICATIONS:

ROUTE:	A00084	AVERAGE ADT:	28162	LENGTH:	9.54
BEGIN-MILEPOINT:	320.00	NUMBER ACCIDENTS:	3	ACCIDENT RATE:	0.03
END-MILEPOINT:	350.00	NUMBER FATAL ACCIDENTS:	0	FATAL ACCIDENT RATE:	0.00
BEGIN DATE:	1 / 1 / 85	NUMBER OF FATALITIES:	0	FATALITY RATE:	0.00
END DATE:	12 / 31 / 85				
BEGIN TIME:	0001				
END TIME:	2400				

****** SUMMARY INFORMATION ******

SUMMARY OF COLLISION-TYPE

COLLISION TYPE	NO OF ACCIDENTS	COLLISION TYPE	NO OF ACCIDENTS
01	0	14	0
02	0	15	0
03	0	16	0
04	0	17	0
05	0	18	0
06	1	19	0
07	0	20	0
08	1	21	0
09	0	22	0
10	0	23	0
11	0	24	0
12	0	25	0
13	0	26	1

SUMMARY OF ROAD-CONDITIONS

SURFACE CONDITIONS	NO OF ACCIDENTS
DRY	0
WET	0
MUDDY	0
SNOWY	0
ICY	0
UNKNOWN	0

SUMMARY OF ACCIDENT-TYPE

ACCIDENT TYPE	NO OF ACCIDENTS
MV-PEDESTRIAN	0
MV-MV	2
MV-TRAIN	1
MV-BICYCLE	0
MV-WILD ANIMAL	0
MV-DOMESTIC ANIMAL	0
MV-FIXED OBJECT	0
MV-OTHER OBJECT	0
OVERTURNED IN ROAD	0
RAN OFF ROAD	0
RAN OF ROAD-RIGHT	0
RAN OFF ROAD-LEFT	0

Figure 2
Sample of Technical Report.

number and type, rates, roadway conditions and collision type.

1.4 Data Maintenance

Once the unified database is completed, the data must be reviewed and updated periodically. A computerized system provides automated maintenance of the files. That is, the files are easy to access for update and archival purposes. Because a number of divisions often collect the same data, the task of archiving and updating each data element must be assigned to a single division within the transportation agency. This promotes the efficient use of staff. Only one user collects the data element, while a number of users are able to access and utilize it. The responsiblity of updating particular data elements by only one division ensures that the information is kept up-to-date and accurate.

The design of the edit function incorporates a quality control technique to restrict access for modification data only to certain user. Although all divisions have access for viewing and report generating capabilities, restrictions are placed on access for revision. Passwords are often required to access the system and screens are designed for specific users.

The archiving function is usually appropriated to the collectors of new data. Old data is filed away, but if the need arises the data can be temporarily reloaded. As part of the archiving process, some summary statistics are left on-line for the detailed data being archived. These summary statistics are loaded onto a summary file.

1.5. Description of Existing File Linkage Systems

A meeting of file linkage system users was held in Salt Lake City, Utah, September 23 to 24, 1986. Presentations were made of the status of these programs by the following states:

- o New York
- o Idaho
- o Kansas
- o Colorado
- o Washington
- o Kentucky
- o Iowa
- o Illinois
- o Alaska
- o Utah

In general, these systems consist of a data-base management function which links data from several files, a report function which produces description reports and tables, and a statistical function which yields comparitive statistics. In many cases, more than one function is performed by a single module or program. The following will be a brief description of the programs of those states with active File Linkage programs.

Utah uses ADABAS for the data-base management function and NATURAL, a fourth generation programming language, to generate programs that link files and produce technical and management reports. Utah also has developed a menu-driven program which allows a user to dynamically create NATURAL programs that will produce customized reports. Utah uses SAS for statistical reports.

Iowa's file-linkage system ALAS until recently consisted of a program written in COBOL to link files and a series of SAS programs used for report generation and statistics. Recently, FOCUS report generating programs have been implemented in order to increase ease and flexibility.

Washington is contracting a consultant to write a system called TRIPS in the COBOL programming language to maintain, link and create reports from their files. By the time TRIPS is in

place, users will also have the capability of generating ad-hoc speciality programs using SUPERNATURAL or other fourth generation languages.

Alaska's system HAS will use ADABAS for data-base management with NATURAL to link files and generate reports. A user-friendly front-end was developed to expedite batch processing and routing of reports. Statistical Analysis will be done with SAS.

Colorado developed a system called CORIS which uses ADABAS for data-base management and NATURAL as the programming language for linking files and generating reports. All information in CORIS can be transferred to IBM-PC equipment. The data is in d-BASE III PLUS format that allows access similar to the NATURAL language on the mainframe.

Kansas has developed the SAGE system which uses ROSCOE, a proprietary on-line program maintenace and development system which includes an interactive programming language called the Roscoe Programming Facility (RPF). SAS is used for Statistical Analysis.

Idaho's system is tape-based. This means that the files are sequential tape files and that data elements from one file are merged to another file. Once all the information is assembled in this manner, SAS is used to produce reports and for Statistical Analysis.

Illinois' system was developed using the procedural programming languages FORTRAN and COBOL to maintain and link data and format reports. Provision will also be made to allow more detailed reports to be proposed using SAS or SPSS

Chapter 2
Program Description

This section describes the organizational structure required to support a highway linkage program and the steps required to achieve implementation.

A review of a number of State Department of Transportation reports on their involvement and development of file linkage systems, as presented at the FHWA Data Management Forum at Salt Lake City found that the organization, structure, database and system development is relatively similiar. Differences primarily resulted from the size of the transportation agency and the degree of detail required for their file linkage program. Therefore, this section represents a "generic" example of organization structure and steps needed to develop a computerized highway linkage program.

2.1 Organizational Structure

Figure 3 presents a general project organization structure which ensures that:

- o top level management of the agency is involved in program.
- o general direction is given to technical staff.
- o all necessary data elements are included.
- o data is filed in usable form.
- o needs of all divisions are met.
- o project is completed within the estimated budget and schedule.

Executive Committee

This top level management committee provides perspective to the highway program, and emphasizes the management support that is necessary for the success of the progam. It is responsible for the overall direction of the program and ensures that program actions affecting policy are reviewed and approved prior to implementation. This committee generally consists of the Department of Transportation director, assistant director, comptroller, engineers for planning and development

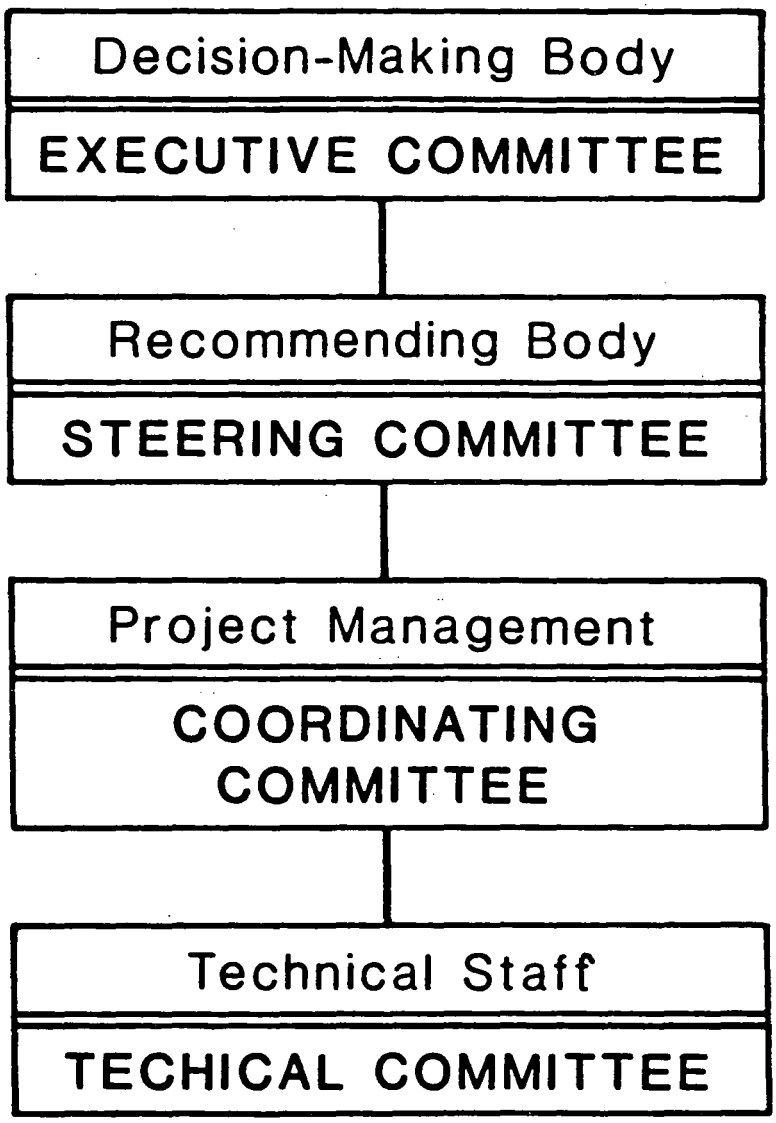

Figure 3
Typical Project Organization.

and the manager of Information Systems.

Steering Committee

The function of this committee is to provide input to assure that the program is responsive to user needs throughout the transportation agency, and not just to the people responsible for data collection and maintenance.

They represent the consumers of the data by providing direction to the project staff and recommending actions to the Executive Commitee. Members of the Steering Committee include representatives of the local FHWA Division Office, various division managers (i.e. design, management services, maintenance, program development) and data processors.

Coordinating Committee

The Coordinating Committee is responsible for overall project control. It monitors progress and develops schedules and detailed work tasks to keep the project on track. This includes identifying problems and implementing solutions. Often only a project manager is chosen for this function. If the State transportation agency decides to hire a consultant to help evaluate the existing situation and prepare the project program, the project manager then manages and directs the consultant's progress and ensures that the needs of the agency are fulfilled. The process involved in deciding whether or not to employ the services of a consultant is decribed in section 2.2, System Development.

Technical Committee

The Technical Committee represents the system users. It has the responsibility for collection and maintenance of the date elements which comprise the program and acts as the program's technical sounding board. Members of this committee include the data gatherers from each division and data processors.

2.2 System Development

Figure 4 presents an overview of procedures involved in basic system development. The procedure involves a number of steps, from project initiation to program evaluation, whose action results are related. Each step necessary for development of a usable highway information system is described below.

I - Study

In this phase the existing system and database is reviewed. Needs, objectives and desires are defined through the interaction among the many divisions in the transportation agency. It is essentially a feasibility study to determine whether or not a computerized highway information system should be developed, how, and what its benefits and costs might be.

The first step in this phase is to determine who will do the planning of the information sytems. A number of States have found that their transportation agency did not have the resources necessary to undertake a project of this magnitude and required analysis help from outside the agency. Both Washington and New York found that they did not have the available staff to accomplish what was needed, and therefore prepared a Request for Proposal (RFP) that asked consultants to evaluate and prepare designs. The transportation agency's RFP generally asks for assistance in the following areas:

- Systems analysis of existing systems, and recommendations for a new system to meet projected needs.
- Design, development, implementation, and testing and training of the recommended data base.

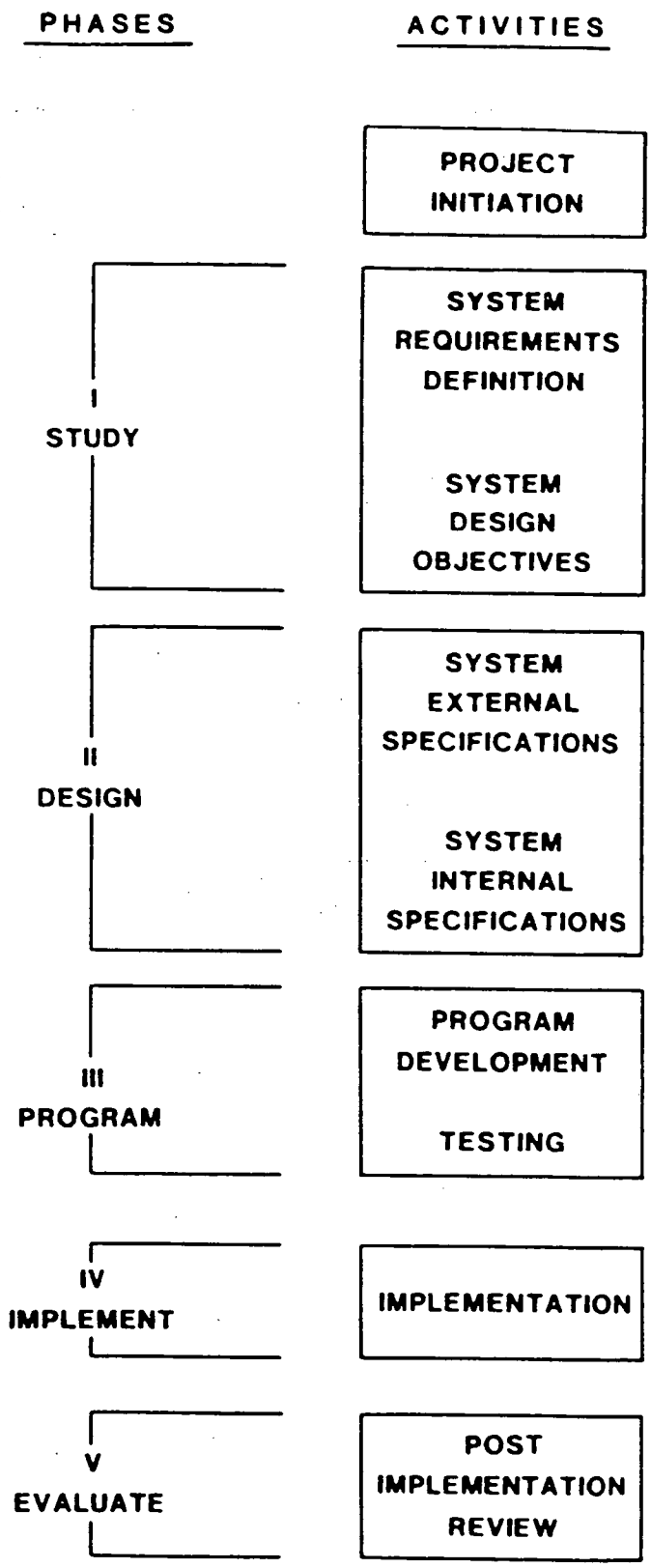

Figure 4
Typical System Development Methodology.

- Extension of the system to provide graphics access.

However, a number of states have found that they do not require the services of a consultant. The Iowa Office of Transportation Research, for example, found that they had the required analysis capabilities in-house, and therefore had no need for a consultant.

Regardless of whether the file linkage is developed in-house or with the assistance of a consultant, objectives of the program must be defined prior to program development. A list of common objectives are:

- Evaluate the effectiveness of existing operations within the agency's goals and objectives.
- Propose procedures to increase the efficiency of existing systems.
- Develop guidelines for the effective purchase of equipment.
- Standardize annual file maintenance.
- Develop cross referenced files to enable inquiry versatility.
- Implement a user friendly report generating system.

The second step in the study phase is to review the existing independent files of each division in the agency. This involves a number of tasks including the following:

- a review of the existing files to determine what information is being gathered, by whom and to what degree of detail.

- an evaluation of the existing staffing situation for degree of efficiency, appropriate division of labor, and the need for additional skills. An integral part of this task is to also evaluate the existing spending on staff and any needed technical services.
- a review of the existing manual and computerized techniques used for data interpretation. The existing computer software and hardware should be evaluated and their application to the comprehensive highway information system determined.

The final and most important step in the Study Phase is to determine what is desired from the program. This requires the identification of the transportation agency's needs, priorities, the file inventory, useful data elements, common referencing system and what software and hardware systems would be appropriate.

Each of the aforementioned items are described below:

Needs - the changing nature of the transportation information activities from manual to increasingly more complex computerized data processing has prompted many States to look to an integrated highway system as a solution to their data problems. The activities of each division, therefore, must be reviewed and a determination made as to the possibility of performing these required activities through the computerized system.

Priorities - As all division functions may not be integrated into the information sytem, a hierarchy of required activities must be established. The most essential programs required for effective decision-making should have priority. Top level management must ensure that activities chosen for integration into the computerized database do not displace more important functions.

File Inventory - Figure 1 presented a typical system of files in a data base. This structure is generally similar among different States although the degree of detailed data in each file

varies. Typical file inventories include: roadway data, traffic data, accident data, physical conditions and structural data. State patrol and safety data may or may not be included in the data base depending on the program's objectives.

Data Elements - During the system study, data elements of each file must be specified. In Alaska a consensus session technique was used to select desired data elements. Data elements are the actual pieces of information required for the file. For example, the Roadway Data file would include the following data elements: roadway width, roadway pavement type, grade and alignment. Each element has a name, format, range of values, audits, owner and source. Figure 5 presents a sample data element sheet for Washington State's Roadway Data File. The entire file consists of five such sheets which list each data element alphabetically.

Data elements and their respective collectors are often chosen on the principle of the lowest common denominator. For example, when describing roadway width, different users collect data to their required degree of detail -- lanes, measurement to the foot, and measurement to the inch. However when selecting the data element the division requiring the greatest detail -- measurement to the inch -- would be chosen. This eliminates duplication of data and ensures that the data collected is usable by all users.

Some data elements are actually a code rather than an actual measurement. In this case, both the set of codes and the corresponding code narrative is specified as part of each data definition. This information resides in a code table which allows on-line code changes without having to change any software.

Common referencing system - a common referencing system must be chosen for the computer system to derive relationships between the files. After review of the existing referencing system of each file a common system as described in section 1.2 must be chosen. A sample milepoint reference system is illustrated in figure 6. A map showing the milepoints was attached to the referenced index to help a user identify specific points along the route.

II. Design

The actual design of the desired highway information system is accomplishe in this phase. This includes structur ing the file inventory within the framework of the system program used, as well as creating the desired links (file interactions) between the files.

During this phase specific features such as formats for report-generating purposes, special screens for data access and the creation of a selective access for edit purposes are designed.

Specific programs and languages used were descibed in Chapter 1.

III. Program

In this phase the concepts of the program design are turned into the language of the computer. The various information management systems as described in Chapter 1, section 5 are used to produce a unified data base and a number of different file linkage programs. During this phase the program committee tests and analyzes the system to ensure that user needs are being met.

IV. Implementation - This step involves the input and integration of the data files. The users of the program are actively accessing the files to enter, update, edit and manipulate the data, and produce reports.

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION
TRANSPORTATION INFORMATION AND PLANNING SUPPORT SYSTEM

ROADWAY DATA ELEMENTS

PICTURE	DATA ELEMENT NAME
PIC 9(8)	ACCEL-LN-LEFT-CTR-DT
PIC V99	ACCEL-LN-LEFT-CTR-LGT
PIC 9(2)	ACCEL-LN-LEFT-CTR-WDT
PIC 9(8)	ACCEL-LN-LEFT-DT
PIC V99	ACCEL-LN-LEFT-LGT
PIC 9(2)	ACCEL-LN-LEFT-WDT
PIC 9(8)	ACCEL-LN-RT-CTR-DT
PIC V99	ACCEL-LN-RT-CTR-LGT
PIC 9(2)	ACCEL-LN-RT-CTR-WDT
PIC 9(8)	ACCEL-LN-RT-DT
PIC V99	ACCEL-LN-RT-LGT
PIC 9(2)	ACCEL-LN-RT-WDT
PIC 9(3)V99	ARM
PIC S9(3)V99	ARM-ADJMT-FACTOR
PIC 9(3)V99	ARM-BEGIN-CHANGE
PIC 9(8)	ARM-DATE
PIC 9(3)V99	ARM-END-CHANGE
PIC 9(8)	BRIDGE-DATE
PIC X	BRIDGE-ILLUM-IND
PIC X(10)	BRIDGE-NUM
PIC X(24)	BRIDGE-XROAD-DESC
PIC X(2)	BRIDGE-XROAD-OWNER-CD
PIC 9(8)	CITY-DATE
PIC X(4)	CITY-NUM
PIC X(2)	CITY-POPULATION-CD
PIC 9(8)	CITY-POPULATION-DATE
PIC 9(8)	CITY-ZONE-DATE
PIC X	CITY-ZONE-TYPE
PIC X(3)	COINCID-BEG-END-IND-1
PIC X(3)	COINCID-BEG-END-IND-2
PIC X(3)	COINCID-BEG-END-IND-3
PIC 9(8)	COINCID-DATE-1
PIC 9(8)	COINCID-DATE-2
PIC 9(8)	COINCID-DATE-3
PIC X(2)	COINCID-MAJ-MINOR-IND
PIC X(6)	COINCID-RDWY-QUAL-1
PIC X(6)	COINCID-RDWY-QUAL-2
PIC X(6)	COINCID-RDWY-QUAL-3
PIC X(2)	COINCID-RDWY-TYPE-1
PIC X(2)	COINCID-RDWY-TYPE-2
PIC X(2)	COINCID-RDWY-TYPE-3
PIC X	COINCID-SRMP-AB-IND-1
PIC X	COINCID-SRMP-AB-IND-2
PIC X	COINCID-SRMP-AB-IND-3
PIC 9(3)V99	COINCID-SRMP-1
PIC 9(3)V99	COINCID-SRMP-2
PIC 9(3)V99	COINCID-SRMP-3
PIC X(3)	COINCID-STATE-ROUTE-1
PIC X(3)	COINCID-STATE-ROUTE-2
PIC X(3)	COINCID-STATE-ROUTE-3
PIC 9(8)	CONTR-CONSTR-BEG-DT
PIC 9(8)	CONTR-CONSTR-END-DT
PIC X(2)	CONTR-EXCEPTION-CD
PIC X(6)	CONTR-NUM
PIC X	CONTR-OLD-PCC-LOC-CD
PIC 9(3)	CONTR-OLD-PCC-WIDTH
PIC V99	CONTR-SURFC-THICK
PIC X(2)	CONTR-SURFC-TYPE
PIC 9V99	CONTR-TREAT-BASE-THICK
PIC X	CONTR-TREAT-BASE-TYPE
PIC X(2)	CONTR-TYPE

Figure 5
Sample Roadway Data Element Sheet.

Route Reference 89 | Location Sanpete County Line North to Utah County Line

County	Number	Dist.&Maint.Sta.No	F.A.System&No.	Functional Class	Route Length	Lanes	Revised
Sanpete	039	3 333/334	FAP-22/FAP-40	Prin. Arterial/Minor Arterial	415.84	2	Nov. 1978

Photo Log Index Reel 5 of 5 M.P. 204.99 to 199.79 Reel 4 of 5 M.P. 219.99 to 205.01

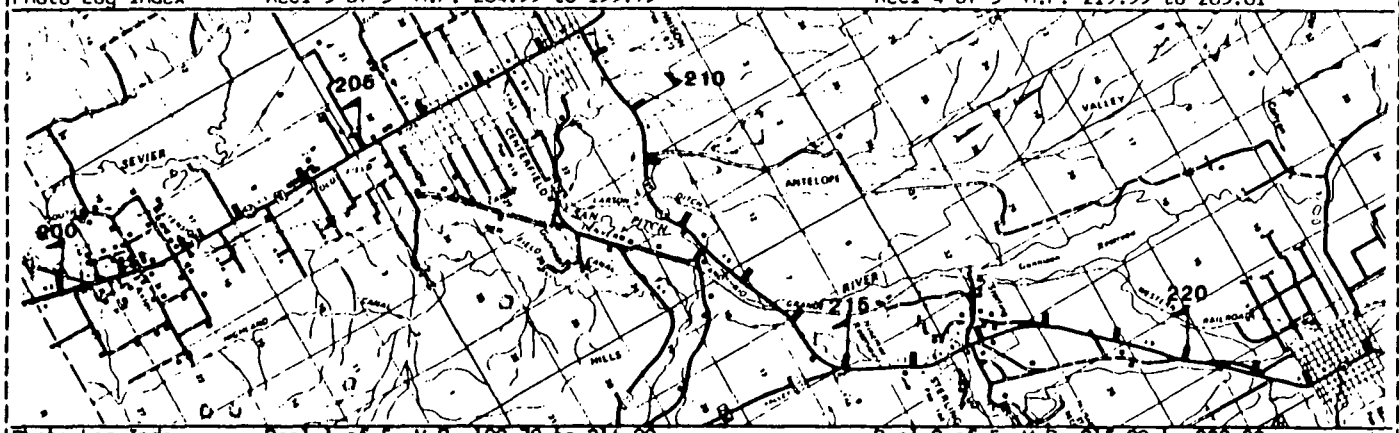

Photo Log Index Reel 1 of 5 M.P. 199.79 to 214.99 Reel 2 of 5 M.P. 215.00 to 229.99

Reference Point	Struct. No.	Reference Point Location	Reference Point	Struct. No.	Reference Point Location
199.79		Sevier-Sanpete County Line	206.27		City Road Crossing Center Street
200.58		Jct. SR-256 Left to Redmond Maint. changes to #328	206.53		City Road Crossing 200 North
			206.80		City Road Crossing 400 North
201.34		Local Road Crossing	207.50		Centerfield North Limits and Gunnison South Limits
201.86		Local Road Crossing			
202.34		Road Left	207.13		City Street Left
202.60		Road Right	207.32		Jct. SR-137 Right - 6th South Street Left
203.36		Road Right			
204.09		Road Right	207.68	00-688	Sanpitch River Bridge
204.46		Road Right	207.93		City Street Right 300 South
204.73		Road Left	208.03		Center Street Crossing
205.24		Road Crossing	208.13		City Street Crossing 100 North
205.61		Centerfield South Limits	208.24		City Street Crossing 200 North
205.75		City Road Crossing 400 South	208.57		Jct. SR-28 (Funct. changes to Minor Arterial) (FAP Changes to FAP-40)
206.01		City Road Crossing 200 South			

Figure 6
Sample Reference System Sheet.

V. Evaluation - After implementation, a review of the program is essential to identify any problems as to technical processes or program shortfalls. Cost savings are also evaluated in this phase. Chapter 3 describes a variety of cost benefits of implementation.

Chapter 3
Program Benefits and Implementation Issues

This chapter presents a summary of economic and qualitative benefits and institutional issues that may arise from implementation of the computerized highway information systems. As each highway information system varies from state to state, the issues and benefits will also vary.

3.1 Program Benefits

A. Economic Benefits - In general, economic benefits fall into three categories: savings in labor, wiser investments and cost benefits.

Savings in Labor - With file linkage, reduced labor hours accrue from the savings in time expended to access and pull together disparate information, and the elimination of duplicate data gathering. For example, the Washington State Department of Transportation found that by eliminating redundant activities and automating manual tasks they would save the labor of ten full time employees. This resulted in substantial salary savings, and second order labor savings included fringe and overhead benefits.

Wiser Investments - One of the greatest benefits from the program is the ability to make wiser investments of taxpayer's dollars. Setting priorities for combining individual projects into a statewide program requires consideration of many more factors than the "professional judgement" often used in small geographic areas, and file linkage provides access to a more comprehensive data base and greater ability to use the data for analytical studies. A fully integrated data base can support a process that could rank capital projects on a statewide basis, allowing the more complex decision making than would be required for individual projects.

Cost Benefits - Although the costs of creating a unified linked database are not trivial ($350,000 to several million dollars for an operating system), the dolar savings within data collection, input, storage and retrieval are recovered after a number of years. Washington and Colorado provide concrete examples of cost savings.

The Washington TRIPS (Transportation Information and Planning Support) System's development cost of approximately $3 million is expected to be recovered in seven years. This is based on a saving of 10 full-time equivalent employees, eliminating redundant data and activities, and automating manual tasks. Other agencies within Washington are so impressed with the TRIPS system that additional links between files and TRIPS are being done. Additional cost benefits are expected to result.

Although, the Colorado Department of Highways has encountered some problems in the creation of the CORIS (Colorado Roadway Information System) Database and in file linkage programs, they believe that the benefits far exceed the problems. For example, the Highway Performance Monitoring System (HPMS) submittal has shown great improvements. Total time to produce the submittal decreased and computer charges were reduced by approximately $120,000, and the reliability of the data was significantly increased.

B. Qualitative Benefits

Qualitative benefits primarily result

from the improvements in access to data and in the quality of analysis. Examples of such benefits are:

- o Improved information quality.
- o Increased support for planning and managing through accurate, current information.
- o Better system flexibility to efficiently service special information requests.
- o Reduced response time required to correlate data for user requests.
- o Greater system responsiveness to changing user requirements.

Other qualitative benefits include a substantial increase in the magnitude of cooperation between various groups within the Transportation agency, thus leaping over some of the institutional difficulties associated with the agency's organization. The need to operate as a team in the development of the program, and actual conduct of the work, will likely yield substantial downstream benefits to the participating parties as they begin to work together on various institutional and turf-related problems.

3.2 Institutional Issues

Achieving a file linkage system requires the cooperation of many departments and individuals, and to varying degrees, a loss of autonomy over departmental files and systems. Thus, overcoming institutional issues ensures cooperation is as vital a step as overcoming technical issues such as software selection, et. al.

Proprietorship

The process of creating a unified data base to be used by many divisions within a transportation agency creates a number of problems relating to the control of information. As files are reviewed in the study phase of program development and duplicate collection of data eliminated, the collectors and owers of the "discarded" files lose their control of the data. The primary problem arises upon selection of one division to collect the data. As all collectors regard their task as integral to their work progress, a conflict results. This is often resolved through careful review of the data elements to determine which division collects the data to the greatest detail. A consensus session of the divisions involved during the project definition/design phase where the needed data elements are selected and where the needs of each division are defined, would help solve the proprietorship problem.

Responsibility/Access for Editing

The issue of who is responsible for maintenance of the data is often resolved by assigning this task to the collector of information. Access to the data for edit and update purposes should be selective, and ideally only the data collectors should be allowed such access. The Colorado Department of Highways has designed their CORIS program to require passwords in order to access the systems, and screens are designed for specific users. This system allows for information to be available to many users, but limits access for edit.

Credibility/Receptivity

Another institutional issue that arises from delegation of data collection to one user for use by many is the validity of the data presented in the unified database. The collection of data by one user increases the credibility and receptivity of the information provided because users now have knowledge of the source of the information. Questions and additional information on specific data can be addressed through contact with the appropriate collector.

The credibility of the information is essential and must be accomplished

through the program itself. During the data element selection process the appropriate division must be chosen to collect the information. The collection of the data element must be as essential to their internal activities as it is to other users. The design of a good collection program further inceases chances for proper data collection and file maintenance. In addition, the creation of a technical committee to continually monitor data collection and review data for input is a necessary part of maintaining a computerized information system.

SUMMARY

This report presents an overview of where the computerized highway information system is now and its status as a planning and programming tool for state highway agencies. The consensus of States already participating in the program is that the difficulties in preparing for program implementation are miniscule compared to the program's benefits.

The following summary from the State of Washington presents an outlook on the computerized highway information system representative of other States participating in the program.

"In conclusion, we're excited about the initial successes that TRIPS has achieved. Wherever we have taken preliminary reports or processes to the districts, other divisions or agencies, the responses have been overwhelmingly supportive. The audiences are particularly appreciative of the fact that now they will have up-to-date information available directly to them on line and that the system will be more responsive to their needs. Other sections of the Department, such as the Bridge Section, are so impressed with TRIPS that they are already at work completing the links between their files and TRIPS. In the CADD/CAM area, a pilot project is underway to directly plot on maps information from the TRIPS files.

From these early successes it is apparent that TRIPS will give WSDOT a leading edge file linkage system capable of growing with the State's information needs."

APPENDIX

FILE LINKAGE FOR

COMPREHENSIVE HIGHWAY SAFETY

A DATA MANAGEMENT

FORUM

Salt Lake City, Utah

September 23-24, 1986

INTRODUCTION

In response to FHWA contract DTFH 61-86-C-00030 and in an effort to review the current State-Of-The-Art of file linkage within the U.S., a File Linkage Forum was held in Salt Lake City, Utah on September 23-24, 1986. Interested and involved states were invited to provide presentations of their individual involvement and development.

Participant states and representatives were as follows:

New York.....David Hartgen
Idaho.....Dave Amick
Kansas.....Verne Walrafen
Colorado.....Bruce Kinney
Washington.....Cal Smith
Kentucky.....Mohammed Taqui
Iowa.....John Nervig
Illinois.....John Blair
Alaska.....Leo Lutchansky
Utah.....Host State

Additional representatives from FHWA, consultants and non-participating interested states were:

FHWA

Washington Offices
Jim Willhite
Dave McElhaney
Peter Hatzi

Region 8
Ray Griffith

Utah Division
Jim Biddiscombe

Consultants
Tom Duffy - Urbitran
Ron Pfefer - Northwestern Traffic Institute
Frank Cahoon - Price Waterhouse

States
Hal Goss - Nevada DOT
John Whitaker - Nevada DOT

The forum was conducted in two basic sessions: First, state presentations of current development and future plans (with open discussion, question and answers) and second, an exploratory query into the following conditions of file linkage development:

Problem areas - present and future.
Appropriate and probable applications.
Conceptualization justification.

The following report attempts a recapitulation of the session's discussions. It is conceded at the outset, that the enormity of he material, the diversity of development and the ambiguity of the subject render this presentation as perspective limited.

SESSIONS ONE

States Presentations

The following agenda includes the states and presentors:

New York.....David Hartgen
Idaho.....Dave Amick
Kansas.....Verne Walrafen
Colorado.....Bruce Kinney
Washington.....Cal Smith
Kentucky.....Mohammed Taqui
Iowa.....John Nervig
Illinois.....John Blair
Utah.....Art Geurts
John Morris
Kent Nielsen - UDOT Demonstration
Alaska.....Leo Lutchansky

Copies of the presentation papers are included.

The primary objective of this session was to review and reflect the current state-of-art of file linkage developments. As an initial effort the forum perhaps created more questions than answers nevertheless presentors did develop a definite trend and/or mosaic of development. The initial reaction of almost all participants was the realization that most development had taken place within individual state's constraints as opposed to comprehensive guidance.

The broad spectrum of presentations indicated file linkage development that spanned from initiation for problem solution to comprehensive planning and development. Almost all reflected a relatively recent entry into the file linkage capability for Highway Information Data Management. Questions and answers conveyed a sense of concept exchange and broadening of perceived potential. Even though the purpose of the forum was to explore file linkage usage in the field of highway safety, it was the almost unanamous consensus of the group that file linkage, as a management tool, had far more comprehensive potential and that highway highway safety was a principal user but discussion could not be confined to safety only. It was also concluded by the group that even though the potential of file linkage was limited only by the individual imaginative use, the pardox lay in the limitation of capability by other intervening factors. These are rehearsed in Session Two- Uses, Problems, & Concept.

A final consensus of the participants was that the information exchange was so beneficial that the recommendation was made that other forums should be sponsored both for idea exchange and for standardization development. The latter eluded to the concept that if file linkage is appropriate intra-state, perhaps it might be just as appropriate inter-state.

SESSION TWO

Concept, Problems & Applications

A secondary objective of the forum was to query the active states as to their perception of problem (encountered and anticipated) and the realistic applications of file linkage. This dialogue represented the second session of the forum with each state offered the opportunity of exclusive input plus group discussion involvement. Tables 1-3 highlight the areas identified, without benefit of elaboration. It is outside the scope of the summary to detail each observation, however, collectively the observations broaden the scope of file linkage far beyond that of singularly producing additional useful data.

An example of the complexity beyond the simple production of file intergrated data is the requirement of effective data presentation and user capabilities. The very capability of vast volumes of data requires highly skilled abilities to make effective use of the information both by the user and the producer. Another constraint recognizes by the group is the receptivity of the user as the produced information deviates from prior conceptions of the user. Clearly the question of credibility will become an increasing issue. Also coupled with the issue of credibility is the ability of the producer to make correct inferences or conclusions of the data. Such a requirement is quite extant from the ability to simply produce the fundamental data. Consistency and changing trends also cloud the intergrity question.

Perception of the buss word - file linkage as a panacea for management decision making also was a major concern of the group. Practical application of file linkage has not yet reached a high state of professionalism recognizing the limitations as well as the potential. It was suggested that at this stage of development perhaps most perceptions were rose-colored or non-existant. The other end of the continum remains to be examined.

While discussion was plentiful and opinions freely given, almost all expressed and optimistic wait and see and learn posture. The desire to continue additional forums ran high.

Problem Areas

More people need more training in analysis using available data (4)*

Better identification of potential users. (3)

Should be broadened from exclusive safety applications. (2)

Data quality control (1)

User familiarity with data (what do they really mean?) (1)

Ability of people to accept/adapt to technological development.

Confidence in system

Flexibility/adaptability of system

Control vs. service - the right balance

Standardized geographic references

Definitions

File linkage is a tool - not a product

Too narrow of organization view - cross agency applications

Should be management-driven not user-driven

*( ) indicate number of additional states approbation

Table 1

Applications

Graphics (5)

Mapping (3)

District viewpoint (2)

Fiscal, project, and budget (2)

Engineering (1)

Pavement management (1)

Maintenance management (1)

Flexibility and adaptability I.E. intersection analysis, correlation of design features

Better indentification of problem locations

Historical tracking

Priority programming

Federal reporting

Bridge management

Evaluations

Most all reports and analysis

Reduce redundancy - data collection and report

Support design

Risk Management/liability

Research

Multi-level reporting

Table 2

Concepts

Good business

Data element approach - simplified

Institutional issues to be addressed

Network issues

Don't link just for link's sake - have a reason or don't do it

Application simplicity (KISS)

Flexible approach

Georeferencing

Learning from experience

Information is Dynamic

Should be readily coupled with collection methods

Driven by user decision needs

Must be flexible and adaptable in analysis mode and data base system integration

Should have local government participation if possible demographic links

Private sector methodology (will it show a profit?)

Multi-level reporting

Table 3

Form FHWA-201
(Rev. 11-67)

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

MINUTE - MEMO

Use this form in lieu of transmittal slips within Dept. of Trans. when message comment is to be retained as file material. Do not prepare carbons. Not to be used in lieu of Form FHWA-121 for informal correspondence.

SUBJECT

2 DAY PILOT WORKSHOP--FILE LINKAGE

TO	MESSAGE/COMMENT	FROM/DATE
	Mr. Peter Hatzi, Implementation Division, called regarding the subject workshop and offering it to Region 7 at no costs. The workshop would be on linking files such as accidents, HPMS, roadway inventory and other files. Utah did the work to develop this technique and is based on 5 case studies. The workshop would be available in late March through early May and could be done just for one state if requested and as long as maintenance, traffic, safety, and planning departments at the state were in attendance. Mr. Hatzi will send us an agenda and a short report. It is a 16 hour workshop.	